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Streams

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Preface

Oracle9i Streams describes the features and functionality of Streams. This document contains conceptual information about Streams, along with information about configuring and managing a Streams environment. In addition, this document contains detailed examples for configuring a Streams messaging environment, a Streams replication environment, and a rule-based application.

This preface contains these topics:

Audience

Oracle9i Streams is intended for database administrators who create and maintain Streams environments. These administrators perform one or more of the following tasks:

- Plan for a Streams environment
- Configure a Streams environment
- Configure conflict resolution in a Streams environment
- Administer a Streams environment
- Monitor a Streams environment
- Perform necessary troubleshooting activities

To use this document, you need to be familiar with relational database concepts, SQL, distributed database administration, Advanced Queuing concepts, PL/SQL, and the operating systems under which you run a Streams environment.

Organization

This document contains:

Part I, Streams Concepts

Contains chapters that describe conceptual information relating to Streams.

Chapter 1, "Introduction to Streams"

Introduces the major features of Streams and how they can be used.

Chapter 2, "Streams Capture Process"

Contains conceptual information about the Streams capture process. Includes information about logical change records (LCRs), datatypes and types of changes captured, and supplemental logging, along with information about capture process architecture.

Chapter 3, "Streams Staging and Propagation"

Contains conceptual information about staging and propagation in a Streams environment. Includes information about the differences between captured and user-enqueued events, propagation, the differences between transactional and

non-transactional queues, and using `SYS.AnyData` queues. Also includes information about queue and propagation architecture.

Chapter 4, "Streams Apply Process"

Contains conceptual information about the Streams apply process. Includes information about event processing with an apply process, considerations for apply changes to tables, conditions for applying DDL changes, and controlling a trigger's firing property, along with information about the oldest SCN for an apply process and apply process architecture.

Chapter 5, "Rules"

Contains conceptual information about rules. Includes information about rule components, rule sets, and privileges related to rules.

Chapter 6, "How Rules Are Used In Streams"

Contains conceptual information about how rules are used in Streams. Includes information about table-level rules, subset rules, schema-level rules, and global-level rules. Also includes information about rule-based transformations.

Chapter 7, "Streams Conflict Resolution"

Contains conceptual information about conflicts. Includes information about the possible types of conflicts, conflict detection, conflict avoidance, and conflict resolution in Streams environments.

Chapter 8, "Streams Tags"

Contains conceptual information about Streams tags. Includes information about how tag values are used in rules, how a tag value can be set for an apply process, and how to avoid change cycling using tags.

Chapter 9, "Streams Heterogeneous Information Sharing"

Contains conceptual information about heterogeneous information sharing using Streams. Includes information about sharing information in an Oracle database with a non-Oracle database, sharing information in a non-Oracle database with an Oracle database, and using Streams to share information between two non-Oracle databases.

Part II, Streams Administration

Contains chapters that describe managing a capture process, staging, propagation, an apply process, rules, rule-based transformations, logical change records (LCRs), and Streams tags.

Chapter 10, "Configuring a Streams Environment"

Contains information about preparing for a Streams environment. Includes instructions for configuring a Streams administrator, setting initialization parameters that are important to Streams, preparing for a capture process, and configuring networking connectivity.

Chapter 11, "Managing a Capture Process"

Contains information about managing a capture process. Includes instructions for creating, starting, stopping, and altering a capture process, as well as other information related to capture process administration.

Chapter 12, "Managing Staging and Propagation"

Contains information about managing staging and propagation of events in a Streams environment. Includes instructions for creating a Streams queue, and instructions for enabling, disabling, and altering a propagation job, as well as other information related to staging, propagation, and messaging.

Chapter 13, "Managing an Apply Process"

Contains information about managing an apply process. Includes instructions for creating, starting, stopping, and altering an apply process, as well as instructions about using apply process handlers, configuring conflict resolution, and managing an error queue.

Chapter 14, "Managing Rules and Rule-Based Transformations"

Contains information about managing rules and rule-based transformations. Includes instructions for managing rules and rule sets, as well as information about granting and revoking privileges related to rules. In addition, this chapter includes instructions for creating, altering, and removing rule-based transformations.

Chapter 15, "Managing LCRs and Streams Tags"

Contains information about managing logical change records (LCRs) and Streams tags. Includes instructions for constructing and enqueuing LCRs, and instructions for setting and removing tag values for a session or an apply process.

Chapter 16, "Monitoring a Streams Environment"

Contains information about using data dictionary views and scripts to monitor a Streams environment. Includes information about monitoring capture processes, queues, propagation jobs, apply processes, rules, rule-based transformations, and tags.

Chapter 17, "Troubleshooting a Streams Environment"

Contains information about possible problems in a Streams environment and how to resolve them. Includes information about troubleshooting a capture process, propagation job, apply process, and rules for Streams jobs and processes, as well as information about checking trace files and the alert log for problems.

Part III, Example Environments and Applications

Contains chapters that illustrate example environments.

Chapter 18, "Example Streams Messaging Environment"

Contains a step by step example that configures a messaging environments using Streams.

Chapter 19, "Example Streams Replication Environments"

Contains step by step examples that configure replication environments using Streams.

Chapter 20, "Example Rule-Based Application"

Contains step by step examples that illustrate a rule-based application that uses the Oracle rules engine.

Appendices

Contains one appendix that describes the XML schema for logical change records (LCRs).

Appendix A, "XML Schema for LCRs"

Contains the definition of the XML schema for LCRs.

Related Documentation

For more information, see these Oracle resources:

- *Oracle9i Database Concepts*
- *Oracle9i Database Administrator's Guide*
- *Oracle9i SQL Reference*
- *Oracle9i Supplied PL/SQL Packages and Types Reference*
- *PL/SQL User's Guide and Reference*
- *Oracle9i Database Utilities*
- *Oracle9i Heterogeneous Connectivity Administrator's Guide*
- *Oracle9i Application Developer's Guide - Advanced Queuing*
- Streams online help for the Streams tool in Oracle Enterprise Manager

You may find more information about a particular topic in the other documents in the Oracle9*i* documentation set.

Many of the examples in this book use the sample schemas of the seed database, which is installed by default when you install Oracle. Refer to *Oracle9i Sample Schemas* for information on how these schemas were created and how you can use them.

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Conventions

This section describes the conventions used in the text and code examples of this documentation set. It describes:

- Conventions in Text
- Conventions in Code Examples

Conventions in Text

We use various conventions in text to help you more quickly identify special terms. The following table describes those conventions and provides examples of their use.

Convention	Meaning	Example
Bold	Bold typeface indicates terms that are defined in the text or terms that appear in a glossary, or both.	When you specify this clause, you create an **index-organized table**.
Italics	Italic typeface indicates book titles or emphasis.	*Oracle9i Database Concepts* Ensure that the recovery catalog and target database do *not* reside on the same disk.
UPPERCASE monospace (fixed-width) font	Uppercase monospace typeface indicates elements supplied by the system. Such elements include parameters, privileges, datatypes, RMAN keywords, SQL keywords, SQL*Plus or utility commands, packages and methods, as well as system-supplied column names, database objects and structures, usernames, and roles.	You can specify this clause only for a NUMBER column. You can back up the database by using the BACKUP command. Query the TABLE_NAME column in the USER_TABLES data dictionary view. Use the DBMS_STATS.GENERATE_STATS procedure.

Convention	Meaning	Example
`lowercase monospace (fixed-width) font`	Lowercase monospace typeface indicates executables, filenames, directory names, and sample user-supplied elements. Such elements include computer and database names, net service names, and connect identifiers, as well as user-supplied database objects and structures, column names, packages and classes, usernames and roles, program units, and parameter values. **Note:** Some programmatic elements use a mixture of UPPERCASE and lowercase. Enter these elements as shown.	Enter `sqlplus` to open SQL*Plus. The password is specified in the `orapwd` file. Back up the datafiles and control files in the `/disk1/oracle/dbs` directory. The `department_id`, `department_name`, and `location_id` columns are in the `hr.departments` table. Set the `QUERY_REWRITE_ENABLED` initialization parameter to `true`. Connect as `oe` user. The `JRepUtil` class implements these methods.
`lowercase italic monospace (fixed-width) font`	Lowercase italic monospace font represents placeholders or variables.	You can specify the *`parallel_clause`*. Run `U`*`old_release`*`.SQL` where *`old_release`* refers to the release you installed prior to upgrading.

Conventions in Code Examples

Code examples illustrate SQL, PL/SQL, SQL*Plus, or other command-line statements. They are displayed in a monospace (fixed-width) font and separated from normal text as shown in this example:

```
SELECT username FROM dba_users WHERE username = 'MIGRATE';
```

The following table describes typographic conventions used in code examples and provides examples of their use.

Convention	Meaning	Example
[ ]	Brackets enclose one or more optional items. Do not enter the brackets.	`DECIMAL (`*`digits`*` [ , `*`precision`*` ])`
{ }	Braces enclose two or more items, one of which is required. Do not enter the braces.	`{ENABLE | DISABLE}`
|	A vertical bar represents a choice of two or more options within brackets or braces. Enter one of the options. Do not enter the vertical bar.	`{ENABLE | DISABLE}` `[COMPRESS | NOCOMPRESS]`

Convention	Meaning	Example
. . .	Horizontal ellipsis points indicate either: ■ That we have omitted parts of the code that are not directly related to the example ■ That you can repeat a portion of the code	`CREATE TABLE ... AS subquery;` `SELECT col1, col2, ... , coln FROM employees;`

.
.
.
	Vertical ellipsis points indicate that we have omitted several lines of code not directly related to the example.	`SQL> SELECT NAME FROM V$DATAFILE;`
		`NAME`
		`----------`
		`/fsl/dbs/tbs_01.dbf`
		`/fs1/dbs/tbs_02.dbf`
		`.`
		`.`
		`.`
		`/fsl/dbs/tbs_09.dbf`
		`9 rows selected.`

Other notation	You must enter symbols other than brackets, braces, vertical bars, and ellipsis points as shown.	`acctbal NUMBER(11,2);` `acct CONSTANT NUMBER(4) := 3;`
Italics	Italicized text indicates placeholders or variables for which you must supply particular values.	`CONNECT SYSTEM/system_password` `DB_NAME = database_name`

UPPERCASE	Uppercase typeface indicates elements supplied by the system. We show these terms in uppercase in order to distinguish them from terms you define. Unless terms appear in brackets, enter them in the order and with the spelling shown. However, because these terms are not case sensitive, you can enter them in lowercase.	`SELECT last_name, employee_id FROM employees;`
		`SELECT * FROM USER_TABLES;`
		`DROP TABLE hr.employees;`

lowercase	Lowercase typeface indicates programmatic elements that you supply. For example, lowercase indicates names of tables, columns, or files.
	Note: Some programmatic elements use a mixture of UPPERCASE and lowercase. Enter these elements as shown.
		`SELECT last_name, employee_id FROM employees;`
		`sqlplus hr/hr`
		`CREATE USER mjones IDENTIFIED BY ty3MU9;`

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Part I

Streams Concepts

This part describes conceptual information about Streams and contains the following chapters:

1

Introduction to Streams

This chapter briefly describes the basic concepts and terminology related to Oracle Streams. These concepts are described in more detail in other chapters in this book.

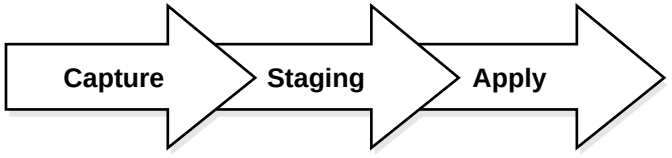
This chapter contains these topics:

Streams Overview

Oracle Streams enables the sharing of data and events in a data stream, either within a database or from one database to another. The stream routes specified information to specified destinations. The result is a new feature that provides greater functionality and flexibility than traditional solutions for capturing and managing events, and sharing the events with other databases and applications. Streams allows customers to break the cycle of trading off one solution for another. Oracle Streams provides the capabilities needed to build and operate distributed enterprises and applications, data warehouses, and high availability solutions. You can use all the capabilities of Oracle Streams at the same time. If your needs change, you can implement a new capability of Streams without sacrificing existing capabilities.

Using Oracle Streams, you control what information is put into a stream, how the stream flows or is routed from database to database, what happens to events in the stream as they flow into each database, and how the stream terminates. By configuring specific capabilities of Streams, you can address specific requirements. Based on your specifications, Streams can capture and manage events in the database automatically, including, but not limited to, data manipulation language (DML) changes and data definition language (DDL) changes. You can also put user-defined events into a stream. Then, Streams can propagate the information to other databases or applications automatically. Again, based on your specifications, Streams can apply events at a destination database. Figure 1–1 shows the Streams information flow.

Figure 1–1 Streams Information Flow



What Can Streams Do?

You can use Streams to:

- **Capture** changes at a database.

  You can configure a background **capture process** to capture changes made to tables, schemas, or the entire database. A capture process captures changes from the redo log and formats each captured change into a logical change record (**LCR**). The database where changes are generated in the redo log is called the **source database**.

- Enqueue **events** into a queue. Two types of events may be staged in a Streams queue: LCRs and user messages.

  A capture process enqueues LCR events into a queue that you specify. The queue can then share the LCR events within the same database or with other databases.

  You can also enqueue user events explicitly with a user application. These explicitly enqueued events can be LCRs or user messages.

- Propagate events from one queue to another. These queues may be in the same database or in different databases.

- Dequeue events.

  A background **apply process** can dequeue events. You can also dequeue events explicitly with a user application.

- **Apply** events at a database.

  You can configure an apply process to apply all of the events in a queue or only the events that you specify. You can also configure an apply process to call your own PL/SQL subprograms to process events.

  The database where LCR events are applied and other types of events are processed is called the **destination database**. In some configurations, the source database and the destination database may be the same.

Other capabilities of Streams include the following:

- Directed Networks
- Automatic Conflict Detection and Resolution
- Transformations
- Heterogeneous Information Sharing

These capabilities are discussed briefly later in this chapter and in detail later in this document.

Why Use Streams?

The following sections briefly describe some of the reasons for using Streams.

Message Queuing

Streams allows user applications to enqueue messages of different types, propagate the messages to subscribing queues, notify user applications that messages are ready for consumption, and dequeue messages at the destination database. Streams introduces a new type of queue that stages messages of `SYS.AnyData` type. Messages of almost any type can be wrapped in a `SYS.AnyData` wrapper and staged in `SYS.AnyData` queues. Streams interoperates with Advanced Queuing (AQ), which supports all the standard features of message queuing systems, including multi-consumer queues, publishing and subscribing, content-based routing, internet propagation, transformations, and gateways to other messaging subsystems.

> **See Also:** *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about AQ

Data Replication

Streams can efficiently capture DML and DDL changes made to database objects and replicate those changes to one or more other databases. The Streams capture process captures changes made to source database objects and formats them into LCRs, which can be propagated to destination databases and then applied by the Streams apply process.

The destination databases can allow DML and DDL changes to the same database objects, and these changes may or may not be propagated to the other databases in the environment. In other words, you can configure a Streams environment with one database that propagates changes, or you can configure an environment where changes are propagated between databases bidirectionally. Also, the tables for which data is shared need not be identical copies at all databases. Both the structure and the contents of these tables can differ at different databases, and the information in these tables can be shared between these databases.

Data Warehouse Loading

Data warehouse loading is a special case of data replication. Some of the most critical tasks in creating and maintaining a data warehouse include refreshing existing data, and adding new data from the operational databases. Streams can capture changes made to a production system and send those changes to a staging database or directly to a data warehouse or operational data store. Streams capture of redo log information avoids unnecessary overhead on the production systems. Support for data transformations and user-defined apply procedures allows the necessary flexibility to reformat data or update warehouse-specific data fields as data is loaded.

> **See Also:** *Oracle9i Data Warehousing Guide* for more information about data warehouses

Data Protection with Oracle Data Guard

One solution for data protection is to create a local or remote copy of a production database. In the event of human error or a catastrophe, the copy can be used to resume processing. Oracle Data Guard, a data protection feature built on Streams, can be used to create and maintain a a logical standby database, which is a logically equivalent standby copy of a production database. As in the case of Streams replication, a capture process captures changes in the redo log and formats these changes into LCRs. These LCRs are applied at the standby databases. The standby databases are fully open for read / write and may include specialized indexes or other database objects. Therefore, these standby databases can be queried as updates are applied, making Oracle Data Guard a good solution for off loading latency sensitive queries from a production database.

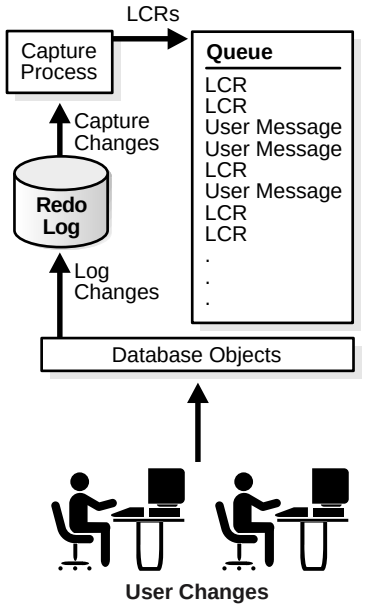
The most notable difference between a logical standby database and a Streams data replication environment is where the changes are captured. It is important to move the updates to the remote site as soon as possible with a logical standby database. Doing so ensures that, in the event of a failure, the exposure to lost transactions is minimal. By directly and synchronously writing the redo logs at the remote database, you can achieve no data loss in the event of a disaster. At the standby system, the changes are captured and directly applied to the standby database with an apply process.

> **See Also:** *Oracle9i Data Guard Concepts and Administration* for more information about logical standby databases

Capture Process

Changes made to database objects in an Oracle database are logged in the redo log to guarantee recoverability in the event of user error or media failure. A capture process is an Oracle background process that reads the database redo log to capture DML and DDL changes made to database objects. A capture process formats these changes into events called LCRs and enqueues them into a queue. You use rules to specify which changes are captured. Figure 1–2 shows a capture process capturing LCRs.

Figure 1–2 The Capture Process



Note: The capture process does not capture some types of DML and DDL changes, and it does not capture changes made in the SYS or SYSTEM schemas.

You can specify Streams tags for redo entries generated by a certain session or by an apply process. These tags then become part of the LCRs captured by a capture process. A tag can be used to determine whether a redo entry or an LCR contains a change that originated in the local database or at a different database, so that you can avoid sending LCRs back to the database where they originated. Tags may be used for other LCR tracking purposes as well. You can also use tags to specify the set of destination databases for each LCR.

See Also:

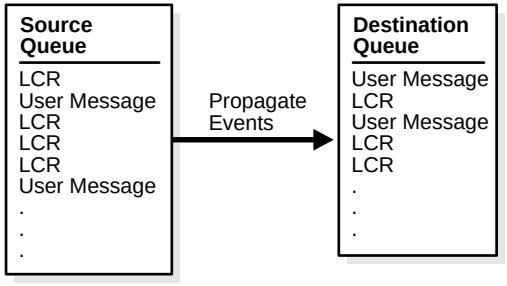
- Chapter 2, "Streams Capture Process" for more information about the capture process and for detailed information about which DML and DDL statements are captured by the capture process
- Chapter 8, "Streams Tags"

Event Staging and Propagation

Streams uses queues to stage events for propagation or consumption. You can use Streams to propagate events from one queue to another, and these queues can be in the same database or in different databases. The queue from which the events are propagated is called the **source queue**, and the queue that receives the events is called the **destination queue**. There can be a one-to-many, many-to-one, or many-to-many relationship between source and destination queues.

Events that are staged in a queue can be consumed by the Streams apply process or by a user-defined subprogram. If you configure a propagation job to propagate changes from a source queue to a destination queue, then you can use rules to specify which changes are propagated. Figure 1–3 shows propagation from a source queue to a destination queue.

Figure 1–3 Propagation from a Source Queue to a Destination Queue

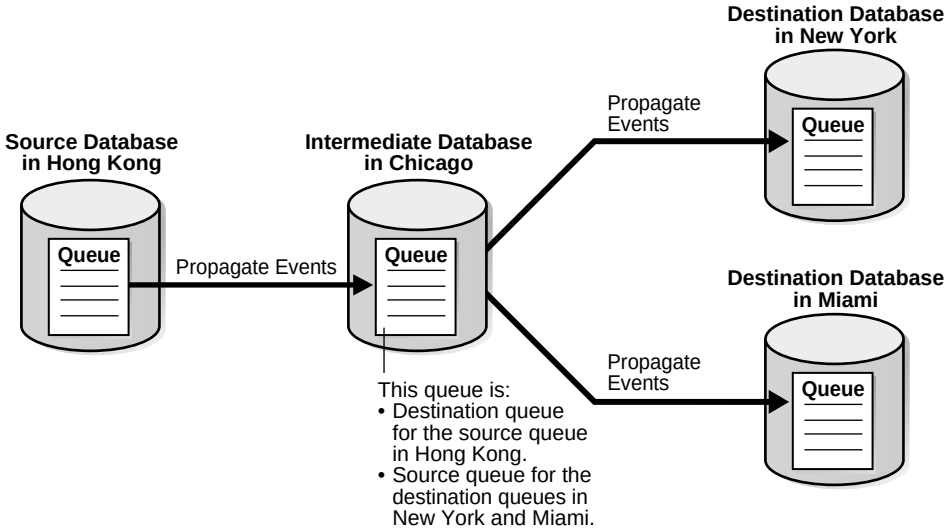


Directed Networks

Streams enables you to configure an environment where changes are shared through **directed networks**. A directed network is one in which propagated events may pass through one or more intermediate databases before arriving at a destination database. The events may or may not be processed at an intermediate database. Using Streams, you can choose which events are propagated to each destination database, and you can specify the route events will traverse on their way to a destination database.

Table 1–4 shows an example directed networks environment. Notice that, in this example, the queue at the intermediate database in Chicago is both a source queue and a destination queue.

Figure 1–4 Example Directed Networks Environment



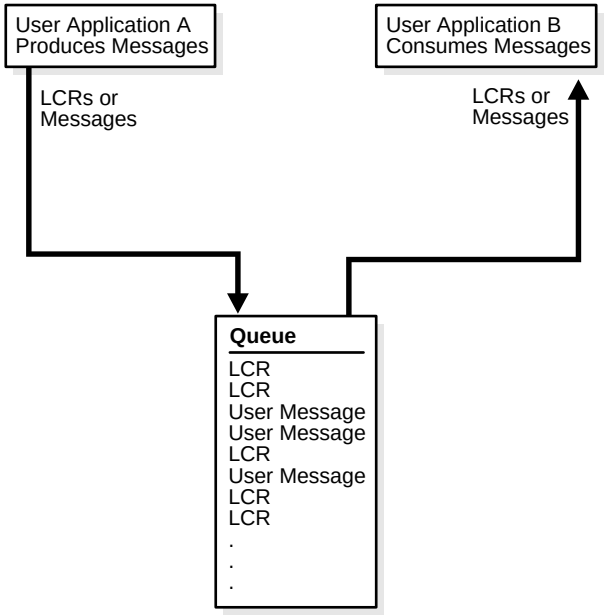
See Also: Chapter 3, "Streams Staging and Propagation" for more information about staging and propagation

Explicit Enqueue and Dequeue of Events

User applications can enqueue events into a queue explicitly. User applications can format these events as LCRs, which allows an apply process to apply them at a destination database. Alternatively, these events can be formatted as user messages for consumption by another user application, which either explicitly dequeues the events or processes the events with callbacks from an apply process.

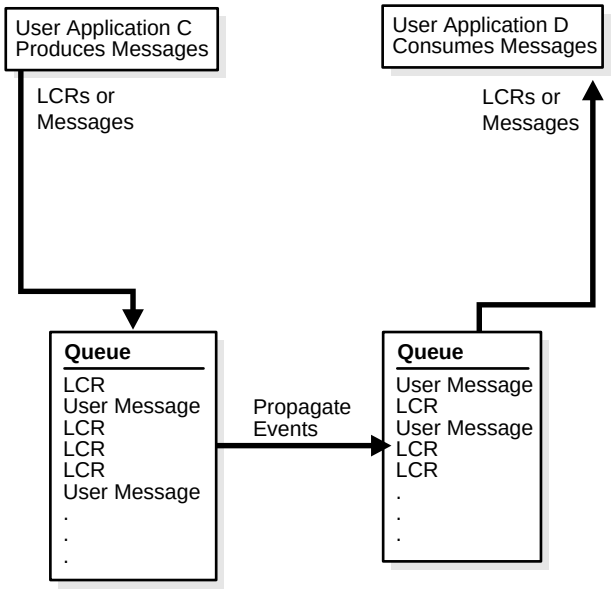
Events that were explicitly enqueued into a queue can be explicitly dequeued from the same queue. Figure 1–5 shows explicit enqueue and dequeue of events from the same queue. If a user-procedure called by an apply process explicitly enqueues an event into a queue, then the event is a user-enqueued event and can be explicitly dequeued, even if the event was originally a captured event.

Figure 1–5 Explicit Enqueue and Dequeue of Events in a Single Queue



When events are propagated between queues, events that were explicitly enqueued into a source queue can be explicitly dequeued from a destination queue by a user application without any intervention from an apply process. Figure 1–6 shows explicit enqueue of events into a source queue, propagation to a destination queue, and then explicit dequeue of events from the destination queue.

Figure 1–6 Explicit Enqueue, Propagation, and Dequeue of Events



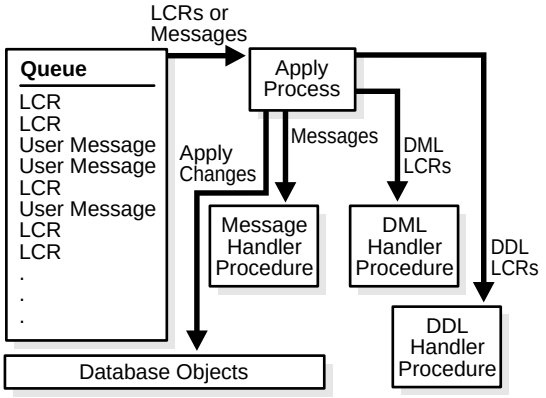
See Also: "SYS.AnyData Queues and User Messages" on page 3-12 for more information about explicit enqueue and dequeue of events

Apply Process

An apply process is an Oracle background process that dequeues events from a queue and either applies each event directly to a database object or passes the event as a parameter to a user-defined procedure called an apply handler. These apply handlers can include message handlers, DML handlers, and DDL handlers.

Typically, an apply process applies events to the local database where it is running, but, in a heterogeneous database environment, it can be configured to apply events at a remote non-Oracle database. You use rules to specify which events in the queue are applied. Figure 1–7 shows an apply process processing LCRs and user messages.

Figure 1–7 The Apply Process



See Also: Chapter 4, "Streams Apply Process"

Automatic Conflict Detection and Resolution

An apply process detects conflicts automatically when directly applying LCRs. Typically, a conflict results when the same row in the source database and destination database is changed at approximately the same time.

When conflicts occur, you need a mechanism to ensure that the conflict is resolved in accordance with your business rules. Streams offers a variety of prebuilt conflict resolution handlers. Using these prebuilt handlers, you can define a conflict resolution system for each of your databases that resolves conflicts in accordance with your business rules. If you have a unique situation that Oracle's prebuilt conflict resolution handlers cannot resolve, then you can build your own conflict resolution handlers.

If a conflict is not resolved, or if a handler procedure raises an error, then all events in the transaction that raised the error are saved in an error queue for later analysis and possible reexecution.

See Also: Chapter 7, "Streams Conflict Resolution"

Rules

Streams enables you to control which information to share and where to share it using **rules**. A rule is specified as a condition that is similar to the condition in the WHERE clause of a SQL query, and you can group related rules together into **rule sets**. A rule consists of the following components:

- The **rule condition** combines one or more expressions and logical operators and returns a Boolean value, which is a value of TRUE, FALSE, or NULL (unknown).
- The **rule evaluation context** defines external data that can be referenced in rule conditions. The external data can either exist as external variables, as table data, or both.
- The **rule action context** is optional information associated with a rule that is interpreted by the client of the rules engine when the rule is evaluated.

For example, the following rule may be used in Streams to specify that the schema name that owns a table must be hr and the table name must be departments for the condition to evaluate to TRUE:

```
:dml.get_object_owner() = 'hr' AND :dml.get_object_name() = 'departments'
```

In a Streams environment, this rule condition may be used in the following ways:

- To instruct a capture process to capture DML changes to the hr.departments table
- To instruct a propagation job to propagate DML changes to the hr.departments table
- To instruct an apply process to apply DML changes to the hr.departments table

Streams performs tasks based on rules. These tasks include capturing changes with a capture process, propagating changes with a propagation job, and applying changes with an apply process. You can define rules for these tasks at three different levels:

- Table Rules
- Schema Rules
- Global Rules

Table Rules

When you define a table rule, the Streams task is performed on the table you specify. For example, you can define a rule that instructs a capture process to capture changes to the `hr.employees` table. Given this rule, if a row is inserted into the `hr.employees` table, then the capture process captures the insert, formats it into an LCR, and enqueues the LCR into a queue.

Schema Rules

When you define a schema rule, the Streams task is performed on the database objects in the schema you specify, and any database objects added to the schema in the future. For example, you can define two rules that instruct a propagation job to propagate DML and DDL changes to the `hr` schema from a source queue to a destination queue. Given these rules, suppose the source queue contains LCRs that define the following changes:

- The `hr.loc_city_ix` index is altered.
- A row is updated in the `hr.jobs` table.

The propagation job propagates these changes from the source queue to the destination queue, because both changes are to database objects in the `hr` schema.

Global Rules

When you define a global rule, the Streams task is performed for all DML changes or all DDL changes to database objects. If it is a global DML capture rule, then a capture process captures all DML changes to the database objects in the database. If it is a global DML propagation or apply rule, then the Streams task is performed for all DML changes in a queue.

Note: The capture process does not capture certain types of changes and changes to certain datatypes in table columns. Also, a capture process never captures changes in the `SYS` and `SYSTEM` schemas.

See Also:

- Chapter 5, "Rules"
- Chapter 6, "How Rules Are Used In Streams"
- Chapter 2, "Streams Capture Process" for more information about the changes captured by a capture process

Transformations

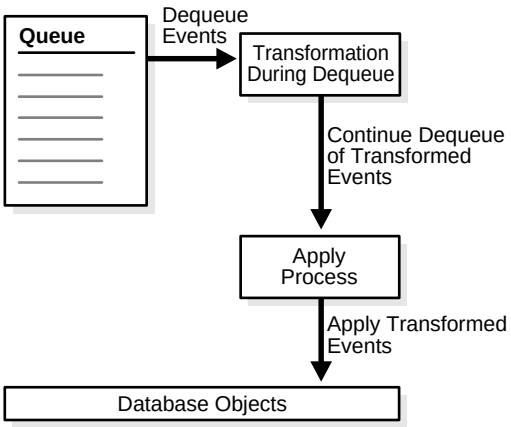
A **rule-based transformation** is any modification to an event that results when a rule evaluates to TRUE. For example, you can use a rule-based transformation when you want to change the datatype of a particular column in a table for an event at a particular database. In this case, the transformation can be a PL/SQL function that takes as input a SYS.AnyData object containing a logical change record (LCR) with a NUMBER datatype for a column and returns a SYS.AnyData object containing an LCR with a VARCHAR2 datatype for the same column.

A transformation can occur at the following times:

- During enqueue of an event, which can be useful for formatting an event in a manner appropriate for a all destination databases
- During propagation of an event, which may be useful for subsetting data before it is sent to a remote site
- During dequeue of an event, which can be useful for formatting an event in a manner appropriate for a specific destination database

Figure 1–8 shows a rule-based transformation during apply.

Figure 1–8 Transformation During Apply



See Also: "Rule-Based Transformations" on page 6-23 for more information about rule-based transformations

Heterogeneous Information Sharing

In addition to information sharing between Oracle databases, Streams supports information sharing between Oracle databases and non-Oracle databases. The following sections contain an overview of this support.

See Also: Chapter 9, "Streams Heterogeneous Information Sharing"

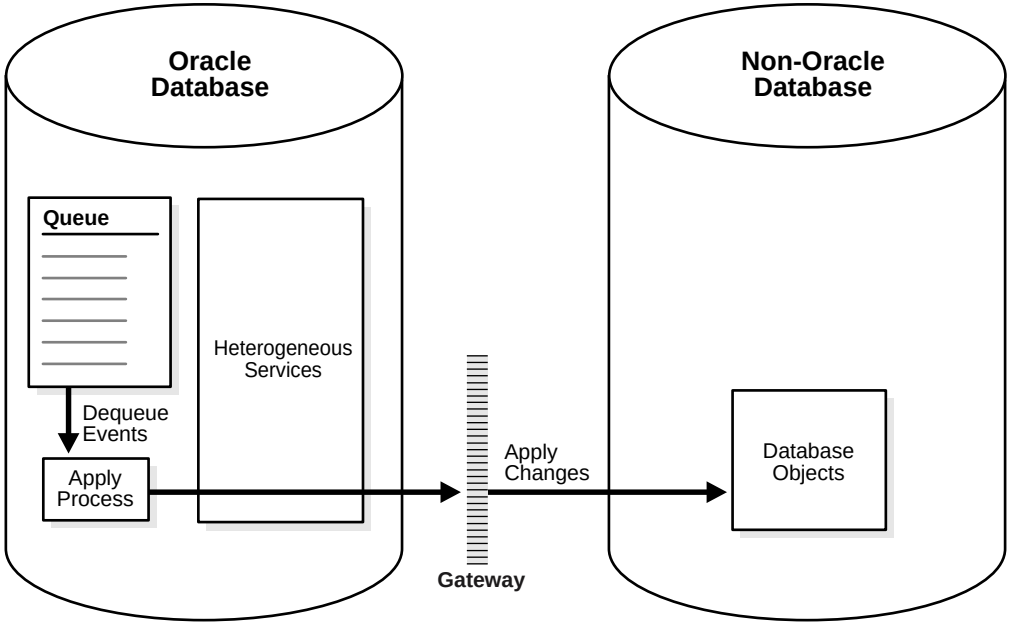
Oracle to Non-Oracle Data Sharing with Streams

If an Oracle database is the source and a non-Oracle database is the destination, then the non-Oracle database destination lacks the following Streams mechanisms:

- A queue to receive events
- An apply process to dequeue and apply events

To share DML changes from an Oracle source database to a non-Oracle destination database, the Oracle database functions as a proxy and carries out some of the steps that would normally be done at the destination database. That is, the events intended for the non-Oracle destination database are dequeued in the Oracle database itself, and an apply process at the Oracle database uses Heterogeneous Services to apply the changes to the non-Oracle database across a network connection through a gateway. Figure 1–9 shows an Oracle databases sharing data with a non-Oracle database.

Figure 1–9 Oracle to Non-Oracle Heterogeneous Data Sharing

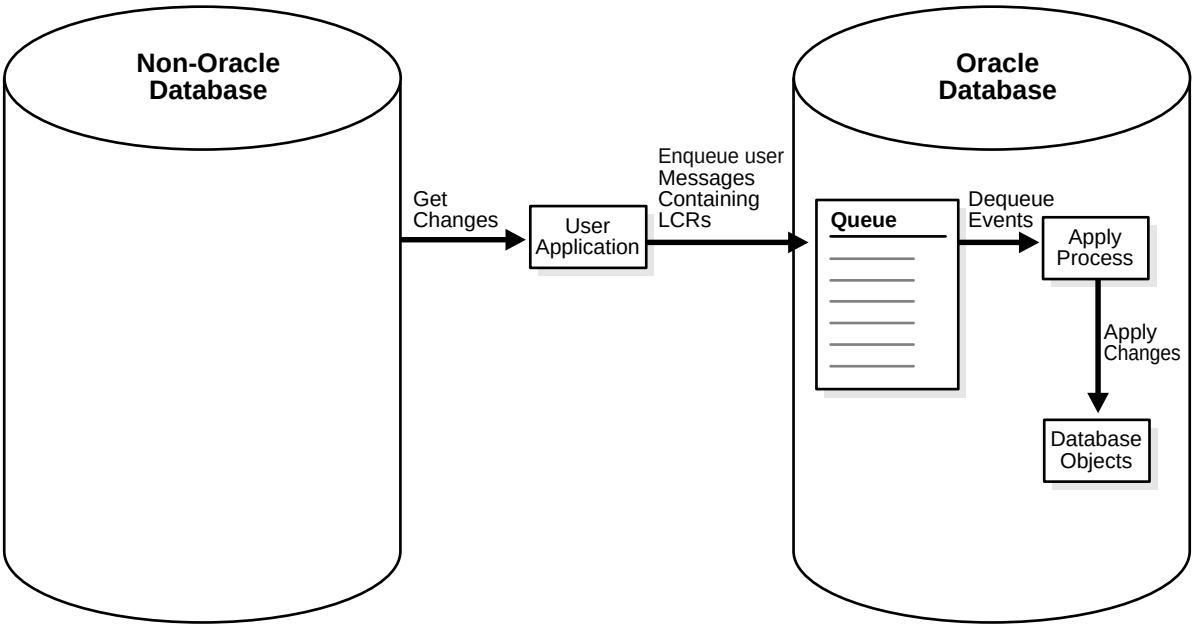


See Also: *Oracle9i Heterogeneous Connectivity Administrator's Guide* for more information about Heterogeneous Services

Non-Oracle to Oracle Data Sharing with Streams

To capture and propagate changes from a non-Oracle database to an Oracle database, a custom application is required. This application gets the changes made to the non-Oracle database by reading from transaction logs, using triggers, or some other method. The application must assemble and order the transactions and must convert each change into a logical change record (LCR). Then, the application must enqueue the LCRs into a queue in an Oracle database by using the PL/SQL interface, where they can be processed by an apply process. Figure 1–10 shows a non-Oracle databases sharing data with an Oracle database.

Figure 1–10 Non-Oracle to Oracle Heterogeneous Data Sharing



Example Streams Configurations

Figure 1–11 shows how Streams might be configured to share information within a single database, while Figure 1–12 shows how Streams might be configured to share information between two different databases.

Figure 1–11 Streams Configuration in a Single Database

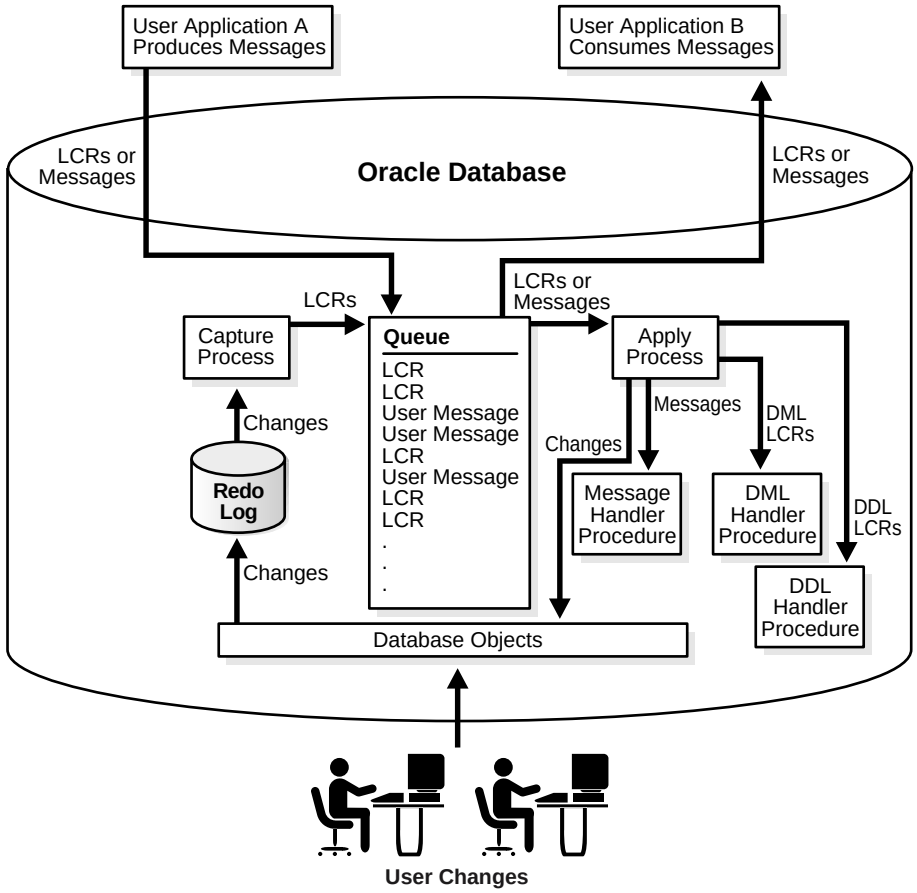
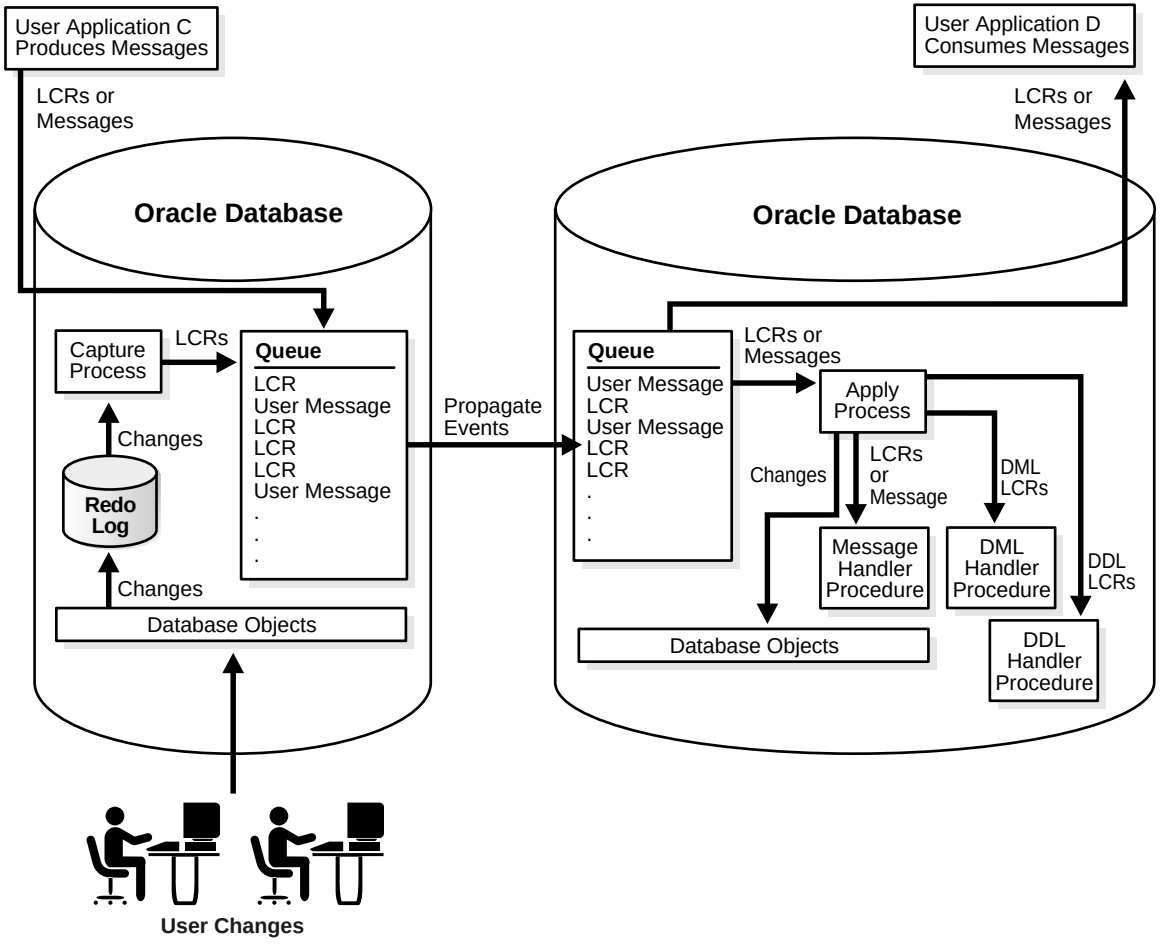


Figure 1–12 Streams Configuration with Different Source and Destination Databases



Administration Tools for a Streams Environment

Several tools are available for configuring, administering, and monitoring your Streams environment. Oracle-supplied PL/SQL packages are the primary configuration and management tool, while the Streams tool in Oracle Enterprise Manager provides some configuration, administration, and monitoring capabilities to help you manage your environment. Additionally, Streams data dictionary views keep you informed about your Streams environment.

Oracle-Supplied PL/SQL Packages

The following Oracle-supplied PL/SQL packages contain procedures and functions that you can use to configure and manage a Streams environment.

> **See Also:** *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about these packages

DBMS_STREAMS_ADM Package

The DBMS_STREAMS_ADM package provides administrative procedures for adding and removing simple rules for capture, propagation, and apply at the table, schema, and database level. This package also contains procedures for creating queues and for managing Streams metadata, such as data dictionary information. This package is provided as an easy way to complete common tasks in a Streams replication environment. You can use other packages, such as the DBMS_CAPTURE_ADM, DBMS_PROPAGATION_ADM, and DBMS_APPLY_ADM packages, to complete these same tasks, as well as tasks that require additional customization.

DBMS_CAPTURE_ADM Package

The DBMS_CAPTURE_ADM package provides administrative procedures for starting, stopping, and configuring a capture process. The source of the captured changes is the redo logs, and the repository for the captured changes is a queue. This package also provides administrative procedures that prepare database objects at the source database for instantiation at a destination database.

DBMS_PROPAGATION_ADM Package

The DBMS_PROPAGATION_ADM package provides administrative procedures for configuring propagation from a source queue to a destination queue.

DBMS_APPLY_ADM Package

The DBMS_APPLY_ADM package provides administrative procedures for starting, stopping, and configuring an apply process.

DBMS_RULE_ADM Package

The DBMS_RULE_ADM package provides the administrative interface for creating and managing rules, rule sets, and rule evaluation contexts.

DBMS_RULE Package

The DBMS_RULE package contains the EVALUATE procedure, which evaluates a rule set. The goal of this procedure is to produce the list of satisfied rules, based on the data.

DBMS_STREAMS Package

The DBMS_STREAMS package provides an interface for annotating redo entries generated by a session with a binary tag. This tag affects the behavior of a capture process, a propagation job, or an apply process whose rules include specifications for these binary tags in the LCRs.

Streams Data Dictionary Views

Every database in a Streams environment has Streams data dictionary views. These views maintain administrative information about local Streams rules, objects, processes, and jobs. You can use these views to monitor your Streams environment.

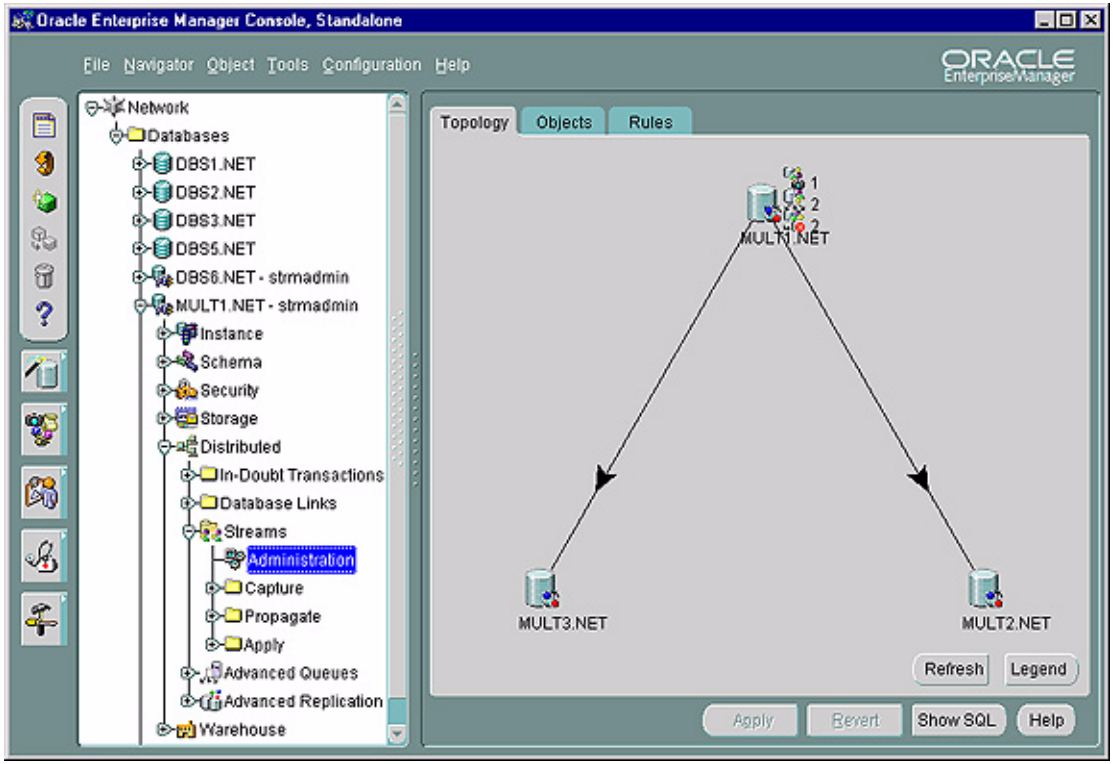
See Also:

- Chapter 16, "Monitoring a Streams Environment"
- *Oracle9i Database Reference* for more information about these data dictionary views

Streams Tool in Oracle Enterprise Manager

To help configure, administer, and monitor Streams environments, Oracle provides a Streams tool in the Oracle Enterprise Manager Console. You can also use the Streams tool to generate Streams configuration scripts, which you can then modify and run to configure your Streams environment. The Streams tool online help is the primary documentation source for this tool. Figure 1–13 shows the **Topology** tab in the Streams tool.

Figure 1–13 Streams Tool



See Also: See the online help for the Streams tool in Oracle Enterprise Manager for more information about using it

2

Streams Capture Process

This chapter explains the concepts and architecture of the Streams capture process.

This chapter contains these topics:

- The Redo Log and the Capture Process
- Logical Change Records (LCRs)
- Capture Rules
- Datatypes Captured
- Types of Changes Captured
- Supplemental Logging
- Streams Capture Process and Oracle Real Application Clusters
- Capture Process Architecture

See Also: Chapter 11, "Managing a Capture Process"

The Redo Log and the Capture Process

Every Oracle database has a set of two or more redo log files. The redo log files for a database are collectively known as the database's redo log. The primary function of the redo log is to record all changes made to the database.

Redo logs are used to guarantee recoverability in the event of human error or media failure. A capture process is an optional Oracle background process that reads the database redo log to capture DML and DDL changes made to database objects.

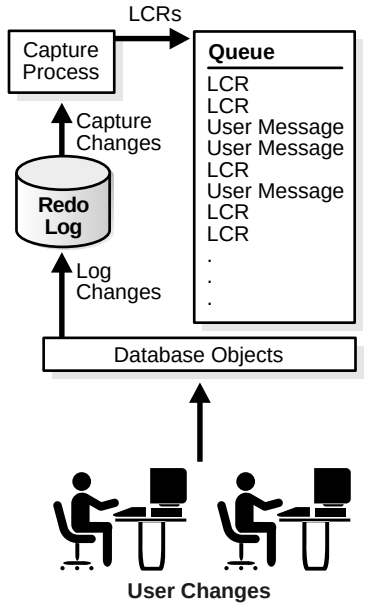
Logical Change Records (LCRs)

A capture process reformats changes captured from the redo log into LCRs. An LCR is an object with a specific format that describes a database change. A capture process captures two types of LCRs: row LCRs and DDL LCRs.

After capturing an LCR, a capture process enqueues an event containing the LCR into a queue. A capture process is always associated with a single `SYS.AnyData` queue, and it enqueues events into this queue only. You can create multiple queues and associate a different capture process with each queue. Figure 2–1 shows a capture process capturing LCRs.

Note: A capture process can be associated only with a `SYS.AnyData` queue, not with a typed queue.

Figure 2–1 The Capture Process



See Also:

- "Managing Logical Change Records (LCRs)" on page 15-2
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about LCRs

Row LCRs

A row LCR describes a change to the data in a single row or a change to a single LOB column in a row. The change results from a data manipulation language (DML) statement or a piecewise update to a LOB. For example, a DML statement may insert or merge multiple rows into a table, may update multiple rows in a table, or may delete multiple rows from a table. So, a single DML statement can produce multiple row LCRs. That is, an LCR is produced for each row that is changed by the DML statement. Further, the DML statement itself may be part of a transaction that includes many DML statements.

A captured row LCR may contain transaction control statements. These row LCRs contain directives such as COMMIT and ROLLBACK. These row LCRs are internal and are used by an apply process to maintain transaction consistency between a source database and a destination database.

Each row LCR contains the following information:

- The name of the source database where the row change occurred
- The type of DML statement that produced the change, either INSERT, UPDATE, DELETE, LOB ERASE, LOB WRITE, or LOB TRIM
- The schema name that contains the table with the changed row
- The name of the table that contains the changed row
- A raw tag that can be used to track the LCR
- The identifier of the transaction in which the DML statement was run
- The system change number (SCN) when the change was written to the redo log
- If the type of DML statement is an UPDATE or DELETE statement, then the values of some or all of the columns in the changed row before the DML statement
- If the type of DML statement is an UPDATE or INSERT statement, then the values of some or all of the columns in the changed row after the DML statement

DDL LCRs

A DDL LCR describes a data dictionary language (DDL) change. A DDL statement changes the structure of the database. For example, a DDL statement may create, alter, or drop a database object.

Each DDL LCR contains the following information:

- The name of the source database where the DDL change occurred
- The type of DDL statement that produced the change
- The schema name of the user who owns the database object on which the DDL statement was run
- The name of the database object on which the DDL statement was run
- The type of database object on which the DDL statement was run
- The text of the DDL statement

- The username of the user who ran the DDL statement
- The current schema in which the DDL is being executed
- The base table owner. If the DDL statement is dependent on a table, then the base table owner is the owner of the table on which it is dependent.
- The base table name. If the DDL statement is dependent on a table, then the base table name is the name of the table on which it is dependent.
- A raw tag that can be used to track the LCR
- The identifier of the transaction in which the DDL statement was run
- The SCN when the change was written to the redo log

Note: Both row LCRs and DDL LCRs contain the source name of the database where a change originated. If captured LCRs will be propagated by a propagation job or applied by an apply process, then, to avoid propagation and apply problems, Oracle Corporations recommends that you do not rename the source database after a capture process has started capturing changes.

See Also: The "SQL Command Codes" table in the *Oracle Call Interface Programmer's Guide* for a complete list of command types possible in DDL statements

Capture Rules

A capture process captures changes based on rules that you define. Each rule specifies the database objects for which the capture process captures changes and the types of changes to capture. You can specify capture rules at the following levels:

- A table rule captures either DML or DDL changes to a particular table.
- A schema rule captures either DML or DDL changes to the database objects in a particular schema.
- A global rule captures either all DML or all DDL changes in the database.

See Also:

- Chapter 5, "Rules"
- Chapter 6, "How Rules Are Used In Streams"

Note: The capture process does not capture certain types of changes and changes to certain datatypes in table columns. Also, a capture process never captures changes in the SYS and SYSTEM schemas.

Datatypes Captured

When capturing changes made to tables, a capture process captures changes made to columns of the following datatypes:

- CHAR
- VARCHAR2
- NCHAR
- NVARCHAR2
- NUMBER
- DATE
- CLOB
- BLOB
- RAW
- TIMESTAMP
- TIMESTAMP WITH TIME ZONE
- TIMESTAMP WITH LOCAL TIME ZONE
- INTERVAL YEAR TO MONTH
- INTERVAL DAY TO SECOND

The capture process does not capture DML changes in columns of the following datatypes: NCLOB, LONG, LONG RAW, BFILE, ROWID, and UROWID, and user-defined types (including object types, REFs, varrays, and nested tables). The capture process raises an error if it attempts to capture DML changes to a table that contains a column of an unsupported datatype.

See Also:

- "Datatypes Applied" on page 4-8
- *Oracle9i SQL Reference* for more information about these datatypes

Types of Changes Captured

A capture process captures only certain types of changes made to a database and its objects. The following sections describe the types of DML and DDL changes that are captured. A capture process ignores changes that it does not capture.

Note: A capture process never captures changes in the SYS and SYSTEM schemas.

See Also: Chapter 4, "Streams Apply Process" for information about the types of changes an apply process applies and ignores

Types of DML Changes Captured

When you specify that DML changes made to certain tables should be captured, a capture process captures the following types of DML changes made to these tables:

- INSERT
- UPDATE
- DELETE
- MERGE
- Piecewise updates to LOBs

Note:

- The capture process converts each MERGE change into an INSERT or UPDATE change. MERGE is not a valid command type in a row LCR.
- The capture process does not capture CALL, EXPLAIN PLAN, or LOCK TABLE statements.
- The capture process cannot capture DML changes made to index-organized tables or object tables.
- Regarding sequences, if you share a sequence at multiple databases, sequence values used for individual rows at these databases may vary. Also, changes to actual sequence values are not captured. For example, if a user references a NEXTVAL or sets the sequence, the capture process does not capture changes resulting from these operations.

See Also:

- "Considerations for Applying DML Changes to Tables" on page 4-9
- "Avoid Uniqueness Conflicts" on page 7-5 for information about strategies to use to avoid having the same sequence-generated value for two different rows at different databases.

Types of DDL Changes Ignored by a Capture Process

A capture process captures the DDL changes that satisfy the rules in the capture process rule set, except for the following types of DDL changes:

- ALTER DATABASE
- CREATE CONTROLFILE
- CREATE DATABASE
- CREATE PFILE
- CREATE SPFILE

Some types of DDL changes that are captured by a capture process cannot be applied by an apply process. If an apply process receives a DDL LCR that specifies an operation that cannot be applied, then the apply process ignores the DDL LCR and records information about it in the trace file for the apply process.

See Also: "Considerations for Applying DDL Changes" on page 4-19

Other Types of Changes Ignored by a Capture Process

The following types of changes are ignored by a capture process

- The session control statements `ALTER SESSION` and `SET ROLE`
- The system control statement `ALTER SYSTEM`
- Invocations of PL/SQL procedures

In addition, online table redefinition using the `DBMS_REDEFINITION` package is not supported on a table or schema for which a capture process captures changes.

Supplemental Logging

Supplemental logging places additional column data into a redo log whenever an `UPDATE` operation is performed. Such updates include piecewise updates to LOBs. The capture process captures this additional information and places it in LCRs.

There are two types of supplemental logging: database supplemental logging and table supplemental logging. Database supplemental logging specifies supplemental logging for an entire database, while table supplemental logging enables you to specify log groups for supplemental logging for a particular table. If you use table supplemental logging, then you can choose between unconditional and conditional log groups.

Unconditional log groups log the before images of specified columns any time the table is updated, regardless of whether the update affected any of the specified columns. This is sometimes referred to as an `ALWAYS` log group. Conditional log groups log the before images of all specified columns only if at least one of the columns in the log group is updated.

If you plan to use one or more apply processes to apply LCRs captured by a capture process, then you must enable supplemental logging *at the source database* for the following types of columns:

- Any primary key columns in tables for which changes are applied at a destination database must be unconditionally logged in a log group or by database supplemental logging of primary key columns.
- If the parallelism of any apply process that will apply the changes is greater than 1, then any multicolumn unique key columns in tables for which changes are applied at a destination database must be specified in a conditionally logged. Supplemental logging need not be specified for single column unique keys.
- If the parallelism of any apply process that will apply the changes is greater than 1, then any multicolumn foreign key columns in tables for which changes are applied at a destination database must be specified in a conditionally logged. Supplemental logging need not be specified for single column foreign keys.
- Any columns that are configured as substitute key columns for an apply process must be unconditionally logged. You specify substitute key columns for a table using the `SET_KEY_COLUMNS` procedure in the `DBMS_APPLY_ADM` package.
- Any columns specified in a column list for conflict resolution during apply must be conditionally logged.
- Any columns needed by a DML handler or error handler specified for update operations or piecewise updates to LOBs associated with an apply process must be unconditionally logged.
- Any columns needed by a rule-based transformation must be unconditionally logged.
- If you specify row subsetting for a table at a destination database, then all of the columns in the destination table and all of the columns in the subset condition must be unconditionally logged. You specify a row subsetting condition for an apply process using the `dml_condition` parameter in the `ADD_SUBSET_RULES` procedure in the `DBMS_STREAMS_ADM` package.

If you do not use supplemental logging for these types of columns at a source database, then changes involving these columns might not apply properly at a destination database.

See Also:

- "Specifying Supplemental Logging at a Source Database" on page 11-9
- *Oracle9i Data Guard Concepts and Administration* and *Oracle9i Database Administrator's Guide* for information about using supplemental logging
- "Considerations for Applying DML Changes to Tables" on page 4-9 for more information about apply process behavior for tables
- "Rule-Based Transformations" on page 6-23

Streams Capture Process and Oracle Real Application Clusters

You can configure a Streams capture process to capture changes in a Real Application Clusters environment. If you use one or more capture processes and Real Application Clusters in the same environment, then the environment must meet the following requirements:

- All archived logs that contain changes to be captured by a capture process must be available to all instances in the Real Application Clusters environment. In a Real Application Clusters environment, a capture process always reads archived redo logs.
- Any call to the `DBMS_CAPTURE_ADM.START_CAPTURE` procedure must be run on the instance that owns the queue that is used by the capture process. Calls to other procedures and functions that operate on a capture process can be performed from any instance.
- Any supplemental logging specifications must be made on each running instance. After it is specified for each running instance, it does not need to be specified again if an instance is shut down and restarted, and it does not need to be specified for any new instances.
- The `ARCHIVE_LAG_TARGET` initialization parameter should be set to a value greater than zero. This initialization parameter specifies the duration after which the log files are switched automatically. LogMiner orders all LCRs by SCN. To do so, it needs the archived log files from all instances. Setting this parameter to switch the log files automatically ensures that LogMiner does not wait for an inordinately long time if one instance has far fewer transactions than another.

If the owner instance for a queue table containing a queue used by a capture process becomes unavailable, then queue ownership is transferred automatically to another instance in the cluster. If this happens, then, to restart the capture process, connect to the owner instance for the queue and run the START_CAPTURE procedure. The DBA_QUEUE_TABLES data dictionary view contains information about the owner instance for a queue table. The capture process maintains a persistent start / stop state in a Real Application Clusters environment only if the owner instance for its queue does not change before the database instance owning the queue is restarted.

Also, any parallel execution processes used by a single capture process run on a single instance in a Real Application Clusters environment.

See Also:

- "Streams Queues and Oracle Real Application Clusters" on page 3-19
- "Streams Apply Process and Oracle Real Application Clusters" on page 4-25
- *Oracle9i Database Administrator's Guide* for more information on the ARCHIVE_LAG_TARGET initialization parameter
- *Oracle9i Database Reference* for more information about the DBA_QUEUE_TABLES data dictionary view
- "The Persistent State of a Capture Process" on page 2-24
- "Supplemental Logging" on page 2-9

Capture Process Architecture

A capture process is an Oracle background process whose process name is cp*nn*, where *nn* is a capture process number. Valid capture process names include cp01 through cp99. A capture process captures changes from the redo log by using the infrastructure of LogMiner. Streams configures LogMiner automatically. You can create, alter, start, stop, and drop a capture process, and you can define capture rules that control which changes a capture process captures.

The user who creates a capture process is the user who captures changes. This user must have the necessary privileges to capture changes.

> **See Also:** "Setting Up Users and Creating Queues and Database Links" on page 19-7 for information about the required privileges. In the example in this section, the privileges are granted to the `strmadmin` user.

This section discusses the following topics:

- Capture Process Components
- Alternate Tablespace for LogMiner Tables
- Capture Process Creation
- ARCHIVELOG Mode and a Capture Process
- Capture Process Parameters
- The Start SCN for a Capture Process
- Capture Process Rule Evaluation
- The Persistent State of a Capture Process

Capture Process Components

The components of a capture process depend on the setting specified for the `parallelism` capture process parameter. If `parallelism` is set to a value of `3` or greater, then a capture process uses the following parallel execution servers to capture changes concurrently:

- One **reader server** that reads the redo log to find changes
- A number of **preparer servers** that format changes found by the reader into LCRs. The number of preparer servers equals the number specified for the `parallelism` capture process parameter minus two.
- One **builder server** that merges the LCRs created by the preparer servers to preserve the SCN order. After merging the LCRs, the builder server enqueues them into the queue associated with the capture process.

For example, if `parallelism` is set to `5`, then a capture process uses a total of five parallel execution servers, assuming five parallel execution servers are available: one reader server, three preparer servers, and one builder server.

If `parallelism` is set to `2` or lower, then a capture process itself (`cp`*nn*) performs all the work without using any parallel execution servers.

See Also:

- "Capture Process Parallelism" on page 2-20 for more information about the `parallelism` parameter
- *Oracle9i Database Administrator's Guide* for information about managing parallel execution servers

LogMiner Configuration

The capture process uses LogMiner to capture changes that are recorded in the redo log. This section describes configuring LogMiner for use by one or more capture processes.

Alternate Tablespace for LogMiner Tables

LogMiner tables include data dictionary tables and temporary tables used by LogMiner. By default, all LogMiner tables are created to use the `SYSTEM` tablespace, but the `SYSTEM` tablespace may not have enough space to accommodate the LogMiner tables. Therefore, Oracle Corporation strongly recommends creating an alternate tablespace for the LogMiner tables before you create a capture process at a database. Use the `DBMS_LOGMNR_D.SET_TABLESPACE` routine to re-create all LogMiner tables in an alternate tablespace.

See Also:

- "Specifying an Alternate Tablespace for LogMiner" on page 10-10
- *Oracle9i Database Administrator's Guide* for more information about using an alternate tablespace for LogMiner tables
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the `SET_TABLESPACE` procedure

Multiple Capture Processes in a Single Database

Each capture process uses one LogMiner session, and the `LOGMNR_MAX_PERSISTENT_SESSIONS` initialization parameter controls the maximum number of active LogMiner sessions allowed in the instance. The default setting for this initialization parameter is 1. Therefore, to use multiple capture processes in a database, set the `LOGMNR_MAX_PERSISTENT_SESSIONS` initialization parameter to a value higher than the number of capture processes.

In addition, if you run multiple capture processes on a single database, you might need to increase the SGA size for each instance. Use the SGA_MAX_SIZE initialization parameter to increase the SGA size.

Note: Oracle Corporation recommends that each capture process use a separate queue to keep LCRs from different capture processes separate.

See Also: *Oracle9i Database Reference* for more information about the LOGMNR_MAX_PERSISTENT_SESSIONS initialization parameter

Capture Process Creation

You can create a capture process using the DBMS_STREAMS_ADM package or the DBMS_CAPTURE_ADM package. Using the DBMS_STREAMS_ADM package to create a capture process is simpler because defaults are used automatically for some configuration options. In addition, when you use the DBMS_STREAMS_ADM package, a rule set is created for the capture process and rules are added to the rule set automatically. The DBMS_STREAMS_ADM package was designed for use in replication environments. Alternatively, using the DBMS_CAPTURE_ADM package to create a capture process is more flexible, and you create a rule set and rules for the capture process either before or after it is created. You can use the procedures in the DBMS_STREAMS_ADM package or the DBMS_RULE_ADM package to add rules to the rule set for the capture process.

When a capture process is created by a procedure in the DBMS_STREAMS_ADM package, a procedure in the DBMS_CAPTURE_ADM package is run automatically on the tables whose changes will be captured by the capture process. The following table lists which procedure is run in the DBMS_CAPTURE_ADM package when you run a procedure in the DBMS_STREAMS_ADM package.

When you run this procedure in the DBMS_STREAMS_ADM package	This procedure in the DBMS_CAPTURE_ADM package is run automatically
ADD_TABLE_RULES	PREPARE_TABLE_INSTANTIATION
ADD_SCHEMA_RULES	PREPARE_SCHEMA_INSTANTIATION
ADD_GLOBAL_RULES	PREPARE_GLOBAL_INSTANTIATION

More than one call to prepare instantiation is allowed. When a capture process is created by the CREATE_CAPTURE procedure in the DBMS_CAPTURE_ADM package, you must run the appropriate procedure manually to prepare each table, schema, or database whose changes will be captured for instantiation, if you plan to instantiate the table, schema, or database at a remote site.

> **See Also:** Chapter 11, "Managing a Capture Process" and *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the following procedures, which can be used to create a capture process:
>
> - DBMS_STREAMS_ADM.ADD_TABLE_RULES
> - DBMS_STREAMS_ADM.ADD_SCHEMA_RULES
> - DBMS_STREAMS_ADM.ADD_GLOBAL_RULES
> - DBMS_CAPTURE_ADM.CREATE_CAPTURE

Data Dictionary Duplication During Capture Process Creation

When the first capture process is created for a database, Streams populates a duplicate data dictionary called a Streams data dictionary for use by capture processes and propagation jobs. Initially, the Streams data dictionary is consistent with the primary data dictionary at the time when the capture process was created.

A capture process requires a Streams data dictionary because the information in the primary data dictionary may not apply to the changes being captured from the redo log. These changes may have occurred minutes or hours before they are captured by a capture process. For example, consider the following scenario:

1. A capture process is configured to capture changes to tables.
2. The capture process is stopped by the database administrator. When the capture process is stopped, it records the SCN of the change it was currently capturing.
3. User applications continue to make changes to the tables while the capture process is stopped.
4. The capture process is restarted three hours after it was stopped.

In this case, to ensure data consistency, the capture process must begin capturing changes in the redo log at the time when it was stopped. The capture process starts at the SCN that it recorded when it was stopped.

The redo log contains raw data. It does not contain database object names and column names in tables. Instead, it uses object numbers and internal column numbers for database objects and columns, respectively. Therefore, when a change is captured, a capture process must reference the data dictionary to determine the details of the change.

The Streams data dictionary is updated when a DDL statement is processed by a capture process, if necessary. If there were any DDL changes to the relevant tables in the time between when a capture process is capturing changes and the current time, then the primary data dictionary may not contain the correct information for the captured changes. However, the Streams data dictionary always reflects the correct time for the captured changes because it versions a subset of the information in the primary data dictionary.

When a capture process determines whether or not to capture DDL changes involving a table, the capture process automatically adds information about the change to the Streams data dictionary. In addition, the capture process determines whether or not to capture the Streams data dictionary information for the new version of the table. To make these determinations, the capture rule set is evaluated with partial information that includes the name and owner of the table created or altered by the DDL statement. Capturing and propagating Streams data dictionary information makes it available in each destination queue, where it can be used by propagation jobs and apply processes.

If at least one rule in the capture rule set either evaluates to `TRUE` (`true_rules`) or could evaluate to `TRUE` given more information (`maybe_rules`), then the Streams data dictionary information is captured for the table. This rule can be either a DML rule or a DDL rule. A capture process at a source database performs a similar rule evaluation when a table is prepared for instantiation at another database.

Because the data dictionary is duplicated when the first capture process is created, it might take some time to create the first capture process for a database. The amount of time required depends on the number of database objects in the database.

The data dictionary is duplicated only once for a database. Additional capture processes use the same Streams data dictionary that the first capture process created in the database. Because the Streams data dictionary is multiversioned, each capture process is in sync with the Streams data dictionary.

See Also:

- "Capture Process Rule Evaluation" on page 2-21
- "Preparing Database Objects for Instantiation at a Source Database" on page 11-11
- "Streams Data Dictionary for Propagation Jobs" on page 3-24
- "Streams Data Dictionary for an Apply Process" on page 4-29

Scenario Illustrating the Need for a Streams Data Dictionary Consider a scenario in which a capture process has been configured to capture changes to table `t1`, which has columns `a` and `b`, and the following changes are made to this table at three different points in time:

Time 1: Insert values `a=7` and `b=15`.

Time 2: Add column `c`.

Time 3: Drop column `b`.

If for some reason the capture process is capturing changes from an earlier time, then the primary data dictionary and the relevant version in the Streams data dictionary contain different information. Table 2–1 illustrates how the information in the Streams data dictionary is used when the current time is different than the change capturing time.

Table 2–1 Information About Table t1 in the Primary and Capture Data Dictionaries

Current Time	Change Capturing Time	Primary Data Dictionary	Streams Data Dictionary
1	1	Table `t1` has columns `a` and `b`.	Table `t1` has columns `a` and `b` at time 1.
2	1	Table `t1` has columns `a`, `b`, and `c`.	Table `t1` has columns `a` and `b` at time 1.
3	1	Table `t1` has columns `a` and `c`.	Table `t1` has columns `a` and `b` at time 1.

The capture process captures the change resulting from the insert at time 1 when the actual time is time 3. If the capture process used the primary data dictionary, then it might assume that a value of `7` was inserted into column `a` and a value of `15` was inserted into column `c`, because those are the two columns for table `t1` at time 3 in the primary data dictionary. However, a value of `15` was actually inserted into column `b`.

Because the capture process uses the Streams data dictionary, the error is avoided. The Streams data dictionary is synchronized with the capture process and continues to record that table `t1` has columns `a` and `b` at time 1. So, the captured change specifies that a value of `15` was inserted into column `b`.

ARCHIVELOG Mode and a Capture Process

A capture process reads online redo logs whenever possible and archived redo logs otherwise. For this reason, the database must be running in `ARCHIVELOG` mode when a capture process is configured to capture changes. You must keep an archived redo log file available until you are certain that no capture process will ever need that file. When a capture process falls behind, there is a seamless transition from reading an online redo log to reading an archived redo log, and, when a capture process catches up, there is a seamless transition from reading an archived redo log to reading an online redo log.

> **See Also:** *Oracle9i Database Administrator's Guide* for information about running a database in `ARCHIVELOG` mode

Capture Process Parameters

After creation, a capture process is disabled so that you can set the capture process parameters for your environment before starting it for the first time. Capture process parameters control the way a capture process operates. For example, the `time_limit` capture process parameter can be used to specify the amount of time a capture process runs before it is shut down automatically. After you set the capture process parameters, you can start the capture process.

> **See Also:**
>
> - "Setting a Capture Process Parameter" on page 11-8
> - The `DBMS_CAPTURE_ADM.SET_PARAMETER` procedure in the *Oracle9i Supplied PL/SQL Packages and Types Reference* for detailed information about the capture process parameters

Capture Process Parallelism

The `parallelism` capture process parameter controls the number of preparer servers used by a capture processes. The preparer servers concurrently format changes found in the redo log into LCRs.

Note:

- Resetting the `parallelism` parameter automatically stops and restarts the capture process.
- Setting the `parallelism` parameter to a number higher than the number of available parallel execution servers might disable the capture process. Make sure the PROCESSES and PARALLEL_MAX_SERVERS initialization parameters are set appropriately when you set the `parallelism` capture process parameter.

See Also: "Capture Process Components" on page 2-13 for more information about preparer servers

Automatic Restart of a Capture Process

You can configure a capture process to stop automatically when it reaches certain limits. The `time_limit` capture process parameter specifies the amount of time a capture process runs, and the `message_limit` capture process parameter specifies the number of events a capture process can capture. The capture process stops automatically when it reaches these limits.

The `disable_on_limit` parameter controls whether a capture process becomes disabled or restarts when it reaches a limit. If you set the `disable_on_limit` parameter to `y`, then the capture process is disabled when it reaches a limit and does not restart until you restart it explicitly. If, however, you set the `disable_on_limit` parameter to `n`, then the capture process stops and restarts automatically when it reaches a limit.

When a capture process is restarted, it starts to capture changes at the point where it last stopped. A restarted capture process gets a new session identifier, and the parallel execution servers associated with the capture process also get new session identifiers. However, the capture process number (cp*nn*) remains the same.

The Start SCN for a Capture Process

The **start SCN** is the time from which a capture process begins to capture changes. When you start a capture process for the first time, by default the start SCN corresponds to the time when the capture process was created. For example, if a capture process is started two days after it was created, then the capture process begins capturing changes from the redo log at the time of creation two days in the past.

You can specify a different start SCN during capture process creation, or you can alter a capture process to set its start SCN. The start SCN value specified must be from a time after the first capture process was created for the database.

See Also:

- "Setting the Start SCN for a Capture Process" on page 11-10
- The DBMS_CAPTURE_ADM.ALTER_CAPTURE procedure in the *Oracle9i Supplied PL/SQL Packages and Types Reference* for information about altering a capture process

Capture Process Rule Evaluation

A running capture process completes the following series of actions to capture changes:

1. Finds changes in the redo log.
2. Performs prefiltering of the changes in the redo log. During this step, a capture process evaluates rules in its rule set at the object level and schema level to place changes found in the redo log into two categories: changes that should be converted into LCRs and changes that should not be converted into LCRs.

   Prefiltering is a safe optimization done with incomplete information. This step identifies relevant changes to be processed subsequently, such that:

   - A change is converted into an LCR if one or more rules may evaluate to TRUE after conversion.
   - A change is not converted into an LCR if the capture process can ensure that no rules would evaluate to TRUE after conversion.
3. Converts changes that may cause one or more rules to evaluate to TRUE into LCRs based on prefiltering.

4. Performs LCR filtering. During this step, a capture process evaluates rules regarding information in each LCR to separate the LCRs into two categories: LCRs that should be enqueued and LCRs that should be discarded.
5. Discards the LCRs that should not be enqueued based on the rules.
6. Enqueues the remaining captured LCRs into the queue associated with the capture process.

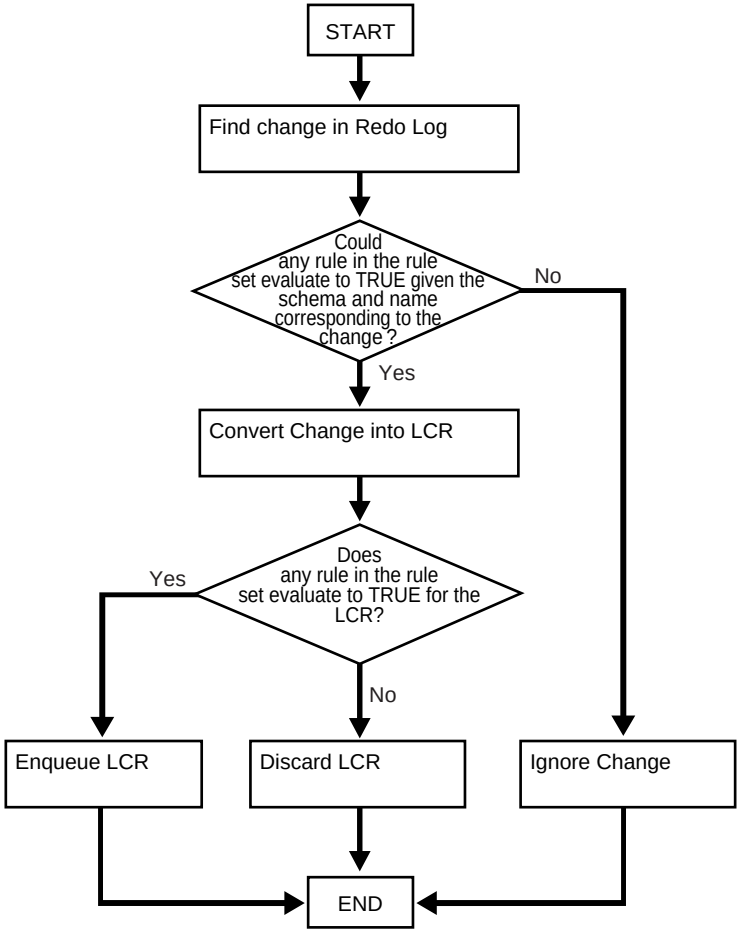
For example, suppose the following rule is defined for a capture process: Capture changes to the `hr.employees` table where the `department_id` is `50`. No other rules are defined for the capture process, and the `parallelism` parameter for the capture process is set to `1`.

Given this rule, suppose an `UPDATE` statement on the `hr.employees` table changes 50 rows in the table. The capture process performs the following series of actions for each row change:

1. Finds the next change resulting from the `UPDATE` statement in the redo log.
2. Determines that the change resulted from an `UPDATE` statement to the `hr.employees` table and must be captured. If the change was made to a different table, then the capture process ignores the change.
3. Captures the change and converts it into an LCR.
4. Filters the LCR to determine whether it involves a row where the `department_id` is `50.`
5. Either enqueues the LCR into the queue associated with the capture process if it involves a row where the `department_id` is `50`, or discards the LCR if it involves a row where the `department_id` is not `50` or is missing.

Figure 2–2 illustrates capture process rule evaluation in a flowchart.

Figure 2–2 Flowchart Showing Capture Process Rule Evaluation



The Persistent State of a Capture Process

A capture process maintains a persistent state. That is, the capture process maintains its current state when the database is shut down and restarted. For example, if the capture process is running when the database is shut down, then the capture process automatically starts when the database is restarted, but, if the capture process is stopped when a database is shut down, then the capture process remains stopped when the database is restarted.

3

Streams Staging and Propagation

This chapter explains the concepts relating to staging events in a queue and propagating events from one queue to another.

This chapter contains these topics:

- Event Staging and Propagation Overview
- Captured and User-Enqueued Events
- Event Propagation Between Queues
- SYS.AnyData Queues and User Messages
- Streams Queues and Oracle Real Application Clusters
- Streams Staging and Propagation Architecture

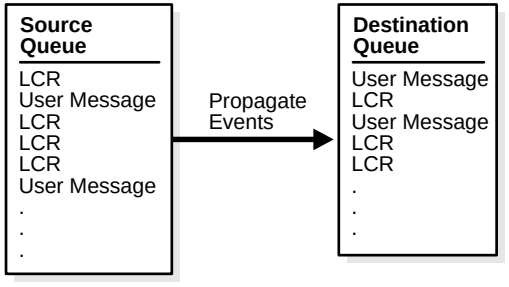
See Also: Chapter 12, "Managing Staging and Propagation"

Event Staging and Propagation Overview

Streams uses queues of type `SYS.AnyData` to stage events. There are two types of events that can be staged in a Streams queue: logical change records (LCRs) and user messages. LCRs are objects that contain information about a change to a database object, while user messages are custom messages created by users or applications. Both types of events are of type `SYS.AnyData` and can be used for information sharing within a single database or between databases.

Staged events can be consumed or propagated, or both. These events can be consumed by an apply process or by a user application that explicitly dequeues them. Even after an event is consumed, it may remain in the queue if you have also configured Streams to propagate the event to one or more other queues or if message retention is specified. These other queues may reside in the same database or in different databases. In either case, the queue from which the events are propagated is called the **source queue**, and the queue that receives the events is called the **destination queue**. There can be a one-to-many, many-to-one, or many-to-many relationship between source and destination queues. Figure 3–1 shows propagation from a source queue to a destination queue.

Figure 3–1 Propagation from a Source Queue to a Destination Queue



You can create, alter, and drop a propagation job, and you can define propagation rules that control which events are propagated. The user who owns the source queue is the user who propagates events. This user must have the necessary privileges to propagate events. These privileges include the following:

- Execute privilege on the rule set used by the propagation job
- Execute privilege on all transformation functions used in the rule set
- Enqueue privilege on the destination queue if the destination queue is in the same database

If the propagation job propagates events to a destination queue in a remote database, then the owner of the source queue must be able to use the propagation job's database link and the user to which the database link connects at the remote database must have enqueue privilege on the destination queue.

Note:

- Currently, a single propagation job propagates all events that use a particular database link, even if the database link propagates events to multiple destination queues.
- The source queue owner performs the propagation, but the propagation job is owned by the user who creates it. These two users may or may not be the same.
- Connection qualifiers cannot be used with Streams propagation jobs.

See Also: *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about message retention

Captured and User-Enqueued Events

Events can be enqueued in two ways:

- A capture process enqueues captured changes in the form of events containing LCRs. An event containing an LCR that was originally captured and enqueued by a capture process is called a **captured event**.
- A user application enqueues user messages of type `SYS.AnyData`. These user messages can contain LCRs or any other type of message. Any user message that was explicitly enqueued by a user or an application is called a **user-enqueued event**. Events that were enqueued by a user procedure called from an apply process are also user-enqueued events.

So, each captured event contains an LCR, but a user-enqueued event may or may not contain an LCR.

Propagating a captured event enqueues it into the destination queue. Propagating a user-enqueued event enqueues it into the destination queue.

Events can be dequeued in two ways:

- An apply process dequeues either captured or user-enqueued events. If the event contains an LCR, then the apply process can either apply it directly or call a user-specified procedure for processing. If the event does not contain an LCR, then the apply process invokes a user-specified procedure called a message handler.
- A user application explicitly dequeues user-enqueued events and processes them. Captured events cannot be dequeued by a user application; they must be dequeued by an apply process. However, if a user procedure called by an apply process explicitly enqueues an event, then the event is a user-enqueued event and can be explicitly dequeued, even if the event was originally a captured event.

The dequeued events may have originated at the same database where they are dequeued, or they may have originated at a different database.

See Also:

- Chapter 2, "Streams Capture Process" for more information about the capture process
- *Oracle9i Application Developer's Guide - Advanced Queuing* for information about enqueuing events into a queue
- Chapter 4, "Streams Apply Process" for more information about the apply process
- "Managing Logical Change Records (LCRs)" on page 15-2

Event Propagation Between Queues

You can use Streams to configure event propagation between two queues, which may reside in different databases. Streams uses job queues to propagate events.

A propagation is always between a source queue and a destination queue. Although propagation is always between two queues, a single queue may participate in many propagations. That is, a single source queue may propagate events to multiple destination queues, and a single destination queue may receive events from multiple source queues. However, only one propagation is allowed between a particular source queue and a particular destination queue. Also, a single queue may be a destination queue for some propagations and a source queue for other propagations.

A propagation may propagate all of the events in a source queue to the destination queue, or a propagation may propagate only a subset of the events. Also, a single propagation job can propagate both captured and user-enqueued events. You can use rules to control which events in the source queue are propagated to the destination queue.

All destination queues at a database receive events from a single source queue through a single propagation job. By using a single propagation job for multiple destination queues, Streams ensures that an event is sent to a destination database only once, even if the same message is received by multiple destination queues in the same database. Communication resources are conserved because messages are not sent more than once to the same database.

Depending on how you set up your Streams environment, changes could be sent back to the site where they originated. You need to ensure that your environment is configured to avoid cycling the change in an endless loop. You can use Streams tags to avoid such a change cycling loop.

See Also:

- "Managing Streams Propagation Jobs" on page 12-7
- *Oracle9i Application Developer's Guide - Advanced Queuing* for detailed information about the propagation infrastructure in AQ
- Chapter 8, "Streams Tags"

Propagation Rules

A propagation job propagates events based on rules that you define. For LCR events, each rule specifies the database objects for which the propagation job propagates changes and the types of changes to propagate. You can specify propagation rules for LCR events at the following levels:

- A table rule propagates either DML or DDL changes to a particular table.
- A schema rule propagates either DML or DDL changes to the database objects in a particular schema.
- A global rule propagates either all DML or all DDL changes in the source queue.

For non-LCR events, you can create your own rules to control propagation.

A queue subscriber that specifies a condition causes the system to generate a rule. The rule sets for all subscribers to a queue are combined into a single system-generated rule set to make subscription more efficient.

See Also:

- Chapter 5, "Rules"
- Chapter 6, "How Rules Are Used In Streams"

Propagation Scheduling

A propagation schedule specifies how often a propagation job propagates events from a source queue to a destination queue. A default propagation schedule is established for the new propagation job when you create the propagation job using one of the following procedures:

- The `ADD_GLOBAL_PROPAGATION_RULE` procedure in the `DBMS_STREAMS_ADM` package
- The `ADD_SCHEMA_PROPAGATION_RULE` procedure in the `DBMS_STREAMS_ADM` package
- The `ADD_TABLE_PROPAGATION_RULE` procedure in the `DBMS_STREAMS_ADM` package
- The `CREATE_PROPAGATION` procedure in the `DBMS_PROPAGATION_ADM` package

The default schedule has the following properties:

- The start time is `SYSDATE()`.
- The duration is `NULL`, which means infinite.
- The next time is `NULL`, which means that propagation restarts as soon as it finishes the current duration.
- The latency is five seconds, which is the wait time for a message to be propagated to a destination queue after it is enqueued into a queue with no messages requiring propagation to the same destination queue.

If you want to alter the default schedule for a propagation job, then use the `ALTER_PROPAGATION_SCHEDULE` procedure in the `DBMS_AQADM` package.

See Also: "Altering the Schedule of a Propagation Job" on page 12-12

Ensured Event Delivery

A user-enqueued event is propagated successfully to a destination queue when the enqueue into the destination queue is committed. A captured event is propagated successfully to a destination queue when both of the following actions are completed:

- The event is processed by all relevant apply processes associated with the destination queue.
- The event is propagated successfully from the destination queue to all of its relevant destination queues.

When an event is successfully propagated between two Streams queues, the destination queue acknowledges successful propagation of the event. If the source queue is configured to propagate an event to multiple destination queues, then the event remains in the source queue until each destination queue has sent confirmation of event propagation to the source queue. When each destination queue acknowledges successful propagation of the event, and all local consumers in the source queue database have consumed the event, the source queue can drop the event.

This confirmation system ensures that events are always propagated from the source queue to the destination queue, but, in some configurations, the source queue can grow larger than an optimal size. When a source queue grows, it uses more SGA memory and may use more disk space.

There are two common reasons for source-queue growth:

- If an event cannot be propagated to a specified destination queue for some reason (such as a network problem), then the event will remain in the source queue indefinitely. This situation could cause the source queue to grow large. So, you should monitor your queues regularly to detect problems early.
- Suppose a source queue is propagating events to multiple destination queues, and one or more destination databases acknowledge successful propagation of events much more slowly than the other queues. In this case, the source queue can grow because the slower destination databases create a backlog of events that have already been acknowledged by the faster destination databases. In an environment such as this, consider creating more than one capture process to capture changes at the source database. Then, you can use one source queue for the slower destination databases and another queue for the faster destination databases.

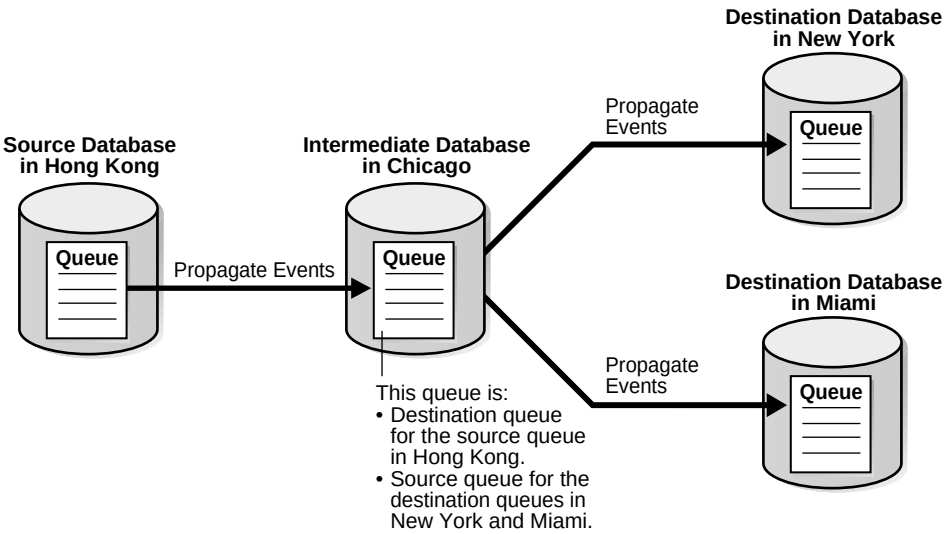
See Also:

- Chapter 2, "Streams Capture Process"
- "Monitoring a Streams Queue" on page 16-11

Directed Networks

A directed network is one in which propagated events may pass through one or more intermediate databases before arriving at a destination database. An event may or may not be processed by an apply process at an intermediate database. Using Streams, you can choose which events are propagated to each destination database, and you can specify the route that events will traverse on their way to a destination database. Figure 3–2 shows an example directed networks environment.

Figure 3–2 Example Directed Networks Environment



The advantage of using a directed network is that a source database need not have a physical network connection with the destination database. So, if you want events to propagate from one database to another, but there is no direct network connection between the computers running these databases, then you can still propagate the events without reconfiguring your network, as long as one or more intermediate databases connect the source database to the destination database.

If you use directed networks, and an intermediate site goes down for an extended period of time or is removed, then you may need to reconfigure the network and the Streams environment.

Queue Forwarding and Apply Forwarding

An intermediate database in a directed network may propagate events using queue forwarding or apply forwarding. **Queue forwarding** means that the events being forwarded at an intermediate database are the events received by the intermediate database. The source database for an event is the database where the event originated.

Apply forwarding means that the events being forwarded at an intermediate database are first processed by an apply process. These events are then recaptured by a capture process at the intermediate database and forwarded. When you use apply forwarding, the intermediate database becomes the new source database for the event because the event is recaptured there.

Consider the following differences between queue forwarding and apply forwarding when you plan your Streams environment:

- With queue forwarding, an event is propagated through the directed network without being changed, assuming there are no capture or propagation transformations. With apply forwarding, events are applied and recaptured at intermediate databases and may be changed by conflict resolution, apply handlers, or apply transformations.
- With queue forwarding, a destination database must have a separate apply process to apply events from each source database. With apply forwarding, fewer apply processes may be required at a destination database because recapturing of events at intermediate databases may result in fewer source databases when changes reach a destination database.
- With queue forwarding, one or more intermediate databases are in place between a source database and a destination database. With apply forwarding, because events are recaptured at intermediate databases, the source database for an event can be the same as the intermediate database connected directly with the destination database.

A single Streams environment may use a combination of queue forwarding and apply forwarding.

Advantages of Queue Forwarding Queue forwarding has the following advantages compared to apply forwarding:

- Performance may be improved because an event is captured only once.
- Less time may be required to propagate an event from the database where the event originated to the destination database, because the events are not applied and recaptured at one or more intermediate databases. In other words, latency may be lower with queue forwarding.
- The source database of an event can be determined easily by running the GET_SOURCE_DATABASE_NAME member procedure on the LCR contained in the event. If you use apply forwarding, then determining the origin of an event requires the use of Streams tags and apply handlers.
- Parallel apply may scale better and provide more throughput when separate apply processes are used because there are fewer dependencies, and because there are multiple apply coordinators and apply reader processes to perform the work.
- If one intermediate database goes down, then you can reroute the queues and reset the start SCN at the capture site to reconfigure end-to-end capture, propagation, and apply.

  If you use apply forwarding, then substantially more work may be required to reconfigure end-to-end capture, propagation, and apply of events, because the destination database(s) downstream from the unavailable intermediate database were using the SCN information of this intermediate database. Without this SCN information, the destination databases cannot apply the changes properly.

Advantages of Apply Forwarding Apply forwarding has the following advantages compared to queue forwarding:

- A Streams environment may be easier to configure because each database can apply changes only from databases directly connected to it, rather than from multiple remote source databases.
- In a large Streams environment where intermediate databases apply changes, the environment may be easier to monitor and manage because fewer apply processes may be required. An intermediate database that applies changes must have one apply process for each source database from which it receives changes. In an apply forwarding environment, the source databases of an intermediate database are only the databases to which it is directly connected. In a queue forwarding environment, the source databases of an intermediate database are all of the other source databases in the environment, whether they are directly connected to the intermediate database or not.
- In a multiple source Streams environment, you can add databases to the Streams environment without stopping all DML on the objects at each database and waiting for all LCRs involving the objects to be captured, propagated, and applied. A new database is instantiated from the one database that will connect it to the rest of the Streams environment. In contrast, in a queue forwarding environment, no single database contains all of the current data for a shared object with multiple sources, and so DML should be stopped when adding new databases to the environment.

See Also:

- Chapter 4, "Streams Apply Process"
- "Single Source Database in a Heterogeneous Environment" on page 19-2 for an example of an environment that uses queue forwarding
- "Primary Database Sharing Data with Several Secondary Databases" on page 8-11 for an example of an environment that uses apply forwarding

SYS.AnyData Queues and User Messages

Streams enables messaging with queues of type `SYS.AnyData`. These queues are called Streams queues. Streams queues can stage user messages whose payloads are of `SYS.AnyData` type. A `SYS.AnyData` payload can be a wrapper for payloads of different datatypes. A queue that can stage messages of only a particular type are called typed queues.

Using `SYS.AnyData` wrappers for message payloads, publishing applications can enqueue messages of different types into a single queue, and subscribing applications can dequeue these messages, either explicitly using a dequeue API or implicitly using an apply process. If the subscribing application is remote, then the messages can be propagated to the remote site, and the subscribing application can dequeue the messages from a local queue in the remote database. Alternatively, a remote subscribing application can dequeue messages directly from the source queue using a variety of standard protocols, such as PL/SQL and OCI.

Streams interoperates with Advanced Queuing (AQ), which supports all the standard features of message queuing systems, including multi-consumer queues, publish and subscribe, content-based routing, internet propagation, transformations, and gateways to other messaging subsystems.

See Also:

- "Managing a Streams Messaging Environment" on page 12-18
- Chapter 18, "Example Streams Messaging Environment"
- *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about AQ

SYS.AnyData Wrapper for User Messages

You can wrap almost any type of payload in a `SYS.AnyData` payload. To do this, you use the `Convert`*`data_type`* static functions of the `SYS.AnyData` type, where *`data_type`* is the type of object to wrap. These functions take the object as input and return a `SYS.AnyData` object.

Note: The following types of payloads cannot be wrapped in a `SYS.AnyData` message:

- Nested table
- LOBs (including `CLOB`s, `BLOB`s, and `BFILE`s)
- `ROWID` and `UROWID`

See Also:

- "Wrapping User Messages in a SYS.AnyData Wrapper" on page 12-18
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the `SYS.AnyData` type

Programmatic Environments for Enqueue and Dequeue of User Messages

Your applications can use the following programmatic environments to enqueue user messages into a Streams queue and dequeue user messages from a Streams queue:

- PL/SQL (`DBMS_AQ` package)
- JMS
- OCI

The following sections provide information about using these interfaces to enqueue user messages into and dequeue user messages from a Streams queue.

See Also: *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about these programmatic interfaces

Enqueuing User Messages Using PL/SQL

To enqueue a user message containing an LCR into a Streams queue using PL/SQL, first create the LCR to be enqueued. You use the constructor for the `SYS.LCR$_ROW_RECORD` type to create a row LCR, and you use the constructor for the `SYS.LCR$_DDL_RECORD` type to create a DDL LCR. Then you use the `SYS.AnyData.ConvertObject` function to convert the LCR into `SYS.AnyData` payload and enqueue it using the `DBMS_AQ.ENQUEUE` procedure.

To enqueue a user message containing a non-LCR object into a Streams queue using PL/SQL, you use one of the SYS.AnyData.Convert* functions to convert the object into SYS.AnyData payload and enqueue it using the DBMS_AQ.ENQUEUE procedure.

See Also:

- "Managing a Streams Messaging Environment" on page 12-18
- Chapter 18, "Example Streams Messaging Environment"

Enqueuing User Messages Using OCI or JMS

To enqueue a user message containing an LCR into a Streams queue using JMS or OCI, you must represent the LCR in XML format. To construct an LCR, use the oracle.xdb.XMLType class. LCRs are defined in the SYS schema. The LCR schema must be loaded into the SYS schema using the catxlcr.sql script in Oracle home in the rdbms/admin/ directory.

To enqueue a message using OCI, perform the same actions that you would to enqueue a message into a typed queue. A typed queue is a queue that can stage messages of a particular type only. To enqueue a message using JMS, a user must have EXECUTE privilege on DBMS_AQ, DBMS_AQIN, and DBMS_AQJMS packages.

A non-LCR user message can be a message of any user-defined type or a JMS type. The JMS types include the following:

- javax.jms.TextMessage
- javax.jms.MapMessage
- javax.jms.StreamMessage
- javax.jms.ObjectMessage
- javax.jms.BytesMessage

When using user-defined types, you must generate the Java class for the message using Jpublisher, which implements the ORAData interface. To enqueue a message into a Streams queue, you can use methods QueueSender.send or TopicPublisher.publish.

See Also:

- "Enqueue and Dequeue Events Using JMS" on page 18-35
- *Oracle9i Application Developer's Guide - Advanced Queuing* and *Oracle9i XML Database Developer's Guide - Oracle XML DB* for more information about representing messages in XML format
- *Oracle9i Supplied Java Packages Reference* for more information about the `oracle.jms` Java package
- The `OCIAQenq` function in the *Oracle Call Interface Programmer's Guide* for more information about enqueuing messages using OCI

Dequeuing User Messages Using PL/SQL

To dequeue a user message from Streams queue using PL/SQL, you use the `DBMS_AQ.DEQUEUE` procedure and specify `SYS.AnyData` as the payload. The user message may contain an LCR or another type of object.

See Also:

- "Managing a Streams Messaging Environment" on page 12-18
- Chapter 18, "Example Streams Messaging Environment"

Dequeuing User Messages Using OCI or JMS

In a Streams queue, user messages containing LCRs in XML format are represented as `oracle.xdb.XMLType`. Non-LCR messages can be one of the following formats:

- A JMS type (`javax.jms.TextMessage`, `javax.jms.MapMessage`, `javax.jms.StreamMessage`, `javax.jms.ObjectMessage`, or `javax.jms.BytesMessage`)
- A user-defined type

To dequeue a message from a Streams queue using JMS, you can use methods `QueueReceiver`, `TopicSubscriber`, or `TopicReceiver`. Because the queue may contain different types of objects wrapped in a `SYS.AnyData` wrapper, you must register a list of SQL types and their corresponding Java classes in the typemap of the JMS session. JMS types are already preregistered in the typemap.

For example, suppose a queue can contains LCR messages represented as `oracle.xdb.XMLType` and messages of type `person` and `address`. The classes `JPerson.java` and `JAddress.java` are the `ORAData` mappings for `person` and `address`, respectively. Before dequeuing the message, the type map must be populated as follows:

```
java.util.Dictionary map = ((AQjmsSession)q_sess).getTypeMap();

map.put("SCOTT.PERSON", Class.forName("JPerson"));
map.put("SCOTT.ADDRESS", Class.forName("JAddress"));
map.put("SYS.XMLTYPE", Class.forName("oracle.xdb.XMLType"));  // For LCRs
```

When using message selectors with `QueueReceiver` or `TopicPublisher`, the selector can contain any SQL92 expression that has a combination of one or more of the following:

- JMS Message header fields or properties, including `JMSPriority`, `JMSCorrelationID`, `JMSType`, `JMSXUserI`, `JMSXAppID`, `JMSXGroupID`, and `JMSXGroupSeq`. The following is an example of a JMS message field:

  ```
  JMSPriority < 3 AND JMSCorrelationID = 'Fiction'
  ```

- User defined message properties, as in the following example:

  ```
  color IN ('RED', 'BLUE', 'GREEN') AND price < 30000
  ```

- PL/SQL functions, as in the following example:

  ```
  hr.GET_TYPE(tab.user_data) = 'HR.EMPLOYEES'
  ```

To dequeue a message using OCI, perform the same actions that you would to dequeue a message from a typed queue.

See Also:

- "Enqueue and Dequeue Events Using JMS" on page 18-35
- *Oracle9i Application Developer's Guide - Advanced Queuing* and *Oracle9i XML Database Developer's Guide - Oracle XML DB* for more information about representing messages in XML format
- *Oracle9i Supplied Java Packages Reference* for more information about the `oracle.jms` Java package
- The `OCIAQdeq` function in the *Oracle Call Interface Programmer's Guide* for more information about dequeuing messages using OCI

Message Propagation

SYS.AnyData queues can interoperate with typed queues in a Streams environment. A typed queue can stage messages of a particular type only. Table 3–1 shows the types of propagation possible between queues.

Table 3–1 Propagation Between Different Types of Queues

Source Queue	Destination Queue	Transformation
SYS.AnyData	SYS.AnyData	None
Typed	SYS.AnyData	Implicit **Note:** Propagation is possible only if the messages in the typed queue meet the restrictions outlined in "User-Defined Type Messages" on page 3-18.
SYS.AnyData	Typed	Requires a rule to filter messages and a user-defined transformation
Typed	Typed	Follows Advanced Queuing (AQ) rules (see *Oracle9i Application Developer's Guide - Advanced Queuing* for information)

To propagate messages containing a payload of a certain type from a SYS.AnyData source queue to a typed destination queue, you must perform a transformation. Only messages containing a payload of the same type as the typed queue can be propagated to the typed queue.

Note: Certain Streams capabilities, such as capturing changes using a capture process and applying changes with an apply process, can be configured only with SYS.AnyData queues.

See Also: "Propagating Messages Between a SYS.AnyData Queue and a Typed Queue" on page 12-23

User-Defined Type Messages

If you plan to enqueue, propagate, or dequeue user-defined type messages in a Streams environment, then each type used in these messages must exist at every database where the message may be staged in a queue. Some environments use directed networks to route messages through intermediate databases before they reach their destination. In such environments, the type must exist at each intermediate database, even if the messages of this type are never enqueued or dequeued at a particular intermediate database.

In addition, the following requirements must be met for such types:

- The type name must be the same at each database.
- The type must be in the same schema at each database.
- The shape of the type must match exactly at each database.
- The type cannot use inheritance or type evolution at any database.
- The type cannot contain nested tables, LOBs, rowids, or urowids.

The object identifier (OID) need not match at each database.

See Also:

- "SYS.AnyData Wrapper for User Messages" on page 3-12 for information about wrapping user-defined type messages in `SYS.AnyData` messages
- "Directed Networks" on page 3-8

Streams Queues and Oracle Real Application Clusters

You can configure a Streams queue to stage and propagate captured and user-enqueued events in a Real Application Clusters environment. In a Real Application Clusters environment, only the owner instance may have a buffer for a queue. Different instances may have buffers for different queues. Queue buffers are discussed later in this chapter. A queue buffer is System Global Area (SGA) memory associated with a Streams queue that contains only captured events.

A Streams queue that contains only user-enqueued events behaves the same as a typed queue in a Real Application Clusters environment. However, if a Streams queue contains or will contain captured events in a Real Application Clusters environment, then the environment must meet the following requirements:

- Each queue table containing a Streams queue with captured events must be created using the `SET_UP_QUEUE` procedure in the `DBMS_STREAMS_ADM` package. Creating or altering a queue table with the `DBMS_AQADM` package is not supported if any queue in the queue table contains captured events.
- All capture processes and apply processes that deal with captured events and use a particular Streams queue must be started on the owner instance for the queue.
- Each job that propagates captured events to a Real Application Clusters destination database must use an instance-specific database link that refers to the owner instance of the destination queue. If the propagation job connects to any other instance, then the propagation job will raise an error.
- The AQ time manager must be running on all instances. Therefore, the `AQ_TM_PROCESSES` initialization parameter must be set to at least `1` on each instance.

If the owner instance for a queue table containing a destination queue becomes unavailable, then queue ownership is transferred automatically to another instance in the cluster. If this happens, then database links from remote source queues must be reconfigured manually to connect to the instance that owns the destination queue. The `DBA_QUEUE_TABLES` data dictionary view contains information about the owner instance for a queue table. A queue table may contain multiple queues. In this case, each queue in a queue table has the same owner instance as the queue table.

See Also:

- "Streams Capture Process and Oracle Real Application Clusters" on page 2-11
- "Streams Apply Process and Oracle Real Application Clusters" on page 4-25
- "Queue Buffers" on page 3-20
- *Oracle9i Database Reference* for more information about the DBA_QUEUE_TABLES data dictionary view
- *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about queues and Real Application Clusters

Streams Staging and Propagation Architecture

In general, Streams queues and propagation jobs use the infrastructure of AQ, and Streams propagation jobs are configured using the DBMS_JOBS package. However, unlike an AQ queue, which stages all events in a queue table, a Streams queue has a queue buffer to stage captured events in shared memory. This section describes queue buffers and discusses how queue buffers are used in a Real Application Clusters environment. This section also discusses secure queues and how they are used in Streams. In addition, this section discusses how transactional queues handle captured and user-enqueued events, as well as the need for a Streams data dictionary at databases that propagate captured events.

See Also:

- *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about AQ infrastructure
- *Oracle9i Database Administrator's Guide* for more information about the DBMS_JOBS package

Queue Buffers

A **queue buffer** is System Global Area (SGA) memory associated with a Streams queue that contains only captured events. A queue buffer enables Oracle to optimize captured events by buffering captured events in the SGA instead of always storing them in a queue table. This buffering of captured events happens in any database where captured events are staged in a Streams queue. Such a database may be a source database, an intermediate database, or a destination database.

User-enqueued LCR events and user-enqueued non-LCR events are always staged in queue tables, not in queue buffers.

Queue buffers improve performance, but the contents of a queue buffer are lost if the instance containing the buffer shuts down normally or abnormally. Streams automatically recovers from these cases, assuming full database recovery is performed on the instance.

A queue buffer may overflow if there is not enough shared memory available to hold captured events. Captured events that overflow a queue buffer are stored in the appropriate queue table. If the events in a queue buffer are lost, the events spilled from the queue buffer are subsequently deleted in order to keep the queue buffer and its queue table in sync. Also, when a transaction is moved to the error queue, all events in the transaction are staged in a queue table, not in a queue buffer.

See Also:

- *Oracle9i Database Concepts* for more information about the SGA
- "Performing Database Point-in-Time Recovery in a Streams Environment" on page 13-41

Secure Queues

Secure queues are queues for which AQ agents must be explicitly associated with one or more database users who can perform queue operations, such as enqueue and dequeue. The owner of a secure queue can perform all queue operations on the queue, but other users cannot perform queue operations on a secure queue unless they are configured as **secure queue users**. In Streams, secure queues can be used to ensure that only the appropriate users and Streams processes enqueue events into a queue and dequeue events from a queue.

All Streams queues created using the `SET_UP_QUEUE` procedure in the `DBMS_STREAMS_ADM` package are secure queues. When you use the `SET_UP_QUEUE` procedure to create a queue, any user specified by the `queue_user` parameter is configured as secure queue users of the queue automatically, if possible. The queue user is also granted `ENQUEUE` and `DEQUEUE` privileges on the queue. To enqueue events into and dequeue events from a queue, a queue user must also have `EXECUTE` privilege on the `DBMS_AQ` package. The `SET_UP_QUEUE` procedure does not grant this privilege.

To configure the queue user as a secure queue user, the SET_UP_QUEUE procedure creates an AQ agent with the same name as the user name, if one does not already exist. The user must use this agent to perform queue operations on the queue. If an agent with this name already exists and is associated with the queue user only, then it is used. SET_UP_QUEUE then runs the ENABLE_DB_ACCESS procedure in the DBMS_AQADM package, specifying the agent and the user. If the agent that SET_UP_QUEUE tries to create already exists and is associated with a user other than the user specified by queue_user, then an error is raised. In this case, rename or remove the existing agent using the ALTER_AQ_AGENT or DROP_AQ_AGENT procedure, respectively, in the DBMS_AQADM package. Then, retry SET_UP_QUEUE.

When you create a capture process or an apply process, an AQ agent of the secure queue associated with the Streams process is configured automatically, and the user who runs the Streams process is specified as a secure queue user for this queue automatically. Therefore, a capture process is configured to enqueue into its secure queue automatically, and an apply process is configured to dequeue from its secure queue automatically.

For a capture process, the user who invokes the procedure that creates the capture process is the user who runs the capture process. For an apply process, the user specified as the apply_user is the user who runs the apply process. If no apply_user is specified, then the user who invokes the procedure that creates the apply process is the user who runs the apply process.

Also, if you change the apply_user for an apply process using the ALTER_APPLY procedure in the DBMS_APPLY_ADM package, then the specified apply_user is configured as a secure queue user of the queue used by the apply process. However, the old apply user remains configured as a secure queue user of the queue. To remove the old apply user, run the DISABLE_DB_ACCESS procedure in the DBMS_AQADM package, specifying the old apply user and the relevant AQ agent. You may also want to drop the agent if it is no longer needed. You can view the AQ agents and their associated users by querying the DBA_AQ_AGENT_PRIVS data dictionary view.

If you create a SYS.AnyData queue using the DBMS_AQADM package, then you use the secure parameter when you run the CREATE_QUEUE_TABLE procedure to specify whether the queue is secure or not. The queue is secure if you specify true for the secure parameter when you run this procedure. When you use the DBMS_AQADM package to create a secure queue, and you want to allow users to perform queue operations on the secure queue, then you must configure these secure queue users manually.

If you use the SET_UP_QUEUE procedure in the DBMS_STREAMS_ADM package to create a secure queue, and you want a user who is not the queue owner and who was not specified by the queue_user parameter to perform operations on the queue, then you can configure the user as a secure queue user of the queue manually. Alternatively, you can run the SET_UP_QUEUE procedure again and specify a different queue_user for the queue. In this case, SET_UP_QUEUE will skip queue creation, but it will configure the user specified by queue_user as a secure queue user of the queue.

If you drop a capture process or an apply process, then the users who were configured as secure queue users for these processes remain secure queue users of the queue. To remove these users as secure queue users, run the DISABLE_DB_ACCESS procedure in the DBMS_AQADM package for each user. You may also want to drop the agent if it is no longer needed.

See Also:

- "Enabling a User to Perform Operations on a Secure Queue" on page 12-3
- "Disabling a User from Performing Operations on a Secure Queue" on page 12-5
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about AQ agents and using the DBMS_AQADM package

Transactional and Nontransactional Queues

A **transactional queue** is one in which user-enqueued events can be grouped into a set that are applied as one transaction. That is, an apply process performs a COMMIT after it applies all the user-enqueued events in a group. The SET_UP_QUEUE procedure in the DBMS_STREMS_ADM package always creates a transactional queue.

A **nontransactional queue** is one in which each user-enqueued event is its own transaction. That is, an apply process performs a COMMIT after each user-enqueued event it applies. In either case, the user-enqueued events may or may not contain user-created LCRs.

The difference between transactional and nontransactional queues is important only for user-enqueued events. An apply process always applies captured events in transactions that preserve the transactions executed at the source database. Table 3–2 shows apply process behavior for each type of event and each type of queue.

Table 3–2 Apply Process Behavior for Transactional and Nontransactional Queues

Event Type	Transactional Queue	Nontransactional Queue
Captured Events	Apply process preserves the original transaction	Apply process preserves the original transaction
User-Enqueued Events	Apply a user-specified group of user-enqueued events as one transaction	Apply each user-enqueued event in its own transaction

See Also:

- "Managing Streams Queues" on page 12-2
- *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about message grouping

Streams Data Dictionary for Propagation Jobs

When a capture process is created, a duplicate data dictionary called the Streams data dictionary is populated automatically. The Streams data dictionary is a multiversioned copy of some of the information in the primary data dictionary at a source database. The Streams data dictionary maps object numbers, object version information, and internal column numbers from the source database into table names, column names, and column datatypes when a capture process evaluates rules and creates LCRs. This mapping keeps each captured event as small as possible because the event can store numbers rather than names.

The mapping information in the Streams data dictionary at the source database may be needed to evaluate rules at any database that propagates the captured events from the source database. To make this mapping information available to a propagation job, Oracle automatically populates a multiversioned Streams data dictionary at each site that has a Streams propagation job. Oracle automatically sends internal messages that contain relevant information from the Streams data dictionary at the source database to all other databases that receive captured events from the source database.

The Streams data dictionary information contained in these internal messages in a queue may or may not be propagated by a propagation job. Which Streams data dictionary information to propagate depends on the rule set for the propagation job. When a propagation job encounters Streams data dictionary information for a table, the propagation job rule set is evaluated with partial information that includes the source database name, table name, and table owner.

If at least one rule in the rule set either evaluates to `TRUE` (`true_rules`) or could evaluate to `TRUE` given more information (`maybe_rules`), then the Streams data dictionary information is propagated. This rule can be either a DML rule or a DDL rule.

When Streams data dictionary information is propagated to a destination queue, it is incorporated into the Streams data dictionary at the database that contains the destination queue, in addition to being enqueued into the destination queue. Therefore, a propagation job reading the destination queue in a directed networks configuration can forward LCRs immediately without waiting for the Streams data dictionary to be populated.

See Also:

- "Data Dictionary Duplication During Capture Process Creation" on page 2-16
- Chapter 6, "How Rules Are Used In Streams"

4

Streams Apply Process

This chapter explains the concepts and architecture of the Streams apply process.

This chapter contains these topics:

- Apply Process Overview
- Apply Rules
- Event Processing with an Apply Process
- Datatypes Applied
- Considerations for Applying DML Changes to Tables
- Considerations for Applying DDL Changes
- Trigger Firing Property
- The Oldest SCN for an Apply Process
- Streams Apply Process and Oracle Real Application Clusters
- Apply Process Architecture

See Also: Chapter 13, "Managing an Apply Process"

Apply Process Overview

An apply process is an optional Oracle background process that dequeues logical change records (LCRs) and user messages from a specific queue and either applies each one directly or passes it as a parameter to a user-defined procedure. The LCRs dequeued by an apply process contain data manipulation language (DML) changes or data definition language (DDL) changes that an apply process can apply to database objects in a destination database. A user-defined message dequeued by an apply process is of type `SYS.AnyData` and can contain any user message, including a user-created LCR.

Note: An apply process can be associated only with a `SYS.AnyData` queue, not with a typed queue.

Apply Rules

An apply process applies changes based on rules that you define. Each rule specifies the database objects to which an apply process applies changes and the types of changes to apply. You can specify apply rules at the following levels:

- A table rule applies either DML or DDL changes to a particular table. Subset rules are table rules that include a subset of the changes to a particular table.
- A schema rule applies either DML or DDL changes to the database objects in a particular schema.
- A global rule applies either all DML or all DDL changes in the queue associated with an apply process.

For non-LCR events, you can create your own rules to control apply process behavior.

See Also:

- Chapter 5, "Rules"
- Chapter 6, "How Rules Are Used In Streams"

Event Processing with an Apply Process

An apply process is a flexible mechanism for processing the events in a queue. You have options to consider when you configure one or more apply processes for your environment. This section discusses the types of events that an apply process can apply and the ways that it can apply them.

Captured and User-Enqueued Events

A single apply process can apply either captured events or user-enqueued events, but not both. If a queue at a destination database contains both captured and user-enqueued events, then the destination database must have at least two apply processes to process the events.

When you create an apply process using a procedure in the `DBMS_STREAMS_ADM` package, the `apply_captured` parameter is set to `true` by default. Therefore, the apply process applies only captured events.

When you create an apply process using the `CREATE_APPLY` procedure in the `DBMS_APPLY_ADM` package, you use the `apply_captured` parameter to specify whether the apply process applies captured or user-enqueued events. By default, the `apply_captured` parameter is set to `false` for an apply process created with this procedure.

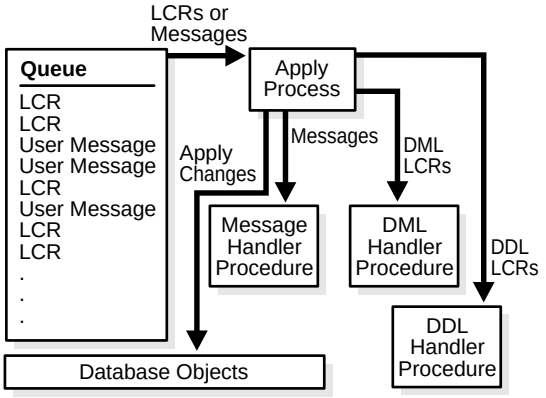
See Also:

- "Event Staging and Propagation Overview" on page 3-2 for more information about captured and user-enqueued events
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the `CREATE_APPLY` procedure

Event Processing Options

Your options for event processing depend on whether or not the event received by an apply process is an LCR event. Figure 4–1 shows the event processing options for an apply process.

Figure 4–1 The Apply Process



LCR Event Processing

Each apply process can apply captured events from only one source database, because processing the LCRs in these events requires knowledge of the dependencies, meaningful transaction ordering, and transactional boundaries at the source database. Captured LCRs from multiple databases may be sent to a single destination queue. However, if a single queue contains captured LCRs from multiple databases, then there must be multiple apply processes retrieving these LCRs. Each of these apply processes should be configured to receive captured LCRs from exactly one source database using rules. If an event is a user-enqueued event containing LCRs (not a captured event), then an apply process can apply these user-enqueued events, even if they are from multiple source databases.

Also, each apply process can apply captured events from only one capture process. If there are multiple capture processes running on a source database, and LCRs from more than one of these capture processes are applied at a destination database, then there must be one apply process to apply changes from each capture process. In such an environment, Oracle Corporation recommends that each Streams queue used by a capture process or apply process have captured events from at most one capture process from a particular source database. A queue can contain LCRs from more than one capture process if each capture process is capturing changes at a different source database.

You can configure an apply process to process a captured or user-enqueued event that contains an LCR in the following ways: directly apply the LCR event or pass the LCR event as a parameter to a user procedure for processing. The following sections explain these options.

Apply the LCR Event Directly If you use this option, then an apply process applies the LCR event without running a user procedure. The apply process either successfully applies the change in the LCR to a database object or, if a conflict or an apply error is encountered, tries to resolve the error with a conflict handler or a user-specified procedure called an error handler.

If a conflict handler can resolve the conflict, then it either applies the LCR or it discards the change in the LCR. If the error handler can resolve the error, then it should apply the LCR, if appropriate. An error handler may resolve an error by modifying the LCR before applying it. If the error handler cannot resolve the error, then the apply process places the transaction, and all LCRs associated with the transaction, into the error queue.

Call a User Procedure to Process the LCR Event If you use this option, then an apply process passes the LCR event as a parameter to a user procedure for processing. The user procedure can then process the LCR event in a customized way.

A user procedure that processes row LCRs resulting from DML statements is called a DML handler, while a user procedure that processes DDL LCRs resulting from DDL statements is called a DDL handler. An apply process can have many DML handlers but only one DDL handler, which processes all DDL LCRs dequeued by the apply process.

For each table associated with an apply process, you can set a separate DML handler to process each of the following types of operations in row LCRs:

- `INSERT`
- `UPDATE`
- `DELETE`
- `LOB_UPDATE`

For example, the `hr.employees` table may have one DML handler to process `INSERT` operations and a different DML handler to process `UPDATE` operations.

A user procedure can be used for any customized processing of LCRs. For example, if you want each insert into a particular table at the source database to result in inserts into multiple tables at the destination database, then you can create a user procedure that processes `INSERT` operations on the table to accomplish this. Or, if you want to log DDL changes before applying them, then you can create a user procedure that processes DDL operations to accomplish this.

A DML handler should never commit and never roll back, except to a named savepoint that the user procedure has established. To execute DDL inside a DDL handler, invoke the EXECUTE member procedure for the LCR.

To associate a DML handler with an apply process, use the SET_DML_HANDLER procedure in the DBMS_APPLY_ADM package. To set a DDL handler, use the ddl_handler parameter in the CREATE_APPLY or the ALTER_APPLY procedure in the DBMS_APPLY_ADM package.

See Also:

- "Logical Change Records (LCRs)" on page 2-2 for more information about row LCRs and DDL LCRs
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the EXECUTE member procedure for LCR types

Non-LCR User Message Processing

A user-enqueued event that does not contain an LCR is always processed by the message handler specified for an apply process. A message handler is a user-defined procedure that can process non-LCR user messages in a customized way for your environment.

The message handler offers advantages in any environment that has applications that need to update one or more remote databases or perform some other remote action. These applications can enqueue user messages into a queue at the local database, and Streams can propagate each user message to the appropriate queues at destination databases. If there are multiple destinations, then Streams provides the infrastructure for automatic propagation and processing of these messages at these destinations. If there is only one destination, then Streams still provides a layer between the application at the source database and the application at the destination database, so that, if the application at the remote database becomes unavailable, then the application at the source database can continue to function normally.

For example, a message handler may format a user message into an electronic mail message. In this case, the user message may contain the attributes you would expect in an electronic mail message, such as from, to, subject, text_of_message, and so on. A message handler could convert these user messages into electronic mail messages and send them out through an electronic mail gateway.

You can specify a message handler for an apply process using the `message_handler` parameter in the `CREATE_APPLY` or the `ALTER_APPLY` procedure in the `DBMS_APPLY_ADM` package. A Streams apply process always assumes that a non-LCR message has no dependencies on any other events in the queue. Therefore, if dependencies exist between these messages in your environment, then Oracle Corporation recommends that you set apply process parallelism to `1`.

Summary of Event Processing Options

Table 4–1 summarizes the event processing options available when you are using one or more of the event handlers described in the previous sections. Event handlers are optional for row LCRs and DDL LCRs because an apply process can apply these events directly. However, a message handler is required for processing non-LCR user messages.

Table 4–1 Summary of Event Processing Options

Type of Event	Default Apply Process Behavior	User Procedure	Scope of User Procedure
Row LCR	Execute DML	DML Handler	One operation on one table
DDL LCR	Execute DDL	DDL Handler	Entire apply process
Non-LCR User Message	Create error transaction (if no message handler exists)	Message Handler	Entire apply process

Note:

- Apply handlers can execute an LCR by calling the LCR's `EXECUTE` member procedure.
- All applied DDL LCRs commit automatically. Therefore, if a DDL handler calls the `EXECUTE` member procedure of a DDL LCR, then a commit is performed automatically.
- If necessary, an apply handler can set a Streams session tag.

See Also:

- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the EXECUTE member procedure for LCR types
- Chapter 8, "Streams Tags"

Datatypes Applied

When applying row LCRs for data manipulation language (DML) changes to tables, an apply process applies changes made to columns of the following datatypes:

- CHAR
- VARCHAR2
- NCHAR
- NVARCHAR2
- NUMBER
- DATE
- CLOB
- BLOB
- RAW
- TIMESTAMP
- TIMESTAMP WITH TIME ZONE
- TIMESTAMP WITH LOCAL TIME ZONE
- INTERVAL YEAR TO MONTH
- INTERVAL DAY TO SECOND

The apply process does not apply DML changes in columns of the following datatypes: NCLOB, LONG, LONG RAW, BFILE, ROWID, and UROWID, and user-defined type (including object types, REFs, varrays, and nested tables). The apply process raises an error if it attempts to apply a row LCR that contains information about a column of an unsupported datatype. Then, the apply process moves the transaction that includes the LCR into the error queue.

See Also:

- "Datatypes Captured" on page 2-6
- *Oracle9i SQL Reference* for more information about these datatypes
- "LCR Event Processing" on page 4-4 for more information about DML handlers
- "Rule-Based Transformations" on page 6-23

Considerations for Applying DML Changes to Tables

The following sections discuss considerations for applying DML changes to tables:

- Key Columns
- Substitute Key Columns
- Row Subsetting
- Apply Process Behavior for Column Discrepancies
- Conflict Resolution
- Handlers and Row LCR Processing

See Also: "Types of DML Changes Captured" on page 2-7

Key Columns

You must ensure that the primary key columns at the destination database are logged in the redo log at the source database for every update. Unique and foreign key columns at the destination database must be logged in the redo log at the source database only if a column in a multicolumn constraint is updated.

There are various ways to ensure that a column is logged at the source database. For example, whenever the value of a column is updated, the column is logged. Also, Oracle has a feature called supplemental logging that automates the logging of specified columns.

For single-column unique key and foreign key constraints, no supplemental logging is required. However, for multicolumn constraints, you must create a conditional supplemental log group containing all the constraint columns at the source database.

See Also: "Supplemental Logging" on page 2-9

Substitute Key Columns

If possible, each table for which changes are applied by an apply process should have a primary key. When a primary key is not possible, Oracle Corporation recommends that each table have a set of columns that can be used as a unique identifier for each row of the table. If the tables that you plan to use in your Streams environment do not have a primary key or a set of unique columns, then consider altering these tables accordingly.

To detect conflicts and handle errors accurately, Oracle must be able to identify uniquely and match corresponding rows at different databases. By default, Streams uses the primary key of a table to identify rows in the table. When a table at a destination database does not have a primary key, or when you want to use columns other than the primary key for the key, you can designate a substitute key at the destination database. A substitute key is a column or set of columns that Oracle can use to identify rows in the table during apply.

You can specify the substitute primary key for a table using the `SET_KEY_COLUMNS` procedure in the `DBMS_APPLY_ADM` package. Unlike true primary keys, the substitute key columns may contain `NULL`s. Also, the substitute key columns take precedence over any existing primary key for the specified table for all apply processes at the destination database.

If you specify a substitute key for a table in a destination database, and these columns are not a primary key for the same table at the source database, then you must create an unconditional supplemental log group containing the substitute key columns at the source database.

Note:

- Oracle Corporation recommends that each column you specify as a substitute key column be a `NOT NULL` column. You should also create a single index that includes all of the columns in a substitute key. Following these guidelines improves performance for updates, deletes, and piecewise updates to LOBs because the database can locate the relevant row more efficiently.
- You should not permit applications to update the primary key or substitute key columns of a table. This ensures that the database can identify rows and preserve the integrity of the data.

See Also:

- The `DBMS_APPLY_ADM.SET_KEY_COLUMNS` procedure in the *Oracle9i Supplied PL/SQL Packages and Types Reference*
- "Supplemental Logging" on page 2-9

Row Subsetting

You can use the `ADD_SUBSET_RULES` procedure in the `DBMS_STREAMS_ADM` package to maintain a subset of the rows in a particular table. To do this, you specify a condition similar to the condition in the `WHERE` clause of a `SELECT` statement in the `dml_condition` parameter for this procedure. For a particular table, only one subset rule is allowed for a particular apply process.

See Also: "Table and Subset Rules" on page 6-7

Row Migration

When you use subset rules, a captured update operation may be converted to an insert or delete operation when it is applied by an apply process. This automatic conversion is called **row migration** and is performed by an internal LCR transformation specified in a rule's action context.

For example, suppose you use a subset rule to specify that an apply process applies changes only to the `hr.employees` table when the employee's `department_id` is `50` with the following condition: `department_id = 50`. If a source database captures a change to an employee that changes the employee's `department_id`

from 80 to 50, then the apply process with the subset rule applies this change by converting the update operation into an insert operation. This conversion is needed because the employee's row does not exist in the destination table. Similarly, if a captured update changes an employee's department_id from 50 to 20, then an apply process with this subset rule converts the update operation into a delete operation.

If an apply process may perform row migration when applying changes to a table and you allow local changes to the table, then the apply process cannot ensure that all rows in the table meet the subset condition. For example, suppose the condition is department_id = 50 for the hr.employees table. If a user or an application inserts a row for an employee whose department_id is 30, then this row remains in the table and is not removed by the apply process. Similarly, if a user or an application updates a row locally and changes the department_id to 30, then this row also remains in the table.

To avoid such errors, Oracle Corporation recommends that you ensure that all DML performed on a subset table satisfy the subset condition.

Supplemental Logging and Row Subsetting

If you specify a subset rule for a table at a destination database, then an unconditional supplemental log group must be specified at the source database for all of the columns in the table at the destination database and all the columns in the subset condition. In certain cases, when a subset rule is specified, an update may be converted to an insert by an apply process, and in these cases supplemental information may be needed for some or all of the columns.

For example, if you specify a subset rule at database dbs2.net on the postal_code column in the hr.locations table, and the source database for changes to this table is dbs1.net, then use supplemental logging at dbs1.net for all of the columns in the hr.locations table at dbs2.net, as well as the postal_code column, even if this column does not exist in the table at the destination database.

See Also: "Supplemental Logging" on page 2-9

Apply Process Behavior for Column Discrepancies

A column discrepancy is any difference in the columns in a table at a source database and the columns in the same table at a destination database. If there are column discrepancies in your Streams environment, then use rule-based transformations or DML handlers to make the columns in row LCRs being applied by an apply process match the columns in the relevant tables at a destination database. The following sections describe apply process behavior for common column discrepancies.

See Also:

- "Rule-Based Transformations" on page 6-23 and "Managing Rule-Based Transformations" on page 14-10
- "LCR Event Processing" on page 4-4 for more information about apply process handlers
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about LCRs

Missing Columns at the Destination Database

If the table at the destination database is missing one or more columns that are in the table at the source database, then an apply process raises an error and moves the transaction that caused the error into the error queue. You can avoid such an error by creating a rule-based transformation or DML handler that eliminates the missing columns from the LCRs before they are applied. Specifically, the transformation or handler can remove the extra columns using the `DELETE_COLUMN` member procedure on the row LCR.

Extra Columns at the Destination Database

If the table at the destination database has more columns than the table at the source database, then apply process behavior depends on whether the extra columns are required for dependency computations. If the extra columns are not used for dependency computations, then an apply process applies changes to the destination table. In this case, if column defaults exist for the extra columns at the destination database, then these defaults are used for these columns for all inserts. Otherwise, these inserted columns are `NULL`.

If, however, the extra columns are used for dependency computations, then an apply process places the transactions that include these changes in the error queue. The following types of columns are required for dependency computations:

- For all changes, all key columns
- For INSERT and DELETE statements, all columns involved with constraints
- For UPDATE statements, if a constraint column is changed, such as a unique key constraint column or a foreign key constraint column, then all columns involved in the constraint

Column Datatype Mismatch

If the datatype for a column in a table at the destination database does not match the datatype for the same column at the source database, then an apply process places transactions containing the changes to the mismatched column into the error queue. To avoid such an error, you can create a rule-based transformation or DML handler that converts the datatype.

Conflict Resolution

Conflicts are possible in a Streams configuration where data is shared between multiple databases. A conflict can occur if DML changes are allowed to a table for which changes are captured and to a table where these changes are applied.

For example, a transaction at the source database may update a row at nearly the same time as a different transaction that updates the same row at a destination database. In this case, if data consistency between the two databases is important, then when the change is propagated to the destination database, an apply process must be instructed either to keep the change at the destination database or replace it with the change from the source database. When data conflicts occur, you need a mechanism to ensure that the conflict is resolved in accordance with your business rules.

Streams automatically detects conflicts and, for update conflicts, tries to use a conflict resolution handler to resolve them if one is configured. Streams offers a variety of prebuilt handlers that enable you to define a conflict resolution system for your database that resolves conflicts in accordance with your business rules. If you have a unique situation that a prebuilt conflict resolution handlers cannot resolve, then you can build and use your own custom conflict resolution handlers in an error handler or DML handler.

See Also: Chapter 7, "Streams Conflict Resolution"

Handlers and Row LCR Processing

Any of the following handlers may process a row LCR:

- DML handler
- Error handler
- Update conflict handler

The following sections describe the possible scenarios involving these handlers:

- No Relevant Handlers
- Relevant Update Conflict Handler
- DML Handler But No Relevant Update Conflict Handler
- DML Handler And a Relevant Update Conflict Handler
- Error Handler But No Relevant Update Conflict Handler
- Error Handler And a Relevant Update Conflict Handler

You cannot have a DML handler and an error handler simultaneously for the same operation on the same table. Therefore, there is no scenario in which they could both be invoked.

No Relevant Handlers

If there are no relevant handlers for a row LCR, then an apply process tries to apply the change specified in the row LCR directly. If the apply process can apply the row LCR, then the change is made to the row in the table. If there is a conflict or an error during apply, then the transaction containing the row LCR is rolled back, and all of the LCRs in the transaction that satisfy the apply process rule set are moved to the error queue.

Relevant Update Conflict Handler

Consider a case where there is a relevant update conflict handler configured, but no other relevant handlers are configured. An apply process tries to apply the change specified in a row LCR directly. If the apply process can apply the row LCR, then the change is made to the row in the table.

If there is an error during apply that is caused by a condition other than an update conflict, including a uniqueness conflict or a delete conflict, then the transaction containing the row LCR is rolled back, and all of the LCRs in the transaction that satisfy the apply process rule set are moved to the error queue.

If there is an update conflict during apply, then the relevant update conflict handler is invoked. If the update conflict handler resolves the conflict successfully, then the apply process either applies the LCR or discards the LCR, depending on the resolution of the update conflict, and the apply process continues applying the other LCRs in the transaction that satisfy the apply process rule set. If the update conflict handler cannot resolve the conflict, then the transaction containing the row LCR is rolled back, and all of the LCRs in the transaction that satisfy the apply process rule set are moved to the error queue.

DML Handler But No Relevant Update Conflict Handler

Consider a case where an apply process passes a row LCR to a DML handler and there is no relevant update conflict handler configured.

The DML handler processes the row LCR. The designer of the DML handler has complete control over this processing. Some DML handlers may perform SQL operations or run the EXECUTE member procedure of the row LCR. If the DML handler runs the EXECUTE member procedure of the row LCR, then the apply process tries to apply the row LCR. This row LCR may have been modified by the DML handler.

If any SQL operation performed by the DML handler fails, or if an attempt to run the EXECUTE member procedure fails, then the DML handler can try to handle the exception. If the DML handler does not raise an exception, then the apply process assumes the DML handler has performed the appropriate action with the row LCR, and the apply process continues applying the other LCRs in the transaction that satisfy the apply process rule set.

If the DML handler cannot handle the exception, then the DML handler should raise an exception. In this case, the transaction containing the row LCR is rolled back, and all of the LCRs in the transaction that satisfy the apply process rule set are moved to the error queue.

DML Handler And a Relevant Update Conflict Handler

Consider a case where an apply process passes a row LCR to a DML handler and there is a relevant update conflict handler configured.

The DML handler processes the row LCR. The designer of the DML handler has complete control over this processing. Some DML handlers may perform SQL operations or run the EXECUTE member procedure of the row LCR. If the DML handler runs the EXECUTE member procedure of the row LCR, then the apply process tries to apply the row LCR. This row LCR may have been modified by the DML handler.

If any SQL operation performed by the DML handler fails, or if an attempt to run the EXECUTE member procedure fails for any reason other than an update conflict, then the behavior is the same as that described in "DML Handler But No Relevant Update Conflict Handler" on page 4-16. Note that uniqueness conflicts and delete conflicts are not update conflicts.

If an attempt to run the EXECUTE member procedure fails because of an update conflict, then the behavior depends on the setting of the `conflict_resolution` parameter in the EXECUTE member procedure:

The conflict_resolution Parameter Is Set To true If the `conflict_resolution` parameter is set to `true`, then the relevant update conflict handler is invoked.

If the update conflict handler resolves the conflict successfully, and all other operations performed by the DML handler succeed, then the DML handler finishes without raising an exception and the apply process continues applying the other LCRs in the transaction that satisfy the apply process rule set.

If the update conflict handler cannot resolve the conflict, then the DML handler can try to handle the exception. If the DML handler does not raise an exception, then the apply process assumes the DML handler has performed the appropriate action with the row LCR, and the apply process continues applying the other LCRs in the transaction that satisfy the apply process rule set. If the DML handler cannot handle the exception, then the DML handler should raise an exception. In this case, the transaction containing the row LCR is rolled back, and all of the LCRs in the transaction that satisfy the apply process rule set are moved to the error queue.

The conflict_resolution Parameter Is Set To false If the `conflict_resolution` parameter is set to `false`, then the relevant update conflict handler is not invoked. In this case, the behavior is the same as that described in "DML Handler But No Relevant Update Conflict Handler" on page 4-16.

Error Handler But No Relevant Update Conflict Handler

Consider a case where an apply process encounters an error when it tries to apply a row LCR. This error may be caused by a conflict or by some other condition. There is an error handler for the table operation but no relevant update conflict handler configured.

The row LCR is passed to the error handler. The error handler processes the row LCR. The designer of the error handler has complete control over this processing. Some error handlers may perform SQL operations or run the EXECUTE member procedure of the row LCR. If the error handler runs the EXECUTE member

procedure of the row LCR, then the apply process tries to apply the row LCR. This row LCR may have been modified by the error handler.

If any SQL operation performed by the error handler fails, or if an attempt to run the EXECUTE member procedure fails, then the error handler can try to handle the exception. If the error handler does not raise an exception, then the apply process assumes the error handler has performed the appropriate action with the row LCR, and the apply process continues applying the other LCRs in the transaction that satisfy the apply process rule set.

If the error handler cannot handle the exception, then the error handler should raise an exception. In this case, the transaction containing the row LCR is rolled back, and all of the LCRs in the transaction that satisfy the apply process rule set are moved to the error queue.

Error Handler And a Relevant Update Conflict Handler

Consider a case where an apply process encounters an error when it tries to apply a row LCR. There is an error handler for the table operation, and there is a relevant update conflict handler configured.

The handler that is invoked to handle the error depends on the type of error it is:

- If the error is caused by a condition other than an update conflict, including a uniqueness conflict or a delete conflict, then the error handler is invoked, and the behavior is the same as that described in "Error Handler But No Relevant Update Conflict Handler" on page 4-17.
- If the error is caused by an update conflict, then the update conflict handler is invoked. If the update conflict handler resolves the conflict successfully, then the apply process continues applying the other LCRs in the transaction that satisfy the apply process rule set. In this case, the error handler is not invoked.

  If the update conflict handler cannot resolve the conflict, then the error handler is invoked. If the error handler does not raise an exception, then the apply process assumes the error handler has performed the appropriate action with the row LCR, and the apply process continues applying the other LCRs in the transaction that satisfy the apply process rule set. If the error handler cannot process the LCR, then the error handler should raise an exception. In this case, the transaction containing the row LCR is rolled back, and all of the LCRs in the transaction that satisfy the apply process rule set are moved to the error queue.

See Also:

- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the EXECUTE member procedure for row LCRs
- "Managing a DML Handler" on page 13-14
- "Managing an Error Handler" on page 13-21
- "Managing Streams Conflict Resolution" on page 13-29

Considerations for Applying DDL Changes

The following sections discuss considerations for applying DDL changes to tables:

- Types of DDL Changes Ignored by an Apply Process
- Database Structures
- Current Schema User Must Exist at Destination Database
- System-Generated Names
- CREATE TABLE AS SELECT Statements

See Also: "Types of DDL Changes Ignored by a Capture Process" on page 2-8

Types of DDL Changes Ignored by an Apply Process

The following types of DDL changes are not supported by an apply process. These types of DDL changes are not applied:

- ALTER MATERIALIZED VIEW
- ALTER MATERIALIZED VIEW LOG
- CREATE DATABASE LINK
- CREATE SCHEMA AUTHORIZATION
- CREATE MATERIALIZED VIEW
- CREATE MATERIALIZED VIEW LOG
- DROP DATABASE LINK

- DROP MATERIALIZED VIEW
- DROP MATERIALIZED VIEW LOG
- RENAME

Also, the following types of CREATE TABLE and ALTER TABLE statements are ignored by an apply process:

- A CREATE TABLE AS SELECT statement on a clustered table is not supported in a Streams environment.
- A CREATE TABLE statement that creates an index-organized table.
- An ALTER TABLE statement that alters an index-organized table.

If an apply process receives a DDL LCR that specifies an operation that cannot be applied, then the apply process ignores the DDL LCR and records the following message in the apply process trace file, followed by the DDL text ignored:

```
Apply process ignored the following DDL:
```

An apply process applies all other types of DDL changes if the DDL LCRs containing the changes satisfy the rules in the apply process rule set.

Note:

- An apply process applies ALTER *object_type object_name* RENAME changes, such as ALTER TABLE jobs RENAME. Therefore, if you want DDL changes that rename objects to be applied, then use ALTER *object_type object_name* RENAME statements instead of RENAME statements.
- The name "materialized view" is synonymous with the name "snapshot". Snapshot equivalents of the statements on materialized views are ignored by an apply process.
- An apply process only applies captured DDL LCRs. It ignores user-enqueued DDL LCRs.

Database Structures

For captured DDL changes to be applied properly at a destination database, either the destination database must have the same database structures as the source database, or the non-identical database structural information must not be specified in the DDL statement. Database structures include data files, tablespaces, rollback segments, and other physical and logical structures that support database objects.

For example, for captured DDL changes to tables to be applied properly at a destination database, the following conditions must be met:

- The same storage parameters must be specified in the CREATE TABLE statement at the source database and destination database.
- If a DDL statement refers to specific tablespaces or rollback segments, then the tablespaces or rollback segments must have the same names and compatible specifications at the source database and destination database.

  However, if the tablespaces and rollback segments are not specified in the DDL statement, then the default tablespaces and rollback segments are used. In this case, the tablespaces and rollback segments can differ at the source database and destination database.
- The same partitioning specifications must be used at the source database and destination database.

Current Schema User Must Exist at Destination Database

For a DDL LCR to be applied at a destination database successfully, the user specified as the `current_schema` in the DDL LCR must exist at the destination database.

See Also:

- *Oracle9i Database Concepts* for more information about database structures
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the `current_schema` attribute in DDL LCRs

System-Generated Names

If you plan to capture DDL changes at a source database and apply these DDL changes at a destination database, then avoid using system-generated names. If a DDL statement results in a system-generated name for an object, then the name of the object typically will be different at the source database and each destination database applying the DDL change from this source database. Different names for objects can result in apply errors for future DDL changes.

For example, suppose the following DDL statement is run at a source database:

```
CREATE TABLE sys_gen_name (n1 NUMBER  NOT NULL);
```

This statement results in a NOT NULL constraint with a system-generated name. For example, the NOT NULL constraint may be named SYS_001500. When this change is applied at a destination database, the system-generated name for this constraint may be SYS_C1000.

Suppose the following DDL statement is run at the source database:

```
ALTER TABLE sys_gen_name DROP CONSTRAINT sys_001500;
```

This DDL statement succeeds at the source database, but it fails at the destination database and results in an apply error.

To avoid such an error, explicitly name all objects resulting from DDL statements. For example, to name a NOT NULL constraint explicitly, run the following DDL statement:

```
CREATE TABLE sys_gen_name (n1 NUMBER CONSTRAINT sys_gen_name_nn NOT NULL);
```

CREATE TABLE AS SELECT Statements

When applying a change resulting from a CREATE TABLE AS SELECT statement, an apply process performs two steps:

1. The CREATE TABLE AS SELECT statement is executed at the destination database, but it creates only the structure of the table. It does not insert any rows into the table. If the CREATE TABLE AS SELECT statement fails, then an apply process error results. Otherwise, the statement autocommits, and the apply process performs Step 2.

2. The apply process inserts the rows that were inserted at the source database as a result of the CREATE TABLE AS SELECT statement into the corresponding table at the destination database. It is possible that a capture process, a propagation job, or an apply process will discard all of the row LCRs with these inserts based on their rule sets. In this case, the table remains empty at the destination database.

   Note: A CREATE TABLE AS SELECT statement on a clustered table is not supported in a Streams environment.

Trigger Firing Property

You can control a DML or DDL trigger's firing property using the SET_TRIGGER_FIRING_PROPERTY procedure in the DBMS_DDL package. This procedure lets you specify whether a trigger's firing property is set to fire once. If a trigger's firing property is set to fire once, then it does not fire in the following cases:

- When a relevant change is made by an apply process
- When a relevant change results from the execution of one or more apply errors using the EXECUTE_ERROR or EXECUTE_ALL_ERRORS procedure in the DBMS_APPLY_ADM package

If a trigger is not set to fire once, then it fires in both of these cases.

By default, DML and DDL triggers are set to fire once. You can check a trigger's firing property by using the IS_TRIGGER_FIRE_ONCE function in the DBMS_DDL package.

For example, in the hr schema, the update_job_history trigger adds a row to the job_history table when data is updated in the job_id or department_id column in the employees table. Suppose, in a Streams environment, the following configuration exists:

- A capture process captures changes to both of these tables at the dbs1.net database.
- A propagation job propagates these changes to the dbs2.net database.
- An apply process applies these changes at the dbs2.net database.
- The update_job_history trigger exists in the hr schema in both databases.

If the update_job_history trigger is not set to fire once at dbs2.net in this scenario, then these actions result:

1. The job_id column is updated for an employee in the employees table at dbs1.net.
2. The update_job_history trigger fires at dbs1.net and adds a row to the job_history table that records the change.
3. The capture process at dbs1.net captures the changes to both the employees table and the job_history table.
4. A propagation job propagates these changes to the dbs2.net database.
5. An apply process at the dbs2.net database applies both changes.
6. The update_job_history trigger fires at dbs2.net when the apply process updates the employees table.

In this case, the change to the employees table is recorded twice at the dbs2.net database: when the apply process applies the change to the job_history table and when the update_job_history trigger fires to record the change made to the employees table by the apply process.

As you can see, the database administrator may not want the update_job_history trigger to fire at the dbs2.net database when a change is made by the apply process. Similarly, a database administrator may not want a trigger to fire because of the execution of an apply error transaction. If the update_job_history trigger's firing property is set to fire once, then it does not fire at dbs2.net when the apply process applies a change to the employees table, and it does not fire when an executed error transaction updates the employees table.

Note: Only DML and DDL triggers can be set to fire once. All other types of triggers always fire.

See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about setting a trigger's firing property with the SET_TRIGGER_FIRING_PROPERTY procedure

The Oldest SCN for an Apply Process

If an apply process is running, then the **oldest SCN** is the earliest SCN of the transactions currently being applied. For a stopped apply process, the oldest SCN is the earliest SCN of the transactions that were being applied when the apply process was stopped.

The following are two common scenarios in which the oldest SCN is important:

- You must recover the database in which the apply process is running to a certain point in time.
- You stop using an existing capture process that captures changes for the apply process and use a different capture process to capture changes for the apply process.

In both cases, you should determine the oldest SCN for the apply process by querying the DBA_APPLY_PROGRESS data dictionary view; the oldest_message_number column in this view contains the oldest SCN. Then, set the start SCN for the capture process that is capturing changes for the apply process to the same value as the oldest SCN value. If the capture process is capturing changes for other apply processes, then these other apply processes may receive duplicate LCR events when you reset the start SCN for the capture process. In this case, the other apply processes automatically discard the duplicate LCR events.

See Also: "The Start SCN for a Capture Process" on page 2-21

Streams Apply Process and Oracle Real Application Clusters

You can configure a Streams apply process to apply changes in a Real Application Clusters environment. If you use an apply process to apply captured LCRs in a Real Application Clusters environment, then any call to the START_APPLY procedure in the DBMS_APPLY_ADM package must be run on owner instance of the queue that is used by the apply process.

Calls to other procedures and functions that operate on an apply process can be performed from any instance. Also, an apply process that applies user-enqueued events can start in any instance.

If the owner instance for a queue table containing a queue used by an apply process becomes unavailable, then queue ownership is transferred automatically to another instance in the cluster. If this happens, then, to restart the apply process, connect to the owner instance for the queue and run the START_APPLY procedure. The DBA_QUEUE_TABLES data dictionary view contains information about the owner

instance for a queue table. The apply process maintains a persistent start/stop state in a Real Application Clusters environment only if the owner instance for its queue does not change before the database instance owning the queue is restarted.

Also, in a Real Application Clusters environment, an apply coordinator process, its corresponding apply reader server, and all of its apply server processes use run on a single instance.

See Also:

- "Streams Queues and Oracle Real Application Clusters" on page 3-19
- "Streams Capture Process and Oracle Real Application Clusters" on page 2-11
- *Oracle9i Database Reference* for more information about the `DBA_QUEUE_TABLES` data dictionary view
- "The Persistent State of an Apply Process" on page 4-32

Apply Process Architecture

You can create, alter, start, stop, and drop an apply process, and you can define apply rules that control which events an apply process dequeues from the queue. The user who creates an apply process is, by default, the user who applies changes. This user must have the necessary privileges to apply changes.

See Also: "Setting Up Users and Creating Queues and Database Links" on page 19-7 for information about the required privileges. In the example in this section, the privileges are granted to the `strmadmin` user.

This section discusses the following topics:

- Apply Process Components
- Apply Process Creation
- Streams Data Dictionary for an Apply Process
- Apply Process Parameters
- The Persistent State of an Apply Process
- The Error Queue

Apply Process Components

An apply process consists of the following components:

- A **reader server** that dequeues events. The reader server is a parallel execution server that computes dependencies between LCRs and assembles events into transactions. The reader server then returns the assembled transactions to the coordinator, which assigns them to idle apply servers.
- A **coordinator process** that gets transactions from the reader and passes them to apply servers. The coordinator process name is `ap`*`nn`*, where *nn* is a coordinator process number. Valid coordinator process names include `ap01` through `ap99`.
- One or more **apply servers** that apply LCRs to database objects as DML or DDL statements or that pass the LCRs to their appropriate handlers. For non-LCR messages, the apply servers pass the events to the message handler. Each apply server is a parallel execution server. If an apply server encounters an error, it then tries to resolve the error with a user-specified error handler. If an apply server cannot resolve an error, then it rolls back the transaction and places the entire transaction, including all of its events, in the error queue.

  When an apply server commits a completed transaction, this transaction has been applied. When an apply server places a transaction in the error queue and commits, this transaction also has been applied.

If a transaction being handled by an apply server has a dependency with another transaction that is not known to have been applied, then the apply server contacts the coordinator and waits for instructions. The coordinator monitors all of the apply servers to ensure that transactions are applied and committed in the correct order.

For example, consider these two transactions:

1. A row is inserted into a table.
2. The same row is updated to change certain column values.

In this case, transaction 2 is dependent on transaction 1, because the row cannot be updated until after it is inserted into the table. Suppose these transactions are captured from the redo log at a source database, propagated to a destination database, and applied at the destination database. Apply server A handles the insert transaction, and apply server B handles the update transaction.

If apply server B is ready to apply the update transaction before apply server A has applied the insert transaction, then apply server B waits for instructions from the coordinator. After apply server A has applied the insert transaction, the coordinator process instructs apply server B to apply the update transaction.

Apply Process Creation

You can create an apply process using the DBMS_STREAMS_ADM package or the DBMS_APPLY_ADM package. Using the DBMS_STREAMS_ADM package to create an apply process is simpler because defaults are used automatically for some configuration options. In addition, when you use the DBMS_STREAMS_ADM package, a rule set is created for the apply process and rules are added to the rule set automatically. The DBMS_STREAMS_ADM package was designed for use in replication environments. Alternatively, using the DBMS_APPLY_ADM package to create an apply process is more flexible, and you create a rule set and rules for the apply process either before or after it is created.

An apply process created by the procedures in the DBMS_STREAMS_ADM package can apply events only at the local database and can apply only captured events. To create an apply process that applies events at a remote database or an apply process that applies user-enqueued events, use the CREATE_APPLY procedure in the DBMS_APPLY_ADM package.

Changes applied by an apply process created by the DBMS_STREAMS_ADM package generate tags in the redo log at the destination database with a value of 00 (double zero), but you can set the tag value if you use the CREATE_APPLY procedure. Alternatively, you can set the tag using the ALTER_APPLY procedure in the DBMS_APPLY_ADM package.

When you create an apply process by running the CREATE_APPLY procedure in the DBMS_APPLY_ADM package, you can specify nondefault values for the apply_captured, apply_database_link, and apply_tag parameters. Then you can use the procedures in the DBMS_STREAMS_ADM package or the DBMS_RULE_ADM package to add rules to the rule set for the apply process.

If you create more than one apply process in a database, then the apply processes are completely independent of each other. These apply processes do not synchronize with each other, even if they apply LCRs from the same source database.

See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the following procedures, which can be used to create an apply process.

- DBMS_STREAMS_ADM.ADD_TABLE_RULES
- DBMS_STREAMS_ADM.ADD_SUBSET_RULES
- DBMS_STREAMS_ADM.ADD_SCHEMA_RULES
- DBMS_STREAMS_ADM.ADD_GLOBAL_RULES
- DBMS_CAPTURE_ADM.CREATE_APPLY

Streams Data Dictionary for an Apply Process

When a capture process is created, a duplicate data dictionary called the Streams data dictionary is populated automatically. The Streams data dictionary is a multiversioned copy of some of the information in the primary data dictionary at a source database. The Streams data dictionary maps object numbers, object version information, and internal column numbers from the source database into table names, column names, and column datatypes when a capture process evaluates rules and creates LCRs. This mapping keeps each captured event as small as possible because a captured event can often use numbers rather than names internally.

Unless a captured event is passed as a parameter to a user transformation during capture or propagation, the mapping information in the Streams data dictionary at the source database is needed to interpret the contents of the LCR at any database that applies the captured events. To make this mapping information available to an apply process, Oracle automatically populates a multiversioned Streams data dictionary at each destination database that has a Streams apply process. Oracle automatically propagates relevant information from the Streams data dictionary at the source database to all other databases that apply captured events from the source database.

See Also: "Data Dictionary Duplication During Capture Process Creation" on page 2-16

Apply Process Parameters

After creation, an apply process is disabled so that you can set the apply process parameters for your environment before starting the process for the first time. Apply process parameters control the way an apply process operates. For example, the `time_limit` apply process parameter can be used to specify the amount of time an apply process runs before it is shut down automatically. After you set the apply process parameters, you can start the apply process.

See Also:

- "Setting an Apply Process Parameter" on page 13-11
- The `DBMS_APPLY_ADM.SET_PARAMETER` procedure in the *Oracle9i Supplied PL/SQL Packages and Types Reference* for detailed information about the apply process parameters

Apply Process Parallelism

The `parallelism` apply process parameter specifies the number of apply servers that may concurrently apply transactions. For example, if `parallelism` is set to `5`, then an apply process uses a total of five apply servers. In addition, the reader server is a parallel execution server. So, if `parallelism` is set to `5`, then an apply process uses a total of six parallel execution servers, assuming six parallel execution servers are available in the database. An apply process always uses one or more parallel execution servers.

Note:

- Resetting the `parallelism` parameter automatically stops and restarts the apply process when the currently executing transactions are applied, which may take some time depending on the size of the transactions.
- Setting the `parallelism` parameter to a number higher than the number of available parallel execution servers may disable the apply process. Make sure the `PROCESSES` and `PARALLEL_MAX_SERVERS` initialization parameters are set appropriately when you set the `parallelism` apply process parameter.

See Also:

- "Apply Process Components" on page 4-27 for more information about apply servers and the reader server
- *Oracle9i Database Administrator's Guide* for information about managing parallel execution servers

Commit Serialization

Apply servers may apply transactions at the destination database in an order that is different from the commit order at the source database. Only nondependent transactions can be applied in a different order from the commit order at the source database. Dependent transactions are always applied at the destination database in the same order as they were committed at the source database.

You control whether the apply servers can apply nondependent transactions in a different order at the destination database than the source database using the `commit_serialization` apply parameter. This parameter has the following settings:

- `full`: An apply process commits applied transactions in the order in which they were committed at the source database. This setting is the default.
- none: An apply process may commit transactions in any order. Performance is best if you specify this value.

If you specify none, then it is possible that a destination database may contain commit changes in a different order from the source database. For example, suppose two nondependent transactions are committed at the source database in the following order:

1. Transaction A
2. Transaction B

At the destination database, these transactions may be committed in the opposite order:

1. Transaction B
2. Transaction A

Automatic Restart of an Apply Process

You can configure an apply process to stop automatically when it reaches certain predefined limits. The `time_limit` apply process parameter specifies the amount of time an apply process runs, and the `transaction_limit` apply process parameter specifies the number of transactions an apply process can apply. The apply process stops automatically when it reaches these limits.

The `disable_on_limit` parameter controls whether an apply process becomes disabled or restarts when it reaches a limit. If you set the `disable_on_limit` parameter to `y`, then the apply process is disabled when it reaches a limit and does not restart until you restart it explicitly. If, however, you set the `disable_on_limit` parameter to `n`, then the apply process stops and restarts automatically when it reaches a limit.

When an apply process is restarted, it gets a new session identifier, and the parallel execution servers associated with the apply process also get new session identifiers. However, the coordinator process number (`ap`*nn*) remains the same.

Stop or Continue on Error

Using the `disable_on_error` apply process parameter, you can either instruct an apply process to become disabled when it encounters an error, or you can allow the apply process to continue applying transactions after it encounters an error.

See Also: "The Error Queue" on page 4-33

The Persistent State of an Apply Process

An apply process maintains a persistent state. That is, an apply process maintains its current state when the database is shut down and restarted. For example, if an apply process is running when the database is shut down, then the apply process automatically starts when the database is restarted, but, if an apply process is stopped when a database is shut down, then the apply process remains stopped when the database is restarted.

The Error Queue

The error queue stores information about transactions that could not be applied successfully at the local destination site. A transaction may include many events, and when an unhandled error occurs during apply, the apply process automatically copies all of the events in the transaction that satisfy the apply process rule set to the error queue. The error queue contains information only about errors encountered at the local destination database. It does not contain information about errors at other databases in a Streams environment.

You can correct the condition that caused an error and then reexecute the error transaction. For example, you might modify a row in a table to correct the condition that caused an error. When the condition that caused the error has been corrected, you can either reexecute the transaction in the error queue using the EXECUTE_ERROR and EXECUTE_ALL_ERRORS procedures or delete the transaction from the error queue using the DELETE_ERROR and DELETE_ALL_ERRORS procedures. Both of these procedures are in the DBMS_APPLY_ADM package.

When you reexecute a transaction in the error queue, you can specify that the transaction be executed either by the user who originally placed the error in the error queue or by the user who is reexecuting the transaction. Also, the current Streams tag for the apply process is used when you reexecute a transaction in the error queue.

A reexecuted transaction uses any relevant apply handlers and conflict resolution handlers. If, to resolve the error, the LCR inside the error queue needs to be modified before it is executed, then you can configure a DML handler to process the LCR that caused the error in the error queue. In this case, the DML handler may modify the LCR in some way to avoid a repeat of the same error. The LCR is passed to the DML handler when you reexecute the error containing the LCR using the EXECUTE_ERROR or EXECUTE_ALL_ERRORS procedure in the DBMS_APPLY_ADM package.

An error queue is created automatically when you create a Streams queue, and each Streams queue has its own error queue. To view information about transactions in the error queue, query the DBA_APPLY_ERROR data dictionary view.

See Also:

- "Managing Apply Errors" on page 13-32
- "Checking for Apply Errors" on page 16-35
- "Displaying Detailed Information About Apply Errors" on page 16-36
- "Managing a DML Handler" on page 13-14
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information on the `DBMS_APPLY_ADM` package
- *Oracle9i Database Reference* for more information about the `DBA_APPLY_ERROR` data dictionary view

5
Rules

This chapter explains the concepts related to rules.

This chapter contains these topics:

- The Components of a Rule
- Rule Set Evaluation
- Database Objects and Privileges Related to Rules

See Also:

- Chapter 6, "How Rules Are Used In Streams"
- Chapter 14, "Managing Rules and Rule-Based Transformations"
- Chapter 20, "Example Rule-Based Application"

The Components of a Rule

A **rule** is a database object that enables a client to perform an action when an event occurs and a condition is satisfied. Rules are evaluated by a **rules engine**, which is a built-in part of Oracle. Both user-created applications and Oracle features, such as Streams, can be clients of the rules engine.

A rule consists of the following components:

- Rule Condition
- Rule Evaluation Context (optional)
- Rule Action Context (optional)

Each rule is specified as a condition that is similar to the condition in the `WHERE` clause of a SQL query. You can group related rules together into **rule sets**. A single rule can be in one rule set, multiple rule sets, or no rule sets.

Note: A rule must be in a rule set for it to be evaluated.

Rule Condition

A **rule condition** combines one or more expressions and operators and returns a Boolean value, which is a value of `TRUE`, `FALSE`, or `NULL` (unknown). An **expression** is a combination of one or more values and operators that evaluate to a value. A value can be data in a table, data in variables, or data returned by a SQL function or a PL/SQL function. For example, the following condition consists of two expressions (`department_id` and `30`) and an operator (`=`):

```
department_id = 30
```

This logical condition evaluates to `TRUE` for a given row when the `department_id` column is `30`. Here, the value is data in the `department_id` column of a table.

A single rule condition may include more than one condition combined with the `AND`, `OR`, and `NOT` conditional operators to form compound conditions. For example, consider the following compound condition:

```
department_id = 30 OR job_title = 'Programmer'
```

This rule condition contains two conditions joined by the `OR` conditional operator. If either condition evaluates to `TRUE`, then the rule condition evaluates to `TRUE`. If the conditional operator were `AND` instead of `OR`, then both conditions would have to evaluate to `TRUE` for the entire rule condition to evaluate to `TRUE`.

Rule conditions may contain variables. When you use variables in rule conditions, precede each variable with a colon (:). The following is an example of a variable used in a rule condition:

```
:x = 55
```

Variables enable you to refer to data that is not stored in a table. A variable may also improve performance by replacing a commonly occurring expression. Performance may improve because, instead of evaluating the same expression multiple times, the variable is evaluated once.

A rule condition may also contain an evaluation of a call to a subprogram. These conditions are evaluated in the same way as other conditions. That is, they evaluate to a value of TRUE, FALSE, or unknown. The following is an example of a condition that contains a call to a simple function named `is_manager` that determines whether an employee is a manager:

```
is_manager(EMPLOYEE_ID) = 'Y'
```

Here, the value of `employee_id` is determined by data in a table where `employee_id` is a column.

> **See Also:** *Oracle9i SQL Reference* for more information about conditions, expressions, and operators

Rule Evaluation Context

A **rule evaluation context** is a database object that defines external data that can be referenced in rule conditions. The external data can either exist as variables, table data, or both.

A rule evaluation context provides the necessary information for interpreting and evaluating the rule conditions that reference external data. For example, if a rule refers to a variable, then the information in the rule evaluation context must contain the variable type. Or, if a rule refers to a table alias, then the information in the evaluation context must define the table alias.

The objects referenced by a rule are determined by the rule evaluation context associated with it. The rule owner must have the necessary privileges to access these objects, such as SELECT privilege on tables, EXECUTE privilege on types, and so on. The rule condition is resolved in the schema that owns the evaluation context.

For example, consider a rule evaluation context named hr_evaluation_context that contains the following information:

- Table alias dep corresponds to the hr.departments table.
- Variables loc_id1 and loc_id2 are both of type NUMBER.

The hr_evaluation_context rule evaluation context provides the necessary information for evaluating the following rule condition:

```
dep.location_id IN (:loc_id1, :loc_id2)
```

In this case, the rule condition evaluates to TRUE for a row in the hr.departments table if that row has a value in the location_id column that corresponds to either of the values passed in by the loc_id1 or loc_id2 variables. The rule cannot be interpreted or evaluated properly without the information in the hr_evaluation_context rule evaluation context.

Explicit and Implicit Variables

The value of a variable referenced in a rule condition may be explicitly specified when the rule is evaluated, or the value of a variable may be implicitly available given the event.

Explicit variables are supplied by the caller at evaluation time. These values are specified by the variable_values parameter when the DBMS_RULE.EVALUATE procedure is run.

Implicit variables are not given a value at evaluation time. The value of an implicit variable is obtained by calling the variable value evaluation function. You define this function when you specify the variable_types list during the creation of an evaluation context using the DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT procedure. If the value for an implicit variable is specified during evaluation, then the specified value overrides the value returned by the variable value function.

Specifically, the variable_types list is of type SYS.RE$VARIABLE_TYPE_LIST, which is a list of variables of type SYS.RE$VARIABLE_TYPE. Within each instance of SYS.RE$VARIABLE_TYPE in the list, the function used to determine the value of an implicit variable is specified as the variable_value_function attribute.

Whether variables are explicit or implicit is the choice of the designer of the application using the rules engine. The following are reasons for using an implicit variable:

- The caller of the DBMS_RULE.EVALUATE procedure does not need to know anything about the variable, which may reduce the complexity of the application using the rules engine. For example, a variable may call a function that returns a value based on the data being evaluated.
- The caller may not have execute privileges on the variable value evaluation function.
- The caller of the DBMS_RULE.EVALUATE procedure does not know the variable value based on the event, which may improve security if the variable value contains confidential information.
- The variable may be used infrequently, and the variable's value always can be derived if necessary. Making such variables implicit means that the caller of the DBMS_RULE.EVALUATE procedure does not need to specify many uncommon variables.

For example, in the following rule condition, the values of variable x and variable y could be specified explicitly, but the value of the variable max could be returned by running the max function:

```
:x = 4 AND :y < :max
```

Alternatively, variable x and y could be implicit variables, and variable max could be an explicit variable. As you can see, there is no syntactic difference between explicit and implicit variables in the rule condition. You can determine whether a variable is explicit or implicit by querying the DBA_EVALUATION_CONTEXT_VARS data dictionary view. For explicit variables, the VARIABLE_VALUE_FUNCTION field is NULL. For implicit variables, this field contains the name of the function called by the implicit variable.

See Also:

- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the DBMS_RULE and DBMS_RULE_ADM packages, and for more information about the Oracle-supplied rule types
- *Oracle9i Database Reference for more information* about the DBA_EVALUATION_CONTEXT_VARS data dictionary view

Evaluation Context Association with Rule Sets and Rules

A single rule evaluation context can be associated with multiple rules or rule sets. The following list describes which evaluation context is used when a rule is evaluated:

- If an evaluation context is associated with a rule, then it is used for the rule whenever the rule is evaluated, and any evaluation context associated with the rule set being evaluated is ignored.
- If a rule does not have an evaluation context, but an evaluation context was specified for the rule when it was added to a rule set using the ADD_RULE procedure in the DBMS_RULE_ADM package, then the evaluation context specified in the ADD_RULE procedure is used for the rule when the rule set is evaluated.
- If no rule evaluation context is associated with a rule and none was specified by the ADD_RULE procedure, then the evaluation context of the rule set is used for the rule when the rule set is evaluated.

Note: If a rule does not have an evaluation context and you try to add it to a rule set that does not have an evaluation context, then an error is raised, unless you specify an evaluation context when you run the ADD_RULE procedure.

Evaluation Function

You have the option of creating an evaluation function to be run with a rule evaluation context. You can then associate the function with the rule evaluation context by specifying the function name for the `evaluation_function` parameter when you create the rule evaluation context with the CREATE_EVALUATION_CONTEXT procedure in the DBMS_RULE_ADM package. Then, this function evaluates rules using the evaluation context. The function must have the same parameter names and types as the DBMS_RULE.EVALUATE procedure.

The evaluation function can be used to decide whether normal evaluation by the rules engine should continue. If evaluation by the rules engine should continue, then the evaluation function returns DBMS_RULE_ADM.EVALUATION_CONTINUE. Otherwise, it returns one of the following values:

- DBMS_RULE_ADM.EVALUATION_SUCCESS
- DBMS_RULE_ADM.EVALUATION_FAILURE

You should create an evaluation function only if you want to bypass the rules engine for evaluation. If you specify an evaluation function for an evaluation context, then the evaluation function is run during evaluation when the evaluation context is used by a rule set or rule, unless a particular rule in the rule set has its own evaluation context or an evaluation context was specified for a rule in the call to the DBMS_RULE_ADM.ADD_RULE procedure.

> **See Also:** *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the evaluation function specified in the CREATE_EVALUATION_CONTEXT

Rule Action Context

A **rule action context** contains optional information associated with a rule that is interpreted by the client of the rules engine when the rule is evaluated for an event. The client of the rules engine can be a user-created application or an internal feature of Oracle, such as Streams. Each rule has only one action context. The information in an action context is of type SYS.RE$NV_LIST, which is a type that contains an array of name-value pairs.

The rule action context information provides a context for the action taken by a client of the rules engine when a rule evaluates to TRUE. The rules engine does not interpret the action context. Instead, it returns the action context information when a rule evaluates to TRUE. Then, a client of the rules engine can interpret the action context information.

For example, suppose an event is defined as the addition of a new employee to a company. If the employee information is stored in the hr.employees table, then the event occurs whenever a row is inserted into this table. The company wants to specify that a number of actions are taken when a new employee is added, but the actions depend on which department the employee joins. One of these actions is that the employee is registered for a course relating to the department.

In this scenario, the company can create a rule for each department with an appropriate action context. Here, an action context returned when a rule evaluates to TRUE specifies the number of a course that an employee should take. Here are the rule conditions and the action contexts for three departments:

Rule Name	Rule Condition	Action Context Name-Value Pair
rule_dep_10	department_id = 10	course_number, 1057
rule_dep_20	department_id = 20	course_number, 1215
rule_dep_30	department_id = 30	NULL

These action contexts return the following instructions to the client application:

- The action context for the `rule_dep_10` rule instructs the client application to enroll the new employee in course number `1057`.
- The action context for the `rule_dep_20` rule instructs the client application to enroll the new employee in course number `1215`.
- The `NULL` action context for the `rule_dep_30` rule instructs the client application not to enroll the new employee any course.

Each action context can contain zero or more name-value pairs. If an action context contains more than one name-value pair, then each name in the list must be unique. In this example, the client application to which the rules engine returns the action context registers the new employee in the course with the returned course number. The client application does not register the employee for a course if a `NULL` action context is returned or if the action context does not contain a course number.

If multiple clients use the same rule, or if you want an action context to return more than one name-value pair, then you can list more than one name-value pair in an action context. For example, suppose the company also adds a new employee to a department electronic mailing list. In this case, the action context for the `rule_dep_10` rule might contain two name-value pairs:

Name	Value
course_number	1057
dist_list	admin_list

The following are considerations for names in name-value pairs:

- If different applications use the same action context, then avoid naming conflicts by using different names or prefixes of names.
- Do not use $ and # in names to avoid conflicts with Oracle-supplied action context names.

Streams uses action contexts for rule-based transformations and, when subset rules are specified, for internal transformations that may be required on LCRs containing `UPDATE` operations.

You can add a name-value pair to an action context using the `ADD_PAIR` member procedure of the `RE$NV_LIST` type. You can remove a name-value pair from an action context using the `REMOVE_PAIR` member procedure of the `RE$NV_LIST` type. If you want to modify an existing name-value pair in an action context, then you should first remove it using the `REMOVE_PAIR` member procedure and then add an appropriate name-value pair using the `ADD_PAIR` member procedure.

See Also:

- "Rule-Based Transformations" on page 6-23
- "Row Subsetting" on page 4-11
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the `RE$NV_LIST` type
- "Rule-Based Transformations" on page 6-23 for examples that add and modify name-value pairs

Rule Set Evaluation

The rules engine evaluates rule sets based on events. An **event** is an occurrence that is defined by the client of the rules engine. When an event occurs, the client sends the event to the `DBMS_RULE.EVALUATION` procedure for evaluation in the form of an **event context**. An event context is a varray of type `SYS.RE$NV_LIST` that contains name-value pairs that identify the event. This information is not directly used or interpreted by the rules engine. Instead, it is passed to client callbacks, such as a callback for an implicit variable. The client also sends the name of the rule set whose rules should be used to evaluate the event.

Along with the event context and rule set name, the client may also send table values and variable values, as well as other information. The table values contain rowids that refer to the data in table rows, and the variable values contain the data for explicit variables.

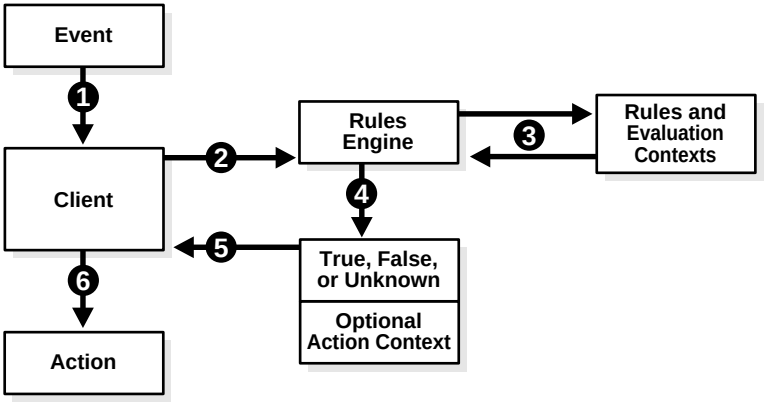
You specify an evaluation context when you run the DBMS_RULE.EVALUATION procedure. Only rules that use the specified evaluation context are evaluated.

The rules engine uses the rules in the specified rule set to evaluate the event. Then, the rules engine returns the results to the client. The rules engine returns rules using the two OUT parameters in the EVALUATE procedure: true_rules and maybe_rules. That is, the true_rules parameter returns rules that evaluate to TRUE, and, optionally, the maybe_rules parameter returns rules that may evaluate to TRUE given more information.

Figure 5–1 show the rule set evaluation process:

1. A client-defined event occurs.
2. The client sends the event to the rules engine in the form of an event context, along with the name of the rule set that should be used to evaluate the event.
3. The rules engine evaluates the event based on rules in the specified rule set and the relevant evaluation contexts.
4. The rules engine obtains the results of the evaluation. Each rule evaluates to either TRUE, FALSE, or NULL (unknown).
5. The rules engine returns rules that evaluated to TRUE to the client. Each returned rule is returned with its entire action context, which may contain information or may be NULL.
6. The client performs actions based on the results returned by the rules engine. The rules engine does not perform actions based rule evaluations.

Figure 5–1 Rule Set Evaluation



See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the DBMS_RULE.EVALUATE procedure

Database Objects and Privileges Related to Rules

You can create the following types of database objects directly using the DBMS_RULE_ADM packages:

- Evaluation contexts
- Rules
- Rule sets

You can create rules and rule sets indirectly using the DBMS_STREAMS_ADM package. You control the privileges for these database objects using the following procedures in the DBMS_RULE_ADM package:

- GRANT_OBJECT_PRIVILEGE
- GRANT_SYSTEM_PRIVILEGE
- REVOKE_OBJECT_PRIVILEGE
- REVOKE_SYSTEM_PRIVILEGE

To allow a user to create rule sets, rules, and evaluation contexts in the user's own schema, grant the user the following system privileges:

- CREATE_RULE_SET_OBJ
- CREATE_RULE_OBJ
- CREATE_EVALUATION_CONTEXT_OBJ

These privileges, and the privileges discussed in the following sections, can be granted to the user directly or through a role.

Note: When you grant a privilege on "ANY" object (for example, ALTER_ANY_RULE), and the initialization parameter O7_DICTIONARY_ACCESSIBILITY is set to FALSE, you give the user access to that type of object in all schemas, except the SYS schema. By default, the initialization parameter O7_DICTIONARY_ACCESSIBILITY is set to FALSE.

If you want to grant access to an object in the SYS schema, then you can grant object privileges explicitly on the object. Alternatively, you can set the O7_DICTIONARY_ACCESSIBILITY initialization parameter to TRUE. Then privileges granted on "ANY" object will allow access to any schema, including SYS.

See Also:

- "The Components of a Rule" on page 5-2 for more information about these database objects
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the system and object privileges for these database objects
- *Oracle9i Database Concepts* and *Oracle9i Database Administrator's Guide* for general information about user privileges
- Chapter 6, "How Rules Are Used In Streams" for more information about creating rules and rule sets indirectly using the DBMS_STREAMS_ADM package

Privileges for Creating Database Objects Related to Rules

To create an evaluation context, rule, or rule set in a schema, a user must meet at least one of the following conditions:

- The schema must be the user's own schema, and the user must be granted the create system privilege for the type of database object being created. For example, to create a rule set in the user's own schema, a user must be granted the CREATE_RULE_SET_OBJ system privilege.
- The user must be granted the create any system privilege for the type of database object being created. For example, to create an evaluation context in any schema, a user must be granted the CREATE_ANY_EVALUATION_CONTEXT system privilege.

- When creating a rule with an evaluation context, the rule owner must have privileges on all objects accessed by the evaluation context.

Privileges for Altering Database Objects Related to Rules

To alter an evaluation context, rule, or rule set, a user must meet at least one of the following conditions:

- The user must own the database object.
- The user must be granted the alter object privilege for the database object if it is in another user's schema. For example, to alter a rule set in another user's schema, a user must be granted the ALTER_ON_RULE_SET object privilege on the rule set.
- The user must be granted the alter any system privilege for the database object. For example, to alter a rule in any schema, a user must be granted the ALTER_ANY_RULE system privilege.

Privileges for Dropping Database Objects Related to Rules

To drop an evaluation context, rule, or rule set, a user must meet at least one of the following conditions:

- The user must own the database object.
- The user must be granted the drop any system privilege for the database object. For example, to drop a rule set in any schema, a user must be granted the DROP_ANY_RULE_SET system privilege.

Privileges for Placing Rules in a Rule Set

This section describes the privileges required to place a rule in a rule set.

The user must meet at least one of the following conditions for the rule:

- The user must own the rule.
- The user must be granted the execute object privilege on the rule if the rule is in another user's schema. For example, to place a rule named `depts` in the `hr` schema in a rule set, a user must be granted the EXECUTE_ON_RULE privilege for the `hr.depts` rule.
- The user must be granted the execute any system privilege for rules. For example, to place any rule in a rule set, a user must be granted the EXECUTE_ANY_RULE system privilege.

The user also must meet at least one of the following conditions for the rule set:

- The user must own the rule set.
- The user must be granted the alter object privilege on the rule set if the rule set is in another user's schema. For example, to place a rule in the `human_resources` rule set in the `hr` schema, a user must be granted the `ALTER_ON_RULE_SET` privilege for the `hr.human_resources` rule set.
- The user must be granted the alter any system privilege for rule sets. For example, to place a rule in any rule set, a user must be granted the `ALTER_ANY_RULE_SET` system privilege.

Privileges for Evaluating a Rule Set

To evaluate a rule set, a user must meet at least one of the following conditions:

- The user must own the rule set.
- The user must be granted the execute object privilege on the rule set if it is in another user's schema. For example, to evaluate a rule set named `human_resources` in the `hr` schema, a user must be granted the `EXECUTE_ON_RULE_SET` privilege for the `hr.human_resources` rule set.
- The user must be granted the execute any system privilege for rule sets. For example, to evaluate any rule set, a user must be granted the `EXECUTE_ANY_RULE_SET` system privilege.

Granting `EXECUTE` object privilege on a rule set requires that the grantor have the `EXECUTE` privilege specified `WITH GRANT OPTION` on all rules currently in the rule set.

Privileges for Using an Evaluation Context

To use an evaluation context, a user must meet at least one of the following conditions for the evaluation context:

- The user must own the evaluation context.
- The user must be granted the `EXECUTE_ON_EVALUATION_CONTEXT` privilege on the evaluation context, if it is in another user's schema.
- The user must be granted the `EXECUTE_ANY_EVALUATION_CONTEXT` system privilege for evaluation contexts.

6

How Rules Are Used In Streams

This chapter explains how rules are used in Streams.

This chapter contains these topics:

- Overview of How Rules Are Used In Streams
- System-Created Rules
- Streams Evaluation Context
- User-Created Rules and Evaluation Contexts
- Rule-Based Transformations

See Also:

- Chapter 5, "Rules" for more information about rules
- Chapter 14, "Managing Rules and Rule-Based Transformations"

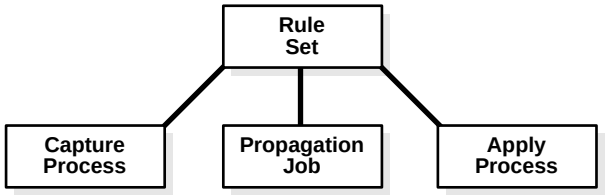
Overview of How Rules Are Used In Streams

In Streams, each of the following mechanisms is a client of a rules engine, when the mechanism is associated with a rule set:

- A capture process
- A propagation job
- An apply process

Each of these mechanisms can be associated with at most one rule set. However, a single rule set can be used by multiple capture processes, propagation jobs, and apply processes within the same database. Figure 6–1 illustrates how multiple clients of a rules engine can use one rule set.

Figure 6–1 One Rule Set Can Be Used by Multiple Clients of a Rules Engine



Specifically, you use rule sets in Streams to do the following:

- Specify the changes a capture process captures from the redo log. That is, if a change found in the redo log causes any rule in the rule set associated with a capture process to evaluate to TRUE, then the change is captured by the capture process.
- Specify the events a propagation job propagates from one queue to another. That is, if an event in a queue causes any rule in the rule set associated with a propagation job to evaluate to TRUE, then the event is propagated by the propagation job.
- Specify the events an apply process retrieves from a queue. That is, if an event in a queue causes any rule in the rule set associated with an apply process to evaluate to TRUE, then the event is retrieved and processed by the apply process.

If there are conflicting rules associated with a mechanism, then the mechanism performs the task if either rule evaluates to TRUE. For example, if a rule set associated with a capture process contains one rule that instructs the capture process to capture DML changes to the hr.employees table, but another rule in the rule set instructs the capture process not to capture DML changes to the hr.employees table, then the capture process captures DML changes to the hr.employees table.

Streams rule sets use a built-in evaluation context in the SYS schema named STREAMS$_EVALUATION_CONTEXT. PUBLIC is granted the EXECUTE privilege on this evaluation context.

In Streams, an action context has two purposes: for internal logical change record (LCR) transformations in subset rules and for user-defined rule-based transformations. If an action context for a rule contains both a subset transformation and a user-defined rule-based transformation, then the subset transformation is performed before the user-defined rule-based transformation.

If you use a non-NULL action context for one or more rules in a rule set, either by specifying a subset rule or a rule-based transformation, then make sure only one rule can evaluate to TRUE for a particular condition. If more than one rule evaluates to TRUE for a particular condition, then only one of the rules is returned, which can lead to unpredictable results.

For example, suppose there are two rules that evaluate to TRUE if an LCR contains a DML change to the hr.employees table. The first rule has a NULL action context. The second rule has an action context that specifies a transformation. If there is a DML change to the hr.employees table, then both rules evaluate to TRUE for the change, but only one rule is returned. In this case, the transformation may or may not occur, depending on which rule is returned.

You may want to ensure that only one rule in a rule set can evaluate to TRUE for any condition, regardless of whether any of the rules have a non-NULL action context. By following this guideline, you can avoid unpredictable results if, for example, a non-NULL action context is added to a rule in the future.

See Also:

- "Row Subsetting" on page 4-11 and "Table and Subset Rules" on page 6-7 for more information about subset rules
- "Streams Evaluation Context" on page 6-16
- "Rule-Based Transformations" on page 6-23

System-Created Rules

Streams performs three tasks based on rules:

- Capturing changes with a capture process
- Propagating changes with a propagation job
- Applying changes with an apply process

A system-created rule specifies one of the following levels of granularity for a task: table, schema, or global. This section describes each of these levels. You can specify more than one level for a particular task. For example, you can instruct a single apply process to perform table-level apply for specific tables in the `hr` schema and schema-level apply for the entire `oe` schema.

Table 6–1 shows what each level of rule means for each Streams task.

Table 6–1 Types of Tasks and Rule Levels

Task	Table Rule	Schema Rule	Global Rule
Capture	Capture the changes in the redo log for the specified table, convert them into LCRs, and enqueue them.	Capture the changes in the redo log for the database objects in the specified schema, convert them into LCRs, and enqueue them.	Capture the changes to all of the database objects in the database, convert them into LCRs, and enqueue them.
Propagate	Propagate the LCRs relating to the specified table in the source queue to the destination queue.	Propagate the LCRs related to the database objects in the specified schema in the source queue to the destination queue.	Propagate all of the changes in the source queue to the destination queue.
Apply	Apply all or a subset of the LCRs in the queue relating to the specified table.	Apply the LCRs in the queue relating to the database objects in the specified schema.	Apply all of the LCRs in the queue.

You can use procedures in the DBMS_STREAMS_ADM package to create rules at each of these levels. Table 6–2 lists the types of system-created rule conditions created in the rules created by the DBMS_STREAMS_ADM package.

Table 6–2 System-Created Rule Conditions Created by DBMS_STREAMS_ADM Package **(Page 1 of 2)**

Rule Condition Evaluates to TRUE for	Streams Mechanism	Create Using Procedure
All DML changes to a particular table	Capture	ADD_TABLE_RULES
All DDL changes to a particular table	Capture	ADD_TABLE_RULES
All DML changes to all of the tables in a particular schema	Capture	ADD_SCHEMA_RULES
All DDL changes to all of the database objects in a particular schema	Capture	ADD_SCHEMA_RULES
All DML changes to all of the tables in a particular database	Capture	ADD_GLOBAL_RULES
All DDL changes to all of the database objects in a particular database	Capture	ADD_GLOBAL_RULES
All LCRs containing DML changes to a particular table	Propagation	ADD_TABLE_PROPAGATION_RULES
All LCRs containing DDL changes to a particular table	Propagation	ADD_TABLE_PROPAGATION_RULES
All LCRs containing DML changes to the tables in a particular schema	Propagation	ADD_SCHEMA_PROPAGATION_RULES
All LCRs containing DDL changes to the database objects in a particular schema	Propagation	ADD_SCHEMA_PROPAGATION_RULES
All LCRs containing DML changes in a particular queue	Propagation	ADD_GLOBAL_PROPAGATION_RULES
All LCRs containing DDL changes in a particular queue	Propagation	ADD_GLOBAL_PROPAGATION_RULES
All LCRs containing DML changes to a subset of rows in a particular table	Apply	ADD_SUBSET_RULES
All LCRs containing DML changes to a particular table	Apply	ADD_TABLE_RULES
All LCRs containing DDL changes to a particular table	Apply	ADD_TABLE_RULES
All LCRs containing DML changes to the tables in a particular schema	Apply	ADD_SCHEMA_RULES

Table 6–2 System-Created Rule Conditions Created by DBMS_STREAMS_ADM Package **(Page 2 of 2)**

Rule Condition Evaluates to TRUE for	Streams Mechanism	Create Using Procedure
All LCRs containing DDL changes to the database objects in a particular schema	Apply	ADD_SCHEMA_RULES
All LCRs containing DML changes in a particular queue	Apply	ADD_GLOBAL_RULES
All LCRs containing DDL changes in a particular queue	Apply	ADD_GLOBAL_RULES

Each procedure listed in Table 6–2 does the following:

- Creates a capture process, propagation job, or apply process if the specified process or job does not already exist.
- Creates a rule set for the specified capture process, propagation job, or apply process, if a rule set does not already exist for the process or job.
- Create zero or more rules and adds the rules to the rule set for the process or job.

All of the rule sets and rules created by these procedures use the SYS.STREAMS$_EVALUATION_CONTEXT evaluation context, which is an Oracle-supplied evaluation context for Streams environments.

Except for ADD_SUBSET_RULES, these procedures create either zero, one, or two rules. If you want to perform the Streams task for only DML changes or for only DDL changes, then only one rule is created. If, however, you want to perform the Streams task for both DML and DDL changes, then a rule is created for each. If you create a DML rule for a table now, then you can create a DDL rule for the same table in the future without modifying the DML rule created earlier. The same applies if you create a DDL rule for a table first and a DML rule for the same table in the future.

The ADD_SUBSET_RULES procedure always creates three rules for three different types of DML operations on a table: INSERT, UPDATE, and DELETE. The ADD_SUBSET_RULES procedure does not create rules for DDL changes to the table. You can use the ADD_TABLE_RULES procedure to create a DDL rule for the table.

When you create propagation rules for captured events, Oracle Corporation recommends that you specify a source database for the changes. An apply process uses transaction control events to assemble captured events into committed transactions. These transaction control events, such as COMMIT and ROLLBACK, contain the name of the source database where the event occurred. To avoid unintended cycling of these events, propagation rules should contain a condition specifying the source database.

The following sections describe table, schema, and global rules in more detail.

Note: To create rules with more complex rule conditions, such as rules that use the NOT or OR conditional operators, use the DBMS_RULE_ADM package.

See Also:

- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the DBMS_STREAMS_ADM package and the DBMS_RULE_ADM package
- "Logical Change Records (LCRs)" on page 2-2
- "Complex Rule Conditions" on page 6-18

Table and Subset Rules

When you use a rule to specify a Streams task that is relevant only for an individual table, you are specifying a table-level rule. You can specify a table-level rule for DML changes, a table-level rule for DDL changes, or two rules for both types of changes for a specific table.

A subset rule is a special type of table-level rule for DML changes that you can create with the ADD_SUBSET_RULES procedure. You can use the ADD_SUBSET_RULES procedure to specify that an apply process only applies a subset of the row LCRs relating to a particular table based on a condition similar to a WHERE clause in a SELECT statement. So, the ADD_SUBSET_RULES procedure can instruct an apply process maintain only certain rows in a table.

See Also: "Row Subsetting" on page 4-11 for more information about subset rules

Table-Level Rules Example

Suppose you use the procedures in the DBMS_STREAMS_ADM package to instruct a Streams apply process to behave in the following ways:

- Apply All DML Changes to the hr.locations Table
- Apply All DDL Changes to the hr.countries Table
- Apply a Subset of DML changes to the hr.regions Table

Apply All DML Changes to the hr.locations Table These changes originated at the dbs1.net source database.

Run the ADD_TABLE_RULES procedure to create this rule:

```
BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name               =>  'hr.locations',
    streams_type             =>  'apply',
    streams_name             =>  'apply',
    queue_name               =>  'streams_queue',
    include_dml              =>  true,
    include_ddl              =>  false,
    include_tagged_lcr       =>  false,
    source_database          =>  'dbs1.net');
END;
/
```

The ADD_TABLE_RULES procedure creates a rule with a rule condition similar to the following:

```
:dml.get_object_owner() = 'HR' AND :dml.get_object_name() = 'LOCATIONS'
AND :dml.is_null_tag() = 'Y' AND :dml.get_source_database_name() = 'DBS1.NET'
```

Here, every condition that begins with :dml is a variable. The value is determined by a call to the specified member function for the row LCR being evaluated. So, :dml.get_object_owner() in the previous example is a call to the get_object_owner member function for the row LCR being evaluated.

Also, the following condition is included by default in all DML rules created by the procedures in the DBMS_STREAMS_ADM package:

```
:dml.is_null_tag() = 'Y'
```

In DDL rules, the condition is the following:

```
:ddl.is_null_tag() = 'Y'
```

For a capture process, these conditions indicate that the tag must be NULL in a redo record for the capture process to capture a change. For a propagation job, these conditions indicate that the tag must be NULL in an LCR for the propagation job to propagate the LCR. For an apply process, these conditions indicate that the tag must be NULL in an LCR for the apply process to apply the LCR. You can omit this condition in system-created rules by specifying true for the include_tagged_lcr parameter when you run a procedure in the DBMS_STREAMS_ADM package.

See Also:

- Chapter 5, "Rules" for more information about variables in conditions
- Chapter 8, "Streams Tags" for more information about tags

Apply All DDL Changes to the hr.countries Table These changes originated at the dbs1.net source database.

Run the ADD_TABLE_RULES procedure to create this rule:

```
BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name                =>  'hr.countries',
    streams_type              =>  'apply',
    streams_name              =>  'apply',
    queue_name                =>  'streams_queue',
    include_dml               =>  false,
    include_ddl               =>  true,
    include_tagged_lcr        =>  false,
    source_database           =>  'dbs1.net');
END;
/
```

The ADD_TABLE_RULES procedure creates a rule with a rule condition similar to the following:

```
:ddl.get_object_owner() = 'HR' AND :ddl.get_object_name() = 'COUNTRIES'
AND :ddl.is_null_tag() = 'Y'
AND :ddl.get_source_database_name() = 'DBS1.NET'
```

Here, every condition that begins with :ddl is a variable. The value is determined by a call to the specified member function for the DDL LCR being evaluated. So,

`:ddl.get_object_owner()` in the previous example is a call to the `get_object_owner` member function for the DDL LCR being evaluated.

Apply a Subset of DML changes to the hr.regions Table The example instructs a Streams apply process to apply a subset of DML changes to the `hr.regions` table where the `region_id` is `2`. These changes originated at the `dbs1.net` source database.

Run the `ADD_SUBSET_RULES` procedure to create three rules:

```
BEGIN
  DBMS_STREAMS_ADM.ADD_SUBSET_RULES(
    table_name               =>  'hr.regions',
    dml_condition            =>  'region_id=2',
    streams_type             =>  'apply',
    streams_name             =>  'apply',
    queue_name               =>  'streams_queue',
    include_tagged_lcr       =>  false,
    source_database          =>  'dbs1.net');
END;
/
```

The `ADD_SUBSET_RULES` procedure creates three rules: one for `INSERT` operations, one for `UPDATE` operations, and one for `DELETE` operations.

Here is the rule condition used by the insert rule:

```
:dml.get_object_owner()='HR' AND :dml.get_object_name()='REGIONS'
AND :dml.is_null_tag()='Y' AND :dml.get_source_database_name() = 'DBS1.NET'
AND :dml.get_command_type() IN ('UPDATE','INSERT')
AND (:dml.get_value('NEW','"REGION_ID"') IS NOT NULL)
AND (:dml.get_value('NEW','"REGION_ID"').AccessNumber()=2)
AND (:dml.get_command_type()='INSERT'
OR ((:dml.get_value('OLD','"REGION_ID"') IS NOT NULL)
AND NOT EXISTS (SELECT 1 FROM SYS.DUAL
WHERE (:dml.get_value('OLD','"REGION_ID"').AccessNumber()=2))))
```

Based on this rule condition, LCRs are evaluated in the following ways:

- For an insert, if the new value in the LCR for `region_id` is `2`, then the insert is applied.
- For an insert, if the new value in the LCR for `region_id` is not `2` or is `NULL`, then the insert is filtered out.
- For an update, if the old value in the LCR for `region_id` is not `2` or is `NULL` and the new value in the LCR for `region_id` is `2`, then the update is converted into an insert and applied.

Here is the rule condition used by the update rule:

```
:dml.get_object_owner()='HR' AND :dml.get_object_name()='REGIONS'
AND :dml.is_null_tag()='Y' AND :dml.get_source_database_name() = 'DBS1.NET'
AND :dml.get_command_type()='UPDATE'
AND (:dml.get_value('NEW','"REGION_ID"') IS NOT NULL)
AND (:dml.get_value('OLD','"REGION_ID"') IS NOT NULL)
AND (:dml.get_value('OLD','"REGION_ID"').AccessNumber()=2)
AND (:dml.get_value('NEW','"REGION_ID"').AccessNumber()=2)
```

Based on this rule condition, LCRs are evaluated in the following ways:

- For an update, if both the old value and the new value in the LCR for `region_id` are `2`, then the update is applied as an update.
- For an update, if either the old value or the new value in the LCR for `region_id` is not `2` or is `NULL`, then the update does not satisfy the update rule. The LCR may satisfy the insert rule, the delete rule, or neither rule.

Here is the rule condition used by the delete rule:

```
:dml.get_object_owner()='HR' AND :dml.get_object_name()='REGIONS'
AND :dml.is_null_tag()='Y' AND :dml.get_source_database_name() = 'DBS1.NET'
AND :dml.get_command_type() IN ('UPDATE','DELETE')
AND (:dml.get_value('OLD','"REGION_ID"') IS NOT NULL)
AND (:dml.get_value('OLD','"REGION_ID"').AccessNumber()=2)
AND (:dml.get_command_type()='DELETE'
OR ((:dml.get_value('NEW','"REGION_ID"') IS NOT NULL)
AND NOT EXISTS (SELECT 1 FROM SYS.DUAL
WHERE (:dml.get_value('NEW','"REGION_ID"').AccessNumber()=2))))
```

Based on this rule condition, LCRs are evaluated in the following ways:

- For a delete, if the old value in the LCR for `region_id` is `2`, then the delete is applied.
- For a delete, if the old value in the LCR for `region_id` is not `2` or is `NULL`, then the delete is filtered out.
- For an update, if the old value in the LCR for `region_id` is `2` and the new value in the LCR for `region_id` is not `2` or is `NULL`, then the update is converted into a delete and applied.

Summary of Rules In this example, the following table and subset rules were defined:

- A table rule that evaluates to TRUE if a DML operation is performed on the hr.locations table.
- A table rule that evaluates to TRUE if a DDL operation is performed on the hr.countries table.
- A subset rule that evaluates to TRUE if an INSERT operation inserts a row with a region_id equal to 2 or an update operation changes the region_id for a row from a value that does not equal 2 or is NULL to a value of 2.
- A subset rule that evaluates to TRUE if an UPDATE operation updates a row and the region_id is equal to 2 both before and after the update.
- A subset rule that evaluates to TRUE if a DELETE operation deletes a row with a region_id equal to 2 or an update operation changes the region_id for a row from a value that equals 2 to a value that does not equal 2 or is NULL.

Given these rules, the following list provides examples of changes applied by an apply process:

- A row is inserted to the hr.locations table.
- Five rows are deleted from the hr.locations table.
- A column is added to the hr.countries table.
- A row is updated in the hr.regions table where the region_id is 2 and the new value of region_id is 1. This update is transformed into a delete.

The apply process dequeues these changes from its associated queue and applies them to the database objects at the destination database.

Given the same rules, the following list provides examples of changes that are ignored by the apply process:

- A row is inserted into the hr.employees table. This change is not applied because the hr.employees table does not satisfy any of the rules.
- A row is updated into the hr.countries table. This change is a DML change, not a DDL change. This change is not applied because the rule on the hr.countries table is for DDL changes only.

- A column is added to the hr.locations table. This change is a DDL change, not a DML change. This change is not applied because the rule on the hr.locations table is for DML changes only.
- A row is updated in the hr.regions table where the region_id was 1 before the update and remains 1 after the update. This change is not applied because the subset rules for the hr.regions table evaluate to TRUE only when the new or old (or both) values for region_id is 2.

Schema Rules

When you use a rule to specify a Streams task that is relevant to a schema, you are specifying a schema-level rule, and the Streams task is performed when there is a change to any of the database objects currently in the schema and any database objects added to the schema in the future. You can specify a schema-level rule for DML changes, a schema-level rule for DDL changes, or two rules for both types of changes for the objects in the schema.

Schema-Level Rule Example

Suppose you use the ADD_SCHEMA_PROPAGATION_RULES procedure in the DBMS_STREAMS_ADM package to instruct a Streams propagate job to propagate LCRs that contain DML and DDL changes to the hr schema from a queue at the dbs1.net database to a queue at the dbs2.net database.

Run the ADD_SCHEMA_PROPAGATION_RULES procedure to create the rules:

```
BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_PROPAGATION_RULES(
    schema_name              =>  'hr',
    streams_name             =>  'dbs1_to_dbs2',
    source_queue_name        =>  'streams_queue',
    destination_queue_name   =>  'streams_queue@dbs2.net',
    include_dml              =>  true,
    include_ddl              =>  true
    include_tagged_lcr       =>  false,
    source_database          =>  'dbs1.net');
END;
/
```

The ADD_SCHEMA_PROPAGATION_RULES procedure creates two rules: one for row LCRs (which contain DML changes) and one for DDL LCRs.

Here is the rule condition used by the row LCR rule:

```
:dml.get_object_owner() = 'HR' AND :dml.is_null_tag() = 'Y'
AND :dml.get_source_database_name() = 'DBS1.NET'
```

Here is the rule condition used by the DDL LCR rule:

```
:ddl.get_object_owner() = 'HR' AND :ddl.is_null_tag() = 'Y'
AND :ddl.get_source_database_name() = 'DBS1.NET'
```

Given these rules, the following list provides examples of changes propagated by the propagation job:

- A row is inserted to the `hr.countries` table.
- The `hr.loc_city_ix` index is altered.
- The `hr.employees` table is truncated.
- A column is added to the `hr.countries` table.
- The `hr.update_job_history` trigger is altered.
- A new table named `candidates` is created in the `hr` schema.
- Twenty rows are inserted into the `hr.candidates` table.

The propagation job propagates the LCRs that contain all of the changes previously listed from the source queue to the destination queue.

Now, given the same rules, suppose a row is inserted into the `oe.customers` table. This change is ignored because the `oe` schema was not specified in a schema-level rule, and the `oe.customers` table was not specified in a table-level rule.

Global Rules

When you use a rule to specify a Streams task that is relevant either to an entire database or to an entire queue, you are specifying a global-level rule. You can specify a global rule for DML changes, a global rule for DDL changes, or two rules for both types of changes.

A single global rule for the capture process means that the capture process captures either all DML changes or all DDL changes to the source database. A single global rule for a propagation job means that the propagation job propagates either all row LCRs or all DDL LCRs in the source queue to the destination queue. A global rule for an apply process means that the apply process applies either all row LCRs or all DDL LCRs in its queue for a specified source database.

Global-Level Rules Example

Suppose you use the ADD_GLOBAL_RULES procedure in the DBMS_STREAMS_ADM package to instruct a Streams capture process to capture all DML and DDL changes in a database.

Run the ADD_GLOBAL_RULES procedure to create the rules:

```
BEGIN DBMS_STREAMS_ADM.ADD_GLOBAL_RULES(
   streams_type             =>  'capture',
   streams_name             =>  'capture',
   queue_name               =>  'streams_queue',
   include_dml              =>  true,
   include_ddl              =>  true,
   include_tagged_lcr       =>  false,
   source_database          =>  NULL);
END;
/
```

The ADD_GLOBAL_RULES procedure creates two rules: one for row LCRs (which contain DML changes) and one for DDL LCRs.

Here is the rule condition used by the row LCR rule:

```
:dml.get_source_database_name() = 'DBS1.NET' AND :dml.is_null_tag() = 'Y'
```

Here is the rule condition used by the DDL LCR rule:

```
:ddl.get_source_database_name() = 'DBS1.NET' AND :ddl.is_null_tag() = 'Y'
```

Given these rules, the capture process captures all supported DML and DDL changes made to the database.

Note: The capture process does not capture some types of DML and DDL changes, and it does not capture changes made in the SYS or SYSTEM schemas.

See Also: Chapter 2, "Streams Capture Process" for more information about the capture process and for detailed information about which DML and DDL statements are captured by the capture process

Streams Evaluation Context

System-created rule sets and rules use a built-in evaluation context in the SYS schema named STREAMS$_EVALUATION_CONTEXT. PUBLIC is granted the EXECUTE privilege on this evaluation context.

During Oracle installation, the following statement creates the Streams evaluation context:

```
DECLARE
  vt  SYS.RE$VARIABLE_TYPE_LIST;
BEGIN
  vt := SYS.RE$VARIABLE_TYPE_LIST(
    SYS.RE$VARIABLE_TYPE('DML', 'SYS.LCR$_ROW_RECORD',
       'SYS.DBMS_STREAMS_INTERNAL.ROW_VARIABLE_VALUE_FUNCTION',
       'SYS.DBMS_STREAMS_INTERNAL.ROW_FAST_EVALUATION_FUNCTION'),
    SYS.RE$VARIABLE_TYPE('DDL', 'SYS.LCR$_DDL_RECORD',
       'SYS.DBMS_STREAMS_INTERNAL.DDL_VARIABLE_VALUE_FUNCTION',
       'SYS.DBMS_STREAMS_INTERNAL.DDL_FAST_EVALUATION_FUNCTION'));
  DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT(
    evaluation_context_name => 'SYS.STREAMS$_EVALUATION_CONTEXT',
    variable_types          => vt,
    evaluation_function     =>
                       'SYS.DBMS_STREAMS_INTERNAL.EVALUATION_CONTEXT_FUNCTION');
END;
/
```

This statement includes references to the following internal functions in the SYS.DBMS_STREAM_INTERNAL package:

- ROW_VARIABLE_VALUE_FUNCTION
- DDL_VARIABLE_VALUE_FUNCTION
- EVALUATION_CONTEXT_FUNCTION
- ROW_FAST_EVALUATION_FUNCTION
- DDL_FAST_EVALUATION_FUNCTION

The ROW_VARIABLE_VALUE_FUNCTION converts a SYS.AnyData payload, which encapsulates a SYS.LCR$_ROW_RECORD instance, into a SYS.LCR$_ROW_RECORD instance prior to evaluating rules on the data.

The DDL_VARIABLE_VALUE_FUNCTION converts a SYS.AnyData payload, which encapsulates a SYS.LCR$_DDL_RECORD instance, into a SYS.LCR$_DDL_RECORD instance prior to evaluating rules on the data.

The EVALUATION_CONTEXT_FUNCTION is specified as an evaluation_function in the call to the CREATE_EVALUATION_CONTEXT procedure. This function supplements normal rule evaluation for captured events. A capture process enqueues row LCRs and DDL LCRs into its queue, and this function enables it to enqueue other internal events into the queue, such as commits, rollbacks, and data dictionary changes. This information is also used during rule evaluation for a propagation job or apply process.

ROW_FAST_EVALUATION_FUNCTION improves performance by optimizing access to the following LCR$_ROW_RECORD member functions during rule evaluation:

- GET_OBJECT_OWNER
- GET_OBJECT_NAME
- IS_NULL_TAG
- GET_SOURCE_DATABASE_NAME
- GET_COMMAND_TYPE

DDL_FAST_EVALUATION_FUNCTION improves performance by optimizing access to the following LCR$_DDL_RECORD member functions during rule evaluation if the operator is <, <=, =, >=, or > and the other operand is a constant:

- GET_OBJECT_OWNER
- GET_OBJECT_NAME
- IS_NULL_TAG
- GET_SOURCE_DATABASE_NAME
- GET_COMMAND_TYPE
- GET_BASE_TABLE_NAME
- GET_BASE_TABLE_OWNER

Rules created using the DBMS_STREAMS_ADM package use ROW_FAST_EVALUATION_FUNCTION or DDL_FAST_EVALUATION_FUNCTION, except for subset rules created using the ADD_SUBSET_RULES procedure.

Attention: Information about these internal functions is provided for reference purposes only. You should never run any of these functions directly.

See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about LCRs and their member functions

User-Created Rules and Evaluation Contexts

If you need to create rules that are more complex than those created by the DBMS_STREAMS_ADM package, then you can use the DBMS_RULE_ADM package to create them. Some of the reasons you may need to use the DBMS_RULE_ADM package are the following:

- You need to specify complex rule conditions, such as those that use the NOT conditional operator or those that pertain only to specific operations.
- You need to create custom evaluation contexts for the rules in your Streams environment.

The following sections discuss these topics in more detail.

Complex Rule Conditions

In a Streams environment, a complex rule condition is one that cannot be created using the DBMS_STREAMS_ADM package. Table 6–2 on page 6-5 describes the types of system-created rule conditions that you can create with the DBMS_STREAMS_ADM package. If you need to create rules with more complex conditions, then use the DBMS_RULE_ADM package.

There are a wide range of complex conditions. The following sections contain some examples of complex rule conditions.

Note:

- In rule conditions, names of database objects, such as tables and users, must exactly match the names in the database, including the case of each character. Also, the name cannot be enclosed in double quotes.
- In rule conditions, if you specify the name of a database, then make sure you include the full database name, including the domain name.

Rule Conditions Using the NOT Conditional Operator to Exclude Objects

You can use the NOT conditional operator to exclude certain changes from being captured, propagated, or applied in a Streams environment.

For example, suppose you want to specify rule conditions that evaluate to TRUE for all DML and DDL changes to all database objects in the hr schema, except for changes to the hr.regions table. You can use the NOT conditional operator to accomplish this with two rules: one for DML changes and one for DDL changes. Here are the rule conditions for these rules:

```
(:dml.get_object_owner() = 'HR' AND NOT :dml.get_object_name() = 'REGIONS')
AND :dml.is_null_tag() = 'Y'

(:ddl.get_object_owner() = 'HR' AND NOT :ddl.get_object_name() = 'REGIONS')
AND :ddl.is_null_tag() = 'Y'
```

Notice that object names, such as HR and REGIONS are specified in all uppercase characters in these examples. For rules to evaluate properly, the case of the characters in object names must match the case of the characters in the data dictionary. Therefore, if no case was specified for an object when the object was created, then specify the object name in all uppercase in rule conditions. However, if a particular case was specified through the use of double quotation marks when the objects was created, then specify the object name in the same case in rule conditions. For example, if the REGIONS table in the HR schema was actually created as "Regions", then specify Regions in rule conditions that involve this table, as in the following example:

```
:dml.get_object_name() = 'Regions'
```

You can use the Streams evaluation context when you create these rules using the DBMS_RULE_ADM package. The following example creates a rule set to hold the complex rules, creates rules with the previous conditions, and adds the rules to the rule set:

```
BEGIN
  -- Create the rule set
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name       => 'strmadmin.complex_rules',
    evaluation_context  => 'SYS.STREAMS$_EVALUATION_CONTEXT');
  -- Create the complex rules
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name  => 'strmadmin.hr_not_regions_dml',
    condition  => ' (:dml.get_object_owner() = ''HR'' AND NOT ' ||
                  ' :dml.get_object_name() = ''REGIONS'') AND ' ||
                  ' :dml.is_null_tag() = ''Y'' ');
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name  => 'strmadmin.hr_not_regions_ddl',
    condition  => ' (:ddl.get_object_owner() = ''HR'' AND NOT ' ||
                  ' :ddl.get_object_name() = ''REGIONS'') AND ' ||
                  ' :ddl.is_null_tag() = ''Y'' ');
  --  Add the rules to the rule set
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.hr_not_regions_dml',
    rule_set_name  => 'strmadmin.complex_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.hr_not_regions_ddl',
    rule_set_name  => 'strmadmin.complex_rules');
END;
/
```

In this case, the rules inherit the Streams evaluation context from the rule set.

Rule Conditions for Specific Types of Operations

In some cases, you may want to capture, propagate, or apply changes that contain only certain types of operations. For example, you may want to apply changes containing only insert operations for a particular table, but not other operations, such as update and delete.

Suppose you want to specify a rule condition that evaluates to TRUE only for INSERT operations on the hr.employees table. You can accomplish this by specifying the INSERT command type in the rule condition:

```
:dml.get_command_type() = 'INSERT' AND :dml.get_object_owner() = 'HR'
AND :dml.get_object_name() = 'EMPLOYEES' AND :dml.is_null_tag() = 'Y'
```

Similarly, suppose you want to specify a rule condition that evaluates to TRUE for all DML operations on the hr.departments table, except DELETE operations:

```
:dml.get_command_type() != 'DELETE' AND :dml.get_object_owner() = 'HR'
AND :dml.get_object_name() = 'DEPARTMENTS' AND :dml.is_null_tag() = 'Y'
```

Rule Set Association with a Streams Process or Job

After you create a rule set using the DBMS_RULE_ADM package, you can associate it with a capture process, propagation job, or apply process.

See Also:

- "Specifying the Rule Set for a Capture Process" on page 11-5
- "Specifying the Rule Set for a Propagation Job" on page 12-13
- "Specifying the Rule Set for an Apply Process" on page 13-8

Avoid maybe_rules Upon Evaluation

When a rule set is evaluated, maybe_rules are rules that may evaluate to TRUE given more information. If you create capture or propagation rules for DML or DDL changes that result in maybe_rules upon evaluation, then more information than necessary may be recorded in the duplicate data dictionary for a capture process, and a propagation job may propagate more information than necessary.

For example, suppose you create a rule with the following condition:

```
my_procedure(:dml) = 'Y'
```

This condition always results in a maybe_rule upon evaluation with partial information about a redo entry or row LCR. As a result, extraneous duplicate data dictionary information for many objects may be recorded by a capture process and propagated by a propagation job.

See Also:

- "Rule Set Evaluation" on page 5-9
- "Data Dictionary Duplication During Capture Process Creation" on page 2-16
- "Streams Data Dictionary for Propagation Jobs" on page 3-24

Custom Evaluation Contexts

You can use a custom evaluation context in a Streams environment. Any user-defined evaluation context involving LCRs must include all the variables in `SYS.STREAMS$_EVALUATION_CONTEXT`. The type of each variable and its variable value function must be the same for each variable as the ones defined in `SYS.STREAMS$_EVALUATION_CONTEXT`. In addition, when creating the evaluation context using `DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT`, the `SYS.DBMS_STREAMS_INTERNAL.EVALUATION_CONTEXT_FUNCTION` must be specified for the `evaluation_function` parameter.

You can find information about an evaluation context in the following data dictionary views:

- `ALL_EVALUATION_CONTEXT_TABLES`
- `ALL_EVALUATION_CONTEXT_VARS`
- `ALL_EVALUATION_CONTEXTS`

If necessary, you can use the information in these data dictionary views to build a new evaluation context based on the `SYS.STREAMS$_EVALUATION_CONTEXT`.

Note: Avoid using variable names with special characters, such as $ and #, to ensure that there are no conflicts with Oracle-supplied evaluation context variables.

See Also: *Oracle9i Database Reference* for more information about these data dictionary views

Rule-Based Transformations

In Streams, a **rule-based transformation** is any modification to an event that results when a rule evaluates to TRUE. For example, a rule-based transformation may be used when the datatype of a particular column in a table is different at two different databases. Such a column could be a NUMBER column in the source database and a VARCHAR2 column in the destination database. In this case, the transformation takes as input a SYS.AnyData object containing a row LCR with a NUMBER datatype for a column and returns a SYS.AnyData object containing a row LCR with a VARCHAR2 datatype for the same column.

A transformation must be defined as a PL/SQL function that takes a SYS.AnyData object as input and returns a SYS.AnyData object. Rule-based transformations support only one to one transformations. Also, the LCR returned by the function must be the same LCR passed to the function. Although you can modify an LCR with a rule-based transformation, constructing a new LCR and returning it is not allowed.

Other examples of transformations on LCRs include:

- Renaming the owner of a database object
- Renaming a database object
- Renaming or removing a column
- Splitting a column into several columns
- Combining several columns into one column
- Modifying the contents of a column

In Streams, you use a rule action context to specify a rule-based transformation. A rule action context is optional information associated with a rule that is interpreted by the client of the rules engine after the rule evaluates to TRUE for an event. The client of the rules engine can be a user-created application or an internal feature of Oracle, such as Streams. The information in an action context is an object of type SYS.RE$NV_LIST, which consists of a list of name-value pairs.

A rule-based transformation in Streams always consists of the following name-value pair in an action context:

- The name is STREAMS$_TRANSFORM_FUNCTION.
- The value is a SYS.AnyData instance containing a PL/SQL function name specified as a VARCHAR2. This function performs the transformation.

The user that calls the transformation function must have EXECUTE privilege on the function. The following list describes which user calls the transformation function:

- If a transformation is specified for a rule used by a capture process or propagation job, then the user that calls the transformation function is the user that created the process or job.
- If a transformation is specified on a rule used by an apply process, then the user that calls the transformation function is the apply user for the apply process.

When a rule evaluates to TRUE for an event in a Streams environment, and an action context that contains a name-value pair with the name STREAMS$_TRANSFORM_FUNCTION is returned, the PL/SQL function is run, taking the event as an input parameter. Other names in an action context beginning with STREAMS$_ are used internally by Oracle and must not be directly added, modified, or removed. Streams ignores any name-value pair that does not begin with STREAMS$_.

When a rule evaluates to FALSE for an event in a Streams environment, the rule is not returned to the client, and any PL/SQL function appearing in a name-value pair in the action context is not run. Different rules can use the same or different transformations. For example, different transformations may be associated with different operation types, tables, or schemas for which changes are being captured, propagated, or applied. The following sections describe how rule-based transformations work with a capture process, a propagation job, and an apply process.

Note:

- Rule-based transformations are different from transformations performed using the DBMS_TRANSFORM package. This section does not discuss transformations performed with the DBMS_TRANSFORM package.
- If you have a large number of transformations, or transformations that are expensive, then you may want to make modifications to events within a DML handler instead, because DML handlers can execute in parallel when apply parallelism is greater than 1.
- When you perform rule-based transformations on DDL LCRs, you probably need to modify the DDL text in the DDL LCR to match any other modification. For example, if the rule-based transformation changes the name of a table in the DDL LCR, then the table name in the DDL text should be changed in the same way.

See Also:

- "Managing Rule-Based Transformations" on page 14-10
- "Rule Action Context" on page 5-7
- *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about using the DBMS_TRANSFORM package
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for reference information on the DBMS_TRANSFORM package
- "Message Propagation" on page 3-17 for examples of using the DBMS_TRANSFORM package to perform a transformation during propagation
- "Event Processing with an Apply Process" on page 4-3 for more information about DML handlers

Rule-Based Transformations and a Capture Process

If a capture process uses a rule set, then both of the following conditions must be met in order for a transformation to be performed during capture:

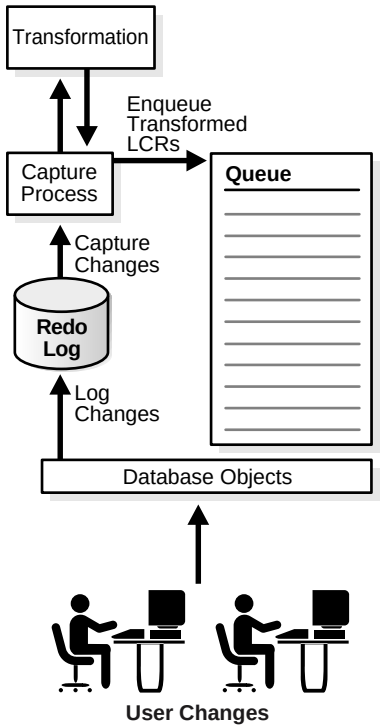
- A rule evaluates to TRUE for a particular change found in the redo log.
- An action context containing a name-value pair with the name STREAMS$_TRANSFORM_FUNCTION is returned to the capture process when the rule is evaluated.

Given these conditions, the capture process completes the following steps:

1. Formats the change in the redo log into an LCR
2. Converts the LCR into a SYS.AnyData object
3. Runs the PL/SQL function in the name-value pair to transform the SYS.AnyData object
4. Enqueues the transformed SYS.AnyData object into the queue associated with the capture process

Figure 6–2 shows a transformation during capture.

Figure 6–2 Transformation During Capture



For example, if an event is transformed during capture, then the transformed event is enqueued into the source queue. Therefore, if such a captured event is propagated from the `dbs1.net` database to the `dbs2.net` and the `dbs3.net` databases, then the queues at `dbs2.net` and `dbs3.net` will contain the transformed event after propagation.

The advantages of performing transformations during capture are the following:

- Security can be improved if the transformation removes or changes private information, because this private information does not appear in the source queue and is not propagated to any destination queue.
- Space consumption may be reduced, depending on the type of transformation performed. For example, a transformation that reduces the amount of data results in less data to enqueue, propagate, and apply.
- Transformation overhead is reduced when there are multiple destinations for a transformed event, because the transformation is performed only once at the source, not at multiple destinations.

The possible disadvantages of performing transformations during capture are the following:

- All sites receive the transformed event.
- The transformation overhead occurs in the source database.

Rule-Based Transformation Errors During Capture

If an error occurs when the transformation function is run during capture, then the change is not captured, the error is returned to the capture process, and the capture process is disabled. Before the capture process can be enabled, you must either change or remove the rule-based transformation to avoid the error.

Rule-Based Transformations and a Propagation Job

If a propagation job uses a rule set, then both of the following conditions must be met in order for a transformation to be performed during propagation:

- A rule evaluates to `TRUE` for an event in the source queue for the propagation job. This event can be a captured or a user-enqueued event.
- An action context containing a name-value pair with the name `STREAMS$_TRANSFORM_FUNCTION` is returned to the propagation job when the rule is evaluated.

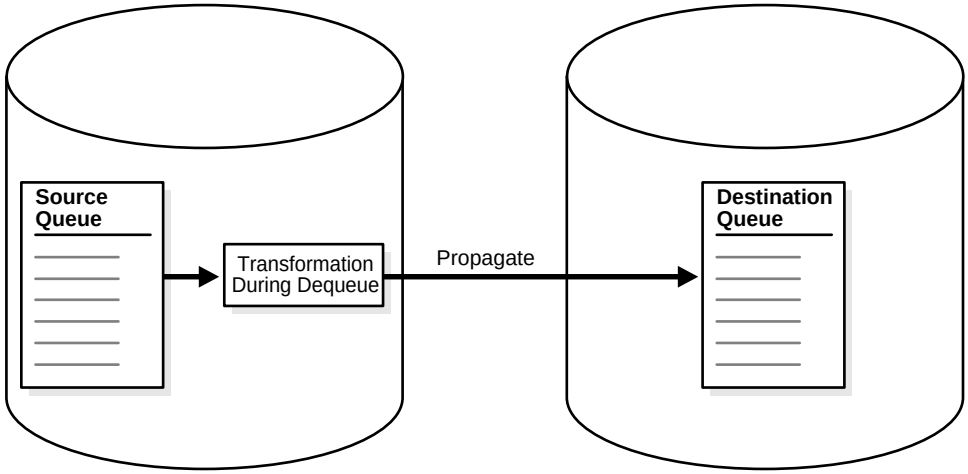
See Also: "Captured and User-Enqueued Events" on page 3-3

Given these conditions, the propagation job completes the following steps:

1. Starts dequeuing the event from the source queue
2. Runs the PL/SQL function in the name-value pair to transform the event
3. Completes dequeuing the transformed event
4. Propagates the transformed event to the destination queue

Figure 6–3 shows a transformation during propagation.

Figure 6–3 Transformation During Propagation



For example, suppose you use a rule-based transformation for a propagation from the `dbs1.net` database to the `dbs2.net` database, but you do not use a rule-based transformation for a propagation from the `dbs1.net` database to the `dbs3.net` database.

In this case, an event in the queue at `dbs1.net` can be transformed before it is propagated to `dbs2.net`, but the same event can remain in its original form when it is propagated to `dbs3.net`. In this case, after propagation, the queue at `dbs2.net` contains the transformed event, and the queue at `dbs3.net` contains the original event.

The advantages of performing transformations during propagation are the following:

- Security can be improved if the transformation removes or changes private information before events are propagated.
- Some destination queues can receive a transformed event, while other destination queues can receive the original event.
- Different destinations can receive different variations of the same event.

The possible disadvantages of performing transformations during propagation are the following:

- Once an event is transformed, any database to which it is propagated after the first propagation receives the transformed event. For example, if `dbs2.net` propagates the event to `dbs4.net`, then `dbs4.net` receives the transformed event.
- When the first propagation in a directed network performs the transformation, the transformation overhead occurs on the source database.
- The same transformation may be done multiple times when multiple destination databases need the same transformation.

Rule-Based Transformation Errors During Propagation

If an error occurs when the transformation function is run during propagation, then the LCR that caused the error is not dequeued, the LCR is not propagated, and the error is returned to the propagation job. Before the LCR can be propagated, you must change or remove the rule-based transformation to avoid the error.

Rule-Based Transformations and an Apply Process

If an apply process uses a rule set, then both of the following conditions must be met in order for a transformation to be performed during apply:

- A rule evaluates to `TRUE` for an event in the queue associated with the apply process. This event can be a captured or a user-enqueued event.
- An action context containing a name-value pair with the name `STREAMS$_TRANSFORM_FUNCTION` is returned to the apply process when the rule is evaluated.

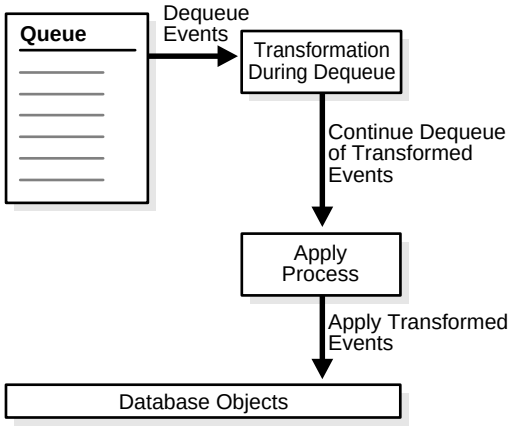
See Also: "Captured and User-Enqueued Events" on page 3-3

Given these conditions, the apply process completes the following steps:

1. Starts to dequeue the event from the queue
2. Runs the PL/SQL function in the name-value pair to transform the event during dequeue
3. Completes dequeuing the transformed event
4. Applies the transformed event

Figure 6–4 shows a transformation during apply.

Figure 6–4 Transformation During Apply



For example, suppose an event is propagated from the `dbs1.net` database to the `dbs2.net` database in its original form. When the apply process dequeues the event from a queue at `dbs2.net`, the event is transformed.

The possible advantages of performing transformations during apply are the following:

- Any database to which the event is propagated after the first propagation can receive the event in its original form. For example, if `dbs2.net` propagates the event to `dbs4.net`, then `dbs4.net` can receive the original event.
- The transformation overhead does not occur on the source database when the source and destination database are different.

The possible disadvantages of performing transformations during apply are the following:

- Security may be a concern if the events contain private information, because all databases to which the events are propagated receive the original events.
- The same transformation may be done multiple times when multiple destination databases need the same transformation.

Rule-Based Transformation Errors During Apply Process Dequeue

If an error occurs when the transformation function is run during apply process dequeue, then the LCR that caused the error is not dequeued, the transaction containing the LCR is not applied, the error is returned to the apply process, and the apply process is disabled. Before the apply process can be enabled, you must change or remove the rule-based transformation to avoid the error.

Apply Errors on Transformed LCRs

If an apply error occurs for a transaction in which some of the LCRs have been transformed by a rule-based transformation, then the transformed LCRs are moved to the error queue with all of the other LCRs in the transaction. If you use the `EXECUTE_ERROR` procedure in the `DBMS_APPLY_ADM` package to reexecute a transaction in the error queue that contains transformed LCRs, then the transformation is not performed on the LCRs again because apply process rule set is not evaluated again.

Multiple Rule-Based Transformations

You can transform an LCR during capture, propagation, or apply, or during any combination of capture, propagation, and apply. For example, if you want to hide sensitive data from all recipients, then you can transform an LCR during capture. If some recipients require additional custom transformations, then you can transform the previously transformed LCR during propagation or apply.

7

Streams Conflict Resolution

Some Streams environments must use conflict handlers to resolve possible data conflicts that can result from sharing data between multiple databases.

This chapter contains these topics:

- About DML Conflicts
- Conflict Types
- Conflicts and Transaction Ordering
- Conflict Detection
- Conflict Avoidance
- Conflict Resolution

See Also: "Managing Streams Conflict Resolution" on page 13-29

About DML Conflicts

Conflicts can occur in a Streams environment that permits concurrent data manipulation language (DML) operations on the same data at multiple databases. In a Streams environment, DML conflicts can occur only when an apply process is applying an event that contains a change resulting from a DML operation. This type of event is called a row logical change record, or row LCR. An apply process automatically detects conflicts caused by row LCRs.

For example, when two transactions originating from different databases update the same row at nearly the same time, a conflict can occur. When you configure a Streams environment, you must consider whether conflicts can occur. You can configure conflict resolution to resolve conflicts automatically, if your system design permits conflicts.

In general, you should try to design a Streams environment that avoids the possibility of conflicts. Using the conflict avoidance techniques discussed later in this chapter, most system designs can avoid conflicts in all or a large percentage of the shared data. However, many applications require that some percentage of the shared data be updatable at multiple databases at any time. If this is the case, then you must address the possibility of conflicts.

Note: An apply process does not detect DDL conflicts or conflicts resulting from user-enqueued events. Make sure your environment avoids these types of conflicts.

See Also: "Row LCRs" on page 2-3

Conflict Types

You may encounter these types of conflicts when you share data at multiple databases:

- Update Conflicts
- Uniqueness Conflicts
- Delete Conflicts

Update Conflicts

An **update conflict** occurs when the apply process applies a row LCR containing an update to a row that conflicts with another update to the same row. Update conflicts can happen when two transactions originating from different databases update the same row at nearly the same time.

Uniqueness Conflicts

A **uniqueness conflict** occurs when the apply process applies a row LCR containing a change to a row that violates a uniqueness integrity constraint, such as a `PRIMARY KEY` or `UNIQUE` constraint. For example, consider what happens when two transactions originate from two different databases, each inserting a row into a table with the same primary key value. In this case, the transactions cause a uniqueness conflict.

Delete Conflicts

A **delete conflict** occurs when two transactions originate from different databases, with one transaction deleting a row and another transaction updating or deleting the same row, because in this case the row referenced in the row LCR does not exist to be either updated or deleted.

Conflicts and Transaction Ordering

Ordering conflicts can occur in Streams environments when three or more databases share data and the data is updated at two or more of these databases. For example, consider a scenario in which three databases share information in the `hr.departments` table. The database names are `dbs1.net`, `dbs2.net`, and `dbs3.net`. Suppose a change is made to a row in the `hr.departments` table at `dbs1.net` that will be propagated to both `dbs2.net` and `dbs3.net`. The following series of actions may occur:

1. The change is propagated to `dbs2.net`.
2. The apply process at `dbs2.net` applies the change from `dbs1.net`.
3. A different change to the same row is made at `dbs2.net`.
4. The change at `dbs2.net` is propagated to `dbs3.net`.
5. The apply process at `dbs3.net` attempts to apply the change from `dbs2.net` before it applies the change from `dbs1.net`.

In this case, a conflict occurs because a column value for the row at dbs3.net does not match the corresponding old value in the row LCR propagated from dbs2.net.

In addition to causing a data conflict, transactions that are applied out of order might experience referential integrity problems at a remote database if supporting data has not been successfully propagated to that database. Consider the scenario where a new customer calls an order department. A customer record is created and an order is placed. If the order data is applied at a remote database before the customer data, then a referential integrity error is raised because the customer that the order references does not exist at the remote database.

If an ordering conflict is encountered, then you can resolve the conflict by reexecuting the transaction in the error queue after the required data has been propagated to the remote database and applied.

Conflict Detection

An apply process detects update, uniqueness, and delete conflicts as follows:

- An apply process detects an update conflict if there is any difference between the old values for a row in a row LCR and the current values of the same row at the destination database.
- An apply process detects a uniqueness conflict if a uniqueness constraint violation occurs when applying an LCR that contains an insert or update operation.
- An apply process detects a delete conflict if it cannot find a row when applying an LCR that contains an update or delete operation, because the primary key of the row does not exist.

A conflict may be detected when an apply process attempts to apply an LCR directly or when an apply process handler, such as a DML handler, runs the EXECUTE member procedure for an LCR. A conflict also may be detected when either the EXECUTE_ERROR or EXECUTE_ALL_ERRORS procedure in the DBMS_APPLY_ADM package is run.

Note: Any old LOB values in update LCRs, delete LCRs, and LCRs dealing with piecewise updates to LOB columns are not used by conflict detection.

Identifying Rows During Conflict Detection

To detect conflicts accurately, Oracle must be able to identify and match corresponding rows at different databases uniquely. By default, Oracle uses the primary key of a table to identify rows in the table uniquely. When a table does not have a primary key, you must designate a substitute key. A substitute key is a column or set of columns that Oracle can use to identify uniquely rows in the table.

See Also: "Substitute Key Columns" on page 4-10

Conflict Avoidance

This section describes ways to avoid data conflicts.

Use a Primary Database Ownership Model

You can avoid the possibility of conflicts by limiting the number of databases in the system that have simultaneous update access to the tables containing shared data. Primary ownership prevents all conflicts, because only a single database permits updates to a set of shared data. Applications can even use row and column subsetting to establish more granular ownership of data than at the table level. For example, applications might have update access to specific columns or rows in a shared table on a database-by-database basis.

Avoid Specific Types of Conflicts

If a primary database ownership model is too restrictive for your application requirements, then you must use a shared ownership data model, which means that conflicts may be possible. Even so, typically you can use some simple strategies to avoid specific types of conflicts.

Avoid Uniqueness Conflicts

You can avoid uniqueness conflicts by ensuring that each database uses unique identifiers for shared data. There are three ways to ensure unique identifiers at all databases in a Streams environment.

One alternative is to construct a unique identifier by executing the following select statement:

```
SELECT SYS_GUID() OID FROM DUAL;
```

This SQL operator returns a 16-byte globally unique identifier. This value is based on an algorithm that uses time, date, and the computer identifier to generate a globally unique identifier. The globally unique identifier appears in a format similar to the following:

```
4595EF13AB785E73E03400400B40F58B
```

You can also create a sequence at each of the databases that shares data and concatenate the database name (or other globally unique value) with the local sequence. This approach helps to avoid any duplicate sequence values and helps to prevent uniqueness conflicts.

Finally, you can create a customized sequence at each of the databases that shares data so that no two databases can generate the same value. You can accomplish this by using a combination of starting, incrementing, and maximum values in the `CREATE SEQUENCE` statement. For example, you might configure the following:

Parameter	Database A	Database B	Database C
`START WITH`	1	3	5
`INCREMENT BY`	10	10	10
Range Example	1, 11, 21, 31, 41,...	3, 13, 23, 33, 43,...	5, 15, 25, 35, 45,...

Using a similar approach, you can define different ranges for each database by specifying a `START WITH` and `MAXVALUE` that would produce a unique range for each database.

Avoid Delete Conflicts

Always avoid delete conflicts in shared data environments. In general, applications that operate within a shared ownership data model should not delete rows using `DELETE` statements. Instead, applications should mark rows for deletion and then configure the system to purge logically deleted rows periodically.

Avoiding Update Conflicts

After trying to eliminate the possibility of uniqueness and delete conflicts, you should also try to limit the number of possible update conflicts. However, in a shared ownership data model, update conflicts cannot be avoided in all cases. If you cannot avoid all update conflicts, then you must understand the types of conflicts possible and configure the system to resolve them if they occur.

Conflict Resolution

After an update conflict has been detected, a conflict handler can attempt to resolve it. Streams provides prebuilt conflict handlers to resolve update conflicts, but not uniqueness, delete, or ordering conflicts. However, you can build your own custom conflict handler to resolve data conflicts specific to your business rules. Such a conflict handler can be part of a DML or an error handler.

Whether you use a prebuilt or custom conflict handlers, a conflict handler is applied as soon as a conflict is detected. If neither the specified conflict handler nor the relevant apply handler can resolve the conflict, then the conflict is logged in the error queue. You may want to use the relevant apply handler to notify the database administrator when a conflict occurs.

When a conflict causes a transaction to be moved to the error queue, sometimes it is possible to correct the condition that caused the conflict. In these cases, you can reexecute a transaction using the `EXECUTE_ERROR` procedure in the `DBMS_APPLY_ADM` package.

See Also:

- "Event Processing Options" on page 4-3 for more information about error handlers
- "Handlers and Row LCR Processing" on page 4-15 for more information about you update conflict handlers interact with DML handlers and error handlers
- "The Error Queue" on page 4-33
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the `EXECUTE_ERROR` procedure

Prebuilt Update Conflict Handlers

This section describes the types of prebuilt update conflict handlers available to you and how column lists and resolution columns are used in prebuilt update conflict handlers. A column list is a list of columns for which the update conflict handler is called when there is an update conflict. The resolution column is the column used to identify an update conflict handler. If you use a `MAXIMUM` or `MINIMUM` prebuilt update conflict handler, then the resolution column is also the column used to resolve the conflict. The resolution column must be one of the columns in the column list for the handler.

Use the SET_UPDATE_CONFLICT_HANDLER procedure in the DBMS_APPLY_ADM package to specify one or more update conflict handlers for a particular table. There are no prebuilt conflict handlers for uniqueness or delete conflicts.

See Also:

- "Managing Streams Conflict Resolution" on page 13-29 for instructions on adding, modifying, and removing an update conflict handler
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the SET_UPDATE_CONFLICT_HANDLER procedure
- "Column Lists" on page 7-11
- "Resolution Columns" on page 7-12

Types of Prebuilt Update Conflict Handlers

Oracle provides the following types of prebuilt update conflict handlers for a Streams environment: OVERWRITE, DISCARD, MAXIMUM, and MINIMUM.

The description for each type of handler refers to the following conflict scenario:

1. The following update is made at the dbs1.net source database:

   ```
   UPDATE hr.employees SET salary = 4900 WHERE employee_id = 200;
   COMMIT;
   ```

   This update changes the salary for employee 200 from 4400 to 4900.

2. At nearly the same time, the following update is made at the dbs2.net destination database:

   ```
   UPDATE hr.employees SET salary = 5000 WHERE employee_id = 200;
   COMMIT;
   ```

3. A capture process captures the update at the dbs1.net source database and puts the resulting row LCR in a queue.
4. A propagation job propagates the row LCR from the queue at dbs1.net to a queue at dbs2.net.
5. An apply process at dbs2.net attempts to apply the row LCR to the hr.employees table but encounters a conflict because the salary value at dbs2.net is 5000, which does not match the old value for the salary in the row LCR (4400).

The following sections describe each prebuilt conflict handler and explain how the handler resolves this conflict.

OVERWRITE When a conflict occurs, the OVERWRITE handler replaces the current value at the destination database with the new value in the LCR from the source database.

If the OVERWRITE handler is used for the hr.employees table at the dbs2.net destination database in the conflict example, then the new value in the row LCR overwrites the value at dbs2.net. Therefore, after the conflict is resolved, the salary for employee 200 is 4900.

DISCARD When a conflict occurs, the DISCARD handler ignores the values in the LCR from the source database and retains the value at the destination database.

If the DISCARD handler is used for the hr.employees table at the dbs2.net destination database in the conflict example, then the new value in the row LCR is discarded. Therefore, after the conflict is resolved, the salary for employee 200 is 5000.

MAXIMUM When a conflict occurs, the MAXIMUM conflict handler compares the new value in the LCR from the source database with the current value in the destination database for a designated resolution column. If the new value of the resolution column in the LCR is greater than the current value of the column at the destination database, then the apply process resolves the conflict in favor of the LCR. If the new value of the resolution column is less than the current value, then the apply process resolves the conflict in favor of the destination database.

If the MAXIMUM handler is used for the salary column in the hr.employees table at the dbs2.net destination database in the conflict example, then the apply process does not apply the row LCR, because the salary in the row LCR is less than the current salary in the table. Therefore, after the conflict is resolved, the salary for employee 200 is 5000.

If you want to resolve conflicts based on the time of the transactions involved, then one way to do this is to add a column to a shared table that automatically records the transaction time with a trigger. Then, you can designate this column as a resolution column for a MAXIMUM conflict handler, and the transaction with the latest (or greater) time would be used automatically.

The following is an example of a trigger that records the time of a transaction for the hr.employees table. Assume that the job_id, salary, and commission_pct columns are part of the column list for the conflict resolution handler. The trigger

should fire only when an UPDATE is performed on the columns in the column list or when an INSERT is performed.

```
CONNECT hr/hr

ALTER TABLE hr.employees ADD (time TIMESTAMP WITH TIME ZONE);

CREATE OR REPLACE TRIGGER hr.insert_time_employees
BEFORE
  INSERT OR UPDATE OF job_id, salary, commission_pct ON hr.employees
FOR EACH ROW
BEGIN
   -- Consider time synchronization problems. The previous update to this
   -- row may have originated from a site with a clock time ahead of the
   -- local clock time.
   IF :OLD.TIME IS NULL OR :OLD.TIME < SYSTIMESTAMP THEN
     :NEW.TIME := SYSTIMESTAMP;
   ELSE
     :NEW.TIME := :OLD.TIME + 1 / 86400;
   END IF;
END;
/
```

If you use such a trigger for conflict resolution, then make sure the trigger's firing property is fire once, which is the default. Otherwise, a new time may be marked when transactions are applied by an apply process, resulting in the loss of the actual time of the transaction.

See Also: "Trigger Firing Property" on page 4-23

MINIMUM When a conflict occurs, the MINIMUM conflict handler compares the new value in the LCR from the source database with the current value in the destination database for a designated resolution column. If the new value of the resolution column in the LCR is less than the current value of the column at the destination database, then the apply process resolves the conflict in favor of the LCR. If the new value of the resolution column is greater than the current value, then the apply process resolves the conflict in favor of the destination database.

If the MINIMUM handler is used for the salary column in the hr.employees table at the dbs2.net destination database in the conflict example, then the apply process resolves the conflict in favor of the row LCR, because the salary in the row LCR is less than the current salary in the table. Therefore, after the conflict is resolved, the salary for employee 200 is 4900.

Column Lists

Each time you specify a prebuilt update conflict handler for a table, you must specify a **column list**. A column list is a list of columns for which the update conflict handler is called. If an update conflict occurs for one or more of the columns in the list when an apply process tries to apply a row LCR, then the update conflict handler is called to resolve the conflict. The update conflict handler is not called if a conflict occurs only in columns that are not in the list. The scope of conflict resolution is a single column list on a single row `LCR`.

You can specify more than one update conflict handler for a particular table, but the same column cannot be in more than one column list. For example, suppose you specify two prebuilt update conflict handlers on `hr.employees` table:

- The first update conflict handler has the following columns in its column list: `salary` and `commission_pct`.
- The second update conflict handler has the following columns in its column list: `job_id` and `department_id`.

Also assume that no other conflict handlers exist for this table. In this case, if a conflict occurs for the `salary` column when an apply process tries to apply a row LCR, then the first update conflict handler is called to resolve the conflict. If, however, a conflict occurs for the `department_id` column, then the second update conflict handler is called to resolve the conflict. If a conflict occurs for a column that is not in a column list for any conflict handler, then no conflict handler is called, and an error results. In this example, if a conflict occurs for the `manager_id` column, then an error results. If conflicts occur in more than one column list when a row LCR is being applied, and there are no conflicts in any columns that are not in a column list, then the appropriate update conflict handler is invoked for each column list with a conflict.

Column lists enable you to use different handlers to resolve conflicts for different types of data. For example, numeric data is often suited for a maximum or minimum conflict handler, while an overwrite or discard conflict handler might be preferred for character data.

If a conflict occurs in a column that is not in a column list, then the error handler for the specific operation on the table attempts to resolve the conflict. If the error handler cannot resolve the conflict, or if there is no such error handler, then the transaction that caused the conflict is moved to the error queue.

Also, if a conflict occurs for a column in a column list that uses either the OVERWRITE, MAXIMUM, or MINIMUM prebuilt method, and the row LCR does not contain all of the columns in this column list, then the conflict cannot be resolved because all of the values are not available. In this case, the transaction that caused the conflict is moved to the error queue. If the column list uses the DISCARD prebuilt method, then the row LCR is discarded and no error results.

A conditional supplemental log group must be specified for any columns specified in a column list. Supplemental logging is specified at the source database and adds additional information to the LCR, which is needed to resolve conflicts properly.

Note: Prebuilt update conflict handlers do not support LOB columns. Therefore, you should not include LOB columns in the column_list parameter when running the procedure SET_UPDATE_CONFLICT_HANDLER.

See Also: "Supplemental Logging" on page 2-9

Resolution Columns

The **resolution column** is the column used to identify an update conflict handler. If you use a MAXIMUM or MINIMUM prebuilt update conflict handler, then the **resolution column** is also the column used to resolve the conflict. The resolution column must be one of the columns in the column list for the handler.

For example, if the salary column in the hr.employees table is specified as the resolution column for a maximum or minimum conflict handler, then the salary column is evaluated to determine whether column list values in the row LCR are applied or the destination database values for the column list are retained.

In either of the following situations involving a resolution column for a conflict, the apply process moves the transaction containing the row LCR that caused the conflict to the error queue, if the error handler cannot resolve the problem. In these cases, the conflict cannot be resolved and the values of the columns at the destination database remain unchanged:

- The new LCR value and the destination row value for the resolution column are the same (for example, if the resolution column was not the column causing the conflict).
- Either the new value of the resolution column or the current value of the resolution column is NULL.

Note: Although the resolution column is not used for OVERWRITE and DISCARD conflict handlers, a resolution column must be specified for these conflict handlers.

Data Convergence

When you share data between multiple databases, and you want the data to be the same at all of these databases, then make sure you use conflict resolution handlers that cause the data to converge at all databases. If you allow changes to shared data at all of your databases, then data convergence for a table is possible only if all databases that are sharing data capture changes to the shared data and propagate these changes to all of the other sites that are sharing the data.

In such an environment, the MAXIMUM conflict resolution method can guarantee convergence only if the values in the resolution column are always increasing. A time-based resolution column meets this requirement, as long as successive timestamps on a row are distinct. The MINIMUM conflict resolution method can guarantee convergence in such an environment only if the values in the resolution column are always decreasing.

Custom Conflict Handlers

You can create a PL/SQL procedure to use as a custom conflict handler. You use the SET_DML_HANDLER procedure in the DBMS_APPLY_ADM package to designate one or more custom conflict handlers for a particular table. Specifically, you set the following parameters when you run this procedure to specify a custom conflict handler:

- Set the object_name parameter to the fully qualified name of the table for which you want to perform conflict resolution.
- Set the object_type parameter to TABLE.
- Set the operation_name parameter to the type of operation for which the custom conflict handler is called. The possible operations are the following: INSERT, UPDATE, DELETE, and LOB_UPDATE.

- If you want an error handler to perform conflict resolution when an error is raised, then set the `error_handler` parameter to `true`. Or, if you want to include conflict resolution in your DML handler, then set the `error_handler` parameter to `false`.

  If you specify `false` for this parameter, then, when you execute a row LCR using the `EXECUTE` member procedure for the LCR, the conflict resolution within the DML handler is performed for the specified object and operation(s).

- Specify the procedure to resolve a conflict by setting the `user_procedure` parameter. This user procedure is called to resolve any conflicts on the specified table resulting from the specified type of operation.

If the custom conflict handler cannot resolve the conflict, then the apply process moves the transaction containing the conflict to the error queue and does not apply the transaction.

If both a prebuilt update conflict handler and a custom conflict handler exist for a particular object, then the prebuilt update conflict handler is invoked only if both of the following conditions are met:

- The custom conflict handler executes the row LCR using the `EXECUTE` member procedure for the LCR.
- The `conflict_resolution` parameter in the `EXECUTE` member procedure for the row LCR is set to `true`.

See Also:

- "Handlers and Row LCR Processing" on page 4-15 for more information about you update conflict handlers interact with DML handlers and error handlers
- "Managing a DML Handler" on page 13-14
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the `SET_DML_HANDLER` procedure

8

Streams Tags

This chapter explains the concepts related to Streams tags.

This chapter contains these topics:

- Introduction to Tags
- Tags and Rules Created by the DBMS_STREAMS_ADM Package
- Tags and an Apply Process
- Avoid Change Cycling with Tags

See Also: "Managing Streams Tags" on page 15-22

Introduction to Tags

Every redo entry in the redo log has a **tag** associated with it. The datatype of the tag is RAW. By default, when a user or application generates redo entries, the value of the tag is NULL for each redo entry, and a NULL tag consumes no space in the redo entry. The size limit for a tag value is 2000 bytes.

You can configure how tag values are interpreted. For example, a tag can be used to determine whether an LCR contains a change that originated in the local database or at a different database, so that you can avoid change cycling (sending an LCR back to the database where it originated). Tags may be used for other LCR tracking purposes as well. You can also use tags to specify the set of destination databases for each LCR.

You can control the value of the tags generated in the redo log in the following ways:

- Use the DBMS_STREAMS.SET_TAG procedure to specify the value of the redo tags generated in the current session. When a database change is made in the session, the tag becomes part of the redo entry that records the change. Different sessions can have the same tag setting or different tag settings.
- Use the CREATE_APPLY or ALTER_APPLY procedure in the DBMS_APPLY_ADM package to control the value of the redo tags generated when an apply process runs. All sessions coordinated by the apply process coordinator use this tag setting. By default, redo entries generated by an apply process have a tag value that is the hexadecimal equivalent of '00' (double zero).

These tags become part of the LCRs captured by a capture process retrieving changes from the redo log. Based on the rules in the rule set for the capture process, the tag value in the redo entry for a change may determine whether or not the change is captured.

Similarly, once a tag is part of an LCR, the value of the tag may determine whether a propagation job propagates the LCR and whether an apply process applies the LCR. The behavior of a transformation, DML handler, or error handler can also depend on the value of the tag. In addition, you can set the tag value for an existing LCR using the SET_TAG member procedure for the LCR. For example, you may set a tag in an LCR during a transformation.

> **See Also:** *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the SET_TAG member procedure for LCRs

Tags and Rules Created by the DBMS_STREAMS_ADM Package

When you use a procedure in the DBMS_STREAMS_ADM package to create rules, by default each rule contains a condition that evaluates to TRUE only if the tag is NULL. In DML rules, the condition is the following:

```
:dml.is_null_tag()='Y'
```

In DDL rules, the condition is the following:

```
:ddl.is_null_tag()='Y'
```

Consider a rule set with a single rule and assume the rule contains such a condition. In this case, Streams processes and jobs behave in the following way:

- A capture process captures a change only if the tag in the redo log for the change is NULL and the rest of the rule conditions evaluate to TRUE for the change.
- A propagation job propagates an event containing an LCR only if the tag in the LCR is NULL and the rest of the rule conditions evaluate to TRUE for the LCR.
- An apply process applies an event containing an LCR only if the tag in the LCR is NULL and the rest of the rule conditions evaluate to TRUE for the LCR.

Specifically, the following procedures in the DBMS_STREAMS_ADM package create rules that contain this condition by default:

- ADD_GLOBAL_PROPAGATION_RULES
- ADD_GLOBAL_RULES
- ADD_SCHEMA_PROPAGATION_RULES
- ADD_SCHEMA_RULES
- ADD_SUBSET_RULES
- ADD_TABLE_PROPAGATION_RULES
- ADD_TABLE_RULES

If you do not want the created rules to contain such a condition, then set the include_tagged_lcr parameter to true when you run these procedures. This setting results in no conditions relating to tags in the rules. Therefore, rule evaluation of the LCR does not depend on the value of the tag.

For example, consider a table-level rule that evaluates to TRUE for all DML changes to the hr.locations table that originated at the dbs1.net source database.

Assume the ADD_TABLE_RULES procedure is run to generate this rule:

```
BEGIN DBMS_STREAMS_ADM.ADD_TABLE_RULES(
   table_name               =>  'hr.locations',
   streams_type             =>  'capture',
   streams_name             =>  'capture',
   queue_name               =>  'streams_queue',
   include_tagged_lcr       =>  false,  -- Note parameter setting
   source_database          =>  'dbs1.net',
   include_dml              =>  true,
   include_ddl              =>  false);
END;
/
```

Notice that the include_tagged_lcr parameter is set to false, which is the default. The ADD_TABLE_RULES procedure generates a rule with a rule condition similar to the following:

```
:dml.get_object_owner() = 'HR' AND :dml.get_object_name() = 'LOCATIONS'
AND :dml.is_null_tag() = 'Y' AND :dml.get_source_database_name() = 'DBS1.NET'
```

If a capture process uses a rule set that contains this rule, then the rule evaluates to FALSE if the tag for a change in a redo entry is a non-NULL value, such as '0' or '1'. So, if a redo entry contains a row change to the hr.locations table, then the change is captured only if the tag for the redo entry is NULL.

However, suppose the include_tagged_lcr parameter is set to true when ADD_TABLE_RULES is run:

```
BEGIN DBMS_STREAMS_ADM.ADD_TABLE_RULES(
   table_name               =>  'hr.locations',
   streams_type             =>  'capture',
   streams_name             =>  'capture',
   queue_name               =>  'streams_queue',
   include_tagged_lcr       =>  true,   -- Note parameter setting
   source_database          =>  'dbs1.net',
   include_dml              =>  true,
   include_ddl              =>  false);
END;
/
```

In this case, the ADD_TABLE_RULES procedure generates a rule with a rule condition similar to the following:

```
:dml.get_object_owner() = 'HR' AND :dml.get_object_name() = 'LOCATIONS'
AND :dml.get_source_database_name() = 'DBS1.NET'
```

Notice that there is no condition relating to the tag. If a capture process uses a rule set that contains this rule, then the rule evaluates to TRUE if the tag in a redo entry for a DML change to the hr.locations table is a non-NULL value, such as '0' or '1'. The rule also evaluates to TRUE if the tag is NULL. So, if a redo entry contains a DML change to the hr.locations table, then the change is captured regardless of the value for the tag.

If you want to modify the is_null_tag condition in a system-created rule, then you should use an appropriate procedure in the DBMS_STREAMS_ADM package to create a new rule that is the same as the rule you want to modify, except for the is_null_tag condition. Then, use the REMOVE_RULE procedure in the DBMS_STREAMS_ADM package to remove the old rule from the appropriate rule set.

If you created a rule with the DBMS_RULE_ADM package, then you can add, remove, or modify the is_null_tag condition in the rule by using the ALTER_RULE procedure in this package.

See Also:

- Chapter 6, "How Rules Are Used In Streams" for examples of rules generated by the procedures in the DBMS_STREAMS_ADM package
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the DBMS_STREAMS_ADM package and the DBMS_RULE_ADM.ALTER_RULE procedure

Tags and an Apply Process

An apply process generates entries in the redo log of a destination database when it applies DML or DDL changes. For example, if the apply process applies a change that updates a row in a table, then that change is recorded in the redo log at the destination database. You can control the tags in these redo entries by setting the apply_tag parameter in the CREATE_APPLY or ALTER_APPLY procedure in the DBMS_APPLY_ADM package. For example, an apply process may generate redo tags that are equivalent to the hexadecimal value of '0' (zero) or '1'.

The default tag value generated in the redo log by an apply process is '00' (double zero). This value is the default tag value for an apply process if you use a procedure in the DBMS_STREAMS_ADM package or the CREATE_APPLY procedure in the DBMS_APPLY_ADM package to create an apply process. There is nothing special about this value beyond the fact that it is a non-NULL value. The fact that it is a non-NULL value is important because rules created by the DBMS_STREAMS_ADM

package by default contain a condition that evaluates to TRUE only if the tag is NULL in a redo entry or LCR. You can alter the tag value for an existing apply process using the ALTER_APPLY procedure in the DBMS_APPLY_ADM package.

If a DML handler, DDL handler, or message handler calls the SET_TAG procedure in the DBMS_STREAMS package, then any subsequent redo entries generated by the handler will include the tag specified in the SET_TAG call, even if the tag for the apply process is different. When the handler exits, any subsequent redo entries generated by the apply process have the tag specified for the apply process.

See Also:

- Chapter 4, "Streams Apply Process" for more information about the apply process
- "Tags and Rules Created by the DBMS_STREAMS_ADM Package" on page 8-3 for more information about the default tag condition in Streams rules
- "Setting the Tag Values Generated by an Apply Process" on page 15-24
- "Event Processing Options" on page 4-3 for more information about DML handlers, DDL handlers, and message handlers
- "Setting the Tag Values Generated by the Current Session" on page 15-22 for more information about the SET_TAG procedure
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the DBMS_STREAMS_ADM package and the DBMS_APPLY_ADM package

Avoid Change Cycling with Tags

In a Streams environment that includes more than one database sharing data bidirectionally, you can use tags to avoid **change cycling**. Change cycling means sending a change back to the database where it originated. Typically, change cycling should be avoided because it can result in each change going through endless loops back to the database where it originated. Such loops can result in unintended data in the database and tax the networking and computer resources of an environment. By default, Streams is designed to avoid change cycling.

Using tags and appropriate rules for Streams processes and jobs, you can avoid such change cycles. The following sections describe various Streams environments and how tags and rules can be used to avoid change cycling in these environments:

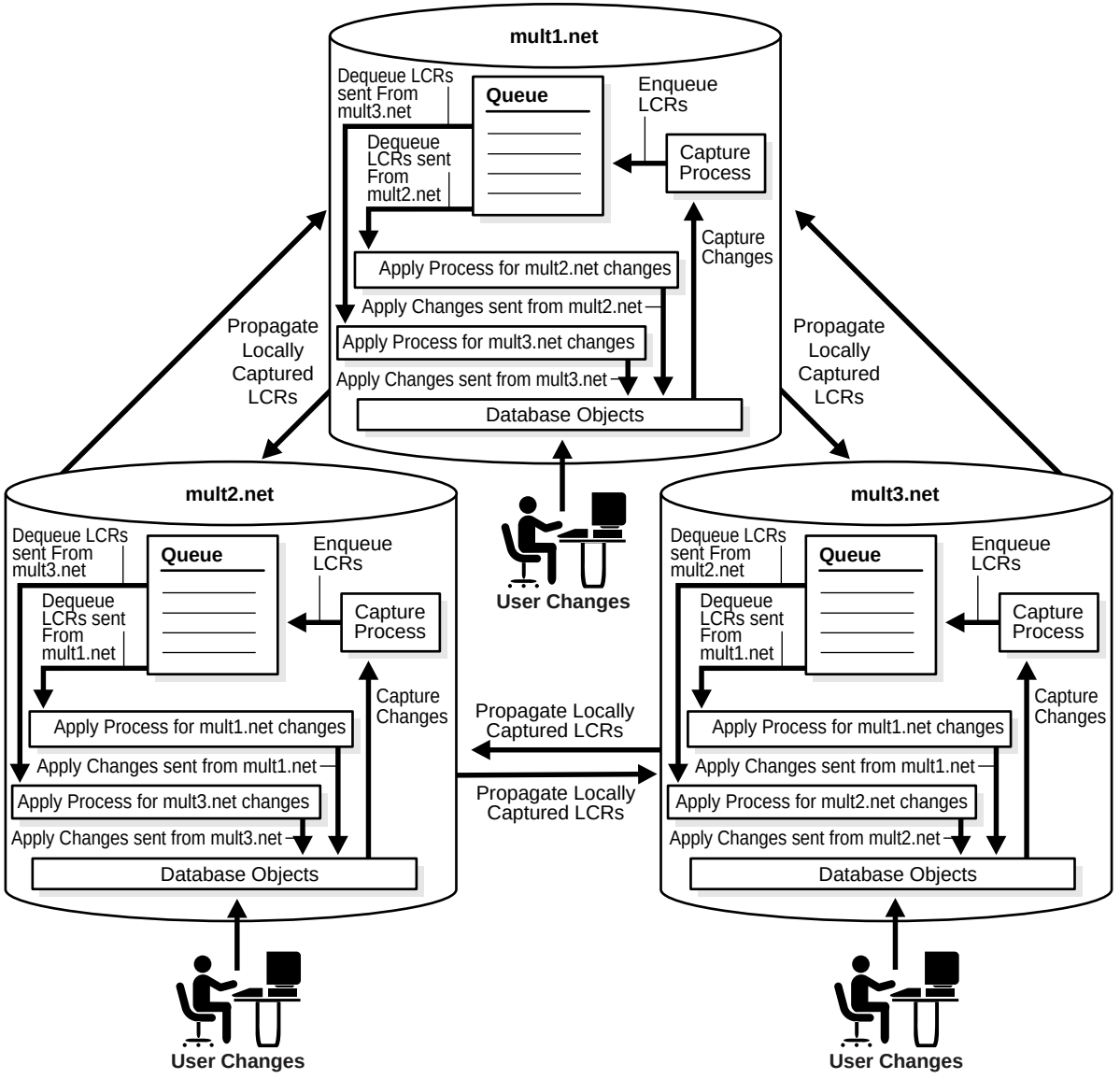
- Each Databases Is a Source and Destination Database for Shared Data
- Primary Database Sharing Data with Several Secondary Databases
- Primary Database Sharing Data with Several Extended Secondary Databases

Each Databases Is a Source and Destination Database for Shared Data

This scenario involves a Streams environment in which each database is a source database for every other database, and each database is a destination database of every other database. Each database communicates directly with every other database.

For example, consider an environment that replicates the database objects and data in the `hr` schema between three Oracle databases: `mult1.net`, `mult2.net`, and `mult3.net`. DML and DDL changes made to tables in the `hr` schema are captured at all three databases in the environment and propagated to each of the other databases in the environment, where changes are applied. Figure 8–1 illustrates an example environment in which each database is a source database.

Figure 8–1 Each Database Is a Source and Destination Database



You can avoid change cycles by configuring such an environment in the following way:

- Configure one apply process at each database to generate non-NULL redo tags for changes from each source database. If you use a procedure in the DBMS_STREAMS_ADM package to create an apply process, then the apply process generates non-NULL tags with a value of '00' in the redo log by default. In this case, no further action is required for the apply process to generate non-NULL tags.

  If you use the CREATE_APPLY procedure in the DBMS_APPLY_ADM package to create an apply process, then do not set the apply_tag parameter. Again, the apply process generates non-NULL tags with a value of '00' in the redo log by default, and no further action is required.

- Configure the capture process at each database to capture changes only if the tag in the redo entry for the change is NULL. You do this by ensuring that each DML rule in the rule set used by the capture process has the following condition:

  ```
  :dml.is_null_tag()='Y'
  ```

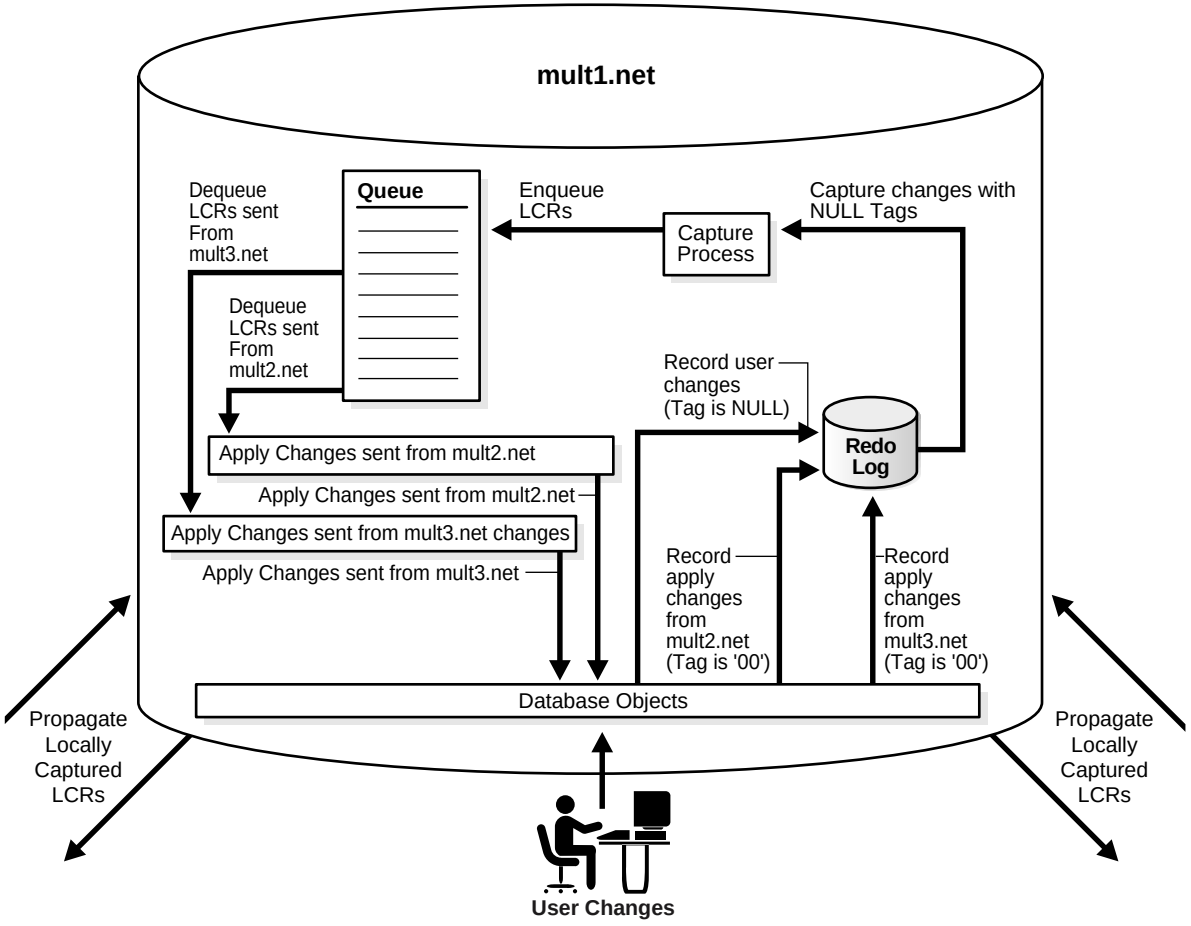
  Each DDL rule should have the following condition:

  ```
  :ddl.is_null_tag()='Y'
  ```

  These rule conditions indicate that the capture process captures a change only if the tag for the change is NULL. If you use the DBMS_STREAMS_ADM package to generate rules, then each rule has one of these conditions by default.

This configuration prevents change cycling because all of the changes applied by the apply processes are never recaptured (they were captured originally at the source databases). Each database sends all of its changes to the hr schema to every other database. So, in this environment, no changes are lost, and all databases are synchronized. Figure 8–2 illustrates how tags can be used in a database in a multiple source environment.

Figure 8–2 Tag Use When Each Database Is a Source and Destination Database



See Also: "Multiple Source Databases in an Oracle-Only Environment" on page 19-82 illustrates this example

Primary Database Sharing Data with Several Secondary Databases

This scenario involves a Streams environment in which one database is the primary database, and this primary database shares data with several secondary databases. The secondary databases share data only with the primary database. The secondary databases do not share data directly with each other, but, instead, share data indirectly with each other through the primary database. This type of environment is sometimes called a "hub and spoke" environment.

In such an environment, changes are captured, propagated, and applied in the following way:

- The primary database captures local changes to the shared data and propagates these changes to all secondary databases, where these changes are applied at each secondary database locally.
- Each secondary database captures local changes to the shared data and propagates these changes to the primary database only, where these changes are applied at the primary database locally.
- The primary database applies changes from each secondary database locally. Then, these changes are captured at the primary database and propagated to all secondary databases, except for the one at which the change originated. Each secondary database applies the changes from the other secondary databases locally, after they have gone through the primary database. This configuration is an example of apply forwarding.

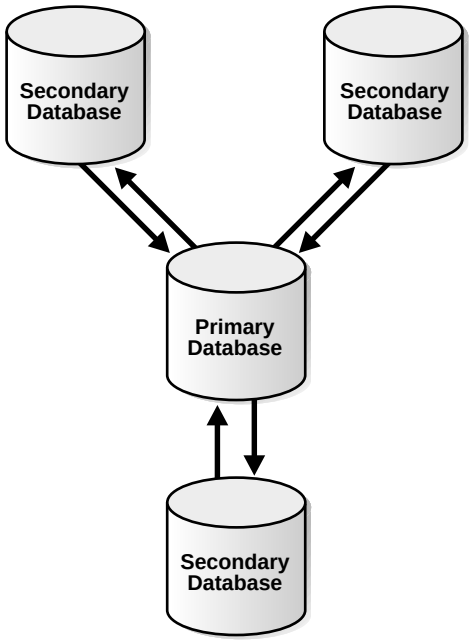
  An alternate scenario may use queue forwarding. If this environment used queue forwarding, then changes from secondary databases that are applied at the primary database are not captured at the primary database. Instead, these changes are forwarded from the queue at the primary database to all secondary databases, except for the one at which the change originated.

  > **See Also:** "Directed Networks" on page 3-8 for more information about apply forwarding and queue forwarding

For example, consider an environment that replicates the database objects and data in the `hr` schema between one primary database named `ps1.net` and three secondary databases named `ps2.net`, `ps3.net`, and `ps4.net`. DML and DDL changes made to tables in the `hr` schema are captured at the primary database and at the three secondary databases in the environment. Then, these changes are propagated and applied as described previously. The environment uses apply forwarding, not queue forwarding, to share data between the secondary databases

through the primary database. Figure 8–3 illustrates an example environment which has one primary database and multiple secondary databases.

Figure 8–3 Primary Database Sharing Data with Several Secondary Databases



You can avoid change cycles by configuring the environment in the following way:

- Configure each apply process at the primary database `ps1.net` to generate non-`NULL` redo tags that indicate the site from which it is receiving changes. In this environment, the primary database has at least one apply process for each secondary database from which it receives changes. For example, if an apply process at the primary database receives changes from the `ps2.net` secondary site, then this apply process may generate a raw value that is equivalent to the hexadecimal value `'2'` for all changes it applies. You do this by setting the `apply_tag` parameter in the `CREATE_APPLY` or `ALTER_APPLY` procedure in the `DBMS_APPLY_ADM` package to the non-`NULL` value.

For example, run the following procedure to create an apply process that generates redo entries with tags that are equivalent to the hexadecimal value '2':

```
BEGIN
  DBMS_APPLY_ADM.CREATE_APPLY(
    queue_name     => 'strmadmin.streams_queue',
    apply_name       => 'apply_ps2',
    rule_set_name    => 'strmadmin.apply_rules_ps2',
    apply_tag        => HEXTORAW('2'),
    apply_captured   => true);
END;
/
```

- Configure the apply process at each secondary database to generate non-NULL redo tags. The exact value of the tags is irrelevant as long as it is non-NULL. In this environment, each secondary database has one apply process that applies changes from the primary database.

  If you use a procedure in the DBMS_STREAMS_ADM package to create an apply process, then the apply process generates non-NULL tags with a value of '00' in the redo log by default. In this case, no further action is required for the apply process to generate non-NULL tags.

  For example, assuming no apply processes exist at the secondary databases, run the ADD_SCHEMA_RULES procedure in the DBMS_STREAMS_ADM package at each secondary database to create an apply process that generates non-NULL redo entries with tags that are equivalent to the hexadecimal value '00':

```
BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name     => 'hr',
    streams_type    => 'apply',
    streams_name    => 'apply',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'ps1.net');
END;
/
```

- Configure the capture process at the primary database to capture changes to the shared data regardless of the tags. You do this by setting the `include_tagged_lcr` parameter to `true` when you run one of the procedures that generate capture rules in the `DBMS_STREAMS_ADM` package. If you use the `DBMS_RULE_ADM` package to create rules for the capture process at the primary database, then make sure the rules do not contain `is_null_tag` conditions, because these conditions involve tags in the redo log.

  For example, run the following procedure at the primary database to produce one DML capture process rule and one DDL capture process rule that each have a condition that evaluates to `TRUE` for changes in the `hr` schema, regardless of the tag for the change:

```
BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name         => 'hr',
    streams_type        => 'capture',
    streams_name        => 'capture',
    queue_name          => 'strmadmin.streams_queue',
    include_tagged_lcr  =>  true, -- Note parameter setting
    include_dml         =>  true,
    include_ddl         =>  true);
END;
/
```

- Configure the capture process at each secondary database to capture changes only if the tag in the redo entry for the change is `NULL`. You do this by ensuring that each DML rule in the rule set used by the capture process at the secondary database has the following condition:

```
:dml.is_null_tag()='Y'
```

  DDL rules should have the following condition:

```
:ddl.is_null_tag()='Y'
```

  These rules indicate that the capture process captures a change only if the tag for the change is `NULL`. If you use the `DBMS_STREAMS_ADM` package to generate rules, then each rule has one of these conditions by default. If you use the `DBMS_RULE_ADM` package to create rules for the capture process at a secondary database, then make sure each rule contains one of these conditions.

- Configure one propagation job from the queue at the primary database to the queue at each secondary database. Each propagation job should use a rule set with rules that instruct the propagation job to propagate all LCRs in the queue at the primary database to the queue at the secondary database, except for changes that originated at the secondary database.

  For example, if a propagation job propagates changes to the secondary database `ps2.net`, whose tags are equivalent to the hexadecimal value `'2'`, then the rules for the propagation job should propagate all LCRs relating to the `hr` schema to the secondary database, except for LCRs with a tag of `'2'`. For row LCRs, such rules should include the following condition:

  ```
  :dml.get_tag()!=HEXTORAW('2')
  ```

  For DDL LCRs, such rules should include the following condition:

  ```
  :ddl.get_tag()!=HEXTORAW('2')
  ```

  You can use the `CREATE_RULE` procedure in the `DBMS_RULE_ADM` package to create rules with these conditions.

- Configure one propagation job from the queue at each secondary database to the queue at the primary database. A queue at one of the secondary databases contains only local changes made by user sessions and applications at the secondary database, not changes made by an apply process. Therefore, no further configuration is necessary for these propagation jobs.

This configuration prevents change cycling in the following way:

- Changes that originated at a secondary database are never propagated back to that secondary database.
- Changes that originated at the primary database are never propagated back to the primary database.
- All changes made to the shared data at any database in the environment are propagated to every other database in the environment.

So, in this environment, no changes are lost, and all databases are synchronized.

Figure 8–4 illustrates how tags are used at the primary database `ps1.net`.

Figure 8–4 Tags Used at the Primary Database

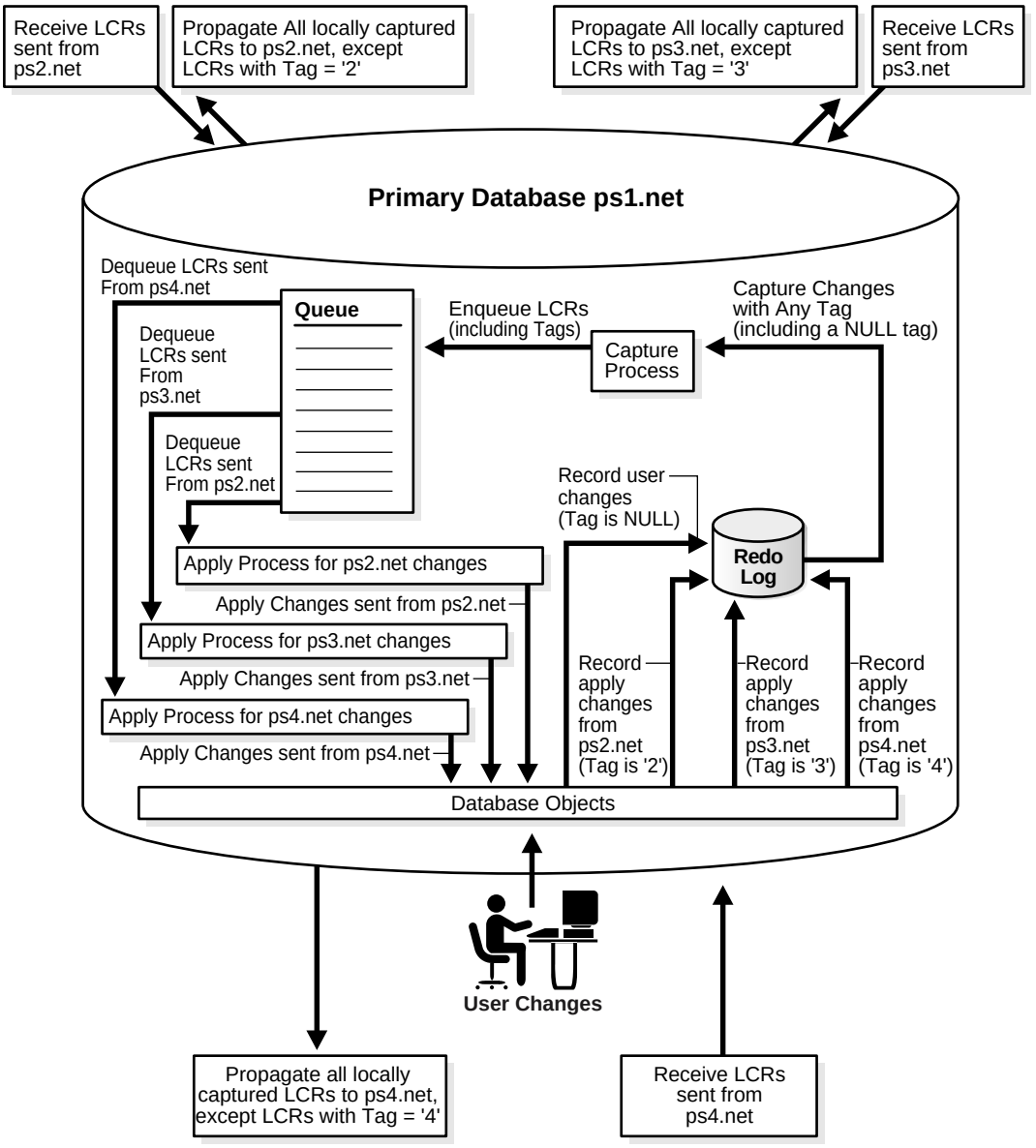
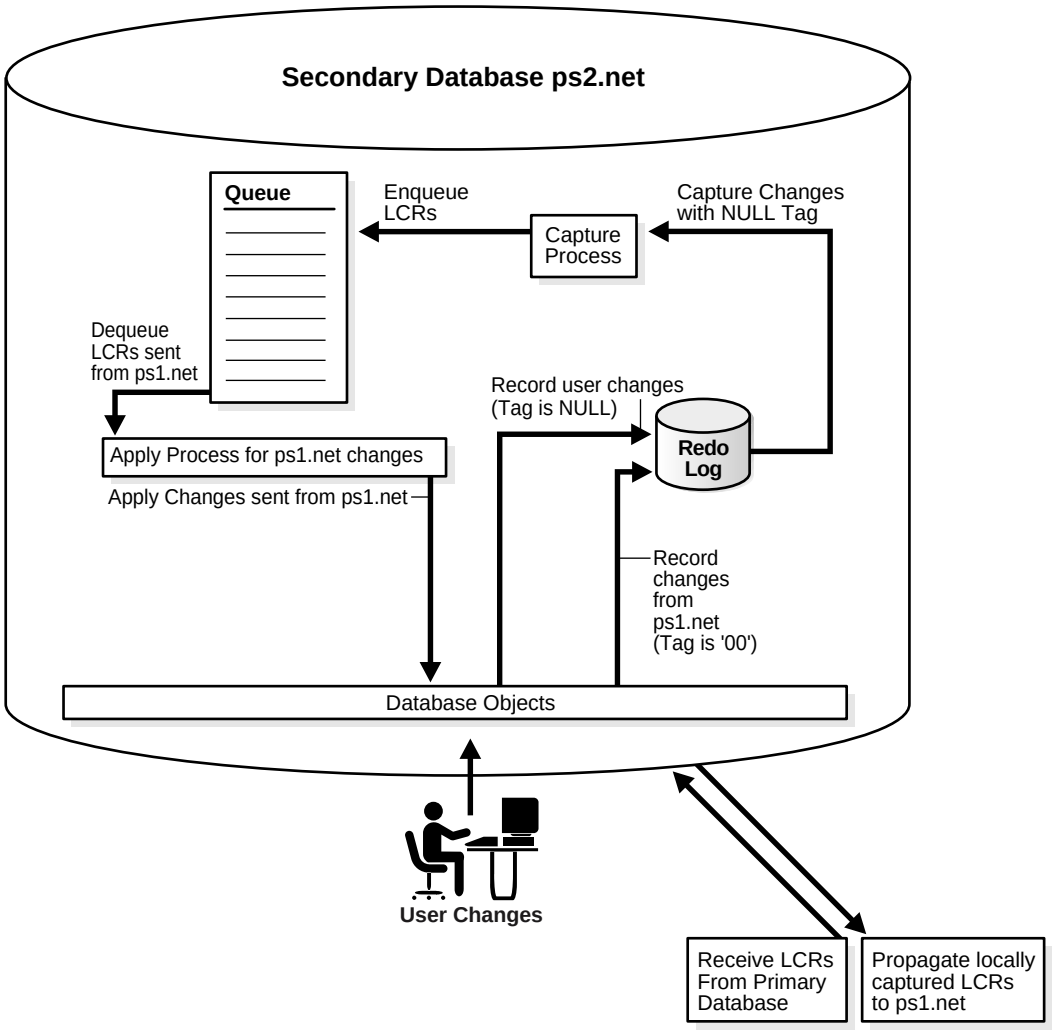


Figure 8–5 illustrates how tags are used at one of the secondary databases (`ps2.net`).

Figure 8–5 Tags Used at a Secondary Database

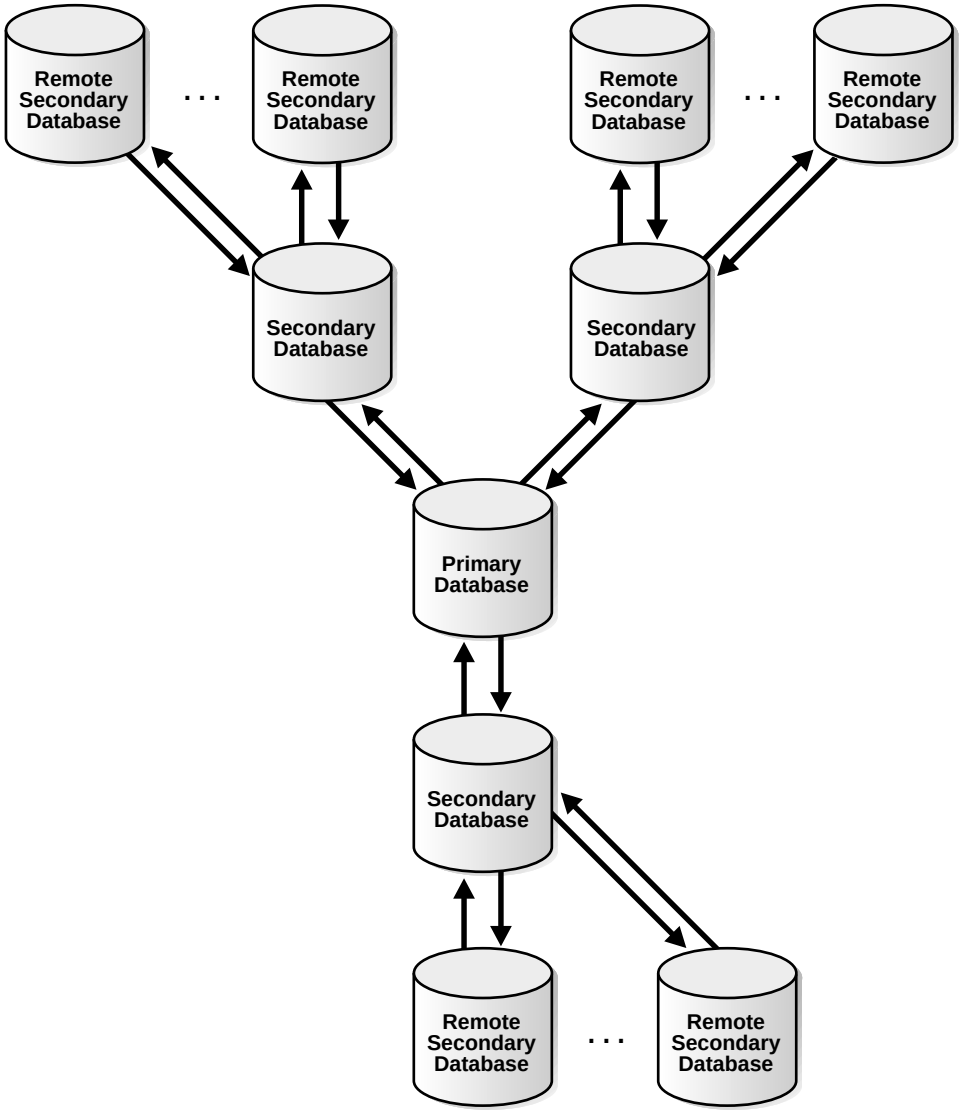


Primary Database Sharing Data with Several Extended Secondary Databases

In this environment, one primary database shares data with several secondary databases, but the secondary databases have other secondary databases connected to them, which will be called *remote secondary* databases. This environment is an extension of the environment described in "Primary Database Sharing Data with Several Secondary Databases" on page 8-11.

A remote secondary database does not share data directly with the primary database, but instead shares data indirectly with the primary database through a secondary database. So, the shared data exists at the primary database, at each secondary database, and at each remote secondary database. Changes made at any of these databases are captured and propagated to all of the other databases. Figure 8–6 illustrates an environment with one primary database and multiple extended secondary databases.

Figure 8–6 Primary Database and Several Extended Secondary Databases



In such an environment, you can avoid change cycling in the following way:

- Configure the primary database in the same way that it is configured in the example described in "Primary Database Sharing Data with Several Secondary Databases" on page 8-11.
- Configure each remote secondary database similar to the way that each secondary database is configured in the example described in "Primary Database Sharing Data with Several Secondary Databases" on page 8-11. The only difference is that the remote secondary databases share data directly with secondary databases, not the primary database.
- At each secondary database, configure one apply process to apply changes from the primary database with a redo tag value that is equivalent to the hexadecimal value `'00'`. This value is the default tag value for an apply process.
- At each secondary database, configure one apply process to apply changes from each of its remote secondary databases with a redo tag value that is unique for the remote secondary database.
- Configure the capture process at each secondary database to capture all changes to the shared data in the redo log, regardless of the tag value for the changes.
- Configure one propagation job from the queue at each secondary database to the queue at the primary database. The propagation job should use a rule set with rules that instruct the propagation job to propagate all LCRs in the queue at the secondary database to the queue at the primary database, except for changes that originated at the primary database. You do this by adding a condition to the rules that evaluates to `TRUE` only if the tag in the LCR does not equal `'00'`. For example, enter a condition similar to the following for row LCRs:

  ```
  :dml.get_tag()!=HEXTORAW('00')
  ```

- Configure one propagation job from the queue at each secondary database to the queue at each remote secondary database. Each propagation job should use a rule set with rules that instruct the propagation job to propagate all LCRs in the queue at the secondary database to the queue at the remote secondary database, except for changes that originated at the remote secondary database. You do this by adding a condition to the rules that evaluates to TRUE only if the tag in the LCR does not equal the tag value for the remote secondary database. For example, if the tag value of a remote secondary database is equivalent to the hexadecimal value `'19'`, then enter a condition similar to the following for row LCRs:

  ```
  :dml.get_tag()!=HEXTORAW('19')
  ```

By configuring the environment in this way, you prevent change cycling, and no changes originating at any database are lost.

9

Streams Heterogeneous Information Sharing

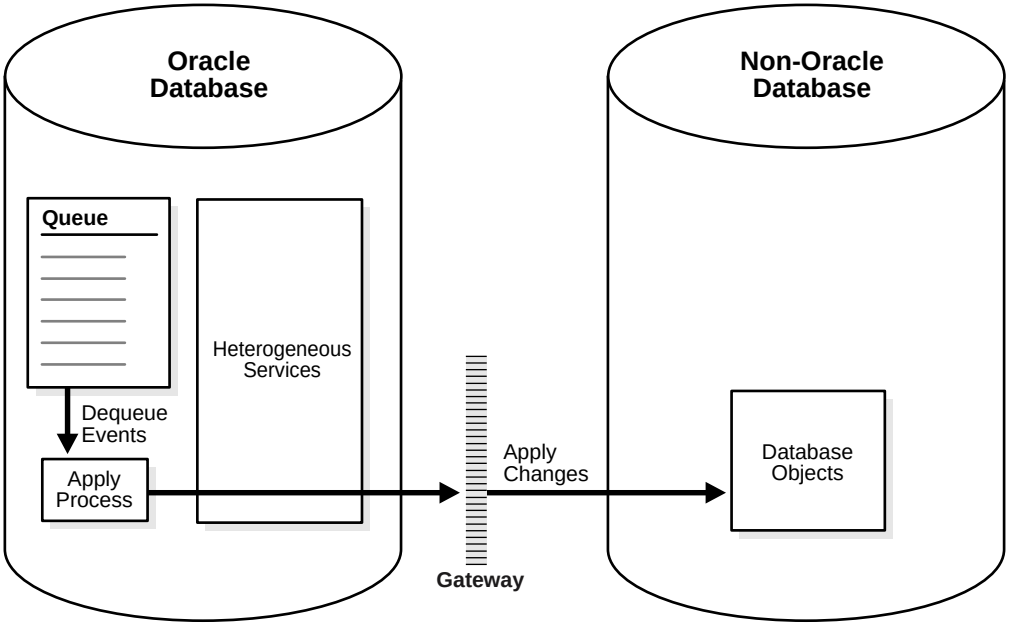
This chapter explains concepts relating to Streams support for information sharing between Oracle databases and non-Oracle databases.

This chapter contains these topics:

Oracle to Non-Oracle Data Sharing with Streams

To share DML changes from an Oracle source database to a non-Oracle destination database, the Oracle database functions as a proxy and carries out some of the steps that would normally be done at the destination database. That is, the events intended for the non-Oracle destination database are dequeued in the Oracle database itself and an apply process at the Oracle database applies the changes to the non-Oracle database across a network connection through a gateway. Figure 9–1 shows an Oracle databases sharing data with a non-Oracle database.

Figure 9–1 Oracle to Non-Oracle Heterogeneous Data Sharing



Change Capture and Staging in an Oracle to Non-Oracle Environment

In an Oracle to non-Oracle environment, the capture process functions the same way as it would in an Oracle-only environment. That is, it finds changes in the redo log, captures them based on capture process rules, and enqueues the captured changes as logical change records (LCRs) in a `SYS.AnyData` queue. In addition, a single capture process may capture changes that will be applied at both Oracle and non-Oracle databases.

Similarly, the `SYS.AnyData` queue that stages the captured LCRs functions the same way as it would in an Oracle-only environment, and you can propagate LCRs to any number of intermediate queues in Oracle databases before they are applied at a non-Oracle database.

See Also:

- Chapter 2, "Streams Capture Process"
- Chapter 3, "Streams Staging and Propagation"

Change Apply in an Oracle to Non-Oracle Environment

An apply process running in an Oracle database uses Heterogeneous Services and a gateway to apply changes encapsulated in LCRs directly to database objects in a non-Oracle database. The LCRs are not propagated to a queue in the non-Oracle database, as they would be in an Oracle-only Streams environment. Instead, the apply process applies the changes directly through a database link to the non-Oracle database.

See Also: Chapter 4, "Streams Apply Process" for detailed information about the apply process

Apply Process Configuration in an Oracle to Non-Oracle Environment

This section describes the configuration of an apply process that will apply changes to a non-Oracle database.

Database Link to the Non-Oracle Database When you create an apply process that will apply changes to a non-Oracle database, you must previously have configured Heterogeneous Services, the gateway, and a database link, which will be used by the apply process to apply the changes to the non-Oracle database. The database link must be created with an explicit `CONNECT TO` clause.

When the database link is created and working properly, create the apply process using the `CREATE_APPLY` procedure in the `DBMS_APPLY_ADM` package and specify the database link for the `apply_database_link` parameter. After you create an apply process, you can use apply process rules to specify which changes are applied at the non-Oracle database.

See Also:

- *Oracle9i Heterogeneous Connectivity Administrator's Guide* for more information about Heterogeneous Services and gateways
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the procedures in the `DBMS_APPLY_ADM` package
- Chapter 6, "How Rules Are Used In Streams" for information about specifying apply process rules

Substitute Key Columns If you use substitute key columns for any of the tables at the non-Oracle database, then specify the database link to the non-Oracle database when you run the `SET_KEY_COLUMNS` procedure in the `DBMS_APPLY_ADM` package.

See Also:

- "Substitute Key Columns" on page 4-10
- "Managing the Substitute Key Columns for a Table" on page 13-27

Parallelism You must set the `parallelism` apply process parameter to `1` when the apply process is applying changes to a non-Oracle database. Currently, parallel apply to non-Oracle databases is not supported.

DML Handlers If you use a DML handler to process row LCRs for any of the tables at the non-Oracle database, then specify the database link to the non-Oracle database when you run the SET_DML_HANDLER procedure in the DBMS_APPLY_ADM package.

See Also:

- "Event Processing Options" on page 4-3
- "Managing a DML Handler" on page 13-14

Message Handlers If you want to use a message handler process user-enqueued messages for a non-Oracle database, then specify the database link to the non-Oracle database using the apply_database_link parameter when you run the CREATE_APPLY procedure in the DBMS_APPLY_ADM package.

See Also:

- "Event Processing Options" on page 4-3
- "Managing the Message Handler for an Apply Process" on page 13-13

Error and Conflict Handlers Currently, error handlers and conflict handlers are not supported when sharing data from an Oracle database to a non-Oracle database. If an apply error occurs, then the transaction containing the LCR that caused the error is moved into the error queue in the Oracle database.

Datatypes Applied at Non-Oracle Databases

When applying changes to a non-Oracle database, an apply process applies changes made to columns of only the following datatypes:

- CHAR
- VARCHAR2
- NCHAR
- NVARCHAR2
- NUMBER
- DATE
- RAW
- TIMESTAMP

- TIMESTAMP WITH TIME ZONE
- TIMESTAMP WITH LOCAL TIME ZONE
- INTERVAL YEAR TO MONTH
- INTERVAL DAY TO SECOND

The apply process does not apply changes in columns of the following datatypes to non-Oracle databases: CLOB, NCLOB, BLOB, BFILE, LONG, LONG RAW, ROWID, UROWID, and user-defined type (including object types, REFs, varrays, and nested tables). The apply process raises an error when an LCR contains a datatype that is not listed, and the transaction containing the LCR that caused the error is moved to the error queue in the Oracle database.

Each transparent gateway may have further limitations regarding datatypes. For a datatype to be supported in an Oracle to non-Oracle environment, the datatype must be supported by both Streams and the gateway being used.

See Also:

- *Oracle9i SQL Reference* for more information about these datatypes
- Your Oracle supplied gateway-specific documentation for information about transparent gateways

Types of DML Changes Applied at Non-Oracle Databases

When you specify that DML changes made to certain tables should be applied at a non-Oracle database, an apply process can apply only the following types of DML changes:

- INSERT
- UPDATE
- DELETE

Note: The apply process cannot apply DDL changes at non-Oracle databases.

Instantiation in an Oracle to Non-Oracle Environment

Before you start an apply process that applies changes to a non-Oracle database, complete the following steps to instantiate each table at the non-Oracle database:

1. Use the DBMS_HS_PASSTHROUGH package or the tools supplied with the non-Oracle database to create the table at the non-Oracle database.
2. Populate the table writing a PL/SQL block (or a C program) that fetches row by row from the table at the Oracle database and then does a row by row INSERT into the table at the non-Oracle database. All fetches should be done at the same SCN.
3. Use the SET_TABLE_INSTANTIATION_SCN procedure in the DBMS_APPLY_ADM package to instruct the apply process to skip all LCRs with changes that occurred before the SCN you used in Step 2. Make sure you set the apply_database_link parameter to the database link for the remote non-Oracle database.

See Also:

- *Oracle9i Heterogeneous Connectivity Administrator's Guide* and your Oracle supplied gateway-specific documentation for more information about Heterogeneous Services and transparent gateways
- "Setting Instantiation SCNs at a Destination Database" on page 13-35 and *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the SET_TABLE_INSTANTIATION_SCN procedure in the DBMS_APPLY_ADM package

Transformations in an Oracle to Non-Oracle Environment

In an Oracle to non-Oracle environment, you can specify rule-based transformations during capture or apply the same way as you would in an Oracle-only environment. In addition, if your environment propagates LCRs to one or more intermediate Oracle databases before they are applied at a non-Oracle database, then you can specify a rule-based transformation during propagation from a queue at an Oracle database to another queue at an Oracle database.

See Also: "Rule-Based Transformations" on page 6-23

Messaging Gateway

Messaging Gateway is a feature of the Oracle database that provides propagation between Oracle queues and non-Oracle message queuing systems. Messages enqueued into an Oracle queue are automatically propagated to a non-Oracle queue, and the messages enqueued into a non-Oracle queue are automatically propagated to an Oracle queue. It provides guaranteed message delivery to the non-Oracle messaging system and supports the native message format for the non-Oracle messaging system. It also supports specification of user-defined transformations that are invoked while propagating from an Oracle queue to the non-Oracle messaging system or from the non-Oracle messaging system to an Oracle queue.

> **See Also:** *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about the Messaging Gateway

Error Handling in an Oracle to Non-Oracle Environment

If the apply process encounters an unhandled error when it tries to apply an LCR at a non-Oracle database, then the transaction containing the LCR is placed in the error queue in the Oracle database that is running the apply process. The apply process detects data conflicts in the same way as it does in an Oracle-only environment, but automatic conflict resolution is not supported currently in an Oracle to non-Oracle environment. Therefore, any data conflicts encountered are treated as apply errors.

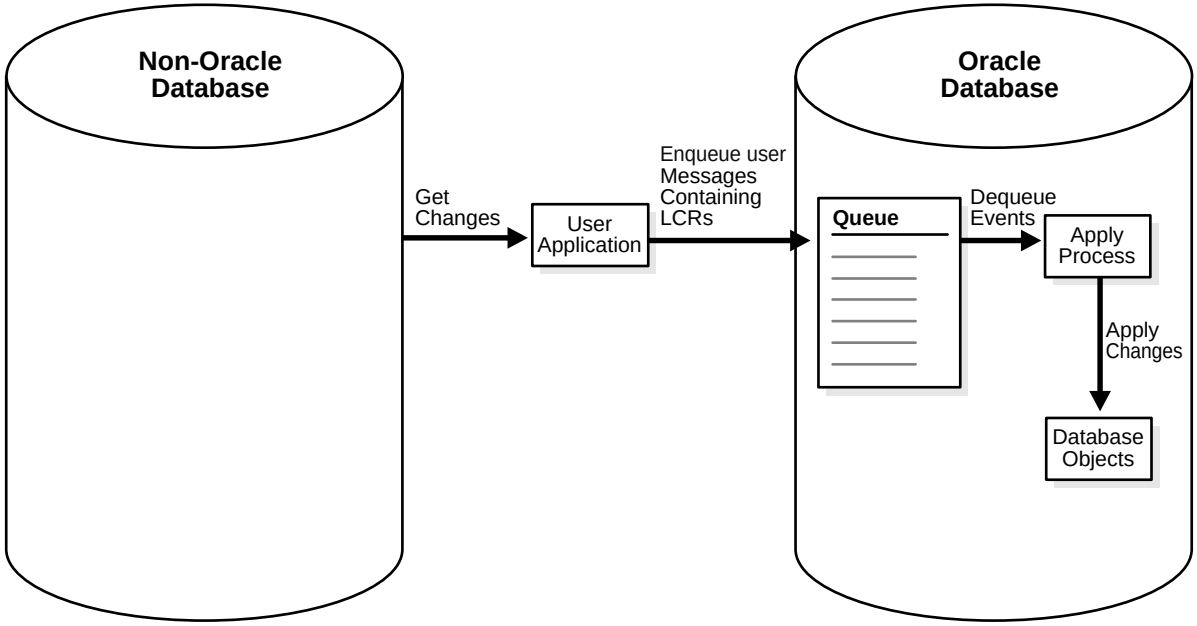
Example Oracle to Non-Oracle Streams Environment

"Single Source Database in a Heterogeneous Environment" on page 19-2 contains a detailed example that includes sharing data in an Oracle to non-Oracle Streams environment.

Non-Oracle to Oracle Data Sharing with Streams

To capture and propagate changes from a non-Oracle database to an Oracle database, a custom application is required. This application gets the changes made to the non-Oracle database by reading from transaction logs, by using triggers, or by some other method. The application must assemble and order the transactions and must convert each change into a logical change record (LCR). Then, the application must enqueue the LCRs into a queue in an Oracle database using the DBMS_AQ package. The application must commit after enqueuing all LCRs in each transaction. Figure 9–2 shows a non-Oracle databases sharing data with an Oracle database.

Figure 9–2 Non-Oracle to Oracle Heterogeneous Data Sharing



Change Capture and Staging in a Non-Oracle to Oracle Environment

Because the custom user application is responsible for assembling changes at the non-Oracle database into LCRs and enqueuing the LCRs into a queue at the Oracle database, the application is completely responsible for change capture. This means that the application must construct LCRs that represent changes at the non-Oracle database and then enqueue these LCRs into the queue at the Oracle database. The application must enqueue transactions serially in the same order as the transactions committed on the non-Oracle source database.

If you want to ensure the same transactional consistency at both the Oracle database where changes are applied and the non-Oracle database where changes originate, then you must use a transactional queue to stage the LCRs at the Oracle database. For example, suppose a single transaction contains three row changes, and the custom application enqueues three row LCRs, one for each change, and then commits. With a transactional queue, a commit is performed by the apply process after the third row LCR, retaining the consistency of the transaction. If you use a nontransactional queue, then a commit is performed for each row LCR by the apply process. The `SET_UP_QUEUE` procedure in the `DBMS_STREAMS_ADM` package creates a transactional queue automatically.

See Also:

- "Constructing and Enqueuing LCRs" on page 15-2
- "SYS.AnyData Queues and User Messages" on page 3-12

Change Apply in a Non-Oracle to Oracle Environment

In a non-Oracle to Oracle environment, the apply process functions the same way as it would in an Oracle-only environment. That is, it dequeues each event from its associated queue based on apply process rules, performs any rule-based transformation, and either sends the event to a handler or applies it directly. Error handling and conflict resolution also function the same as they would in an Oracle-only environment. So, you can specify a prebuilt update conflict handler or create a custom conflict handler to resolve conflicts.

See Also:

- Chapter 4, "Streams Apply Process"
- Chapter 5, "Rules"
- Chapter 7, "Streams Conflict Resolution"
- "Rule-Based Transformations" on page 6-23

Instantiation from a Non-Oracle Database to an Oracle Database

There is no automatic way to instantiate tables that exist at a non-Oracle database at an Oracle database. However, you can perform the following general procedure to instantiate a table manually:

1. At the non-Oracle database, use a non-Oracle utility to export the table to a flat file.
2. At the Oracle database, create an empty table that matches the table at the non-Oracle database.
3. At the Oracle database, use SQL*Loader to load the contents of the flat file into the table.

Non-Oracle to Non-Oracle Data Sharing with Streams

Streams supports data sharing between two non-Oracle databases through a combination of non-Oracle to Oracle data sharing and Oracle to non-Oracle data sharing. Such an environment would use Streams in an Oracle database as an intermediate database between two non-Oracle databases.

For example, a non-Oracle to non-Oracle environment may consist of the following databases:

- A non-Oracle database named `het1.net`
- An Oracle database named `dbs1.net`
- A non-Oracle database named `het2.net`

A user application assembles changes at `het1.net` and enqueues them into a queue in `dbs1.net`. Then, the apply process at `dbs1.net` applies the changes to `het2.net` using Heterogeneous Services and a gateway. Another apply process at `dbs1.net` could apply some or all of the changes in the queue locally at `dbs1.net`. One or more propagation jobs at `dbs1.net` could propagate some or all of the changes in the queue to other Oracle databases.

Part II

Streams Administration

This part describes managing a Streams environment, including step-by-step instructions for configuring, administering, monitoring and troubleshooting. This part contains the following chapters:

10

Configuring a Streams Environment

This chapter provides instructions for preparing a database or a distributed database environment to use Streams and for configuring a Streams environment.

This chapter contains these topics:

Configuring a Streams Administrator

To manage a Streams environment, either create a new user with the appropriate privileges or grant these privileges to an existing user. You should not use the SYS or SYSTEM user as a Streams administrator, and the Streams administrator should not use the SYSTEM tablespace as its default tablespace.

Complete the following steps to configure a Streams administrator at each database in the environment that will use Streams:

1. Connect as an administrative user who can create users, grant privileges, create tablespaces, and alter users.
2. Create a new user to act as the Streams administrator or use an existing user. For example, to create a new user named `strmadmin`, run the following statement:

```
CREATE USER strmadmin IDENTIFIED BY strmadminpw;
```

> **Note:** To ensure security, use a password other than `strmadminpw` for the Streams administrator.

3. Grant the Streams administrator at least the following privileges:

```
GRANT CONNECT, RESOURCE TO strmadmin;
GRANT EXECUTE ON DBMS_AQADM TO strmadmin;
GRANT EXECUTE ON DBMS_STREAMS_ADM TO strmadmin;

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/
```

4. If necessary, grant the Streams administrator the following privileges:

   - EXECUTE privilege on the DBMS_APPLY_ADM package if the Streams administrator will manage one or more apply processes on the database
   - EXECUTE privilege on the DBMS_CAPTURE_ADM package if the Streams administrator will manage one or more capture processes on the database
   - EXECUTE privilege on the DBMS_PROPAGATION_ADM package if the Streams administrator will manage one or more propagation jobs on the database
   - EXECUTE privilege on the DBMS_FLASHBACK package if the Streams administrator will need to obtain the current SCN for a database. Typically, the Streams administrator must determine the current SCN to set an instantiation SCN using the SET_TABLE_INSTANTIATION_SCN, SET_SCHEMA_INSTANTIATION_SCN, or SET_GLOBAL_INSTANTIATION_SCN procedure in the DBMS_APPLY_ADM package.
   - SELECT_CATALOG_ROLE if you want to enable the Streams administrator to monitor the environment easily
   - SELECT ANY DICTIONARY privilege if you plan to use the Streams tool in Oracle Enterprise Manager
   - SELECT privilege on the DBA_APPLY_ERROR data dictionary view if you want the Streams administrator to be able to select from this view within a PL/SQL subprogram. See "Displaying Detailed Information About Apply Errors" on page 16-36 for an example of such a PL/SQL subprogram.
   - If no apply user is specified for an apply process, then the necessary privileges to perform DML and DDL changes on the apply objects owned by another user. If an apply user is specified, then the apply user must have these privileges.
   - If no apply user is specified for an apply process, then EXECUTE privilege on any PL/SQL procedure owned by another user that is executed by a Streams an apply process. These procedures may be used in apply handlers. If an apply user is specified, then the apply user must have these privileges

- EXECUTE privilege on any PL/SQL function owned by another user that is specified in a rule-based transformation for a rule used by a Streams process or job. For an apply process, if an apply user is specified, then the apply user must have these privileges.
- If the Streams administrator does not own a queue used by a Streams process or job, and is not specified as the queue user for the queue when the queue is created, then the Streams administrator must be configured as a secure queue user of the queue. The Streams administrator may also need ENQUEUE or DEQUEUE privileges on the queue, or both.

5. Either create a tablespace for the Streams administrator or use an existing tablespace. For example, the following statement creates a new tablespace for the Streams administrator:

```
CREATE TABLESPACE streams_tbs DATAFILE '/usr/oracle/dbs/streams_tbs.dbf'
  SIZE 25 M REUSE AUTOEXTEND ON MAXSIZE UNLIMITED;
```

6. Specify the tablespace for the Streams administrator:

```
ALTER USER strmadmin DEFAULT TABLESPACE streams_tbs
                     QUOTA UNLIMITED ON streams_tbs;
```

7. Repeat all of the previous steps at each database in the environment that will use Streams.

See Also: "Enabling a User to Perform Operations on a Secure Queue" on page 12-3

Setting Initialization Parameters Relevant to Streams

Table 10–1 lists initialization parameters that are important for the operation, reliability, and performance of a Streams environment. Set these parameters appropriately for your Streams environment.

See Also: *Oracle9i Database Reference* for more information about these initialization parameters

Table 10–1 Initialization Parameters Relevant to Streams **(Page 1 of 3)**

Parameter	Values	Description
ARCHIVE_LAG_TARGET	**Default**: 0 **Range**: 0 or any integer in [60, 7200]	Limits the amount of data that can be lost and effectively increases the availability of the standby database by forcing a log switch after a user-specified time period elapses. If you are using Streams in a Real Application Clusters environment, then set this parameter to a value greater than zero to switch the log files automatically. **See Also**: "Streams Capture Process and Oracle Real Application Clusters" on page 2-11
AQ_TM_PROCESSES	**Default**: 0 **Range**: 0 to 10	Establishes queue monitor processes. Setting the parameter to 1 or more starts the specified number of queue monitor processes. These queue monitor processes are responsible for managing time-based operations of messages such as delay and expiration, cleaning up retained messages after the specified retention time, and cleaning up consumed messages if the retention time is zero. If you want to enqueue user events into a Streams queue, then set this parameter to 1 or higher. User events are those created by users and applications, not by a Streams capture process.
COMPATIBLE	**Default**: 8.1.0 **Range**: 8.1.0 to Current Release Number	This parameter specifies the release with which the Oracle server must maintain compatibility. Oracle servers with different compatibility levels can interoperate. To use Streams, this parameter must be set to 9.2.0 or higher.
GLOBAL_NAMES	**Default**: false **Range**: true or false	Specifies whether a database link is required to have the same name as the database to which it connects. If you want to use Streams to share information between databases, then set this parameter to true at each database that is participating in your Streams environment.

Table 10–1 Initialization Parameters Relevant to Streams **(Page 2 of 3)**

Parameter	Values	Description
JOB_QUEUE_PROCESSES	**Default:** 0 **Range:** 0 to 1000	Specifies the number of J*n* job queue processes for each instance (J000 ... J999). Job queue processes handle requests created by DBMS_JOB. You can change the setting for JOB_QUEUE_PROCESSES dynamically by using the ALTER SYSTEM statement. This parameter must be set to at least 2 at each database that is propagating events in your Streams environment, and should be set to the same value as the maximum number of jobs that can run simultaneously plus two.
LOG_PARALLELISM	**Default:** 1 **Range:** 1 to 255	Specifies the level of concurrency for redo allocation within Oracle. If you plan to run one or more capture processes on a database, then this parameter must be set to 1. Setting this parameter to 1 does not affect the parallelism of capture. You can set parallelism for a capture process using the SET_PARAMETER procedure in the DBMS_CAPTURE_ADM package.
LOGMNR_MAX_PERSISTENT_SESSIONS	**Default:** 1 **Range:** 1 to LICENSE_MAX_SESSIONS	Specifies the maximum number of persistent LogMiner mining sessions that are concurrently active when all sessions are mining redo logs generated by instances. If you plan to run multiple Streams capture processes on a single database, then set this parameter equal to or higher than the number of planned capture processes.
OPEN_LINKS	**Default:** 4 **Range:** 0 to 255	Specifies the maximum number of concurrent open connections to remote databases in one session. These connections include database links, as well as external procedures and cartridges, each of which uses a separate process. In a Streams environment, make sure this parameter is set to the default value of 4 or higher.

Table 10–1 Initialization Parameters Relevant to Streams **(Page 3 of 3)**

Parameter	Values	Description
PARALLEL_MAX_SERVERS	**Default**: Derived from the values of the following parameters: CPU_COUNT PARALLEL_AUTOMATIC_TUNING PARALLEL_ADAPTIVE_MULTI_USER **Range**: 0 to 3599	Specifies the maximum number of parallel execution processes and parallel recovery processes for an instance. As demand increases, Oracle will increase the number of processes from the number created at instance startup up to this value. In a Streams environment, each capture process and apply process may use multiple parallel execution servers. Set this initialization parameter to an appropriate value to ensure that there are enough parallel execution servers.
PROCESSES	**Default**: Derived from PARALLEL_MAX_SERVERS **Range**: 6 to operating system dependent limit	Specifies the maximum number of operating system user processes that can simultaneously connect to Oracle. Make sure the value of this parameter allows for all background processes, such as locks, job queue processes, and parallel execution processes. In Streams, capture processes and apply processes use background processes and parallel execution processes, and propagation jobs use job queue processes.
SHARED_POOL_SIZE	**Default**: 32-bit platforms: 8 MB, rounded up to the nearest granule size 64-bit platforms: 64 MB, rounded up to the nearest granule size **Range**: Minimum: the granule size Maximum: operating system-dependent	Specifies (in bytes) the size of the shared pool. The shared pool contains shared cursors, stored procedures, control structures, and other structures. You should increase the size of the shared pool by 10 MB for each capture process on a database.
SGA_MAX_SIZE	**Default**: Initial size of SGA at startup **Range**: 0 to operating system dependent limit	Specifies the maximum size of SGA for the lifetime of a database instance. If you plan to run multiple capture processes on a single database, then you may need to increase the size of this parameter.

Setting Export and Import Parameters Relevant to Streams

This section describes Export and Import utility parameters that are relevant to Streams.

> **See Also:** *Oracle9i Database Utilities* for information about performing a exports and imports

Export Utility Parameters Relevant to Streams

The following Export utility parameter is relevant to Streams.

OBJECT_CONSISTENT

The OBJECT_CONSISTENT Export utility parameter specifies whether or not the Export utility repeatedly uses the SET TRANSACTION READ ONLY statement to ensure that the exported data and the exported procedural actions for each object are consistent to a single point in time. If OBJECT_CONSISTENT is set to Y, then each object is exported in its own read-only transaction, even if it is partitioned. In contrast, if you use the CONSISTENT parameter, then there is only one read-only transaction.

When you perform an instantiation in a Streams environment, some degree of consistency is required in the export dump file. The OBJECT_CONSISTENT Export utility parameter is sufficient to ensure this consistency for Streams instantiations. If you are using an export dump file for other purposes in addition to a Streams instantiation, and these other purposes have more stringent consistency requirements than that provided by OBJECT_CONSISTENT, then you can use Export utility parameters CONSISTENT, FLASHBACK_SCN, or FLASHBACK_TIME for Streams instantiations.

By default the OBJECT_CONSISTENT Export utility parameter is set to N. Specify y when an export is performed as part of a Streams instantiation and no more stringent Export utility parameter is needed.

Attention: During an export for a Streams instantiation, make sure no DDL changes are made to objects being exported.

Import Utility Parameters Relevant to Streams

The following Import utility parameters are relevant to Streams.

STREAMS_INSTANTIATION

The STREAMS_INSTANTIATION Import utility parameter specifies whether to import Streams instantiation metadata that may be present in the export dump file. When this parameter is set to Y, the import session sets its Streams tag to the hexadecimal equivalent of '00' to avoid cycling the changes made by the import. Redo entries resulting from the import have this tag value.

By default the STREAMS_INSTANTIATION Import utility parameter is set to N. Specify y when an import is performed as part of a Streams instantiation.

See Also: Chapter 8, "Streams Tags"

STREAMS_CONFIGURATION

The STREAMS_CONFIGURATION Import utility parameter specifies whether to import any general Streams metadata that may be present in the export dump file.

By default the STREAMS_CONFIGURATION Import utility parameter is set to Y. Typically, specify y if an import is part of a backup or restore operation.

Configuring a Database to Run a Streams Capture Process

The following sections describe database requirements for running a Streams capture process:

- Configuring the Database to Run in ARCHIVELOG Mode
- Specifying an Alternate Tablespace for LogMiner

In addition to these tasks, make sure the initialization parameters are set properly on any database that will run a capture process.

See Also: "Setting Initialization Parameters Relevant to Streams" on page 10-4

Configuring the Database to Run in ARCHIVELOG Mode

Any database where changes are captured by a capture process must be running in ARCHIVELOG mode.

See Also:

- "ARCHIVELOG Mode and a Capture Process" on page 2-19
- *Oracle9i Database Administrator's Guide* for information about running a database in ARCHIVELOG mode

Specifying an Alternate Tablespace for LogMiner

By default, the LogMiner tables are in the SYSTEM tablespace, but the SYSTEM tablespace may not have enough space for these tables once a capture process starts to capture changes. Therefore, you must create an alternate tablespace for the LogMiner tables.

The following example creates a tablespace named logmnrts for use by LogMiner:

1. Connect as an administrative user who has privileges to create tablespaces and execute subprograms in the DBMS_LOGMNR_D package.
2. Either create an alternate tablespace for the LogMiner tables or use an existing tablespace. For example, the following statement creates an alternate tablespace for the LogMiner tables:

   ```
   CREATE TABLESPACE logmnrts DATAFILE '/usr/oracle/dbs/logmnrts.dbf'
     SIZE 25 M REUSE AUTOEXTEND ON MAXSIZE UNLIMITED;
   ```

3. Run the SET_TABLESPACE procedure in the DBMS_LOGMNR_D package to set the alternate tablespace for LogMiner. For example, to specify a tablespace named logmnrts, run the following procedure:

   ```
   EXECUTE DBMS_LOGMNR_D.SET_TABLESPACE('logmnrts');
   ```

Configuring Network Connectivity and Database Links

If you plan to use Streams to share information between databases, then configure network connectivity and database links between these databases:

- For Oracle databases, configure your network and Oracle Net so that the databases can communicate with each other.

  See Also: *Oracle9i Net Services Administrator's Guide*

- For non-Oracle databases, configure an Oracle gateway for communication between the Oracle database and the non-Oracle database.

  See Also: *Oracle9i Heterogeneous Connectivity Administrator's Guide*

- If you plan to propagate events from a source queue at a database to a destination queue at another database, then create a private database link between the database containing the source queue and the database containing the destination queue. Each database link should use a `CONNECT TO` clause for the user propagating events between databases.

  For example, to create a database link to a database named `dbs2.net` connecting as a Streams administrator named `strmadmin`, run the following statement:

  ```
  CREATE DATABASE LINK dbs2.net CONNECT TO strmadmin IDENTIFIED BY strmadminpw
     USING 'dbs2.net';
  ```

  See Also: *Oracle9i Database Administrator's Guide* for more information about creating database links

Configuring a Capture-Based Streams Environment

This section describes the general steps for performing the following tasks:

- Creating a New Streams Single Source Environment
- Adding Shared Objects to an Existing Single Source Environment
- Adding a New Destination Database to an Existing Single Source Environment
- Creating a New Multiple Source Environment
- Adding Shared Objects to an Existing Multiple Source Environment
- Adding a New Database to an Existing Multiple Source Environment

---

Note: The instructions in the following sections assume you will use the `DBMS_STREAMS_ADM` package to configure your Streams environment. If you use other packages, then extra steps may be necessary for each task.

See Also: Chapter 19, "Example Streams Replication Environments" for detailed examples of configuring Streams capture-based environments

Creating a New Streams Single Source Environment

This section lists the general steps to perform when creating a new single source Streams environment. A single source environment is one in which there is only one source database for shared data. There may be more than one source database in a single source environment, but two source databases do not capture any of the same data.

Before starting capture processes and configuring propagation jobs in a new Streams environment, make sure any propagation jobs or apply processes that will receive events are configured to handle these events. That is, the propagation jobs or apply processes should exist, and each one should be associated with a rule set that handles the events appropriately. If these propagation jobs and apply processes are not configured properly to handle these events, then events may be lost.

In general, if you are configuring a new Streams environment in which changes for shared objects are captured at one database and then propagated and applied at remote databases, then you should configure the environment in the following order:

1. Complete the necessary tasks described previously in this chapter to prepare each database in your environment for Streams:
   - "Configuring a Streams Administrator" on page 10-2
   - "Setting Initialization Parameters Relevant to Streams" on page 10-4
   - "Configuring a Database to Run a Streams Capture Process" on page 10-9
   - "Configuring Network Connectivity and Database Links" on page 10-11

   Some of these tasks may not be required at certain databases.
2. Create any necessary Streams queues that do not already exist. When you create a capture process or apply process, you associate the process with a specific Streams queue. When you create a propagation job, you associate it with a specific source queue and destination queue. See "Creating a Streams Queue" on page 12-2 for instructions.
3. Specify supplemental logging at each source database for any shared object. See "Specifying Supplemental Logging at a Source Database" on page 11-9 for instructions.
4. At each database, create the required capture processes, propagation jobs, and apply processes for your environment. You can create these processes and jobs in any order.
   - Create one or more capture processes at each database that will capture changes. Make sure each capture process uses a rule set that is appropriate for capturing changes. Do not start the capture processes you create. See "Creating a Capture Process" on page 11-2 for instructions.

     When you use the `DBMS_STREAMS_ADM` package to add the capture rules, it automatically runs the `PREPARE_TABLE_INSTANTIATION`, `PREPARE_SCHEMA_INSTANTIATION`, or `PREPARE_GLOBAL_INSTANTIATION` procedure in the `DBMS_CAPTURE_ADM` package for the specified table, specified schema, or entire database, respectively.

You must run the appropriate procedure to prepare for instantiation manually if any of the following conditions is true:

- You use the DBMS_RULE_ADM package to add or modify capture rules.
- You use an existing capture process and do not add capture rules for any shared object.

If you must prepare for instantiation manually, then see "Preparing Database Objects for Instantiation at a Source Database" on page 11-11 for instructions.

- Create all propagation jobs that propagate the captured events from a source queue to a destination queue. Make sure each propagation job uses a rule set that is appropriate for propagating changes. See "Creating a Propagation Job" on page 12-8 for instructions.
- Create one or more apply processes at each database that will apply changes. Make sure each apply process uses a rule set that is appropriate for applying changes. Do not start the apply processes you create. See "Creating an Apply Process" on page 13-2 for instructions.

5. Either instantiate, or set the instantiation SCN for, each database object for which changes are applied by an apply process. If a database object does not exist at a destination database, then instantiate it using Export/Import. If a database object already exists at a destination database, then set the instantiation SCN for it manually.

   - To instantiate database objects using Export/Import, first export them at the source database with the OBJECT_CONSISTENT export parameter set to Y, or use a more stringent degree of consistency. Then, import them at the destination database with the STREAMS_INSTANTIATION import parameter set to Y. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for information.
   - To set the instantiation SCN for a table, schema, or database manually, run the appropriate procedure or procedures in the DBMS_APPLY_ADM package at the destination database:
     - SET_TABLE_INSTANTIATION_SCN
     - SET_SCHEMA_INSTANTIATION_SCN
     - SET_GLOBAL_INSTANTIATION_SCN

When you run one of these procedures, you must ensure that the shared objects at the destination database are consistent with the source database as of the instantiation SCN.

If you run `SET_GLOBAL_INSTANTIATION_SCN` at a destination database, then you must also run `SET_SCHEMA_INSTANTIATION_SCN` for each existing schema in the source database whose DDL changes you are applying, and you must run `SET_TABLE_INSTANTIATION_SCN` for each existing table in the source database whose DML or DDL changes you are applying.

If you run `SET_SCHEMA_INSTANTIATION_SCN` at a destination database, then you must also run `SET_TABLE_INSTANTIATION_SCN` for each existing source database table in the schema whose DML or DDL changes you are applying.

See "Setting Instantiation SCNs Using a DBMS_APPLY_ADM Package Procedure" on page 13-38 for instructions.

Alternatively, you can perform a metadata export/import to set the instantiation SCNs for existing database objects. If you choose this option, then make sure no rows are imported. Also, make sure the shared objects at all of the destination databases are consistent with the source database that performed the export at the time of the export. If you are sharing DML changes only, then table level export/import is sufficient. If you are sharing DDL changes also, then additional considerations apply. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for more information about performing a metadata export/import.

6. Start each apply process you created in Step 4. See "Starting an Apply Process" on page 13-7 for instructions.
7. Start each capture process you created in Step 4. See "Starting a Capture Process" on page 11-5 for instructions.

When you are configuring the environment, remember that capture processes and apply processes are stopped when they are created, but propagation jobs are scheduled to propagate events immediately when they are created. The capture process must be created before the relevant objects are instantiated at a remote destination database. You must create the propagation jobs and apply processes before starting the capture process, and you must instantiate the objects before running the whole stream.

See Also: "Single Source Database in a Heterogeneous Environment" on page 19-2 for a detailed example that sets up a single source environment

Adding Shared Objects to an Existing Single Source Environment

You add existing database objects to an existing single source environment by adding the necessary rules to the appropriate capture processes, propagation jobs, and apply processes. Before creating or altering capture or propagation rules in a running Streams environment, make sure any propagation jobs or apply processes that will receive events as a result of the new or altered rules are configured to handle these events. That is, the propagation jobs or apply processes should exist, and each one should be associated with a rule set that handles the events appropriately. If these propagation jobs and apply processes are not configured properly to handle these events, then events may be lost.

For example, suppose you want to add a table to a Streams environment that already captures, propagates, and applies changes to other tables. Assume only one capture process will capture changes to this table, and only one apply process will apply changes to this table. In this case, you must add one or more table-level rules to the following rule sets:

- The rule set for the capture process that will capture changes to the table
- The rule set for each propagation job that will propagate changes to the table
- The rule set for the apply process that will apply changes to the table

If you perform administrative steps in the wrong order, you may lose events. For example, if you add the rule to the capture rule set first, without stopping the capture process, then the propagation job will not propagate the changes if it does not have a rule that instructs it to do so, and the changes may be lost.

To avoid losing events, you should complete the configuration in the following order:

1. Either stop the capture process, disable one of the propagation jobs, or stop the apply processes. See one of the following sections for instructions:
   - "Stopping a Capture Process" on page 11-14
   - "Disabling a Propagation Job" on page 12-16
   - "Stopping an Apply Process" on page 13-7

2. Add the relevant rules to the rule sets for the propagation jobs and the apply processes. See the following sections for instructions:
   - "Adding Rules to the Rule Set for a Propagation Job" on page 12-14
   - "Adding Rules to the Rule Set for an Apply Process" on page 13-8
3. Add the relevant rules to the rule set used by the capture process. See "Adding Rules to the Rule Set for a Capture Process" on page 11-5 for instructions.

   When you use the `DBMS_STREAMS_ADM` package to add the capture rules, it automatically runs the `PREPARE_TABLE_INSTANTIATION`, `PREPARE_SCHEMA_INSTANTIATION`, or `PREPARE_GLOBAL_INSTANTIATION` procedure in the `DBMS_CAPTURE_ADM` package for the specified table, specified schema, or entire database, respectively.

   You must run the appropriate procedure to prepare for instantiation manually if any of the following conditions is true:
   - You use `DBMS_RULE_ADM` to create or modify rules in the capture process rule set.
   - You do not add rules for the added objects to the capture process rule set, because the capture process already captures changes to these objects. In this case, rules for the objects may be added to propagation jobs and apply processes in the environment, but not to the capture process.

   If you must prepare for instantiation manually, then see "Preparing Database Objects for Instantiation at a Source Database" on page 11-11 for instructions.
4. At each destination database, either instantiate, or set the instantiation SCN for, each database object you are adding to the Streams environment. If a database objects does not exist at a destination database, then instantiate it using Export/Import. If a database object exists at a destination database, then set the instantiation SCN for it.
   - To instantiate a database objects using Export/Import, first export them at the source database with the `OBJECT_CONSISTENT` export parameter set to `Y`, or use a more stringent degree of consistency. Then, import them at the destination database with the `STREAMS_INSTANTIATION` import parameter set to `Y`. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for information.

- To set the instantiation SCN for a table, schema, or database manually, run the appropriate procedure or procedures in the DBMS_APPLY_ADM package at a destination database:
  - SET_TABLE_INSTANTIATION_SCN
  - SET_SCHEMA_INSTANTIATION_SCN
  - SET_GLOBAL_INSTANTIATION_SCN

  When you run one of these procedures at a destination database, you must ensure that every added object at the destination database is consistent with the source database as of the instantiation SCN.

  If you run SET_GLOBAL_INSTANTIATION_SCN at a destination database, then you must also run SET_SCHEMA_INSTANTIATION_SCN for each existing source database schema whose changes you are applying and SET_TABLE_INSTANTIATION_SCN for each existing source database table whose changes you are applying.

  If you run SET_SCHEMA_INSTANTIATION_SCN at a destination database, then you must also run SET_TABLE_INSTANTIATION_SCN for each existing source database table in the schema whose DML or DDL changes you are applying.

  See "Setting Instantiation SCNs Using a DBMS_APPLY_ADM Package Procedure" on page 13-38 for instructions.

  Alternatively, you can perform a metadata export/import to set the instantiation SCNs for existing database objects. If you choose this option, then make sure no rows are imported. Also, make sure every added object at the importing destination database is consistent with the source database that performed the export at the time of the export. If you are sharing DML changes only, then table level export/import is sufficient. If you are sharing DDL changes also, then additional considerations apply. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for more information about performing a metadata export/import.

5. Start any process you stopped in Step 1 or enable any job you disabled in Step 1. See one of the following sections for instructions:
   - "Starting a Capture Process" on page 11-5
   - "Enabling a Propagation Job" on page 12-11
   - "Starting an Apply Process" on page 13-7

You must stop the capture process, disable one of the propagation jobs, or stop the apply process in Step 1 to ensure that the table or schema is instantiated before the first LCR resulting from the added rule(s) reaches the apply process. Otherwise, events could be lost or could result in apply errors, depending on whether the apply rule(s) have been added.

If you are certain that the added table is not being modified at the source database during this procedure, and that there are no LCRs for the table already in the stream or waiting to be captured, then you can perform Step 5 before Step 4 to reduce the amount of time that a process or job is stopped.

> **See Also:** "Adding Objects to an Existing Streams Replication Environment" on page 19-59 for a detailed example that adds objects to an existing single source environment

Adding a New Destination Database to an Existing Single Source Environment

You add a destination database to an existing single source environment by creating one or more new apply processes at the new destination database and, if necessary, configuring one or more propagation jobs to propagate changes to the new destination database. You may also need to add rules to existing propagation jobs in the stream that propagates to the new destination database.

As in the example that describes "Adding Shared Objects to an Existing Single Source Environment" on page 10-16, before creating or altering propagation rules in a running Streams environment, make sure any propagation jobs or apply processes that will receive events as a result of the new or altered rules are configured to handle these events. Otherwise, events may be lost.

To avoid losing events, you should complete the configuration in the following order:

1. Complete the necessary tasks described previously in this chapter to prepare the new destination database for Streams:
   - "Configuring a Streams Administrator" on page 10-2
   - "Setting Initialization Parameters Relevant to Streams" on page 10-4
   - "Configuring Network Connectivity and Database Links" on page 10-11

   Some of these tasks may not be required at the new database.
2. Create any necessary Streams queues that do not already exist at the destination database. When you create an apply process, you associate the apply process with a specific Streams queue. See "Creating a Streams Queue" on page 12-2 for instructions.
3. Create one or more apply processes at the new destination database to apply the changes from its source databases. Make sure each apply process uses a rule set that is appropriate for applying changes. Do not start any apply process at the new database. See "Creating an Apply Process" on page 13-2 for instructions.

   Keeping the apply processes stopped prevents changes made at the source databases from being applied before the instantiation of the new database is completed, which would otherwise lead to incorrect data and errors.
4. Configure any necessary propagation jobs to propagate changes from the source databases to the new destination database. Make sure each propagation job uses a rule set that is appropriate for propagating changes. See "Creating a Propagation Job" on page 12-8.
5. At the source database, prepare for instantiation each database object for which changes will be applied by an apply process at the new destination database. Run either the `PREPARE_TABLE_INSTANTIATION`, `PREPARE_SCHEMA_INSTANTIATION`, or `PREPARE_GLOBAL_INSTANTIATION` procedure in the `DBMS_CAPTURE_ADM` package for the specified table, specified schema, or entire database, respectively. See "Preparing Database Objects for Instantiation at a Source Database" on page 11-11 for instructions.

6. At the new destination database, either instantiate, or set the instantiation SCNs for, each database object for which changes will be applied by an apply process. If the database objects do not already exist at the new destination database, then instantiate them using Export/Import. If the database objects exist at the new destination database, then set the instantiation SCN for them.

   - To instantiate database objects using Export/Import, first export them at the source database with the `OBJECT_CONSISTENT` export parameter set to `Y`, or use a more stringent degree of consistency. Then, import them at the new destination database with the `STREAMS_INSTANTIATION` import parameter set to `Y`. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for information.
   - To set the instantiation SCN for a table, schema, or database manually, run the appropriate procedure or procedures in the `DBMS_APPLY_ADM` package at the new destination database:
     - `SET_TABLE_INSTANTIATION_SCN`
     - `SET_SCHEMA_INSTANTIATION_SCN`
     - `SET_GLOBAL_INSTANTIATION_SCN`

     When you run one of these procedures, you must ensure that the shared objects at the new destination database are consistent with the source database as of the instantiation SCN.

     If you run `SET_GLOBAL_INSTANTIATION_SCN` at a destination database, then you must also run `SET_SCHEMA_INSTANTIATION_SCN` for each existing schema in the source database whose DDL changes you are applying, and you must run `SET_TABLE_INSTANTIATION_SCN` for each existing table in the source database whose DML or DDL changes you are applying.

     If you run `SET_SCHEMA_INSTANTIATION_SCN` at a destination database, then you must also run `SET_TABLE_INSTANTIATION_SCN` for each existing source database table in the schema whose DML or DDL changes you are applying.

     See "Setting Instantiation SCNs Using a DBMS_APPLY_ADM Package Procedure" on page 13-38 for instructions.

Alternatively, you can perform a metadata export/import to set the instantiation SCNs for existing database objects. If you choose this option, then make sure no rows are imported. Also, make sure the shared objects at the importing destination database are consistent with the source database that performed the export at the time of the export. If you are sharing DML changes only, then table level export/import is sufficient. If you are sharing DDL changes also, then additional considerations apply. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for more information about performing a metadata export/import.

7. Start the apply processes you created in Step 3. See "Starting an Apply Process" on page 13-7 for instructions.

See Also: "Adding a Database to an Existing Streams Replication Environment" on page 19-69 for detailed example that adds a database to an existing single source environment

Creating a New Multiple Source Environment

This section lists the general steps to perform when creating a new multiple source Streams environment. A multiple source environment is one in which there is more than one source database for any of the shared data.

This example uses the following terms:

- **Populated database:** A database that already contains the shared database objects before you create the new multiple source environment. You must have at least one populated database to create the new Streams environment.
- **Export database:** A populated database on which you perform an export of the shared database objects. This export is used to instantiate the shared database objects at the import databases. You may not have an export database if all of the databases in the environment are populated databases.
- **Import database:** A database that does not contain the shared database objects before you create the new multiple source environment. You instantiate the shared database objects at an import database using the export dump file from the export database. You may not have any import databases if all of the databases in the environment are populated databases.

Complete the following steps to create a new multiple source environment:

> **Note:** Make sure no changes are made to the objects being shared at the database you are adding to the Streams environment until the instantiation at the database is complete.

1. Complete the necessary tasks described previously in this chapter to prepare each database in the environment for Streams:
   - "Configuring a Streams Administrator" on page 10-2
   - "Setting Initialization Parameters Relevant to Streams" on page 10-4
   - "Configuring a Database to Run a Streams Capture Process" on page 10-9
   - "Configuring Network Connectivity and Database Links" on page 10-11

   Some of these tasks may not be required at certain databases.
2. At each populated database, specify any necessary supplemental logging for the shared objects. See "Specifying Supplemental Logging at a Source Database" on page 11-9 for instructions.
3. Create any necessary Streams queues that do not already exist. When you create a capture process or apply process, you associate the process with a specific Streams queue. When you create a propagation job, you associate it with a specific source queue and destination queue. See "Creating a Streams Queue" on page 12-2 for instructions.
4. At each database, create the required capture processes, propagation jobs, and apply processes for your environment. You can create these processes and jobs in any order.
   - Create one or more capture processes at each database that will capture changes. Make sure each capture process uses a rule set that is appropriate for capturing changes. Do not start the capture processes you create. See "Creating a Capture Process" on page 11-2 for instructions.

     When you use the `DBMS_STREAMS_ADM` package to add the capture rules, it automatically runs the `PREPARE_TABLE_INSTANTIATION`, `PREPARE_SCHEMA_INSTANTIATION`, or `PREPARE_GLOBAL_INSTANTIATION` procedure in the `DBMS_CAPTURE_ADM` package for the specified table, specified schema, or entire database, respectively.

You must run the appropriate procedure to prepare for instantiation manually if any of the following conditions is true:

- You use the DBMS_RULE_ADM package to add or modify capture rules.
- You use an existing capture process and do not add capture rules for any shared object.

If you must prepare for instantiation manually, then see "Preparing Database Objects for Instantiation at a Source Database" on page 11-11 for instructions.

- Create all propagation jobs that propagate the captured events from a source queue to a destination queue. Make sure each propagation job uses a rule set that is appropriate for propagating changes. See "Creating a Propagation Job" on page 12-8 for instructions.
- Create one or more apply processes at each database that will apply changes. Make sure each apply process uses a rule set that is appropriate for applying changes. Do not start the apply processes you create. See "Creating an Apply Process" on page 13-2 for instructions.

After completing these steps, complete the steps in each of the following sections that apply to your environment. You may need to complete the steps in only one of these sections or in both of these sections:

- For each populated database, complete the steps in "Configuring Populated Databases" on page 10-25.
- For each import database, complete the steps in "Adding Shared Objects to Import Databases" on page 10-26.

Configuring Populated Databases

After completing the steps in "Creating a New Multiple Source Environment" on page 10-22, complete the following steps for the populated databases:

1. For each populated database, set the instantiation SCN at each of the other populated databases in the environment. These instantiation SCNs must be set, and only the changes made at a particular populated database that are committed after the corresponding SCN for that database will be applied at another populated database.

   For each populated database, you can set these instantiation SCNs in one of the following ways:

   a. Perform a metadata only export of the shared objects at the populated database and import the metadata at each of the other populated databases. Such an import sets the required instantiation SCNs for the populated database at the other populated databases. Make sure no rows are imported. Also, make sure the shared objects at each populated database performing a metadata import are consistent with the populated database that performed the metadata export at the time of the export.

      If you are sharing DML changes only, then table level export/import is sufficient. If you are sharing DDL changes also, then additional considerations apply. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for more information about performing a metadata export/import.

   b. Set the instantiation SCNs manually at each of the other populated databases. Do this for each of the shared objects. Make sure the shared objects at each populated database are consistent with the instantiation SCNs you set at that database. See "Setting Instantiation SCNs Using a DBMS_APPLY_ADM Package Procedure" on page 13-38 for instructions.

Adding Shared Objects to Import Databases

After completing the steps in "Creating a New Multiple Source Environment" on page 10-22, complete the following steps for the import databases:

1. Pick the populated database that you will use as the export database. Do not perform the instantiations yet.
2. For each import database, set the instantiation SCNs at all of the other databases in the environment, including all populated databases and all of the other import databases.
   a. If one or more schemas will be created at an import database during instantiation or by a subsequent shared DDL change, then run the `SET_GLOBAL_INSTANTIATION_SCN` procedure in the `DBMS_APPLY_ADM` package for this import database at all of the other databases in the environment.
   b. If a schema exists at an import database, and one or more tables will be created in the schema during instantiation or by a subsequent shared DDL change, then run the `SET_SCHEMA_INSTANTIATION_SCN` procedure in the `DBMS_APPLY_ADM` package for the schema at all of the other databases in the environment for the import database. Do this for each such schema.

   Because you are running these procedures before any tables are instantiated at the import databases, and because the local capture processes are configured already for these import databases, you will not need to run the `SET_TABLE_INSTANTIATION_SCN` for each table created during the instantiation.

   See "Setting Instantiation SCNs at a Destination Database" on page 13-35 for instructions.
3. At the export database you chose in Step 1, perform an export of the shared data with the `OBJECT_CONSISTENT` export parameter set to `Y`, or use a more stringent degree of consistency. Then, perform an import with the `STREAMS_INSTANTIATION` import parameter set to `y` at each import database. See "Setting Export and Import Parameters Relevant to Streams" on page 10-8 and *Oracle9i Database Utilities* for information about using Export/Import.
4. For each populated database, except for the export database, set the instantiation SCNs at each import database. These instantiation SCNs must be set, and only the changes made at a populated database that are committed after the corresponding SCN for that database will be applied at an import database.

You can set these instantiation SCNs in one of the following ways:

a. Perform a metadata only export at each populated database and import the metadata at each import database. Each import sets the required instantiation SCNs for the populated database at the import database. In this case, ensure that the shared objects at the import database are consistent with the populated database at the time of the export.

If you are sharing DML changes only, then table level export/import is sufficient. If you are sharing DDL changes also, then additional considerations apply. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for more information about performing a metadata export/import.

b. For each populated database, set the instantiation SCN manually for each shared object at each import database. Make sure the shared objects at each import database are consistent with the populated database as of the corresponding instantiation SCN. See "Setting Instantiation SCNs Using a DBMS_APPLY_ADM Package Procedure" on page 13-38 for instructions.

5. At each import database, specify any necessary supplemental logging:

a. Set the session tag to an appropriate non-`NULL` value. See "Setting the Tag Values Generated by the Current Session" on page 15-22 for instructions. This step ensures that the supplemental logging specifications are not applied at the other databases.

b. Specify any necessary supplemental logging. See "Specifying Supplemental Logging at a Source Database" on page 11-9 for instructions.

c. Set the session tag back to `NULL`.

Make sure no changes are made to the relevant objects until after you have specified supplemental logging.

Complete the Multiple Source Environment Configuration

Before completing the steps in this section, you should have completed the following tasks:

- "Creating a New Multiple Source Environment" on page 10-22
- "Configuring Populated Databases" on page 10-25, if your environment has more than one populated database
- "Adding Shared Objects to Import Databases" on page 10-26, if your environment has one or more import databases

When all of the previous configuration steps are finished, complete the following steps:

1. Start each apply process in the environment. See "Starting an Apply Process" on page 13-7 for instructions.
2. Start each capture process the environment. See "Starting a Capture Process" on page 11-5 for instructions.

> **See Also:** "Multiple Source Databases in an Oracle-Only Environment" on page 19-82 for a detailed example that creates a multiple source environment

Adding Shared Objects to an Existing Multiple Source Environment

You add existing database objects to an existing multiple source environment by adding the necessary rules to the appropriate capture processes, propagation jobs, and apply processes.

This example uses the following terms:

- **Populated database:** A database that already contains the shared database objects being added to the multiple source environment. You must have at least one populated database to add the objects to the environment.
- **Export database:** A populated database on which you perform an export of the database objects you are adding to the environment. This export is used to instantiate the added database objects at the import databases. You may not have an export database if all of the databases in the environment are populated databases.
- **Import database:** A database that does not contain the shared database objects before they are added to the multiple source environment. You instantiate the added database objects at an import database using the export dump file from the export database. You may not have any import databases if all of the databases in the environment are populated databases.

Before creating or altering capture or propagation rules in a running Streams environment, make sure any propagation jobs or apply processes that will receive events as a result of the new or altered rules are configured to handle these events. That is, the propagation jobs or apply processes should exist, and each one should be associated with a rule set that handles the events appropriately. If these propagation jobs and apply processes are not configured properly to handle these events, then events may be lost.

For example, suppose you want to add a new table to a Streams environment that already captures, propagates, and applies changes to other tables. Assume multiple capture processes in the environment will capture changes to this table, and multiple apply processes will apply changes to this table. In this case, you must add one or more table-level rules to the following rule sets:

- The rule set for each capture process that will capture changes to the table
- The rule set for each propagation job that will propagate changes to the table
- The rule set for each apply process that will apply changes to the table.

If you perform administrative steps in the wrong order, you may lose events. For example, if you add the rule to the capture rule set first, without stopping the capture process, then the propagation job will not propagate the changes if it does not have a rule that instructs it to do so, and the changes may be lost.

To avoid losing events, you should complete the configuration in the following order:

1. At each populated database, specify any necessary supplemental logging for the objects being added to the environment. See "Specifying Supplemental Logging at a Source Database" on page 11-9 for instructions.
2. Either stop all of the capture processes that will capture changes to the added objects, disable all of the propagation jobs that will propagate changes to the added objects, or stop all of the apply process that will apply changes to the added objects. See one of the following sections for instructions:
   - "Stopping a Capture Process" on page 11-14
   - "Disabling a Propagation Job" on page 12-16
   - "Stopping an Apply Process" on page 13-7
3. Add the relevant rules to the rule sets for the propagation jobs and the apply processes that will propagate or apply changes to the added objects. See the following sections for instructions:
   - "Adding Rules to the Rule Set for a Propagation Job" on page 12-14
   - "Adding Rules to the Rule Set for an Apply Process" on page 13-8

4. Add the relevant rules to the rule set used by each capture process that will capture changes to the added objects. See "Adding Rules to the Rule Set for a Capture Process" on page 11-5 for instructions.

   When you use the DBMS_STREAMS_ADM package to add the capture rules, it automatically runs the PREPARE_TABLE_INSTANTIATION, PREPARE_SCHEMA_INSTANTIATION, or PREPARE_GLOBAL_INSTANTIATION procedure in the DBMS_CAPTURE_ADM package for the specified table, specified schema, or entire database, respectively.

   You must run the appropriate procedure to prepare for instantiation manually if any of the following conditions is true:

   - You use DBMS_RULE_ADM to create or modify rules in a capture process rule set.
   - You do not add rules for the added objects to a capture process rule set, because the capture process already captures changes to these objects. In this case, rules for the objects may be added to propagation jobs and apply processes in the environment, but not to the capture process.

   If you must prepare for instantiation manually, then see "Preparing Database Objects for Instantiation at a Source Database" on page 11-11 for instructions.

After completing these steps, complete the steps in each of the following sections that apply to your environment. You may need to complete the steps in only one of these sections or in both of these sections:

- For each populated database, complete the steps in "Configuring Populated Databases" on page 10-31.
- For each import database, complete the steps in "Adding Shared Objects to Import Databases" on page 10-32.

Configuring Populated Databases

After completing the steps in "Adding Shared Objects to an Existing Multiple Source Environment" on page 10-28, complete the following steps for each populated database:

1. For each populated database, set the instantiation SCN at the other populated databases in the environment. These instantiation SCNs must be set, and only the changes made at a particular populated database that are committed after the corresponding SCN for that database will be applied at another populated database.

   For each populated database, you can set these instantiation SCNs in one of the following ways:

   a. Perform a metadata only export of the added objects at the populated database and import the metadata at each of the other populated databases. Such an import sets the required instantiation SCNs for the database at the other databases. Make sure no rows are imported. Also, make sure the shared objects at each of the other populated databases are consistent with the populated database that performed the export at the time of the export.

      If you are sharing DML changes only, then table level export/import is sufficient. If you are sharing DDL changes also, then additional considerations apply. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for more information about performing a metadata export/import.

   b. Set the instantiation SCNs manually for the added objects at each of the other populated databases. Make sure every added object at each populated database is consistent with the instantiation SCNs you set at that database. See "Setting Instantiation SCNs Using a DBMS_APPLY_ADM Package Procedure" on page 13-38 for instructions.

Adding Shared Objects to Import Databases

After completing the steps in "Adding Shared Objects to an Existing Multiple Source Environment" on page 10-28, complete the following steps for the import databases:

1. Pick the populated database that you will use as the export database. Do not perform the instantiations yet
2. For each import database, set the instantiation SCNs at all of the other databases in the environment, including all of the populated databases and all of the other import databases.
   a. If one or more schemas will be created at an import database during instantiation or by a subsequent shared DDL change, then run the `SET_GLOBAL_INSTANTIATION_SCN` procedure in the `DBMS_APPLY_ADM` package for this import database at all of the other databases in the environment.
   b. If a schema exists at an import database, and one or more tables will be created in the schema during instantiation or by a subsequent shared DDL change, the run the `SET_SCHEMA_INSTANTIATION_SCN` procedure in the `DBMS_APPLY_ADM` package for the schema for this import database at each of the other databases in the environment. Do this for each such schema.

   Because you are running these procedures before any tables are instantiated at the import databases, and because the local capture processes are configured already for these import databases, you will not need to run the `SET_TABLE_INSTANTIATION_SCN` for each table created during instantiation.

   See "Setting Instantiation SCNs at a Destination Database" on page 13-35 for instructions.
3. At the export database you chose in Step 1, perform an export of the added objects with the `OBJECT_CONSISTENT` export parameter set to Y, or use a more stringent degree of consistency. Then, perform an import of the added objects at each import database with the `STREAMS_INSTANTIATION` import parameter set to Y. See "Setting Export and Import Parameters Relevant to Streams" on page 10-8 and *Oracle9i Database Utilities* for information about using Export/Import.
4. For each populated database, except for the export database, set the instantiation SCNs at each import database. These instantiation SCNs must be set, and only the changes made at a populated database that are committed after the corresponding SCN for that database will be applied at an import database.

For each populated database, you can set these instantiation SCNs in one of the following ways:

a. Perform a metadata only export of the added objects at the populated database and import the metadata at each import database. Each import sets the required instantiation SCNs for the populated database at the import database. In this case, ensure that every added object at the import database is consistent with the populated database at the time of the export.

If you are sharing DML changes only, then table level export/import is sufficient. If you are sharing DDL changes also, then additional considerations apply. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for more information about performing a metadata export/import.

b. Set the instantiation SCNs manually for the added objects at each import database. Make sure every added object at each import database is consistent with the populated database as of the corresponding instantiation SCN. See "Setting Instantiation SCNs Using a DBMS_APPLY_ADM Package Procedure" on page 13-38 for instructions.

5. At each import database, specify any necessary supplemental logging.

a. Set the session tag to an appropriate non-`NULL` value. See "Setting the Tag Values Generated by the Current Session" on page 15-22 for instructions. This step ensures that the supplemental logging specifications are not applied at the other databases.

b. Specify any necessary supplemental logging. See "Specifying Supplemental Logging at a Source Database" on page 11-9 for instructions.

c. Set the session tag back to `NULL`.

Make sure no changes are made to the relevant objects until after you have specified supplemental logging.

Complete the Adding Objects to a Multiple Source Environment Configuration

Before completing the configuration, you should have completed the following tasks:

- "Creating a New Multiple Source Environment" on page 10-22
- "Configuring Populated Databases" on page 10-25, if your environment had populated databases
- "Adding Shared Objects to Import Databases" on page 10-26, if your environment had import databases

When all of the previous configuration steps are finished, start each process you stopped and enable each propagation job you disabled in Step 2 on page 10-29 in "Adding a New Database to an Existing Multiple Source Environment". See one of the following sections for instructions:

- "Starting a Capture Process" on page 11-5
- "Enabling a Propagation Job" on page 12-11
- "Starting an Apply Process" on page 13-7

Adding a New Database to an Existing Multiple Source Environment

Complete the following steps to add a new database to an existing multiple source Streams environment:

> **Note:** Make sure no changes are made to the objects being shared at the database you are adding to the Streams environment until the instantiation at the database is complete.

1. Complete the necessary tasks described previously in this chapter to prepare the new database for Streams:
   - "Configuring a Streams Administrator" on page 10-2
   - "Setting Initialization Parameters Relevant to Streams" on page 10-4
   - "Configuring a Database to Run a Streams Capture Process" on page 10-9
   - "Configuring Network Connectivity and Database Links" on page 10-11

   Some of these tasks may not be required at the new database.

2. Create any necessary Streams queues that do not already exist. When you create a capture process or apply process, you associate the process with a specific Streams queue. When you create a propagation job, you associate it with a specific source queue and destination queue. See "Creating a Streams Queue" on page 12-2 for instructions.

3. Create one or more apply processes at the new database to apply the changes from its source databases. Make sure each apply process uses a rule set that is appropriate for applying changes. Do not start any apply process at the new database. See "Creating an Apply Process" on page 13-2 for instructions.

   Keeping the apply processes stopped prevents changes made at the source databases from being applied before the instantiation of the new database is completed, which would otherwise lead to incorrect data and errors.

4. If the new database will be a source database, then, for all databases that will be destination databases for the changes made at the new database, create one or more apply processes to apply changes from the new database. Make sure each apply process uses a rule set that is appropriate for applying changes. Do not start any of these new apply processes. See "Creating an Apply Process" on page 13-2 for instructions.

5. Configure propagation jobs at the databases that will be source databases of the new database to send changes to the new database. Make sure each propagation job uses a rule set that is appropriate for propagating changes. See "Creating a Propagation Job" on page 12-8.

6. If the new database will be a source database, then configure propagation jobs at the new database to send changes from the new database to each of its destination databases. Make sure each propagation job uses a rule set that is appropriate for propagating changes. See "Creating a Propagation Job" on page 12-8.

7. If the new database will be a source database, and the shared objects already exist at the new database, then specify any necessary supplemental logging for the shared objects at the new database. See "Specifying Supplemental Logging at a Source Database" on page 11-9 for instructions.

8. At each source database for the new database, prepare for instantiation each database object for which changes will be applied by an apply process at the new database. Run either the `PREPARE_TABLE_INSTANTIATION`, `PREPARE_SCHEMA_INSTANTIATION`, or `PREPARE_GLOBAL_INSTANTIATION` procedure in the `DBMS_CAPTURE_ADM` package for the specified table, specified schema, or entire database, respectively. See "Preparing Database Objects for Instantiation at a Source Database" on page 11-11 for instructions.

9. If the new database will be a source database, then create one or more capture processes to capture the relevant changes. See "Creating a Capture Process" on page 11-2 for instructions.

   When you use the DBMS_STREAMS_ADM package to add the capture rules, it automatically runs the PREPARE_TABLE_INSTANTIATION, PREPARE_SCHEMA_INSTANTIATION, or PREPARE_GLOBAL_INSTANTIATION procedure in the DBMS_CAPTURE_ADM package for the specified table, specified schema, or entire database, respectively.

   You must run the appropriate procedure to prepare for instantiation manually if any of the following conditions is true:

   - You use the DBMS_RULE_ADM package to add or modify capture rules.
   - You use an existing capture process and do not add capture rules for any shared object.

   If you must prepare for instantiation manually, then see "Preparing Database Objects for Instantiation at a Source Database" on page 11-11 for instructions.

10. If the new database will be a source database, then start any capture processes you created in Step 9. See "Starting a Capture Process" on page 11-5 for instructions.

After completing these steps, complete the steps in the appropriate section:

- If the objects that are to be shared with the new database already exist at the new database, then complete the steps in "Configuring Databases If the Shared Objects Already Exist at the New Database" on page 10-37.
- If the objects that are to be shared with the new database do not already exist at the new database, complete the steps in "Adding Shared Objects to a New Database" on page 10-39.

Configuring Databases If the Shared Objects Already Exist at the New Database

After completing the steps in "Adding a New Database to an Existing Multiple Source Environment" on page 10-34, complete the following steps if the objects that are to be shared with the new database already exist at the new database:

1. For each source database of the new database, set the instantiation SCNs at the new database. These instantiation SCNs must be set, and only the changes made at a source database that are committed after the corresponding SCN for that database will be applied at the new database.

   For each source database of the new database, you can set these instantiation SCNs in one of the following ways:

   a. Perform a metadata only export of the shared objects at the source database and import the metadata at the new database. The import sets the required instantiation SCNs for the source database at the new database. Make sure no rows are imported. In this case, ensure that the shared objects at the new database are consistent with the source database at the time of the export.

      If you are sharing DML changes only, then table level export/import is sufficient. If you are sharing DDL changes also, then additional considerations apply. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for more information about performing a metadata export/import.

   b. Set the instantiation SCNs manually at the new database for the shared objects. Make sure the shared objects at the new database are consistent with the source database as of the corresponding instantiation SCN. See "Setting Instantiation SCNs Using a DBMS_APPLY_ADM Package Procedure" on page 13-38 for instructions.

2. For the new database, set the instantiation SCNs at each destination database of the new database. These instantiation SCNs must be set, and only the changes made at the new source database that are committed after the corresponding SCN will be applied at a destination database. If the new database is not a source database, then do not complete this step.

You can set these instantiation SCNs for the new database in one of the following ways:

a. Perform a metadata only export at the new database and import the metadata at each destination database. Make sure no rows are imported. The import sets the required instantiation SCNs for the new database at each destination database. In this case, ensure that the shared objects at each destination database are consistent with the new database at the time of the export.

If you are sharing DML changes only, then table level export/import is sufficient. If you are sharing DDL changes also, then additional considerations apply. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for more information about performing a metadata export/import.

b. Set the instantiation SCNs manually at each destination database for the shared objects. Make sure the shared objects at each destination database are consistent with the new database as of the corresponding instantiation SCN. See "Setting Instantiation SCNs Using a DBMS_APPLY_ADM Package Procedure" on page 13-38 for instructions.

3. Start the apply processes that you created at the new database in Step 3 on page 10-35. See "Starting an Apply Process" on page 13-7 for instructions.

4. Start the apply processes that you created at each of the other destination databases in Step 4 on page 10-35. See "Starting an Apply Process" on page 13-7 for instructions. If the new database is not a source database, then do not complete this step.

Adding Shared Objects to a New Database

After completing the steps in "Adding a New Database to an Existing Multiple Source Environment" on page 10-34, complete the following steps if the objects that are to be shared with the new database do not already exist at the new database:

1. If the new database is a source database for other databases, then, at each destination database of the new source database, set the instantiation SCNs for the new database.

   a. If one or more schemas will be created at the new database during instantiation or by a subsequent shared DDL change, then run the `SET_GLOBAL_INSTANTIATION_SCN` procedure in the `DBMS_APPLY_ADM` package for the new database at each destination database of the new database.

   b. If a schema exists at the new database, and one or more tables will be created in the schema during instantiation or by a subsequent shared DDL change, then run the `SET_SCHEMA_INSTANTIATION_SCN` procedure in the `DBMS_APPLY_ADM` package for the schema at each destination database of the new database. Do this for each such schema.

   Because you are running these procedures before any tables are instantiated at the new database, and because the local capture processes are configured already at the new database, you will not need to run the `SET_TABLE_INSTANTIATION_SCN` for each table created during instantiation.

   See "Setting Instantiation SCNs at a Destination Database" on page 13-35 for instructions.

   If the new database will not be a source database, then do not complete this step, and continue with the next step.

2. Pick one source database from which to instantiate the shared objects at the new database using Export/Import. First, perform the export at the source database with the `OBJECT_CONSISTENT` export parameter set to `Y`, or use a more stringent degree of consistency. Then, perform the import at the new database with the `STREAMS_INSTANTIATION` import parameter set to `Y`. See "Setting Export and Import Parameters Relevant to Streams" on page 10-8 and *Oracle9i Database Utilities* for information about using Export/Import.

3. If the new database is a source database for other databases, then specify any necessary supplemental logging at the new database:

   a. Set the session tag to an appropriate non-NULL value. See "Setting the Tag Values Generated by the Current Session" on page 15-22 for instructions. This step ensures that the supplemental logging specifications are not applied at the other databases.

   b. Specify any necessary supplemental logging. See "Specifying Supplemental Logging at a Source Database" on page 11-9 for instructions.

   c. Set the session tag back to NULL.

   Make sure no changes are made to the relevant objects until after you have specified supplemental logging.

4. For each source database of the new database, except for the source database that performed the export for instantiation in Step 2, set the instantiation SCNs at the new database. These instantiation SCNs must be set, and only the changes made at a source database that are committed after the corresponding SCN for that database will be applied at the new database.

   For each source database, you can set these instantiation SCNs in one of the following ways:

   a. Perform a metadata only export at the source database and import the metadata at the new database. The import sets the required instantiation SCNs for the source database at the new database. In this case, ensure that the shared objects at the new database are consistent with the source database at the time of the export.

      If you are sharing DML changes only, then table level export/import is sufficient. If you are sharing DDL changes also, then additional considerations apply. See "Setting Instantiation SCNs Using Export/Import" on page 13-36 for more information about performing a metadata export/import.

   b. Set the instantiation SCNs manually at the new database for the shared objects. Make sure the shared objects at the new database are consistent with the source database as of the corresponding instantiation SCN. See "Setting Instantiation SCNs Using a DBMS_APPLY_ADM Package Procedure" on page 13-38 for instructions.

5. Start the apply processes at the new database that you created in Step 3 on page 10-35. See "Starting an Apply Process" on page 13-7 for instructions.
6. Start the apply processes at each of the other destination databases that you created in Step 4 on page 10-35. See "Starting an Apply Process" on page 13-7 for instructions. If the new database is not a source database, then do not complete this step.

11

Managing a Capture Process

A capture process captures changes in a redo log, reformats the captured changes into logical change records (LCRs), and enqueues the LCRs into a Streams queue.

This chapter contains these topics:

Each task described in this section should be completed by a Streams administrator that has been granted the appropriate privileges, unless specified otherwise.

See Also:

- Chapter 2, "Streams Capture Process"
- "Configuring a Streams Administrator" on page 10-2

Creating a Capture Process

You can use any of the following procedures to create a capture process:

- DBMS_STREAMS_ADM.ADD_TABLE_RULES
- DBMS_STREAMS_ADM.ADD_SCHEMA_RULES
- DBMS_STREAMS_ADM.ADD_GLOBAL_RULES
- DBMS_CAPTURE_ADM.CREATE_CAPTURE

Each of the procedures in the DBMS_STREAMS_ADM package creates a capture process with the specified name if it does not already exist, creates a rule set for the capture process if the capture process does not have a rule set, and may add table, schema, or global rules to the rule set.

The CREATE_CAPTURE procedure creates a capture process, but does not create a rule set or rules for the capture process. However, the CREATE_CAPTURE procedure enables you to specify an existing rule set to associate with the capture process and a start SCN for the capture process.

The following tasks must be completed before you create a capture process:

- Complete the tasks described in "Configuring a Database to Run a Streams Capture Process" on page 10-9.
- Create a Streams queue to associate with the capture process, if one does not exist. See "Creating a Streams Queue" on page 12-2 for instructions.

Note: Creation of the first capture process in a database may take some time because the data dictionary is duplicated during this creation.

Example of Creating a Capture Process Using DBMS_STREAMS_ADM

The following is an example that runs the ADD_TABLE_RULES procedure in the DBMS_STREAMS_ADM package to create a capture process:

```
BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name         => 'hr.employees',
    streams_type       => 'capture',
    streams_name       => 'strm01_capture',
    queue_name         => 'strm01_queue',
    include_dml        => true,
    include_ddl        => true,
    include_tagged_lcr => false);
END;
/
```

Running this procedure performs the following actions:

- Creates a capture process named `strm01_capture`. The capture process is created only if it does not already exist. If a new capture process is created, then this procedure also sets the start SCN to the point in time of creation.
- Associates the capture process with an existing queue named `strm01_queue`
- Creates a rule set and associates it with the capture process, if the capture process does not have a rule set. The rule set uses the SYS.STREAMS$_EVALUATION_CONTEXT evaluation context. The rule set name is specified by the system.
- Creates two rules. One rule specifies that the capture process captures DML changes to the `hr.employees` table, and the other rule specifies that the capture process captures DDL changes to the `hr.employees` table. The rule names are specified by the system.
- Adds the two rules to the rule set associated with the capture process
- Specifies that the capture process captures a change in the redo log only if the change has a NULL tag, because the `include_tagged_lcr` parameter is set to `false`. This behavior is accomplished through the system-created rules for the capture process.

See Also:

- "Capture Process Creation" on page 2-15
- "System-Created Rules" on page 6-4
- "Tags and Rules Created by the DBMS_STREAMS_ADM Package" on page 8-3

Example of Creating a Capture Process Using DBMS_CAPTURE_ADM

The following is an example that runs the `CREATE_CAPTURE` procedure in the `DBMS_CAPTURE_ADM` package to create a capture process:

```
BEGIN
  DBMS_CAPTURE_ADM.CREATE_CAPTURE(
    queue_name     => 'strm01_queue',
    capture_name   => 'strm02_capture',
    rule_set_name => 'strmadmin.strm01_rule_set',
    start_scn      => 829381993);
END;
/
```

Running this procedure performs the following actions:

- Creates a capture process named `strm02_capture`. A capture process with the same name must not exist.
- Associates the capture process with an existing queue named `strm01_queue`
- Associates the capture process with an existing rule set named `strm01_rule_set`
- Specifies `829381993` as the start SCN for the capture process.

See Also:

- "Capture Process Creation" on page 2-15
- "The Start SCN for a Capture Process" on page 2-21

Starting a Capture Process

You run the START_CAPTURE procedure in the DBMS_CAPTURE_ADM package to start an existing capture process. For example, the following procedure starts a capture process named strm01_capture:

```
BEGIN
  DBMS_CAPTURE_ADM.START_CAPTURE(
    capture_name => 'strm01_capture');
END;
/
```

Specifying the Rule Set for a Capture Process

You specify an existing rule set that you want to associate with an existing capture process using the rule_set_name parameter in the ALTER_CAPTURE procedure in the DBMS_CAPTURE_ADM package. For example, the following procedure sets the rule set for a capture process named strm01_capture to strm02_rule_set.

```
BEGIN
  DBMS_CAPTURE_ADM.ALTER_CAPTURE(
    capture_name  => 'strm01_capture',
    rule_set_name => 'strmadmin.strm02_rule_set');
END;
/
```

See Also:

- Chapter 5, "Rules"
- Chapter 6, "How Rules Are Used In Streams"

Adding Rules to the Rule Set for a Capture Process

To add rules to the rule set for an existing capture process, you can run one of the following procedures and specify the existing capture process:

- DBMS_STREAMS_ADM.ADD_TABLE_RULES
- DBMS_STREAMS_ADM.ADD_SCHEMA_RULES
- DBMS_STREAMS_ADM.ADD_GLOBAL_RULES

The following is an example that runs the ADD_TABLE_RULES procedure in the DBMS_STREAMS_ADM package to add rules to the rule set of a capture process named strm01_capture:

```
BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name         => 'hr.departments',
    streams_type       => 'capture',
    streams_name       => 'strm01_capture',
    queue_name         => 'strm01_queue',
    include_dml        => true,
    include_ddl        => true);
END;
/
```

Running this procedure performs the following actions:

- Creates two rules. One rule specifies that the capture process captures DML changes to the hr.departments table, and the other rule specifies that the capture process captures DDL changes to the hr.departments table. The rule names are specified by the system.
- Adds the two rules to the rule set associated with the capture process

See Also: "System-Created Rules" on page 6-4

Removing a Rule from the Rule Set for a Capture Process

You specify that you want to remove a rule from the rule set for an existing capture process by running the REMOVE_RULE procedure in the DBMS_STREAMS_ADM package. For example, the following procedure removes a rule named DEPARTMENTS3 from the rule set of a capture process named strm01_capture.

```
BEGIN
  DBMS_STREAMS_ADM.REMOVE_RULE(
    rule_name        => 'DEPARTMENTS3',
    streams_type     => 'capture',
    streams_name     => 'strm01_capture',
    drop_unused_rule => true);
END;
/
```

In this example, the drop_unused_rule parameter in the REMOVE_RULE procedure is set to true, which is the default setting. Therefore, if the rule being removed is not in any other rule set, then it will be dropped from the database. If the drop_unused_rule parameter is set to false, then the rule is removed from the rule set, but it is not dropped from the database.

In addition, if you want to remove all of the rules in the rule set for the capture process, then specify NULL for the rule_name parameter when you run the REMOVE_RULE procedure.

Note: If you drop all of the rules in the rule set for a capture process, then the capture process captures no events.

Removing the Rule Set for a Capture Process

You specify that you want to remove the rule set from an existing capture process by setting the remove_rule_set parameter to true in the ALTER_CAPTURE procedure in the DBMS_CAPTURE_ADM package. For example, the following procedure removes the rule set from a capture process named strm01_capture.

```
BEGIN
  DBMS_CAPTURE_ADM.ALTER_CAPTURE(
    capture_name    => 'strm01_capture',
    remove_rule_set => true);
END;
/
```

Note: If you remove a rule set for a capture process, then the capture process captures all supported changes to all objects in the database, excluding database objects in the SYS and SYSTEM schemas.

Setting a Capture Process Parameter

You set a capture process parameter using the SET_PARAMETER procedure in the DBMS_CAPTURE_ADM package. Capture process parameters control the way a capture process operates.

For example, the following procedure sets the parallelism parameter for a capture process named strm01_capture to 3.

```
BEGIN
  DBMS_CAPTURE_ADM.SET_PARAMETER(
    capture_name => 'strm01_capture',
    parameter    => 'parallelism',
    value        => '3');
END;
/
```

Note:

- Setting the parallelism parameter automatically stops and restarts a capture process.
- The value parameter is always entered as a VARCHAR2, even if the parameter value is a number.

See Also:

- "Capture Process Parameters" on page 2-19
- The DBMS_CAPTURE_ADM.SET_PARAMETER procedure in the *Oracle9i Supplied PL/SQL Packages and Types Reference* for detailed information about the capture process parameters

Specifying Supplemental Logging at a Source Database

Supplemental logging must be specified for certain columns at a source database for changes to the columns to be applied successfully at a destination database. This section illustrates how to specify supplemental logging at a source database.

> **See Also:** "Supplemental Logging" on page 2-9 for information about when supplemental logging is required

Specifying Table Supplemental Logging Using Unconditional Log Groups

To specify an unconditional supplemental log group, you must create redo log groups that include the necessary columns using the ADD SUPPLEMENTAL LOG GROUP clause and the ALWAYS specification in an ALTER TABLE statement. These redo log groups can include key columns, if necessary.

For example, the following statement adds the primary key column of the `hr.departments` table to an unconditional log group named `log_group_dep_pk`:

```
ALTER TABLE hr.departments ADD SUPPLEMENTAL LOG GROUP log_group_dep_pk
  (department_id) ALWAYS;
```

The ALWAYS specification makes this log group an unconditional log group.

Specifying Table Supplemental Logging Using Conditional Log Groups

To specify a conditional supplemental log group, you must create redo log groups that include the necessary columns using the ADD SUPPLEMENTAL LOG GROUP clause in the ALTER TABLE statement. To make the log group condition, do not include the ALWAYS specification.

For example, suppose the `min_salary` and `max_salary` columns in the `hr.jobs` table are included in a column list for conflict resolution at a destination database. The following statement adds the `min_salary` and `max_salary` columns to a log conditional group named `log_group_jobs_cr`:

```
ALTER TABLE hr.jobs ADD SUPPLEMENTAL LOG GROUP log_group_jobs_cr
  (min_salary, max_salary);
```

Specifying Database Supplemental Logging of Key Columns

You also have the option of specifying supplemental logging for all primary key and unique key columns in a source database. You may choose this option if you configure a capture process to capture changes to an entire database. To specify supplemental logging for all primary key and unique key columns in a source database, issue the following SQL statement:

```
ALTER DATABASE ADD SUPPLEMENTAL LOG DATA (PRIMARY KEY, UNIQUE INDEX) COLUMNS;
```

If your primary and unique key columns are the same at all source and destination databases, then running this command at the source database provides the supplemental logging needed for primary and unique key columns at all destination databases.

Switching the Log File

If you specify supplemental logging before any capture process is created on a database, then you must switch the log file after you submit the supplemental logging statement. Switching the log file causes the supplemental logging statement to take effect. The following command switches the log file:

```
ALTER SYSTEM ARCHIVE LOG CURRENT;
```

If a capture process was created on a database before you specify supplemental logging, then you do not need to switch the log file.

Setting the Start SCN for a Capture Process

You specify the start SCN for an existing capture process using the `start_scn` parameter in the `ALTER_CAPTURE` procedure in the `DBMS_CAPTURE_ADM` package. The SCN value specified must be from a point in time after the first capture process was created for the database. The first capture process for the database may or may not be the capture process being altered. An error is returned if an invalid SCN is specified. Typically, you reset a start SCN for a capture process if point-in-time recovery must be performed on one of the destination databases for changes from the capture process.

For example, the following procedure sets the start SCN for a capture process named `strm01_capture` to `750338948`.

```
BEGIN
  DBMS_CAPTURE_ADM.ALTER_CAPTURE(
    capture_name => 'strm01_capture',
    start_scn    => 750338948);
END;
/
```

See Also:

- "The Start SCN for a Capture Process" on page 2-21
- "Performing Database Point-in-Time Recovery in a Streams Environment" on page 13-41

Preparing Database Objects for Instantiation at a Source Database

In a Streams environment that shares a database object within a single database or between multiple databases, a source database is the database where changes to the object are generated in the redo log. If a capture process captures or will capture such changes and the changes will be applied locally or propagated to other databases and applied at destination databases, then you may need to instantiate source database objects at destination databases. In any event, you must always prepare the object for instantiation.

The following procedures in the `DBMS_CAPTURE_ADM` package prepare database objects for instantiation:

- `PREPARE_TABLE_INSTANTIATION` prepares a single table for instantiation.
- `PREPARE_SCHEMA_INSTANTIATION` prepares for instantiation all of the database objects in a schema and all database objects added to the schema in the future.
- `PREPARE_GLOBAL_INSTANTIATION` prepares for instantiation all of the database objects in a database and all database objects added to the database in the future.

These procedures record the lowest SCN of each object for instantiation. SCNs subsequent to the lowest SCN for an object can be used for instantiating the object. If you run one of these procedures while a long running transaction is modifying one or more database objects being prepared for instantiation, then the procedure will wait until the long running transaction is complete before it records the lowest SCN.

These procedures also populate the Streams data dictionary for the relevant capture processes, propagation jobs, and apply processes that capture, propagate, or apply changes to the table, schema, or database being prepared for instantiation. Therefore, whenever you add or modify the condition of a capture or propagation rule for an object, you must run the appropriate procedure to prepare the object for instantiation.

Specifically, you must run the appropriate procedure to prepare an object for instantiation at the source database of the object if any of the following conditions are met:

- One or more rules are added to the rule set for a capture process that instruct the capture process to capture changes made to the object. When you use the `DBMS_STREAMS_ADM` package to add rules to a rule set for a capture process, the appropriate procedure to prepare for instantiation is run automatically at the source database. When you use the `DBMS_RULE_ADM` package to add these rules, you must prepare for instantiation manually.
- One or more conditions of rules in the rule set for a capture process are modified to instruct the capture process to capture changes made to the object.
- One or more rules are added to the rule set for a propagation job that instruct the propagation job to propagate changes made to the object.
- One or more conditions of rules in the rule set for a propagation job are modified to instruct the propagation job to propagate changes made to the object.

When any of these conditions are met, you must prepare database objects for instantiation at a source database to populate any relevant Streams data dictionary that requires information about the source object, even if the object already exists at a remote database where the rules were added.

The relevant Streams data dictionaries are populated asynchronously for both the local dictionary and all remote dictionaries. The procedure that prepares for instantiation adds information to the redo log at the source database. The local Streams data dictionary is populated with the information about the object when a capture process captures these redo entries, and any remote Streams data dictionaries are populated when the information is propagated to them.

For example, to prepare the `hr.regions` table for instantiation, run the following procedure:

```
BEGIN
  DBMS_CAPTURE_ADM.PREPARE_TABLE_INSTANTIATION(
    table_name  => 'hr.regions');
END;
/
```

See Also:

- "Streams Data Dictionary for Propagation Jobs" on page 3-24
- "Streams Data Dictionary for an Apply Process" on page 4-29
- "Configuring a Capture-Based Streams Environment" on page 10-12

Aborting Preparation for Instantiation at a Source Database

The following procedures in the `DBMS_CAPTURE_ADM` package abort preparation for instantiation:

- `ABORT_TABLE_INSTANTIATION` reverses the effects of `PREPARE_TABLE_INSTANTIATION`.
- `ABORT_SCHEMA_INSTANTIATION` reverses the effects of `PREPARE_SCHEMA_INSTANTIATION`.
- `ABORT_GLOBAL_INSTANTIATION` reverses the effects of `PREPARE_GLOBAL_INSTANTIATION`.

These procedures remove data dictionary information related to the potential instantiation of the relevant database objects.

For example, to abort the preparation for instantiation of the `hr.regions` table, run the following procedure:

```
BEGIN
  DBMS_CAPTURE_ADM.ABORT_TABLE_INSTANTIATION(
    table_name  => 'hr.regions');
END;
/
```

Stopping a Capture Process

You run the STOP_CAPTURE procedure in the DBMS_CAPTURE_ADM package to stop an existing capture process. For example, the following procedure stops a capture process named strm01_capture:

```
BEGIN
  DBMS_CAPTURE_ADM.STOP_CAPTURE(
    capture_name => 'strm01_capture');
END;
/
```

Dropping a Capture Process

You run the DROP_CAPTURE procedure in the DBMS_CAPTURE_ADM package to drop an existing capture process. For example, the following procedure drops a capture process named strm01_capture:

```
BEGIN
  DBMS_CAPTURE_ADM.DROP_CAPTURE(
    capture_name => 'strm01_capture');
END;
/
```

12

Managing Staging and Propagation

This chapter provides instructions for managing Streams queues, propagation jobs, and messaging environments.

This chapter contains these topics:

- Managing Streams Queues
- Managing Streams Propagation Jobs
- Managing a Streams Messaging Environment

Each task described in this section should be completed by a Streams administrator that has been granted the appropriate privileges, unless specified otherwise.

See Also:

- Chapter 3, "Streams Staging and Propagation"
- "Configuring a Streams Administrator" on page 10-2

Managing Streams Queues

A Streams queue stages events whose payloads are of SYS.AnyData type. Therefore, a Streams queue can stage an event with payload of nearly any type, if the payload is wrapped in a SYS.AnyData wrapper. Each Streams capture process and apply process is associated with one Streams queue, and each Streams propagation job is associated with one Streams source queue and one Streams destination queue.

This section provides instructions for completing the following tasks related to Streams queues:

- Creating a Streams Queue
- Enabling a User to Perform Operations on a Secure Queue
- Disabling a User from Performing Operations on a Secure Queue

Creating a Streams Queue

You use the SET_UP_QUEUE procedure in the DBMS_STREAMS_ADM package to create a Streams queue. This procedure enables you to specify the following for the Streams queue it creates:

- The queue table for the queue
- A storage clause for the queue table
- The queue name
- A queue user that will be configured as a secure queue user of the queue and granted ENQUEUE and DEQUEUE privileges on the queue
- A comment for the queue

This procedure creates a queue that is both a secure queue and a transactional queue and starts the newly created queue.

For example, to create a Streams queue named strm01_queue with a queue table named strm01_queue_table and grant the hr user the privileges necessary to enqueue events into and dequeue events from the queue, run the following procedure:

```
BEGIN
  DBMS_STREAMS_ADM.SET_UP_QUEUE(
    queue_table  => 'strm01_queue_table',
    queue_name   => 'strm01_queue',
    queue_user   => 'hr');
END;
/
```

You can also use procedures in the DBMS_AQADM package to create a SYS.AnyData queue.

See Also:

- "Wrapping User Messages in a SYS.AnyData Wrapper" on page 12-18 for an example that creates a SYS.AnyData queue using procedures in the DBMS_AQADM package
- "Secure Queues" on page 3-21
- "Transactional and Nontransactional Queues" on page 3-23

Enabling a User to Perform Operations on a Secure Queue

For a user to perform queue operations, such as enqueue and dequeue, on a secure queue, the user must be configured as a secure queue user of the queue. If you use the SET_UP_QUEUE procedure in the DBMS_STREAMS_ADM package to create the secure queue, then the queue owner and the user specified by the queue_user parameter are configured as secure users of the queue automatically. If you want to enable other users to perform operations on the queue, then you can configure these users in one of the following ways:

- Run SET_UP_QUEUE and specify a queue_user. Queue creation is skipped if the queue already exists, but a new queue user is configured if one is specified.
- Associate the users with an agent manually

The following example illustrates associating a user with an agent manually. Suppose you want to enable the oe user to perform queue operations on the strm01_queue created in "Creating a Streams Queue" on page 12-2. The following steps configure the oe user as a secure queue user of strm01_queue:

1. Connect as an administrative user who can create agents and alter users.
2. Create an agent:

```
EXEC DBMS_AQADM.CREATE_AQ_AGENT(agent_name => 'strm01_queue_agent');
```

3. If the user must be able to dequeue events from queue, then make the agent a subscriber of the secure queue:

```
DECLARE
  subscriber SYS.AQ$_AGENT;
BEGIN
  subscriber :=  SYS.AQ$_AGENT('strm01_queue_agent', NULL, NULL);
  SYS.DBMS_AQADM.ADD_SUBSCRIBER(
    queue_name          =>  'strmadmin.strm01_queue',
    subscriber          =>  subscriber,
    rule                =>  NULL,
    transformation      =>  NULL);
END;
/
```

4. Associate the user with the agent:

```
BEGIN
  DBMS_AQADM.ENABLE_DB_ACCESS(
    agent_name  => 'strm01_queue_agent',
    db_username => 'oe');
END;
/
```

5. Grant the user EXECUTE privilege on the DBMS_AQ package, if the user is not already granted this privilege.

```
GRANT EXECUTE ON DBMS_AQ TO oe;
```

When these steps are complete, the oe user is a secure user of the strm01_queue queue and can perform operations on the queue. You still must grant the user specific privileges to perform queue operations, such as enqueue and dequeue privileges.

See Also:

- "Secure Queues" on page 3-21
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about AQ agents and using the DBMS_AQADM package

Disabling a User from Performing Operations on a Secure Queue

You may want to disable a user from performing queue operations on a secure queue for the following reasons:

- You dropped a capture process, but you did not drop the queue that was used by the capture process, and you do not want the user who was the capture user to be able to perform operations on the remaining secure queue.
- You dropped an apply process, but you did not drop the queue that was used by the apply process, and you do not want the user who was the apply user to be able to perform operations on the remaining secure queue.
- You used the ALTER_APPLY procedure in the DBMS_APPLY_ADM package to change the apply_user for an apply process, and you do not want the old apply_user to be able to perform operations on the apply process queue.
- You enabled a user to perform operations on a secure queue by completing the steps described in Enabling a User to Perform Operations on a Secure Queue on page 12-3, but you no longer want this user to be able to perform operations on the secure queue.

To disable a secure queue user, you can revoke ENQUEUE and DEQUEUE privilege on the queue from the user, or you can run the DISABLE_DB_ACCESS procedure in the DBMS_AQADM package. For example, suppose you want to disable the oe user from performing queue operations on the strm01_queue created in "Creating a Streams Queue" on page 12-2.

Attention: If an agent is used for multiple secure queues, then running DISABLE_DB_ACCESS for the agent prevents the user from performing operations on all of these queues.

---

1. Run the following procedure to disable the `oe` user from performing queue operations on the secure queue `strm01_queue`:

```
BEGIN
  DBMS_AQADM.DISABLE_DB_ACCESS(
    agent_name  => 'strm01_queue_agent',
    db_username => 'oe');
END;
/
```

2. If the agent is no longer needed, you can drop the agent:

```
BEGIN
  DBMS_AQADM.DROP_AQ_AGENT(
    agent_name  => 'strm01_queue_agent',
END;
/
```

3. Revoke privileges on the queue from the user, if the user no longer needs these privileges.

```
BEGIN
  DBMS_AQADM.REVOKE_QUEUE_PRIVILEGE (
   privilege   => 'ALL',
   queue_name  => 'strm01_queue',
   grantee     => 'oe');
END;
/
```

See Also:

- "Secure Queues" on page 3-21
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about AQ agents and using the `DBMS_AQADM` package

Managing Streams Propagation Jobs

A propagation job propagates events from a Streams source queue to a Streams destination queue. This section provides instructions for completing the following tasks:

- Creating a Propagation Job
- Enabling a Propagation Job
- Scheduling a Propagation Job
- Altering the Schedule of a Propagation Job
- Unscheduling a Propagation Job
- Specifying the Rule Set for a Propagation Job
- Adding Rules to the Rule Set for a Propagation Job
- Removing a Rule from the Rule Set for a Propagation Job
- Removing the Rule Set for a Propagation Job
- Disabling a Propagation Job
- Dropping a Propagation Job

In addition, you can use the features of Oracle Advanced Queuing (AQ) to manage Streams propagation jobs.

> **See Also:** *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about managing propagation jobs with the features of AQ

Creating a Propagation Job

You can use any of the following procedures to create a propagation job:

- DBMS_STREAMS_ADM.ADD_TABLE_PROPAGATION_RULES
- DBMS_STREAMS_ADM.ADD_SCHEMA_PROPAGATION_RULES
- DBMS_STREAMS_ADM.ADD_GLOBAL_PROPAGATION_RULES
- DBMS_PROPAGATION_ADM.CREATE_PROPAGATION

Each of the procedures in the DBMS_STREAMS_ADM package creates a propagation job with the specified name if it does not already exist, creates a rule set for the propagation job if the propagation job does not have a rule set, and may add table, schema, or global rules to the rule set. The CREATE_PROPAGATION procedure creates a propagation job, but does not create a rule set or rules for the propagation job. All propagation jobs are started automatically upon creation.

The following tasks must be completed before you create a propagation job:

- Create a source queue and a destination queue for the propagation job, if they do not exist. See "Creating a Streams Queue" on page 12-2 for instructions.
- Create a database link between the database containing the source queue and the database containing the destination queue. See "Configuring Network Connectivity and Database Links" on page 10-11 for information.

Example of Creating a Propagation Job Using DBMS_STREAMS_ADM

The following is an example that runs the ADD_TABLE_RULES procedure in the DBMS_STREAMS_ADM package to create a propagation job:

```
BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_PROPAGATION_RULES(
    table_name              => 'hr.departments',
    streams_name            => 'strm01_propagation',
    source_queue_name       => 'strmadmin.strm01_queue',
    destination_queue_name  => 'strmadmin.strm02_queue@dbs2.net',
    include_dml             => true,
    include_ddl             => true,
    include_tagged_lcr      => false,
    source_database         => 'dbs1.net' );
END;
/
```

Running this procedure performs the following actions:

- Creates a propagation job named `strm01_propagation`. The propagation job is created only if it does not already exist.
- Specifies that the propagation job propagates LCRs from `strm01_queue` in the current database to `strm02_queue` in the `dbs2.net` database
- Specifies that the propagation job uses the `dbs2.net` database link to propagate the LCRs, because the `destination_queue_name` parameter contains `@dbs2.net`
- Creates a rule set and associates it with the propagation job, if the propagation job does not have a rule set. The rule set uses the evaluation context `SYS.STREAMS$_EVALUATION_CONTEXT`. The rule set name is specified by the system.
- Creates two rules. One rule specifies that the propagation job propagates row LCRs that contain the results of DML changes to the `hr.departments` table, and the other rule specifies that the propagation job propagates DDL LCRs that contain changes to the `hr.departments` table. The rule names are specified by the system.
- Adds the two rules to the rule set associated with the propagation job
- Specifies that the propagation job propagates an LCR only if it has a `NULL` tag, because the `include_tagged_lcr` parameter is set to `false`. This behavior is accomplished through the system-created rules for the propagation job.
- Specifies that the source database of the LCRs to be propagated is `dbs1.net`, which may or may not be the current database

See Also:

- "Event Propagation Between Queues" on page 3-4
- "System-Created Rules" on page 6-4
- "Tags and Rules Created by the DBMS_STREAMS_ADM Package" on page 8-3

Example of Creating a Propagation Job Using DBMS_PROPAGATION_ADM

The following is an example that runs the CREATE_PROPAGATION procedure in the DBMS_PROPAGATION_ADM package to create a propagation job:

```
BEGIN
  DBMS_PROPAGATION_ADM.CREATE_PROPAGATION(
    propagation_name   => 'strm02_propagation',
    source_queue       => 'strmadmin.strm01_queue',
    destination_queue  => 'strmadmin.strm02_queue',
    destination_dblink => 'dbs2.net',
    rule_set_name      => 'strmadmin.strm01_rule_set');
END;
/
```

Running this procedure performs the following actions:

- Creates a propagation job named strm02_propagation. A propagation job with the same name must not exist.
- Specifies that the propagation job propagates events from strm01_queue in the current database to strm02_queue in the dbs2.net database. Depending on the rules in the rule set, the propagated events may be captured events or user-enqueued events.
- Specifies that the propagation job uses the dbs2.net database link to propagate the events
- Associates the propagation job with an existing rule set named strm01_rule_set

See Also:

- "Captured and User-Enqueued Events" on page 3-3
- "Event Propagation Between Queues" on page 3-4

Enabling a Propagation Job

By default, propagation jobs are enabled upon creation. If you disable a propagation job and want to enable it, then use the ENABLE_PROPAGATION_SCHEDULE procedure in the DBMS_AQADM package.

For example, to enable a propagation job that propagates events from the strmadmin.strm01_queue source queue using the dbs2.net database link, run the following procedure:

```
BEGIN
  DBMS_AQADM.ENABLE_PROPAGATION_SCHEDULE(
    queue_name  => 'strmadmin.strm01_queue',
    destination => 'dbs2.net');
END;
/
```

Note: Completing this task affects the propagation of events from the source queue to all destination queues that use the dbs2.net database link.

See Also: *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about using the ENABLE_PROPAGATION_SCHEDULE procedure

Scheduling a Propagation Job

You can schedule a propagation job using the SCHEDULE_PROPAGATION procedure in the DBMS_AQADM package. If there is a problem with a propagation job, then unscheduling and scheduling the propagation job may correct the problem.

For example, the following procedure schedules a propagation job that propagates events from the strmadmin.strm01_queue source queue using the dbs2.net database link:

```
BEGIN
  DBMS_AQADM.SCHEDULE_PROPAGATION(
   queue_name  => 'strmadmin.strm01_queue',
   destination => 'dbs2.net');
END;
/
```

Note: Completing this task affects the propagation of events from the source queue to all destination queues that use the `dbs2.net` database link.

See Also:

- "Unscheduling a Propagation Job" on page 12-13
- *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about using the `SCHEDULE_PROPAGATION` procedure

Altering the Schedule of a Propagation Job

You can alter the schedule of an existing propagation job using the `ALTER_PROPAGATION_SCHEDULE` procedure in the `DBMS_AQADM` package.

For example, suppose you want to alter the schedule of a propagation job that propagates events from the `strmadmin.strm01_queue` source queue using the `dbs2.net` database link. The following procedure sets the propagation job to propagate events every 15 minutes (900 seconds), with each propagation lasting 300 seconds, and a 25 second wait before new events in a completely propagated queue are propagated.

```
BEGIN
  DBMS_AQADM.ALTER_PROPAGATION_SCHEDULE(
    queue_name  => 'strmadmin.strm01_queue',
    destination => 'dbs2.net',
    duration    => 300,
    next_time   => 'SYSDATE + 900/86400',
    latency     => 25);
END;
/
```

Note: Completing this task affects the propagation of events from the source queue to all destination queues that use the `dbs2.net` database link.

See Also: *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about using the `ALTER_PROPAGATION_SCHEDULE` procedure

Unscheduling a Propagation Job

You can unschedule a propagation job using the UNSCHEDULE_PROPAGATION procedure in the DBMS_AQADM package. If there is a problem with a propagation job, then unscheduling and scheduling the propagation job may correct the problem.

For example, the following procedure unschedules a propagation job that propagates events from the strmadmin.strm01_queue source queue using the dbs2.net database link:

```
BEGIN
  DBMS_AQADM.UNSCHEDULE_PROPAGATION(
   queue_name  => 'strmadmin.strm01_queue',
   destination => 'dbs2.net');
END;
/
```

Note: Completing this task affects the propagation of events from the source queue to all destination queues that use the dbs2.net database link.

See Also:

- "Scheduling a Propagation Job" on page 12-11
- *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about using the SCHEDULE_PROPAGATION procedure

Specifying the Rule Set for a Propagation Job

You specify the rule set that you want to associate with a propagation job using the rule_set_name parameter in the ALTER_PROPAGATION procedure in the DBMS_PROPAGATION_ADM package. For example, the following procedure sets the rule set for a propagation job named strm01_propagation to strm02_rule_set.

```
BEGIN
  DBMS_PROPAGATION_ADM.ALTER_PROPAGATION(
    propagation_name  => 'strm01_propagation',
    rule_set_name     => 'strmadmin.strm02_rule_set');
END;
/
```

See Also:

- Chapter 5, "Rules"
- Chapter 6, "How Rules Are Used In Streams"

Adding Rules to the Rule Set for a Propagation Job

Yo add rules to the rule set of a propagation job, you can run one of the following procedures:

- DBMS_STREAMS_ADM.ADD_TABLE_PROPAGATION_RULES
- DBMS_STREAMS_ADM.ADD_SCHEMA_PROPAGATION_RULES
- DBMS_STREAMS_ADM.ADD_GLOBAL_PROPAGATION_RULES

The following is an example that runs the ADD_TABLE_RULES procedure in the DBMS_STREAMS_ADM package to add rules to the rule set of a propagation job named strm01_propagation:

```
BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_PROPAGATION_RULES(
    table_name              => 'hr.locations',
    streams_name            => 'strm01_propagation',
    source_queue_name       => 'strmadmin.strm01_queue',
    destination_queue_name  => 'strmadmin.strm02_queue@dbs2.net',
    include_dml             => true,
    include_ddl             => true,
    source_database         => 'dbs1.net' );
END;
/
```

Running this procedure performs the following actions:

- Creates a propagation job named strm01_propagation. The propagation job is created only if it does not already exist.
- Specifies that the propagation job propagates LCRs from strm01_queue in the current database to strm02_queue in the dbs2.net database
- Specifies that the propagation job uses the dbs2.net database link to propagate the LCRs, because the destination_queue_name parameter contains @dbs2.net

- Creates two rules. One rule specifies that the propagation job propagates row LCRs that contain the results of DML changes to the `hr.locations` table, and the other rule specifies that the propagation job propagates DDL LCRs that contain changes to the `hr.locations` table. The rule names are specified by the system.
- Adds the two rules to the rule set associated with the propagation job
- Specifies that the source database of the LCRs to be propagated is `dbs1.net`, which may or may not be the current database

See Also:

- "Event Propagation Between Queues" on page 3-4
- "System-Created Rules" on page 6-4

Removing a Rule from the Rule Set for a Propagation Job

You specify that you want to remove a rule from the rule set for an existing propagation job by running the `REMOVE_RULE` procedure in the `DBMS_STREAMS_ADM` package. For example, the following procedure removes a rule named `DEPARTMENTS3` from the rule set of a propagation job named `strm01_propagation`.

```
BEGIN
  DBMS_STREAMS_ADM.REMOVE_RULE(
    rule_name        => 'DEPARTMENTS3',
    streams_type     => 'propagate',
    streams_name     => 'strm01_propagation',
    drop_unused_rule => true);
END;
/
```

In this example, the `drop_unused_rule` parameter in the `REMOVE_RULE` procedure is set to `true`, which is the default setting. Therefore, if the rule being removed is not in any other rule set, then it will be dropped from the database. If the `drop_unused_rule` parameter is set to `false`, then the rule is removed from the rule set, but it is not dropped from the database.

In addition, if you want to remove all of the rules in the rule set for the propagation job, then specify `NULL` for the `rule_name` parameter when you run the `REMOVE_RULE` procedure.

Note: If you drop all of the rules in the rule set for a propagation job, then the propagation job propagations no events in the source queue to the destination queue.

Removing the Rule Set for a Propagation Job

You specify that you want to remove the rule set from a propagation job by setting the `rule_set_name` parameter to `NULL` in the `ALTER_PROPAGATION` procedure in the `DBMS_PROPAGATION_ADM` package. For example, the following procedure removes the rule set from a propagation job named `strm01_propagation`.

```
BEGIN
  DBMS_PROPAGATION_ADM.ALTER_PROPAGATION(
    propagation_name => 'strm01_propagation',
    rule_set_name    => NULL);
END;
/
```

Note: If you remove a rule set for a propagation job, then the propagation job propagates all events in the source queue to the destination queue.

Disabling a Propagation Job

To stop a propagation job, use the `DISABLE_PROPAGATION_SCHEDULE` procedure in the `DBMS_AQADM` package.

For example, to stop a propagation job that propagates events from the `strmadmin.strm01_queue` source queue using the `dbs2.net` database link, run the following procedure:

```
BEGIN
  DBMS_AQADM.DISABLE_PROPAGATION_SCHEDULE(
    queue_name  => 'strmadmin.strm01_queue',
    destination => 'dbs2.net');
END;
/
```

Note:

- Completing this task affects the propagation of events from the source queue to all destination queues that use the `dbs2.net` database link.
- The `DISABLE_PROPAGATION_SCHEDULE` disables the propagation job immediately. It does not wait for the current duration to end.

See Also: *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about using the `DISABLE_PROPAGATION_SCHEDULE` procedure

Dropping a Propagation Job

You run the `DROP_PROPAGATION` procedure in the `DBMS_PROPAGATION_ADM` package to drop an existing propagation job. For example, the following procedure drops a propagation job named `strm01_propagation`:

```
BEGIN
  DBMS_PROPAGATION_ADM.DROP_PROPAGATION(
    propagation_name => 'strm01_propagation');
END;
/
```

Managing a Streams Messaging Environment

Streams enables messaging with queues of type SYS.AnyData. These queues stage user messages whose payloads are of SYS.AnyData type, and a SYS.AnyData payload can be a wrapper for payloads of different datatypes.

This section provides instructions for completing the following tasks:

- Wrapping User Messages in a SYS.AnyData Wrapper
- Propagating Messages Between a SYS.AnyData Queue and a Typed Queue

See Also:

- "SYS.AnyData Queues and User Messages" on page 3-12 for conceptual information about messaging in Streams
- Chapter 18, "Example Streams Messaging Environment"
- *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about AQ
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the SYS.AnyData type

Wrapping User Messages in a SYS.AnyData Wrapper

You can wrap almost any type of payload in a SYS.AnyData payload. The following sections provide examples enqueuing messages into, and dequeuing messages from, a SYS.AnyData queue. These examples assume that you have configured a Streams administrator at each database.

See Also: "Configuring a Streams Administrator" on page 10-2

Example of Wrapping a Payload in a SYS.AnyData Payload and Enqueuing It

The following steps illustrate how to wrap payloads of various types in a SYS.AnyData payload.

1. Connect as an administrative user who can create users, grant privileges, create tablespaces, and alter users.
2. Grant EXECUTE privilege on the DBMS_AQ package to the oe user so that this user can run the ENQUEUE and DEQUEUE procedures in that package:

```
GRANT EXECUTE ON DBMS_AQ TO oe;
```

3. Connect as the Streams administrator, as in the following example:

```
CONNECT strmadmin/strmadminpw
```

4. Create a SYS.AnyData queue if one does not already exist.

```
BEGIN
  DBMS_STREAMS_ADM.SET_UP_QUEUE(
    queue_table  => 'oe_q_table_any',
    queue_name   => 'oe_q_any',
    queue_user   => 'oe');
END;
/
```

   The oe user is configured automatically as a secure queue user of the oe_q_any queue and is given ENQUEUE and DEQUEUE privileges on the queue.

5. Add a subscriber to the oe_q_any queue. This subscriber will perform explicit dequeues of events.

```
DECLARE
  subscriber SYS.AQ$_AGENT;
BEGIN
  subscriber :=  SYS.AQ$_AGENT('OE', NULL, NULL);
  SYS.DBMS_AQADM.ADD_SUBSCRIBER(
    queue_name  =>  'strmadmin.oe_q_any',
    subscriber  =>  subscriber);
END;
/
```

6. Connect as the oe user.

```
CONNECT oe/oe
```

7. Create a procedure that takes as an input parameter an object of `SYS.AnyData` type and enqueues a message containing the payload into an existing `SYS.AnyData` queue.

```
CREATE OR REPLACE PROCEDURE oe.enq_proc (payload SYS.AnyData) IS
  enqopt     DBMS_AQ.ENQUEUE_OPTIONS_T;
  mprop      DBMS_AQ.MESSAGE_PROPERTIES_T;
  enq_msgid  RAW(16);
BEGIN
  mprop.SENDER_ID := SYS.AQ$_AGENT('OE', NULL, NULL);
  DBMS_AQ.ENQUEUE(
    queue_name          =>  'strmadmin.oe_q_any',
    enqueue_options     =>  enqopt,
    message_properties  =>  mprop,
    payload             =>  payload,
    msgid               =>  enq_msgid);
END;
/
```

8. Run the procedure you created in Step 7 by specifying the appropriate `Convert`*`data_type`* function. The following commands enqueue messages of various types.

   `VARCHAR2` type:

```
EXEC oe.enq_proc(SYS.AnyData.ConvertVarchar2('Chemicals - SW'));
COMMIT;
```

   `NUMBER` type:

```
EXEC oe.enq_proc(SYS.AnyData.ConvertNumber('16'));
COMMIT;
```

   User-defined type:

```
EXEC oe.enq_proc(SYS.AnyData.ConvertObject(oe.cust_address_typ('1646 Brazil
Blvd','361168','Chennai','Tam', 'IN')));
COMMIT;
```

> **See Also:** "Viewing the Contents of User-Enqueued Events in a Queue" on page 16-13 for information about viewing the contents of these enqueued messages

Example of Dequeuing a Payload That Is Wrapped in a SYS.AnyData Payload

The following steps illustrate how to dequeue a payload wrapped in a `SYS.AnyData` payload. This example assumes that you have completed the steps in "Example of Wrapping a Payload in a SYS.AnyData Payload and Enqueuing It" on page 12-18.

To dequeue messages, you must know the consumer of the messages. To find the consumer for the messages in a queue, connect as the owner of the queue and query the `AQ$`*`queue_table_name`*, where *`queue_table_name`* is the name of the queue table. For example, to find the consumers of the messages in the `oe_q_any` queue, run the following query:

```
CONNECT strmadmin/strmadminpw

SELECT MSG_ID, MSG_STATE, CONSUMER_NAME FROM AQ$OE_Q_TABLE_ANY;
```

1. Connect as the `oe` user:

   ```
   CONNECT oe/oe
   ```

2. Create a procedure that takes as an input the consumer of the messages you want to dequeue. The following example procedure dequeues messages of `oe.cust_address_typ` and prints the contents of the messages.

   ```
   CREATE OR REPLACE PROCEDURE oe.get_cust_address (
   consumer IN VARCHAR2) AS
     address         OE.CUST_ADDRESS_TYP;
     deq_address     SYS.AnyData;
     msgid           RAW(16);
     deqopt          DBMS_AQ.DEQUEUE_OPTIONS_T;
     mprop           DBMS_AQ.MESSAGE_PROPERTIES_T;
     new_addresses   BOOLEAN := TRUE;
     next_trans      EXCEPTION;
     no_messages     EXCEPTION;
     pragma exception_init (next_trans, -25235);
     pragma exception_init (no_messages, -25228);
     num_var         pls_integer;
   BEGIN
        deqopt.consumer_name := consumer;
        deqopt.wait := 1;
        WHILE (new_addresses) LOOP
        BEGIN
         DBMS_AQ.DEQUEUE(
            queue_name          =>  'strmadmin.oe_q_any',
            dequeue_options     =>  deqopt,
   ```

```
            message_properties  =>  mprop,
            payload             =>  deq_address,
            msgid               =>  msgid);
          deqopt.navigation := DBMS_AQ.NEXT;
            DBMS_OUTPUT.PUT_LINE('****');
            IF (deq_address.GetTypeName() = 'OE.CUST_ADDRESS_TYP') THEN
                DBMS_OUTPUT.PUT_LINE('Message TYPE is: ' ||
                                      deq_address.GetTypeName());
                num_var := deq_address.GetObject(address);
                DBMS_OUTPUT.PUT_LINE(' **** CUSTOMER ADDRESS **** ');
                DBMS_OUTPUT.PUT_LINE(address.street_address);
                DBMS_OUTPUT.PUT_LINE(address.postal_code);
                DBMS_OUTPUT.PUT_LINE(address.city);
                DBMS_OUTPUT.PUT_LINE(address.state_province);
                DBMS_OUTPUT.PUT_LINE(address.country_id);
            ELSE
               DBMS_OUTPUT.PUT_LINE('Message TYPE is: ' ||
                                    deq_address.GetTypeName());
            END IF;
           COMMIT;
        EXCEPTION
          WHEN next_trans THEN
          deqopt.navigation := DBMS_AQ.NEXT_TRANSACTION;
          WHEN no_messages THEN
            new_addresses := FALSE;
            DBMS_OUTPUT.PUT_LINE('No more messages');
         END;
      END LOOP;
    END;
    /
```

3. Run the procedure you created in Step 1 and specify the consumer of the messages you want to dequeue, as in the following example:

```
SET SERVEROUTPUT ON SIZE 100000
EXEC oe.get_cust_address('OE');
```

Propagating Messages Between a SYS.AnyData Queue and a Typed Queue

SYS.AnyData queues can interoperate with typed queues in a Streams environment. A typed queue is a queue that can stage messages of a particular type only. To propagate a message from a SYS.AnyData queue to a typed queue, the message must be transformed to match the type of the typed queue. The following sections provide examples of propagating non-LCR user messages and LCRs between a SYS.AnyData queue and a typed queue.

> **See Also:** "Message Propagation" on page 3-17 for more information about propagation between SYS.AnyData and typed queues

Example of Propagating Non-LCR User Messages to a Typed Queue

The following steps set up propagation from a SYS.AnyData queue named oe_q_any to a typed queue of type oe.cust_address_typ named oe_q_address. The source queue oe_q_any is at the dbs1.net database, and the destination queue oe_q_address is at the dbs2.net database.

1. Create a database link between dbs1.net and dbs2.net if one does not already exist.

```
CONNECT oe/oe@dbs1.net

CREATE DATABASE LINK dbs2.net CONNECT TO oe IDENTIFIED BY oe
  USING 'DBS2.NET';
```

2. Create a typed queue if one does not already exist.

```
CONNECT system/manager@dbs2.net

BEGIN
  DBMS_AQADM.CREATE_QUEUE_TABLE(
    queue_table         => 'oe.oe_q_table_address',
    queue_payload_type  => 'oe.cust_address_typ',
    multiple_consumers  => true);
  DBMS_AQADM.CREATE_QUEUE(
    queue_name   => 'oe.oe_q_address',
    queue_table  => 'oe.oe_q_table_address');
  DBMS_AQADM.START_QUEUE(
    queue_name   => 'oe.oe_q_address');
END;
/
```

3. Create a function called `any_to_cust_address_typ` in the `oe` schema at `dbs1.net` that takes a `SYS.AnyData` payload containing a `oe.cust_address_typ` object and returns the `oe.cust_address_typ` object.

```
CONNECT oe/oe@dbs1.net

CREATE OR REPLACE FUNCTION oe.any_to_cust_address_typ(in_any IN SYS.AnyData)
RETURN OE.CUST_ADDRESS_TYP
AS
  address       OE.CUST_ADDRESS_TYP;
  num_var       NUMBER;
  type_name     VARCHAR2(100);
BEGIN
  -- Get the type of object
  type_name := in_any.GetTypeName();
  -- Check if the object type is OE.CUST_ADDRESS_TYP
  IF (type_name = 'OE.CUST_ADDRESS_TYP') THEN
    -- Put the address in the message into the address variable
    num_var := in_any.GetObject(address);
    RETURN address;
  ELSE
    raise_application_error(-20101, 'Conversion failed - ' || type_name);
  END IF;
END;
/
```

4. Create a transformation at `dbs1.net` using the `DBMS_TRANSFORM` package.

```
CONNECT system/manager@dbs1.net

BEGIN
  DBMS_TRANSFORM.CREATE_TRANSFORMATION(
   schema         => 'OE',
   name           => 'ANYTOADDRESS',
   from_schema    => 'SYS',
   from_type      => 'ANYDATA',
   to_schema      => 'OE',
   to_type        => 'CUST_ADDRESS_TYP',
   transformation => 'oe.any_to_cust_address_typ(source.user_data)');
END;
/
```

5. Create a subscriber for the typed queue if one does not already exist. The subscriber must contain a rule that ensures that only messages of the appropriate type are propagated to the destination queue.

```
DECLARE
  subscriber  SYS.AQ$_AGENT;
BEGIN
  subscriber := SYS.AQ$_AGENT ('OE',
                               'OE.OE_Q_ADDRESS@DBS2.NET',
                               0);
  DBMS_AQADM.ADD_SUBSCRIBER(
    queue_name     => 'strmadmin.oe_q_any',
    subscriber     => subscriber,
    rule           =>
               'TAB.USER_DATA.GetTypeName()=''OE.OE_CUST_ADDRESS''',
    transformation => 'OE.ANYTOADDRESS');
END;
/
```

6. Schedule propagation between the `SYS.AnyData` queue at `dbs1.net` and the typed queue at `dbs2.net`.

```
BEGIN
  DBMS_AQADM.SCHEDULE_PROPAGATION(
    queue_name   => 'strmadmin.oe_q_any',
    destination  => 'dbs2.net');
END;
/
```

See Also: *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about transformations during propagation

Example of Propagating LCRs to a Typed Queue

To propagate LCRs from a SYS.AnyData queue to a typed queue, you complete the same steps as you do for non-LCR events, but Oracle supplies the transformation functions. You can use the following functions in the DBMS_STREAMS package to transform LCRs in SYS.AnyData queues to messages in typed queues:

- The CONVERT_ANYDATA_TO_LCR_ROW function transforms SYS.AnyData payload containing a row LCR into SYS.LCR$_ROW_RECORD payload.
- The CONVERT_ANYDATA_TO_LCR_DDL function transforms SYS.AnyData payload containing a DDL LCR into SYS.LCR$_DDL_RECORD payload.

You should only propagate user-enqueued LCRs to a typed queue. Do not propagate captured LCRs to a typed queue.

The following example sets up propagation of row LCRs from a SYS.AnyData queue named oe_q_any to a typed queue of type SYS.LCR$_ROW_RECORD named oe_q_lcr. The source queue oe_q_any is at the dbs1.net database, and the destination queue oe_q_lcr is at the dbs3.net database.

1. Create a database link between dbs1.net and dbs3.net if one does not already exist.

```
CONNECT oe/oe@dbs1.net

CREATE DATABASE LINK dbs3.net CONNECT TO oe IDENTIFIED BY oe
  USING 'DBS3.NET';
```

2. Create a queue of the LCR type if one does not already exist.

```
CONNECT system/manager@dbs3.net

BEGIN
  DBMS_AQADM.CREATE_QUEUE_TABLE(
    queue_table         => 'oe.oe_q_table_lcr',
    queue_payload_type  => 'SYS.LCR$_ROW_RECORD',
    multiple_consumers  => true);
  DBMS_AQADM.CREATE_QUEUE(
    queue_name   => 'oe.oe_q_lcr',
    queue_table  => 'oe.oe_q_table_lcr');
  DBMS_AQADM.START_QUEUE(
    queue_name   => 'oe.oe_q_lcr');
END;
/
```

3. Create a transformation at `dbs1.net` using the `DBMS_TRANSFORM` package.

```
CONNECT system/manager@dbs1.net

BEGIN
  DBMS_TRANSFORM.CREATE_TRANSFORMATION(
    schema         => 'oe',
    name           => 'ANYTOLCR',
    from_schema    => 'SYS',
    from_type      => 'ANYDATA',
    to_schema      => 'SYS',
    to_type        => 'LCR$_ROW_RECORD',
    transformation  =>
          'SYS.DBMS_STREAMS.CONVERT_ANYDATA_TO_LCR_ROW(source.user_data)');
END;
/
```

4. Create a subscriber at the typed queue if one does not already exist. The subscriber specifies the `CONVERT_ANYDATA_TO_LCR_ROW` function for the transformation parameter.

```
DECLARE
  subscriber  SYS.AQ$_AGENT;
BEGIN
  subscriber := SYS.AQ$_AGENT ('OE', 'OE.OE_Q_LCR@DBS3.NET', 0);
  DBMS_AQADM.ADD_SUBSCRIBER(
    queue_name     => 'strmadmin.oe_q_any',
    subscriber     => subscriber,
    rule           => 'TAB.USER_DATA.GetTypeName()=''SYS.LCR$_ROW_RECORD''',
    transformation => 'oe.anytolcr');
END;
/
```

5. Schedule propagation between the SYS.AnyData queue at dbs1.net and the LCR queue at dbs3.net.

```
BEGIN
  DBMS_AQADM.SCHEDULE_PROPAGATION(
    queue_name   => 'strmadmin.oe_q_any',
    destination  => 'dbs3.net');
END;
/
```

See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the row LCR and DDL LCR conversion functions

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Managing an Apply Process

A Streams apply process dequeues logical change records (LCRs) and user messages from a specific queue and either applies each one directly or passes it as a parameter to a user-defined procedure.

This chapter contains these topics:

Each task described in this section should be completed by a Streams administrator that has been granted the appropriate privileges, unless specified otherwise.

See Also:

- Chapter 4, "Streams Apply Process"
- "Configuring a Streams Administrator" on page 10-2
- "Managing Streams Tags for an Apply Process" on page 15-23

Creating, Starting, Stopping, and Dropping an Apply Process

This section contains instructions for creating, starting, stopping and dropping an apply process.

Creating an Apply Process

You can use any of the following procedures to create an apply process:

- `DBMS_STREAMS_ADM.ADD_TABLE_RULES`
- `DBMS_STREAMS_ADM.ADD_SUBSET_RULES`
- `DBMS_STREAMS_ADM.ADD_SCHEMA_RULES`
- `DBMS_STREAMS_ADM.ADD_GLOBAL_RULES`
- `DBMS_APPLY_ADM.CREATE_APPLY`

Each of the procedures in the `DBMS_STREAMS_ADM` package creates an apply process with the specified name if it does not already exist, creates a rule set for the apply process if the apply process does not have a rule set, and may add table, schema, or global rules to the rule set.

The `CREATE_APPLY` procedure creates an apply process, but does not create a rule set or rules for the apply process. However, the `CREATE_APPLY` procedure enables you to specify an existing rule set to associate with the apply process and a number of other options, such as event handlers, an apply user, an apply tag, and whether to apply captured or user-enqueued events.

Before you create an apply process, create a Streams queue to associate with the apply process, if one does not exist.

Note: Depending on the configuration of the apply process you create, supplemental logging may be required at the source database on columns in the tables for which an apply process applies changes.

See Also:

- "Creating a Streams Queue" on page 12-2
- "Supplemental Logging" on page 2-9 for information about when supplemental logging is required
- "Specifying Supplemental Logging at a Source Database" on page 11-9

Example of Creating an Apply Process Using DBMS_STREAMS_ADM

The following is an example that runs the ADD_SCHEMA_RULES procedure in the DBMS_STREAMS_ADM package to create an apply process:

```
BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name         => 'hr',
    streams_type        => 'apply',
    streams_name        => 'strm01_apply',
    queue_name          => 'strm01_queue',
    include_dml         => true,
    include_ddl         => false,
    include_tagged_lcr  => false,
    source_database     => 'dbs1.net');
END;
/
```

Running this procedure performs the following actions:

- Creates an apply process named `strm01_apply` that applies captured events to the local database. The apply process is created only if it does not already exist.
- Associates the apply process with an existing queue named `strm01_queue`
- Creates a rule set and associates it with the apply process, if the apply process does not have a rule set. The rule set uses the SYS.STREAMS$_EVALUATION_CONTEXT evaluation context. The rule set name is specified by the system.
- Creates one rule that specifies that the apply process applies row LCRs that contain the results of DML changes to database objects in the `hr` schema. The rule name is specified by the system.

- Adds the rule to the rule set associated with the apply process
- Sets the `apply_tag` for the apply process to a value that is the hexadecimal equivalent of `'00'` (double zero). Redo entries generated by the apply process have a tag with this value.
- Specifies that the apply process applies a row LCR only if it has a `NULL` tag, because the `include_tagged_lcr` parameter is set to `false`. This behavior is accomplished through the system-created rule for the apply process.

See Also:

- "Apply Process Creation" on page 4-28
- "System-Created Rules" on page 6-4
- "Tags and Rules Created by the DBMS_STREAMS_ADM Package" on page 8-3

Examples of Creating an Apply Process Using DBMS_APPLY_ADM

The first example in this section creates an apply process that applies captured events, and the second example in this section creates an apply process that applies user-enqueued events. A single apply process cannot apply both captured and user-enqueued events.

See Also:

- "Apply Process Creation" on page 4-28
- "Event Processing Options" on page 4-3 for more information about event handlers
- "Tags and an Apply Process" on page 8-5
- "Oracle to Non-Oracle Data Sharing with Streams" on page 9-2 for information about configuring an apply process to apply events to a non-Oracle database using the `apply_database_link` parameter

Example of Creating an Apply Process to Apply Captured Events The following is an example that runs the CREATE_APPLY procedure in the DBMS_APPLY_ADM package to create an apply process that applies captured events:

```
BEGIN
  DBMS_APPLY_ADM.CREATE_APPLY(
    queue_name          => 'strm01_queue',
    apply_name          => 'strm02_apply',
    rule_set_name       => 'strmadmin.strm01_rule_set',
    message_handler     => NULL,
    ddl_handler         => 'hr.ddl_handler',
    apply_user          => 'hr',
    apply_database_link => NULL,
    apply_tag           => HEXTORAW('5'),
    apply_captured      => true);
END;
/
```

Running this procedure performs the following actions:

- Creates an apply process named strm02_apply. An apply process with the same name must not exist.
- Associates the apply process with the queue named strm01_queue
- Associates the apply process with an existing rule set named strm01_rule_set
- Specifies that the apply process does not use a message handler.
- Specifies that the DDL handler is the ddl_handler PL/SQL procedure in the hr schema.
- Specifies that the user who applies the changes is hr, and not the user who is running the CREATE_APPLY procedure (the Streams administrator).
- Specifies that the apply process applies changes to the local database because the apply_database_link parameter is set to NULL.
- Specifies that each redo entry generated by the apply process has a tag that is the hexadecimal equivalent of '5'.
- Specifies that the apply process applies captured LCRs, and not user-enqueued events. Therefore, if an LCR that was constructed by a user application, not by by the capture process, is staged in the queue for the apply process, then this apply process does not apply the LCR.

Example of Creating an Apply Process to Apply User-Enqueued Events The following is an example that runs the CREATE_APPLY procedure in the DBMS_APPLY_ADM package to create an apply process that applies user-enqueued events:

```
BEGIN
  DBMS_APPLY_ADM.CREATE_APPLY(
    queue_name          => 'strm01_queue',
    apply_name          => 'strm03_apply',
    rule_set_name       => 'strmadmin.strm02_rule_set',
    message_handler     => 'hr.mes_handler',
    ddl_handler         => NULL,
    apply_user          => NULL,
    apply_database_link => NULL,
    apply_tag           => NULL,
    apply_captured      => false);
END;
/
```

Running this procedure performs the following actions:

- Creates an apply process named strm03_apply. An apply process with the same name must not exist.
- Associates the apply process with the queue named strm01_queue
- Associates the apply process with an existing rule set named strm02_rule_set
- Specifies that the message handler is the mes_handler PL/SQL procedure in the hr schema.
- Specifies that the apply process does not use a DDL handler.
- Specifies that the user who applies the changes is the user who runs the CREATE_APPLY procedure, because the apply_user parameter is NULL.
- Specifies that the apply process applies changes to the local database, because the apply_database_link parameter is set to NULL.
- Specifies that each redo entry generated by the apply process has a NULL tag.
- Specifies that the apply process applies user-enqueued events, and not captured events.

Starting an Apply Process

You run the START_APPLY procedure in the DBMS_APPLY_ADM package to start an existing apply process. For example, the following procedure starts an apply process named strm01_apply:

```
BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name => 'strm01_apply');
END;
/
```

Stopping an Apply Process

You run the STOP_APPLY procedure in the DBMS_APPLY_ADM package to stop an existing apply process. For example, the following procedure stops an apply process named strm01_apply:

```
BEGIN
  DBMS_APPLY_ADM.STOP_APPLY(
    apply_name => 'strm01_apply');
END;
/
```

Dropping an Apply Process

You run the DROP_APPLY procedure in the DBMS_APPLY_ADM package to drop an existing apply process. For example, the following procedure drops an apply process named strm01_apply:

```
BEGIN
  DBMS_APPLY_ADM.DROP_APPLY(
    apply_name => 'strm01_apply');
END;
/
```

Managing the Rule Set for an Apply Process

This section contains instructions for completing the following tasks:

- Specifying the Rule Set for an Apply Process
- Adding Rules to the Rule Set for an Apply Process
- Removing a Rule from the Rule Set for an Apply Process
- Removing the Rule Set for an Apply Process

See Also:

- Chapter 5, "Rules"
- Chapter 6, "How Rules Are Used In Streams"

Specifying the Rule Set for an Apply Process

You specify the rule set that you want to associate with an apply process using the `rule_set_name` parameter in the `ALTER_APPLY` procedure in the `DBMS_APPLY_ADM` package. For example, the following procedure sets the rule set for an apply process named `strm01_apply` to `strm02_rule_set`.

```
BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name    => 'strm01_apply',
    rule_set_name => 'strmadmin.strm02_rule_set');
END;
/
```

Adding Rules to the Rule Set for an Apply Process

To add rules to the rule set for an apply process, you can run one of the following procedures:

- `DBMS_STREAMS_ADM.ADD_TABLE_RULES`
- `DBMS_STREAMS_ADM.ADD_SUBSET_RULES`
- `DBMS_STREAMS_ADM.ADD_SCHEMA_RULES`
- `DBMS_STREAMS_ADM.ADD_GLOBAL_RULES`

The following is an example that runs the ADD_SCHEMA_RULES procedure in the DBMS_STREAMS_ADM package to add rules to the rule set of an apply process named strm01_apply:

```
BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name         => 'oe.orders',
    streams_type       => 'apply',
    streams_name       => 'strm01_apply',
    queue_name         => 'strm01_queue',
    include_dml        => true,
    include_ddl        => true,
    source_database    => 'dbs1.net');
END;
/
```

Running this procedure performs the following actions:

- Creates one rule that specifies that the apply process applies row LCRs that contain the results of DML changes to the oe.orders table. The rule name is specified by the system.
- Creates one rule that specifies that the apply process applies DDL LCRs that contain the results of DDL changes to the oe.orders table. The rule name is specified by the system.
- Adds the rule to the rule set associated with the apply process
- Specifies that the apply process applies LCRs only from the dbs1.net source database.

See Also: "System-Created Rules" on page 6-4

Removing a Rule from the Rule Set for an Apply Process

You specify that you want to remove a rule from the rule set for an existing apply process by running the REMOVE_RULE procedure in the DBMS_STREAMS_ADM package. For example, the following procedure removes a rule named DEPARTMENTS3 from the rule set of a apply process named strm01_apply.

```
BEGIN
  DBMS_STREAMS_ADM.REMOVE_RULE(
    rule_name        => 'DEPARTMENTS3',
    streams_type     => 'apply',
    streams_name     => 'strm01_apply',
    drop_unused_rule => true);
END;
/
```

In this example, the drop_unused_rule parameter in the REMOVE_RULE procedure is set to true, which is the default setting. Therefore, if the rule being removed is not in any other rule set, then it will be dropped from the database. If the drop_unused_rule parameter is set to false, then the rule is removed from the rule set, but it is not dropped from the database.

In addition, if you want to remove all of the rules in the rule set for the apply process, then specify NULL for the rule_name parameter when you run the REMOVE_RULE procedure.

Note: If you drop all of the rules in the rule set for an apply process that applies captured events, then the apply process does not apply any captured events in its queue. Similarly, if you drop all of the rules in the rule set for an apply process that applies user-enqueued events, then the apply process does not apply any user-enqueued events in its queue.

Removing the Rule Set for an Apply Process

You specify that you want to remove the rule set from an apply process by setting the `remove_rule_set` parameter to `true` in the `ALTER_APPLY` procedure in the `DBMS_APPLY_ADM` package. For example, the following procedure removes the rule set from an apply process named `strm01_apply`.

```
BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name      => 'strm01_apply',
    remove_rule_set => true);
END;
/
```

> **Note:** If you remove a rule set for an apply process that applied captured events, then the apply process applies all captured events in its queue. Similarly, if you remove a rule set for an apply process that applies user-enqueued events, then the apply process applies all user-enqueued events in its queue.

Setting an Apply Process Parameter

You set an apply process parameter using the `SET_PARAMETER` procedure in the `DBMS_APPLY_ADM` package. Apply process parameters control the way an apply process operates.

For example, the following procedure sets the `commit_serialization` parameter for an apply process named `strm01_apply` to `none`. This setting for the `commit_serialization` parameter enables the apply process to commit transactions in any order.

```
BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name   => 'strm01_apply',
    parameter    => 'commit_serialization',
    value        => 'none');
END;
/
```

Note:

- The `value` parameter is always entered as a VARCHAR2, even if the parameter value is a number.
- If you set the `parallelism` apply process parameter to a value greater than `1`, then you must specify a conditional supplemental log group at the source database for all of the unique key and foreign columns in the tables for which an apply process applies changes. Supplemental logging may be required for other columns in these tables as well, depending on your configuration.

See Also:

- "Apply Process Parameters" on page 4-30
- The `DBMS_APPLY_ADM.SET_PARAMETER` procedure in the *Oracle9i Supplied PL/SQL Packages and Types Reference* for detailed information about the apply process parameters
- "Specifying Supplemental Logging at a Source Database" on page 11-9

Setting the Apply User for an Apply Process

The apply user is the user who applies all DML statements and DDL statements and who runs user-defined apply handlers. You set the apply user for an apply process using the `apply_user` parameter in the `ALTER_APPLY` procedure in the `DBMS_APPLY_ADM` package. For example, the following procedure sets the apply user for an apply process named `strm03_apply` to `hr`.

```
BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name => 'strm03_apply',
    apply_user => 'hr');
END;
/
```

The user specified by the `apply_user` parameter must have the necessary privileges to perform DML and DDL changes on the apply objects and to run any apply handlers. The specified user must also have dequeue privileges on the queue used by the apply process and privileges to execute the rule set and transformation

functions used by the apply process. These privileges must be granted directly to the apply user; they cannot be granted through roles.

Managing the Message Handler for an Apply Process

This section contains instructions for setting and removing the message handler for an apply process.

See Also:

- "Event Processing with an Apply Process" on page 4-3
- Chapter 18, "Example Streams Messaging Environment" for an example of creating a message handler

Setting the Message Handler for an Apply Process

You set the message handler for an apply process using the `message_handler` parameter in the `ALTER_APPLY` procedure in the `DBMS_APPLY_ADM` package. For example, the following procedure sets the message handler for an apply process named `strm03_apply` to the `mes_proc` procedure in the `hr` schema.

```
BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name      => 'strm03_apply',
    message_handler => 'hr.mes_proc');
END;
/
```

Removing the Message Handler for an Apply Process

You remove the message handler for an apply process by setting the `remove_message_handler` parameter to `true` in the `ALTER_APPLY` procedure in the `DBMS_APPLY_ADM` package. For example, the following procedure removes the message handler from an apply process named `strm03_apply`.

```
BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name             => 'strm03_apply',
    remove_message_handler => true);
END;
/
```

Managing a DML Handler

This section contains instructions for creating, setting, and removing a DML handler.

See Also: "Event Processing with an Apply Process" on page 4-3

Creating a DML Handler

A DML handler must have the following signature:

```
PROCEDURE user_procedure (
   parameter_name   IN  SYS.AnyData);
```

Here, *user_procedure* stands for the name of the procedure and *parameter_name* stands for the name of the parameter passed to the procedure. The parameter passed to the procedure is a SYS.AnyData encapsulation of a row LCR.

The following restrictions apply to the user procedure:

- Do not execute COMMIT or ROLLBACK statements. Doing so may endanger the consistency of the transaction that contains the LCR.
- If you are manipulating a row using the EXECUTE member procedure for the row LCR, then do not attempt to manipulate more than one row in a row operation. You must construct and execute manually any DML statements that manipulate more than one row.
- If the command type is UPDATE or DELETE, then row operations resubmitted using the EXECUTE member procedure for the LCR must include the entire key in the list of old values. The key is the primary key, unless a substitute key has been specified by the SET_KEY_COLUMNS procedure.
- If the command type is INSERT, then row operations resubmitted using the EXECUTE member procedure for the LCR should include the entire key in the list of new values. Otherwise, duplicate rows are possible. The key is the primary key, unless a substitute key has been specified by the SET_KEY_COLUMNS procedure.

A DML handler can be used for any customized processing of row LCRs. For example, the handler may modify an LCR and then execute it using the EXECUTE member procedure for the LCR. When you execute a row LCR in a DML handler, the apply process applies the row LCR without calling any DML handler or error handler for the row LCR.

You may also use a DML handler for recording the history of DML changes. For example, a DML handler may insert information about an LCR it processes into a table and then apply the LCR using the EXECUTE member procedure. To create such a DML handler, first create a table to hold the history information:

```
CREATE TABLE strmadmin.history_row_lcrs(
  timestamp             DATE,
  source_database_name  VARCHAR2(128),
  command_type          VARCHAR2(30),
  object_owner          VARCHAR2(32),
  object_name           VARCHAR2(32),
  tag                   RAW(10),
  transaction_id        VARCHAR2(10),
  scn                   NUMBER,
  old_values            SYS.LCR$_ROW_LIST,
  new_values            SYS.LCR$_ROW_LIST)
    NESTED TABLE old_values STORE AS old_values_ntab
    NESTED TABLE new_values STORE AS new_values_ntab;
```

Then, create the procedure that inserts the information in the row LCR into the `history_row_lcrs` table and executes the row LCR:

```
CREATE OR REPLACE PROCEDURE history_dml(in_any IN SYS.ANYDATA)
 IS
  lcr   SYS.LCR$_ROW_RECORD;
  rc    PLS_INTEGER;
 BEGIN
  -- Access the LCR
  rc := in_any.GETOBJECT(lcr);
  -- Insert information in the LCR into the history_row_lcrs table
  INSERT INTO strmadmin.history_row_lcrs VALUES
   (SYSDATE, lcr.GET_SOURCE_DATABASE_NAME(), lcr.GET_COMMAND_TYPE(),
    lcr.GET_OBJECT_OWNER(), lcr.GET_OBJECT_NAME(),
    lcr.GET_TAG(), lcr.GET_TRANSACTION_ID(), lcr.GET_SCN(),
    lcr.GET_VALUES('OLD'), lcr.GET_VALUES('NEW'));
  --  Apply row LCR
  lcr.EXECUTE(true);
END;
/
```

Note: You must specify an unconditional supplemental log group at the source database for any columns needed by a DML handler at the destination database. This example DML handler does not require any additional supplemental logging because it simply records information about the row LCR and does not manipulate the row LCR in any other way.

See Also: "Specifying Supplemental Logging at a Source Database" on page 11-9

Setting a DML Handler

A DML handler processes each row LCR dequeued by any apply process that contains a specific operation on a specific table. You can specify multiple DML handlers on the same table, to handle different operations on the table. All apply processes that apply changes to the specified table in the local database use the specified DML handler.

You set the DML handler using the `SET_DML_HANDLER` procedure in the `DBMS_APPLY_ADM` package. For example, the following procedure sets the DML handler for `UPDATE` operations on the `hr.locations` table. Therefore, when any apply process that applies changes locally dequeues a row LCR containing an `UPDATE` operation on the `hr.locations` table, the apply process sends the row LCR to the `history_dml` PL/SQL procedure in the `strmadmin` schema for processing. The apply process does not apply a row LCR containing such a change directly.

```
BEGIN
  DBMS_APPLY_ADM.SET_DML_HANDLER(
    object_name         => 'hr.locations',
    object_type         => 'TABLE',
    operation_name      => 'UPDATE',
    error_handler       => false,
    user_procedure      => 'strmadmin.history_dml',
    apply_database_link => NULL);
END;
/
```

Note: If an apply process applies changes to a remote non-Oracle database, then it may use a different DML handler for the same table. You can run the SET_DML_HANDLER procedure in the DBMS_APPLY_ADM package to specify a DML handler for changes that will be applied to a remote non-Oracle database by setting the apply_database_link parameter to a non-NULL value.

See Also: "Apply Process Configuration in an Oracle to Non-Oracle Environment" on page 9-4

Removing a DML Handler

You remove a DML handler using the SET_DML_HANDLER procedure in the DBMS_APPLY_ADM package. When you run that procedure, set the user_procedure parameter to NULL for a specific operation on a specific table. For example, the following procedure removes the DML handler for UPDATE operations on the hr.locations table. After the DML handler is removed, any apply process that applies changes locally will apply a row LCR containing such a change directly.

```
BEGIN
  DBMS_APPLY_ADM.SET_DML_HANDLER(
    object_name    => 'hr.locations',
    object_type    => 'TABLE',
    operation_name => 'UPDATE',
    error_handler  => false,
    user_procedure => NULL);
END;
/
```

Managing the DDL Handler for an Apply Process

This section contains instructions for creating, specifying, and removing the DDL handler for an apply process.

Note: All applied DDL LCRs commit automatically. Therefore, if a DDL handler calls the EXECUTE member procedure of a DDL LCR, then a commit is performed automatically.

See Also:

- "Event Processing with an Apply Process" on page 4-3
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the EXECUTE member procedure for LCR types

Creating a DDL Handler for an Apply Process

A DDL handler must have the following signature:

```
PROCEDURE handler_procedure (
   parameter_name   IN  SYS.AnyData);
```

Here, *handler_procedure* stands for the name of the procedure and *parameter_name* stands for the name of the parameter passed to the procedure. The parameter passed to the procedure is a SYS.AnyData encapsulation of a DDL LCR.

A DDL handler can be used for any customized processing of DDL LCRs. For example, the handler may modify the LCR and then execute it using the EXECUTE member procedure for the LCR. When you execute a DDL LCR in a DDL handler, the apply process applies the LCR without calling the DDL handler again.

You may also use a DDL handler to record the history of DDL changes. For example, a DDL handler may insert information about an LCR it processes into a table and then apply the LCR using the EXECUTE member procedure.

To create such a DDL handler, first create a table to hold the history information:

```
CREATE TABLE strmadmin.history_ddl_lcrs(
  timestamp             DATE,
  source_database_name  VARCHAR2(128),
  command_type          VARCHAR2(30),
  object_owner          VARCHAR2(32),
  object_name           VARCHAR2(32),
  object_type           VARCHAR2(18),
  ddl_text              CLOB,
  logon_user            VARCHAR2(32),
  current_schema        VARCHAR2(32),
  base_table_owner      VARCHAR2(32),
  base_table_name       VARCHAR2(32),
  tag                   RAW(10),
  transaction_id        VARCHAR2(10),
  scn                   NUMBER);
```

Then, create the procedure that inserts the information in the DDL LCR into the `history_ddl_lcrs` table and executes the DDL LCR:

```
CREATE OR REPLACE procedure history_ddl(in_any IN SYS.ANYDATA)
 IS
   lcr       SYS.LCR$_DDL_RECORD;
   rc        PLS_INTEGER;
   ddl_text  CLOB;
 BEGIN
   -- Access the LCR
   rc := in_any.GETOBJECT(lcr);
   DBMS_LOB.CREATETEMPORARY(ddl_text, TRUE);
   lcr.GET_DDL_TEXT(ddl_text);
   --  Insert DDL LCR information into history_ddl_lcrs table
   INSERT INTO strmadmin.history_ddl_lcrs VALUES(
     SYSDATE, lcr.GET_SOURCE_DATABASE_NAME(), lcr.GET_COMMAND_TYPE(),
     lcr.GET_OBJECT_OWNER(), lcr.GET_OBJECT_NAME(), lcr.GET_OBJECT_TYPE(),
     ddl_text, lcr.GET_LOGON_USER(), lcr.GET_CURRENT_SCHEMA(),
     lcr.GET_BASE_TABLE_OWNER(), lcr.GET_BASE_TABLE_NAME(), lcr.GET_TAG(),
     lcr.GET_TRANSACTION_ID(), lcr.GET_SCN());
   --  Apply DDL LCR
   lcr.EXECUTE();
   -- Free temporary LOB space
   DBMS_LOB.FREETEMPORARY(ddl_text);
END;
/
```

Setting the DDL Handler for an Apply Process

A DDL handler processes all DDL LCRs dequeued by an apply process. You set the DDL handler for an apply process using the `ddl_handler` parameter in the `ALTER_APPLY` procedure in the `DBMS_APPLY_ADM` package. For example, the following procedure sets the DDL handler for an apply process named `strm02_apply` to the `history_ddl` procedure in the `strmadmin` schema.

```
BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name  => 'strm02_apply',
    ddl_handler => 'strmadmin.history_ddl');
END;
/
```

Removing the DDL Handler for an Apply Process

A DDL handler processes all DDL LCRs dequeued by an apply process. You remove the DDL handler for an apply process by setting the `remove_ddl_handler` parameter to `true` in the `ALTER_APPLY` procedure in the `DBMS_APPLY_ADM` package. For example, the following procedure removes the DDL handler from an apply process named `strm02_apply`.

```
BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name         => 'strm02_apply',
    remove_ddl_handler => true);
END;
/
```

Managing an Error Handler

This section contains instructions for creating, setting, and removing an error handler.

See Also: "Event Processing with an Apply Process" on page 4-3

Creating an Error Handler

You create an error handler by running the SET_DML_HANDLER procedure in the DBMS_APPLY_ADM package and setting the error_handler parameter to true.

An error handler must have the following signature:

```
PROCEDURE user_procedure (
     message             IN SYS.AnyData,
     error_stack_depth   IN NUMBER,
     error_numbers       IN DBMS_UTILITY.NUMBER_ARRAY,
     error_messages      IN emsg_array);
```

Here, *user_procedure* stands for the name of the procedure. Each parameter is required and must have the specified datatype. However, you can change the names of the parameters. The emsg_array parameter must be a user-defined array that is a PL/SQL table of type VARCHAR2 with at least 76 characters.

Note: Certain restrictions on the user procedure specified in SET_DML_HANDLER must be met for error handlers. See "Creating a DML Handler" on page 13-14 for information about these restrictions.

Running an error handler results in one of the following outcomes:

- The error handler successfully resolves the error, applies the row LCR if appropriate, and returns control back to the apply process.
- The error handler fails to resolve the error, and the error is raised. The raised error causes the transaction to be rolled back and placed in the error queue.

If you want to retry the DML operation, then have the error handler procedure run the EXECUTE member procedure for the LCR.

The following example creates an error handler named `regions_pk_error` that resolves primary key violations for the `hr.regions` table. At a destination database, assume users insert rows into the `hr.regions` table and an apply process applies changes to the `hr.regions` table that originated from a capture process at a remote source database. In this environment, there is a possibility of errors resulting from users at the destination database inserting rows with the same primary key value as LCRs applied from the source database.

This example creates a table in the `strmadmin` schema called `errorlog` to record the following information about each primary key violation error on the `hr.regions` table:

- The timestamp when the error occurred
- The user who caused the error (sender), which is the capture process name for captured LCRs or the name of the AQ agent for user-enqueued LCRs
- The name of the object on which the DML operation was run, because errors for other objects may be logged in the future
- The type of command used in the DML operation
- The name of the constraint violated
- The error message
- The LCR that caused the error

This error handler resolves only errors that are caused by a primary key violation on the `hr.regions` table. To resolve this type of error, the error handler modifies the `region_id` value in the row LCR using a sequence and then executes the row LCR to apply it. If other types of errors occur, then you can use the row LCR you stored in the `errorlog` table to resolve the error manually.

For example, the following error is resolved by the error handler:

1. At the destination database, a user inserts a row into the `hr.regions` table with a `region_id` value of `6` and a `region_name` value of `'LILLIPUT'`.
2. At the source database, a user inserts a row into the `hr.regions` table with a `region_id` value of `6` and a `region_name` value of `'BROBDINGNAG'`.
3. A capture process at the source database captures the change described in Step 2.
4. A propagation job propagates the LCR containing the change from a queue at the source database to the queue used by the apply process at the destination database.

5. When the apply process tries to apply the LCR, an error results because of a primary key violation.
6. The apply process invokes the error handler to handle the error.
7. The error handler logs the error in the `strmadmin.errorlog` table.
8. The error handler modifies the `region_id` value in the LCR using a sequence and executes the LCR to apply it.

Complete the following steps to create the `regions_pk_error` error handler:

1. Create the sequence used by the error handler to assign new primary key values by connecting as `hr` user and running the following statement:

```
CONNECT hr/hr

CREATE SEQUENCE hr.reg_exception_s START WITH 9000;
```

   This example assumes that users at the destination database will never insert a row into the `hr.regions` table with a `region_id` greater than `8999`.

2. Grant the Streams administrator `ALL` privilege on the sequence:

```
GRANT ALL ON reg_exception_s TO strmadmin;
```

3. Create the `errorlog` table by connecting as the Streams administrator and running the following statement:

```
CONNECT strmadmin/strmadminpw

CREATE TABLE strmadmin.errorlog(
  logdate       DATE,
  sender        VARCHAR2(100) ,
  object_name   VARCHAR2(32),
  command_type  VARCHAR2(30),
  errnum        NUMBER,
  errmsg        VARCHAR2(2000),
  text          VARCHAR2(2000),
  lcr           SYS.LCR$_ROW_RECORD);
```

4. Create a package that includes the `regions_pk_error` procedure:

```
CREATE OR REPLACE PACKAGE errors_pkg
AS
 TYPE emsg_array IS TABLE OF VARCHAR2(2000) INDEX BY BINARY_INTEGER;
 PROCEDURE regions_pk_error(
   message            IN SYS.ANYDATA ,
   error_stack_depth  IN NUMBER ,
   error_numbers      IN DBMS_UTILITY.NUMBER_ARRAY,
   error_messages     IN EMSG_ARRAY);
END errors_pkg ;
/
```

5. Create the package body that includes the `regions_pk_error` procedure:

```
CREATE OR REPLACE PACKAGE BODY errors_pkg AS
 PROCEDURE regions_pk_error (
   message            IN SYS.ANYDATA,
   error_stack_depth  IN NUMBER,
   error_numbers      IN DBMS_UTILITY.NUMBER_ARRAY,
   error_messages     IN EMSG_ARRAY )
 IS
  reg_id     NUMBER;
  ad         SYS.ANYDATA;
  lcr        SYS.LCR$_ROW_RECORD;
  ret        PLS_INTEGER;
  vc         VARCHAR2(30) ;
  errlog_rec errorlog%ROWTYPE ;
  ov2        SYS.LCR$_ROW_LIST;
 BEGIN
  -- Access the error number from the top of the stack.
  -- In case of check constraint violation,
  -- get the name of the constraint violated
  IF error_numbers(1) IN ( 1 , 2290 ) THEN
   ad  := DBMS_STREAMS.GET_INFORMATION('CONSTRAINT_NAME');
   ret := ad.GetVarchar2(errlog_rec.text);
  ELSE
   errlog_rec.text := NULL ;
  END IF ;
  ad  := DBMS_STREAMS.GET_INFORMATION('SENDER');
  ret := ad.GETVARCHAR2(errlog_rec.sender);
  -- Try to access the LCR
  ret := message.GETOBJECT(lcr);
  errlog_rec.object_name  := lcr.GET_OBJECT_NAME() ;
  errlog_rec.command_type := lcr.GET_COMMAND_TYPE() ;
  errlog_rec.errnum := error_numbers(1) ;
```

```
  errlog_rec.errmsg := error_messages(1) ;
  INSERT INTO strmadmin.errorlog VALUES (SYSDATE, errlog_rec.sender,
       errlog_rec.object_name, errlog_rec.command_type,
       errlog_rec.errnum, errlog_rec.errmsg, errlog_rec.text, lcr);
  -- Add the logic to change the contents of LCR with correct values
  -- In this example, get a new region_id number
  -- from the hr.reg_exception_s sequence
  ov2 := lcr.GET_VALUES('NEW');
  FOR i IN 1 .. ov2.count
  LOOP
    IF ov2(i).column_name = 'REGION_ID' THEN
     SELECT hr.reg_exception_s.NEXTVAL INTO reg_id FROM DUAL;
     ov2(i).data := Sys.AnyData.ConvertNumber(reg_id) ;
    END IF ;
  END LOOP ;
  -- Set the NEW values in the LCR
  lcr.SET_VALUES(value_type => 'NEW', value_list => ov2);
  -- Execute the modified LCR to apply it
  lcr.EXECUTE(true);
 END regions_pk_error;
END errors_pkg;
/
```

Note:

- For subsequent changes to the modified row to be applied successfully, you should converge the rows at the two databases as quickly as possible. That is, you should make the `region_id` for the row match at the source and destination database. If you do not want these manual changes to be recaptured at a database, then use the SET_TAG procedure in the DBMS_STREAMS package to set the tag for the session in which you make the change to a value that is not captured.
- This example error handler illustrates the use of the GET_VALUES member function and SET_VALUES member procedure for the LCR. However, if you are modifying only one value in the LCR, then the GET_VALUE member function and SET_VALUE member procedure may be more convenient and more efficient.

See Also: "Setting the Tag Values Generated by the Current Session" on page 15-22

Setting an Error Handler

An error handler handles errors resulting from a row LCR dequeued by any apply process that contains a specific operation on a specific table. You can specify multiple error handlers on the same table, to handle errors resulting from different operations on the table. All apply processes that apply changes to the specified table in the local database use the specified error handler.

You can set the error handler using the `SET_DML_HANDLER` procedure in the `DBMS_APPLY_ADM` package. When you run this procedure to set an error handler, set the `error_handler` parameter to `true`.

For example, the following procedure sets the error handler for `INSERT` operations on the `hr.regions` table. Therefore, when any apply process dequeues a row LCR containing an `INSERT` operation on the local `hr.regions` table, and the row LCR results in an error, the apply process sends the row LCR to the `strmadmin.errors_pkg.regions_pk_error` PL/SQL procedure for processing. If the error handler cannot resolve the error, then the row LCR and all of the other row LCRs in the same transaction are moved to the error queue.

Run the following procedure to set the error handler:

```
BEGIN
  DBMS_APPLY_ADM.SET_DML_HANDLER(
    object_name         => 'hr.regions',
    object_type         => 'TABLE',
    operation_name      => 'INSERT',
    error_handler       => true,
    user_procedure      => 'strmadmin.errors_pkg.regions_pk_error',
    apply_database_link => NULL);
END;
/
```

Removing an Error Handler

You remove an error handler using the SET_DML_HANDLER procedure in the DBMS_APPLY_ADM package. When you run that procedure, set the user_procedure parameter to NULL for a specific operation on a specific table.

For example, the following procedure removes the error handler for INSERT operations on the hr.regions table:

```
BEGIN
  DBMS_APPLY_ADM.SET_DML_HANDLER(
    object_name    => 'hr.regions',
    object_type    => 'TABLE',
    operation_name => 'INSERT',
    user_procedure => NULL);
END;
/
```

Note: The error_handler parameter need not be specified.

Managing the Substitute Key Columns for a Table

This section contains instructions for setting and removing the substitute key columns for a table.

See Also: "Substitute Key Columns" on page 4-10

Setting Substitute Key Columns for a Table

When an apply process applies changes to a table, substitute key columns can either replace the primary key columns for a table that has a primary key or act as the primary key columns for a table that does not have a primary key. You set the substitute key columns for a table using the SET_KEY_COLUMNS procedure in the DBMS_APPLY_ADM package. This setting applies to all of the apply processes that apply local changes to the database.

For example, to set the substitute key columns for the `hr.employees` table to the `first_name`, `last_name`, and `hire_date` columns, replacing the `employee_id` column, run the following procedure:

```
BEGIN
  DBMS_APPLY_ADM.SET_KEY_COLUMNS(
    object_name         => 'hr.employees',
    column_list         => 'first_name,last_name,hire_date');
END;
/
```

Note:

- You must specify an unconditional supplemental log group at the source database for all of the columns specified as substitute key columns in the `column_list` or `column_table` parameter at the destination database. In this example, you would specify an unconditional supplemental log group including the `first_name`, `last_name`, and `hire_date` columns in the `hr.employees` table.
- If an apply process applies changes to a remote non-Oracle database, then it may use different substitute key columns for the same table. You can run the `SET_KEY_COLUMNS` procedure in the `DBMS_APPLY_ADM` package to specify substitute key columns for changes that will be applied to a remote non-Oracle database by setting the `apply_database_link` parameter to a non-`NULL` value.

See Also:

- "Specifying Supplemental Logging at a Source Database" on page 11-9
- "Apply Process Configuration in an Oracle to Non-Oracle Environment" on page 9-4

Removing the Substitute Key Columns for a Table

You remove the substitute key columns for a table by specifying NULL for the column_list or column_table parameter in the SET_KEY_COLUMNS procedure in the DBMS_APPLY_ADM package. If the table has a primary key, then the table's primary key is used by any apply process for local changes to the database after you remove the substitute primary key.

For example, to remove the substitute key columns for the hr.employees table, run the following procedure:

```
BEGIN
  DBMS_APPLY_ADM.SET_KEY_COLUMNS(
    object_name  => 'hr.employees',
    column_list  => NULL);
END;
/
```

Managing Streams Conflict Resolution

This section contains instructions for creating, specifying, and removing update conflict handlers a table. All apply processes running on a database that apply changes to the specified table use the specified update conflict handler.

See Also: Chapter 7, "Streams Conflict Resolution"

Setting an Update Conflict Handler

You set an update conflict handler using the SET_UPDATE_CONFLICT_HANDLER procedure in the DBMS_APPLY_ADM package. You can use one of the following prebuilt methods when you create an update conflict resolution handler:

- OVERWRITE
- DISCARD
- MAXIMUM
- MINIMUM

For example, suppose a Streams environment captures changes to the hr.jobs table at dbs1.net and propagates these changes to the dbs2.net destination database, where they are applied. In this environment, applications can perform DML changes on the hr.jobs table at both databases, but, if there is a conflict for a particular DML change, then the change at the dbs1.net database should always overwrite the change at the dbs2.net database. In this environment, you can accomplish this goal by specifying an OVERWRITE handler at the dbs2.net database.

To specify an update conflict handler for the hr.jobs table in the hr schema at the dbs2.net database, run the following procedure at dbs2.net:

```
DECLARE
  cols DBMS_UTILITY.NAME_ARRAY;
  BEGIN
    cols(1) := 'job_title';
    cols(2) := 'min_salary';
    cols(3) := 'max_salary';
    DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
      object_name       => 'hr.assignments',
      method_name       => 'OVERWRITE',
      resolution_column => 'job_title',
      column_list       => cols);
END;
/
```

Note:

- The resolution_column is not used for OVERWRITE and DISCARD methods, but one of the columns in the column_list still must be specified.
- You must specify a conditional supplemental log group at the source database for all of the columns in the column_list at the destination database. In this example, you would specify a conditional supplemental log group including the job_title, min_salary, and max_salary columns in the hr.jobs table at the dbs1.net database.
- Conflict resolution does not support LOB columns. Therefore, you should not include LOB columns in the column_list parameter when running SET_UPDATE_CONFLICT_HANDLER.

See Also:

- "Specifying Supplemental Logging at a Source Database" on page 11-9
- "Multiple Source Databases in an Oracle-Only Environment" on page 19-82 for an example Streams environment that illustrates using the MAXIMUM prebuilt method for time-based conflict resolution

Modifying an Existing Update Conflict Handler

You can modify an existing update conflict handler by running the SET_UPDATE_CONFLICT_HANDLER procedure in the DBMS_APPLY_ADM package. To update an existing conflict handler, specify the same table and resolution column as the existing conflict handler.

To modify the update conflict handler created in "Setting an Update Conflict Handler" on page 13-29, you specify the hr.jobs table and the job_title column as the resolution column. You can modify this update conflict handler by specifying a different type of prebuilt method or a different column list, or both. However, if you want to change the resolution column for an update conflict handler, then you must remove and re-create the handler.

For example, suppose the environment changes, and you want changes from dbs1.net to be discarded in the event of a conflict, whereas previously changes from dbs1.net overwrote changes at dbs2.net. You can accomplish this goal by specifying a DISCARD handler at the dbs2.net database.

To modify the existing update conflict handler for the hr.jobs table in the hr schema at the dbs2.net database, run the following procedure:

```
DECLARE
  cols DBMS_UTILITY.NAME_ARRAY;
  BEGIN
    cols(1) := 'job_title';
    cols(2) := 'min_salary';
    cols(3) := 'max_salary';
    DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
      object_name       => 'hr.assignments',
      method_name       => 'DISCARD',
      resolution_column => 'job_title',
      column_list       => cols);
END;
/
```

Removing an Existing Update Conflict Handler

You can remove an existing update conflict handler by running the SET_UPDATE_CONFLICT_HANDLER procedure in the DBMS_APPLY_ADM package. To remove a an existing conflict handler, specify NULL for the method, and specify the same table, column list, and resolution column as the existing conflict handler.

For example, suppose you want to remove the update conflict handler created in "Setting an Update Conflict Handler" on page 13-29 and then modified in "Modifying an Existing Update Conflict Handler" on page 13-31. To remove this update conflict handler, run the following procedure:

```
DECLARE
  cols DBMS_UTILITY.NAME_ARRAY;
  BEGIN
    cols(1) := 'job_title';
    cols(2) := 'min_salary';
    cols(3) := 'max_salary';
    DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
      object_name       => 'hr.assignments',
      method_name       => NULL,
      resolution_column => 'job_title',
      column_list       => cols);
END;
/
```

Managing Apply Errors

This section contains instructions for retrying and deleting apply errors.

See Also:

- "The Error Queue" on page 4-33
- "Checking for Apply Errors" on page 16-35
- "Displaying Detailed Information About Apply Errors" on page 16-36
- "Considerations for Applying DML Changes to Tables" on page 4-9 for information about the possible causes of apply errors

Retrying Apply Error Transactions

The following sections describe how to retry a specific error transaction and how to retry all error transactions for an apply process.

Retrying a Specific Apply Error Transaction

After you correct the conditions that caused an apply error, you can retry the transaction by running the EXECUTE_ERROR procedure in the DBMS_APPLY_ADM package. For example, to retry a transaction with the transaction identifier 5.4.312, run the following procedure:

```
BEGIN
  DBMS_APPLY_ADM.EXECUTE_ERROR(
    local_transaction_id => '5.4.312',
    execute_as_user      => false);
END;
/
```

If execute_as_user is true, then the apply process reexecutes the transaction in the security context of the current user. If execute_as_user is false, then the apply process reexecutes the transaction in the security context of the original receiver of the transaction. The original receiver is the user who was processing the transaction when the error was raised.

In either case, the user who executes the transaction must have privileges to perform DML and DDL changes on the apply objects and to run any apply handlers. This user must also have dequeue privileges on the queue used by the apply process.

Retrying All Error Transactions for an Apply Process

After you correct the conditions that caused all of the apply errors for an apply process, you can retry all of the error transactions by running the EXECUTE_ALL_ERRORS procedure in the DBMS_APPLY_ADM package. For example, to retry all of the error transactions for an apply process named apply_oe, you can run the following procedure:

```
BEGIN
  DBMS_APPLY_ADM.EXECUTE_ALL_ERRORS(
    apply_name       => 'apply_oe',
    execute_as_user  => false);
END;
/
```

Note: If you specify NULL for the apply_name parameter, and you have multiple apply processes, then all of the apply errors are retried for all of the apply processes.

Deleting Apply Error Transactions

The following sections describe how to delete a specific error transaction and how to delete all error transactions for an apply process.

Deleting a Specific Apply Error Transaction

If an error transaction should not be applied, then you can delete the transaction from the error queue using the DELETE_ERROR procedure in the DBMS_APPLY_ADM package. For example, a transaction with the transaction identifier 5.4.312, run the following procedure:

```
EXEC DBMS_APPLY_ADM.DELETE_ERROR(local_transaction_id => '5.4.312');
```

Deleting All Error Transactions for an Apply Process

If none of the error transactions in the error queue should be applied, then you can delete all of the error transactions by running the DELETE_ALL_ERRORS procedure in the DBMS_APPLY_ADM package. For example, to delete all of the error transactions for an apply process named apply_oe, you can run the following procedure:

```
EXEC DBMS_APPLY_ADM.DELETE_ALL_ERRORS(apply_name => 'apply_oe');
```

Note: If you specify NULL for the apply_name parameter, and you have multiple apply processes, then all of the apply errors are deleted for all of the apply processes.

Setting Instantiation SCNs at a Destination Database

In a Streams environment that shares information between multiple databases, a source database is the database where changes are generated in the redo log. Suppose an environment has the following characteristics:

- A capture process will capture changes to tables at the source database.
- The changes to the tables will be propagated to a destination database and applied there.
- The destination database already contains some or all of the tables for which changes will be captured, propagated, and applied.

In such an environment, the tables that already exist at the destination database are not instantiated. That is, because these tables already exist at the destination database, they are not created at the destination by exporting them at the source database and then importing them at the destination database. Instead, the apply process at the destination database must be instructed explicitly to apply changes that committed after a specific SCN for each source database table. The instantiation SCN for the tables specifies this SCN.

The instantiation SCN for a database object controls which LCRs that contain changes to the database object are ignored by an apply process and which LCRs are applied by an apply process. If the commit SCN of an LCR for a database object from a source database is less than or equal to the instantiation SCN for that database object at a destination database, then the apply process at the destination database discards the LCR. Otherwise, the apply process applies the LCR. Also, if there are multiple source databases for a shared database object at a destination database, then an instantiation SCN must be set for each source database, and the instantiation SCN may be different for each source database.

You can set instantiation SCNs in one of the following ways:

- Perform instantiation of the relevant database objects by exporting them at the source database and importing them into the destination database. In this case, the instantiation creates the database objects at the destination database, populates them with the data from the source database, and sets the relevant instantiation SCNs.
- Perform a metadata only export/import by setting the ROWS parameter to n during export at the source database or import at the destination database, or both. In this case, the database objects are instantiated, but no data is imported.
- Set the instantiation SCN using the SET_TABLE_INSTANTIATION_SCN, SET_SCHEMA_INSTANATIATION_SCN, and SET_GLOBAL_INSTANTIATION_SCN procedures in the DBMS_APPLY_ADM package.

Setting Instantiation SCNs Using Export/Import

This section discusses setting instantiation SCNs by performing an export/import. The information in this section applies to both metadata export/import operations and to export/import operations that import rows.

To set instantiation SCNs for database objects using Export/Import, first export them at the source database with the OBJECT_CONSISTENT export parameter set to Y, or use a more stringent degree of consistency. Then, import them at the destination database with the STREAMS_INSTANTIATION import parameter set to Y.

Note:

- If a non-NULL instantiation SCN already exists for a database object at a destination database that performs an import, then the import does not update the instantiation SCN for that database object.
- During an export for a Streams instantiation, make sure no DDL changes are made to objects being exported.

The following sections describe the instantiation SCNs set for different types of export/import operations. These sections refer to prepared tables. Prepared tables are tables that have been prepared for instantiation using the PREPARE_TABLE_INSTANTIATION, PREPARE_SCHEMA_INSTANTIATION, or PREPARE_GLOBAL_INSTANTIATION procedures in the DBMS_CAPTURE_ADM package. A table must be a prepared table before export in order for an instantiation SCN to be set for it during import. However, the database and schemas do not need to be prepared before the export in order for their instantiation SCNs to be set during import.

Full Database Export and Full Database Import

A full database export and full database import sets the following instantiation SCNs at the import database:

- The database level, or global, instantiation SCN
- The schema level instantiation SCN for each imported schema
- The table level instantiation SCNs for each prepared table that is imported

Full Database or Schema Level Export and Schema Level Import

A full database or schema level export and schema level import sets the following instantiation SCNs at the import database:

- The schema level instantiation SCN for each imported schema
- The table level instantiation SCN for each prepared tables that is imported

Full Database, Schema, or Table Level Export and Table Level Import

Any export that includes one or more tables and a table level import sets the table level instantiation SCN for each prepared table that is imported at the import database.

See Also:

- "Setting Export and Import Parameters Relevant to Streams" on page 10-8 and *Oracle9i Database Utilities* for information about using Export/Import
- "Configuring a Capture-Based Streams Environment" on page 10-12 for more information about performing export/import operations to set instantiation SCNs when configuring a Streams environment
- "Preparing Database Objects for Instantiation at a Source Database" on page 11-11

Setting Instantiation SCNs Using a DBMS_APPLY_ADM Package Procedure

You can set an instantiation SCN at a destination database for a specified table, a specified schema, or an entire database using one of the following procedures in the `DBMS_APPLY_ADM` package:

- `SET_TABLE_INSTANTIATION_SCN`
- `SET_SCHEMA_INSTANTIATION_SCN`
- `SET_GLOBAL_INSTANTIATION_SCN`

If you set the instantiation SCN for a schema using `SET_SCHEMA_INSTANTIATION_SCN`, then you should set the instantiation SCN for each table in the schema using `SET_TABLE_INSTANTIATION_SCN`. Similarly, if you set the instantiation SCN for a database using `SET_GLOBAL_INSTANTIATION_SCN`, then you should set the instantiation SCN for each schema in the database using `SET_SCHEMA_INSTANTIATION_SCN`

Table 13–1 lists each procedure and the types of statements for which they set an instantiation SCN.

Table 13–1 Set Instantiation SCN Procedures and the Statements They Cover

Procedure	Sets Instantiation SCN for	Examples
SET_TABLE_INSTANTIATION_SCN	DML and DDL statements on tables, except CREATE TABLE DDL statements on table indexes and table triggers	UPDATE ALTER TABLE DROP TABLE CREATE, ALTER, or DROP INDEX on a table CREATE, ALTER, or DROP TRIGGER on a table
SET_SCHEMA_INSTANTIATION_SCN	DDL statements on users, except CREATE USER DDL statements on all database objects that have a non-PUBLIC owner, except for those DDL statements handled by a table-level instantiation SCN	CREATE TABLE ALTER USER DROP USER CREATE PROCEDURE
SET_GLOBAL_INSTANTIATION_SCN	DDL statements on database objects other than users with no owner DDL statements on database objects owned by public CREATE USER statements	CREATE USER CREATE TABLESPACE

The following example sets the instantiation SCN for the `hr.departments` table at the `hrdb2.net` database to the current SCN by running the following procedure at the source database `hrdb1.net`:

```
DECLARE
  iscn  NUMBER;         -- Variable to hold instantiation SCN value
BEGIN
  iscn := DBMS_FLASHBACK.GET_SYSTEM_CHANGE_NUMBER();
  DBMS_APPLY_ADM.SET_TABLE_INSTANTIATION_SCN@HRDB2.NET(
    source_object_name    => 'hr.departments',
    source_database_name  => 'hrdb1.net',
    instantiation_scn     => iscn);
END;
/
```

Note:

- If a relevant instantiation SCN is not present, then an error is raised during apply.
- The `SET_SCHEMA_INSTANTIATION_SCN` procedure does not set the instantiation SCN for any of the tables in the schema.
- The `SET_GLOBAL_INSTANTIATION_SCN` procedure does not set the instantiation SCN for any of the schemas in the database.
- If an apply process applies changes to a remote non-Oracle database, then set the `apply_database_link` parameter to the database link used for remote apply when you set the instantiation SCN.

See Also:

- Chapter 10, "Configuring a Streams Environment" for more information when to set instantiation SCNs when you are configuring a Streams environment
- "Single Source Database in a Heterogeneous Environment" on page 19-2 for a detailed example that uses the `SET_TABLE_INSTANTIATION_SCN` procedure
- The information about the `DBMS_APPLY_ADM` package in the *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about which instantiation SCN can be used for a DDL LCR
- "Instantiation in an Oracle to Non-Oracle Environment" on page 9-7

Performing Database Point-in-Time Recovery in a Streams Environment

Point-in-time recovery is the recovery of a database to a specified noncurrent time, SCN, or log sequence number. If point-in-time recovery is required at a destination database in a Streams environment, then you must reapply the captured changes that had already been applied after the point-in-time of the recovery.

For each relevant capture process, you can choose either of the following methods to perform point-in-time recovery at a destination database in a Streams environment

- Reset the start SCN for the existing capture process that captures the changes that are applied at the destination database.
- Create a new capture process to capture the changes that must be reapplied at the destination database.

Resetting the start SCN for the capture process is simpler than creating a new capture process. However, if the capture process captures changes that are applied at multiple destination databases, then the changes are resent to all the destination databases, including the ones that did not perform point-in-time recovery. If a change is already applied at a destination database, then it is discarded by the apply process, but you may not want to use the network and computer resources required to resend the changes to multiple destination databases. In this case, you can create and temporarily use a new capture process and a new propagation job that propagates changes only to the destination database that was recovered.

Both of these methods reapply only captured events at the destination database, not user-enqueued events. Also, if the destination database to be recovered is also a source database, then do not use either of these methods. In this case, you must manually resynchronize the data at all destination databases.

The following sections provide instructions for each task:

- Resetting the Start SCN for the Existing Capture Process to Perform Recovery
- Creating a New Capture Process to Perform Recovery

Note: If there are multiple apply processes at the destination database where you performed point-in-time recovery, then complete one of the tasks in this section for each apply process.

See Also:

- *Oracle9i Backup and Recovery Concepts* for more information about point-in-time recovery
- "The Start SCN for a Capture Process" on page 2-21

Resetting the Start SCN for the Existing Capture Process to Perform Recovery

If you decide to reset the start SCN for the existing capture process to perform point-in-time recovery, then complete the following steps:

1. If you are not using directed networks between the source database and destination database, then drop the propagation job that propagates changes from the source queue at the source database to the destination queue at the destination database. Use the `DROP_PROPAGATION` procedure in the `DBMS_PROPAGATION_ADM` package to drop the propagation.

   If you are using directed networks, and there are intermediate databases between the source database and destination database, then drop the propagation job at each intermediate database in the path to the destination database, including the propagation job at the source database.

   Note: You must drop the appropriate propagation job(s). Disabling them is not sufficient. You will re-create the propagation job(s) in Step 6, and dropping them now ensures that only events created after resetting the start SCN for the capture process are propagated.

   See Also: "Directed Networks" on page 3-8

2. Perform the point-in-time recovery at the destination database.
3. Query for the oldest message number from the source database for the apply process at the destination database. Then, make a note of the results of the query. The oldest message number is the earliest system change number (SCN) that may need to be applied.

   The following statement is an example of the query to perform:

   ```
   SELECT APPLY_NAME, OLDEST_MESSAGE_NUMBER FROM DBA_APPLY_PROGRESS;
   ```

4. Stop the existing capture process using the STOP_CAPTURE procedure in the DBMS_CAPTURE_ADM package.

5. Reset the start SCN of the existing capture process.

   To reset the start SCN for an existing capture process, run the ALTER_CAPTURE procedure in the DBMS_CAPTURE_ADM package and set the start_scn parameter to the value you recorded from the query in Step 3. For example, to reset the start SCN for a capture process named strm01_capture to the value 829381993, run the following ALTER_CAPTURE procedure:

   ```
   BEGIN
     DBMS_CAPTURE_ADM.ALTER_CAPTURE(
       capture_name  =>  'strm01_capture',
       start_scn     =>  829381993);
   END;
   /
   ```

6. If you are not using directed networks between the source database and destination database, then create a new propagation job to propagate changes from the source queue to the destination queue using the CREATE_PROPAGATION procedure in the DBMS_PROPAGATION_ADM package. Specify the rule set used by the original propagation job for the rule_set_name parameter when you create the propagation job.

   If you are using directed networks, and there are intermediate databases between the source database and destination database, then create a new propagation job at each intermediate database in the path to the destination database, including the propagation job at the source database.

7. Start the existing capture process using the START_CAPTURE procedure in the DBMS_CAPTURE_ADM package.

Creating a New Capture Process to Perform Recovery

If you decide to create a new capture process to perform point-in-time recovery, then complete the following steps:

1. If you are not using directed networks between the source database and destination database, then drop the propagation job that propagates changes from the source queue at the source database to the destination queue at the destination database. Use the `DROP_PROPAGATION` procedure in the `DBMS_PROPAGATION_ADM` package to drop the propagation.

   If you are using directed networks, and there are intermediate databases between the source database and destination database, then drop the propagation job that propagates events between the last intermediate database and the destination database. You do not need to drop the propagation jobs at the other intermediate databases nor at the source database.

   Note: You must drop the appropriate propagation job. Disabling it not sufficient.

   See Also: "Directed Networks" on page 3-8

2. Perform the point-in-time recovery at the destination database.

3. Query for the oldest message number from the source database for the apply process at the destination database. Then, make a note of the results of the query. The oldest message number is the earliest system change number (SCN) that may need to be applied.

   The following statement is an example of the query to perform:

   ```
   SELECT APPLY_NAME, OLDEST_MESSAGE_NUMBER FROM DBA_APPLY_PROGRESS;
   ```

4. Create a queue at the source database to be used by the capture process using the `SET_UP_QUEUE` procedure in the `DBMS_STREAMS_ADM` package.

   If you are using directed networks, and there are intermediate databases between the source database and destination database, then create a queue at each intermediate database in the path to the destination database, including the new queue at the source database. Do not create a new queue at the destination database.

5. If you are not using directed networks between the source database and destination database, then create a new propagation job to propagate changes from the source queue created in Step 4 to the destination queue using the CREATE_PROPAGATION procedure in the DBMS_PROPAGATION_ADM package. Specify the rule set used by the original propagation job for the rule_set_name parameter when you create the propagation job.

   If you are using directed networks, and there are intermediate databases between the source database and destination database, then create a propagation job at each intermediate database in the path to the destination database, including the propagation job from the source database to the first intermediate database. These propagation jobs propagate changes captured by the capture process you will create in Step 6 between the queues created in Step 4.

6. Create a new capture process at the source database using the CREATE_CAPTURE procedure in the DBMS_CAPTURE_ADM package. Set the source_queue parameter to the queue you created in Step 4, the rule_set_name parameter to the rule set used by the original capture process, and the start_scn parameter to the value you recorded from the query in Step 3. If the rule set used by the original capture process captures events that should not be sent to the destination database that was recovered, then you can create and use a smaller, customized rule set that shares some rules with the original rule set.

7. Start the capture process you created in Step 6 using the START_CAPTURE procedure in the DBMS_CAPTURE_ADM package.

8. When the oldest message number of the apply process at the recovered database is approaching the capture number of the original capture process at the source database, stop the original capture process using the STOP_CAPTURE procedure in the DBMS_CAPTURE_ADM package.

   At the destination database, you can use the following query to determine the oldest message number from the source database for the apply process:

   ```
   SELECT APPLY_NAME, OLDEST_MESSAGE_NUMBER FROM DBA_APPLY_PROGRESS;
   ```

   At the source database, you can use the following query to determine the capture number of the original capture process:

   ```
   SELECT CAPTURE_NAME, CAPTURE_MESSAGE_NUMBER FROM V$STREAMS_CAPTURE;
   ```

9. When the oldest message number of the apply process at the recovered database is beyond the capture number of the original capture process at the source database, drop the new capture process created in Step 6.

10. If you are not using directed networks between the source database and destination database, then drop the new propagation job created in Step 5.

    If you are using directed networks, and there are intermediate databases between the source database and destination database, then drop the new propagation job at each intermediate database in the path to the destination database, including the new propagation job at the source database.

11. If you are not using directed networks between the source database and destination database, then remove the queue created in Step 4.

    If you are using directed networks, and there are intermediate databases between the source database and destination database, then drop the new queue at each intermediate database in the path to the destination database, including the new queue at the source database. Do not drop the queue at the destination database.

12. If you are not using directed networks between the source database and destination database, then create a propagation job that propagates changes from the original source queue at the source database to the destination queue at the destination database. Use the `CREATE_PROPAGATION` procedure in the `DBMS_PROPAGATION_ADM` package to create the propagation. Specify the rule set used by the original propagation job for the `rule_set_name` parameter when you create the propagation job.

    If you are using directed networks, and there are intermediate databases between the source database and destination database, then re-create the propagation job from the last intermediate database to the destination database. You dropped this propagation job in Step 1.

13. Start the capture process you stopped in Step 8.

All of the steps after Step 7 can be deferred to a later time, or they can be done as soon as the condition described in Step 8 is met.

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Managing Rules and Rule-Based Transformations

A Streams environment uses rules to control the behavior of capture processes, propagation jobs, and apply processes. A Streams environment uses rule-based transformations to modify an event that results when a rule evaluates to TRUE. Transformations can occur during capture, propagation, or apply of an event. This chapter contains instructions for managing rule sets, rules, and rule-based transformations.

This chapter contains these topics:

- Managing Rule Sets and Rules
- Managing Privileges on Evaluation Contexts, Rule Sets, and Rules
- Managing Rule-Based Transformations

Each task described in this section should be completed by a Streams administrator that has been granted the appropriate privileges, unless specified otherwise.

See Also:

- Chapter 5, "Rules"
- Chapter 6, "How Rules Are Used In Streams"
- "Rule-Based Transformations" on page 6-23
- Chapter 20, "Example Rule-Based Application"
- "Configuring a Streams Administrator" on page 10-2

Managing Rule Sets and Rules

This section provides instructions for completing the following tasks:

- Creating a Rule Set
- Creating a Rule
- Adding a Rule to a Rule Set
- Altering a Rule
- Modifying System-Created Rules
- Removing a Rule from a Rule Set
- Dropping a Rule
- Dropping a Rule Set

Creating a Rule Set

The following is an example that runs the CREATE_RULE_SET procedure in the DBMS_RULE_ADM package to create a rule set:

```
BEGIN
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name       => 'strmadmin.hr_capture_rules',
    evaluation_context  => 'SYS.STREAMS$_EVALUATION_CONTEXT');
END;
/
```

Running this procedure performs the following actions:

- Creates a rule set named hr_capture_rules in the strmadmin schema. A rule set with the same name and owner must not exist.
- Associates the rule set with the SYS.STREAMS$_EVALUATION_CONTEXT evaluation context, which is the Oracle-supplied evaluation context for Streams

You can also use the following procedures in the DBMS_STREAMS_ADM package to create a rule set automatically, if one does not exist for a Streams process or job:

- ADD_GLOBAL_PROPAGATION_RULES
- ADD_GLOBAL_RULES
- ADD_SCHEMA_PROPAGATION_RULES
- ADD_SCHEMA_RULES

- ADD_SUBSET_RULES
- ADD_TABLE_PROPAGATION_RULES
- ADD_TABLE_RULES

See Also:

- "Example of Creating a Capture Process Using DBMS_STREAMS_ADM" on page 11-3
- "Example of Creating a Propagation Job Using DBMS_STREAMS_ADM" on page 12-8
- "Example of Creating an Apply Process Using DBMS_STREAMS_ADM" on page 13-3

Creating a Rule

The following is an example that runs the CREATE_RULE procedure in the DBMS_RULE_ADM package to create a rule:

```
BEGIN
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name          => 'strmadmin.hr_dml',
    condition          => ' :dml.get_object_owner() = ''HR'' ',
    evaluation_context => NULL);
END;
/
```

Running this procedure performs the following actions:

- Creates a rule named hr_dml in the strmadmin schema. A rule with the same name and owner must not exist.
- Creates a condition that evaluates to TRUE for any DML change to a table in the hr schema

In this example, no evaluation context is specified for the rule. Therefore, the rule will either inherit the evaluation context of any rule set to which it is added, or it will be assigned an evaluation context explicitly when the DBMS_RULE_ADM.ADD_RULE procedure is run to add it to a rule set. At this point, the rule cannot be evaluated because it is not part of any rule set.

You can also use the following procedures in the DBMS_STREAMS_ADM package to create rules and add them to a rule set automatically:

- ADD_GLOBAL_PROPAGATION_RULES
- ADD_GLOBAL_RULES
- ADD_SCHEMA_PROPAGATION_RULES
- ADD_SCHEMA_RULES
- ADD_SUBSET_RULES
- ADD_TABLE_PROPAGATION_RULES
- ADD_TABLE_RULES

See Also:

- "Example of Creating a Capture Process Using DBMS_STREAMS_ADM" on page 11-3
- "Example of Creating a Propagation Job Using DBMS_STREAMS_ADM" on page 12-8
- "Example of Creating an Apply Process Using DBMS_STREAMS_ADM" on page 13-3

Adding a Rule to a Rule Set

The following is an example that runs the ADD_RULE procedure in the DBMS_RULE_ADM package to add the hr_dml rule to the hr_capture_rules rule set:

```
BEGIN
  DBMS_RULE_ADM.ADD_RULE(
    rule_name          => 'strmadmin.hr_dml',
    rule_set_name      => 'strmadmin.hr_capture_rules',
    evaluation_context => NULL);
END;
/
```

In this example, no evaluation context is specified when running the ADD_RULE procedure. Therefore, if the rule does not have its own evaluation context, it will inherit the evaluation context of the hr_capture_rules rule set. If you want a rule to use an evaluation context other than the one specified for the rule set, then you can set the evaluation_context parameter to this evaluation context when you run the ADD_RULE procedure.

Altering a Rule

You can use the ALTER_RULE procedure in the DBMS_RULE_ADM package to alter an existing rule. Specifically, you can use this procedure to do the following:

- Change a rule's condition
- Change a rule's evaluation context
- Remove a rule's evaluation context
- Change a rule's action context
- Remove a rule's action context
- Change the comment for a rule
- Remove the comment for a rule

For example, suppose you want to change the condition of the rule created in "Creating a Rule" on page 14-3. The condition in the existing hr_dml rule evaluates to TRUE for any DML change to any object in the hr schema. If you want to exclude changes to the employees table in this schema, then you can alter the rule so that it evaluates to FALSE for DML changes to the hr.employees table, but continues to evaluate to TRUE for DML changes to any other table in this schema. The following procedure alters the rule in this way:

```
BEGIN
  DBMS_RULE_ADM.ALTER_RULE(
    rule_name          => 'strmadmin.hr_dml',
    condition          => ' :dml.get_object_owner() = ''HR'' AND NOT ' ||
                          ' :dml.get_object_name() = ''EMPLOYEES'' ',
    evaluation_context => NULL);
END;
/
```

Note: Changing the condition of a rule affects all rule sets that contain the rule.

Modifying System-Created Rules

System-created rules are rules created by running a procedure in the DBMS_STREAMS_ADM package. If you want to use a rule-based transformation for a system-created rule, then you can modify the rule's action context to add the rule-based transformation.

Also, if you cannot create a rule with the rule condition you need using the DBMS_STREAMS_ADM package, then you can create a new rule with a condition based on a system-created rule by following these general steps:

1. Copy the rule condition of the system-created rule. You can view the rule condition of a system-created rule by querying the DBA_STREAMS_TABLE_RULES, DBA_STREAMS_SCHEMA_RULES, or DBA_STREAMS_GLOBAL_RULES data dictionary view.
2. Use the copied rule condition to create a new rule by modifying the condition.
3. Add the new rule to the rule set for the Streams process or job.
4. Remove the original rule if it is no longer needed using the REMOVE_RULE procedure in the DBMS_STREAMS_ADM package.

See Also:

- "Rule-Based Transformations" on page 6-23
- Chapter 16, "Monitoring a Streams Environment" for more information about the data dictionary views related to Streams

Removing a Rule from a Rule Set

The following is an example that runs the REMOVE_RULE procedure in the DBMS_RULE_ADM package to remove the hr_dml rule from the hr_capture_rules rule set:

```
BEGIN
  DBMS_RULE_ADM.REMOVE_RULE(
    rule_name     => 'strmadmin.hr_dml',
    rule_set_name => 'strmadmin.hr_capture_rules');
END;
/
```

After running the REMOVE_RULE procedure, the rule still exists in the database and, if it was in any other rule sets, it remains in those rule sets.

Dropping a Rule

The following is an example that runs the DROP_RULE procedure in the DBMS_RULE_ADM package to drop the hr_dml rule from the database:

```
BEGIN
  DBMS_RULE_ADM.DROP_RULE(
    rule_name => 'strmadmin.hr_dml',
    force     => false);
END;
/
```

In this example, the force parameter in the DROP_RULE procedure is set to false, which is the default setting. Therefore, the rule cannot be dropped if it is in one or more rule sets. If the force parameter is set to true, then the rule is dropped from the database and automatically removed from any rule sets that contain it.

Dropping a Rule Set

The following is an example that runs the DROP_RULE_SET procedure in the DBMS_RULE_ADM package to drop the hr_capture_rules rule set from the database:

```
BEGIN
  DBMS_RULE_ADM.DROP_RULE_SET(
    rule_set_name => 'strmadmin.hr_capture_rules',
    delete_rules  => false);
END;
/
```

In this example, the delete_rules parameter in the DROP_RULE_SET procedure is set to false, which is the default setting. Therefore, if the rule set contains any rules, then these rules are not dropped. If the delete_rules parameter is set to true, then any rules in the rule set, which are not in another rule set, are dropped from the database automatically. If some of the rules in the rule set are in one or more other rule sets, then these rules are not dropped.

Managing Privileges on Evaluation Contexts, Rule Sets, and Rules

This section provides instructions for completing the following tasks:

- Granting System Privileges on Evaluation Contexts, Rule Sets, and Rules
- Granting Object Privileges on an Evaluation Context, Rule Set, or Rule
- Revoking System Privileges on Evaluation Contexts, Rule Sets, and Rules
- Revoking Object Privileges on an Evaluation Context, Rule Set, or Rule

See Also:

- "Database Objects and Privileges Related to Rules" on page 5-11
- The GRANT_SYSTEM_PRIVILEGE and GRANT_OBJECT_PRIVILEGE procedures in the DBMS_RULE_ADM package in *Oracle9i Supplied PL/SQL Packages and Types Reference*

Granting System Privileges on Evaluation Contexts, Rule Sets, and Rules

You can use the GRANT_SYSTEM_PRIVILEGE procedure in the DBMS_RULE_ADM package to grant system privileges on evaluation contexts, rule sets, and rules to users and roles. These privileges enable a user to create, alter, execute, or drop these objects in the user's own schema or, if the "ANY" version of the privilege is granted, in any schema.

For example, to grant the strmadmin user the privilege to create an evaluation context in the user's own schema, enter the following:

```
BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => SYS.DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT_OBJ,
    grantee      => 'strmadmin',
    grant_option => false);
END;
/
```

In this example, the grant_option parameter in the GRANT_SYSTEM_PRIVILEGE procedure is set to false, which is the default setting. Therefore, the strmadmin user cannot grant the CREATE_EVALUATION_CONTEXT_OBJ system privilege to other users or roles. If the grant_option parameter were set to true, then the strmadmin user could grant this system privilege to other users.

Granting Object Privileges on an Evaluation Context, Rule Set, or Rule

You can use the GRANT_OBJECT_PRIVILEGE procedure in the DBMS_RULE_ADM package to grant object privileges on a specific evaluation context, rule set, or rule. These privileges enable a user to alter or execute the specified object.

For example, to grant the hr user the privilege to both alter and execute a rule set named hr_capture_rules in the strmadmin schema, enter the following:

```
BEGIN
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege    => SYS.DBMS_RULE_ADM.ALL_ON_RULE_SET,
    object_name  => 'strmadmin.hr_capture_rules',
    grantee      => 'hr',
    grant_option => false);
END;
/
```

In this example, the grant_option parameter in the GRANT_OBJECT_PRIVILEGE procedure is set to false, which is the default setting. Therefore, the hr user cannot grant the ALL_ON_RULE_SET object privilege for the specified rule set to other users or roles. If the grant_option parameter were set to true, then the hr user could grant this object privilege to other users.

Revoking System Privileges on Evaluation Contexts, Rule Sets, and Rules

You can use the REVOKE_SYSTEM_PRIVILEGE procedure in the DBMS_RULE_ADM package to revoke system privileges on evaluation contexts, rule sets, and rules.

For example, to revoke from the strmadmin user the privilege to create an evaluation context in the user's own schema, enter the following:

```
BEGIN
  DBMS_RULE_ADM.REVOKE_SYSTEM_PRIVILEGE(
    privilege    => SYS.DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT_OBJ,
    revokee      => 'strmadmin');
END;
/
```

Revoking Object Privileges on an Evaluation Context, Rule Set, or Rule

You can use the REVOKE_OBJECT_PRIVILEGE procedure in the DBMS_RULE_ADM package to revoke object privileges on a specific evaluation context, rule set, or rule.

For example, to revoke from the hr user the privilege to both alter and execute a rule set named hr_capture_rules in the strmadmin schema, enter the following:

```
BEGIN
  DBMS_RULE_ADM.REVOKE_OBJECT_PRIVILEGE(
    privilege     => SYS.DBMS_RULE_ADM.ALL_ON_RULE_SET,
    object_name   => 'strmadmin.hr_capture_rules',
    revokee       => 'hr');
END;
/
```

Managing Rule-Based Transformations

In Streams, a rule-based transformation is any modification to an event that results when a rule evaluates to TRUE. You use a rule action context to specify a rule-based transformation. In the name-value pair that specifies a rule-based transformation in an action context, the name is STREAMS$_TRANSFORM_FUNCTION and the value is a SYS.AnyData instance containing the name of the PL/SQL function that performs the transformation.

This section provides instructions for completing the following tasks:

- Creating a Rule-Based Transformation
- Altering a Rule-Based Transformation
- Removing a Rule-Based Transformation

Note:

- There is no automatic locking mechanism for a rule's action context. Therefore, make sure an action context is not updated by two or more sessions at the same time.
- When you perform rule-based transformations on DDL LCRs, you probably need to modify the DDL text in the DDL LCR to match any other modification. For example, if the rule-based transformation changes the name of a table in the DDL LCR, then the table name in the DDL text should be changed in the same way.

See Also: "Rule-Based Transformations" on page 6-23

Creating a Rule-Based Transformation

A function in a rule-based transformation must have the following signature:

```
FUNCTION user_function (
   parameter_name   IN  SYS.AnyData)
RETURN SYS.AnyData;
```

Here, *user_function* stands for the name of the function and *parameter_name* stands for the name of the parameter passed to the function. The parameter passed to the function is a `SYS.AnyData` encapsulation of an LCR, and the function must return a `SYS.AnyData` encapsulation of an LCR.

The following steps outline the general procedure for creating a rule-based transformation:

1. Create a PL/SQL function that performs the transformation.

   Caution: Make sure the transformation function does not raise any exceptions. Exceptions may cause the capture process, propagation job, or apply process to become disabled, and you will need to correct the transformation function before the process or job can proceed.

   The following example creates a function called `executive_to_management` in the `hr` schema that changes the value in the `department_name` column of the `departments` table from `Executive` to `Management`. Such a transformation may be necessary if one branch in a company uses a different name for this department.

```
CONNECT hr/hr

CREATE OR REPLACE FUNCTION hr.executive_to_management(in_any IN SYS.AnyData)
RETURN SYS.AnyData
IS
  lcr SYS.LCR$_ROW_RECORD;
  rc  NUMBER;
  ob_owner VARCHAR2(30);
  ob_name VARCHAR2(30);
  dep_value_anydata SYS.AnyData;
  dep_value_varchar2 VARCHAR2(30);
BEGIN
  -- Get the type of object
  -- Check if the object type is SYS.LCR$_ROW_RECORD
  IF in_any.GETTYPENAME='SYS.LCR$_ROW_RECORD' THEN
    -- Put the row LCR into lcr
    rc := in_any.GETOBJECT(lcr);
    -- Get the object owner and name
    ob_owner := lcr.GET_OBJECT_OWNER();
    ob_name := lcr.GET_OBJECT_NAME();
```

```
    -- Check for the hr.departments table
    IF ob_owner = 'HR' AND ob_name = 'DEPARTMENTS' THEN
      -- Get the old value of the department_name column in the LCR
      dep_value_anydata := lcr.GET_VALUE('OLD','DEPARTMENT_NAME');
      IF dep_value_anydata IS NOT NULL THEN
        -- Put the column value into dep_value_varchar2
        rc := dep_value_anydata.GETVARCHAR2(dep_value_varchar2);
        -- Change a value of Executive in the column to Management
        IF (dep_value_varchar2 = 'Executive') THEN
          lcr.SET_VALUE('OLD','DEPARTMENT_NAME',
            SYS.ANYDATA.CONVERTVARCHAR2('Management'));
        END IF;
      END IF;
      -- Get the new value of the department_name column in the LCR
      dep_value_anydata := lcr.GET_VALUE('NEW','DEPARTMENT_NAME');
      IF dep_value_anydata IS NOT NULL THEN
        -- Put the column value into dep_value_varchar2
        rc := dep_value_anydata.GETVARCHAR2(dep_value_varchar2);
        -- Change a value of Executive in the column to Management
        IF (dep_value_varchar2 = 'Executive') THEN
          lcr.SET_VALUE('NEW','DEPARTMENT_NAME',
            SYS.ANYDATA.CONVERTVARCHAR2('Management'));
        END IF;
      END IF;
    RETURN SYS.ANYDATA.CONVERTOBJECT(lcr);
    END IF;
  END IF;
RETURN in_any;
END;
/
```

2. Grant the Streams administrator EXECUTE privilege on the `hr.executive_to_management` function.

   ```
   GRANT EXECUTE ON hr.executive_to_management TO strmadmin;
   ```

3. Create subset rules for DML operations on the `hr.departments` table. The subset rules will use the transformation created in Step 1.

   Subset rules are not required to use rule-based transformations. This example uses subset rules to illustrate an action context with more than one name-value pair. You must use caution when altering an action context with more than one name value pair, as described in "Altering a Rule-Based Transformation" on page 14-18.

This example creates subset rules for an apply process on a database named dbs1.net. These rules evaluate to TRUE when an LCR contains a DML change to a row with a location_id of 1700 in the hr.departments table.

To create these rules, connect as the Streams administrator and run the following ADD_SUBSET_RULES procedure:

```
CONNECT strmadmin/strmadminpw

BEGIN
  DBMS_STREAMS_ADM.ADD_SUBSET_RULES(
    table_name                =>  'hr.departments',
    dml_condition             =>  'location_id=1700',
    streams_type              =>  'apply',
    streams_name              =>  'strm01_apply',
    queue_name                =>  'strm01_queue',
    include_tagged_lcr        =>  false,
    source_database           =>  'dbs1.net');
END;
/
```

Note:

- To create the rule and the rule set, the Streams administrator must have CREATE_RULE_SET_OBJ (or CREATE_ANYRULE_SET_OBJ) and CREATE_RULE_OBJ (or CREATE_ANY_RULE_OBJ) system privileges. You grant these privileges using the GRANT_SYSTEM_PRIVILEGE procedure in the DBMS_RULE_ADM package.
- This example creates the rule using the DBMS_STREAMS_ADM package. Alternatively, you can create a rule, add it to a rule set, and specify a rule-based transformation using the DBMS_RULE_ADM package. The "Flexible Configuration for Sharing Data from a Single Database" on page 19-40 contains an example of this.

4. Determine the names of the system-created rules by running the following query:

```
SELECT RULE_NAME, SUBSETTING_OPERATION FROM DBA_STREAMS_TABLE_RULES
  WHERE TABLE_NAME='DEPARTMENTS' AND DML_CONDITION='location_id=1700';
```

This query displays output similar to the following:

```
RULE_NAME                      SUBSET
------------------------------ ------
DEPARTMENTS5                   INSERT
DEPARTMENTS6                   UPDATE
DEPARTMENTS7                   DELETE
```

Note: You can also obtain this information using the OUT parameters when you run ADD_SUBSET_RULES.

Because these are subset rules, two of them contain a non-NULL action context that performs an internal transformation:

- The rule with a subsetting condition of INSERT contains an internal transformation that converts updates into inserts if the update changes the value of the location_id column to 1700 from some other value. The internal transformation does not affect inserts.
- The rule with a subsetting condition of DELETE contains an internal transformation that converts updates into deletes if the update changes the value of the location_id column from 1700 to a different value. The internal transformation does not affect deletes.

In this example, you can confirm that the rules DEPARTMENTS5 and DEPARTMENTS7 have a non-NULL action context, and that the rule DEPARTMENTS6 has a NULL action context, by running the following query:

```
COLUMN RULE_NAME HEADING 'Rule Name' FORMAT A12
COLUMN ACTION_CONTEXT_NAME HEADING 'Action Context Name' FORMAT A27
COLUMN ACTION_CONTEXT_VALUE HEADING 'Action Context Value' FORMAT A26

SELECT
    RULE_NAME,
    AC.NVN_NAME ACTION_CONTEXT_NAME,
    AC.NVN_VALUE.ACCESSVARCHAR2() ACTION_CONTEXT_VALUE
  FROM DBA_RULES R, TABLE(R.RULE_ACTION_CONTEXT.ACTX_LIST) AC
  WHERE RULE_NAME IN ('DEPARTMENTS5','DEPARTMENTS6','DEPARTMENTS7');
```

This query displays output similar to the following:

```
Rule Name    Action Context Name         Action Context Value
------------ -------------------------- ------------------------
DEPARTMENTS5 STREAMS$_ROW_SUBSET         INSERT
DEPARTMENTS7 STREAMS$_ROW_SUBSET         DELETE
```

The DEPARTMENTS6 rule does not appear in the output because its action context is NULL.

5. Alter the action context of each subset rule to add the name-value pair for the rule-based transformation. Make sure no other users are modifying the action context at the same time. The name in the name-value pair must be STREAMS$_TRANSFORM_FUNCTION.

   Add the rule-based transformation to the DEPARTMENTS5 rule. The following statement preserves the existing name-value pairs in the action context by selecting the action context into a variable before adding the new pair.

```
DECLARE
  action_ctx       SYS.RE$NV_LIST;
  ac_name          VARCHAR2(30) := 'STREAMS$_TRANSFORM_FUNCTION';
BEGIN
  SELECT RULE_ACTION_CONTEXT
    INTO action_ctx
    FROM DBA_RULES R
    WHERE RULE_OWNER='STRMADMIN' AND RULE_NAME='DEPARTMENTS5';
  action_ctx.ADD_PAIR(ac_name,
                SYS.ANYDATA.CONVERTVARCHAR2('hr.executive_to_management'));
  DBMS_RULE_ADM.ALTER_RULE(
    rule_name       =>  'strmadmin.departments5',
    action_context  => action_ctx);
END;
/
```

Add the rule-based transformation to the DEPARTMENTS6 rule. This statement does not need to query for the action context because it is NULL for the DEPARTMENTS6 rule.

```
DECLARE
  action_ctx       SYS.RE$NV_LIST;
  ac_name          VARCHAR2(30) := 'STREAMS$_TRANSFORM_FUNCTION';
BEGIN
  action_ctx := SYS.RE$NV_LIST(SYS.RE$NV_ARRAY());
  action_ctx.ADD_PAIR(ac_name,
                SYS.ANYDATA.CONVERTVARCHAR2('hr.executive_to_management'));
  DBMS_RULE_ADM.ALTER_RULE(
    rule_name       =>  'strmadmin.departments6',
    action_context  => action_ctx);
END;
/
```

Add the rule-based transformation to the DEPARTMENTS7 rule. This statements queries for the existing action context and inserts it into a variable before adding a new name-value pair.

```
DECLARE
  action_ctx       SYS.RE$NV_LIST;
  ac_name          VARCHAR2(30) := 'STREAMS$_TRANSFORM_FUNCTION';
BEGIN
  SELECT RULE_ACTION_CONTEXT
    INTO action_ctx
    FROM DBA_RULES R
    WHERE RULE_OWNER='STRMADMIN' AND RULE_NAME='DEPARTMENTS7';
  action_ctx.ADD_PAIR(ac_name,
                SYS.ANYDATA.CONVERTVARCHAR2('hr.executive_to_management'));
  DBMS_RULE_ADM.ALTER_RULE(
    rule_name       =>  'strmadmin.departments7',
    action_context  => action_ctx);
END;
/
```

Now, if you run the query that displays the name-value pairs in the action context for these rules, each rule, including the DEPARTMENTS6 rule, shows the name-value pair for the rule-based transformation:

```
SELECT
    RULE_NAME,
    AC.NVN_NAME ACTION_CONTEXT_NAME,
    AC.NVN_VALUE.ACCESSVARCHAR2() ACTION_CONTEXT_VALUE
  FROM DBA_RULES R, TABLE(R.RULE_ACTION_CONTEXT.ACTX_LIST) AC
  WHERE RULE_NAME IN ('DEPARTMENTS5','DEPARTMENTS6','DEPARTMENTS7');
```

This query displays output similar to the following:

```
Rule Name    Action Context Name         Action Context Value
------------ -------------------------- -------------------------
DEPARTMENTS5 STREAMS$_ROW_SUBSET         INSERT
DEPARTMENTS5 STREAMS$_TRANSFORM_FUNCTION hr.executive_to_management
DEPARTMENTS6 STREAMS$_TRANSFORM_FUNCTION hr.executive_to_management
DEPARTMENTS7 STREAMS$_ROW_SUBSET         DELETE
DEPARTMENTS7 STREAMS$_TRANSFORM_FUNCTION hr.executive_to_management
```

See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the rule types used in this example

Altering a Rule-Based Transformation

To alter a rule-based transformation, you either can edit the transformation function or edit the action context to run a different transformation function. This example edits the action context to run a different function. If you edit the function itself, then you do not need to alter the action context.

This example alters a rule-based transformation for rule DEPARTMENTS5 by first removing the name-value pair with the name STREAMS$_TRANSFORM_FUNCTION from the rule's action context and then adding a different name-value pair back to the rule's action context. This rule based transformation was added to the DEPARTMENTS5 rule in the example in "Creating a Rule-Based Transformation" on page 14-11.

If an action context contains name-value pairs in addition to the name-value pair that specifies the transformation, then be cautious when you modify the action context so that you do not change or remove any name-value pairs that are unrelated to the transformation.

In Streams, subset rules use name-value pairs in an action context to perform internal transformations that convert UPDATE operations into INSERT and DELETE operations in certain situations. Such a conversion is called a row migration. If you specify a new transformation or alter an existing transformation for a subset rule, then make sure you preserve the name-value pairs that perform row migrations.

See Also: "Row Migration" on page 4-11

Complete the following steps to alter a rule-based transformation:

1. You can view all of the name-value pairs in the action context of a rule by performing the following query:

```
COLUMN ACTION_CONTEXT_NAME HEADING 'Action Context Name' FORMAT A30
COLUMN ACTION_CONTEXT_VALUE HEADING 'Action Context Value' FORMAT A26

SELECT
    AC.NVN_NAME ACTION_CONTEXT_NAME,
    AC.NVN_VALUE.ACCESSVARCHAR2() ACTION_CONTEXT_VALUE
  FROM DBA_RULES R, TABLE(R.RULE_ACTION_CONTEXT.ACTX_LIST) AC
  WHERE RULE_NAME = 'DEPARTMENTS5';
```

This query displays output similar to the following:

```
Action Context Name            Action Context Value
------------------------------ -------------------------
STREAMS$_ROW_SUBSET            INSERT
STREAMS$_TRANSFORM_FUNCTION    hr.executive_to_management
```

2. For the DEPARTMENTS5 rule, the transformation function is executive_to_management. To alter the transformation function, this step first removes the name-value pair containing the function name from the action context for the DEPARTMENTS5 rule. Then, this step adds a name-value pair containing the new function name to the rule's action context. In this example, it is assumed that the new transformation function is hr.executive_to_lead and that the strmadmin user has EXECUTE privilege on it.

   To preserve any existing name-value pairs in the rule's action context, this example selects for the rule's action context and into a variable before altering it:

```
DECLARE
  action_ctx       SYS.RE$NV_LIST;
  ac_name          VARCHAR2(30) := 'STREAMS$_TRANSFORM_FUNCTION';
BEGIN
  SELECT RULE_ACTION_CONTEXT
    INTO action_ctx
    FROM DBA_RULES R
    WHERE RULE_OWNER='STRMADMIN' AND RULE_NAME='DEPARTMENTS5';
  action_ctx.REMOVE_PAIR(ac_name);
  action_ctx.ADD_PAIR(ac_name,
                SYS.ANYDATA.CONVERTVARCHAR2('hr.executive_to_lead'));
  DBMS_RULE_ADM.ALTER_RULE(
    rule_name       =>  'strmadmin.departments5',
    action_context  => action_ctx);
END;
/
```

   You should alter the action context for the DEPARTMENTS6 and DEPARTMENTS7 rules in a similar way to keep the three subset rules consistent.

Removing a Rule-Based Transformation

To remove a rule-based transformation from a rule, you remove the name-value pair with the name STREAMS$_TRANSFORM_FUNCTION from the rule's action. This example removes a rule-based transformation for rule DEPARTMENTS5. This rule based transformation was added to the DEPARTMENTS5 rule in the example in "Creating a Rule-Based Transformation" on page 14-11.

Removing a rule-based transformation means altering the action context of a rule. If an action context contains name-value pairs in addition to the name-value pair that specifies the transformation, then be cautious when you modify the action context so that you do not change or remove any name-value pairs that are unrelated to the transformation.

In Streams, subset rules use name-value pairs in an action context to perform internal transformations that convert UPDATE operations into INSERT and DELETE operations in certain situations. Such a conversion is called a row migration. If you specify a new transformation or alter an existing transformation for a subset rule, then make sure you preserve the name-value pairs that perform row migrations.

This example queries for the rule's action context and places it in a variable before removing the name-value pair for the rule-based transformation:

```
DECLARE
  action_ctx       SYS.RE$NV_LIST;
  ac_name          VARCHAR2(30) := 'STREAMS$_TRANSFORM_FUNCTION';
BEGIN
  SELECT RULE_ACTION_CONTEXT
    INTO action_ctx
    FROM DBA_RULES R
    WHERE RULE_OWNER='STRMADMIN' AND RULE_NAME='DEPARTMENTS5';
  action_ctx.REMOVE_PAIR(ac_name);
  DBMS_RULE_ADM.ALTER_RULE(
    rule_name       =>  'strmadmin.departments5',
    action_context  =>  action_ctx);
END;
/
```

You should alter the action context for the DEPARTMENTS6 and DEPARTMENTS7 rules in a similar way to keep the three subset rules consistent.

See Also: "Row Migration" on page 4-11

15

Managing LCRs and Streams Tags

This chapter provides instructions for managing logical change records (LCRs) and Streams tags.

This chapter contains these topics:

- Managing Logical Change Records (LCRs)
- Managing Streams Tags

Each task described in this chapter should be completed by a Streams administrator that has been granted the appropriate privileges, unless specified otherwise.

See Also: "Configuring a Streams Administrator" on page 10-2

Managing Logical Change Records (LCRs)

This section describes managing logical change records (LCRs). Make sure you meet the following requirements when you create or modify an LCR:

- If you create or modify a row LCR, then make sure the `command_type` attribute is consistent with the presence or absence of old column values and the presence or absence of new column values.
- If you create or modify a DDL LCR, then make sure the `ddl_text` is consistent with the `base_table_name`, `base_table_owner`, `object_type`, `object_owner`, `object_name`, and `command_type` attributes.

Constructing and Enqueuing LCRs

Use the following LCR constructors to create LCRs:

- To create a row LCR that contains a change to a row that resulted from a data manipulation language (DML) statement, use the `SYS.LCR$_ROW_RECORD` constructor.
- To create a DDL LCR that contains a data definition language change, use the `SYS.LCR$_DDL_RECORD` constructor. Make sure the DDL text specified in the `ddl_text` attribute of each DDL LCR conforms to Oracle SQL syntax.

The following example creates a queue in an Oracle database and an apply process associated with the queue. Then, it creates a PL/SQL procedure that constructs a row LCR based on information passed to it and enqueues the row LCR into the queue:

1. Create a Streams queue in an Oracle database.

```
BEGIN DBMS_STREAMS_ADM.SET_UP_QUEUE(
   queue_table          =>  'strm02_queue_table',
   storage_clause       =>  NULL,
   queue_name           =>  'strm02_queue');
END;
/
```

2. Create and start an apply process at the Oracle database to receive messages in the queue. Make sure the `apply_captured` parameter is set to `false` when you create the apply process, because the apply process will be applying user-enqueued events, not events captured by a capture process.

```
BEGIN
  DBMS_APPLY_ADM.CREATE_APPLY(
     queue_name      => 'strm02_queue',
     apply_name      => 'strm02_apply',
     apply_captured  => false);
END;
/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'strm02_apply',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

EXEC DBMS_APPLY_ADM.START_APPLY('strm02_apply');
```

3. Create a procedure called `construct_row_lcr` that constructs a row LCR and then enqueues it into the queue created in Step 1.

```
CREATE OR REPLACE PROCEDURE construct_row_lcr(
                  source_dbname  VARCHAR2,
                  cmd_type       VARCHAR2,
                  obj_owner      VARCHAR2,
                  obj_name       VARCHAR2,
                  old_vals       SYS.LCR$_ROW_LIST,
                  new_vals       SYS.LCR$_ROW_LIST) AS
  eopt           DBMS_AQ.ENQUEUE_OPTIONS_T;
  mprop          DBMS_AQ.MESSAGE_PROPERTIES_T;
  enq_msgid      RAW(16);
  row_lcr        SYS.LCR$_ROW_RECORD;
BEGIN
  mprop.SENDER_ID := SYS.AQ$_AGENT('strmadmin', NULL, NULL);
  -- Construct the LCR based on information passed to procedure
  row_lcr := SYS.LCR$_ROW_RECORD.CONSTRUCT(
    source_database_name  =>  source_dbname,
    command_type          =>  cmd_type,
    object_owner          =>  obj_owner,
    object_name           =>  obj_name,
    old_values            =>  old_vals,
    new_values            =>  new_vals);
  -- Enqueue the created row LCR
  DBMS_AQ.ENQUEUE(
    queue_name         =>  'strm02_queue',
    enqueue_options    =>  eopt,
    message_properties =>  mprop,
    payload            =>  SYS.AnyData.ConvertObject(row_lcr),
    msgid              =>  enq_msgid);
END construct_row_lcr;
/
```

Note: The application does not need to specify a transaction identifier or SCN when it creates an LCR because the apply process generates these values and stores them in memory. If a transaction identifier or SCN is specified in the LCR, then the apply process ignores it and assigns a new value.

See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about LCR constructors

4. Create and enqueue LCRs using the `construct_row_lcr` procedure created in Step 2.

   a. Create a row LCR that inserts a row into the `hr.regions` table.

```
DECLARE
  newunit1  SYS.LCR$_ROW_UNIT;
  newunit2  SYS.LCR$_ROW_UNIT;
  newvals   SYS.LCR$_ROW_LIST;
BEGIN
  newunit1 := SYS.LCR$_ROW_UNIT(
    'region_id',
    SYS.AnyData.ConvertNumber(5),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  newunit2 := SYS.LCR$_ROW_UNIT(
    'region_name',
    SYS.AnyData.ConvertVarchar2('Moon'),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  newvals := SYS.LCR$_ROW_LIST(newunit1,newunit2);
construct_row_lcr(
  source_dbname  =>  'dbs1.net',
  cmd_type       =>  'INSERT',
  obj_owner      =>  'hr',
  obj_name       =>  'regions',
  old_vals       =>  NULL,
  new_vals       =>  newvals);
END;
/
COMMIT;
```

b. Create a row LCR that updates a row from the `hr.regions` table.

```
DECLARE
  oldunit1  SYS.LCR$_ROW_UNIT;
  oldunit2  SYS.LCR$_ROW_UNIT;
  oldvals   SYS.LCR$_ROW_LIST;
  newunit1  SYS.LCR$_ROW_UNIT;
  newvals   SYS.LCR$_ROW_LIST;
BEGIN
  oldunit1 := SYS.LCR$_ROW_UNIT(
    'region_id',
    SYS.AnyData.ConvertNumber(5),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  oldunit2 := SYS.LCR$_ROW_UNIT(
    'region_name',
    SYS.AnyData.ConvertVarchar2('Moon'),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  oldvals := SYS.LCR$_ROW_LIST(oldunit1,oldunit2);
  newunit1 := SYS.LCR$_ROW_UNIT(
    'region_name',
    SYS.AnyData.ConvertVarchar2('Mars'),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  newvals := SYS.LCR$_ROW_LIST(newunit1);
construct_row_lcr(
  source_dbname  =>  'dbs1.net',
  cmd_type       =>  'UPDATE',
  obj_owner      =>  'hr',
  obj_name       =>  'regions',
  old_vals       =>  oldvals,
  new_vals       =>  newvals);
END;
/
COMMIT;
```

c. Create a row LCR that deletes a row from the `hr.regions` table.

```
DECLARE
  oldunit1  SYS.LCR$_ROW_UNIT;
  oldunit2  SYS.LCR$_ROW_UNIT;
  oldvals   SYS.LCR$_ROW_LIST;
BEGIN
  oldunit1 := SYS.LCR$_ROW_UNIT(
    'region_id',
    SYS.AnyData.ConvertNumber(5),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  oldunit2 := SYS.LCR$_ROW_UNIT(
    'region_name',
    SYS.AnyData.ConvertVarchar2('Mars'),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  oldvals := SYS.LCR$_ROW_LIST(oldunit1,oldunit2);
construct_row_lcr(
  source_dbname  =>  'dbs1.net',
  cmd_type       =>  'DELETE',
  obj_owner      =>  'hr',
  obj_name       =>  'regions',
  old_vals       =>  oldvals,
  new_vals       =>  NULL);
END;
/
COMMIT;
```

Constructing and Processing LCRs Containing LOB Columns

The following sections contain information about the requirements you must meet when constructing or processing LOBs and about apply process behavior for LCRs containing LOBs. This section also includes an example that constructs and enqueues LCRs containing LOBs.

Requirements for Constructing and Processing LCRs Containing LOBs

If your environment uses LCRs that contain LOB columns, then you must meet the following requirements when you construct these LCRs or process them with an apply handler or a rule-based transformation:

- The data portion of the LCR LOB column must by of type VARCHAR2 or RAW. A VARCHAR2 is interpreted as a CLOB, and a RAW is interpreted as a BLOB.
- LOB WRITE, LOB ERASE, and LOB TRIM are the only valid command types for out-of-line LOBs.
- For LOB WRITE, LOB ERASE, and LOB TRIM LCRs, the old_values collection should be empty or NULL and new_values should not be empty.
- The lob_offset should be a valid value for LOB WRITE and LOB ERASE LCRs. For all other command types, lob_offset should be NULL, under the assumption that LOB chunks for that column will follow.
- The lob_operation_size should be a valid value for LOB ERASE and LOB TRIM LCRs. For all other command types, lob_operation_size should be NULL.
- LOB TRIM and LOB ERASE are valid command types only for an LCR containing a LOB column with lob_information set to LAST_LOB_CHUNK.
- LOB WRITE is a valid command type only for an LCR containing a LOB column with lob_information set to LAST_LOB_CHUNK or LOB_CHUNK.
- For LOBs with lob_information set to NULL_LOB, the data portion of the column should be a NULL of VARCHAR2 type (for a CLOB) or a NULL of RAW type (for a BLOB). Otherwise, it is interpreted as a non-NULL inline LOB column.
- Only one LOB column reference with one new chunk is allowed for each LOB WRITE, LOB ERASE, and LOB TRIM LCR.
- The new LOB chunk for a LOB ERASE and a LOB TRIM LCR should be a NULL value encapsulated in a SYS.AnyData.

All validation of these requirements is done by an apply process. If these requirements are not met, then an LCR containing a LOB column cannot be applied by an apply process nor processed by an apply handler. In this case, the LCR is moved to the error queue with the rest of the LCRs in the same transaction.

See Also:

- "Constructing and Enqueuing LCRs" on page 15-2
- "Event Processing with an Apply Process" on page 4-3 for more information about apply handlers
- *Oracle9i Application Developer's Guide - Large Objects (LOBs)* for more information about LOBs

Apply Process Behavior for LCRs Containing LOBs

An apply process behaves in the following way when it encounters an LCR that contains a LOB:

- If an LCR whose command type is `INSERT` or `UPDATE` has a new LOB that contains data and the `lob_information` is not `DBMS_LCR.LOB_CHUNK` or `DBMS_LCR.LAST_LOB_CHUNK`, then the data is applied.
- If an LCR whose command type is `INSERT` or `UPDATE` has a new LOB that contains no data, and the `lob_information` is `DBMS_LCR.EMPTY_LOB`, then it is applied as an empty LOB.
- If an LCR whose command type is `INSERT` or `UPDATE` has a new LOB that contains no data, and the `lob_information` is `DBMS_LCR.NULL_LOB` or `DBMS_LCR.INLINE_LOB`, then it is applied as a `NULL`.
- If an LCR whose command type is `INSERT` or `UPDATE` has a new LOB and the `lob_information` is `DBMS_LCR.LOB_CHUNK` or `DBMS_LCR.LAST_LOB_CHUNK`, then any LOB value is ignored. If the command type is `INSERT`, then an empty LOB is inserted into the column under the assumption that LOB chunks will follow. If the command type is `UPDATE`, then the column value is ignored under the assumption that LOB chunks will follow.
- If all of the new columns in an LCR whose command type is `UPDATE` are LOBs whose `lob_information` is `DBMS_LCR.LOB_CHUNK` or `DBMS_LCR.LAST_LOB_CHUNK`, then the update is skipped under the assumption that LOB chunks will follow.
- For any LCR whose command type is `UPDATE` or `DELETE`, old LOB values are ignored.

Example Script for Constructing and Enqueuing LCRs Containing LOBs

The following example illustrates creating a PL/SQL procedure for constructing and enqueuing LCRs containing LOBs. This example assumes that you have prepared your database for Streams by completing the necessary actions in Chapter 10, "Configuring a Streams Environment".

1. Show Output and Spool Results
2. Connect as the Streams Administrator
3. Create a Streams Queue
4. Create and Start an Apply Process
5. Create a Schema with Tables Containing LOB Columns
6. Grant the StreamsAdministrator Necessary Privileges on the Tables
7. Create a PL/SQL Procedure to Enqueue LCRs Containing LOBs
8. Create the do_enq_clob Function to Enqueue CLOBs
9. Enqueue CLOBs Using the do_enq_clob Function
10. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 15-21 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************* BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run `SET ECHO ON` and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL lob_construct.out
```

```
/*
```

Step 2 Connect as the Streams Administrator

```
*/

SET ECHO ON
SET FEEDBACK 1
SET NUMWIDTH 10
SET LINESIZE 80
SET TRIMSPOOL ON
SET TAB OFF
SET PAGESIZE 100
SET SERVEROUTPUT ON

CONNECT strmadmin/strmadminpw

/*
```

Step 3 Create a Streams Queue

```
*/

BEGIN
  DBMS_STREAMS_ADM.SET_UP_QUEUE(
    queue_table => 'lobex_queue_table',
    queue_name  => 'lobex_queue');
END;
/

/*
```

Step 4 Create and Start an Apply Process

```
*/

BEGIN
  DBMS_APPLY_ADM.CREATE_APPLY(
    queue_name      => 'strmadmin.lobex_queue',
    apply_name      => 'apply_lob'
    apply_captured  => false);
END;
/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name => 'apply_lob',
    parameter  => 'disable_on_error',
    value      => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    'apply_lob');
END;
/

/*
```

Step 5 Create a Schema with Tables Containing LOB Columns

```
*/

CONNECT sys/change_on_install AS SYSDBA

CREATE USER lob_user IDENTIFIED BY Lob_user_pw;
GRANT CONNECT,RESOURCE TO lob_user;

CONNECT lob_user/lob_user_pw

CREATE TABLE with_clob (a  NUMBER PRIMARY KEY,
                        c1 CLOB,
                        c2 CLOB,
                        c3 CLOB);

CREATE TABLE with_blob (a NUMBER PRIMARY KEY,
                        b BLOB);

/*
```

Step 6 Grant the StreamsAdministrator Necessary Privileges on the Tables

Granting these privileges enables the Streams administrator to get the LOB length for offset and to perform DML operations on the tables.

```
*/

GRANT ALL ON with_clob TO strmadmin;
GRANT ALL ON with_blob TO strmadmin;
COMMIT;

/*
```

Step 7 Create a PL/SQL Procedure to Enqueue LCRs Containing LOBs

```
*/

CONNECT strmadmin/strmadminpw

CREATE OR REPLACE PROCEDURE enq_row_lcr(source_dbname  VARCHAR2,
                                        cmd_type       VARCHAR2,
                                        obj_owner      VARCHAR2,
                                        obj_name       VARCHAR2,
                                        old_vals       SYS.LCR$_ROW_LIST,
                                        new_vals       SYS.LCR$_ROW_LIST) AS
  eopt           DBMS_AQ.ENQUEUE_OPTIONS_T;
  mprop          DBMS_AQ.MESSAGE_PROPERTIES_T;
  enq_msgid      RAW(16);
  xr_lcr         SYS.LCR$_ROW_RECORD;
BEGIN
  xr_lcr := SYS.LCR$_ROW_RECORD.CONSTRUCT(
              source_database_name => source_dbname,
              command_type         => cmd_type,
              object_owner         => obj_owner,
              object_name          => obj_name,
              old_values           => old_vals,
              new_values           => new_vals);
  -- Enqueue a row lcr
  DBMS_AQ.ENQUEUE(
        queue_name         => 'lobex_queue',
        enqueue_options    => eopt,
        message_properties => mprop,
        payload            => SYS.AnyData.ConvertObject(xr_lcr),
        msgid              => enq_msgid);
END enq_row_lcr;
/
SHOW ERRORS

/*
```

Step 8 Create the do_enq_clob Function to Enqueue CLOBs

```
*/

-- Description of each variable:
-- src_dbname  : Source database name
-- tab_owner   : Table owner
-- tab_name    : Table name
-- col_name    : Name of the CLOB column
-- new_vals    : SYS.LCR$_ROW_LIST containing primary key and supplementally
--               logged colums
-- clob_data   : CLOB that contains data to be sent
-- offset      : Offset from which data should be sent, default is 1
-- lsize       : Size of data to be sent, default is 0
-- chunk_size  : Size used for creating LOB chunks, default is 2048

CREATE OR REPLACE FUNCTION do_enq_clob(src_dbname     VARCHAR2,
                                       tab_owner      VARCHAR2,
                                       tab_name       VARCHAR2,
                                       col_name       VARCHAR2,
                                       new_vals       SYS.LCR$_ROW_LIST,
                                       clob_data      CLOB,
                                       offset         NUMBER default 1,
                                       lsize          NUMBER default 0,
                                       chunk_size     NUMBER default 2048)
RETURN NUMBER IS
  lob_offset NUMBER; -- maintain lob offset
  newunit    SYS.LCR$_ROW_UNIT;
  tnewvals   SYS.LCR$_ROW_LIST;
  lob_flag   NUMBER;
  lob_data   VARCHAR2(32767);
  lob_size   NUMBER;
  unit_pos   NUMBER;
  final_size NUMBER;
  exit_flg   BOOLEAN;
  c_size     NUMBER;
  i          NUMBER;
BEGIN
  lob_size := DBMS_LOB.GETLENGTH(clob_data);
  unit_pos := new_vals.count + 1;
  tnewvals := new_vals;
  c_size   := chunk_size;
  i := 0;
```

```
-- validate parameters
IF (unit_pos <= 1) THEN
  DBMS_OUTPUT.PUT_LINE('Invalid new_vals list');
  RETURN 1;
END IF;

IF (c_size < 1) THEN
  DBMS_OUTPUT.PUT_LINE('Invalid LOB chunk size');
  RETURN 1;
END IF;

IF (lsize < 0 OR lsize > lob_size) THEN
  DBMS_OUTPUT.PUT_LINE('Invalid LOB size');
  RETURN 1;
END IF;

IF (offset < 1 OR offset >= lob_size) THEN
  DBMS_OUTPUT.PUT_LINE('Invalid lob offset');
  RETURN 1;
ELSE
  lob_offset := offset;
END IF;

-- calculate final size
IF (lsize = 0) THEN
  final_size := lob_size;
ELSE
  final_size := lob_offset + lsize;
END IF;

--  The following output lines are for debugging purposes only.
-- DBMS_OUTPUT.PUT_LINE('Final size: ' || final_size);
-- DBMS_OUTPUT.PUT_LINE('Lob size: ' || lob_size);

IF (final_size < 1 OR final_size > lob_size) THEN
  DBMS_OUTPUT.PUT_LINE('Invalid lob size');
  RETURN 1;
END IF;

-- expand new_vals list for LOB column
tnewvals.extend();

exit_flg := FALSE;
```

```
-- Enqueue all LOB chunks
LOOP
  --  The following output line is for debugging purposes only.
  DBMS_OUTPUT.PUT_LINE('About to write chunk#' || i);
  i := i + 1;

  -- check if last LOB chunk
  IF ((lob_offset + c_size) < final_size) THEN
    lob_flag := DBMS_LCR.LOB_CHUNK;
  ELSE
    lob_flag := DBMS_LCR.LAST_LOB_CHUNK;
    exit_flg := TRUE;
    --  The following output line is for debugging purposes only.
    DBMS_OUTPUT.PUT_LINE('Last LOB chunk');
  END IF;

  --  The following output lines are for debugging purposes only.
  DBMS_OUTPUT.PUT_LINE('lob offset: ' || lob_offset);
  DBMS_OUTPUT.PUT_LINE('Chunk size: ' || to_char(c_size));

  lob_data := DBMS_LOB.SUBSTR(clob_data, c_size, lob_offset);

  -- create row unit for clob
  newunit := SYS.LCR$_ROW_UNIT(col_name,
                               SYS.AnyData.ConvertVarChar2(lob_data),
                               lob_flag,
                               lob_offset,
                               NULL);

  -- insert new LCR$_ROW_UNIT
  tnewvals(unit_pos) := newunit;

  -- enqueue lcr
  enq_row_lcr(
        source_dbname => src_dbname,
        cmd_type      => 'LOB WRITE',
        obj_owner     => tab_owner,
        obj_name      => tab_name,
        old_vals      => NULL,
        new_vals      => tnewvals);
```

```
    -- calculate next chunk size
    lob_offset := lob_offset + c_size;

    IF ((final_size - lob_offset) < c_size) THEN
      c_size := final_size - lob_offset + 1;
    END IF;

    --  The following output line is for debugging purposes only.
    DBMS_OUTPUT.PUT_LINE('Next chunk size : ' || TO_CHAR(c_size));

    IF (c_size < 1) THEN
      exit_flg := TRUE;
    END IF;

    EXIT WHEN exit_flg;

  END LOOP;

  RETURN 0;
END do_enq_clob;
/

SHOW ERRORS

/*
```

Step 9 Enqueue CLOBs Using the do_enq_clob Function

```
*/

SET SERVEROUTPUT ON
DECLARE
  c1_data CLOB;
  c2_data CLOB;
  c3_data CLOB;
  newunit1 SYS.LCR$_ROW_UNIT;
  newunit2 SYS.LCR$_ROW_UNIT;
  newunit3 SYS.LCR$_ROW_UNIT;
  newunit4 SYS.LCR$_ROW_UNIT;
  newvals  SYS.LCR$_ROW_LIST;
  big_data VARCHAR(22000);
  n        NUMBER;
```

```
BEGIN
  -- Create primary key for LCR$_ROW_UNIT
  newunit1 := SYS.LCR$_ROW_UNIT('A',
                                Sys.AnyData.ConvertNumber(3),
                                NULL,
                                NULL,
                                NULL);
  -- Create empty CLOBs
  newunit2 := sys.lcr$_row_unit('C1',
                                Sys.AnyData.ConvertVarChar2(NULL),
                                DBMS_LCR.EMPTY_LOB,
                                NULL,
                                NULL);
  newunit3 := SYS.LCR$_ROW_UNIT('C2',
                                Sys.AnyData.ConvertVarChar2(NULL),
                                DBMS_LCR.EMPTY_LOB,
                                NULL,
                                NULL);
  newunit4 := SYS.LCR$_ROW_UNIT('C3',
                                Sys.AnyData.ConvertVarChar2(NULL),
                                DBMS_LCR.EMPTY_LOB,
                                NULL,
                                NULL);
  newvals := SYS.LCR$_ROW_LIST(newunit1,newunit2,newunit3,newunit4);

  -- Perform an insert
  enq_row_lcr(
    source_dbname => 'MYDB.NET',
    cmd_type      => 'INSERT',
    obj_owner     => 'LOB_USER',
    obj_name      => 'WITH_CLOB',
    old_vals      => NULL,
    new_vals      => newvals);

  -- construct clobs
  big_data := RPAD('Hello World', 1000, '_');
  big_data := big_data || '#';
  big_data := big_data || big_data || big_data || big_data || big_data;
  DBMS_LOB.CREATETEMPORARY(
    lob_loc => c1_data,
    cache   => TRUE);
  DBMS_LOB.WRITEAPPEND(
    lob_loc => c1_data,
    amount  => length(big_data),
    buffer  => big_data);
```

```
big_data := RPAD('1234567890#', 1000, '_');
big_data := big_data || big_data || big_data || big_data;
DBMS_LOB.CREATETEMPORARY(
  lob_loc => c2_data,
  cache   => TRUE);
DBMS_LOB.WRITEAPPEND(
  lob_loc => c2_data,
  amount  => length(big_data),
  buffer  => big_data);

big_data := RPAD('ASDFGHJKLQW', 2000, '_');
big_data := big_data || '#';
big_data := big_data || big_data || big_data || big_data || big_data;
DBMS_LOB.CREATETEMPORARY(
  lob_loc => c3_data,
  cache   => TRUE);
DBMS_LOB.WRITEAPPEND(
  lob_loc => c3_data,
  amount  => length(big_data),
  buffer  => big_data);

-- pk info
newunit1 := SYS.LCR$_ROW_UNIT('A',
                              SYS.AnyData.ConvertNumber(3),
                              NULL,
                              NULL,
                              NULL);
newvals  := SYS.LCR$_ROW_LIST(newunit1);

-- write c1 clob
n := do_enq_clob(
       src_dbname => 'MYDB.NET',
       tab_owner  => 'LOB_USER',
       tab_name   => 'WITH_CLOB',
       col_name   => 'C1',
       new_vals   => newvals,
       clob_data  => c1_data,
       offset     => 1,
       chunk_size => 1024);
DBMS_OUTPUT.PUT_LINE('n=' || n);
```

```
  -- write c2 clob
  newvals  := SYS.LCR$_ROW_LIST(newunit1);
  n := do_enq_clob(
         src_dbname => 'MYDB.NET',
         tab_owner  => 'LOB_USER',
         tab_name   => 'WITH_CLOB',
         col_name   => 'C2',
         new_vals   => newvals,
         clob_data  => c2_data,
         offset     => 1,
         chunk_size => 2000);
  DBMS_OUTPUT.PUT_LINE('n=' || n);

  -- write c3 clob
  newvals  := SYS.LCR$_ROW_LIST(newunit1);
  n := do_enq_clob(src_dbname=>'MYDB.NET',
         tab_owner  => 'LOB_USER',
         tab_name   => 'WITH_CLOB',
         col_name   => 'C3',
         new_vals   => newvals,
         clob_data  => c3_data,
         offset     => 1,
         chunk_size => 500);
  DBMS_OUTPUT.PUT_LINE('n=' || n);

  COMMIT;

END;
/

/*
```

Step 10 Check the Spool Results

Check the `lob_construct.out` spool file to ensure that all actions completed successfully after this script completes.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT ****************************/
```

After you run the script, you can check the `lob_user.with_clob` table to list the rows applied by the apply process. The `DBMS_LOCK.SLEEP` statement is used to give the apply process time to apply the enqueued rows.

```
CONNECT lob_user/lob_user_pw

EXECUTE DBMS_LOCK.SLEEP(10);

SELECT a, c1, c2, c3 FROM with_clob ORDER BY a;

SELECT a, LENGTH(c1), LENGTH(c2), LENGTH(c3) FROM with_clob ORDER BY a;
```

Managing Streams Tags

You can set or get the value of the tags generated by the current session or by an apply process. The following sections describe how to set and get tag values.

- Managing Streams Tags for the Current Session
- Managing Streams Tags for an Apply Process

See Also:

- Chapter 8, "Streams Tags"
- "Monitoring Streams Tags" on page 16-49

Managing Streams Tags for the Current Session

This section contains instructions for setting and getting the tag for the current session.

Setting the Tag Values Generated by the Current Session

You can set the tag for all redo entries generated by the current session using the `SET_TAG` procedure in the `DBMS_STREAMS` package. For example, to set the tag to the hexadecimal value of `'1D'` in the current session, run the following procedure:

```
BEGIN
   DBMS_STREAMS.SET_TAG(
      tag  =>  HEXTORAW('1D'));
END;
/
```

After running this procedure, each redo entry generated by DML or DDL statements in the current session will have a tag value of 1D. Running this procedure affects only the current session.

Getting the Tag Value for the Current Session

You can get the tag for all redo entries generated by the current session using the GET_TAG procedure in the DBMS_STREAMS package. For example, to get the hexadecimal value of the tags generated in the redo entries for the current session, run the following procedure:

```
SET SERVEROUTPUT ON
DECLARE
   raw_tag RAW(2048);
BEGIN
   raw_tag := DBMS_STREAMS.GET_TAG();
   DBMS_OUTPUT.PUT_LINE('Tag Value = ' || RAWTOHEX(raw_tag));
END;
/
```

You can also display the tag value for the current session by querying the DUAL view:

```
SELECT DBMS_STREAMS.GET_TAG FROM DUAL;
```

Managing Streams Tags for an Apply Process

This section contains instructions for setting and removing the tag for an apply process.

See Also:

- "Tags and an Apply Process" on page 8-5 for conceptual information about how tags are used by an apply process and apply handlers
- Chapter 4, "Streams Apply Process"
- Chapter 13, "Managing an Apply Process"

Setting the Tag Values Generated by an Apply Process

An apply process generates redo entries when it applies changes to a database or invokes handlers. You can set the default tag for all redo entries generated by an apply process when you create the apply process using the CREATE_APPLY procedure in the DBMS_APPLY_ADM package, or when you alter an existing apply process using the ALTER_APPLY procedure in the DBMS_APPLY_ADM package. In both of these procedures, set the apply_tag parameter to the value you want to specify for the tags generated by the apply process.

For example, to set the value of the tags generated in the redo log by an existing apply process named strm01_apply to the hexadecimal value of '7', run the following procedure:

```
BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
     apply_name  =>  'strm01_apply',
     apply_tag   =>  HEXTORAW('7'));
END;
/
```

After running this procedure, each redo entry generated by the apply process will have a tag value of 7.

Removing the Apply Tag for an Apply Process

You remove the apply tag for an apply process by setting the remove_apply_tag parameter to true in the ALTER_APPLY procedure in the DBMS_APPLY_ADM package. Removing the apply tag means that each redo entry generated by the apply process has a NULL tag. For example, the following procedure removes the apply tag from an apply process named strm02_apply.

```
BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name       => 'strm02_apply',
    remove_apply_tag => true);
END;
/
```

16

Monitoring a Streams Environment

This chapter provides information about the static data dictionary views and dynamic performance views related to Streams. You can use these views to monitor your Streams environment. This chapter also illustrates example queries that you may want to use to monitor your Streams environment.

This chapter contains these topics:

Note: The Streams tool in Oracle Enterprise Manager is also an excellent way to monitor a Streams environment. See the online help for the Streams tool for more information.

See Also: *Oracle9i Database Reference* for information about the data dictionary views described in this chapter

Summary of Streams Static Data Dictionary Views

The following table lists the Streams static data dictionary views.

Table 16–1 Streams Static Data Dictionary Views

ALL_ Views	DBA_ Views	USER_ Views
ALL_APPLY	DBA_APPLY	No USER_ view
ALL_APPLY_CONFLICT_COLUMNS	DBA_APPLY_CONFLICT_COLUMNS	No USER_ view
ALL_APPLY_DML_HANDLERS	DBA_APPLY_DML_HANDLERS	No USER_ view
ALL_APPLY_ERROR	DBA_APPLY_ERROR	No USER_ view
No ALL_ view	DBA_APPLY_INSTANTIATED_OBJECTS	No USER_ view
ALL_APPLY_KEY_COLUMNS	DBA_APPLY_KEY_COLUMNS	No USER_ view
ALL_APPLY_PARAMETERS	DBA_APPLY_PARAMETERS	No USER_ view
ALL_APPLY_PROGRESS	DBA_APPLY_PROGRESS	No USER_ view
ALL_CAPTURE	DBA_CAPTURE	No USER_ view
ALL_CAPTURE_PARAMETERS	DBA_CAPTURE_PARAMETERS	No USER_ view
ALL_CAPTURE_PREPARED_DATABASE	DBA_CAPTURE_PREPARED_DATABASE	No USER_ view
ALL_CAPTURE_PREPARED_SCHEMAS	DBA_CAPTURE_PREPARED_SCHEMAS	No USER_ view
ALL_CAPTURE_PREPARED_TABLES	DBA_CAPTURE_PREPARED_TABLES	No USER_ view
ALL_EVALUATION_CONTEXT_TABLES	DBA_EVALUATION_CONTEXT_TABLES	USER_EVALUATION_CONTEXT_TABLES
ALL_EVALUATION_CONTEXT_VARS	DBA_EVALUATION_CONTEXT_VARS	USER_EVALUATION_CONTEXT_VARS
ALL_EVALUATION_CONTEXTS	DBA_EVALUATION_CONTEXTS	USER_EVALUATION_CONTEXTS
ALL_PROPAGATION	DBA_PROPAGATION	No USER_ view
ALL_RULE_SET_RULES	DBA_RULE_SET_RULES	USER_RULE_SET_RULES
ALL_RULE_SETS	DBA_RULE_SETS	USER_RULE_SETS
ALL_RULES	DBA_RULES	USER_RULES
ALL_STREAMS_GLOBAL_RULES	DBA_STREAMS_GLOBAL_RULES	No USER_ view
ALL_STREAMS_SCHEMA_RULES	DBA_STREAMS_SCHEMA_RULES	No USER_ view
ALL_STREAMS_TABLE_RULES	DBA_STREAMS_TABLE_RULES	No USER_ view

Summary of Streams Dynamic Performance Views

The following list includes the Streams dynamic performance views

- V$STREAMS_APPLY_COORDINATOR
- V$STREAMS_APPLY_READER
- V$STREAMS_APPLY_SERVER
- V$STREAMS_CAPTURE

Monitoring a Streams Capture Process

The following sections contain queries that you can run to display information about a capture process:

- Displaying the Queue, Rule Set, and Status of Each Capture Process
- Displaying General Information About a Capture Process
- Listing the Parameter Settings for a Capture Process
- Determining Redo Log Scanning Latency for a Capture Process
- Determining Event Enqueuing Latency for a Capture Process
- Determining Which Database Objects Are Prepared for Instantiation
- Displaying Supplemental Log Groups at a Source Database

See Also:

- Chapter 2, "Streams Capture Process"
- Chapter 11, "Managing a Capture Process"

Displaying the Queue, Rule Set, and Status of Each Capture Process

You can display the following general information about each capture process in a database by running the query in this section:

- The capture process name
- The name of the queue used by the capture process
- The name of the rule set used by the capture process
- The status of the capture process, which may be ENABLE, DISABLED, or ABORTED

To display this general information about each capture process in a database, run the following query:

```
COLUMN CAPTURE_NAME HEADING 'Capture|Process|Name' FORMAT A10
COLUMN QUEUE_NAME HEADING 'Capture|Process|Queue' FORMAT A20
COLUMN RULE_SET_NAME HEADING 'Capture|Process|Rule Set' FORMAT A10
COLUMN STATUS HEADING 'Capture|Process|Status' FORMAT A10

SELECT CAPTURE_NAME, QUEUE_NAME, RULE_SET_NAME, STATUS FROM DBA_CAPTURE;
```

Your output looks similar to the following:

```
Capture    Capture              Capture    Capture
Process    Process              Process    Process
Name       Queue                Rule Set   Status
---------- -------------------- ---------- ----------
CAPTURE    STREAMS_QUEUE        RULESET$_6 ENABLED
```

Displaying General Information About a Capture Process

The query in this section displays the following general information about a particular capture process:

- The process number (cp*nn*)
- The session identifier
- The serial number of the session
- The current state of the capture process, either INITIALIZING, CAPTURING CHANGES, EVALUATING RULE, ENQUEUING MESSAGE, SHUTTING DOWN, or CREATING LCR
- The total number of redo entries scanned
- The total number LCRs enqueued

For example, to display this information for a capture process named capture, run the following query:

```
COLUMN PROCESS_NAME HEADING "Capture|Process|Number" FORMAT A7
COLUMN SID HEADING 'Session|ID' FORMAT 9999
COLUMN SERIAL# HEADING 'Session|Serial|Number' FORMAT 9999
COLUMN STATE HEADING 'State' FORMAT A17
COLUMN TOTAL_MESSAGES_CAPTURED HEADING 'Redo Entries|Scanned' FORMAT 9999999
COLUMN TOTAL_MESSAGES_ENQUEUED HEADING 'Total|LCRs|Enqueued' FORMAT 999999
```

```
SELECT SUBSTR(s.PROGRAM,INSTR(S.PROGRAM,'(')+1,4) PROCESS_NAME,
       c.SID,
       c.SERIAL#,
       c.STATE,
       c.TOTAL_MESSAGES_CAPTURED,
       c.TOTAL_MESSAGES_ENQUEUED
  FROM V$STREAMS_CAPTURE c, V$SESSION s
  WHERE c.CAPTURE_NAME = 'CAPTURE' AND
        c.SID = s.SID AND
        c.SERIAL# = s.SERIAL#;
```

Your output looks similar to the following:

```
Capture         Session                                      Total
Process Session  Serial                   Redo Entries     LCRs
Number       ID  Number State                 Scanned Enqueued
------- ------- ------- ----------------- ------------ --------
CP01         18     150 CAPTURING CHANGES        56900        7
```

The number of redo entries scanned may be higher than the number of DML and DDL redo entries that evaluate to `TRUE` for a capture process rule set. Only DML and DDL redo entries that evaluate to `TRUE` for a capture process rule set are enqueued into the capture process queue. Also, the total LCRs enqueued includes LCRs that contain transaction control statements. These row LCRs contain directives such as `COMMIT` and `ROLLBACK`. Therefore, the total LCRs enqueued is a number higher than the number of row changes and DDL changes enqueued by a capture process.

> **See Also:** "Row LCRs" on page 2-3 for more information about transaction control statements

Listing the Parameter Settings for a Capture Process

The query in this section displays the current setting for each capture process parameter for a particular capture process.

For example, to display the settings for the capture process parameters of a capture process named `capture`, run the following query:

```
COLUMN PARAMETER HEADING 'Parameter' FORMAT A20
COLUMN VALUE HEADING 'Value' FORMAT A20
COLUMN SET_BY_USER HEADING 'Set by User?' FORMAT A20
```

```
SELECT PARAMETER,
       VALUE,
       SET_BY_USER
  FROM DBA_CAPTURE_PARAMETERS
  WHERE CAPTURE_NAME = 'CAPTURE';
```

Your output looks similar to the following:

```
Parameter            Value                Set by User?
-------------------- -------------------- --------------------
DISABLE_ON_LIMIT     N                    NO
MAXIMUM_SCN          INFINITE             NO
MESSAGE_LIMIT        INFINITE             NO
PARALLELISM          3                    YES
STARTUP_SECONDS      0                    NO
TIME_LIMIT           INFINITE             NO
TRACE_LEVEL          0                    NO
WRITE_ALERT_LOG      Y                    NO
```

Note: If the `Set by User?` column is `NO` for a parameter, then the parameter is set to its default value. If the `Set by User?` column is `YES` for a parameter, then the parameter may or may not be set to its default value.

See Also:

- "Capture Process Parameters" on page 2-19
- "Setting a Capture Process Parameter" on page 11-8

Determining Redo Log Scanning Latency for a Capture Process

You can find the following information about a capture process by running the query in this section:

- The redo log scanning latency, which specifies the number of seconds between the creation time of the most recent redo log event scanned by a capture process and the current time. This number may be relatively large immediately after you start a capture process.
- The seconds since last recorded status, which is the number of seconds since a capture process last recorded its status

- The current capture process time, which is the latest time when the capture process recorded its status
- The event creation time, which is the time when the data manipulation language (DML) or data definition language (DDL) change generated the redo information for the most recently captured event

The information displayed by this query is valid only for an enabled capture process.

Run the following query to determine the redo scanning latency for a capture process named `capture`:

```
COLUMN LATENCY_SECONDS HEADING 'Latency|in|Seconds' FORMAT 999999
COLUMN LAST_STATUS HEADING 'Seconds Since|Last Status' FORMAT 999999
COLUMN CAPTURE_TIME HEADING 'Current|Process|Time'
COLUMN CREATE_TIME HEADING 'Event|Creation Time' FORMAT 999999

SELECT ((SYSDATE - CAPTURE_MESSAGE_CREATE_TIME)*86400) LATENCY_SECONDS,
       ((SYSDATE - CAPTURE_TIME)*86400) LAST_STATUS,
       TO_CHAR(CAPTURE_TIME, 'HH24:MI:SS MM/DD/YY') CAPTURE_TIME,
       TO_CHAR(CAPTURE_MESSAGE_CREATE_TIME, 'HH24:MI:SS MM/DD/YY') CREATE_TIME
  FROM V$STREAMS_CAPTURE
  WHERE CAPTURE_NAME = 'CAPTURE';
```

Your output looks similar to the following:

```
Latency               Current
     in Seconds Since Process           Event
Seconds   Last Status Time              Creation Time
------- ------------ ----------------- -----------------
      4            4 12:04:13 03/01/02 12:04:13 03/01/02
```

The "Latency in Seconds" returned by this query is the difference between the current time (SYSDATE) and the "Event Creation Time." The "Seconds Since Last Status" returned by this query is the difference between the current time (SYSDATE) and the "Current Process Time."

Determining Event Enqueuing Latency for a Capture Process

You can find the following information about a capture process by running the query in this section:

- The event enqueuing latency, which specifies the number of seconds between when an event was recorded in the redo log and when the event was enqueued by the capture process
- The event creation time, which is the time when the data manipulation language (DML) or data definition language (DDL) change generated the redo information for the most recently enqueued event
- The enqueue time, which is when the capture process enqueued the event into its queue
- The message number of the enqueued event

The information displayed by this query is valid only for an enabled capture process.

Run the following query to determine the event capturing latency for a capture process named `capture`:

```
COLUMN LATENCY_SECONDS HEADING 'Latency|in|Seconds' FORMAT 999999
COLUMN CREATE_TIME HEADING 'Event Creation|Time' FORMAT A20
COLUMN ENQUEUE_TIME HEADING 'Enqueue Time' FORMAT A20
COLUMN ENQUEUE_MESSAGE_NUMBER HEADING 'Message|Number' FORMAT 999999

SELECT (ENQUEUE_TIME-ENQUEUE_MESSAGE_CREATE_TIME)*86400 LATENCY_SECONDS,
       TO_CHAR(ENQUEUE_MESSAGE_CREATE_TIME, 'HH24:MI:SS MM/DD/YY') CREATE_TIME,
       TO_CHAR(ENQUEUE_TIME, 'HH24:MI:SS MM/DD/YY') ENQUEUE_TIME,
       ENQUEUE_MESSAGE_NUMBER
  FROM V$STREAMS_CAPTURE
  WHERE CAPTURE_NAME = 'CAPTURE';
```

Your output looks similar to the following:

```
Latency
     in Event Creation                          Message
Seconds Time                 Enqueue Time         Number
------- -------------------- -------------------- -------
      0 10:56:51 03/01/02    10:56:51 03/01/02     253962
```

The "Latency in Seconds" returned by this query is the difference between the "Enqueue Time" and the "Event Creation Time."

Determining Which Database Objects Are Prepared for Instantiation

You prepare a database object for instantiation using one of the following procedures in the DBMS_CAPTURE_ADM package:

- PREPARE_TABLE_INSTANTIATION prepares a single table for instantiation.
- PREPARE_SCHEMA_INSTANTIATION prepares all of the database objects in a schema for instantiation.
- PREPARE_GLOBAL_INSTANTIATION prepares all of the database objects in a database for instantiation.

To determine which database objects have been prepared for instantiation, query the following corresponding data dictionary views:

- DBA_CAPTURE_PREPARED_TABLES
- DBA_CAPTURE_PREPARED_SCHEMAS
- DBA_CAPTURE_PREPARED_DATABASE

For example, to list all of the tables that have been prepared for instantiation, the SCN for the time when each table was prepared, and the time when each table was prepared, run the following query:

```
COLUMN TABLE_OWNER HEADING 'Table Owner' FORMAT A15
COLUMN TABLE_NAME HEADING 'Table Name' FORMAT A15
COLUMN SCN HEADING 'Instantiation SCN' FORMAT 999999
COLUMN TIMESTAMP HEADING 'Time Ready for|Instantiation'

SELECT TABLE_OWNER,
       TABLE_NAME,
       SCN,
       TO_CHAR(TIMESTAMP, 'HH24:MI:SS MM/DD/YY') TIMESTAMP
  FROM DBA_CAPTURE_PREPARED_TABLES;
```

Your output looks similar to the following:

```
                                                    Time Ready for
Table Owner     Table Name      Instantiation SCN Instantiation
--------------- --------------- ----------------- -----------------
HR              COUNTRIES                 196655 12:59:30 02/28/02
HR              DEPARTMENTS               196658 12:59:30 02/28/02
HR              EMPLOYEES                 196659 12:59:30 02/28/02
HR              JOBS                      196660 12:59:30 02/28/02
HR              JOB_HISTORY               196661 12:59:30 02/28/02
HR              LOCATIONS                 196662 12:59:30 02/28/02
HR              REGIONS                   196664 12:59:30 02/28/02
```

See Also: "Preparing Database Objects for Instantiation at a Source Database" on page 11-11

Displaying Supplemental Log Groups at a Source Database

Supplemental logging places additional column data into a redo log whenever an UPDATE operation is performed. The capture process captures this additional information and places it in LCRs. An apply process that applies captured LCRs may need this additional information to schedule or apply changes correctly.

To check whether one or more log groups are specified for the table at the source database, run the following query:

```
COLUMN LOG_GROUP_NAME HEADING 'Log Group' FORMAT A20
COLUMN TABLE_NAME HEADING 'Table' FORMAT A20
COLUMN ALWAYS HEADING 'Type of Log Group' FORMAT A30

SELECT
    LOG_GROUP_NAME,
    TABLE_NAME,
    DECODE(ALWAYS,
             'ALWAYS', 'Unconditional',
             NULL,     'Conditional') ALWAYS
  FROM DBA_LOG_GROUPS;
```

Your output looks similar to the following:

```
Log Group            Table                Type of Log Group
-------------------- -------------------- ------------------------------
LOG_GROUP_DEP_PK     DEPARTMENTS          Unconditional
LOG_GROUP_JOBS_CR    JOBS                 Conditional
```

To list the columns in a particular log group, query the DBA_LOG_GROUP_COLUMNS data dictionary view. You can also query the V$DATABASE dynamic performance view to display supplemental logging specified at the database level.

See Also:

- "Supplemental Logging" on page 2-9
- "Specifying Supplemental Logging at a Source Database" on page 11-9

Monitoring a Streams Queue

The following sections contain queries that you can run to display information about a Streams queue:

- Displaying the Streams Queues in a Database
- Determining the Consumer of Each User-Enqueued Event in a Queue
- Viewing the Contents of User-Enqueued Events in a Queue

See Also:

- Chapter 3, "Streams Staging and Propagation"
- Chapter 12, "Managing Staging and Propagation"

Displaying the Streams Queues in a Database

Streams queues are of object type SYS.AnyData. To display all of the Streams queues in a database, run the following query:

```
COLUMN OWNER HEADING 'Owner' FORMAT A10
COLUMN NAME HEADING 'Queue Name' FORMAT A25
COLUMN QUEUE_TABLE HEADING 'Queue Table' FORMAT A20
COLUMN USER_COMMENT HEADING 'Comment' FORMAT A20

SELECT q.OWNER, q.NAME, t.QUEUE_TABLE, q.USER_COMMENT
  FROM DBA_QUEUES q, DBA_QUEUE_TABLES t
  WHERE t.OBJECT_TYPE = 'SYS.ANYDATA' AND
        q.QUEUE_TABLE = t.QUEUE_TABLE AND
        q.OWNER       = t.OWNER;
```

Your output looks similar to the following:

```
Owner      Queue Name                 Queue Table          Comment
---------- ------------------------- -------------------- --------------------
STRMADMIN  AQ$_STREAMS_QUEUE_TABLE_E STREAMS_QUEUE_TABLE  exception queue
STRMADMIN  STREAMS_QUEUE              STREAMS_QUEUE_TABLE
```

An exception queue is created automatically when you create a Streams queue.

See Also: "Managing Streams Queues" on page 12-2

Determining the Consumer of Each User-Enqueued Event in a Queue

To determine the consumer for each user-enqueued event in a queue, query AQ$*queue_table_name* in the queue owner's schema, where *queue_table_name* is the name of the queue table. For example, to find the consumers of the user-enqueued events in the oe_queue_table queue table, run the following query:

```
COLUMN MSG_ID HEADING 'Message ID' FORMAT 9999
COLUMN MSG_STATE HEADING 'Message State' FORMAT A13
COLUMN CONSUMER_NAME HEADING 'Consumer' FORMAT A30

SELECT MSG_ID, MSG_STATE, CONSUMER_NAME FROM AQ$OE_QUEUE_TABLE;
```

Your output looks similar to the following:

```
Message ID                       Message State Consumer
-------------------------------- ------------- ------------------------------
99315B276CFA1872E034080020AE3E0A PROCESSED    APPLY_OE
99315B276CFB1872E034080020AE3E0A PROCESSED    APPLY_OE
99315B276CFA1872E034080020AE3E0A READY        EXPLICIT_DQ
99315B276CFB1872E034080020AE3E0A READY        EXPLICIT_DQ
```

Note: This query lists only user-enqueued events, not captured events.

See Also: Chapter 18, "Example Streams Messaging Environment" for an example that enqueues the events shown in this example into a Streams queue

Viewing the Contents of User-Enqueued Events in a Queue

In a Streams queue, to view the contents of a payload that is encapsulated within a SYS.AnyData payload, you query the queue table using the Access*data_type* static functions of the SYS.AnyData type, where *data_type* is the type of payload to view.

For example, to view the contents of payload of type NUMBER in a queue with a queue table named oe_queue_table, run the following query as the queue owner:

```
SELECT qt.user_data.AccessNumber() "Numbers in Queue"
  FROM strmadmin.oe_q_table_any qt;
```

Your output looks similar to the following:

```
Numbers in Queue
----------------
              16
```

Similarly, to view the contents of a payload of type VARCHAR2 in a queue with a queue table named oe_q_table_any, run the following query:

```
SELECT qt.user_data.AccessVarchar2() "Varchar2s in Queue"
   FROM strmadmin.oe_q_table_any qt;
```

Your output looks similar to the following:

```
Varchar2s in Queue
--------------------------------------------------------------------------------
Chemicals - SW
```

To view the contents of a user-defined datatype, you query the queue table using a custom function that you create. For example, to view the contents of a payload of oe.cust_address_typ, connect as the Streams administrator and create a function similar to the following:

```
CONNECT oe/oe
```

```
CREATE OR REPLACE FUNCTION oe.view_cust_address_typ(
in_any IN SYS.AnyData)
RETURN oe.cust_address_typ
IS
  address   OE.CUST_ADDRESS_TYP;
  num_var   NUMBER;
BEGIN
  IF (in_any.GetTypeName() = 'OE.CUST_ADDRESS_TYP') THEN
    num_var := in_any.GetObject(address);
    RETURN address;
  ELSE RETURN NULL;
  END IF;
END;
/

GRANT EXECUTE ON oe.view_cust_address_typ TO STRMADMIN;

GRANT EXECUTE ON oe.cust_address_typ TO STRMADMIN;
```

Then, query the queue table using the function, as in the following example:

```
CONNECT strmadmin/strmadminpw

SELECT oe.view_cust_address_typ(qt.user_data) "Customer Addresses"
  FROM strmadmin.oe_q_table_any qt
  WHERE qt.user_data.GetTypeName() = 'OE.CUST_ADDRESS_TYP';
```

Your output looks similar to the following:

```
Customer Addresses(STREET_ADDRESS, POSTAL_CODE, CITY, STATE_PROVINCE, COUNTRY_ID
--------------------------------------------------------------------------------
CUST_ADDRESS_TYP('1646 Brazil Blvd', '361168', 'Chennai', 'Tam', 'IN')
```

> **See Also:** "Wrapping User Messages in a SYS.AnyData Wrapper" on page 12-18 for an example that enqueues the events shown in this example into a Streams queue

Monitoring a Streams Propagation Job

The following sections contain queries that you can run to display information about an apply process:

- Determining the Source Queue and Destination Queue for a Propagation Job
- Determining the Rule Set for a Propagation Job
- Displaying the Schedule for a Propagation Job
- Determining the Total Number of Events and Bytes Propagated

See Also:

- Chapter 3, "Streams Staging and Propagation"
- "Managing Streams Propagation Jobs" on page 12-7

Determining the Source Queue and Destination Queue for a Propagation Job

You can determine the source queue and destination queue for a propagation job by querying the `DBA_PROPAGATION` data dictionary view at the database that contains the source queue.

For example, the following query displays the following information for a propagation job named `dbs1_to_dbs2`:

- The source queue owner
- The source queue name
- The database that contains the source queue
- The destination queue owner
- The destination queue name
- The database link used by the propagation job

```
COLUMN "Source Queue" FORMAT A35
COLUMN "Destination Queue" FORMAT A35
```

```
SELECT p.SOURCE_QUEUE_OWNER ||'.'||
       p.SOURCE_QUEUE_NAME ||'@'||
       g.GLOBAL_NAME "Source Queue",
       p.DESTINATION_QUEUE_OWNER ||'.'||
       p.DESTINATION_QUEUE_NAME ||'@'||
       p.DESTINATION_DBLINK "Destination Queue"
  FROM DBA_PROPAGATION p, GLOBAL_NAME g
  WHERE PROPAGATION_NAME = 'DBS1_TO_DBS2';
```

Your output looks similar to the following:

```
Source Queue                          Destination Queue
------------------------------------ ------------------------------------
STRMADMIN.STREAMS_QUEUE@DBS1.NET     STRMADMIN.STREAMS_QUEUE@DBS2.NET
```

Determining the Rule Set for a Propagation Job

The following query displays the owner and name of a rule set used by a propagation job named `dbs1_to_dbs2`:

```
COLUMN RULE_SET_OWNER HEADING 'Rule Set Owner' FORMAT A35
COLUMN RULE_SET_NAME HEADING 'Rule Set Name' FORMAT A35

SELECT RULE_SET_OWNER, RULE_SET_NAME
  FROM DBA_PROPAGATION
  WHERE PROPAGATION_NAME = 'DBS1_TO_DBS2';
```

Your output looks similar to the following:

```
Rule Set Owner                        Rule Set Name
------------------------------------ ------------------------------------
STRMADMIN                             RULESET$_3
```

Displaying the Schedule for a Propagation Job

The query in this section displays the following information about the propagation schedule for a propagation job named `dbs1_to_dbs2`:

- The date and time when the propagation schedule started (or will start)
- The duration of the propagation job, which is the amount of time the job propagates events before restarting
- The latency of the propagation job, which is the maximum wait time to propagate a new message during the duration, when all other messages in the queue to the relevant destination have been propagated

- Whether or not the propagation job is enabled
- The name of the process that most recently executed the schedule
- The number of consecutive times schedule execution has failed, if any. After 16 consecutive failures, a propagation job becomes disabled automatically.

Run this query at the database that contains the source queue:

```
COLUMN START_DATE HEADING 'Start Date'
COLUMN PROPAGATION_WINDOW HEADING 'Duration|in Seconds' FORMAT 99999
COLUMN NEXT_TIME HEADING 'Next|Time' FORMAT A8
COLUMN LATENCY HEADING 'Latency|in Seconds' FORMAT 99999
COLUMN SCHEDULE_DISABLED HEADING 'Status' FORMAT A8
COLUMN PROCESS_NAME HEADING 'Process' FORMAT A8
COLUMN FAILURES HEADING 'Number of|Failures' FORMAT 99

SELECT TO_CHAR(s.START_DATE, 'HH24:MI:SS MM/DD/YY') START_DATE,
       s.PROPAGATION_WINDOW,
       TO_CHAR(s.NEXT_TIME, 'HH24:MI:SS MM/DD/YY') NEXT_TIME,
       s.LATENCY,
       DECODE(s.SCHEDULE_DISABLED,
                'Y', 'Disabled',
                'N', 'Enabled') SCHEDULE_DISABLED,
       PROCESS_NAME,
       FAILURES
  FROM DBA_QUEUE_SCHEDULES s, DBA_PROPAGATION p
  WHERE p.PROPAGATION_NAME = 'DBS1_TO_DBS2'
  AND p.DESTINATION_DBLINK = s.DESTINATION
  AND s.SCHEMA = p.SOURCE_QUEUE_OWNER
  AND s.QNAME = p.SOURCE_QUEUE_NAME;
```

Your output looks similar to the following:

```
                    Duration Next        Latency                    Number of
Start Date        in Seconds Time     in Seconds Status   Process   Failures
----------------- ---------- -------- ---------- -------- -------- ---------
15:23:40 03/02/02                             5 Enabled  J002             0
```

This propagation job uses the default schedule for a Streams propagation job. That is, the duration and next time are both NULL, and the latency is five seconds. When the duration is NULL, the job propagates changes without restarting automatically. When the next time is NULL, the propagation job is running currently.

See Also:

- "Propagation Scheduling" on page 3-6 for more information about the default propagation schedule for a Streams propagation job
- "Is the Propagation Job Enabled?" on page 17-6 if the propagation job is disabled
- *Oracle9i Application Developer's Guide - Advanced Queuing* and *Oracle9i Database Reference* for more information about the DBA_QUEUE_SCHEDULES data dictionary view

Determining the Total Number of Events and Bytes Propagated

All propagation jobs from a source queue that share the same database link have a single propagation schedule. The query in this section displays the following information for a propagation schedule associated with a particular propagation job:

- The total time spent by the system executing the propagation schedule
- The total number of events propagated by the propagation schedule
- The total number of bytes propagated by the propagation schedule

For example, to display this information for a propagation job named dbs1_to_dbs2, run the following query at the database that contains the source queue:

```
COLUMN TOTAL_TIME HEADING 'Total Time Executing|in Seconds' FORMAT 999999
COLUMN TOTAL_NUMBER HEADING 'Total Events Propagated' FORMAT 999999999
COLUMN TOTAL_BYTES HEADING 'Total Bytes Propagated' FORMAT 9999999999999

SELECT s.TOTAL_TIME, s.TOTAL_NUMBER, s.TOTAL_BYTES
  FROM DBA_QUEUE_SCHEDULES s, DBA_PROPAGATION p
  WHERE p.PROPAGATION_NAME = 'DBS1_TO_DBS2'
  AND p.DESTINATION_DBLINK = s.DESTINATION
  AND s.SCHEMA = p.SOURCE_QUEUE_OWNER
  AND s.QNAME = p.SOURCE_QUEUE_NAME;
```

Your output looks similar to the following:

```
Total Time Executing
          in Seconds Total Events Propagated Total Bytes Propagated
------------------- ---------------------- ---------------------
                 65                     71                 46536
```

See Also: *Oracle9i Application Developer's Guide - Advanced Queuing* and *Oracle9i Database Reference* for more information about the DBA_QUEUE_SCHEDULES data dictionary view

Monitoring a Streams Apply Process

The following sections contain queries that you can run to display information about an apply process:

- Displaying General Information About Each Apply Process
- Listing the Parameter Settings for an Apply Process
- Displaying Information About Apply Handlers
- Displaying the Substitute Key Columns Specified at a Destination Database
- Displaying Information About Update Conflict Handlers for a Destination Database
- Determining the Tables for Which an Instantiation SCN Has Been Set
- Displaying Information About the Reader Server for an Apply Process
- Determining Capture to Dequeue Latency for an Event
- Displaying Information About the Coordinator Process
- Determining the Capture to Apply Latency for an Event
- Displaying Information About the Apply Servers for an Apply Process
- Displaying Effective Apply Parallelism for an Apply Process
- Checking for Apply Errors
- Displaying Detailed Information About Apply Errors

See Also:

- Chapter 4, "Streams Apply Process"
- Chapter 13, "Managing an Apply Process"

Displaying General Information About Each Apply Process

You can display the following general information about each apply process in a database by running the query in this section:

- The apply process name
- The name of the queue used by the apply process
- The name of the rule set used by the apply process
- The type of events applied by the apply process. An apply process may apply either events that were captured by a capture process or events that were enqueued by a user or application.
- The status of the apply process, which may be ENABLED, DISABLED, or ABORTED

To display this general information about each capture process in a database, run the following query:

```
COLUMN CAPTURE_NAME HEADING 'Apply|Process|Name' FORMAT A10
COLUMN QUEUE_NAME HEADING 'Apply|Process|Queue' FORMAT A20
COLUMN RULE_SET_NAME HEADING 'Apply|Process|Rule Set' FORMAT A20
COLUMN APPLY_CAPTURED HEADING 'Type of|Events Applied' FORMAT A15
COLUMN STATUS HEADING 'Apply|Process|Status' FORMAT A10

SELECT APPLY_NAME,
       QUEUE_NAME,
       RULE_SET_NAME,
       DECODE(APPLY_CAPTURED,
              'YES', 'Captured',
              'NO',  'User-Enqueued') APPLY_CAPTURED,
       STATUS
FROM DBA_APPLY;
```

Your output looks similar to the following:

```
Apply    Apply                Apply                          Apply
Process  Process              Process             Type of    Process
Name     Queue                Rule Set            Events Applied  Status
-------- -------------------- ------------------- -------------- ----------
APPLY_OE OE_QUEUE             APPLY_OE_RS         User-Enqueued  ENABLED
APPLY    OE_QUEUE             RULESET$_4          Captured       DISABLED
```

Listing the Parameter Settings for an Apply Process

The query in this section displays the current setting for each apply process parameter for a particular apply process.

For example, to display the settings for the apply process parameters of an apply process named `strm01_apply`, run the following query:

```
COLUMN PARAMETER HEADING 'Parameter' FORMAT A20
COLUMN VALUE HEADING 'Value' FORMAT A20
COLUMN SET_BY_USER HEADING 'Set by User?' FORMAT A20

SELECT PARAMETER,
       VALUE,
       SET_BY_USER
  FROM DBA_APPLY_PARAMETERS
  WHERE APPLY_NAME = 'STRM01_APPLY';
```

Your output looks similar to the following:

```
Parameter            Value                Set by User?
-------------------- -------------------- --------------------
COMMIT_SERIALIZATION FULL                 NO
DISABLE_ON_ERROR     Y                    YES
DISABLE_ON_LIMIT     N                    NO
MAXIMUM_SCN          INFINITE             NO
PARALLELISM          1                    NO
STARTUP_SECONDS      0                    NO
TIME_LIMIT           INFINITE             NO
TRACE_LEVEL          0                    NO
TRANSACTION_LIMIT    INFINITE             NO
WRITE_ALERT_LOG      Y                    NO
```

Note: If the `Set by User?` column is `NO` for a parameter, then the parameter is set to its default value. If the `Set by User?` column is `YES` for a parameter, then the parameter may or may not be set to its default value.

See Also:

- "Apply Process Parameters" on page 4-30
- "Setting an Apply Process Parameter" on page 13-11

Displaying Information About Apply Handlers

This section contains queries that display information about apply process DML handlers, DDL handlers, and error handlers.

See Also: "Event Processing with an Apply Process" on page 4-3

Displaying All of the DML and Error Handlers for Local Apply

When you specify a local DML or error handler using the SET_DML_HANDLER procedure in the DBMS_APPLY_ADM package at a destination database, the handler is run for all apply processes in the database that apply changes locally, when appropriate. DML and error handlers are run for a specified operation on a specific table.

To display the DML or error handler for each apply process that applies changes locally in a database, run the following query:

```
COLUMN OBJECT_OWNER HEADING 'Table|Owner' FORMAT A5
COLUMN OBJECT_NAME HEADING 'Table Name' FORMAT A10
COLUMN OPERATION_NAME HEADING 'Operation' FORMAT A9
COLUMN USER_PROCEDURE HEADING 'Handler Procedure' FORMAT A40
COLUMN ERROR_HANDLER HEADING 'Type of|Handler' FORMAT A10

SELECT OBJECT_OWNER,
       OBJECT_NAME,
       OPERATION_NAME,
       USER_PROCEDURE,
       DECODE(ERROR_HANDLER,
              'Y', 'Error',
              'N', 'DML') ERROR_HANDLER
  FROM DBA_APPLY_DML_HANDLERS
  WHERE APPLY_DATABASE_LINK IS NULL
  ORDER BY OBJECT_OWNER, OBJECT_NAME, ERROR_HANDLER;
```

Your output looks similar to the following:

```
Table                                                                  Type of
Owner Table Name Operation Handler Procedure                           Handler
----- ---------- --------- ---------------------------------------- ----------
HR    LOCATIONS  UPDATE    STRMADMIN.HISTORY_DML                    DML
HR    REGIONS    INSERT    STRMADMIN.ERRORS_PKG.REGIONS_PK_ERROR    Error
```

Note: You can also specify DML handlers to process changes for remote non-Oracle databases. This query does not display such DML handlers because it lists a DML handler only if the APPLY_DATABASE_LINK column is NULL for a DML handler.

See Also:

- "Managing a DML Handler" on page 13-14
- "Managing an Error Handler" on page 13-21

Displaying the DDL Handler and Message Handler for Each Apply Process

To display the DDL handler and message handler for each apply process in a database, run the following query:

```
COLUMN APPLY_NAME HEADING 'Apply Process Name' FORMAT A20
COLUMN DDL_HANDLER HEADING 'DDL Handler' FORMAT A20
COLUMN MESSAGE_HANDLER HEADING 'Message Handler' FORMAT A20

SELECT APPLY_NAME, DDL_HANDLER, MESSAGE_HANDLER FROM DBA_APPLY;
```

Your output looks similar to the following:

```
Apply Process Name   DDL Handler          Message Handler
-------------------- -------------------- --------------------
APPLY                oe.ddl_handler
APPLY_OE                                  oe.msg_handler
```

See Also:

- "Managing the DDL Handler for an Apply Process" on page 13-18
- "Managing the Message Handler for an Apply Process" on page 13-13

Displaying the Substitute Key Columns Specified at a Destination Database

You can designate a substitute key at a destination database, which is a column or set of columns that Oracle can use to identify rows in the table during apply. Substitute key columns can be used to specify key columns for a table that has no primary key, or they can be used instead of a table's primary key when the table is processed by any apply process at a destination database.

To display all of the substitute key columns specified at a destination database, run the following query:

```
COLUMN OBJECT_OWNER HEADING 'Table Owner' FORMAT A20
COLUMN OBJECT_NAME HEADING 'Table Name' FORMAT A20
COLUMN COLUMN_NAME HEADING 'Substitute Key Name' FORMAT A20
COLUMN APPLY_DATABASE_LINK HEADING 'Database Link|for Remote|Apply' FORMAT A15

SELECT OBJECT_OWNER, OBJECT_NAME, COLUMN_NAME, APPLY_DATABASE_LINK
  FROM DBA_APPLY_KEY_COLUMNS
  ORDER BY APPLY_DATABASE_LINK, OBJECT_OWNER, OBJECT_NAME;
```

Your output looks similar to the following:

```
                                                          Database Link
                                                          for Remote
Table Owner          Table Name          Substitute Key Name  Apply
-------------------- -------------------- -------------------- ---------------
HR                   DEPARTMENTS         DEPARTMENT_NAME
HR                   DEPARTMENTS         LOCATION_ID
HR                   EMPLOYEES           FIRST_NAME
HR                   EMPLOYEES           LAST_NAME
HR                   EMPLOYEES           HIRE_DATE
```

Note: This query shows the database link in the last column if the substitute key columns are for a remote non-Oracle database. The last column is `NULL` if a substitute key column is specified for the local destination database.

See Also:

- "Substitute Key Columns" on page 4-10
- "Managing the Substitute Key Columns for a Table" on page 13-27

Displaying Information About Update Conflict Handlers for a Destination Database

When you specify an update conflict handler using the SET_UPDATE_CONFLICT_HANDLER procedure in the DBMS_APPLY_ADM package, the update conflict handler is run for all apply processes in the database, when a relevant conflict occurs.

The query in this section displays all of the columns for which conflict resolution has been specified using a prebuilt update conflict handler. That is, it shows the columns in all of the column lists specified in the database. This query also shows the type of prebuilt conflict handler specified and the resolution column specified for the column list.

To display information about all of the update conflict handlers in a database, run the following query:

```
COLUMN OBJECT_OWNER HEADING 'Table|Owner' FORMAT A5
COLUMN OBJECT_NAME HEADING 'Table Name' FORMAT A12
COLUMN METHOD_NAME HEADING 'Method' FORMAT A12
COLUMN RESOLUTION_COLUMN HEADING 'Resolution|Column' FORMAT A13
COLUMN COLUMN_NAME HEADING 'Column Name' FORMAT A30

SELECT OBJECT_OWNER,
       OBJECT_NAME,
       METHOD_NAME,
       RESOLUTION_COLUMN,
       COLUMN_NAME
  FROM DBA_APPLY_CONFLICT_COLUMNS
  ORDER BY OBJECT_OWNER, OBJECT_NAME, RESOLUTION_COLUMN;
```

Your output looks similar to the following:

```
Table                          Resolution
Owner Table Name   Method       Column        Column Name
----- ------------ ------------ ------------- ------------------------------
HR    COUNTRIES    MAXIMUM      TIME          COUNTRY_NAME
HR    COUNTRIES    MAXIMUM      TIME          REGION_ID
HR    COUNTRIES    MAXIMUM      TIME          TIME
HR    DEPARTMENTS  MAXIMUM      TIME          DEPARTMENT_NAME
HR    DEPARTMENTS  MAXIMUM      TIME          LOCATION_ID
HR    DEPARTMENTS  MAXIMUM      TIME          MANAGER_ID
HR    DEPARTMENTS  MAXIMUM      TIME          TIME
```

See Also:

- Chapter 7, "Streams Conflict Resolution"
- "Managing Streams Conflict Resolution" on page 13-29

Determining the Tables for Which an Instantiation SCN Has Been Set

An instantiation SCN is set at a destination database. It controls which captured LCRs for a table are ignored by an apply process and which captured LCRs for a database object are applied by an apply process. If the commit SCN of an LCR for a table from a source database is less than or equal to the instantiation SCN for that table at a destination database, then the apply process at the destination database discards the LCR. Otherwise, the apply process applies the LCR.

The following query lists each table for which an instantiation SCN has been set at a destination database and the instantiation SCN for each table:

```
COLUMN SOURCE_DATABASE HEADING 'Source Database' FORMAT A15
COLUMN SOURCE_OBJECT_OWNER HEADING 'Object Owner' FORMAT A15
COLUMN SOURCE_OBJECT_NAME HEADING 'Object Name' FORMAT A15
COLUMN INSTANTIATION_SCN HEADING 'Instantiation SCN' FORMAT 999999

SELECT SOURCE_DATABASE,
       SOURCE_OBJECT_OWNER,
       SOURCE_OBJECT_NAME,
       INSTANTIATION_SCN
  FROM DBA_APPLY_INSTANTIATED_OBJECTS;
```

Your output looks similar to the following:

```
Source Database Object Owner    Object Name     Instantiation SCN
--------------- --------------- --------------- -----------------
DBS1.NET        HR              REGIONS                    196660
DBS1.NET        HR              COUNTRIES                  196660
DBS1.NET        HR              LOCATIONS                  196660
```

See Also: "Setting Instantiation SCNs at a Destination Database" on page 13-35

Displaying Information About the Reader Server for an Apply Process

The reader server for an apply process dequeues events from the queue. The reader server is a parallel execution server that computes dependencies between LCRs and assembles events into transactions. The reader server then returns the assembled transactions to the coordinator, which assigns them to idle apply servers.

The query in this section displays the following information about the reader server for a particular apply process:

- The type of events dequeued by the reader server, either captured LCRs or user-enqueued messages
- The name of the parallel execution server used by the reader server
- The current state of the reader server, either `IDLE`, `DEQUEUE MESSAGES`, or `SCHEDULE MESSAGES`
- The total number of events dequeued by the reader server since the last time the apply process was started

The information displayed by this query is valid only for an enabled apply process.

For example, to display this information for an apply process named `apply`, run the following query:

```
COLUMN APPLY_CAPTURED HEADING 'Apply Type' FORMAT A22
COLUMN PROCESS_NAME HEADING 'Process Name' FORMAT A12
COLUMN STATE HEADING 'State' FORMAT A17
COLUMN TOTAL_MESSAGES_DEQUEUED HEADING 'Total Events Dequeued' FORMAT 99999999

SELECT DECODE(ap.APPLY_CAPTURED,
                'YES','Captured LCRS',
                'NO','User-enqueued messages','UNKNOWN') APPLY_CAPTURED,
       SUBSTR(s.PROGRAM,INSTR(S.PROGRAM,'(')+1,4) PROCESS_NAME,
       r.STATE,
       r.TOTAL_MESSAGES_DEQUEUED
       FROM V$STREAMS_APPLY_READER r, V$SESSION s, DBA_APPLY ap
       WHERE r.APPLY_NAME = 'APPLY' AND
             r.SID = s.SID AND
             r.SERIAL# = s.SERIAL# AND
             r.APPLY_NAME = ap.APPLY_NAME;
```

Your output looks similar to the following:

```
Apply Type            Process Name State             Total Events Dequeued
--------------------- ------------ ----------------- ---------------------
Captured LCRS         P000         DEQUEUE MESSAGES                   3803
```

Determining Capture to Dequeue Latency for an Event

The query in this section displays the following information about the last event dequeued by a particular apply process:

- The amount of time between when the event was created at a source database and when the event was dequeued by the apply process
- The event creation time. For captured events, the event creation time is the time when the data manipulation language (DML) or data definition language (DDL) change generated the redo information at the source database for the event. For user-enqueued events, the event creation time is the last time the event was enqueued. A user-enqueued event may be enqueued one or more additional times by propagation before it reaches an apply process.
- The time when the event was dequeued by the apply process
- The message number of the event that was last dequeued by the apply process

Here, the latency is the amount of time required for an event recently dequeued by the apply process to be captured by a capture process, propagated to the destination database, and dequeued by an apply process.

The information displayed by this query is valid only for an enabled apply process.

For example, to display the capture and propagation latency for the last captured event dequeued by an apply process named `apply`, run the following query:

```
COLUMN LATENCY HEADING "Latency|in|Seconds" FORMAT 9999
COLUMN CREATION HEADING "Event Creation" FORMAT A17
COLUMN LAST_DEQUEUE HEADING "Last Dequeue Time" FORMAT A20
COLUMN DEQUEUED_MESSAGE_NUMBER HEADING "Dequeued|Message Number" FORMAT 999999

SELECT (DEQUEUE_TIME-DEQUEUED_MESSAGE_CREATE_TIME)*86400 LATENCY,
     TO_CHAR(DEQUEUED_MESSAGE_CREATE_TIME,'HH24:MI:SS MM/DD/YY') CREATION,
     TO_CHAR(DEQUEUE_TIME,'HH24:MI:SS MM/DD/YY') LAST_DEQUEUE,
     DEQUEUED_MESSAGE_NUMBER
  FROM V$STREAMS_APPLY_READER
  WHERE APPLY_NAME = 'APPLY';
```

Your output looks similar to the following:

```
Latency
     in                                              Dequeued
Seconds Event Creation    Last Dequeue Time    Message Number
------- ----------------- -------------------- --------------
     36 10:56:51 03/01/02 10:57:27 03/01/02            253962
```

Displaying Information About the Coordinator Process

A coordinator process gets transactions from the reader server and passes these transactions to apply servers. The coordinator process name is ap*nn*, where *nn* is a coordinator process number.

The query in this section displays the following information about the coordinator process for a particular apply process:

- The number of the coordinator in the process name (ap*nn*)
- The session identifier of the coordinator's session
- The serial number of the coordinator's session
- The current state of the coordinator, either `INITIALIZING`, `APPLYING`, `SHUTTING DOWN` `CLEANLY`, or `ABORTING`
- The total number of transactions received by the coordinator process since the apply process was last started
- The total number of transactions successfully applied by the apply process since the apply process was last started
- The number of transactions applied by the apply process that resulted in an apply error since the apply process was last started

The information displayed by this query is valid only for an enabled apply process.

For example, to display this information for an apply process named `apply`, run the following query:

```
COLUMN PROCESS_NAME HEADING "Coordinator|Process|Name" FORMAT A11
COLUMN SID HEADING 'Session|ID' FORMAT 9999
COLUMN SERIAL# HEADING 'Session|Serial|Number' FORMAT 9999
COLUMN STATE HEADING 'State' FORMAT A21
COLUMN TOTAL_RECEIVED HEADING 'Total|Trans|Received' FORMAT 99999999
COLUMN TOTAL_APPLIED HEADING 'Total|Trans|Applied' FORMAT 99999999
COLUMN TOTAL_ERRORS HEADING 'Total|Apply|Errors' FORMAT 9999
```

```
SELECT SUBSTR(s.PROGRAM,INSTR(S.PROGRAM,'(')+1,4) PROCESS_NAME,
       c.SID,
       c.SERIAL#,
       c.STATE,
       c.TOTAL_RECEIVED,
       c.TOTAL_APPLIED,
       c.TOTAL_ERRORS
       FROM V$STREAMS_APPLY_COORDINATOR c, V$SESSION s
       WHERE c.APPLY_NAME = 'APPLY' AND
             c.SID = s.SID AND
             c.SERIAL# = s.SERIAL#;
```

Your output looks similar to the following:

```
Coordinator         Session                          Total     Total  Total
Process     Session  Serial                          Trans     Trans  Apply
Name             ID  Number State                 Received   Applied Errors
----------- ------- ------- -------------------- --------- --------- ------
AP01             11      40 APPLYING                    78        73      2
```

Determining the Capture to Apply Latency for an Event

This section contains two different queries that show the capture to apply latency for a particular event. That is, these queries show the amount of time between when the event was created at a source database and when the event was applied by the apply process. One query uses the V$STREAMS_APPLY_COORDINATOR dynamic performance view, while the other uses the DBA_APPLY_PROGRESS static data dictionary view. The following are the major differences between these two queries:

- The apply process must be enabled when you run the query on the V$STREAMS_APPLY_COORDINATOR view, while the apply process can be enabled or disabled when you run the query on the DBA_APPLY_PROGRESS view.
- The query on the V$STREAMS_APPLY_COORDINATOR view may show the latency for a more recent transaction than the query on the DBA_APPLY_PROGRESS view.

Both queries display the following information about an event applied by a particular apply process:

- The capture to apply latency for the event
- The event creation time. For captured events, the event creation time is the time when the data manipulation language (DML) or data definition language (DDL) change generated the redo information at the source database for the event. For user-enqueued events, the event creation time is the last time the event was enqueued. A user-enqueued event may be enqueued one or more additional times by propagation before it reaches an apply process.
- The time when the event was applied by the apply process
- The message number of the event

Example V$STREAMS_APPLY_COORDINATOR Query for Latency

To display the capture to apply latency using the V$STREAMS_APPLY_COORDINATOR view for an event applied by an apply process named apply, run the following query:

```
COLUMN "Latency in Seconds" FORMAT 999999
COLUMN "Event Creation" FORMAT A17
COLUMN "Apply Time" FORMAT A17
COLUMN "Applied Message Number" FORMAT 999999

SELECT (HWM_TIME-HWM_MESSAGE_CREATE_TIME)*86400 "Latency in Seconds",
     TO_CHAR(HWM_MESSAGE_CREATE_TIME,'HH24:MI:SS MM/DD/YY')
        "Event Creation",
     TO_CHAR(HWM_TIME,'HH24:MI:SS MM/DD/YY') "Apply Time",
     HWM_MESSAGE_NUMBER "Applied Message Number"
  FROM V$STREAMS_APPLY_COORDINATOR
  WHERE APPLY_NAME = 'APPLY';
```

Your output looks similar to the following:

```
Latency in Seconds Event Creation    Apply Time        Applied Message Number
------------------ ----------------- ----------------- ----------------------
                36 10:56:51 03/01/02 10:57:27 03/01/02                 253962
```

Example DBA_APPLY_PROGRESS Query for Latency

To display the capture to apply latency using the DBA_APPLY_PROGRESS view for an event applied by an apply process named apply, run the following query:

```
COLUMN "Latency in Seconds" FORMAT 999999
COLUMN "Event Creation" FORMAT A17
COLUMN "Apply Time" FORMAT A17
COLUMN "Applied Message Number" FORMAT 999999

SELECT (APPLY_TIME-APPLIED_MESSAGE_CREATE_TIME)*86400 "Latency in Seconds",
     TO_CHAR(APPLIED_MESSAGE_CREATE_TIME,'HH24:MI:SS MM/DD/YY')
        "Event Creation",
     TO_CHAR(APPLY_TIME,'HH24:MI:SS MM/DD/YY') "Apply Time",
     APPLIED_MESSAGE_NUMBER "Applied Message Number"
  FROM DBA_APPLY_PROGRESS
  WHERE APPLY_NAME = 'APPLY';
```

Your output looks similar to the following:

```
Latency in Seconds Event Creation    Apply Time        Applied Message Number
------------------ ----------------- ----------------- ----------------------
                38 10:50:09 03/01/02 10:50:47 03/01/02                 253678
```

Displaying Information About the Apply Servers for an Apply Process

An apply process can use one or more apply servers that apply LCRs to database objects as DML statements or DDL statements or pass the LCRs to their appropriate handlers. For non-LCR messages, the apply servers pass the events to the message handler. Each apply server is a parallel execution server.

The query in this section displays the following information about the apply servers for a particular apply process:

- The type of events applied by each apply server, either captured LCRs or user-enqueued messages
- The process names of the parallel execution servers, in order
- The current state of each apply server, either IDLE, POLL SHUTDOWN, RECORD LOW-WATERMARK, ADD PARTITION, DROP PARTITION, EXECUTE TRANSACTION, WAIT COMMIT, WAIT DEPENDENCY, GET TRANSACTIONS, or WAIT FOR NEXT CHUNK

- The total number of transactions assigned to each apply server since the last time the apply process was started. A transaction may contain more than one event.
- The total number of events applied by each apply server since the last time the apply process was started

The information displayed by this query is valid only for an enabled apply process.

For example, to display this information for an apply process named `apply`, run the following query:

```
COLUMN APPLY_CAPTURED HEADING 'Apply Type' FORMAT A22
COLUMN PROCESS_NAME HEADING 'Process Name' FORMAT A12
COLUMN STATE HEADING 'State' FORMAT A17
COLUMN TOTAL_ASSIGNED HEADING 'Total|Transactions|Assigned' FORMAT 99999999
COLUMN TOTAL_MESSAGES_APPLIED HEADING 'Total|Events|Applied' FORMAT 99999999

SELECT DECODE(ap.APPLY_CAPTURED,
              'YES','Captured LCRS',
              'NO','User-enqueued messages','UNKNOWN') APPLY_CAPTURED,
       SUBSTR(s.PROGRAM,INSTR(S.PROGRAM,'(')+1,4) PROCESS_NAME,
       r.STATE,
       r.TOTAL_ASSIGNED,
       r.TOTAL_MESSAGES_APPLIED
  FROM V$STREAMS_APPLY_SERVER R, V$SESSION S, DBA_APPLY AP
  WHERE r.APPLY_NAME = 'APPLY' AND
        r.SID = s.SID AND
        r.SERIAL# = s.SERIAL# AND
        r.APPLY_NAME = ap.APPLY_NAME
  ORDER BY r.SERVER_ID;
```

Your output looks similar to the following:

```
                                                          Total     Total
                                                    Transactions    Events
Apply Type             Process Name State               Assigned   Applied
---------------------- ------------ ----------------- ------------ ---------
Captured LCRs          P001         IDLE                        94      2141
Captured LCRs          P002         IDLE                        12       276
Captured LCRs          P003         IDLE                         0         0
```

Displaying Effective Apply Parallelism for an Apply Process

In some environments, an apply process may not use all of the apply servers available to it. For example, apply process parallelism may be set to five, but only three apply servers are ever used by the apply process. In this case, the effective apply parallelism is three.

The following query displays the effective apply parallelism for an apply process named `apply`:

```
SELECT COUNT(SERVER_ID) "Effective Parallelism"
  FROM V$STREAMS_APPLY_SERVER
  WHERE APPLY_NAME = 'APPLY' AND
        TOTAL_MESSAGES_APPLIED > 0;
```

Your output looks similar to the following:

```
Effective Parallelism
---------------------
2
```

This query returned two for the effective parallelism. If parallelism is set to three for the apply process named `apply`, then one apply server has not been used since the last time the apply process was started.

You can display the total number of events applied by each apply server by running the following query:

```
COLUMN SERVER_ID HEADING 'Apply Server ID' FORMAT 99
COLUMN TOTAL_MESSAGES_APPLIED HEADING 'Total Events Applied' FORMAT 999999

SELECT SERVER_ID, TOTAL_MESSAGES_APPLIED
  FROM V$STREAMS_APPLY_SERVER
  WHERE APPLY_NAME = 'APPLY'
  ORDER BY SERVER_ID;
```

Your output looks similar to the following:

```
Apply Server ID Total Events Applied
--------------- --------------------
              1                 2141
              2                  276
              3                    0
```

In this case, apply server 3 has not been used by the apply process since it was last restarted. If the `parallelism` setting for an apply process is higher than the

effective parallelism for the apply process, then consider lowering the `parallelism` setting.

Checking for Apply Errors

To check for apply errors, run the following query:

```
COLUMN APPLY_NAME HEADING 'Apply|Process|Name' FORMAT A8
COLUMN SOURCE_DATABASE HEADING 'Source|Database' FORMAT A8
COLUMN LOCAL_TRANSACTION_ID HEADING 'Local|Transaction|ID' FORMAT A11
COLUMN ERROR_MESSAGE HEADING 'Error Message' FORMAT A50

SELECT APPLY_NAME, SOURCE_DATABASE, LOCAL_TRANSACTION_ID, ERROR_MESSAGE
  FROM DBA_APPLY_ERROR;
```

If there are any apply errors, then your output looks similar to the following:

```
Apply            Local
Process  Source   Transaction
Name     Database ID          Error Message
-------- -------- ----------- --------------------------------------------------
APPLY    DBS1.NET 5.4.312     ORA-00001: unique constraint (HR.JOB_ID_PK)
                              violated
```

If there are apply errors, then you can either try to reexecute the transactions that encountered the errors, or you can delete the transactions from the error queue. If you want to reexecute a transaction that encountered an error, then first correct the condition that caused the transaction to raise an error.

If you want to delete a transaction that encountered an error, then you may need to resynchronize data manually if you are sharing data between multiple databases. Remember to set an appropriate session tag, if necessary, when you resynchronize data manually.

See Also:

- "The Error Queue" on page 4-33
- "Managing Apply Errors" on page 13-32
- "Considerations for Applying DML Changes to Tables" on page 4-9 for information about the possible causes of apply errors
- "Managing Streams Tags for the Current Session" on page 15-22

Displaying Detailed Information About Apply Errors

This section contains SQL scripts that you can use to display detailed information about the error transactions in an error queue. These scripts are designed to display information about LCR events, but you can extend them to display information about any non-LCR events used in your environment as well.

> **Note:** The user who creates and runs the `print_errors` and `print_transaction` procedures described in the following sections must be granted explicit `SELECT` privilege on the `DBA_APPLY_ERROR` data dictionary view. This privilege cannot be granted through a role.

Creating a Procedure That Prints the Value in a Specified SYS.AnyData Object

The following procedure prints the value in a specified `SYS.AnyData` object for some selected value types.

```
CREATE OR REPLACE PROCEDURE print_any(data IN SYS.AnyData) IS
  tn  VARCHAR2(61);
  str VARCHAR2(4000);
  chr CHAR(255);
  num NUMBER;
  dat DATE;
  rw  RAW(4000);
  res NUMBER;
BEGIN
  IF data IS NULL THEN
    DBMS_OUTPUT.PUT_LINE('NULL value');
    RETURN;
  END IF;
  tn := data.GETTYPENAME();
  IF tn = 'SYS.VARCHAR2' THEN
    res := data.GETVARCHAR2(str);
    DBMS_OUTPUT.PUT_LINE(str);
  ELSIF tn = 'SYS.CHAR' then
    res := data.GETCHAR(chr);
    DBMS_OUTPUT.PUT_LINE(chr);
  ELSIF tn = 'SYS.VARCHAR' THEN
    res := data.GETVARCHAR(chr);
    DBMS_OUTPUT.PUT_LINE(chr);
  ELSIF tn = 'SYS.NUMBER' THEN
    res := data.GETNUMBER(num);
    DBMS_OUTPUT.PUT_LINE(num);
```

```
  ELSIF tn = 'SYS.DATE' THEN
    res := data.GETDATE(dat);
    DBMS_OUTPUT.PUT_LINE(dat);
  ELSIF tn = 'SYS.RAW' THEN
    res := data.GETRAW(rw);
    DBMS_OUTPUT.PUT_LINE(RAWTOHEX(rw));
  ELSE
    DBMS_OUTPUT.PUT_LINE('typename is ' || tn);
  END IF;
END print_any;
/
```

Creating a Procedure That Prints a Specified LCR

The following procedure prints a specified LCR. It calls the `print_any` procedure created in "Creating a Procedure That Prints the Value in a Specified SYS.AnyData Object" on page 16-36.

```
CREATE OR REPLACE PROCEDURE print_lcr(lcr IN SYS.ANYDATA) IS
  typenm   VARCHAR2(61);
  ddllcr   SYS.LCR$_DDL_RECORD;
  proclcr  SYS.LCR$_PROCEDURE_RECORD;
  rowlcr   SYS.LCR$_ROW_RECORD;
  res      NUMBER;
  newlist  SYS.LCR$_ROW_LIST;
  oldlist  SYS.LCR$_ROW_LIST;
  ddl_text CLOB;
BEGIN
  typenm := lcr.GETTYPENAME();
  DBMS_OUTPUT.PUT_LINE('type name: ' || typenm);
  IF (typenm = 'SYS.LCR$_DDL_RECORD') THEN
    res := lcr.GETOBJECT(ddllcr);
    DBMS_OUTPUT.PUT_LINE('source database: ' ||
                         ddllcr.GET_SOURCE_DATABASE_NAME);
    DBMS_OUTPUT.PUT_LINE('owner: ' || ddllcr.GET_OBJECT_OWNER);
    DBMS_OUTPUT.PUT_LINE('object: ' || ddllcr.GET_OBJECT_NAME);
    DBMS_OUTPUT.PUT_LINE('is tag null: ' || ddllcr.IS_NULL_TAG);
    DBMS_LOB.CREATETEMPORARY(ddl_text, TRUE);
    ddllcr.GET_DDL_TEXT(ddl_text);
    DBMS_OUTPUT.PUT_LINE('ddl: ' || ddl_text);
    DBMS_LOB.FREETEMPORARY(ddl_text);
```

```
  ELSIF (typenm = 'SYS.LCR$_ROW_RECORD') THEN
    res := lcr.GETOBJECT(rowlcr);
    DBMS_OUTPUT.PUT_LINE('source database: ' ||
                         rowlcr.GET_SOURCE_DATABASE_NAME);
    DBMS_OUTPUT.PUT_LINE('owner: ' || rowlcr.GET_OBJECT_OWNER);
    DBMS_OUTPUT.PUT_LINE('object: ' || rowlcr.GET_OBJECT_NAME);
    DBMS_OUTPUT.PUT_LINE('is tag null: ' || rowlcr.IS_NULL_TAG);
    DBMS_OUTPUT.PUT_LINE('command_type: ' || rowlcr.GET_COMMAND_TYPE);
    oldlist := rowlcr.GET_VALUES('OLD');
    FOR i IN 1..oldlist.COUNT LOOP
      if oldlist(i) is not null then
        DBMS_OUTPUT.PUT_LINE('old(' || i || '): ' || oldlist(i).column_name);
        print_any(oldlist(i).data);
      END IF;
    END LOOP;
    newlist := rowlcr.GET_VALUES('NEW');
    FOR i in 1..newlist.count LOOP
      IF newlist(i) IS NOT NULL THEN
        DBMS_OUTPUT.PUT_LINE('new(' || i || '): ' || newlist(i).column_name);
        print_any(newlist(i).data);
      END IF;
    END LOOP;
    ELSE
      DBMS_OUTPUT.PUT_LINE('Non-LCR Message with type ' || typenm);
  END IF;
END print_lcr;
/
```

Creating a Procedure That Prints All the LCRs in the Error Queue

The following procedure prints all of the LCRs in the error queue. It calls the `print_lcr` procedure created in "Creating a Procedure That Prints a Specified LCR" on page 16-37.

```
CREATE OR REPLACE PROCEDURE print_errors IS
  CURSOR c IS
    SELECT LOCAL_TRANSACTION_ID,
           SOURCE_DATABASE,
           MESSAGE_COUNT,
           ERROR_NUMBER,
           ERROR_MESSAGE
      FROM DBA_APPLY_ERROR
      ORDER BY SOURCE_DATABASE, SOURCE_COMMIT_SCN;
  i      NUMBER;
  txnid  VARCHAR2(30);
  source VARCHAR2(128);
  msgcnt NUMBER;
  errnum NUMBER := 0;
  errno  NUMBER;
  errmsg VARCHAR2(128);
  lcr    SYS.AnyData;
  r      NUMBER;
BEGIN
  FOR r IN c LOOP
    errnum := errnum + 1;
    msgcnt := r.MESSAGE_COUNT;
    txnid  := r.LOCAL_TRANSACTION_ID;
    source := r.SOURCE_DATABASE;
    errmsg := r.ERROR_MESSAGE;
    errno  := r.ERROR_NUMBER;
    DBMS_OUTPUT.PUT_LINE('************************************************');
    DBMS_OUTPUT.PUT_LINE('----- ERROR #' || errnum);
    DBMS_OUTPUT.PUT_LINE('----- Local Transaction ID: ' || txnid);
    DBMS_OUTPUT.PUT_LINE('----- Source Database: ' || source);
    DBMS_OUTPUT.PUT_LINE('----Error Number: '||errno);
    DBMS_OUTPUT.PUT_LINE('----Message Text: '||errmsg);
    FOR i IN 1..msgcnt LOOP
      DBMS_OUTPUT.PUT_LINE('--message: ' || i);
        lcr := DBMS_APPLY_ADM.GET_ERROR_MESSAGE(i, txnid);
        print_lcr(lcr);
    END LOOP;
  END LOOP;
END print_errors;
/
```

To run this procedure after you create it, enter the following:

```
SET SERVEROUTPUT ON SIZE 1000000

EXEC print_errors
```

Creating a Procedure that Prints All the Error LCRs for a Transaction

The following procedure prints all the LCRs in the error queue for a particular transaction. It calls the `print_lcr` procedure created in "Creating a Procedure That Prints a Specified LCR" on page 16-37.

```
CREATE OR REPLACE PROCEDURE print_transaction(ltxnid IN VARCHAR2) IS
  i      NUMBER;
  txnid  VARCHAR2(30);
  source VARCHAR2(128);
  msgcnt NUMBER;
  errno  NUMBER;
  errmsg VARCHAR2(128);
  lcr    SYS.ANYDATA;
BEGIN
  SELECT LOCAL_TRANSACTION_ID,
         SOURCE_DATABASE,
         MESSAGE_COUNT,
         ERROR_NUMBER,
         ERROR_MESSAGE
      INTO txnid, source, msgcnt, errno, errmsg
      FROM DBA_APPLY_ERROR
      WHERE LOCAL_TRANSACTION_ID =  ltxnid;
  DBMS_OUTPUT.PUT_LINE('----- Local Transaction ID: ' || txnid);
  DBMS_OUTPUT.PUT_LINE('----- Source Database: ' || source);
  DBMS_OUTPUT.PUT_LINE('----Error Number: '||errno);
  DBMS_OUTPUT.PUT_LINE('----Message Text: '||errmsg);
  FOR i IN 1..msgcnt LOOP
  DBMS_OUTPUT.PUT_LINE('--message: ' || i);
    lcr := DBMS_APPLY_ADM.GET_ERROR_MESSAGE(i, txnid); -- gets the LCR
    print_lcr(lcr);
  END LOOP;
END print_transaction;
/
```

To run this procedure after you create it, pass it the local transaction identifier of a transaction in the error queue. For example, if the local transaction identifier is `1.17.2485`, then enter the following:

```
SET SERVEROUTPUT ON SIZE 1000000

EXEC print_transaction('1.6.2753')
```

Monitoring Rules and Rule-Based Transformations

The following sections contain queries that you can run to display information about rules and rule-based transformations:

- Displaying the Streams Rules Used by a Streams Process or Job
- Displaying the Condition for a Streams Rule
- Displaying the Evaluation Context for Each Rule Set
- Displaying Information About the Tables Used by an Evaluation Context
- Displaying Information About the Variables Used in an Evaluation Context
- Displaying All of the Rules in a Rule Set
- Displaying the Condition for Each Rule in a Rule Set
- Displaying the Rule-Based Transformations in a Rule Set

See Also:

- Chapter 5, "Rules"
- Chapter 6, "How Rules Are Used In Streams"
- Chapter 14, "Managing Rules and Rule-Based Transformations"

Displaying the Streams Rules Used by a Streams Process or Job

Streams rules are rules created using the DBMS_STREAMS_ADM package for a capture process, propagation job, or apply process. These rules determine behavior of the process or job. For example, if a capture rule evaluates to TRUE for DML changes to the hr.employees table, then the capture process captures DML changes to this table.

You query the following data dictionary views to display Streams rules:

- ALL_STREAMS_GLOBAL_RULES
- DBA_STREAMS_GLOBAL_RULES
- ALL_STREAMS_SCHEMA_RULES
- DBA_STREAMS_SCHEMA_RULES
- ALL_STREAMS_TABLE_RULES
- DBA_STREAMS_TABLE_RULES

> **Note:** These views display only rules created using the DBMS_STREAMS_ADM package or the Streams tool in Oracle Enterprise Manager. These views do not display any manual modifications to these rules made by the DBMS_RULE_ADM package, nor do they display rules created using the DBMS_RULE_ADM package.

For example, the following query displays all of the schema rules for an apply process named strm01_apply:

```
COLUMN SCHEMA_NAME HEADING 'Schema|Name' FORMAT A10
COLUMN SOURCE_DATABASE HEADING 'Source' FORMAT A10
COLUMN RULE_TYPE HEADING 'Rule Type' FORMAT A10
COLUMN RULE_NAME HEADING 'Rule Name' FORMAT A10
COLUMN RULE_OWNER HEADING 'Rule Owner' FORMAT A10
COLUMN INCLUDE_TAGGED_LCR HEADING 'Apply|Tagged|LCRs?' FORMAT A15

SELECT SCHEMA_NAME, SOURCE_DATABASE, RULE_TYPE,
       RULE_NAME, RULE_OWNER, INCLUDE_TAGGED_LCR
  FROM DBA_STREAMS_SCHEMA_RULES
  WHERE STREAMS_NAME = 'STRM01_APPLY' AND STREAMS_TYPE = 'APPLY';
```

Your output looks similar to the following:

```
                                                                  Apply
Schema                                                            Tagged
Name       Source     Rule Type  Rule Name  Rule Owner LCRs?
---------- ---------- ---------- ---------- ---------- ---------------
HR         DBS1.NET   DML        HR1        STRMADMIN  NO
```

These results show that the apply process applies LCRs containing DML changes to the `hr` schema that originated at the `dbs1.net` database. The rule in the apply process rule set that instructs the apply process to apply these changes is owned by the `strmadmin` user and is named `hr1`. Also, the apply process applies these changes only if the tag in the LCR is `NULL`.

See Also: "System-Created Rules" on page 6-4

Displaying the Condition for a Streams Rule

If you know the name and level of a Streams rule, then you can display its rule condition. The level is either global, schema, or table.

For example, consider the rule returned by the query in "Displaying the Streams Rules Used by a Streams Process or Job" on page 16-42. The name of the Streams schema rule is `hr1`, and you can display its condition by running the following query:

```
SELECT RULE_CONDITION "Schema Rule Condition"
  FROM DBA_STREAMS_SCHEMA_RULES
  WHERE RULE_NAME = 'HR1' AND
        RULE_OWNER = 'STRMADMIN';
```

Your output looks similar to the following:

```
Schema Rule Condition
--------------------------------------------------------------------
(:dml.get_object_owner() = 'HR' and :dml.is_null_tag() = 'Y' and
:dml.get_source_database_name() = 'DBS1.NET' )
```

See Also:

- "Rule Condition" on page 5-2
- "System-Created Rules" on page 6-4

Displaying the Evaluation Context for Each Rule Set

The following query displays the default evaluation context for each rule set in a database:

```
COLUMN RULE_SET_OWNER HEADING 'Rule Set|Owner' FORMAT A15
COLUMN RULE_SET_NAME HEADING 'Rule Set Name' FORMAT A20
COLUMN RULE_SET_EVAL_CONTEXT_OWNER HEADING 'Eval Context|Owner' FORMAT A11
COLUMN RULE_SET_EVAL_CONTEXT_NAME HEADING 'Eval Context Name' FORMAT A27

SELECT RULE_SET_OWNER,
       RULE_SET_NAME,
       RULE_SET_EVAL_CONTEXT_OWNER,
       RULE_SET_EVAL_CONTEXT_NAME
  FROM DBA_RULE_SETS;
```

Your output looks similar to the following:

```
Rule Set                         Eval Contex
Owner           Rule Set Name    Owner       Eval Context Name
--------------- ---------------- ----------- --------------------------
STRMADMIN       RULESET$_2       SYS         STREAMS$_EVALUATION_CONTEXT
STRMADMIN       STRM02_QUEUE_R   STRMADMIN   AQ$_STRM02_QUEUE_TABLE_V
STRMADMIN       APPLY_OE_RS      STRMADMIN   OE_EVAL_CONTEXT
STRMADMIN       OE_QUEUE_R       STRMADMIN   AQ$_OE_QUEUE_TABLE_V
STRMADMIN       AQ$_1_RE         STRMADMIN   AQ$_OE_QUEUE_TABLE_V
SUPPORT         RS               SUPPORT     EVALCTX
```

See Also: "Rule Evaluation Context" on page 5-3

Displaying Information About the Tables Used by an Evaluation Context

The following query displays information about the tables used by an evaluation context named `evalctx`, which is owned by the `support` user:

```
COLUMN TABLE_ALIAS HEADING 'Table Alias' FORMAT A20
COLUMN TABLE_NAME HEADING 'Table Name' FORMAT A20

SELECT TABLE_ALIAS,
       TABLE_NAME
  FROM DBA_EVALUATION_CONTEXT_TABLES
  WHERE EVALUATION_CONTEXT_OWNER = 'SUPPORT' AND
        EVALUATION_CONTEXT_NAME = 'EVALCTX';
```

Your output looks similar to the following:

```
Table Alias          Table Name
-------------------- --------------------
PROB                 problems
```

See Also: "Rule Evaluation Context" on page 5-3

Displaying Information About the Variables Used in an Evaluation Context

The following query displays information about the variables used by an evaluation context named `evalctx`, which is owned by the `support` user:

```
COLUMN VARIABLE_NAME HEADING 'Variable Name' FORMAT A15
COLUMN VARIABLE_TYPE HEADING 'Variable Type' FORMAT A15
COLUMN VARIABLE_VALUE_FUNCTION HEADING 'Variable Value|Function' FORMAT A20
COLUMN VARIABLE_METHOD_FUNCTION HEADING 'Variable Method|Function' FORMAT A20

SELECT VARIABLE_NAME,
       VARIABLE_TYPE,
       VARIABLE_VALUE_FUNCTION,
       VARIABLE_METHOD_FUNCTION
  FROM DBA_EVALUATION_CONTEXT_VARS
  WHERE EVALUATION_CONTEXT_OWNER = 'SUPPORT' AND
        EVALUATION_CONTEXT_NAME = 'EVALCTX';
```

Your output looks similar to the following:

```
                               Variable Value       Variable Method
Variable Name   Variable Type  Function             Function
--------------- --------------- -------------------- --------------------
CURRENT_TIME    DATE           timefunc
```

See Also: "Rule Evaluation Context" on page 5-3

Displaying All of the Rules in a Rule Set

The query in this section displays the following information about all of the rules in a rule set:

- The owner of the rule
- The name of the rule
- The evaluation context for the rule, if any. If a rule does not have an evaluation context, and no evaluation context is specified in the ADD_RULE procedure when the rule is added to a rule set, then it inherits the evaluation context of the rule set
- The evaluation context owner, if the rule has an evaluation context

For example, to display this information for each rule in a rule set named oe_queue_r that is owned by the user strmadmin, run the following query:

```
COLUMN RULE_OWNER HEADING 'Rule Owner' FORMAT A10
COLUMN RULE_NAME HEADING 'Rule Name' FORMAT A20
COLUMN RULE_EVALUATION_CONTEXT_NAME HEADING 'Eval Context Name' FORMAT A27
COLUMN RULE_EVALUATION_CONTEXT_OWNER HEADING 'Eval Context|Owner' FORMAT A11

SELECT R.RULE_OWNER,
       R.RULE_NAME,
       R.RULE_EVALUATION_CONTEXT_NAME,
       R.RULE_EVALUATION_CONTEXT_OWNER
  FROM DBA_RULES R, DBA_RULE_SET_RULES RS
  WHERE RS.RULE_SET_OWNER = 'STRMADMIN' AND
  RS.RULE_SET_NAME = 'OE_QUEUE_R' AND
  RS.RULE_NAME = R.RULE_NAME AND
  RS.RULE_OWNER = R.RULE_OWNER;
```

Your output looks similar to the following:

```
                                                                Eval Contex
Rule Owner Rule Name            Eval Context Name               Owner
---------- -------------------- --------------------------- -----------
STRMADMIN  HR1                  STREAMS$_EVALUATION_CONTEXT SYS
STRMADMIN  APPLY_LCRS           STREAMS$_EVALUATION_CONTEXT SYS
STRMADMIN  OE_QUEUE$3
STRMADMIN  APPLY_ACTION
```

Displaying the Condition for Each Rule in a Rule Set

The following query displays the condition for each rule in a rule set named `oe_queue_r` that is owned by the user `strmadmin`:

```
SET LONGCHUNKSIZE 4000
SET LONG 4000
COLUMN RULE_OWNER HEADING 'Rule Owner' FORMAT A15
COLUMN RULE_NAME HEADING 'Rule Name' FORMAT A15
COLUMN RULE_CONDITION HEADING 'Rule Condition' FORMAT A45

SELECT R.RULE_OWNER,
       R.RULE_NAME,
       R.RULE_CONDITION
  FROM DBA_RULES R, DBA_RULE_SET_RULES RS
  WHERE RS.RULE_SET_OWNER = 'STRMADMIN' AND
  RS.RULE_SET_NAME = 'OE_QUEUE_R' AND
  RS.RULE_NAME = R.RULE_NAME AND
  RS.RULE_OWNER = R.RULE_OWNER;
```

Your output looks similar to the following:

```
Rule Owner      Rule Name       Rule Condition
--------------- --------------- --------------------------------------------
STRMADMIN       APPLY_ACTION     oe.get_oe_action(tab.user_data) = 'APPLY'
STRMADMIN       APPLY_LCRS      :dml.get_object_owner() = 'OE' AND  (:dml.get
                                _object_name() = 'ORDERS' OR :dml.get_object_
                                name() = 'CUSTOMERS')

STRMADMIN       OE_QUEUE$3      oe.get_oe_action(tab.user_data) != 'APPLY'
```

See Also:

- "Rule Condition" on page 5-2
- "System-Created Rules" on page 6-4

Displaying the Rule-Based Transformations in a Rule Set

In Streams, a rule-based transformation is specified in a rule action context that has the name STREAMS$_TRANSFORM_FUNCTION in the name-value pair. The value in the name-value pair is the name of the PL/SQL procedure that performs the transformation.

The following query displays all of the rule-based transformations specified for rules in a rule set named RULESET$_4:

```
COLUMN RULE_NAME HEADING 'Rule Name' FORMAT A20
COLUMN ACTION_CONTEXT_VALUE HEADING 'Transformation Procedure' FORMAT A40

SELECT
    r.RULE_NAME,
    ac.NVN_VALUE.ACCESSVARCHAR2() ACTION_CONTEXT_VALUE
  FROM DBA_RULES r,
       TABLE(R.RULE_ACTION_CONTEXT.ACTX_LIST) ac,
       DBA_RULE_SET_RULES s
  WHERE ac.NVN_NAME      = 'STREAMS$_TRANSFORM_FUNCTION' AND
        s.RULE_SET_NAME  = 'RULESET$_4' AND
        s.RULE_SET_OWNER = 'STRMADMIN' AND
        r.RULE_NAME      = s.RULE_NAME AND
        r.RULE_OWNER     = s.RULE_OWNER;
```

If there rule-based transformations specified for rules in the rule set, then your output looks similar to the following:

```
Rule Name            Transformation Procedure
-------------------- ----------------------------------------
DEPARTMENTS7         hr.executive_to_management
DEPARTMENTS6         hr.executive_to_management
DEPARTMENTS5         hr.executive_to_management
```

See Also:

- "Rule-Based Transformations" on page 6-23
- "Managing Rule-Based Transformations" on page 14-10

Monitoring Streams Tags

The following sections contain queries that you can run to display the Streams tag for the current session and for an apply process:

- Displaying the Tag Value for the Current Session
- Displaying the Tag Value for an Apply Process

See Also:

- Chapter 8, "Streams Tags"
- "Managing Streams Tags" on page 15-22
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the DBMS_STREAMS package

Displaying the Tag Value for the Current Session

You can display the tag value generated in all redo entries for the current session by querying the DUAL view:

```
SELECT DBMS_STREAMS.GET_TAG FROM DUAL;
```

Your output looks similar to the following:

```
GET_TAG
--------------------------------------------------------------------------------
1D
```

You can also determine the tag for a session by calling the DBMS_STREAMS.GET_TAG function.

Displaying the Tag Value for an Apply Process

You can get the default tag for all redo entries generated by an apply process by querying for the APPLY_TAG value in the DBA_APPLY data dictionary view. For example, to get the hexadecimal value of the tags generated in the redo entries by an apply process named apply_oe, run the following query:

```
SELECT APPLY_TAG "Tag Value for APPLY_OE"
  FROM DBA_APPLY WHERE APPLY_NAME = 'STRM01_APPLY';
```

Your output looks similar to the following:

```
Tag Value for APPLY_OE
--------------------------------------------------------------------------------
00
```

A handler or transformation function associated with an apply process can get the tag by calling the DBMS_STREAMS.GET_TAG function.

17

Troubleshooting a Streams Environment

This chapter contains information about identifying and resolving common problems in a Streams environment.

This chapter contains these topics:

Troubleshooting Capture Problems

If a capture process is not capturing changes as expected or if you are having other problems with a capture process, then use the following checklist to identify and resolve capture problems:

- ❏ Is the Capture Process Enabled?
- ❏ Is the Capture Process Current?
- ❏ Is LOG_PARALLELISM Set to 1?
- ❏ Is LOGMNR_MAX_PERSISTENT_SESSIONS Set High Enough?

See Also:

- Chapter 2, "Streams Capture Process"
- Chapter 11, "Managing a Capture Process"
- "Monitoring a Streams Capture Process" on page 16-3

Is the Capture Process Enabled?

A capture process captures changes only when it is enabled. You can check whether a capture process is enabled, disabled, or aborted by querying the DBA_CAPTURE data dictionary view.

For example, to check whether a capture process named CAPTURE is enabled, run the following query:

```
SELECT STATUS FROM DBA_CAPTURE WHERE CAPTURE_NAME = 'CAPTURE';
```

If the capture process is disabled, then your output looks similar to the following:

```
STATUS
--------
DISABLED
```

If the capture process is disabled or aborted, then try restarting it. If you do not know why the capture process was disabled or aborted, then check the trace file for the capture process.

See Also:

- "Starting a Capture Process" on page 11-5
- "Checking the Trace Files and Alert Log for Problems" on page 17-24
- "Streams Capture Process and Oracle Real Application Clusters" on page 2-11 for information about restarting a capture process in an Oracle Real Application Clusters environment

Is the Capture Process Current?

If a capture process has not captured recent changes, then the cause may be that the capture process has fallen behind. To check, you can query the `V$STREAMS_CAPTURE` dynamic performance view. If capture process latency is high, then you may be able to improve performance by adjusting the setting of the `parallelism` capture process parameter.

See Also:

- "Determining Redo Log Scanning Latency for a Capture Process" on page 16-6
- "Determining Event Enqueuing Latency for a Capture Process" on page 16-8
- "Capture Process Parallelism" on page 2-20
- "Setting a Capture Process Parameter" on page 11-8

Is LOG_PARALLELISM Set to 1?

The `LOG_PARALLELISM` initialization parameter specifies the level of concurrency for redo allocation within Oracle. If you plan to run one or more capture processes on a database, then this parameter must be set to `1`. If this initialization parameter is set higher than one, you may encounter error `ORA-01374`.

Setting this parameter to `1` does not affect the parallelism of capture. You can set parallelism for a capture process using the `SET_PARAMETER` procedure in the `DBMS_CAPTURE_ADM` package.

Is LOGMNR_MAX_PERSISTENT_SESSIONS Set High Enough?

The LOGMNR_MAX_PERSISTENT_SESSIONS initialization parameter specifies the maximum number of persistent LogMiner mining sessions that are concurrently active when all sessions are mining redo logs generated by instances. If you plan to run multiple Streams capture processes on a single database, then set this parameter equal to or higher than the number of planned capture processes.

If you cannot drop a capture process, and you are using multiple capture processes, then it may be because the LOGMNR_MAX_PERSISTENT_SESSIONS initialization parameter is not set high enough. Try increasing this initialization parameter and retrying the drop capture process operation.

Alternatively, if you do not want to increase the size of this initialization parameter, try stopping at least one of the running capture processes and then retrying the drop capture process operation. If the drop operation succeeds, then restart any capture process you stopped.

Troubleshooting Propagation Problems

If a propagation job is not propagating changes as expected, then use the following checklist to identify and resolve propagation problems:

- ❏ Does the Propagation Use the Correct Source and Destination Queue?
- ❏ Is the Propagation Job Enabled?
- ❏ Are There Enough Job Queue Processes?
- ❏ Is Security Configured Properly for the Streams Queue?

See Also:

- Chapter 3, "Streams Staging and Propagation"
- Chapter 12, "Managing Staging and Propagation"
- "Monitoring a Streams Propagation Job" on page 16-15

Does the Propagation Use the Correct Source and Destination Queue?

If events are not appearing in the destination queue for a propagation as expected, then the propagation may not be configured to propagate events from the correct source queue to the correct destination queue.

For example, to check the source queue and destination queue for a propagation job named `dbs1_to_dbs2`, run the following query:

```
COLUMN SOURCE_QUEUE HEADING 'Source Queue' FORMAT A35
COLUMN DESTINATION_QUEUE HEADING 'Destination Queue' FORMAT A35

SELECT
  p.SOURCE_QUEUE_OWNER||'.'||
    p.SOURCE_QUEUE_NAME||'@'||
    g.GLOBAL_NAME SOURCE_QUEUE,
  p.DESTINATION_QUEUE_OWNER||'.'||
    p.DESTINATION_QUEUE_NAME||'@'||
    p.DESTINATION_DBLINK DESTINATION_QUEUE
  FROM DBA_PROPAGATION p, GLOBAL_NAME g
  WHERE p.PROPAGATION_NAME = 'DBS1_TO_DBS2';
```

Your output looks similar to the following:

```
Source Queue                          Destination Queue
------------------------------------ ------------------------------------
STRMADMIN.STREAMS_QUEUE@DBS1.NET     STRMADMIN.STREAMS_QUEUE@DBS2.NET
```

If the propagation job is not using the correct queues, then create a new propagation job. You may need to remove the existing propagation job if it is not appropriate for your environment.

Is the Propagation Job Enabled?

For a propagation job to propagate events, the propagation schedule for the propagation job must be enabled. If events are not being propagated by a propagation job as expected, then the propagation schedule may not be enabled.

You can find the following information about the schedule for a propagation job by running the query in this section:

- The database link used to propagate events from the source queue to the destination queue
- Whether the propagation schedule is enabled or disabled
- The job queue process used to propagate the last event
- The number of consecutive failures when execution of the propagation schedule was attempted. The schedule is disabled automatically if this number reaches 16.
- If there are any propagation errors, then the time of the last error
- If there are any propagation errors, then the error message of the last error

For example, to check whether a propagation job named `dbs1_to_dbs2` is enabled, run the following query:

```
COLUMN DESTINATION_DBLINK HEADING 'Destination|DB Link' FORMAT A15
COLUMN SCHEDULE_DISABLED HEADING 'Schedule' FORMAT A8
COLUMN PROCESS_NAME HEADING 'Process' FORMAT A7
COLUMN FAILURES HEADING 'Number of|Failures' FORMAT 9999
COLUMN LAST_ERROR_TIME HEADING 'Last Error Time' FORMAT A15
COLUMN LAST_ERROR_MSG HEADING 'Last Error Message' FORMAT A18

SELECT p.DESTINATION_DBLINK,
       DECODE(s.SCHEDULE_DISABLED,
                'Y', 'Disabled',
                'N', 'Enabled') SCHEDULE_DISABLED,
       s.PROCESS_NAME,
       s.FAILURES,
       s.LAST_ERROR_TIME,
       s.LAST_ERROR_MSG
  FROM DBA_QUEUE_SCHEDULES s, DBA_PROPAGATION p
  WHERE p.PROPAGATION_NAME = 'DBS1_TO_DBS2'
  AND p.DESTINATION_DBLINK = s.DESTINATION
  AND s.SCHEMA = p.SOURCE_QUEUE_OWNER
  AND s.QNAME = p.SOURCE_QUEUE_NAME;
```

If the schedule is enabled currently for the propagation job, then your output looks similar to the following:

```
Destination                    Number of
DB Link         Schedule Process  Failures Last Error Time Last Error Message
--------------- -------- ------- --------- -------------- -----------------
DBS2.NET        Enabled  J001            0
```

Try the following actions to correct a problem:

- If a propagation job is disabled, then you can enable it using the `ENABLE_PROPAGATION_SCHEDULE` procedure in the `DBMS_AQADM` package, if you have not done so already.
- If the propagation job is disabled, and you do not know why, then check the trace file for the process that last propagated an event. In the previous output, the process is `J001`.
- If the propagation job is enabled, but is not propagating events, then try unscheduling and scheduling the propagation job.

See Also:

- "Enabling a Propagation Job" on page 12-11
- "Checking the Trace Files and Alert Log for Problems" on page 17-24
- "Unscheduling a Propagation Job" on page 12-13
- "Scheduling a Propagation Job" on page 12-11
- "Displaying the Schedule for a Propagation Job" on page 16-16

Are There Enough Job Queue Processes?

Propagation jobs use job queue processes to propagate events. Make sure the `JOB_QUEUE_PROCESSES` initialization parameter is set to 2 or higher in each database instance that does propagation. It should be set to a value that is high enough to accommodate all of the jobs that run simultaneously.

See Also:

- "Setting Initialization Parameters Relevant to Streams" on page 10-4
- The description of propagation features in *Oracle9i Application Developer's Guide - Advanced Queuing* for more information about setting the JOB_QUEUE_PROCESSES initialization parameter when you use propagation jobs
- *Oracle9i Database Reference* for more information about the JOB_QUEUE_PROCESSES initialization parameter
- *Oracle9i Database Administrator's Guide* for more information about job queues

Is Security Configured Properly for the Streams Queue?

Streams queues are secure queues, and security must be configured properly for users to be able to perform operations on them. You may encounter one of the following errors if security is not configured properly for a Streams queue:

- ORA-24093 AQ Agent not granted privileges of database user
- ORA-25224 Sender name must be specified for enqueue into secure queues

See Also: "Secure Queues" on page 3-21

ORA-24093 AQ Agent not granted privileges of database user

Secure queue access must be granted to an agent explicitly for both enqueue and dequeue operations. You grant the agent these privileges using the ENABLE_DB_ACCESS procedure in the DBMS_AQADM package.

For example, to grant an agent named explicit_dq privileges of the database user oe, run the following procedure:

```
BEGIN
  DBMS_AQADM.ENABLE_DB_ACCESS(
    agent_name  => 'explicit_dq',
    db_username => 'oe');
END;
/
```

To check the privileges of the agents in a database, run the following query:

```
SELECT AGENT_NAME "Agent", DB_USERNAME "User" FROM DBA_AQ_AGENT_PRIVS;
```

Your output looks similar to the following:

```
Agent                          User
------------------------------ ------------------------------
EXPLICIT_ENQ                   OE
APPLY_OE                       OE
EXPLICIT_DQ                    OE
```

> **See Also:** "Enabling a User to Perform Operations on a Secure Queue" on page 12-3 for a detailed example that grants privileges to an agent

ORA-25224 Sender name must be specified for enqueue into secure queues

To enqueue into a secure queue, the `SENDER_ID` must be set to an agent with secure queue privileges for the queue in the message properties.

> **See Also:** "Create the Procedure to Enqueue Non-LCR Events" on page 18-12 for an example that sets the `SENDER_ID` for enqueue

Troubleshooting Apply Problems

If an apply process is not applying changes as expected, then use the following checklist to identify and resolve apply problems:

- ❏ Is the Apply Process Enabled?
- ❏ Is the Apply Process Current?
- ❏ Does the Apply Process Apply Captured Events or User-Enqueued Events?
- ❏ Is a Custom Apply Handler Specified?
- ❏ Is the Apply Process Waiting for a Dependent Transaction?
- ❏ Are There Any Apply Errors in the Error Queue?

> **See Also:**
>
> - Chapter 4, "Streams Apply Process"
> - Chapter 13, "Managing an Apply Process"
> - "Monitoring a Streams Apply Process" on page 16-19

Is the Apply Process Enabled?

An apply process applies changes only when it is enabled. You can check whether an apply process is enabled, disabled, or aborted by querying the DBA_APPLY data dictionary view.

For example, to check whether an apply process named APPLY is enabled, run the following query:

```
SELECT STATUS FROM DBA_APPLY WHERE APPLY_NAME = 'APPLY';
```

If the apply process is disabled, then your output looks similar to the following:

```
STATUS
--------
DISABLED
```

If the apply process is disabled or aborted, then try restarting it. If you do not know why the apply process was disabled or aborted, then check the trace file for the apply process.

See Also:

- "Starting an Apply Process" on page 13-7
- "Checking the Trace Files and Alert Log for Problems" on page 17-24
- "Streams Apply Process and Oracle Real Application Clusters" on page 4-25 for information about restarting an apply process in an Oracle Real Application Clusters environment

Is the Apply Process Current?

If an apply process has not applied recent changes, then the cause may be that the apply process has fallen behind. You can check apply process latency by querying the V$STREAMS_APPLY_COORDINATOR dynamic performance view. If apply process latency is high, then you may be able to improve performance by adjusting the setting of the `parallelism` apply process parameter.

See Also:

- "Determining the Capture to Apply Latency for an Event" on page 16-30
- "Apply Process Parallelism" on page 4-30
- "Setting an Apply Process Parameter" on page 13-11

Does the Apply Process Apply Captured Events or User-Enqueued Events?

An apply process can apply either captured events or user-enqueued events, but not both types of events. If an apply process is not applying events of a certain type, then it may be because the apply process was configured to apply the other type of events. You can check the type of events applied by an apply process by querying the DBA_APPLY data dictionary view.

For example, to check whether an apply process named APPLY applies captured or user-enqueued events, run the following query:

```
COLUMN APPLY_CAPTURED HEADING 'Type of Events Applied' FORMAT A25

SELECT DECODE(APPLY_CAPTURED,
              'YES', 'Captured',
              'NO',  'User-Enqueued') APPLY_CAPTURED
  FROM DBA_APPLY
  WHERE APPLY_NAME = 'APPLY';
```

If the apply process applies captured events, then your output looks similar to the following:

```
Type of Events Applied
------------------------
Captured
```

If an apply process is not applying the expected type of events, then you may need to create a new apply process to apply the events.

See Also:

- "Captured and User-Enqueued Events" on page 3-3
- "Creating a Capture Process" on page 11-2

Is a Custom Apply Handler Specified?

You can use PL/SQL procedures to handle events dequeued by an apply process in a customized way. These handlers include DML handlers, DDL handlers, and message handlers. If an apply process is not behaving as expected, then check the handler procedures used by the apply process, and correct any flaws. You can find the names of these procedures by querying the DBA_APPLY_DML_HANDLERS and DBA_APPLY data dictionary views. You may need to modify a handler procedure or remove it to correct an apply problem.

See Also:

- "Event Processing Options" on page 4-3 for general information about apply handlers
- Chapter 13, "Managing an Apply Process" for information about managing apply handlers
- "Displaying Information About Apply Handlers" on page 16-22 for queries that display information about apply handlers

Is the Apply Process Waiting for a Dependent Transaction?

If you set the parallelism parameter for an apply process to a value greater than 1 and you set the commit_serialization parameter of the apply process to full, then the apply process may wait an indefinite period of time if there is a transaction that is dependent on another transaction with a higher SCN. When an apply process detects such a dependency, information is recorded in the alert log and apply process trace file for the database.

Such a dependency may occur if the session that created the transaction waited for an ITL (interested transaction list) slot in a block. This happens when the session wants to lock a row in the block but one or more other sessions have rows locked in the same block, and there is no free ITL slot in the block. Usually, Oracle dynamically adds another ITL slot. This may not be possible if there is insufficient free space in the block to add an ITL.

Such a dependency is also possible if the session is waiting due to shared bitmap index fragment. Bitmap indexes index key values and a range of rowids. Each 'entry' in a bitmap index can cover many rows in the actual table. If two sessions want to update rows covered by the same bitmap index fragment, then the second session waits for the first transaction to either COMMIT or ROLLBACK.

To correct the problem in the future, perform one of the following actions:

- Increase the number of ITLs available. You can do so by changing the INITRANS or MAXTRANS settings for the table using the ALTER TABLE statement.
- Set the commit_serialization parameter to none for the apply process.
- Set the parallelism apply process parameter to 1 for the apply process.

See Also:

- "Apply Process Parameters" on page 4-30
- "Checking the Trace Files and Alert Log for Problems" on page 17-24
- *Oracle9i Database Administrator's Guide* and *Oracle9i SQL Reference* for more information about INITRANS and MAXTRANS

Are There Any Apply Errors in the Error Queue?

When an apply process cannot apply an event, it moves the event and all of the other events in the same transaction into the error queue. You should check the error queue periodically to see if there are any transactions that could not be applied. You can check for apply errors by querying the DBA_APPLY_ERROR data dictionary view.

See Also:

- "Checking for Apply Errors" on page 16-35
- "Managing Apply Errors" on page 13-32

You may encounter the following types of apply process errors for LCR events:

- ORA-01403 No Data Found
- ORA-26687 Instantiation SCN Not Set
- ORA-26688 Metadata Mismatch
- ORA-26689 Column Type Mismatch

ORA-01403 No Data Found

Typically, this error occurs when an update is attempted on an existing row and the OLD_VALUES in the row LCR do not match the current values at this target site.

To correct this problem, you can update the current values in the row so that the row LCR can be applied successfully. If changes to the row are captured by a capture process at the destination database, then you probably do not want apply this manual change at destination sites. In this case, complete the following steps:

1. Set an apply tag in the session that corrects the row. Make sure you set the tag to a value that prevents the manual change from being applied at some of all destination databases.

   ```
   EXEC DBMS_STREAMS.SET_TAG(tag => HEXTORAW('17'));
   ```

2. Update the row to correct the old values.

3. Reexecute the error or reexecute all errors in the error queue. To reexecute an error, run the EXECUTE_ERROR procedure in the DBMS_APPLY_ADM package, and specify the transaction identifier for the transaction that caused the error.

   ```
   EXEC DBMS_APPLY_ADM.EXECUTE_ERROR(local_transaction_id => '5.4.312');
   ```

   Or, execute all errors for the apply process by running the EXECUTE_ALL_ERRORS procedure:

   ```
   EXEC DBMS_APPLY_ADM.EXECUTE_ALL_ERRORS(apply_name => 'APPLY');
   ```

4. If you are going to make other changes in the current session that you want to apply at destination databases, then reset the tag for the session to an appropriate value, as in the following example:

   ```
   EXEC DBMS_STREAMS.SET_TAG(tag => NULL);
   ```

ORA-26687 Instantiation SCN Not Set

Typically, this error occurs because the instantiation SCN is not set on an object for which an apply process is attempting to apply changes. You can query the DBA_APPLY_INSTANTIATED_OBJECTS to list the objects that have an instantiation SCN.

You can set an instantiation SCN for one or more objects by exporting the objects at the source database, and then importing them at the destination database. If you do not want to use Export/Import, then you can run one or more of the following procedures in the DBMS_APPLY_ADM package:

- SET_TABLE_INSTANTIATION_SCN
- SET_SCHEMA_INSTANTIATION_SCN
- SET_GLOBAL_INSTANTIATION_SCN

> **See Also:** "Setting Instantiation SCNs at a Destination Database" on page 13-35

ORA-26688 Metadata Mismatch

Typically, this error occurs because of one of the following conditions:

- The object for which an LCR is applying a change does not exist in the destination database. In this case, check to see if the object exists. Also, make sure you use the correct character case in rule conditions and apply handlers. For example, if a column name has all uppercase characters in the data dictionary, then you should specify the column name with all uppercase characters in rule conditions and in apply handlers.
- There is a problem with the primary key in the table for which an LCR is applying a change. In this case, make sure the primary key is enabled by querying the DBA_CONSTRAINTS data dictionary view. If no primary key exists for the table, then specify substitute key columns using the SET_KEY_COLUMNS procedure in the DBMS_APPLY_ADM package. You may also encounter error ORA-23416 if a table being applied does not have a primary key.

> **See Also:**
>
> - "Considerations for Applying DML Changes to Tables" on page 4-9
> - "Managing the Substitute Key Columns for a Table" on page 13-27

- Supplemental logging is not specified for columns that require supplemental logging at the source database. In this case, LCRs from the source database may not contain values for key columns.

  See Also:

  - "Displaying Supplemental Log Groups at a Source Database" on page 16-10
  - "Supplemental Logging" on page 2-9
  - "Specifying Supplemental Logging at a Source Database" on page 11-9

ORA-26689 Column Type Mismatch

Typically, this error occurs because one or more columns at a table in the source database do not match the corresponding columns at the destination database. The LCRs from the source database may contain more columns than the table at the destination database, or there may be a type mismatch for one or more columns. If the columns differ at the databases, you can use rule-based transformations to avoid errors.

This error may also occur because supplemental logging is not specified where it is required for nonkey columns at the source database. In this case, LCRs from the source database may not contain needed values for these nonkey columns.

See Also:

- "Considerations for Applying DML Changes to Tables" on page 4-9
- Rule-Based Transformations on page 6-23
- "Managing Rule-Based Transformations" on page 14-10
- "Supplemental Logging" on page 2-9

Troubleshooting Problems with Rules and Rule-Based Transformations

If a capture process, a propagation job, or an apply process is not behaving as expected, then the problem may be that rules or rule-based transformations for the process or job are not configured properly. Use the following checklist to identify and resolve problems with rules and rule-based transformations:

- ❏ Are Rules Configured Properly for the Streams Process or Job?
- ❏ Are the Rule-Based Transformations Configured Properly?

Note:

- Chapter 5, "Rules"
- Chapter 6, "How Rules Are Used In Streams"
- Chapter 14, "Managing Rules and Rule-Based Transformations"

Are Rules Configured Properly for the Streams Process or Job?

If a Streams process or job is behaving in an unexpected way, then the problem may be that the rules in the rule set for the process or job are not configured properly. For example, if you expect a capture process to capture changes made to a particular table, but the capture process is not capturing these changes, then the cause may be that the rule set for the capture process does not contain a rule that evaluates to `TRUE` when a change is made to the object.

You can check the rules for a particular Streams process or job by querying the following data dictionary views:

- `DBA_STREAMS_TABLE_RULES`
- `DBA_STREAMS_SCHEMA_RULES`
- `DBA_STREAMS_GLOBAL_RULES`

Note: These data dictionary views contain information about rules created using the `DBMS_STREAMS_ADM` package or the Streams tool in Oracle Enterprise Manager. They do not contain information about rules created using the `DBMS_RULE_ADM` package. To view information about rules created with the `DBMS_RULE_ADM` package, query the `DBA_RULES` data dictionary view.

> **See Also:** "Monitoring Rules and Rule-Based Transformations" on page 16-41

A rule set with no rules is not the same as no rule set. For example, if you use a rule set with no rules for a propagation job, then the propagation job will not propagate anything. If you do not use a rule set at all for a propagation job, then the propagation job propagates everything in its source queue.

This section includes the following subsections:

- Example That Checks for Capture Process Rules on a Table
- Example That Checks for Apply Process Rules on a Table
- Checking for Schema and Global Rules
- Resolving Problems with Rules

Example That Checks for Capture Process Rules on a Table

For example, suppose a database is running a capture process named CAPTURE, and you want to check for table rules that evaluate to TRUE for this capture process when there are changes to the hr.departments table. To determine whether there are any such rules in the rule set for the capture process, run the following query:

```
COLUMN RULE_NAME HEADING 'Rule Name' FORMAT A30
COLUMN RULE_TYPE HEADING 'Rule Type' FORMAT A30

SELECT RULE_NAME, RULE_TYPE
  FROM DBA_STREAMS_TABLE_RULES
  WHERE STREAMS_NAME   = 'CAPTURE' AND
        STREAMS_TYPE   = 'CAPTURE' AND
        TABLE_OWNER    = 'HR' AND
        TABLE_NAME = 'DEPARTMENTS';
```

Your output looks similar to the following:

```
Rule Name                      Rule Type
------------------------------ ------------------------------
DEPARTMENTS1                   DML
```

Based on these results, the capture process named CAPTURE should capture DML changes to the hr.departments table. In other words, a rule exists in the capture process rule set that evaluates to TRUE when the capture process finds a DML change to the hr.departments table in the redo log.

A rule of type DDL for the table in the query results means that the capture process should capture DDL changes to the table. If a capture process should capture both DML and DDL changes to the table, then a rule of each type would appear for the table in the query results.

Example That Checks for Apply Process Rules on a Table

If you expect an apply process to apply changes to a particular table, but the apply process is not applying these changes, then the cause may be that the rule set for the apply process does not contain a rule that evaluates to TRUE when an LCR is in the apply process queue. As with capture rules and propagation rules, you can check the rules that were created using the procedures in the DBMS_STREAMS_ADM package by querying the following data dictionary views:

- DBA_STREAMS_TABLE_RULES
- DBA_STREAMS_SCHEMA_RULES
- DBA_STREAMS_GLOBAL_RULES

In addition, an apply process must receive events in its queue before it can apply these events. Therefore, if an apply process is applying captured events, then the rule set for the capture process that captures these events must be configured properly. Similarly, if events are propagated from one or more databases before reaching the apply process, then the rules for each propagation job must be configured properly. If the rules for a capture process or a propagation job on which the apply process depends are not configured properly, then the events may never reach the apply process queue.

In an environment where a capture process captures changes that are propagated and applied at multiple databases, you can use the following guidelines to determine whether a problem is caused by the capture process or propagation jobs on which an apply process depends, or a problem is caused by the apply process itself:

- If no other destination databases of the capture process are applying changes from the capture process, then the problem is most likely caused by the capture process or a propagation job near the capture process. In this case, first make sure the rules for the capture process are configured properly, and then check the rules for the propagation jobs nearest the capture process.
- If other destination databases of the capture process are applying changes from the capture process, then the problem is most likely caused by the apply process itself or a propagation job near the apply process. In this case, first

make sure the rules for the apply process are configured properly, and then check the rules for the propagation jobs nearest the apply process.

Also, when you are checking for apply rules, there is the possibility that subset rules exist for one or more tables. A subset rules evaluates to TRUE only if an LCR contains a change to a particular subset of rows in the table. For example, to check for table rules that evaluate to TRUE for an apply process named APPLY when there are changes to the hr.departments table, run the following query:

```
COLUMN RULE_NAME HEADING 'Rule Name' FORMAT A20
COLUMN RULE_TYPE HEADING 'Rule Type' FORMAT A20
COLUMN DML_CONDITION HEADING 'Subset Condition' FORMAT A30

SELECT RULE_NAME, RULE_TYPE, DML_CONDITION
  FROM DBA_STREAMS_TABLE_RULES
  WHERE STREAMS_NAME   = 'APPLY' AND
        STREAMS_TYPE   = 'APPLY' AND
        TABLE_OWNER    = 'HR' AND
        TABLE_NAME     = 'DEPARTMENTS';


Rule Name            Rule Type            Subset Condition
-------------------- -------------------- ------------------------------
DEPARTMENTS5         DML                  location_id=1700
DEPARTMENTS6         DML                  location_id=1700
DEPARTMENTS7         DML                  location_id=1700
```

Notice that this query returns any subset condition for the table in the DML_CONDITION column. In this example, subset rules are specified for the hr.departments table. These subset rules evaluate to TRUE only if an LCR contains a change that involves a row where the location_id is 1700. So, if you expected the apply process to apply all changes to the table, then the subset rules cause the apply process to discard changes that involve rows where the location_id is not 1700.

See Also:

- "Row Subsetting" on page 4-11 for conceptual information about subset rules
- "Table-Level Rules Example" on page 6-8 for more information about specifying subset rules

Checking for Schema and Global Rules

Schema rules or global rules may also be used to capture changes to all of the database objects in a particular schema or database, respectively. For example, to check for schema rules that evaluate to TRUE for a capture process named CAPTURE when there are changes to the oe schema, run the following query:

```
SELECT RULE_NAME, RULE_TYPE
  FROM DBA_STREAMS_SCHEMA_RULES
  WHERE STREAMS_NAME   = 'CAPTURE' AND
        SCHEMA_NAME    = 'OE';
```

Your output looks similar to the following:

```
Rule Name                      Rule Type
------------------------------ ------------------------------
OE7                            DML
OE8                            DDL
```

Based on these results, the capture process named CAPTURE should capture DML and DDL changes to all objects in the oe schema.

If the DBA_STREAMS_GLOBAL_RULES data dictionary view returns any rows when you query it for a capture process, then the capture process captures all changes in the database, except for unsupported changes and changes made to the SYS and SYSTEM schemas.

> **See Also:** "Datatypes Captured" on page 2-6 and "Types of Changes Captured" on page 2-7 for information about the types of changes that are captured and are not captured by a capture process

Resolving Problems with Rules

If you determine that a Streams process or job is not behaving as expected because one or more rules must be added to the rule set for the process or job, then you can use one of the following procedures in the DBMS_STREAMS_ADM package to add appropriate rules:

- ADD_GLOBAL_PROPAGATION_RULES
- ADD_GLOBAL_RULES
- ADD_SCHEMA_PROPAGATION_RULES
- ADD_SCHEMA_RULES

- ADD_SUBSET_RULES
- ADD_TABLE_PROPAGATION_RULES
- ADD_TABLE_RULES

You can use the DBMS_RULE_ADM package to add customized rules, if necessary.

It is also possible that the Streams process or job is not behaving as expected because one or more rules should be altered or removed from a rule set.

If you have the correct rules, and the changes for the relevant objects are still filtered out by a Streams process or job, then check your trace files and alert log for a warning about a missing "multi-version data dictionary", which is a Streams data dictionary. The following information may be included in such messages:

- gdbnm: Global Name of the source database of the missing object
- scn: SCN for the transaction that has been missed

If you find such messages and you are using custom capture rules or reusing existing capture rules for a new destination database, then make sure you run the appropriate procedure to prepare for instantiation:

- PREPARE_TABLE_INSTANTIATION
- PREPARE_SCHEMA_INSTANTIATION
- PREPARE_GLOBAL_INSTANTIATION

See Also:

- "Altering a Rule" on page 14-5
- "Removing a Rule from a Rule Set" on page 14-6
- "Preparing Database Objects for Instantiation at a Source Database" on page 11-11
- "Data Dictionary Duplication During Capture Process Creation" on page 2-16 for more information about the Streams data dictionary

Are the Rule-Based Transformations Configured Properly?

A rule-based transformation is any modification to an event that results when a rule evaluates to TRUE. A rule-based transformation is specified in the action context of a rule, and these action contexts contain a name-value pair with STREAMS$_TRANSFORM_FUNCTION for the name and a user-created procedure for the value. This user-created procedure performs the transformation. If the user-defined procedure contains any flaws, then unexpected behavior may result.

If a Streams process or job is not behaving as expected, then check the rule-based transformation procedures specified for the process or job, and correct any flaws. You can find the names of these procedures by querying the action context of the rules in the rule set used by the Streams process or job. You may need to modify a transformation procedure or remove a rule-based transformation to correct the problem. Make sure the name portion of the name-value pair in the action context is spelled correctly.

Rule evaluation is done before a rule-based transformation. For example, if you have a transformation that changes the name of a table from `emps` to `employees`, then make sure each rule using the transformation specifies the table name `emps` rather than `employees`, in its rule condition.

See Also:

- "Displaying the Queue, Rule Set, and Status of Each Capture Process" on page 16-3 for a query that displays the rule set used by a capture process
- "Displaying the Rule-Based Transformations in a Rule Set" on page 16-48 for a query that displays the rule-based transformation procedures specified for the rules in a rule set
- "Managing Rule-Based Transformations" on page 14-10 for information about modifying or removing rule-based transformations

Checking the Trace Files and Alert Log for Problems

Messages about each capture process, propagation job, and apply process are recorded in trace files for the database in which the process or job is running. A capture process runs on a source database, a propagation job runs on the database containing the source queue in the propagation, and an apply process runs on a destination database. These trace file messages can help you to identify and resolve problems in a Streams environment.

All trace files for background processes are written to the destination directory specified by the initialization parameter BACKGROUND_DUMP_DEST. The names of trace files are operating system specific, but each file usually includes the name of the process writing the file.

For example, on some operating systems, the default location of the trace file is the `rdbms/log` directory in Oracle home, and the trace file name for a process is *`sid`*`_`*`xxxxx`*`_`*`iiiii`*`.trc`, where:

- *`sid`* is the system identifier for the database
- *`xxxxx`* is the name of the process
- *`iiiii`* is the operating system process number

Also, you can set the `write_alert_log` parameter to `y` for both the capture process and apply process. When this parameter is set to `y`, which is the default setting, the alert log for the database contains messages about why the capture process or apply process stopped.

Use the following checklist to check the trace files related to Streams:

- ❏ Does a Capture Process Trace File Contain Messages About Capture Problems?
- ❏ Do the Trace Files Related to Propagation Jobs Contain Messages About Problems?
- ❏ Does an Apply Process Trace File Contain Messages About Apply Problems?

See Also:

- *Oracle9i Database Administrator's Guide* for more information about trace files and the alert log
- Your operating system specific Oracle documentation for more information about the names and locations of trace files

Does a Capture Process Trace File Contain Messages About Capture Problems?

A capture process is an Oracle background process named cp*nn*, where *nn* is the capture process number. For example, on some operating systems, if the system identifier for a database running a capture process is hqdb and the capture process number is 01, then the trace file for the capture process starts with hqdb_cp01.

> **See Also:** "Displaying General Information About a Capture Process" on page 16-4 for a query that displays the capture process number of a capture process

Do the Trace Files Related to Propagation Jobs Contain Messages About Problems?

Each propagation uses a job that depends on the job queue coordinator process and a job queue process. The job queue coordinator process is named cjq*nn*, where *nn* is the job queue coordinator process number, and a job queue process is named j*nnn*, where *nnn* is the job queue process number.

For example, on some operating systems, if the system identifier for a database running a propagation job is hqdb and the job queue coordinator process is 01, then the trace file for the job queue coordinator process starts with hqdb_cjq01. Similarly, on the same database, if a job queue process is 001, then the trace file for the job queue process starts with hqdb_j001. You can check the process name by querying the PROCESS_NAME column in the DBA_QUEUE_SCHEDULES data dictionary view.

> **See Also:** "Is the Propagation Job Enabled?" on page 17-6 for a query that displays the job queue process used by a propagation job

Does an Apply Process Trace File Contain Messages About Apply Problems?

An apply process is an Oracle background process named ap*nn*, where *nn* is the apply process number. For example, on some operating systems, if the system identifier for a database running an apply process is hqdb and the apply process number is 01, then the trace file for the apply process starts with hqdb_ap01.

An apply process also uses parallel execution servers. Information about an apply process may be recorded in the trace file for one or more parallel execution servers. The process name of a parallel execution server is p*nnn*, where *nnn* is the process number. So, on some operating systems, if the system identifier for a database running an apply process is hqdb and the process number is 001, then the trace file that may contain information about an apply process starts with hqdb_p001.

See Also:

- "Displaying Information About the Coordinator Process" on page 16-29 for a query that displays the apply process number of an apply process
- "Displaying Information About the Reader Server for an Apply Process" on page 16-27 for a query that displays the parallel execution server used by the reader server of an apply process
- "Displaying Information About the Apply Servers for an Apply Process" on page 16-29 for a query that displays the parallel execution servers used by the apply servers of an apply process

Part III

Example Environments and Applications

This part includes the following detailed examples:

- Chapter 18, "Example Streams Messaging Environment"
- Chapter 19, "Example Streams Replication Environments"
- Chapter 20, "Example Rule-Based Application"

18

Example Streams Messaging Environment

This chapter illustrates a messaging environment that can be constructed using Streams.

This chapter contains these topics:

- Overview of Messaging Example
- Prerequisites
- Setting Up Users and Creating a Streams Queue
- Create the Enqueue Procedures
- Configure an Apply Process
- Configure Explicit Dequeue
- Enqueue Events
- Dequeue Events Explicitly and Query for Applied Events
- Enqueue and Dequeue Events Using JMS

See Also:

- Chapter 3, "Streams Staging and Propagation"
- Chapter 12, "Managing Staging and Propagation"
- "Monitoring a Streams Queue" on page 16-11

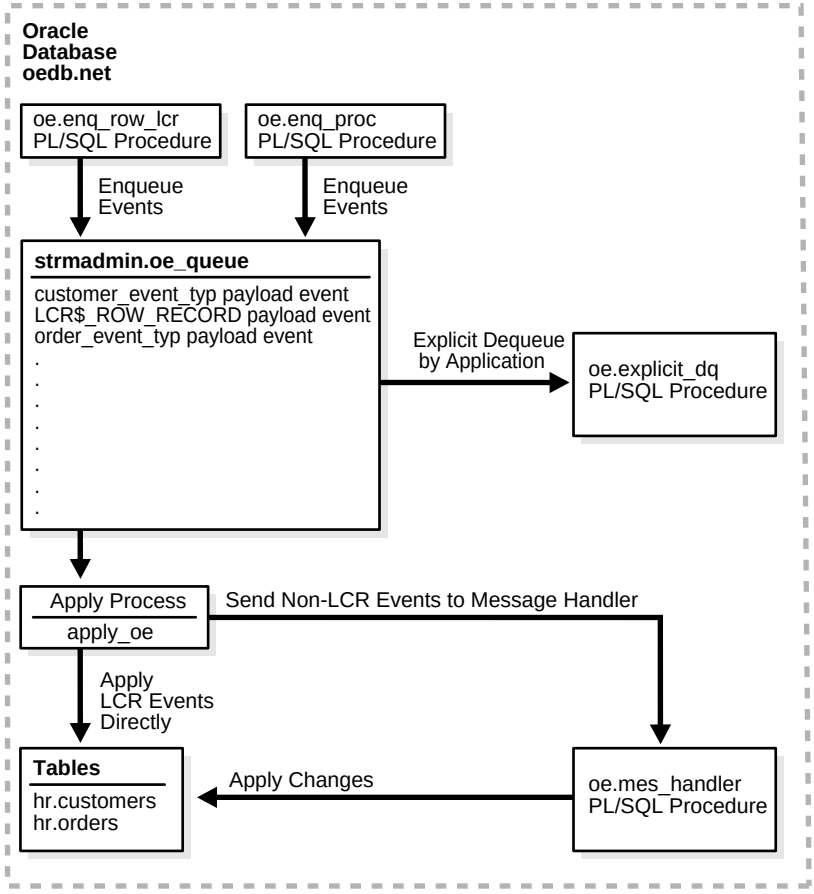
Overview of Messaging Example

This example illustrates using a single `SYS.AnyData` queue at a database called `oedb.net` to create a Streams messaging environment in which events containing message payloads of different types are stored in the same queue. Specifically, this example illustrates the following messaging features of Streams:

- Enqueuing messages containing order payload and customer payload as `SYS.Anydata` events into the queue
- Enqueuing messages containing row LCR payload as `SYS.Anydata` events into the queue
- Creating a rule set for applying the events
- Creating an evaluation context used by the rule set
- Creating a Streams apply process to dequeue and process the events based on rules
- Creating a message handler and associating it with the apply process
- Explicitly dequeuing and processing events based on rules without using the apply process

Figure 18–1 provides an overview of this environment.

Figure 18–1 Example Streams Messaging Environment



Prerequisites

The following are prerequisites that must be completed before you begin the example in this section.

- Set the following initialization parameters to the values indicated for all databases in the environment:
  - AQ_TM_PROCESSES: This parameter establishes queue monitor processes. Values from 1 to 10 specify the number of queue monitor processes created to monitor the messages. If AQ_TM_PROCESSES is not specified or is set to 0, then the queue monitor processes are not created. In this example, AQ_TM_PROCESSES should be set to at least 1.

    Setting the parameter to 1 or more starts the specified number of queue monitor processes. These queue monitor processes are responsible for managing time-based operations of messages such as delay and expiration, cleaning up retained messages after the specified retention time, and cleaning up consumed messages if the retention time is 0.
  - COMPATIBLE: This parameter must be set to 9.2.0 or higher.
- Configure your network and Oracle Net so that you can access the oedb.net database from the client where you run these scripts.

  See Also: *Oracle9i Net Services Administrator's Guide*

- This examples creates a new user to function as the Streams administrator (strmadmin) and prompts you for the tablespace you want to use for this user's data. Before you start this example, either create a new tablespace or identify an existing tablespace for the Streams administrator to use. The Streams administrator should not use the SYSTEM tablespace.

Setting Up Users and Creating a Streams Queue

Complete the following steps to set up users and create a Streams queue for a Streams messaging environment.

1. Show Output and Spool Results
2. Set Up Users
3. Create the Streams Queue
4. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 18-9 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to the database.

```
/************************* BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run `SET ECHO ON` and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_setup_message.out

/*
```

Step 2 Set Up Users

Connect to `oedb.net` as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@oedb.net AS SYSDBA

/*
```

This example uses the oe sample schema. For this example to work properly, the oe user must have privileges to execute the subprograms in the DBMS_AQ package. The oe user will be specified as the queue user when the Streams queue is created in Step 3. The SET_UP_QUEUE procedure will grant the oe user ENQUEUE and DEQUEUE privileges on the queue, but the oe user also needs EXECUTE privilege on the DBMS_AQ package to enqueue events into and dequeue events from the queue.

Also, most of the configuration and administration actions illustrated in this example are performed by the Streams administrator. In this step, create the Streams administrator named strmadmin and grant this user the necessary privileges. These privileges enable the user to execute subprograms in packages related to Streams, create rule sets, create rules, and monitor the Streams environment by querying data dictionary views. You may choose a different name for this user.

Note:

- To ensure security, use a password other than strmadminpw for the Streams administrator.
- The SELECT_CATALOG_ROLE is not required for the Streams administrator. It is granted in this example so that the Streams administrator can monitor the environment easily.
- If you plan to use the Streams tool in Oracle Enterprise Manager, then grant the Streams administrator SELECT ANY DICTIONARY privilege, in addition to the privileges shown in this step.
- The ACCEPT command must appear on a single line in the script.

```
*/

GRANT EXECUTE ON DBMS_AQ TO oe;

GRANT CONNECT, RESOURCE, SELECT_CATALOG_ROLE
  TO strmadmin IDENTIFIED BY strmadminpw;

ACCEPT streams_tbs PROMPT 'Enter the tablespace for the Streams administrator: '

ALTER USER strmadmin DEFAULT TABLESPACE &streams_tbs
                     QUOTA UNLIMITED ON &streams_tbs;
```

```
GRANT EXECUTE ON DBMS_APPLY_ADM   TO strmadmin;
GRANT EXECUTE ON DBMS_AQ          TO strmadmin;
GRANT EXECUTE ON DBMS_AQADM       TO strmadmin;
GRANT EXECUTE ON DBMS_STREAMS_ADM TO strmadmin;

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

/*
```

Step 3 Create the Streams Queue

Connect as the Streams administrator.

```
*/

CONNECT strmadmin/strmadminpw@oedb.net

/*
```

Run the `SET_UP_QUEUE` procedure to create a queue named `oe_queue` at `oedb.net`. This queue will function as the Streams queue by holding events used in the messaging environment.

Running the SET_UP_QUEUE procedure performs the following actions:

- Creates a queue table named oe_queue_table. This queue table is owned by the Streams administrator (strmadmin) and uses the default storage of this user.
- Creates a queue named oe_queue owned by the Streams administrator (strmadmin)
- Starts the queue

```
*/

BEGIN
  DBMS_STREAMS_ADM.SET_UP_QUEUE(
    queue_table => 'oe_queue_table',
    queue_name  => 'oe_queue');
END;
/

/*
```

Step 4 Grant the oe User Privileges on the Queue

```
*/

BEGIN
  SYS.DBMS_AQADM.GRANT_QUEUE_PRIVILEGE(
    privilege  => 'ALL',
    queue_name => 'strmadmin.oe_queue',
    grantee    => 'oe');
END;
/

/*
```

Step 5 Create an Agent for Explicit Enqueue

Create an agent that will be used to perform explicit enqueue operations on the oe_queue queue.

```
*/

BEGIN
  SYS.DBMS_AQADM.CREATE_AQ_AGENT(
    agent_name  => 'explicit_enq');
END;
/

/*
```

Step 6 Associate the oe User with the explicit_enq Agent

For a user to perform queue operations, such as enqueue and dequeue, on a secure queue, the user must be configured as a secure queue user of the queue. The oe_queue queue is a secure queue because it was created using SET_UP_QUEUE. This step enables the oe user to perform enqueue operations on this queue.

```
*/

BEGIN
  DBMS_AQADM.ENABLE_DB_ACCESS(
    agent_name  => 'explicit_enq',
    db_username => 'oe');
END;
/

/*
```

Step 7 Check the Spool Results

Check the streams_setup_message.out spool file to ensure that all actions completed successfully after this script completes.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT ****************************/
```

Create the Enqueue Procedures

Complete the following steps to create one PL/SQL procedure that enqueues non-LCR events into the Streams queue and one PL/SQL procedure that enqueues row LCR events into the Streams queue.

1. Show Output and Spool Results
2. Create a Type to Represent Orders
3. Create a Type to Represent Customers
4. Create the Procedure to Enqueue Non-LCR Events
5. Create a Procedure to Construct and Enqueue Row LCR Events
6. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 18-14 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to the database.

```
/************************* BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run `SET ECHO ON` and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_enqprocs_message.out

/*
```

Step 2 Create a Type to Represent Orders

Connect as oe.

```
*/

CONNECT oe/oe@oedb.net

/*
```

Create a type to represent orders based on the columns in the oe.orders table. The type attributes include the columns in the oe.orders table, along with one extra attribute named action. The value of the action attribute for instances of this type will be used to determine correct action to perform on the instance (either apply process dequeue or explicit dequeue). This type will be used for events that will be enqueued into the Streams queue.

```
*/

CREATE OR REPLACE TYPE order_event_typ AS OBJECT (
  order_id       NUMBER(12),
  order_date     TIMESTAMP(6) WITH LOCAL TIME ZONE,
  order_mode     VARCHAR2(8),
  customer_id    NUMBER(6),
  order_status   NUMBER(2),
  order_total    NUMBER(8,2),
  sales_rep_id   NUMBER(6),
  promotion_id   NUMBER(6),
  action         VARCHAR(7));
/

/*
```

Step 3 Create a Type to Represent Customers

Create a type to represent customers based on the columns in the `oe.customers` table. The type attributes include the columns in the `oe.customers` table, along with one extra attribute named `action`. The value of the `action` attribute for instances of this type will be used to determine correct action to perform on the instance (either apply process dequeue or explicit dequeue). This type will be used for events that will be enqueued into the Streams queue.

```
*/

CREATE OR REPLACE TYPE customer_event_typ AS OBJECT (
  customer_id         NUMBER(6),
  cust_first_name     VARCHAR2(20),
  cust_last_name      VARCHAR2(20),
  cust_address        CUST_ADDRESS_TYP,
  phone_numbers       PHONE_LIST_TYP,
  nls_language        VARCHAR2(3),
  nls_territory       VARCHAR2(30),
  credit_limit        NUMBER(9,2),
  cust_email          VARCHAR2(30),
  account_mgr_id      NUMBER(6),
  cust_geo_location   MDSYS.SDO_GEOMETRY,
  action              VARCHAR(7));
/

/*
```

Step 4 Create the Procedure to Enqueue Non-LCR Events

Create a PL/SQL procedure called `enq_proc` to enqueue events into the Streams queue.

Note: A single enqueued message can be dequeued by an apply process and by an explicit dequeue, but this example does not illustrate this capability.

```
*/

CREATE OR REPLACE PROCEDURE oe.enq_proc (event IN SYS.Anydata) IS
    enqopt       DBMS_AQ.ENQUEUE_OPTIONS_T;
    mprop        DBMS_AQ.MESSAGE_PROPERTIES_T;
    enq_eventid  RAW(16);
  BEGIN
    mprop.SENDER_ID := SYS.AQ$_AGENT('explicit_enq', NULL, NULL);
    DBMS_AQ.ENQUEUE(
      queue_name          =>  'strmadmin.oe_queue',
      enqueue_options     =>  enqopt,
      message_properties  =>  mprop,
      payload             =>  event,
      msgid               =>  enq_eventid);
END;
/

/*
```

Step 5 Create a Procedure to Construct and Enqueue Row LCR Events

Create a procedure called `enq_row_lcr` that constructs a row LCR and then enqueues the row LCR into the queue.

> **See Also:** *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about LCR constructors

```
*/

CREATE OR REPLACE PROCEDURE oe.enq_row_lcr(
                  source_dbname  VARCHAR2,
                  cmd_type       VARCHAR2,
                  obj_owner      VARCHAR2,
                  obj_name       VARCHAR2,
                  old_vals       SYS.LCR$_ROW_LIST,
                  new_vals       SYS.LCR$_ROW_LIST) AS
  eopt           DBMS_AQ.ENQUEUE_OPTIONS_T;
  mprop          DBMS_AQ.MESSAGE_PROPERTIES_T;
  enq_msgid      RAW(16);
  row_lcr        SYS.LCR$_ROW_RECORD;
BEGIN
  mprop.SENDER_ID := SYS.AQ$_AGENT('explicit_enq', NULL, NULL);
  -- Construct the LCR based on information passed to procedure
  row_lcr := SYS.LCR$_ROW_RECORD.CONSTRUCT(
    source_database_name  =>  source_dbname,
    command_type          =>  cmd_type,
    object_owner          =>  obj_owner,
    object_name           =>  obj_name,
    old_values            =>  old_vals,
    new_values            =>  new_vals);
  -- Enqueue the created row LCR
  DBMS_AQ.ENQUEUE(
    queue_name         =>  'strmadmin.oe_queue',
    enqueue_options    =>  eopt,
    message_properties =>  mprop,
    payload            =>  SYS.AnyData.ConvertObject(row_lcr),
    msgid              =>  enq_msgid);
END enq_row_lcr;
/

/*
```

Step 6 Check the Spool Results

Check the `streams_enqprocs_message.out` spool file to ensure that all actions completed successfully after this script completes.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT ******************************/
```

Configure an Apply Process

Complete the following steps to configure an apply process to apply the user-enqueued events in the Streams queue.

1. Show Output and Spool Results
2. Create a Function to Determine the Value of the action Attribute
3. Create a Message Handler
4. Grant strmadmin EXECUTE Privilege on the Procedures
5. Create the Evaluation Context for the Rule Set
6. Create a Rule Set for the Apply Process
7. Create a Rule that Evaluates to TRUE if the Event Action Is apply
8. Create a Rule that Evaluates to TRUE for the Row LCR Events
9. Add the Rules to the Rule Set
10. Create an Apply Process
11. Grant EXECUTE Privilege on the Rule Set To oe User
12. Start the Apply Process
13. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 18-23 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to the database.

```
/************************ BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run SET ECHO ON and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_apply_message.out

/*
```

Step 2 Create a Function to Determine the Value of the action Attribute

Connect as oe.

```
*/

CONNECT oe/oe@oedb.net

/*
```

Create a function called get_oe_action to determine the value of the action attribute in the events in the queue. This function is used in rules later in this example to determine the value of the action attribute for an event. Then, the clients of the rules engine perform the appropriate action for the event (either dequeue by apply process or explicit dequeue). In this example, the clients of the rules engine are the apply process and the oe.explicit_dq PL/SQL procedure.

```
*/

CREATE OR REPLACE FUNCTION oe.get_oe_action (event IN SYS.Anydata)
RETURN VARCHAR2
IS
  ord         oe.order_event_typ;
  cust        oe.customer_event_typ;
  num           NUMBER;
  type_name     VARCHAR2(61);
BEGIN
  type_name := event.GETTYPENAME;
  IF type_name = 'OE.ORDER_EVENT_TYP' THEN
    num := event.GETOBJECT(ord);
    RETURN ord.action;
  ELSIF type_name = 'OE.CUSTOMER_EVENT_TYP' THEN
    num := event.GETOBJECT(cust);
    RETURN cust.action;
  ELSE
    RETURN NULL;
  END IF;
END;
/

/*
```

Step 3 Create a Message Handler

Create a message handler called `mes_handler` that will be used as a message handler by the apply process. This procedure takes the payload in a user-enqueued event of type `oe.order_event_typ` or `oe.customer_event_typ` and inserts it as a row in the `oe.orders` table and `oe.customers` table, respectively.

```
*/

CREATE OR REPLACE PROCEDURE oe.mes_handler (event SYS.AnyData)
IS
  ord           oe.order_event_typ;
  cust          oe.customer_event_typ;
  num           NUMBER;
  type_name     VARCHAR2(61);
BEGIN
  type_name := event.GETTYPENAME;
  IF type_name = 'OE.ORDER_EVENT_TYP' THEN
    num := event.GETOBJECT(ord);
    INSERT INTO oe.orders VALUES (ord.order_id, ord.order_date,
      ord.order_mode, ord.customer_id, ord.order_status, ord.order_total,
      ord.sales_rep_id, ord.promotion_id);
  ELSIF type_name = 'OE.CUSTOMER_EVENT_TYP' THEN
    num := event.GETOBJECT(cust);
    INSERT INTO oe.customers VALUES (cust.customer_id, cust.cust_first_name,
      cust.cust_last_name, cust.cust_address, cust.phone_numbers,
     cust.nls_language, cust.nls_territory, cust.credit_limit, cust.cust_email,
      cust.account_mgr_id, cust.cust_geo_location);
  END IF;
END;
/

/*
```

Step 4 Grant strmadmin EXECUTE Privilege on the Procedures

```
*/

GRANT EXECUTE ON get_oe_action TO strmadmin;

GRANT EXECUTE ON mes_handler TO strmadmin;

/*
```

Step 5 Create the Evaluation Context for the Rule Set

Connect as the Streams administrator.

```
*/

CONNECT strmadmin/strmadminpw@oedb.net

/*
```

Create the evaluation context for the rule set. The table alias is `tab` in this example, but you can use a different table alias name if you wish.

```
*/

DECLARE
    table_alias     SYS.RE$TABLE_ALIAS_LIST;
  BEGIN
    table_alias := SYS.RE$TABLE_ALIAS_LIST(SYS.RE$TABLE_ALIAS(
                                          'tab',
                                          'strmadmin.oe_queue_table'));
    DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT(
      evaluation_context_name  =>  'oe_eval_context',
      table_aliases            =>  table_alias);
END;
/

/*
```

Step 6 Create a Rule Set for the Apply Process

Create the rule set for the apply process.

```
*/

BEGIN
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name       =>  'apply_oe_rs',
    evaluation_context  =>  'strmadmin.oe_eval_context');
END;
/

/*
```

Step 7 Create a Rule that Evaluates to TRUE if the Event Action Is apply

Create a rule that evaluates to TRUE if the `action` value of an `event` is `apply`. Notice that `tab.user_data` is passed to the `oe.mes_handler` function. The `tab.user_data` column holds the event payload in a queue table. The table alias for the queue table was specified as tab in Step 5 on page 18-18.

```
*/

BEGIN
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name   => 'strmadmin.apply_action',
    condition   => ' oe.get_oe_action(tab.user_data) = ''APPLY'' ');
END;
/

/*
```

Step 8 Create a Rule that Evaluates to TRUE for the Row LCR Events

Create a rule that evaluates to TRUE if the event in the queue is a row LCR that changes either the `oe.orders` table or the `oe.customers` table. This rule will enable the apply process to apply user-enqueued changes to the tables directly. For convenience, this rule uses the Oracle-supplied evaluation context `SYS.STREAMS$_EVALUATION_CONTEXT` because the rule is used to evaluate LCRs. When this rule is added to the rule set, this evaluation context is used for the rule during evaluation instead of the rule set's evaluation context.

```
*/

BEGIN
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name           =>  'apply_lcrs',
    condition           =>  ':dml.get_object_owner() = ''OE'' AND ' ||
                            ' (:dml.get_object_name() = ''ORDERS'' OR ' ||
                            ':dml.get_object_name() = ''CUSTOMERS'') ',
    evaluation_context  =>  'SYS.STREAMS$_EVALUATION_CONTEXT');
END;
/

/*
```

Step 9 Add the Rules to the Rule Set

Add the rules created in Step 7 and Step 8 to the rule set created in Step 6 on page 18-19.

```
*/

BEGIN
  DBMS_RULE_ADM.ADD_RULE(
    rule_name          =>  'apply_action',
    rule_set_name      =>  'apply_oe_rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name          =>  'apply_lcrs',
    rule_set_name      =>  'apply_oe_rs');
END;
/

/*
```

Step 10 Create an Apply Process

Create an apply process that is associated with the `oe_queue`, that uses the `apply_oe_rs` rule set, and that uses the `mes_handler` procedure as a message handler.

```
*/

BEGIN
  DBMS_APPLY_ADM.CREATE_APPLY(
    queue_name       =>  'strmadmin.oe_queue',
    apply_name       =>  'apply_oe',
    rule_set_name    =>  'strmadmin.apply_oe_rs',
    message_handler  =>  'oe.mes_handler',
    apply_user       =>  'oe',
    apply_captured   =>  false);
END;
/

/*
```

Step 11 Grant EXECUTE Privilege on the Rule Set To oe User

Grant EXECUTE privilege on the strmadmin.apply_oe_rs rule set. Because oe was specified as the apply user when the apply process was created in Step 10, oe needs execute privilege on the rule set used by the apply process.

```
*/

BEGIN
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name  => 'strmadmin.apply_oe_rs',
    grantee      => 'oe',
    grant_option => FALSE);
END;
/

/*
```

Step 12 Start the Apply Process

Set the disable_on_error parameter to n so that the apply process is not disabled if it encounters an error, and start the apply process at oedb.net.

```
*/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply_oe',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  =>  'apply_oe');
END;
/

/*
```

Step 13 Check the Spool Results

Check the `streams_apply_message.out` spool file to ensure that all actions completed successfully after this script completes.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT *****************************/
```

Configure Explicit Dequeue

Complete the following steps to configure explicit dequeue of messages based on message contents.

1. Show Output and Spool Results
2. Create an Agent for Explicit Dequeue
3. Associate the oe User with the explicit_dq Agent
4. Add a Subscriber to the oe_queue Queue
5. Create a Procedure to Dequeue Events Explicitly
6. Check Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 18-28 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to the database.

```
/************************ BEGINNING OF SCRIPT ****************************
```

Step 1 Show Output and Spool Results

Run SET ECHO ON and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_explicit_dq.out

/*
```

Step 2 Create an Agent for Explicit Dequeue

Connect as the Streams administrator.

```
*/

CONNECT strmadmin/strmadminpw@oedb.net

/*
```

Create an agent that will be used to perform explicit dequeue operations on the oe_queue queue.

```
*/

BEGIN
  SYS.DBMS_AQADM.CREATE_AQ_AGENT(
    agent_name  => 'explicit_dq');
END;
/

/*
```

Step 3 Associate the oe User with the explicit_dq Agent

For a user to perform queue operations, such as enqueue and dequeue, on a secure queue, the user must be configured as a secure queue user of the queue. The oe_queue queue is a secure queue because it was created using SET_UP_QUEUE. The oe user will be able to perform dequeue operations on this queue when the agent is used to create a subscriber to the queue in the next step.

```
*/

BEGIN
  DBMS_AQADM.ENABLE_DB_ACCESS(
    agent_name  => 'explicit_dq',
    db_username => 'oe');
END;
/

/*
```

Step 4 Add a Subscriber to the oe_queue Queue

Add a subscriber to the `oe_queue` queue. This subscriber will perform explicit dequeues of events. A subscriber rule is used to dequeue any events where the `action` value is not `apply`. If the action value is `apply` for an event, then the event is ignored by the subscriber. Such events are dequeued and processed by the apply process.

```
*/

DECLARE
  subscriber SYS.AQ$_AGENT;
BEGIN
  subscriber :=  SYS.AQ$_AGENT('explicit_dq', NULL, NULL);
  SYS.DBMS_AQADM.ADD_SUBSCRIBER(
    queue_name  =>  'strmadmin.oe_queue',
    subscriber  =>  subscriber,
    rule        =>  'oe.get_oe_action(tab.user_data) != ''APPLY''');
END;
/

/*
```

Step 5 Create a Procedure to Dequeue Events Explicitly

Connect as `oe`.

```
*/

CONNECT oe/oe@oedb.net

/*
```

Create a PL/SQL procedure called `explicit_dq` to dequeue events explicitly using the subscriber created in Step 4 on page 18-25.

Note:

- This procedure commits after the dequeue of the events. The commit informs the queue that the dequeued messages have been consumed successfully by this subscriber.
- This procedure can process multiple transactions and uses two exception handlers. The first exception handler `next_trans` moves to the next transaction while the second exception handler `no_messages` exits the loop when there are no more messages.

```
*/

CREATE OR REPLACE PROCEDURE oe.explicit_dq (consumer IN VARCHAR2) AS
  deqopt       DBMS_AQ.DEQUEUE_OPTIONS_T;
  mprop        DBMS_AQ.MESSAGE_PROPERTIES_T;
  msgid        RAW(16);
  payload      SYS.AnyData;
  new_messages BOOLEAN := TRUE;
  ord          oe.order_event_typ;
  cust         oe.customer_event_typ;
  tc           pls_integer;
  next_trans   EXCEPTION;
  no_messages  EXCEPTION;
  pragma exception_init (next_trans, -25235);
  pragma exception_init (no_messages, -25228);
BEGIN
  deqopt.consumer_name := consumer;
  deqopt.wait := 1;
  WHILE (new_messages) LOOP
    BEGIN
    DBMS_AQ.DEQUEUE(
      queue_name          =>  'strmadmin.oe_queue',
      dequeue_options     =>  deqopt,
      message_properties  =>  mprop,
      payload             =>  payload,
      msgid               =>  msgid);
    COMMIT;
    deqopt.navigation := DBMS_AQ.NEXT;
    DBMS_OUTPUT.PUT_LINE('Event Dequeued');
    DBMS_OUTPUT.PUT_LINE('Type Name := ' || payload.GetTypeName);
```

```
    IF (payload.GetTypeName = 'OE.ORDER_EVENT_TYP') THEN
      tc := payload.GetObject(ord);
      DBMS_OUTPUT.PUT_LINE('order_id     - ' || ord.order_id);
      DBMS_OUTPUT.PUT_LINE('order_date   - ' || ord.order_date);
      DBMS_OUTPUT.PUT_LINE('order_mode   - ' || ord.order_mode);
      DBMS_OUTPUT.PUT_LINE('customer_id  - ' || ord.customer_id);
      DBMS_OUTPUT.PUT_LINE('order_status - ' || ord.order_status);
      DBMS_OUTPUT.PUT_LINE('order_total  - ' || ord.order_total);
      DBMS_OUTPUT.PUT_LINE('sales_rep_id - ' || ord.sales_rep_id);
      DBMS_OUTPUT.PUT_LINE('promotion_id - ' || ord.promotion_id);
    END IF;
    IF (payload.GetTypeName = 'OE.CUSTOMER_EVENT_TYP') THEN
      tc := payload.GetObject(cust);
      DBMS_OUTPUT.PUT_LINE('customer_id     - ' || cust.customer_id);
      DBMS_OUTPUT.PUT_LINE('cust_first_name - ' || cust.cust_first_name);
      DBMS_OUTPUT.PUT_LINE('cust_last_name  - ' || cust.cust_last_name);
      DBMS_OUTPUT.PUT_LINE('street_address  - ' ||
                           cust.cust_address.street_address);
      DBMS_OUTPUT.PUT_LINE('postal_code     - ' ||
                           cust.cust_address.postal_code);
      DBMS_OUTPUT.PUT_LINE('city            - ' || cust.cust_address.city);
      DBMS_OUTPUT.PUT_LINE('state_province  - ' ||
                           cust.cust_address.state_province);
      DBMS_OUTPUT.PUT_LINE('country_id      - ' ||
                           cust.cust_address.country_id);
      DBMS_OUTPUT.PUT_LINE('phone_number1   - ' || cust.phone_numbers(1));
      DBMS_OUTPUT.PUT_LINE('phone_number2   - ' || cust.phone_numbers(2));
      DBMS_OUTPUT.PUT_LINE('phone_number3   - ' || cust.phone_numbers(3));
      DBMS_OUTPUT.PUT_LINE('nls_language    - ' || cust.nls_language);
      DBMS_OUTPUT.PUT_LINE('nls_territory   - ' || cust.nls_territory);
      DBMS_OUTPUT.PUT_LINE('credit_limit    - ' || cust.credit_limit);
      DBMS_OUTPUT.PUT_LINE('cust_email      - ' || cust.cust_email);
      DBMS_OUTPUT.PUT_LINE('account_mgr_id  - ' || cust.account_mgr_id);
    END IF;
    EXCEPTION
      WHEN next_trans THEN
      deqopt.navigation := DBMS_AQ.NEXT_TRANSACTION;
      WHEN no_messages THEN
        new_messages  := FALSE;
        DBMS_OUTPUT.PUT_LINE('No more events');
     END;
  END LOOP;
END;
/
```

```
/*
```

Step 6 Check Spool Results

Check the `streams_explicit_dq.out` spool file to ensure that all actions completed successfully after this script completes.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT *****************************/
```

Enqueue Events

Complete the following steps to enqueue non-LCR events and row LCR events into the queue.

1. Show Output and Spool Results
2. Enqueue Non-LCR Events to be Dequeued by the Apply Process
3. Enqueue Non-LCR Events to be Dequeued Explicitly
4. Enqueue Row LCR Events to be Dequeued by the Apply Process
5. Check Spool Results

Note:

- It is possible to dequeue user-enqueued LCRs explicitly, but this example does not illustrate this capability.
- If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 18-34 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to the database.

```
/************************ BEGINNING OF SCRIPT ****************************
```

Step 1 Show Output and Spool Results

Run SET ECHO ON and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_enq_deq.out

/*
```

Step 2 Enqueue Non-LCR Events to be Dequeued by the Apply Process

Connect as oe.

```
*/

CONNECT oe/oe@oedb.net

/*
```

Enqueue events with apply for the action value. Based on the apply process rules, the apply process will dequeue and process these events with the oe.mes_handler message handler procedure created in "Create a Message Handler" on page 18-17. The COMMIT after the enqueues makes these two enqueues part of the same transaction. An enqueued message is not visible until the session that enqueued it commits the enqueue.

```
*/

BEGIN
  oe.enq_proc(SYS.AnyData.convertobject(oe.order_event_typ(
    2500,'05-MAY-01','online',117,3,44699,161,NULL,'APPLY')));
END;
/
```

```
BEGIN
  oe.enq_proc(SYS.AnyData.convertobject(oe.customer_event_typ(
    990,'Hester','Prynne',oe.cust_address_typ('555 Beacon Street','Boston',
    'MA',02109,'US'),oe.phone_list_typ('+1 617 123 4104', '+1 617 083 4381',
    '+1 617 742 5813'),'i','AMERICA',5000,'a@scarlet_letter.com',145,
    NULL,'APPLY')));
END;
/

COMMIT;

/*
```

Step 3 Enqueue Non-LCR Events to be Dequeued Explicitly

Enqueue events with `dequeue` for the `action` value. The `oe.explicit_dq` procedure created in "Create a Procedure to Dequeue Events Explicitly" on page 18-25 will dequeue these events because the `action` is not `apply`. Based on the apply process rules, the apply process will ignore these events. The `COMMIT` after the enqueues makes these two enqueues part of the same transaction.

```
*/

BEGIN
  oe.enq_proc(SYS.AnyData.convertobject(oe.order_event_typ(
    2501,'22-JAN-00','direct',117,3,22788,161,NULL,'DEQUEUE')));
END;
/

BEGIN
  oe.enq_proc(SYS.AnyData.convertobject(oe.customer_event_typ(
    991,'Nick','Carraway',oe.cust_address_typ('10th Street',
    11101,'Long Island','NY','US'),oe.phone_list_typ('+1 718 786 2287',
    '+1 718 511 9114', '+1 718 888 4832'),'i','AMERICA',3000,
    'nick@great_gatsby.com',149,NULL,'DEQUEUE')));
END;
/

COMMIT;

/*
```

Step 4 Enqueue Row LCR Events to be Dequeued by the Apply Process

Enqueue row LCR events. The apply process will apply these events directly. Enqueued LCRs should commit at transaction boundaries. In this step, a `COMMIT` statement is run after each enqueue, making each enqueue a separate transaction. However, you can perform multiple LCR enqueues before a commit if there is more than one LCR in a transaction.

Create a row LCR that inserts a row into the `oe.orders` table.

```
*/

DECLARE
  newunit1  SYS.LCR$_ROW_UNIT;
  newunit2  SYS.LCR$_ROW_UNIT;
  newunit3  SYS.LCR$_ROW_UNIT;
  newunit4  SYS.LCR$_ROW_UNIT;
  newunit5  SYS.LCR$_ROW_UNIT;
  newunit6  SYS.LCR$_ROW_UNIT;
  newunit7  SYS.LCR$_ROW_UNIT;
  newunit8  SYS.LCR$_ROW_UNIT;
  newvals   SYS.LCR$_ROW_LIST;
BEGIN
  newunit1 := SYS.LCR$_ROW_UNIT(
    'ORDER_ID',
    SYS.AnyData.ConvertNumber(2502),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  newunit2 := SYS.LCR$_ROW_UNIT(
    'ORDER_DATE',
    SYS.AnyData.ConvertTimestampLTZ('04-NOV-00'),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  newunit3 := SYS.LCR$_ROW_UNIT(
    'ORDER_MODE',
    SYS.AnyData.ConvertVarchar2('online'),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
```

```
  newunit4 := SYS.LCR$_ROW_UNIT(
    'CUSTOMER_ID',
    SYS.AnyData.ConvertNumber(145),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  newunit5 := SYS.LCR$_ROW_UNIT(
    'ORDER_STATUS',
    SYS.AnyData.ConvertNumber(3),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  newunit6 := SYS.LCR$_ROW_UNIT(
    'ORDER_TOTAL',
    SYS.AnyData.ConvertNumber(35199),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  newunit7 := SYS.LCR$_ROW_UNIT(
    'SALES_REP_ID',
    SYS.AnyData.ConvertNumber(160),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  newunit8 := SYS.LCR$_ROW_UNIT(
    'PROMOTION_ID',
    SYS.AnyData.ConvertNumber(1),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  newvals := SYS.LCR$_ROW_LIST(newunit1,newunit2,newunit3,newunit4,
                               newunit5,newunit6,newunit7,newunit8);
oe.enq_row_lcr(
  source_dbname  =>  'OEDB.NET',
  cmd_type       =>  'INSERT',
  obj_owner      =>  'OE',
  obj_name       =>  'ORDERS',
  old_vals       =>  NULL,
  new_vals       =>  newvals);
END;
/
COMMIT;

/*
```

Create a row LCR that updates the row inserted into the `oe.orders` table previously.

```
*/

DECLARE
  oldunit1  SYS.LCR$_ROW_UNIT;
  oldunit2  SYS.LCR$_ROW_UNIT;
  oldvals   SYS.LCR$_ROW_LIST;
  newunit1  SYS.LCR$_ROW_UNIT;
  newvals   SYS.LCR$_ROW_LIST;
BEGIN
  oldunit1 := SYS.LCR$_ROW_UNIT(
    'ORDER_ID',
    SYS.AnyData.ConvertNumber(2502),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  oldunit2 := SYS.LCR$_ROW_UNIT(
    'ORDER_TOTAL',
    SYS.AnyData.ConvertNumber(35199),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  oldvals := SYS.LCR$_ROW_LIST(oldunit1,oldunit2);
  newunit1 := SYS.LCR$_ROW_UNIT(
    'ORDER_TOTAL',
    SYS.AnyData.ConvertNumber(5235),
    DBMS_LCR.NOT_A_LOB,
    NULL,
    NULL);
  newvals := SYS.LCR$_ROW_LIST(newunit1);
oe.enq_row_lcr(
  source_dbname  =>  'OEDB.NET',
  cmd_type       =>  'UPDATE',
  obj_owner      =>  'OE',
  obj_name       =>  'ORDERS',
  old_vals       =>  oldvals,
  new_vals       =>  newvals);
END;
/
COMMIT;

/*
```

Step 5 Check Spool Results

Check the `streams_enq_deq.out` spool file to ensure that all actions completed successfully after this script completes.

```
*/

SET ECHO OFF
SPOOL OFF

/*************************** END OF SCRIPT ******************************/
```

Dequeue Events Explicitly and Query for Applied Events

Complete the following steps to dequeue the events explicitly and query the events that were applied by the apply process. These events were enqueued in the "Enqueue Events" on page 18-28.

Step 1 Run the Procedure to Dequeue Events Explicitly

Run the procedure you created in "Create a Procedure to Dequeue Events Explicitly" on page 18-25 and specify the consumer of the events you want to dequeue. In this case, the consumer is the subscriber you added in "Add a Subscriber to the oe_queue Queue" on page 18-25. In this example, events that are not dequeued explicitly by this procedure are dequeued by the apply process.

```
CONNECT oe/oe@oedb.net

SET SERVEROUTPUT ON SIZE 100000

EXEC oe.explicit_dq('explicit_dq');
```

Step 2 Query for Applied Events

Query the oe.orders and oe.customers table to see the rows corresponding to the events applied by the apply process:

```
SELECT * FROM oe.orders WHERE order_id = 2500;

SELECT cust_first_name, cust_last_name, cust_email
  FROM oe.customers WHERE customer_id = 990;

SELECT * FROM oe.orders WHERE order_id = 2502;
```

Enqueue and Dequeue Events Using JMS

This example enqueues non-LCR events and row LCR events into the queue using JMS. Then, this example dequeues these events from the queue using JMS.

Complete the following steps:

1. Run the catxlcr.sql Script
2. Create the Types for User Events
3. Set the CLASSPATH
4. Create Java Classes that Map to the Oracle Object Types
5. Create a Java Script for Enqueuing Messages
6. Create a Java Script for Dequeuing Messages
7. Compile the scripts
8. Run the Enqueue Program
9. Run the Dequeue Program

Step 1 Run the catxlcr.sql Script

For this example to complete successfully, the LCR schema must be loaded into the SYS schema using the `catxlcr.sql` script in Oracle home in the `rdbms/admin/` directory. Run this script now if it has not been run already.

For example, if your Oracle home directory is `/usr/oracle`, then enter the following to run the script:

```
CONNECT SYS/CHANGE_ON_INSTALL AS SYSDBA

@/usr/oracle/rdbms/admin/catxlcr.sql
```

Step 2 Create the Types for User Events

```
CONNECT oe/oe

CREATE TYPE address AS OBJECT (street VARCHAR (30), num NUMBER)
/

CREATE TYPE person AS OBJECT (name VARCHAR (30), home ADDRESS)
/
```

Step 3 Set the CLASSPATH

The following jar and zip files should be in the CLASSPATH based on the release of JDK you are using.

Also, make sure LD_LIBRARY_PATH (Solaris) or PATH (Windows NT) has $ORACLE_HOME/lib set.

```
-- For JDK1.3.x
$ORACLE_HOME/jdbc/lib/classes12.zip
$ORACLE_HOME/rdbms/jlib/aqapi13.jar
$ORACLE_HOME/rdbms/jlib/jmscommon.jar
$ORACLE_HOME/rdbms/jlib/xdb.jar
$ORACLE_HOME/xdk/lib/xmlparserv2.jar
$ORACLE_HOME/jlib/jndi.jar

-- For JDK1.2.x
$ORACLE_HOME/jdbc/lib/classes12.zip
$ORACLE_HOME/rdbms/jlib/aqapi12.jar
$ORACLE_HOME/rdbms/jlib/jmscommon.jar
$ORACLE_HOME/rdbms/jlib/xdb.jar
$ORACLE_HOME/xdk/lib/xmlparserv2.jar
$ORACLE_HOME/jlib/jndi.jar

-- For JDK1.1.x
$ORACLE_HOME/jdbc/lib/classes111.zip
$ORACLE_HOME/rdbms/jlib/aqapi11.jar
$ORACLE_HOME/rdbms/jlib/jmscommon.jar
$ORACLE_HOME/rdbms/jlib/xdb.jar
$ORACLE_HOME/xdk/lib/xmlparserv2.jar
$ORACLE_HOME/jlib/jndi.jar
```

Step 4 Create Java Classes that Map to the Oracle Object Types

First, create a file input.typ with the following lines:

```
SQL PERSON AS JPerson
SQL ADDRESS AS JAddress
```

Then, run Jpublisher.

```
jpub -input=input.typ -user=OE/OE
```

Completing these actions generates two Java classes named JPerson and JAddress for the person and address types, respectively.

Step 5 Create a Java Script for Enqueuing Messages

This program uses the Oracle JMS API to publish messages into a Streams topic.

This program does the following:

- Publishes a non-LCR based ADT message to the topic
- Publishes a JMS text message to a topic
- Publish an LCR based message to the topic

```
import oracle.AQ.*;
import oracle.jms.*;
import javax.jms.*;
import java.lang.*;
import oracle.xdb.*;

public class StreamsEnq
{
  public static void main (String args [])
       throws java.sql.SQLException, ClassNotFoundException, JMSException
  {
     TopicConnectionFactory tc_fact= null;
     TopicConnection        t_conn = null;
     TopicSession           t_sess = null;

     try
     {
       if (args.length < 3 )
         System.out.println("Usage:java filename [SID] [HOST] [PORT]");
       else
       {
         /* Create the TopicConnectionFactory
          * Only the JDBC OCI driver can be used to access Streams through JMS
          */
         tc_fact = AQjmsFactory.getTopicConnectionFactory(
                     args[1], args[0], Integer.parseInt(args[2]), "oci8");

         t_conn = tc_fact.createTopicConnection( "OE","OE");

         /* Create a Topic Session */
         t_sess = t_conn.createTopicSession(true, Session.CLIENT_ACKNOWLEDGE);

         /* Start the connection */
         t_conn.start() ;
```

```
        /* Publish non-LCR based messages */
        publishUserMessages(t_sess);

        /* Publish LCR based messages */
        publishLcrMessages(t_sess);

        t_sess.close() ;
        t_conn.close() ;
        System.out.println("End of StreamsEnq Demo") ;
      }
    }
    catch (Exception ex)
    {
      System.out.println("Exception-1: " + ex);
      ex.printStackTrace();
    }
}


/*
 * publishUserMessages - this method publishes an ADT message and a
 * JMS text message to a streams topic
 */
public static void publishUserMessages(TopicSession t_sess) throws Exception
{
  Topic           topic     = null;
  TopicPublisher  t_pub     = null;
  JPerson         pers      = null;
  JAddress        addr      = null;
  TextMessage     t_msg     = null;
  AdtMessage      adt_msg   = null;
  AQjmsAgent      agent     = null;
  AQjmsAgent[]    recipList = null;

  try
  {
    /* Get the topic */
    topic = ((AQjmsSession)t_sess).getTopic("strmadmin", "oe_queue");

    /* Create a publisher */
    t_pub = t_sess.createPublisher(topic);


    /* Agent to access oe_queue */
    agent = new AQjmsAgent("explicit_enq", null);
```

```
/* Create a PERSON adt message */
adt_msg = ((AQjmsSession)t_sess).createAdtMessage();

pers = new JPerson();
addr = new JAddress();

addr.setNum(new java.math.BigDecimal(500));
addr.setStreet("Oracle Pkwy");

pers.setName("Mark");
pers.setHome(addr);

/* Set the payload in the message */
adt_msg.setAdtPayload(pers);

((AQjmsMessage)adt_msg).setSenderID(agent);

System.out.println("Publish message 1 -type  PERSON\n");

/* Create the recipient list */
recipList = new AQjmsAgent[1];
recipList[0] = new AQjmsAgent("explicit_dq", null);

/* Publish the message */
((AQjmsTopicPublisher)t_pub).publish(topic, adt_msg, recipList);

t_sess.commit();

t_msg = t_sess.createTextMessage();

t_msg.setText("Test message");
t_msg.setStringProperty("color", "BLUE");
t_msg.setIntProperty("year", 1999);

((AQjmsMessage)t_msg).setSenderID(agent);

System.out.println("Publish message 2 -type  JMS TextMessage\n");
```

```
    /* Publish the message */
    ((AQjmsTopicPublisher)t_pub).publish(topic, t_msg, recipList);

    t_sess.commit();

  }
  catch (JMSException jms_ex)
  {
    System.out.println("JMS Exception: " + jms_ex);

    if(jms_ex.getLinkedException() != null)
      System.out.println("Linked Exception: " + jms_ex.getLinkedException());
  }
}

/*
 * publishLcrMessages - this method publishes an XML LCR message to a
 * streams topic
 */
public static void publishLcrMessages(TopicSession t_sess) throws Exception
{
  Topic               topic     = null;
  TopicPublisher      t_pub     = null;
  XMLType             xml_lcr   = null;
  AdtMessage          adt_msg   = null;
  AQjmsAgent          agent     = null;
  StringBuffer        lcr_data  = null;
  AQjmsAgent[]        recipList = null;
  java.sql.Connection db_conn   = null;

  try
  {
    /* Get the topic */
    topic = ((AQjmsSession)t_sess).getTopic("strmadmin", "oe_queue");

    /* Create a publisher */
    t_pub = t_sess.createPublisher(topic);

    /* Get the JDBC connection */
    db_conn = ((AQjmsSession)t_sess).getDBConnection();

    /* Agent to access oe_queue */
    agent = new AQjmsAgent("explicit_enq", null);
```

```
      /* Create a adt message */
      adt_msg = ((AQjmsSession)t_sess).createAdtMessage();

    /* Create the LCR representation in XML */
    lcr_data = new StringBuffer();

    lcr_data.append("<ROW_LCR ");
    lcr_data.append("xmlns='http://xmlns.oracle.com/streams/schemas/lcr' \n");
    lcr_data.append("xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance' \n");
      lcr_data.append("xsi:schemaLocation='http://xmlns.oracle.com/streams/schemas/lcr
http://xmlns.oracle.com/streams/schemas/lcr/streamslcr.xsd'");
      lcr_data.append("> \n");

lcr_data.append("<source_database_name>source_dbname</source_database_name> \n");
      lcr_data.append("<command_type>INSERT</command_type> \n");
      lcr_data.append("<object_owner>Ram</object_owner> \n");
      lcr_data.append("<object_name>Emp</object_name> \n");
      lcr_data.append("<tag>0ABC</tag> \n");
      lcr_data.append("<transaction_id>0.0.0</transaction_id> \n");
      lcr_data.append("<scn>0</scn> \n");
      lcr_data.append("<old_values> \n");
      lcr_data.append("<old_value> \n");
      lcr_data.append("<column_name>C01</column_name> \n");
      lcr_data.append("<data><varchar2>Clob old</varchar2></data> \n");
      lcr_data.append("</old_value> \n");
      lcr_data.append("<old_value> \n");
      lcr_data.append("<column_name>C02</column_name> \n");
      lcr_data.append("<data><varchar2>A123FF</varchar2></data> \n");
      lcr_data.append("</old_value> \n");
      lcr_data.append("<old_value> \n");
      lcr_data.append("<column_name>C03</column_name> \n");
      lcr_data.append("<data> \n");
      lcr_data.append("<date><value>1997-11-24</value><format>SYYYY-MM-DD</format></date> \n");
      lcr_data.append("</data> \n");
      lcr_data.append("</old_value> \n");
      lcr_data.append("<old_value> \n");
      lcr_data.append("<column_name>C04</column_name> \n");
      lcr_data.append("<data> \n");
```

```
lcr_data.append("<timestamp><value>1999-05-31T13:20:00.000</value><format>SYYYY-MM-DD'T'HH24:MI:
SS.FF</format></timestamp> \n");
      lcr_data.append("</data> \n");
      lcr_data.append("</old_value> \n");
      lcr_data.append("<old_value> \n");
      lcr_data.append("<column_name>C05</column_name> \n");
      lcr_data.append("<data><raw>ABCDE</raw></data> \n");
      lcr_data.append("</old_value> \n");
      lcr_data.append("</old_values> \n");
      lcr_data.append("<new_values> \n");
      lcr_data.append("<new_value> \n");
      lcr_data.append("<column_name>C01</column_name> \n");
      lcr_data.append("<data><varchar2>A123FF</varchar2></data> \n");
      lcr_data.append("</new_value> \n");
      lcr_data.append("<new_value> \n");
      lcr_data.append("<column_name>C02</column_name> \n");
      lcr_data.append("<data><number>35.23</number></data> \n");
      lcr_data.append("</new_value> \n");
      lcr_data.append("<new_value> \n");
      lcr_data.append("<column_name>C03</column_name> \n");
      lcr_data.append("<data><number>-100000</number></data> \n");
      lcr_data.append("</new_value> \n");
      lcr_data.append("<new_value> \n");
      lcr_data.append("<column_name>C04</column_name> \n");
      lcr_data.append("<data><varchar>Hel lo</varchar></data> \n");
      lcr_data.append("</new_value> \n");
      lcr_data.append("<new_value> \n");
      lcr_data.append("<column_name>C05</column_name> \n");
      lcr_data.append("<data><char>wor ld</char></data> \n");
      lcr_data.append("</new_value> \n");
      lcr_data.append("</new_values> \n");
      lcr_data.append("</ROW_LCR>");

      /* Create the XMLType containing the LCR */
      xml_lcr = oracle.xdb.XMLType.createXML(db_conn, lcr_data.toString());

      /* Set the payload in the message */
      adt_msg.setAdtPayload(xml_lcr);

      ((AQjmsMessage)adt_msg).setSenderID(agent);

      System.out.println("Publish message 3 - XMLType containing LCR ROW\n");
```

```
      /* Create the recipient list */
      recipList = new AQjmsAgent[1];
      recipList[0] = new AQjmsAgent("explicit_dq", null);

      /* Publish the message */
      ((AQjmsTopicPublisher)t_pub).publish(topic, adt_msg, recipList);

      t_sess.commit();

    }
    catch (JMSException jms_ex)
    {
      System.out.println("JMS Exception: " + jms_ex);

      if(jms_ex.getLinkedException() != null)
        System.out.println("Linked Exception: " + jms_ex.getLinkedException());
    }
  }

}
```

Step 6 Create a Java Script for Dequeuing Messages

This program uses Oracle JMS API to receive messages from a Streams topic.

This program does the following:

- Registers mappings for `person`, `address` and `XMLType` in JMS typemap
- Receives LCR messages from a streams topic
- Receives user ADT messages from a streams topic

```
import oracle.AQ.*;
import oracle.jms.*;
import javax.jms.*;
import java.lang.*;
import oracle.xdb.*;
import java.sql.SQLException;
```

```
public class StreamsDeq
{
  public static void main (String args [])
       throws java.sql.SQLException, ClassNotFoundException, JMSException
  {
     TopicConnectionFactory tc_fact= null;
     TopicConnection        t_conn = null;
     TopicSession           t_sess = null;

     try
     {
       if (args.length < 3 )
         System.out.println("Usage:java filename [SID] [HOST] [PORT]");
       else
       {
         /* Create the TopicConnectionFactory
          * Only the JDBC OCI driver can be used to access Streams through JMS
          */
         tc_fact = AQjmsFactory.getTopicConnectionFactory(
                     args[1], args[0], Integer.parseInt(args[2]), "oci8");

         t_conn = tc_fact.createTopicConnection( "OE","OE");

         /* Create a Topic Session */
         t_sess = t_conn.createTopicSession(true, Session.CLIENT_ACKNOWLEDGE);

         /* Start the connection */
         t_conn.start() ;

         receiveMessages(t_sess);

         t_sess.close() ;
         t_conn.close() ;
         System.out.println("\nEnd of StreamsDeq Demo") ;
       }
     }
     catch (Exception ex)
     {
       System.out.println("Exception-1: " + ex);
       ex.printStackTrace();
     }
  }
```

```
/*
 * receiveMessages -This method receives messages from the Streams queue
 */
public static void receiveMessages(TopicSession t_sess) throws Exception
{
  Topic           topic   = null;
  JPerson         pers    = null;
  JAddress        addr    = null;
  XMLType         xtype   = null;
  TextMessage     t_msg   = null;
  AdtMessage      adt_msg = null;
  Message         jms_msg = null;
  TopicReceiver   t_recv  = null;
  int             i       = 0;
  java.util.Dictionary map= null;

  try
  {
    /* Get the topic */
    topic = ((AQjmsSession)t_sess).getTopic("strmadmin", "oe_queue");

    /* Create a TopicReceiver to receive messages for consumer "jms_recv */
    t_recv = ((AQjmsSession)t_sess).createTopicReceiver(topic,
                                                        "jms_recv", null);

    map = ((AQjmsSession)t_sess).getTypeMap();

    /* Register mappings for ADDRESS and PERSON in the JMS typemap */
    map.put("OE.PERSON", Class.forName("JPerson"));
    map.put("OE.ADDRESS", Class.forName("JAddress"));

    /* Register mapping for XMLType in the TypeMap - required for LCRs */
    map.put("SYS.XMLTYPE", Class.forName("oracle.xdb.XMLTypeFactory"));

    System.out.println("Receive messages ...\n");

    do
    {
      try
      {
        jms_msg = (t_recv.receive(10));

        i++;
```

```
          /* Set navigation mode to NEXT_MESSAGE */

((AQjmsTopicReceiver)t_recv).setNavigationMode(AQjmsConstants.NAVIGATION_NEXT_MESSAGE);
        }
        catch (JMSException jms_ex2)
        {
          if((jms_ex2.getLinkedException() != null) &&
             (jms_ex2.getLinkedException() instanceof SQLException))
          {
            SQLException sql_ex2 =(SQLException)(jms_ex2.getLinkedException());

            /* End of current transaction group
             * Use NEXT_TRANSACTION navigation mode
             */
            if(sql_ex2.getErrorCode() == 25235)
            {

((AQjmsTopicReceiver)t_recv).setNavigationMode(AQjmsConstants.NAVIGATION_NEXT_TRANSACTION);

              continue;
            }
            else
              throw jms_ex2;
          }
          else
            throw jms_ex2;
        }

        if(jms_msg == null)
        {
          System.out.println("\nNo more messages");
        }
        else
        {
          if(jms_msg instanceof AdtMessage)
          {
            adt_msg = (AdtMessage)jms_msg;

            System.out.println("Retrieved message " + i + ": " +
                               adt_msg.getAdtPayload());
```

```
        if(adt_msg.getAdtPayload() instanceof JPerson)
        {
          pers =(JPerson)( adt_msg.getAdtPayload());

          System.out.println("PERSON: Name: " + pers.getName());
        }
        else if(adt_msg.getAdtPayload() instanceof JAddress)
        {
          addr =(JAddress)( adt_msg.getAdtPayload());

          System.out.println("ADDRESS: Street" + addr.getStreet());
        }
        else if(adt_msg.getAdtPayload() instanceof oracle.xdb.XMLType)
        {
          xtype = (XMLType)adt_msg.getAdtPayload();

          System.out.println("XMLType: Data: \n" + xtype.getStringVal());

        }
        System.out.println("Msg id: " + adt_msg.getJMSMessageID());
        System.out.println();

      }
      else if(jms_msg instanceof TextMessage)
      {
        t_msg = (TextMessage)jms_msg;

        System.out.println("Retrieved message " + i + ": " +
                           t_msg.getText());

        System.out.println("Msg id: " + t_msg.getJMSMessageID());
        System.out.println();
      }
      else
        System.out.println("Invalid message type");
    }
  } while (jms_msg != null);

  t_sess.commit();
}
catch (JMSException jms_ex)
{
  System.out.println("JMS Exception: " + jms_ex);
```

```
      if(jms_ex.getLinkedException() != null)
        System.out.println("Linked Exception: " + jms_ex.getLinkedException());

      t_sess.rollback();
    }
    catch (java.sql.SQLException sql_ex)
    {
      System.out.println("SQL Exception: " + sql_ex);
      sql_ex.printStackTrace();

      t_sess.rollback();
    }
  }
}
```

Step 7 Compile the scripts

```
javac StreamsEnq.java StreamsDeq.java JPerson.java JAddress.java
```

Step 8 Run the Enqueue Program

```
java StreamsEnq  ORACLE_SID HOST PORT
```

For example, if your Oracle SID is `orc182`, your host is `hq_server`, and your port is `1520`, then enter the following:

```
java StreamsEnq orcl82 hq_server 1521
```

Step 9 Run the Dequeue Program

```
java StreamsDeq  ORACLE_SID HOST PORT
```

For example, if your Oracle SID is `orc182`, your host is `hq_server`, and your port is `1520`, then enter the following:

```
java StreamsDeq orcl82 hq_server 1521
```

19

Example Streams Replication Environments

This chapter illustrates some of the replication environments that can be constructed using Streams.

This chapter contains these topics:

Single Source Database in a Heterogeneous Environment

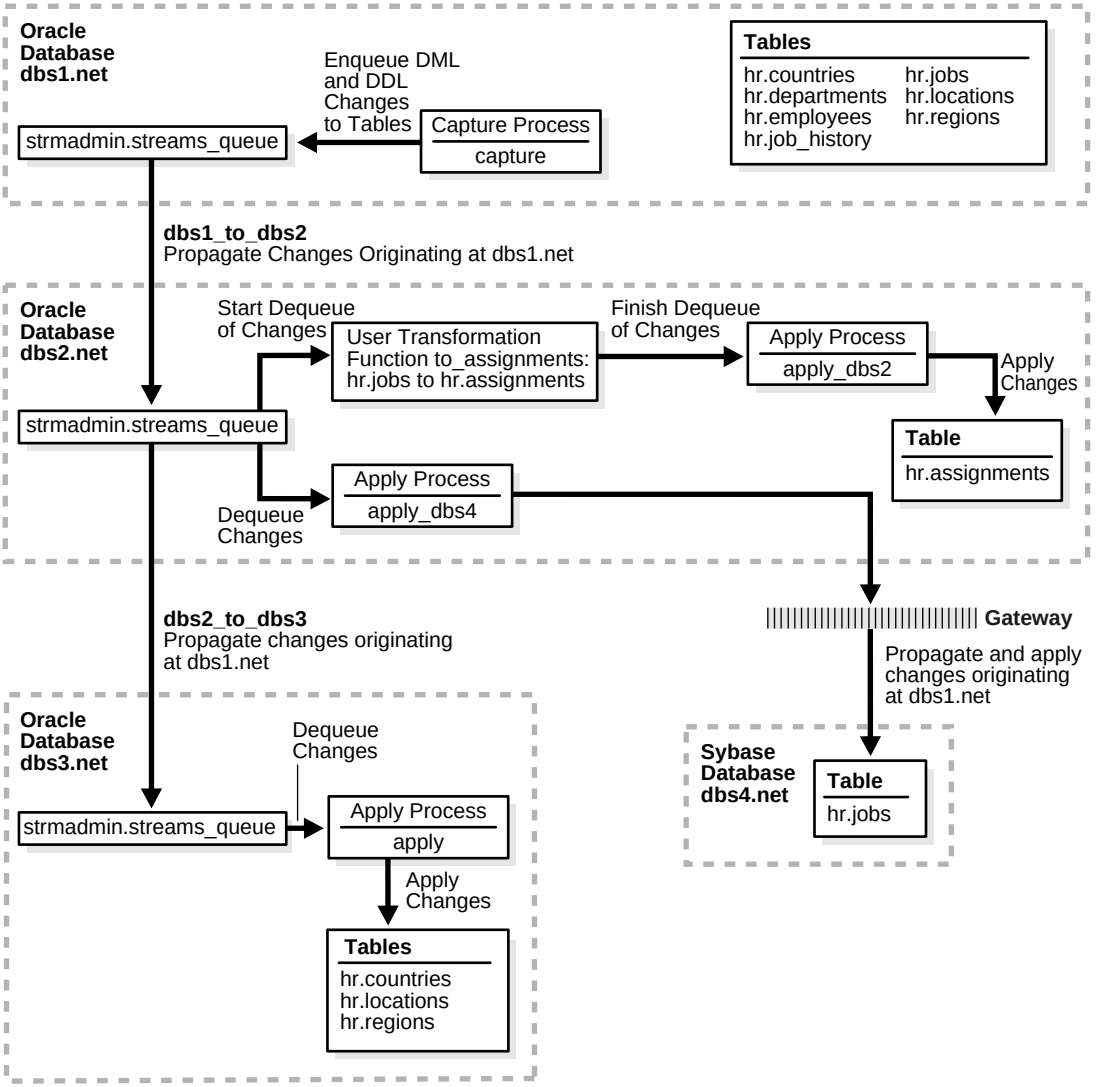
This example illustrates using Streams to replicate data between four databases. The environment is heterogeneous because three of the databases are Oracle databases and one is a Sybase database. DML and DDL changes made to tables in the `hr` schema at the `dbs1.net` Oracle database are captured and propagated to the other two Oracle databases. Only DML changes are captured and propagated to the `dbs4.net` database, because an apply process cannot apply DDL changes to a non-Oracle database. Changes to the `hr` schema occur only at `dbs1.net`. The `hr` schema is read-only at the other databases in the environment.

This example contains these parts:

- "Setting Up Users and Creating Queues and Database Links" on page 19-7
- "Example Scripts for Sharing Data from One Database" on page 19-20. This part illustrates two different example scripts that accomplish the same task:
  - "Simple Configuration for Sharing Data from a Single Database" on page 19-21
  - "Flexible Configuration for Sharing Data from a Single Database" on page 19-40
- "Adding Objects to an Existing Streams Replication Environment" on page 19-59
- "Adding a Database to an Existing Streams Replication Environment" on page 19-69

Figure 19–1 provides an overview of the environment.

Figure 19–1 Example Environment That Shares Data from a Single Source Database



As illustrated in Figure 19–1, dbs1.net contains the following tables in the hr schema:

- countries
- departments
- employees
- job_history
- jobs
- locations
- regions

This example uses directed networks, which means that captured changes at a source database are propagated to another database through one or more intermediate databases. Here, the dbs1.net database propagates changes to the dbs3.net database through the intermediate database dbs2.net. Also, the dbs1.net database propagates changes to the dbs2.net database, which applies the changes directly to the dbs4.net database through a gateway.

Some of the databases in the environment do not have certain tables. If the database is not an intermediate database for a table and the database does not contain the table, then changes to the table do not need to be propagated to that database. For example, the departments, employees, job_history, and jobs tables do not exist at dbs3.net. Therefore, dbs2.net does not propagate changes to these tables to dbs3.net.

In this example, Streams is used to perform the following series of actions:

1. The capture process captures DML and DDL changes for all of the tables in the hr schema and enqueues them into a queue at the dbs1.net database. In this example, changes to only four of the seven tables are propagated to destination databases, but in the example that illustrates "Adding Objects to an Existing Streams Replication Environment" on page 19-59, the remaining tables in the hr schema are added to a destination database.
2. The dbs1.net database propagates these changes in the form of messages to a queue at dbs2.net.
3. At dbs2.net, DML changes to the jobs table are transformed into DML changes for the assignments table (which is a direct mapping of jobs) and then applied. Changes to other tables in the hr schema are not applied at dbs2.net.

4. Because the queue at dbs3.net receives changes from the queue at dbs2.net that originated in countries, locations, and regions tables at dbs1.net, these changes are propagated from dbs2.net to dbs3.net. This configuration is an example of directed networks.
5. The apply process at dbs3.net applies changes to the countries, locations, and regions tables.
6. Because dbs4.net, a Sybase database, receives changes from the queue at dbs2.net to the jobs table that originated at dbs1.net, these changes are applied remotely from dbs2.net using the dbs4.net database link through a gateway. This configuration is an example of heterogeneous support.

Prerequisites

The following prerequisites must be completed before you begin the example in this section.

- Set the following initialization parameters to the values indicated for all databases in the environment:
  - GLOBAL_NAMES: This parameter must be set to true at each database that is participating in your Streams environment.
  - JOB_QUEUE_PROCESSES: This parameter must be set to at least 2 at each database that is propagating events in your Streams environment. It should be set to the same value as the maximum number of jobs that can run simultaneously plus one. In this example, dbs1.net and dbs2.net propagate events. So, JOB_QUEUE_PROCESSES must be set to at least 2 at these databases.
  - COMPATIBLE: This parameter must be set to 9.2.0 or higher.
  - LOG_PARALLELISM: This parameter must be set to 1 at each database that captures events. In this example, this parameter must be set to 1 at dbs1.net.

    See Also: "Setting Initialization Parameters Relevant to Streams" on page 10-4 for information about other initialization parameters that are important in a Streams environment

- Any database where changes are captured must be running in ARCHIVELOG mode. In this example, changes are captured at dbs1.net, and so dbs1.net must be running in ARCHIVELOG mode.

  See Also: *Oracle9i Database Administrator's Guide* for information about running a database in ARCHIVELOG mode

- Configure an Oracle gateway on dbs2.net to communicate with the Sybase database dbs4.net.

  See Also: *Oracle9i Heterogeneous Connectivity Administrator's Guide*

- At the Sybase database dbs4.net, set up the hr user and create the jobs table. The table shape should match the jobs table on dbs1.net.

  See Also: Your Sybase documentation for information about creating users and tables in your Sybase database

- At the Sybase database dbs4.net, add data to the jobs table to make it consistent with the jobs table at the Oracle database dbs1.net. Record the SCN that corresponds to the point in time when the data was copied from the dbs1.net database to the dbs4.net database.

  See Also:

  - *Oracle9i Heterogeneous Connectivity Administrator's Guide*
  - Your Sybase documentation for information about inserting data into tables in your Sybase database

- Configure your network and Oracle Net so that the following databases can communicate with each other:
  - dbs1.net and dbs2.net
  - dbs2.net and dbs3.net
  - dbs2.net and dbs4.net

  See Also: *Oracle9i Net Services Administrator's Guide*

- This examples creates a new user to function as the Streams administrator (`strmadmin`) at each database and prompts you for the tablespace you want to use for this user's data. Before you start this example, either create a new tablespace or identify an existing tablespace for the Streams administrator to use at each database. The Streams administrator should not use the `SYSTEM` tablespace.

Setting Up Users and Creating Queues and Database Links

Complete the following steps to set up users and create queues and database links for a Streams replication environment that includes three Oracle databases and one Sybase database.

1. Show Output and Spool Results
2. Alter the hr.countries Table at dbs1.net
3. Set Up Users at dbs1.net
4. Create the Streams Queue at dbs1.net
5. Create the Database Link at dbs1.net
6. Set Up Users at dbs2.net
7. Create the Streams Queue at dbs2.net
8. Create the Database Links at dbs2.net
9. Create the hr.assignments Table at dbs2.net
10. Set Up Users at dbs3.net
11. Create the Streams Queue at dbs3.net
12. Drop All of the Tables in the hr Schema at dbs3.net
13. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 19-19 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************ BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run `SET ECHO ON` and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_setup_single.out

/*
```

Step 2 Alter the hr.countries Table at dbs1.net

Connect to `dbs1.net` as the `hr` user.

```
*/

CONNECT hr/hr@dbs1.net

/*
```

Convert the `hr.countries` table from an index-organized table to a regular table. Currently, the capture process cannot capture changes to index-organized tables.

```
*/

ALTER TABLE countries RENAME TO countries_orig;

CREATE TABLE hr.countries(
  country_id      CHAR(2) CONSTRAINT  country_id_nn_noiot NOT NULL,
  country_name    VARCHAR2(40),
  region_id       NUMBER,
  CONSTRAINT      country_c_id_pk_noiot  PRIMARY KEY (country_id));
```

```
ALTER TABLE hr.countries
ADD (CONSTRAINT countr_reg_fk_noiot
         FOREIGN KEY (region_id)
         REFERENCES regions(region_id)) ;

INSERT INTO COUNTRIES (SELECT * FROM hr.countries_orig);

ALTER TABLE locations DROP CONSTRAINT loc_c_id_fk;

ALTER TABLE locations
  ADD (CONSTRAINT loc_c_id_fk
    FOREIGN KEY (country_id)
    REFERENCES countries(country_id));

/*
```

Step 3 Set Up Users at dbs1.net

Connect to `dbs1.net` as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@dbs1.net AS SYSDBA

/*
```

Create the Streams administrator named `strmadmin` and grant this user the necessary privileges. These privileges enable the user to manage queues, execute subprograms in packages related to Streams, create rule sets, create rules, and monitor the Streams environment by querying data dictionary views and queue tables. You may choose a different name for this user.

Note:

- To ensure security, use a password other than `strmadminpw` for the Streams administrator.
- The `SELECT_CATALOG_ROLE` is not required for the Streams administrator. It is granted in this example so that the Streams administrator can monitor the environment easily.
- If you plan to use the Streams tool in Oracle Enterprise Manager, then grant the Streams administrator `SELECT ANY DICTIONARY` privilege, in addition to the privileges shown in this step.
- The `ACCEPT` command must appear on a single line in the script.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

GRANT CONNECT, RESOURCE, SELECT_CATALOG_ROLE
  TO strmadmin IDENTIFIED BY strmadminpw;

ACCEPT streams_tbs PROMPT 'Enter the tablespace for the Streams administrator on
dbs1.net: '

ALTER USER strmadmin DEFAULT TABLESPACE &streams_tbs
                     QUOTA UNLIMITED ON &streams_tbs;

GRANT EXECUTE ON DBMS_APPLY_ADM        TO strmadmin;
GRANT EXECUTE ON DBMS_AQADM            TO strmadmin;
GRANT EXECUTE ON DBMS_CAPTURE_ADM      TO strmadmin;
GRANT EXECUTE ON DBMS_FLASHBACK        TO strmadmin;
GRANT EXECUTE ON DBMS_PROPAGATION_ADM  TO strmadmin;
GRANT EXECUTE ON DBMS_STREAMS_ADM      TO strmadmin;
```

```
BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

/*
```

Step 4 Create the Streams Queue at dbs1.net

Connect as the Streams administrator at the database where you want to capture changes. In this example, that database is `dbs1.net`.

```
*/

CONNECT strmadmin/strmadminpw@dbs1.net

/*
```

Run the `SET_UP_QUEUE` procedure to create a queue named `streams_queue` at `dbs1.net`. This queue will function as the Streams queue by holding the captured changes that will be propagated to other databases.

Running the `SET_UP_QUEUE` procedure performs the following actions:

- Creates a queue table named `streams_queue_table`. This queue table is owned by the Streams administrator (`strmadmin`) and uses the default storage of this user.
- Creates a queue named `streams_queue` owned by the Streams administrator (`strmadmin`).
- Starts the queue.

```
*/

EXEC DBMS_STREAMS_ADM.SET_UP_QUEUE();

/*
```

Step 5 Create the Database Link at dbs1.net

Create the database link from the database where changes are captured to the database where changes are propagated. In this example, the database where changes are captured is `dbs1.net`, and these changes are propagated to `dbs2.net`.

```
*/

CREATE DATABASE LINK dbs2.net CONNECT TO strmadmin IDENTIFIED BY strmadminpw
   USING 'dbs2.net';

/*
```

Step 6 Set Up Users at dbs2.net

Connect to `dbs2.net` as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@dbs2.net AS SYSDBA

/*
```

Create the Streams administrator named `strmadmin` and grant this user the necessary privileges. These privileges enable the user to manage queues, execute subprograms in packages related to Streams, create rule sets, create rules, and monitor the Streams environment by querying data dictionary views and queue tables. You may choose a different name for this user.

Note:

- To ensure security, use a password other than `strmadminpw` for the Streams administrator.
- The `SELECT_CATALOG_ROLE` is not required for the Streams administrator. It is granted in this example so that the Streams administrator can monitor the environment easily.
- If you plan to use the Streams tool in Oracle Enterprise Manager, then grant the Streams administrator `SELECT ANY DICTIONARY` privilege, in addition to the privileges shown in this step.
- The `ACCEPT` command must appear on a single line in the script.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

GRANT CONNECT, RESOURCE, SELECT_CATALOG_ROLE
  TO strmadmin IDENTIFIED BY strmadminpw;

ACCEPT streams_tbs PROMPT 'Enter the tablespace for the Streams administrator on
dbs2.net: '

ALTER USER strmadmin DEFAULT TABLESPACE &streams_tbs
                     QUOTA UNLIMITED ON &streams_tbs;

GRANT EXECUTE ON DBMS_APPLY_ADM        TO strmadmin;
GRANT EXECUTE ON DBMS_AQADM            TO strmadmin;
GRANT EXECUTE ON DBMS_CAPTURE_ADM      TO strmadmin;
GRANT EXECUTE ON DBMS_PROPAGATION_ADM  TO strmadmin;
GRANT EXECUTE ON DBMS_STREAMS_ADM      TO strmadmin;

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/
```

```
BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

/*
```

Step 7 Create the Streams Queue at dbs2.net

Connect as the Streams administrator at `dbs2.net`.

```
*/

CONNECT strmadmin/strmadminpw@dbs2.net

/*
```

Run the `SET_UP_QUEUE` procedure to create a queue named `streams_queue` at `dbs2.net`. This queue will function as the Streams queue by holding the changes that will be applied at this database and the changes that will be propagated to other databases.

Running the `SET_UP_QUEUE` procedure performs the following actions:

- Creates a queue table named `streams_queue_table`. This queue table is owned by the Streams administrator (`strmadmin`) and uses the default storage of this user.
- Creates a queue named `streams_queue` owned by the Streams administrator (`strmadmin`).
- Starts the queue.

```
*/

EXEC  DBMS_STREAMS_ADM.SET_UP_QUEUE();

/*
```

Step 8 Create the Database Links at dbs2.net

Create the database links to the databases where changes are propagated. In this example, database dbs2.net propagates changes to dbs3.net, which is another Oracle database, and to dbs4.net, which is a Sybase database. Notice that the database link to the Sybase database connects to the owner of the tables, not to the Streams administrator. This database link can connect to any user at dbs4.net that has privileges to change the hr.jobs table at that database.

> **Note:** On some non-Oracle databases, including Sybase, you must ensure that the characters in the username and password are in the correct case. Therefore, double quotation marks are specified for the username and password at the Sybase database.

```
*/

CREATE DATABASE LINK dbs3.net CONNECT TO strmadmin IDENTIFIED BY strmadminpw
   USING 'dbs3.net';

CREATE DATABASE LINK dbs4.net CONNECT TO "hr" IDENTIFIED BY "hrpass"
   USING 'dbs4.net';

/*
```

Step 9 Create the hr.assignments Table at dbs2.net

This example illustrates a transformation in which changes to the hr.jobs table at dbs1.net are transformed into changes to the hr.assignments table at dbs2.net. You must create the hr.assignments table on dbs2.net for the transformation portion of this example to work properly.

Connect as hr at dbs2.net.

```
*/

CONNECT hr/hr@dbs2.net

/*
```

Create the hr.assignments table in the dbs2.net database.

```
*/

CREATE TABLE hr.assignments AS SELECT * FROM hr.jobs;

ALTER TABLE hr.assignments ADD PRIMARY KEY (job_id);

/*
```

Step 10 Set Up Users at dbs3.net

Connect to dbs3.net as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@dbs3.net AS SYSDBA

/*
```

Create the Streams administrator named strmadmin and grant this user the necessary privileges. These privileges enable the user to manage queues, execute subprograms in packages related to Streams, create rule sets, create rules, and monitor the Streams environment by querying data dictionary views and queue tables. You may choose a different name for this user.

Note:

- To ensure security, use a password other than strmadminpw for the Streams administrator.
- The SELECT_CATALOG_ROLE is not required for the Streams administrator. It is granted in this example so that the Streams administrator can monitor the environment easily.
- If you plan to use the Streams tool in Oracle Enterprise Manager, then grant the Streams administrator SELECT ANY DICTIONARY privilege, in addition to the privileges shown in this step.
- The ACCEPT command must appear on a single line in the script.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

GRANT CONNECT, RESOURCE, SELECT_CATALOG_ROLE
  TO strmadmin IDENTIFIED BY strmadminpw;

ACCEPT streams_tbs PROMPT 'Enter the tablespace for the Streams administrator on
dbs3.net: '

ALTER USER strmadmin DEFAULT TABLESPACE &streams_tbs
                     QUOTA UNLIMITED ON &streams_tbs;

GRANT EXECUTE ON DBMS_APPLY_ADM        TO strmadmin;
GRANT EXECUTE ON DBMS_AQADM            TO strmadmin;
GRANT EXECUTE ON DBMS_CAPTURE_ADM      TO strmadmin;
GRANT EXECUTE ON DBMS_PROPAGATION_ADM  TO strmadmin;
GRANT EXECUTE ON DBMS_STREAMS_ADM      TO strmadmin;

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

/*
```

Step 11 Create the Streams Queue at dbs3.net

Connect as the Streams administrator at `dbs3.net`.

```
*/

CONNECT strmadmin/strmadminpw@dbs3.net

/*
```

Run the SET_UP_QUEUE procedure to create a queue named streams_queue at dbs3.net. This queue will function as the Streams queue by holding the changes that will be applied at this database.

Running the SET_UP_QUEUE procedure performs the following actions:

- Creates a queue table named streams_queue_table. This queue table is owned by the Streams administrator (strmadmin) and uses the default storage of this user.
- Creates a queue named streams_queue owned by the Streams administrator (strmadmin).
- Starts the queue.

```
*/

EXEC  DBMS_STREAMS_ADM.SET_UP_QUEUE();

/*
```

Step 12 Drop All of the Tables in the hr Schema at dbs3.net

This example illustrates instantiating tables in the hr schema by exporting them from dbs1.net and importing them into dbs3.net. You must delete these tables at dbs3.net for the instantiation portion of this example to work properly.

Connect as hr at dbs3.net.

```
*/

CONNECT hr/hr@dbs3.net

/*
```

Drop all tables in the hr schema in the dbs3.net database.

> **Attention:** If you complete this step and drop all of the tables in the hr schema, then you should complete the remaining sections of this example to reinstantiate the hr schema at dbs3.net. If the hr schema does not exist in an Oracle database, then some examples in the Oracle documentation set may fail.

```
*/

DROP TABLE hr.countries CASCADE CONSTRAINTS;
DROP TABLE hr.departments CASCADE CONSTRAINTS;
DROP TABLE hr.employees CASCADE CONSTRAINTS;
DROP TABLE hr.job_history CASCADE CONSTRAINTS;
DROP TABLE hr.jobs CASCADE CONSTRAINTS;
DROP TABLE hr.locations CASCADE CONSTRAINTS;
DROP TABLE hr.regions CASCADE CONSTRAINTS;

/*
```

Step 13 Check the Spool Results

Check the `streams_setup_single.out` spool file to ensure that all actions finished successfully after this script is completed.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT ****************************/
```

Example Scripts for Sharing Data from One Database

This example illustrates two ways to accomplish the replication of the tables in the `hr` schema using Streams.

- "Simple Configuration for Sharing Data from a Single Database" on page 19-21 demonstrates a simple way to configure the environment. This example uses the `DBMS_STREAMS_ADM` package to create a capture process, propagation jobs, and apply processes, as well as the rule sets associated with these processes and jobs. Using the `DBMS_STREAMS_ADM` package is the simplest way to configure a Streams environment.
- "Flexible Configuration for Sharing Data from a Single Database" on page 19-40 demonstrates a more flexible way to configure this environment. This example uses the `DBMS_CAPTURE_ADM` package to create a capture process, the `DBMS_PROPAGATION_ADM` package to create propagation jobs, and the `DBMS_APPLY_ADM` package to create apply processes. Also, this example uses the `DBMS_RULES_ADM` package to create and populate the rule sets associated with these processes and jobs. Using these packages, instead of the `DBMS_STREAMS_ADM` package, provides more configuration options and flexibility.

Note: These examples illustrate two different ways to configure the same Streams environment. Therefore, you should run only one of the examples for a particular distributed database system. Otherwise, errors stating that objects already exist will result.

Simple Configuration for Sharing Data from a Single Database

Complete the following steps to specify the capture, propagation, and apply definitions using primarily the DBMS_STEAMS_ADM package.

1. Show Output and Spool Results
2. Create an Alternate Tablespace for the LogMiner Tables at dbs1.net
3. Specify Supplemental Logging at dbs1.net
4. Configure Propagation at dbs1.net
5. Configure the Capture Process at dbs1.net
6. Set the Instantiation SCN for the Existing Tables at Other Databases
7. Instantiate the dbs1.net Tables at dbs3.net
8. Configure the Apply Process at dbs3.net
9. Specify hr as the Apply User for the Apply Process at dbs3.net
10. Grant the hr User Execute Privilege on the Apply Process Rule Set
11. Start the Apply Process at dbs3.net
12. Configure Propagation at dbs2.net
13. Create the Transformation for Row LCRs at dbs2.net
14. Configure the Apply Process for Local Apply at dbs2.net
15. Specify hr as the Apply User for the Apply Process at dbs2.net
16. Grant the hr User Execute Privilege on the Apply Process Rule Set
17. Start the Apply Process at dbs2.net for Local Apply
18. Configure the Apply Process at dbs2.net for Apply at dbs4.net
19. Start the Apply Process at dbs2.net for Apply at dbs4.net
20. Start the Capture Process at dbs1.net
21. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 19-39 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************ BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run SET ECHO ON and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_share_schema1.out

/*
```

Step 2 Create an Alternate Tablespace for the LogMiner Tables at dbs1.net

By default, the LogMiner tables are in the SYSTEM tablespace, but the SYSTEM tablespace may not have enough space for these tables once a capture process starts to capture changes. Therefore, you must create an alternate tablespace for the LogMiner tables.

See Also: "Alternate Tablespace for LogMiner Tables" on page 2-14

Connect to dbs1.net as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@dbs1.net AS SYSDBA

/*
```

Create an alternate tablespace for the LogMiner tables.

> **Note:** Each ACCEPT command must appear on a single line in the script.

```
*/

ACCEPT tspace_name DEFAULT 'logmnrts' PROMPT 'Enter the name of the tablespace
(for example, logmnrts): '

ACCEPT db_file_directory DEFAULT '' PROMPT 'Enter the complete path to the
datafile directory (for example, /usr/oracle/dbs): '

ACCEPT db_file_name DEFAULT 'logmnrts.dbf' PROMPT 'Enter the name of the
datafile (for example, logmnrts.dbf): '

CREATE TABLESPACE &tspace_name DATAFILE '&db_file_directory/&db_file_name'
  SIZE 25 M REUSE AUTOEXTEND ON MAXSIZE UNLIMITED;

EXECUTE DBMS_LOGMNR_D.SET_TABLESPACE('&tspace_name');

/*
```

Step 3 Specify Supplemental Logging at dbs1.net

Supplemental logging places additional information in the redo log for changes made to tables. The apply process needs this extra information to perform certain operations, such as unique row identification and conflict resolution. Because `dbs1.net` is the only database where changes are captured in this environment, it is the only database where you must specify supplemental logging for the tables in the `hr` schema.

Specify an unconditional supplemental log group for all primary key columns in the `hr` schema.

See Also:

- "Supplemental Logging" on page 2-9
- "Specifying Supplemental Logging at a Source Database" on page 11-9

```
*/

ALTER TABLE hr.countries ADD SUPPLEMENTAL LOG GROUP log_group_countries_pk
  (country_id) ALWAYS;

ALTER TABLE hr.departments ADD SUPPLEMENTAL LOG GROUP log_group_departments_pk
  (department_id) ALWAYS;

ALTER TABLE hr.employees ADD SUPPLEMENTAL LOG GROUP log_group_employees_pk
  (employee_id) ALWAYS;

ALTER TABLE hr.jobs ADD SUPPLEMENTAL LOG GROUP log_group_jobs_pk
  (job_id) ALWAYS;

ALTER TABLE hr.job_history ADD SUPPLEMENTAL LOG GROUP log_group_job_history_pk
  (employee_id, start_date) ALWAYS;

ALTER TABLE hr.locations ADD SUPPLEMENTAL LOG GROUP log_group_locations_pk
  (location_id) ALWAYS;

ALTER TABLE hr.regions ADD SUPPLEMENTAL LOG GROUP log_group_regions_pk
  (region_id) ALWAYS;

ALTER SYSTEM ARCHIVE LOG CURRENT;

/*
```

Step 4 Configure Propagation at dbs1.net

Connect to `dbs1.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs1.net

/*
```

Configure and schedule propagation of DML and DDL changes in the hr schema from the queue at dbs1.net to the queue at dbs2.net.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_PROPAGATION_RULES(
    schema_name              => 'hr',
    streams_name             => 'dbs1_to_dbs2',
    source_queue_name        => 'strmadmin.streams_queue',
    destination_queue_name   => 'strmadmin.streams_queue@dbs2.net',
    include_dml              =>  true,
    include_ddl              =>  true,
    source_database          => 'dbs1.net');
END;
/

/*
```

Step 5 Configure the Capture Process at dbs1.net

Configure the capture process to capture changes to the entire hr schema at dbs1.net. This step specifies that changes to the tables in the specified schema are captured by the capture process and enqueued into the specified queue.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name    => 'hr',
    streams_type   => 'capture',
    streams_name   => 'capture',
    queue_name     => 'strmadmin.streams_queue',
    include_dml    =>  true,
    include_ddl    =>  true);
END;
/

/*
```

Step 6 Set the Instantiation SCN for the Existing Tables at Other Databases

In this example, the hr.jobs table already exists at dbs2.net and dbs4.net. At dbs2.net, this table is named assignments, but it has the same shape and data as the jobs table at dbs1.net. Also, in this example, dbs4.net is a Sybase database. All of the other tables in the Streams environment are instantiated at the other databases using Export/Import.

Because the hr.jobs table already exists at dbs2.net and dbs4.net, this example uses the GET_SYSTEM_CHANGE_NUMBER function in the DBMS_FLASHBACK package at dbs1.net to obtain the current SCN for the database. This SCN is used at dbs2.net to run the SET_TABLE_INSTANTIATION_SCN procedure in the DBMS_APPLY_ADM package. Running this procedure twice sets the instantiation SCN for the hr.jobs table at dbs2.net and dbs4.net.

The SET_TABLE_INSTANTIATION_SCN procedure controls which LCRs for a table are ignored by an apply process and which LCRs for a table are applied by an apply process. If the commit SCN of an LCR for a table from a source database is less than or equal to the instantiation SCN for that table at a destination database, then the apply process at the destination database discards the LCR. Otherwise, the apply process applies the LCR.

In this example, both of the apply processes at dbs2.net will apply transactions to the hr.jobs table with SCNs that were committed after SCN obtained in this step.

Note: This example assumes that the contents of the hr.jobs table at dbs1.net, dbs2.net (as hr.assignments), and dbs4.net are consistent when you complete this step. You may want to lock the table at each database while you complete this step to ensure consistency.

```
*/

DECLARE
  iscn  NUMBER;         -- Variable to hold instantiation SCN value
BEGIN
  iscn := DBMS_FLASHBACK.GET_SYSTEM_CHANGE_NUMBER();
  DBMS_APPLY_ADM.SET_TABLE_INSTANTIATION_SCN@DBS2.NET(
    source_object_name    => 'hr.jobs',
    source_database_name  => 'dbs1.net',
    instantiation_scn     => iscn);
  DBMS_APPLY_ADM.SET_TABLE_INSTANTIATION_SCN@DBS2.NET(
    source_object_name    => 'hr.jobs',
    source_database_name  => 'dbs1.net',
    instantiation_scn     => iscn,
    apply_database_link   => 'dbs4.net');
END;
/

/*
```

Step 7 Instantiate the dbs1.net Tables at dbs3.net

Open a different window and export the tables at `dbs1.net` that will be instantiated at `dbs3.net`. Make sure you set the `OBJECT_CONSISTENT` export parameter to `y` when you run the export command. Also, make sure no DDL changes are made to the objects being exported during the export.

The following is an example export command:

```
exp userid=hr/hr FILE=hr_instant1.dmp TABLES=countries,locations,regions
OBJECT_CONSISTENT=y
```

> **See Also:** *Oracle9i Database Utilities* for information about performing an export

```
*/

PAUSE Press <RETURN> to continue when the export is complete in the other window
that you opened.

/*
```

Transfer the export dump file `hr_instant1.dmp` to the destination database. In this example, the destination database is `dbs3.net`.

You can use binary FTP or some other method to transfer the export dump file to the destination database. You may need to open a different window to transfer the file.

```
*/

PAUSE Press <RETURN> to continue after transferring the dump file.

/*
```

In a different window, connect to the computer that runs the `dbs3.net` database and import the export dump file `hr_instant1.dmp` to instantiate the `countries`, `locations`, and `regions` tables in the `dbs3.net` database. You can use telnet or remote login to connect to the computer that runs `dbs3.net`.

When you run the import command, make sure you set the `STREAMS_INSTANTIATION` import parameter to `y`. This parameter ensures that the import records export SCN information for each object imported.

The following is an example import command:

```
imp userid=hr/hr FILE=hr_instant1.dmp IGNORE=y FULL=y COMMIT=y LOG=import.log
STREAMS_INSTANTIATION=y
```

> **See Also:** *Oracle9i Database Utilities* for information about performing an import

```
*/

PAUSE Press <RETURN> to continue after the import is complete at dbs3.net.

/*
```

Step 8 Configure the Apply Process at dbs3.net

Connect to `dbs3.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs3.net

/*
```

Configure `dbs3.net` to apply changes to the `countries` table, `locations` table, and `regions` table.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name      => 'hr.countries',
    streams_type    => 'apply',
    streams_name    => 'apply',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'dbs1.net');
END;
/

BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name      => 'hr.locations',
    streams_type    => 'apply',
    streams_name    => 'apply',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'dbs1.net');
END;
/

BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name      => 'hr.regions',
    streams_type    => 'apply',
    streams_name    => 'apply',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'dbs1.net');
END;
/

/*
```

Step 9 Specify hr as the Apply User for the Apply Process at dbs3.net

In this example, the `hr` user owns all of the database objects for which changes are applied by the apply process at this database. Therefore, `hr` already has the necessary privileges to change these database objects, and it is convenient to make `hr` the apply user.

When the apply process was created in the previous step, the Streams administrator `strmadmin` was specified as the apply user by default, because `strmadmin` ran the procedure that created the apply process. Instead of specifying hr as the apply user, you could retain `strmadmin` as the apply user, but then you must grant `strmadmin` privileges on all of the database objects for which changes are applied and privileges to execute all user procedures used by the apply process. In an environment where an apply process applies changes to database objects in multiple schemas, it may be more convenient to use the Streams administrator as the apply user.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name => 'apply',
    apply_user => 'hr');
END;
/

/*
```

Step 10 Grant the hr User Execute Privilege on the Apply Process Rule Set

Because the hr user was specified as the apply user in the previous step, the hr user requires execute privilege on the rule set used by the apply process

```
*/

DECLARE
   rs_name  VARCHAR2(64);   -- Variable to hold rule set name
BEGIN
  SELECT RULE_SET_OWNER||'.'||RULE_SET_NAME
    INTO rs_name
    FROM DBA_APPLY
    WHERE APPLY_NAME='APPLY';
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege   => SYS.DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name => rs_name,
    grantee     => 'hr');
END;
/

/*
```

Step 11 Start the Apply Process at dbs3.net

Set the disable_on_error parameter to n so that the apply process will not be disabled if it encounters an error, and start the apply process at dbs3.net.

```
*/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply');
END;
/

/*
```

Step 12 Configure Propagation at dbs2.net

Connect to dbs2.net as the strmadmin user.

```
*/

CONNECT strmadmin/strmadminpw@dbs2.net

/*
```

Configure and schedule propagation from the queue at dbs2.net to the queue at dbs3.net. You must specify this propagation for each table that will apply changes at dbs3.net. This configuration is an example of directed networks because the changes at dbs2.net originated at dbs1.net.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_PROPAGATION_RULES(
    table_name               => 'hr.countries',
    streams_name             => 'dbs2_to_dbs3',
    source_queue_name        => 'strmadmin.streams_queue',
    destination_queue_name   => 'strmadmin.streams_queue@dbs3.net',
    include_dml              =>  true,
    include_ddl              =>  true,
    source_database          => 'dbs1.net');
END;
/

BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_PROPAGATION_RULES(
    table_name               => 'hr.locations',
    streams_name             => 'dbs2_to_dbs3',
    source_queue_name        => 'strmadmin.streams_queue',
    destination_queue_name   => 'strmadmin.streams_queue@dbs3.net',
    include_dml              =>  true,
    include_ddl              =>  true,
    source_database          => 'dbs1.net');
END;
/
```

```
BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_PROPAGATION_RULES(
    table_name              => 'hr.regions',
    streams_name            => 'dbs2_to_dbs3',
    source_queue_name       => 'strmadmin.streams_queue',
    destination_queue_name  => 'strmadmin.streams_queue@dbs3.net',
    include_dml             =>  true,
    include_ddl             =>  true,
    source_database         => 'dbs1.net');
END;
/

/*
```

Step 13 Create the Transformation for Row LCRs at dbs2.net

Connect to `dbs2.net` as the `hr` user.

```
*/

CONNECT hr/hr@dbs2.net

/*
```

Create the transformation function that transforms row changes resulting from DML statements to the `jobs` table from `dbs1.net` into row changes to the `assignments` table on `dbs2.net`.

The following function transforms every row LCR for the `jobs` table into a row LCR for the `assignments` table.

> **Note:** If DDL changes were also applied to the `assignments` table, then another transformation would be required for the DDL LCRs. This transformation would need to change the object name and the DDL text.

```
*/

CREATE OR REPLACE FUNCTION hr.to_assignments_trans_dml(
  p_in_data in SYS.AnyData)
  RETURN SYS.AnyData IS out_data SYS.LCR$_ROW_RECORD;
  tc   pls_integer;
BEGIN
  -- Typecast AnyData to LCR$_ROW_RECORD
     tc := p_in_data.GetObject(out_data);
     IF out_data.get_object_name() = 'JOBS'
     THEN
  -- Transform the in_data into the out_data
     out_data.set_object_name('ASSIGNMENTS');
     END IF;
  -- Convert to AnyData
     RETURN SYS.AnyData.ConvertObject(out_data);
END;
/

/*
```

Step 14 Configure the Apply Process for Local Apply at dbs2.net

Connect to `dbs2.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs2.net

/*
```

Configure dbs2.net to apply changes to the assignments table. Remember that the assignments table receives changes from the jobs table at dbs1.net.

```
*/

DECLARE
  to_assignments_rulename_dml   VARCHAR2(30);
  dummy_rule                    VARCHAR2(30);
  action_ctx_dml                SYS.RE$NV_LIST;
  ac_name                       VARCHAR2(30) := 'STREAMS$_TRANSFORM_FUNCTION';
BEGIN
--  DML changes to the jobs table from dbs1.net are applied to the assignments
--  table. The to_assignments_rulename_dml variable is an out parameter
--  in this call.
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name      => 'hr.jobs', -- jobs, not assignments, specified
    streams_type    => 'apply',
    streams_name    => 'apply_dbs2',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     => true,
    include_ddl     => false,
    source_database => 'dbs1.net',
    dml_rule_name   => to_assignments_rulename_dml,
    ddl_rule_name   => dummy_rule);
-- Specify the name-value pair in the action context
  action_ctx_dml := SYS.RE$NV_LIST(SYS.RE$NV_ARRAY());
  action_ctx_dml.ADD_PAIR(
    ac_name,
    SYS.ANYDATA.CONVERTVARCHAR2('hr.to_assignments_trans_dml'));
--  Modify the rule for jobs to use the transformation.
  DBMS_RULE_ADM.ALTER_RULE(
    rule_name        => to_assignments_rulename_dml,
    action_context   => action_ctx_dml);
END;
/

/*
```

Step 15 Specify hr as the Apply User for the Apply Process at dbs2.net

In this example, the hr user owns all of the database objects for which changes are applied by the apply process at this database. Therefore, hr already has the necessary privileges to change these database objects, and it is convenient to make hr the apply user.

When the apply process was created in the previous step, the Streams administrator `strmadmin` was specified as the apply user by default, because `strmadmin` ran the procedure that created the apply process. Instead of specifying hr as the apply user, you could retain `strmadmin` as the apply user, but then you must grant `strmadmin` privileges on all of the database objects for which changes are applied and privileges to execute all user procedures used by the apply process. In an environment where an apply process applies changes to database objects in multiple schemas, it may be more convenient to use the Streams administrator as the apply user.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name => 'apply_dbs2',
    apply_user => 'hr');
END;
/

/*
```

Step 16 Grant the hr User Execute Privilege on the Apply Process Rule Set

Because the `hr` user was specified as the apply user in the previous step, the `hr` user requires execute privilege on the rule set used by the apply process

```
*/

DECLARE
   rs_name  VARCHAR2(64);   -- Variable to hold rule set name
BEGIN
  SELECT RULE_SET_OWNER||'.'||RULE_SET_NAME
    INTO rs_name
    FROM DBA_APPLY
    WHERE APPLY_NAME='APPLY_DBS2';
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege   => SYS.DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name => rs_name,
    grantee     => 'hr');
END;
/

/*
```

Step 17 Start the Apply Process at dbs2.net for Local Apply

Set the `disable_on_error` parameter to `n` so that the apply process will not be disabled if it encounters an error, and start the apply process for local apply at `dbs2.net`.

```
*/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply_dbs2',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply_dbs2');
END;
/

/*
```

Step 18 Configure the Apply Process at dbs2.net for Apply at dbs4.net

Configure the apply process for `dbs4.net`, which is a Sybase database. The `dbs2.net` database is acting as a gateway to `dbs4.net`. Therefore, the apply process for `dbs4.net` must be configured at `dbs2.net`. The apply process cannot apply DDL changes to non-Oracle databases. Therefore, the `include_ddl` parameter is set to `false` when the `ADD_TABLE_RULES` procedure is run.

```
*/

BEGIN
  DBMS_APPLY_ADM.CREATE_APPLY(
    queue_name          => 'strmadmin.streams_queue',
    apply_name          => 'apply_dbs4',
    apply_database_link => 'dbs4.net',
    apply_captured      => true);
END;
/
```

```
BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name      => 'hr.jobs',
    streams_type    => 'apply',
    streams_name    => 'apply_dbs4',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  false,
    source_database => 'dbs1.net');
END;
/

/*
```

Step 19 Start the Apply Process at dbs2.net for Apply at dbs4.net

Set the `disable_on_error` parameter to `n` so that the apply process will not be disabled if it encounters an error, and start the remote apply for Sybase using database link `dbs4.net`.

```
*/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply_dbs4',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply_dbs4');
END;
/

/*
```

Step 20 Start the Capture Process at dbs1.net

Connect to `dbs1.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs1.net

/*
```

Start the capture process at `dbs1.net`.

```
*/

BEGIN
  DBMS_CAPTURE_ADM.START_CAPTURE(
    capture_name  => 'capture');
END;
/

/*
```

Step 21 Check the Spool Results

Check the `streams_share_schema1.out` spool file to ensure that all actions finished successfully after this script is completed.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT ****************************/
```

Flexible Configuration for Sharing Data from a Single Database

Complete the following steps to use a more flexible approach for specifying the capture, propagation, and apply definitions. This approach does not use the DBMS_STREAMS_ADM package. Instead, it uses the following packages:

- The DBMS_CAPTURE_ADM package to configure capture processes
- The DBMS_PROPAGATION_ADM package to configure propagation jobs
- The DBMS_APPLY_ADM package to configure apply processes
- The DBMS_RULES_ADM package to specify capture, propagation, and apply rules and rule sets

> **Note:** Neither the ALL_STREAMS_TABLE_RULES nor the DBA_STREAMS_TABLE_RULES data dictionary view is populated by the rules created in this example. To view the rules created in this example, you must query the ALL_RULES, DBA_RULES, or USER_RULES data dictionary view.

This example includes the following steps:

1. Show Output and Spool Results
2. Create an Alternate Tablespace for the LogMiner Tables at dbs1.net
3. Specify Supplemental Logging at dbs1.net
4. Configure Propagation at dbs1.net
5. Configure the Capture Process at dbs1.net
6. Prepare the hr Schema at dbs1.net for Instantiation
7. Set the Instantiation SCN for the Existing Tables at Other Databases
8. Instantiate the dbs1.net Tables at dbs3.net
9. Configure the Apply Process at dbs3.net
10. Grant the hr User Execute Privilege on the Apply Process Rule Set
11. Start the Apply Process at dbs3.net
12. Configure Propagation at dbs2.net
13. Create the Transformation for Row LCRs at dbs2.net
14. Configure the Apply Process for Local Apply at dbs2.net

15. Grant the hr User Execute Privilege on the Apply Process Rule Set
16. Start the Apply Process at dbs2.net for Local Apply
17. Configure the Apply Process at dbs2.net for Apply at dbs4.net
18. Start the Apply Process at dbs2.net for Apply at dbs4.net
19. Start the Capture Process at dbs1.net
20. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 19-59 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************* BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run `SET ECHO ON` and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_share_schema2.out

/*
```

Step 2 Create an Alternate Tablespace for the LogMiner Tables at dbs1.net

By default, the LogMiner tables are in the `SYSTEM` tablespace, but the `SYSTEM` tablespace may not have enough space for these tables once a capture process starts to capture changes. Therefore, you must create an alternate tablespace for the LogMiner tables.

See Also: "Alternate Tablespace for LogMiner Tables" on page 2-14

Connect to dbs1.net as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@dbs1.net AS SYSDBA

/*
```

Create an alternate tablespace for the LogMiner tables.

> **Note:** Each ACCEPT command must appear on a single line in the script.

```
*/

ACCEPT tspace_name DEFAULT 'logmnrts' PROMPT 'Enter the name of the tablespace
(for example, logmnrts): '

ACCEPT db_file_directory DEFAULT '' PROMPT 'Enter the complete path to the
datafile directory (for example, /usr/oracle/dbs): '

ACCEPT db_file_name DEFAULT 'logmnrts.dbf' PROMPT 'Enter the name of the
datafile (for example, logmnrts.dbf): '

CREATE TABLESPACE &tspace_name DATAFILE '&db_file_directory/&db_file_name'
  SIZE 25 M REUSE AUTOEXTEND ON MAXSIZE UNLIMITED;

EXECUTE DBMS_LOGMNR_D.SET_TABLESPACE('&tspace_name');

/*
```

Step 3 Specify Supplemental Logging at dbs1.net

Supplemental logging places additional information in the redo log for changes made to tables. The apply process needs this extra information to perform certain operations, such as unique row identification and conflict resolution. Because dbs1.net is the only database where changes are captured in this environment, it is the only database where you must specify supplemental logging for the tables in the hr schema.

Specify an unconditional supplemental log group for all primary key columns in the hr schema.

See Also:

- "Supplemental Logging" on page 2-9
- "Specifying Supplemental Logging at a Source Database" on page 11-9

```
*/

ALTER TABLE hr.countries ADD SUPPLEMENTAL LOG GROUP log_group_countries_pk
  (country_id) ALWAYS;

ALTER TABLE hr.departments ADD SUPPLEMENTAL LOG GROUP log_group_departments_pk
  (department_id) ALWAYS;

ALTER TABLE hr.employees ADD SUPPLEMENTAL LOG GROUP log_group_employees_pk
  (employee_id) ALWAYS;

ALTER TABLE hr.jobs ADD SUPPLEMENTAL LOG GROUP log_group_jobs_pk
  (job_id) ALWAYS;

ALTER TABLE hr.job_history ADD SUPPLEMENTAL LOG GROUP log_group_job_history_pk
  (employee_id, start_date) ALWAYS;

ALTER TABLE hr.locations ADD SUPPLEMENTAL LOG GROUP log_group_locations_pk
  (location_id) ALWAYS;

ALTER TABLE hr.regions ADD SUPPLEMENTAL LOG GROUP log_group_regions_pk
  (region_id) ALWAYS;

ALTER SYSTEM ARCHIVE LOG CURRENT;

/*
```

Step 4 Configure Propagation at dbs1.net

Connect to `dbs1.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs1.net

/*
```

Configure and schedule propagation from the queue at `dbs1.net` to the queue at `dbs2.net`. This configuration specifies that the propagation job propagates all changes to the `hr` schema. You have the option of omitting the rule set specification, but then everything in the queue will be propagated, which may not be desired if, in the future, multiple capture processes will use the `streams_queue`.

```
*/

BEGIN
  -- Create the rule set
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name       => 'strmadmin.propagation_dbs1_rules',
    evaluation_context  => 'SYS.STREAMS$_EVALUATION_CONTEXT');
  -- Create rules for all modifications to the hr schema
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name  => 'strmadmin.all_hr_dml',
    condition  => ' :dml.get_object_owner() = ''HR'' AND ' ||
                  ' :dml.is_null_tag() = ''Y'' AND ' ||
                  ' :dml.get_source_database_name() = ''DBS1.NET'' ');
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name  => 'strmadmin.all_hr_ddl',
    condition  => ' :ddl.get_object_owner() = ''HR''  AND ' ||
                  ' :ddl.is_null_tag() = ''Y'' AND ' ||
                  ' :ddl.get_source_database_name() = ''DBS1.NET'' ');
  -- Add rules to rule set
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_hr_dml',
    rule_set_name  => 'strmadmin.propagation_dbs1_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_hr_ddl',
    rule_set_name  => 'strmadmin.propagation_dbs1_rules');
  -- Create the propagation job
  DBMS_PROPAGATION_ADM.CREATE_PROPAGATION(
    propagation_name    => 'dbs1_to_dbs2',
    source_queue        => 'strmadmin.streams_queue',
    destination_queue   => 'strmadmin.streams_queue',
    destination_dblink  => 'dbs2.net',
    rule_set_name       => 'strmadmin.propagation_dbs1_rules');
END;
/

/*
```

Step 5 Configure the Capture Process at dbs1.net

Create a capture process and rules to capture the entire hr schema at dbs1.net.

```
*/

BEGIN
  -- Create the rule set
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name       => 'strmadmin.demo_rules',
    evaluation_context  => 'SYS.STREAMS$_EVALUATION_CONTEXT');
  --   Create rules that specify the entire hr schema
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name  => 'strmadmin.schema_hr_dml',
    condition  => ' :dml.get_object_owner() = ''HR''  AND ' ||
                  ' :dml.is_null_tag() = ''Y'' AND ' ||
                  ' :dml.get_source_database_name() = ''DBS1.NET'' ');
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name  => 'strmadmin.schema_hr_ddl',
    condition  => ' :ddl.get_object_owner() = ''HR''  AND ' ||
                  ' :ddl.is_null_tag() = ''Y'' AND ' ||
                  ' :ddl.get_source_database_name() = ''DBS1.NET'' ');
  --  Add the rules to the rule set
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.schema_hr_dml',
    rule_set_name  => 'strmadmin.demo_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.schema_hr_ddl',
    rule_set_name  => 'strmadmin.demo_rules');
  --  Create a capture process that uses the rule set
  DBMS_CAPTURE_ADM.CREATE_CAPTURE(
    queue_name    => 'strmadmin.streams_queue',
    capture_name  => 'capture',
    rule_set_name => 'strmadmin.demo_rules');
END;
/

/*
```

Step 6 Prepare the hr Schema at dbs1.net for Instantiation

While still connected as the Streams administrator at dbs1.net, prepare the hr schema at dbs1.net for instantiation at dbs3.net. This step marks the lowest SCN of the tables in the schema for instantiation. SCNs subsequent to the lowest SCN can be used for instantiation.

> **Note:** This step is not required in the "Simple Configuration for Sharing Data from a Single Database" on page 19-21. In that example, when the ADD_SCHEMA_RULES procedure in the DBMS_STREAMS_ADM package is run in Step 5, the PREPARE_SCHEMA_INSTANTIATION procedure in the DBMS_CAPTURE_ADM package is run automatically for the hr schema.

```
*/

BEGIN
  DBMS_CAPTURE_ADM.PREPARE_SCHEMA_INSTANTIATION(
    schema_name   => 'hr');
END;
/

/*
```

Step 7 Set the Instantiation SCN for the Existing Tables at Other Databases

In this example, the hr.jobs table already exists at dbs2.net and dbs4.net. At dbs2.net, this table is named assignments, but it has the same shape and data as the jobs table at dbs1.net. Also, in this example, dbs4.net is a Sybase database. All of the other tables in the Streams environment are instantiated at the other databases using Export/Import.

Because the hr.jobs table already exists at dbs2.net and dbs4.net, this example uses the GET_SYSTEM_CHANGE_NUMBER function in the DBMS_FLASHBACK package at dbs1.net to obtain the current SCN for the database. This SCN is used at dbs2.net to run the SET_TABLE_INSTANTIATION_SCN procedure in the DBMS_APPLY_ADM package. Running this procedure twice sets the instantiation SCN for the hr.jobs table at dbs2.net and dbs4.net.

The SET_TABLE_INSTANTIATION_SCN procedure controls which LCRs for a table are ignored by an apply process and which LCRs for a table are applied by an apply process. If the commit SCN of an LCR for a table from a source database is less than or equal to the instantiation SCN for that table at a destination database, then the apply process at the destination database discards the LCR. Otherwise, the apply process applies the LCR.

In this example, both of the apply processes at dbs2.net will apply transactions to the hr.jobs table with SCNs that were committed after SCN obtained in this step.

Note: This example assumes that the contents of the hr.jobs table at dbs1.net, dbs2.net (as hr.assignments), and dbs4.net are consistent when you complete this step. You may want to lock the table at each database while you complete this step to ensure consistency.

```
*/

DECLARE
  iscn  NUMBER;         -- Variable to hold instantiation SCN value
BEGIN
  iscn := DBMS_FLASHBACK.GET_SYSTEM_CHANGE_NUMBER();
  DBMS_APPLY_ADM.SET_TABLE_INSTANTIATION_SCN@DBS2.NET(
    source_object_name    => 'hr.jobs',
    source_database_name  => 'dbs1.net',
    instantiation_scn     => iscn);
  DBMS_APPLY_ADM.SET_TABLE_INSTANTIATION_SCN@DBS2.NET(
    source_object_name    => 'hr.jobs',
    source_database_name  => 'dbs1.net',
    instantiation_scn     => iscn,
    apply_database_link   => 'dbs4.net');
END;
/

/*
```

Step 8 Instantiate the dbs1.net Tables at dbs3.net

Open a different window and export the tables at dbs1.net that will be instantiated at dbs3.net. Make sure you set the OBJECT_CONSISTENT export parameter to y when you run the export command. Also, make sure no DDL changes are made to the objects being exported during the export.

The following is an example export command:

```
exp userid=hr/hr FILE=hr_instant1.dmp TABLES=countries,locations,regions
OBJECT_CONSISTENT=y
```

See Also: *Oracle9i Database Utilities* for information about performing an export

```
*/

PAUSE Press <RETURN> to continue when the export is complete in the other window
that you opened.

/*
```

Transfer the export dump file `hr_instant1.dmp` to the destination database. In this example, the destination database is `dbs3.net`.

You can use binary FTP or some other method to transfer the export dump file to the destination database. You may need to open a different window to transfer the file.

```
*/

PAUSE Press <RETURN> to continue after transferring the dump file.

/*
```

In a different window, connect to the computer that runs the `dbs3.net` database and import the export dump file `hr_instant1.dmp` to instantiate the `countries`, `locations`, and `regions` tables in the `dbs3.net` database. You can use telnet or remote login to connect to the computer that runs `dbs3.net`.

When you run the import command, make sure you set the `STREAMS_INSTANTIATION` import parameter to `y`. This parameter ensures that the import records export SCN information for each object imported.

The following is an example import command:

```
imp userid=hr/hr FILE=hr_instant1.dmp IGNORE=y FULL=y COMMIT=y LOG=import.log
STREAMS_INSTANTIATION=y
```

> **See Also:** *Oracle9i Database Utilities* for information about performing an import

```
*/

PAUSE Press <RETURN> to continue after the import is complete at dbs3.net.

/*
```

Step 9 Configure the Apply Process at dbs3.net

Connect to `dbs3.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs3.net

/*
```

Configure `dbs3.net` to apply DML and DDL changes to the `countries` table, `locations` table, and `regions` table.

```
*/

BEGIN
  -- Create the rule set
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name       => 'strmadmin.apply_rules',
    evaluation_context  => 'SYS.STREAMS$_EVALUATION_CONTEXT');
  -- Rules for hr.countries
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name    => 'strmadmin.all_countries_dml',
    condition    => ' :dml.get_object_owner() = ''HR'' AND ' ||
                    ' :dml.get_object_name() = ''COUNTRIES''  AND ' ||
                    ' :dml.is_null_tag() = ''Y'' AND ' ||
                    ' :dml.get_source_database_name() = ''DBS1.NET'' ');
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name    => 'strmadmin.all_countries_ddl',
    condition    => ' :ddl.get_object_owner() = ''HR'' AND ' ||
                    ' :ddl.get_object_name() = ''COUNTRIES'' AND ' ||
                    ' :ddl.is_null_tag() = ''Y'' AND ' ||
                    ' :ddl.get_source_database_name() = ''DBS1.NET'' ');
  -- Rules for hr.locations
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name    => 'strmadmin.all_locations_dml',
    condition    => ' :dml.get_object_owner() = ''HR'' AND ' ||
                    ' :dml.get_object_name() = ''LOCATIONS'' AND ' ||
                    ' :dml.is_null_tag() = ''Y'' AND ' ||
                    ' :dml.get_source_database_name() = ''DBS1.NET'' ');
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name    => 'strmadmin.all_locations_ddl',
    condition    => ' :ddl.get_object_owner() = ''HR'' AND ' ||
                    ' :ddl.get_object_name() = ''LOCATIONS'' AND ' ||
                    ' :ddl.is_null_tag() = ''Y'' AND ' ||
                    ' :ddl.get_source_database_name() = ''DBS1.NET'' ');
```

```
  -- Rules for hr.regions
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name    => 'strmadmin.all_regions_dml',
    condition    => ' :dml.get_object_owner() = ''HR'' AND ' ||
                    ' :dml.get_object_name() = ''REGIONS'' AND ' ||
                    ' :dml.is_null_tag() = ''Y'' AND ' ||
                    ' :dml.get_source_database_name() = ''DBS1.NET'' ');
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name    => 'strmadmin.all_regions_ddl',
    condition    => ' :ddl.get_object_owner() = ''HR'' AND ' ||
                    ' :ddl.get_object_name() = ''REGIONS'' AND ' ||
                    ' :ddl.is_null_tag() = ''Y'' AND ' ||
                    ' :ddl.get_source_database_name() = ''DBS1.NET'' ');
  -- Add rules to rule set
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_countries_dml',
    rule_set_name  => 'strmadmin.apply_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_countries_ddl',
    rule_set_name  => 'strmadmin.apply_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_locations_dml',
    rule_set_name  => 'strmadmin.apply_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_locations_ddl',
    rule_set_name  => 'strmadmin.apply_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_regions_dml',
    rule_set_name  => 'strmadmin.apply_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_regions_ddl',
    rule_set_name  => 'strmadmin.apply_rules');
  -- Create the apply process
  DBMS_APPLY_ADM.CREATE_APPLY(
    queue_name     => 'strmadmin.streams_queue',
    apply_name     => 'apply',
    rule_set_name  => 'strmadmin.apply_rules',
    apply_user     => 'hr',
    apply_captured => true);
END;
/

/*
```

Step 10 Grant the hr User Execute Privilege on the Apply Process Rule Set

Because the `hr` user was specified as the apply user in the previous step, the `hr` user requires execute privilege on the rule set used by the apply process

```
*/

BEGIN
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege   => SYS.DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name => 'strmadmin.apply_rules',
    grantee     => 'hr');
END;
/

/*
```

Step 11 Start the Apply Process at dbs3.net

Set the `disable_on_error` parameter to `n` so that the apply process will not be disabled if it encounters an error, and start the apply process at `dbs3.net`.

```
*/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply');
END;
/

/*
```

Step 12 Configure Propagation at dbs2.net

Connect to `dbs2.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs2.net

/*
```

Configure and schedule propagation from the queue at `dbs2.net` to the queue at `dbs3.net`. This configuration is an example of directed networks because the changes at `dbs2.net` originated at `dbs1.net`.

```
*/

BEGIN
  -- Create the rule set
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name       => 'strmadmin.propagation_dbs3_rules',
    evaluation_context  => 'SYS.STREAMS$_EVALUATION_CONTEXT');
  -- Create rules for all modifications to the countries table
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name  => 'strmadmin.all_countries_dml',
    condition  => ' :dml.get_object_owner() = ''HR'' AND ' ||
                  ' :dml.get_object_name() = ''COUNTRIES'' AND ' ||
                  ' :dml.is_null_tag() = ''Y'' AND ' ||
                  ' :dml.get_source_database_name() = ''DBS1.NET'' ');
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name  => 'strmadmin.all_countries_ddl',
    condition  => ' :ddl.get_object_owner() = ''HR'' AND ' ||
                  ' :ddl.get_object_name() = ''COUNTRIES'' AND ' ||
                  ' :ddl.is_null_tag() = ''Y'' AND ' ||
                  ' :ddl.get_source_database_name() = ''DBS1.NET'' ');
  -- Create rules for all modifications to the locations table
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name   => 'strmadmin.all_locations_dml',
    condition  => ' :dml.get_object_owner() = ''HR'' AND ' ||
                  ' :dml.get_object_name() = ''LOCATIONS'' AND ' ||
                  ' :dml.is_null_tag() = ''Y'' AND ' ||
                  ' :dml.get_source_database_name() = ''DBS1.NET'' ');
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name   => 'strmadmin.all_locations_ddl',
    condition  => ' :ddl.get_object_owner() = ''HR'' AND ' ||
                  ' :ddl.get_object_name() = ''LOCATIONS'' AND ' ||
                  ' :ddl.is_null_tag() = ''Y'' AND ' ||
                  ' :ddl.get_source_database_name() = ''DBS1.NET'' ');
```

```
  -- Create rules for all modifications to the regions table
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name   => 'strmadmin.all_regions_dml',
    condition  => ' :dml.get_object_owner() = ''HR'' AND ' ||
                  ' :dml.get_object_name() = ''REGIONS'' AND ' ||
                  ' :dml.is_null_tag() = ''Y'' AND ' ||
                  ' :dml.get_source_database_name() = ''DBS1.NET'' ');
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name   => 'strmadmin.all_regions_ddl',
    condition  => ' :ddl.get_object_owner() = ''HR'' AND ' ||
                  ' :ddl.get_object_name() = ''REGIONS'' AND ' ||
                  ' :ddl.is_null_tag() = ''Y'' AND ' ||
                  ' :ddl.get_source_database_name() = ''DBS1.NET'' ');
  -- Add rules to rule set
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_countries_dml',
    rule_set_name  => 'strmadmin.propagation_dbs3_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_countries_ddl',
    rule_set_name  => 'strmadmin.propagation_dbs3_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_locations_dml',
    rule_set_name  => 'strmadmin.propagation_dbs3_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_locations_ddl',
    rule_set_name  => 'strmadmin.propagation_dbs3_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_regions_dml',
    rule_set_name  => 'strmadmin.propagation_dbs3_rules');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_regions_ddl',
    rule_set_name  => 'strmadmin.propagation_dbs3_rules');
  -- Create the propagation job
  DBMS_PROPAGATION_ADM.CREATE_PROPAGATION(
    propagation_name    => 'dbs2_to_dbs3',
    source_queue        => 'strmadmin.streams_queue',
    destination_queue   => 'strmadmin.streams_queue',
    destination_dblink  => 'dbs3.net',
    rule_set_name       => 'strmadmin.propagation_dbs3_rules');
END;
/

/*
```

Step 13 Create the Transformation for Row LCRs at dbs2.net

Connect to `dbs2.net` as the `hr` user.

```
*/

CONNECT hr/hr@dbs2.net

/*
```

Create the transformation function that transforms row changes resulting from DML statements to the `jobs` table from `dbs1.net` into row changes to the `assignments` table on `dbs2.net`.

The following function transforms every row LCR for the `jobs` table into a row LCR for the `assignments` table.

> **Note:** If DDL changes were also applied to the `assignments` table, then another transformation would be required for the DDL LCRs. This transformation would need to change the object name and the DDL text.

```
*/

CREATE OR REPLACE FUNCTION hr.to_assignments_trans_dml(
  p_in_data in SYS.AnyData)
  RETURN SYS.AnyData IS out_data SYS.LCR$_ROW_RECORD;
  tc   pls_integer;
BEGIN
  -- Typecast AnyData to LCR$_ROW_RECORD
     tc := p_in_data.GetObject(out_data);
     IF out_data.get_object_name() = 'JOBS'
     THEN
  -- Transform the in_data into the out_data
     out_data.set_object_name('ASSIGNMENTS');
     END IF;
  -- Convert to AnyData
     RETURN SYS.AnyData.ConvertObject(out_data);
END;
/

/*
```

Step 14 Configure the Apply Process for Local Apply at dbs2.net

Connect to `dbs2.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs2.net

/*
```

Configure `dbs2.net` to apply changes to the local `assignments` table. Remember that the `assignments` table receives changes from the `jobs` table at `dbs1.net`.

```
*/

DECLARE
  action_ctx_dml       SYS.RE$NV_LIST;
  action_ctx_ddl       SYS.RE$NV_LIST;
  ac_name              VARCHAR2(30) := 'STREAMS$_TRANSFORM_FUNCTION';
BEGIN
  -- Specify the name-value pair in the action context
  action_ctx_dml := SYS.RE$NV_LIST(SYS.RE$NV_ARRAY());
  action_ctx_dml.ADD_PAIR(
    ac_name,
    SYS.ANYDATA.CONVERTVARCHAR2('hr.to_assignments_trans_dml'));
  --  Create the rule set strmadmin.apply_rules
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name       => 'strmadmin.apply_rules',
    evaluation_context  => 'SYS.STREAMS$_EVALUATION_CONTEXT');
  --  Create a rule that transforms all DML changes to the jobs table into
  --  DML changes for assignments table
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name       => 'strmadmin.all_jobs_dml',
    condition       => ' :dml.get_object_owner() = ''HR'' AND ' ||
                       ' :dml.get_object_name() = ''JOBS'' AND ' ||
                       ' :dml.is_null_tag() = ''Y'' AND ' ||
                       ' :dml.get_source_database_name() = ''DBS1.NET'' ',
    action_context  => action_ctx_dml);
  --  Add the rule to the rule set
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_jobs_dml',
    rule_set_name  => 'strmadmin.apply_rules');
```

```
  -- Create an apply process that uses the rule set
  DBMS_APPLY_ADM.CREATE_APPLY(
    queue_name     => 'strmadmin.streams_queue',
    apply_name     => 'apply_dbs2',
    rule_set_name  => 'strmadmin.apply_rules',
    apply_user     => 'hr',
    apply_captured => true);
END;
/

/*
```

Step 15 Grant the hr User Execute Privilege on the Apply Process Rule Set

Because the `hr` user was specified as the apply user in the previous step, the `hr` user requires execute privilege on the rule set used by the apply process

```
*/

BEGIN
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege   => SYS.DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name => 'strmadmin.apply_rules',
    grantee     => 'hr');
END;
/

/*
```

Step 16 Start the Apply Process at dbs2.net for Local Apply

Set the `disable_on_error` parameter to `n` so that the apply process will not be disabled if it encounters an error, and start the apply process for local apply at `dbs2.net`.

```
*/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply_dbs2',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/
```

```
BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply_dbs2');
END;
/

/*
```

Step 17 Configure the Apply Process at dbs2.net for Apply at dbs4.net

Configure `dbs2.net` to apply DML changes to the `jobs` table at `dbs4.net`, which is a Sybase database. Remember that these changes originated at `dbs1.net`.

```
*/

BEGIN
  -- Create the rule set
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name      => 'strmadmin.apply_dbs4_rules',
    evaluation_context => 'SYS.STREAMS$_EVALUATION_CONTEXT');
  -- Create rule strmadmin.all_jobs_remote for all modifications
  -- to the jobs table
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name    => 'strmadmin.all_jobs_remote',
    condition    => ' :dml.get_object_owner() = ''HR'' AND ' ||
                    ' :dml.get_object_name() = ''JOBS'' AND ' ||
                    ' :dml.is_null_tag() = ''Y'' AND ' ||
                    ' :dml.get_source_database_name() = ''DBS1.NET'' ');
  -- Add the rule to the rule set
  DBMS_RULE_ADM.ADD_RULE(
    rule_name      => 'strmadmin.all_jobs_remote',
    rule_set_name  => 'strmadmin.apply_dbs4_rules');
  -- Create an apply process that uses the rule set
  DBMS_APPLY_ADM.CREATE_APPLY(
    queue_name          => 'strmadmin.streams_queue',
    apply_name          => 'apply_dbs4',
    rule_set_name       => 'strmadmin.apply_dbs4_rules',
    apply_database_link => 'dbs4.net',
    apply_captured      => true);
END;
/

/*
```

Step 18 Start the Apply Process at dbs2.net for Apply at dbs4.net

Set the `disable_on_error` parameter to `n` so that the apply process will not be disabled if it encounters an error, and start the remote apply for Sybase using database link `dbs4.net`.

```
*/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply_dbs4',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply_dbs4');
END;
/

/*
```

Step 19 Start the Capture Process at dbs1.net

Connect to `dbs1.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs1.net

/*
```

Start the capture process at `dbs1.net`.

```
*/

BEGIN
  DBMS_CAPTURE_ADM.START_CAPTURE(
    capture_name  => 'capture');
END;
/

/*
```

Step 20 Check the Spool Results

Check the `streams_share_schema2.out` spool file to ensure that all actions finished successfully after this script is completed.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT ****************************/
```

Adding Objects to an Existing Streams Replication Environment

This example extends the Streams environment configured in the previous sections by adding replicated objects to an existing database. To complete this example, you must have completed the tasks in one of the previous examples in this chapter.

This example will add the following tables to the `hr` schema in the `dbs3.net` database:

- `departments`
- `employees`
- `job_history`
- `jobs`

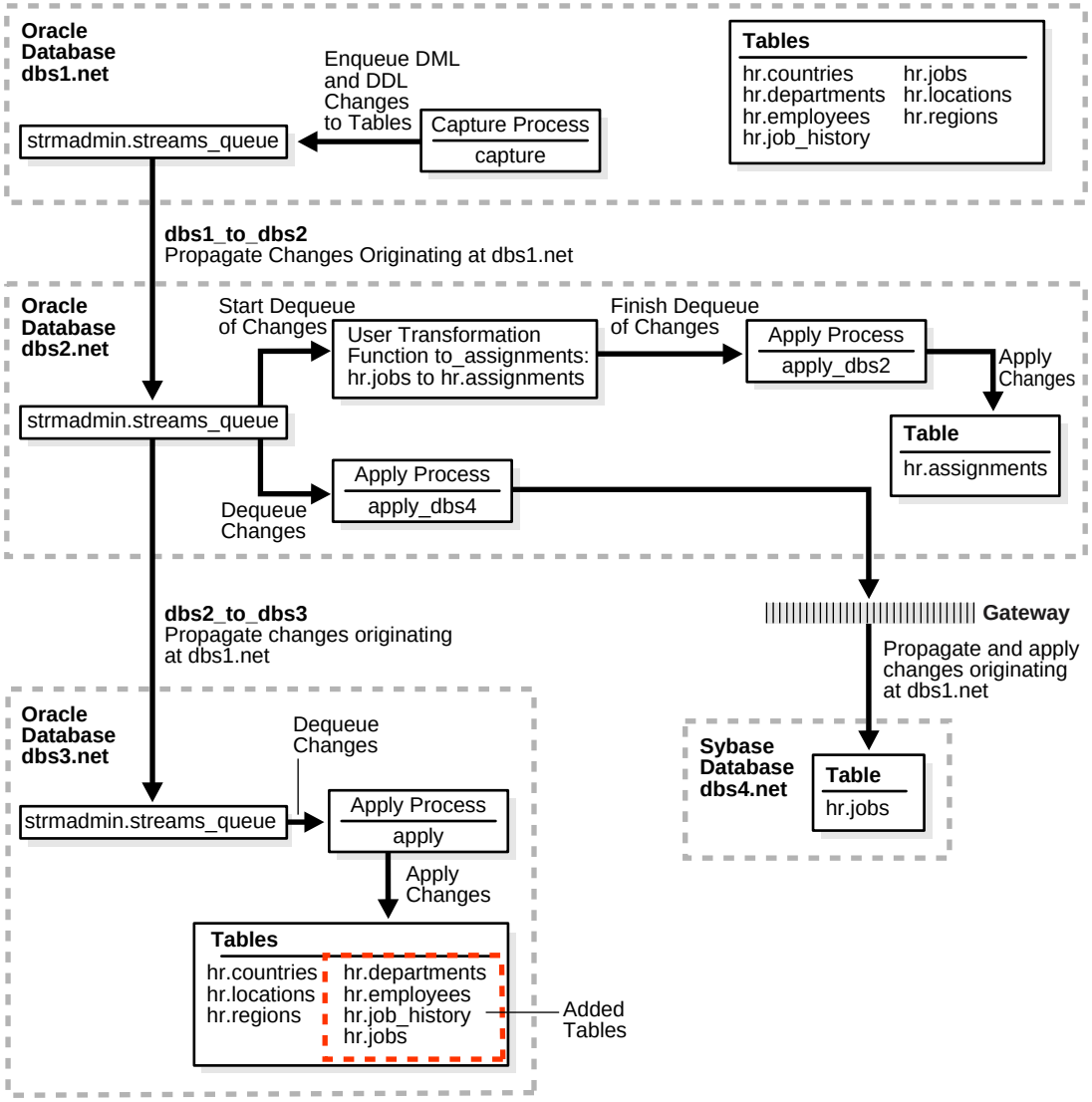
When you complete this example, Streams processes changes to these tables with the following series of actions:

1. The capture process captures changes at `dbs1.net` and enqueues them at `dbs1.net`.
2. A job propagates changes from the queue at `dbs1.net` to the queue at `dbs2.net`.
3. A job propagates changes from the queue at `dbs2.net` to the queue at `dbs3.net`.
4. The apply process at `dbs3.net` applies the changes at `dbs3.net`.

When you complete this example, the `hr` schema at the `dbs3.net` database will have all of its original tables, because the `countries`, `locations`, and `regions` tables were instantiated at `dbs3.net` in the previous section.

Figure 19–2 provides an overview of the environment with the added tables.

Figure 19–2 Adding Objects to dbs3.net in the Environment



Complete the following steps to replicate these tables to the dbs3.net database.

1. Show Output and Spool Results
2. Stop the Apply Process at dbs3.net
3. Configure the Apply Process for the Added Tables at dbs3.net
4. Specify the Table Propagation Rules for the Added Tables at dbs2.net
5. Prepare the Four Added Tables for Instantiation at dbs1.net
6. Instantiate the dbs1.net Tables at dbs3.net
7. Start the Apply Process at dbs3.net
8. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 19-68 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************* BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run SET ECHO ON and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_addobjs.out

/*
```

Step 2 Stop the Apply Process at dbs3.net

Until you finish adding objects to dbs3.net, you must ensure that the apply process that will apply changes for the added objects does not try to apply changes for these objects. You can do this by stopping the capture process at the source database. Or, you can do this by stopping propagation of changes from dbs2.net

to dbs3.net. Yet another alternative is to stop the apply process at dbs3.net. This example stops the apply process at dbs3.net.

Connect to dbs3.net as the strmadmin user.

```
*/

CONNECT strmadmin/strmadminpw@dbs3.net

/*
```

Stop the apply process at dbs3.net.

```
*/

BEGIN
  DBMS_APPLY_ADM.STOP_APPLY(
    apply_name  => 'apply');
END;
/

/*
```

Step 3 Configure the Apply Process for the Added Tables at dbs3.net

Configure the apply process at dbs3.net to apply changes to the tables you are adding.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name      => 'hr.departments',
    streams_type    => 'apply',
    streams_name    => 'apply',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'dbs1.net');
END;
/
```

```
BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name      => 'hr.employees',
    streams_type    => 'apply',
    streams_name    => 'apply',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'dbs1.net');
END;
/

BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name      => 'hr.job_history',
    streams_type    => 'apply',
    streams_name    => 'apply',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'dbs1.net');
END;
/

BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_RULES(
    table_name      => 'hr.jobs',
    streams_type    => 'apply',
    streams_name    => 'apply',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'dbs1.net');
END;
/

/*
```

Step 4 Specify the Table Propagation Rules for the Added Tables at dbs2.net

Connect to `dbs2.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs2.net

/*
```

Add the tables to the rules for propagation from the queue at `dbs2.net` to the queue at `dbs3.net`.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_PROPAGATION_RULES(
    table_name               => 'hr.departments',
    streams_name             => 'dbs2_to_dbs3',
    source_queue_name        => 'strmadmin.streams_queue',
    destination_queue_name   => 'strmadmin.streams_queue@dbs3.net',
    include_dml              =>  true,
    include_ddl              =>  true,
    source_database          => 'dbs1.net');
END;
/

BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_PROPAGATION_RULES(
    table_name              => 'hr.employees',
    streams_name            => 'dbs2_to_dbs3',
    source_queue_name       => 'strmadmin.streams_queue',
    destination_queue_name  => 'strmadmin.streams_queue@dbs3.net',
    include_dml             =>  true,
    include_ddl             =>  true,
    source_database         => 'dbs1.net');
END;
/
```

```
BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_PROPAGATION_RULES(
    table_name              => 'hr.job_history',
    streams_name            => 'dbs2_to_dbs3',
    source_queue_name       => 'strmadmin.streams_queue',
    destination_queue_name  => 'strmadmin.streams_queue@dbs3.net',
    include_dml             =>  true,
    include_ddl             =>  true,
    source_database         => 'dbs1.net');
END;
/

BEGIN
  DBMS_STREAMS_ADM.ADD_TABLE_PROPAGATION_RULES(
    table_name              => 'hr.jobs',
    streams_name            => 'dbs2_to_dbs3',
    source_queue_name       => 'strmadmin.streams_queue',
    destination_queue_name  => 'strmadmin.streams_queue@dbs3.net',
    include_dml             =>  true,
    include_ddl             =>  true,
    source_database         => 'dbs1.net');
END;
/

/*
```

Step 5 Prepare the Four Added Tables for Instantiation at dbs1.net

Connect to `dbs1.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs1.net

/*
```

Prepare the tables for instantiation. These tables will be instantiated at `dbs3.net`. This step marks the lowest SCN of the tables for instantiation. SCNs subsequent to the lowest SCN can be used for instantiation. Also, this preparation is necessary so that the Streams data dictionary for the relevant propagation jobs and the apply process at `dbs3.net` contain information about these tables.

See Also:

- "Preparing Database Objects for Instantiation at a Source Database" on page 11-11
- "Streams Data Dictionary for Propagation Jobs" on page 3-24
- "Streams Data Dictionary for an Apply Process" on page 4-29

```
*/

BEGIN
  DBMS_CAPTURE_ADM.PREPARE_TABLE_INSTANTIATION(
    table_name  => 'hr.departments');
END;
/

BEGIN
  DBMS_CAPTURE_ADM.PREPARE_TABLE_INSTANTIATION(
    table_name  => 'hr.employees');
END;
/

BEGIN
  DBMS_CAPTURE_ADM.PREPARE_TABLE_INSTANTIATION(
    table_name  => 'hr.job_history');
END;
/

BEGIN
  DBMS_CAPTURE_ADM.PREPARE_TABLE_INSTANTIATION(
    table_name  => 'hr.jobs');
END;
/

/*
```

Step 6 Instantiate the dbs1.net Tables at dbs3.net

Open a different window and export the tables at `dbs1.net` that will be instantiated at `dbs3.net`. Make sure you set the `OBJECT_CONSISTENT` export parameter to `y` when you run the export command. Also, make sure no DDL changes are made to the objects being exported during the export.

The following is an example export command:

```
exp userid=hr/hr FILE=hr_instant2.dmp
TABLES=departments,employees,job_history,jobs OBJECT_CONSISTENT=y
```

> **See Also:** *Oracle9i Database Utilities* for information about performing an export

```
*/

PAUSE Press <RETURN> to continue when the export is complete in the other window
that you opened.

/*
```

Transfer the export dump file `hr_instant2.dmp` to the destination database. In this example, the destination database is `dbs3.net`.

You can use binary FTP or some other method to transfer the export dump file to the destination database. You may need to open a different window to transfer the file.

```
*/

PAUSE Press <RETURN> to continue after transferring the dump file.

/*
```

In a different window, connect to the computer that runs the `dbs3.net` database and import the export dump file `hr_instant2.dmp` to instantiate the tables in the `dbs3.net` database. You can use telnet or remote login to connect to the computer that runs `dbs3.net`.

When you run the import command, make sure you set the `STREAMS_INSTANTIATION` import parameter to `y`. This parameter ensures that the import records export SCN information for each object imported.

The following is an example import command:

```
imp userid=hr/hr FILE=hr_instant2.dmp IGNORE=y FULL=y COMMIT=y LOG=import.log
STREAMS_INSTANTIATION=y
```

> **See Also:** *Oracle9i Database Utilities* for information about performing an import

```
*/

PAUSE Press <RETURN> to continue after the import is complete at dbs3.net.

/*
```

Step 7 Start the Apply Process at dbs3.net

Start the apply process at `dbs3.net`. This apply process was stopped in Step 2.

Connect to `dbs3.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs3.net

/*
```

Start the apply process at `dbs3.net`.

```
*/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply');
END;
/

/*
```

Step 8 Check the Spool Results

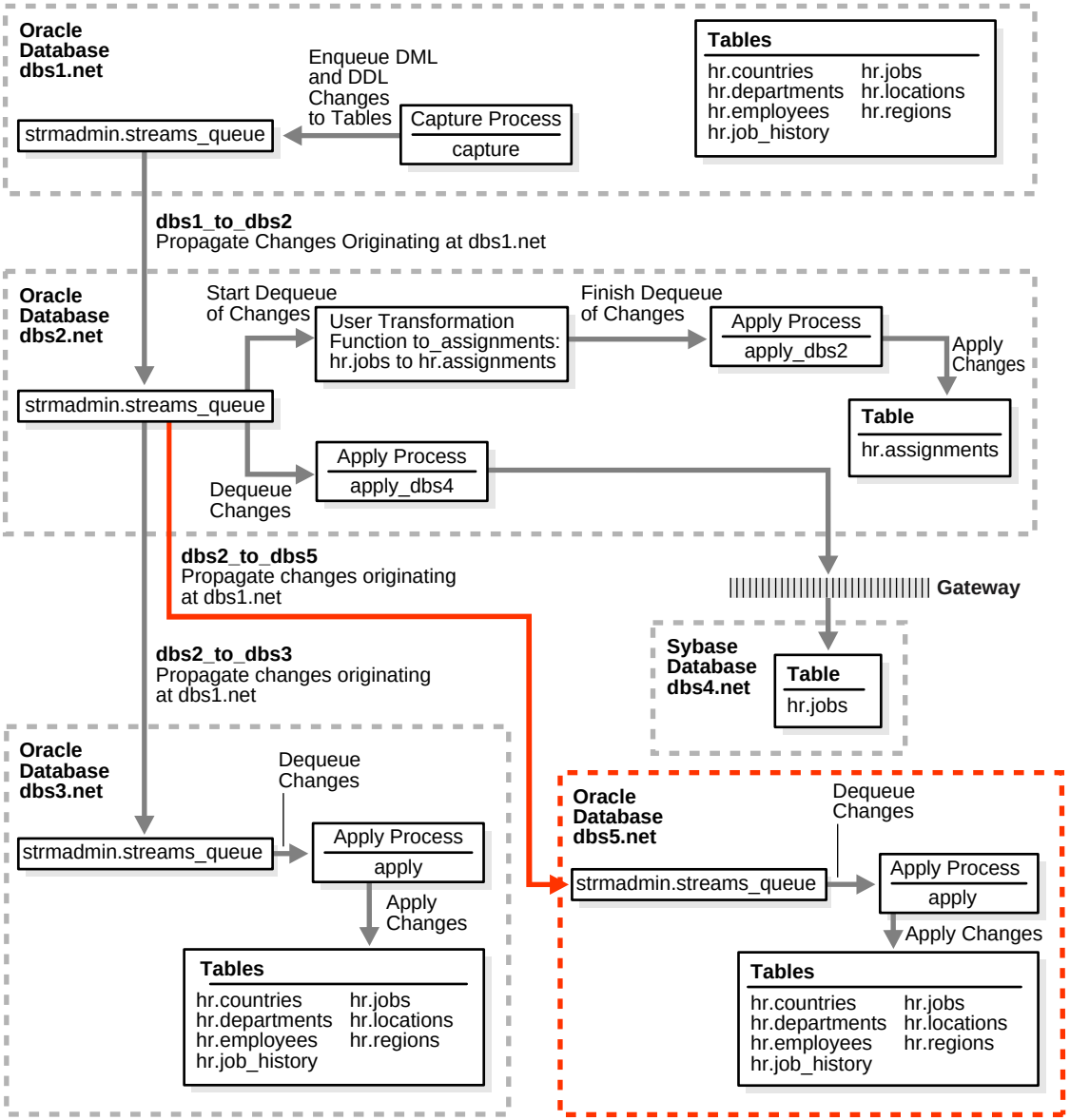
Check the `streams_addobjs.out` spool file to ensure that all actions finished successfully after this script is completed.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT *****************************/
```

Adding a Database to an Existing Streams Replication Environment

This example extends the Streams environment configured in the previous sections by adding an additional database to the existing configuration. In this example, an existing Oracle database named `dbs5.net` is added to receive changes to the entire `hr` schema from the queue at `dbs2.net`. Figure 19–3 provides an overview of the environment with the added database.

Figure 19–3 Adding the dbs5.net Oracle Database to the Environment



To complete this example, you must meet the following prerequisites:

- The `dbs5.net` database must exist.
- The `dbs2.net` and `dbs5.net` databases must be able to communicate with each other through Oracle Net.
- You must have completed the tasks in the previous examples in this chapter.
- The "Prerequisites" on page 19-5 must be met if you want the entire Streams environment to work properly.

  See Also: *Oracle9i Net Services Administrator's Guide*

- This examples creates a new user to function as the Streams administrator (`strmadmin`) at each database and prompts you for the tablespace you want to use for this user's data. Before you start this example, either create a new tablespace or identify an existing tablespace for the Streams administrator to use at each database. The Streams administrator should not use the `SYSTEM` tablespace.

Complete the following steps to add `dbs5.net` to the Streams environment.

1. Show Output and Spool Results
2. Drop All of the Tables in the hr Schema at dbs5.net
3. Set Up Users at dbs5.net
4. Create the Streams Queue at dbs5.net
5. Configure the Apply Process at dbs5.net
6. Specify hr as the Apply User for the Apply Process at dbs5.net
7. Grant the hr User Execute Privilege on the Apply Process Rule Set
8. Create the Database Link Between dbs2.net and dbs5.net
9. Configure Propagation Between dbs2.net and dbs5.net
10. Prepare the hr Schema for Instantiation at dbs1.net
11. Instantiate the dbs1.net Tables at dbs5.net
12. Start the Apply Process at dbs5.net
13. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 19-81 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************ BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run SET ECHO ON and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_adddb.out

/*
```

Step 2 Drop All of the Tables in the hr Schema at dbs5.net

This example illustrates instantiating the tables in the hr schema by exporting them from dbs1.net and importing them into dbs5.net. You must delete these tables at dbs5.net for the instantiation portion of this example to work properly.

Connect as hr at dbs5.net.

```
*/

CONNECT hr/hr@dbs5.net

/*
```

Drop all tables in the hr schema in the dbs5.net database.

Attention: If you complete this step and drop all of the tables in the hr schema, then you should complete the remaining sections of this example to reinstantiate the hr schema at dbs5.net. If the hr schema does not exist in an Oracle database, then some examples in the Oracle documentation set may fail.

```
*/

DROP TABLE hr.countries CASCADE CONSTRAINTS;
DROP TABLE hr.departments CASCADE CONSTRAINTS;
DROP TABLE hr.employees CASCADE CONSTRAINTS;
DROP TABLE hr.job_history CASCADE CONSTRAINTS;
DROP TABLE hr.jobs CASCADE CONSTRAINTS;
DROP TABLE hr.locations CASCADE CONSTRAINTS;
DROP TABLE hr.regions CASCADE CONSTRAINTS;

/*
```

Step 3 Set Up Users at dbs5.net

Connect to `dbs5.net` as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@dbs5.net AS SYSDBA

/*
```

Create the Streams administrator named `strmadmin` and grant this user the necessary privileges. These privileges enable the user to manage queues, execute subprograms in packages related to Streams, create rule sets, create rules, and monitor the Streams environment by querying data dictionary views and queue tables. You may choose a different name for this user.

Note:

- To ensure security, use a password other than `strmadminpw` for the Streams administrator.
- The SELECT_CATALOG_ROLE is not required for the Streams administrator. It is granted in this example so that the Streams administrator can monitor the environment easily.
- If you plan to use the Streams tool in Oracle Enterprise Manager, then grant the Streams administrator SELECT ANY DICTIONARY privilege, in addition to the privileges shown in this step.
- The ACCEPT command must appear on a single line in the script.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

GRANT CONNECT, RESOURCE, SELECT_CATALOG_ROLE
  TO strmadmin IDENTIFIED BY strmadminpw;

ACCEPT streams_tbs PROMPT 'Enter the tablespace for the Streams administrator on
dbs5.net: '

ALTER USER strmadmin DEFAULT TABLESPACE &streams_tbs
                     QUOTA UNLIMITED ON &streams_tbs;

GRANT EXECUTE ON DBMS_APPLY_ADM        TO strmadmin;
GRANT EXECUTE ON DBMS_AQADM            TO strmadmin;
GRANT EXECUTE ON DBMS_CAPTURE_ADM      TO strmadmin;
GRANT EXECUTE ON DBMS_PROPAGATION_ADM  TO strmadmin;
GRANT EXECUTE ON DBMS_STREAMS_ADM      TO strmadmin;

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

/*
```

Step 4 Create the Streams Queue at dbs5.net

Connect as the Streams administrator at the database you are adding. In this example, that database is dbs5.net.

```
*/

CONNECT strmadmin/strmadminpw@dbs5.net

/*
```

Run the SET_UP_QUEUE procedure to create a queue named streams_queue at dbs5.net. This queue will function as the Streams queue by holding the changes that will be applied at this database.

Running the SET_UP_QUEUE procedure performs the following actions:

- Creates a queue table named streams_queue_table. This queue table is owned by the Streams administrator (strmadmin) and uses the default storage of this user.
- Creates a queue named streams_queue owned by the Streams administrator (strmadmin).
- Starts the queue.

```
*/

EXEC  DBMS_STREAMS_ADM.SET_UP_QUEUE();

/*
```

Step 5 Configure the Apply Process at dbs5.net

While still connected as the Streams administrator at `dbs5.net`, configure the apply process to apply changes to the `hr` schema.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name     => 'hr',
    streams_type    => 'apply',
    streams_name    => 'apply',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'dbs1.net');
END;
/

/*
```

Step 6 Specify hr as the Apply User for the Apply Process at dbs5.net

In this example, the `hr` user owns all of the database objects for which changes are applied by the apply process at this database. Therefore, `hr` already has the necessary privileges to change these database objects, and it is convenient to make `hr` the apply user.

When the apply process was created in the previous step, the Streams administrator `strmadmin` was specified as the apply user by default, because `strmadmin` ran the procedure that created the apply process. Instead of specifying hr as the apply user, you could retain `strmadmin` as the apply user, but then you must grant `strmadmin` privileges on all of the database objects for which changes are applied and privileges to execute all user procedures used by the apply process. In an environment where an apply process applies changes to database objects in multiple schemas, it may be more convenient to use the Streams administrator as the apply user.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name => 'apply',
    apply_user => 'hr');
END;
/

/*
```

Step 7 Grant the hr User Execute Privilege on the Apply Process Rule Set

Because the `hr` user was specified as the apply user in the previous step, the `hr` user requires execute privilege on the rule set used by the apply process

```
*/

DECLARE
   rs_name  VARCHAR2(64);   -- Variable to hold rule set name
BEGIN
  SELECT RULE_SET_OWNER||'.'||RULE_SET_NAME
    INTO rs_name
    FROM DBA_APPLY
    WHERE APPLY_NAME='APPLY';
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege   => SYS.DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name => rs_name,
    grantee     => 'hr');
END;
/

/*
```

Step 8 Create the Database Link Between dbs2.net and dbs5.net

Connect to `dbs2.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@dbs2.net

/*
```

Create the database links to the databases where changes are propagated. In this example, database dbs2.net propagates changes to dbs5.net.

```
*/

CREATE DATABASE LINK dbs5.net CONNECT TO strmadmin IDENTIFIED BY strmadminpw
   USING 'dbs5.net';

/*
```

Step 9 Configure Propagation Between dbs2.net and dbs5.net

While still connected as the Streams administrator at dbs2.net, Configure and schedule propagation from the queue at dbs2.net to the queue at dbs5.net. Remember, changes to the hr schema originated at dbs1.net.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_PROPAGATION_RULES(
    schema_name             => 'hr',
    streams_name            => 'dbs2_to_dbs5',
    source_queue_name       => 'strmadmin.streams_queue',
    destination_queue_name  => 'strmadmin.streams_queue@dbs5.net',
    include_dml             =>  true,
    include_ddl             =>  true,
    source_database         => 'dbs1.net');
END;
/

/*
```

Step 10 Prepare the hr Schema for Instantiation at dbs1.net

Connect to dbs1.net as the strmadmin user.

```
*/

CONNECT strmadmin/strmadminpw@dbs1.net

/*
```

Prepare the hr schema for instantiation. These tables in this schema will be instantiated at dbs5.net. This preparation is necessary so that the Streams data dictionary for the relevant propagation jobs and the apply process at dbs5.net contain information about the hr schema and the objects in the schema.

See Also:

- "Preparing Database Objects for Instantiation at a Source Database" on page 11-11
- "Streams Data Dictionary for Propagation Jobs" on page 3-24
- "Streams Data Dictionary for an Apply Process" on page 4-29

```
*/

BEGIN
  DBMS_CAPTURE_ADM.PREPARE_SCHEMA_INSTANTIATION(
    schema_name  => 'hr');
END;
/

/*
```

Step 11 Instantiate the dbs1.net Tables at dbs5.net

Open a different window and export the schema at `dbs1.net` that will be instantiated at `dbs5.net`. Make sure you set the `OBJECT_CONSISTENT` export parameter to `y` when you run the export command. Also, make sure no DDL changes are made to the objects being exported during the export.

The following is an example export command:

```
exp hr/hr FILE=hr_schema.dmp OWNER=hr OBJECT_CONSISTENT=y
```

See Also: *Oracle9i Database Utilities* for information about performing an export

```
*/

PAUSE Press <RETURN> to continue when the export is complete in the other window
that you opened.

/*
```

Transfer the export dump file `hr_schema.dmp` to the destination database. In this example, the destination database is `dbs5.net`.

You can use binary FTP or some other method to transfer the export dump file to the destination database. You may need to open a different window to transfer the file.

```
*/

PAUSE Press <RETURN> to continue after transferring the dump file.

/*
```

In a different window, connect to the computer that runs the `dbs5.net` database and import the export dump file `hr_schema.dmp` to instantiate the tables in the `dbs5.net` database. You can use telnet or remote login to connect to the computer that runs `dbs5.net`.

When you run the import command, make sure you set the `STREAMS_INSTANTIATION` import parameter to `y`. This parameter ensures that the import records export SCN information for each object imported.

The following is an example import command:

```
imp hr/hr FILE=hr_schema.dmp FROMUSER=hr IGNORE=y COMMIT=y LOG=import.log
STREAMS_INSTANTIATION=y
```

> **See Also:** *Oracle9i Database Utilities* for information about performing an import

```
*/

PAUSE Press <RETURN> to continue after the import is complete at dbs5.net.

/*
```

Step 12 Start the Apply Process at dbs5.net

Connect as the Streams administrator at `dbs5.net`.

```
*/

CONNECT strmadmin/strmadminpw@dbs5.net

/*
```

Set the `disable_on_error` parameter to `n` so that the apply process will not be disabled if it encounters an error, and start apply process at `dbs5.net`.

```
*/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply');
END;
/

/*
```

Step 13 Check the Spool Results

Check the `streams_adddb.out` spool file to ensure that all actions finished successfully after this script is completed.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT ****************************/
```

Multiple Source Databases in an Oracle-Only Environment

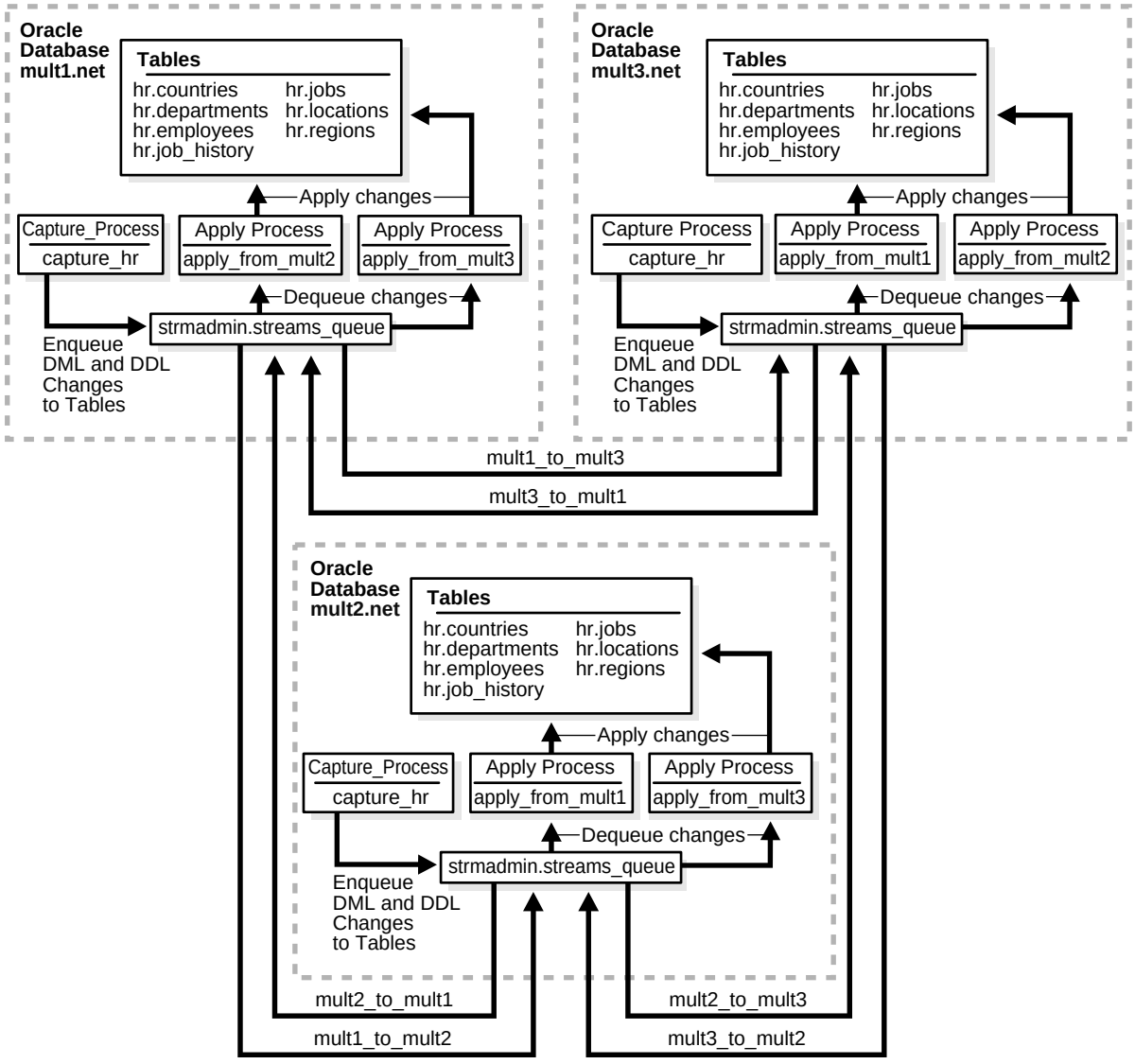
This example illustrates using Streams to replicate data for a schema among three Oracle databases. DML and DDL changes made to tables in the `hr` schema are captured at all databases in the environment and propagated to each of the other databases in the environment.

This example contains these parts:

- "Setting Up Users and Creating Queues and Database Links" on page 19-85
- "Example Script for Sharing Data from Multiple Databases" on page 19-104

Figure 19–4 provides an overview of the environment.

Figure 19–4 Example Environment That Shares Data from Multiple Databases



As illustrated in Figure 19–4, all of the databases will contain the hr schema when the example is complete. However, at the beginning of the example, the hr schema exists only at mult1.net. During the example, you instantiate the hr schema at mult2.net and mult3.net.

In this example, Streams is used to perform the following series of actions:

1. After instantiation, the capture process at each database captures DML and DDL changes for all of the tables in the hr schema and enqueues them into a local queue.
2. Each database propagates these changes to all of the other databases in the environment.
3. The apply process at each database applies changes in the hr schema received from the other databases in the environment.

This example uses only one queue for each database, but you can use multiple queues for each database if you want to separate changes from different source databases. In addition, this example avoids sending changes back to their source database by using the default apply tag for the apply processes. When you create an apply process, the changes applied by the apply process have redo entries with a tag of '00' (double zero) by default. These changes are not recaptured because, by default, rules created by the DBMS_STREAMS_ADM package have an is_null_tag()='Y' condition by default, and this condition ensures that each capture process captures a change in a redo entry only if the tag for the redo entry is NULL.

See Also: *Oracle9i Streams* for more information about tags

Prerequisites

The following prerequisites must be completed before you begin the example in this section.

- Set the following initialization parameters to the values indicated:
  - GLOBAL_NAMES: This parameter must be set to true at each database that is participating in your Streams environment. Make sure the global names of the databases are mult1.net, mult2.net, and mult3.net.
  - JOB_QUEUE_PROCESSES: This parameter must be set to at least 2 at each database that is propagating changes. It should be set to the same value as the maximum number of jobs that can run simultaneously plus one.

  - `COMPATIBLE`: This parameter must be set to `9.2.0` or higher.
  - `LOG_PARALLELISM`: This parameter must be set to `1` at each database that captures events. In this example, this parameter must be set to `1` at each database.

    See Also: "Setting Initialization Parameters Relevant to Streams" on page 10-4 for information about other initialization parameters that are important in a Streams environment

- Any database where changes are captured must be running in `ARCHIVELOG` mode. In this example, all databases are capturing changes, and so all databases must be running in `ARCHIVELOG` mode.

  See Also: *Oracle9i Database Administrator's Guide* for information about running a database in `ARCHIVELOG` mode

- Configure your network and Oracle Net so that all three databases can communicate with each other.

  See Also: *Oracle9i Net Services Administrator's Guide*

Setting Up Users and Creating Queues and Database Links

This section illustrates how to set up users and create queues and database links for a Streams replication environment that includes three Oracle databases. The remaining parts of this example depend on the users and queues that you configure in this section.

Complete the following steps to set up the users and to create the `streams_queue` at all of the databases.

1. Show Output and Spool Results
2. Alter the hr.countries Table at mult1.net
3. Create an Alternate Tablespace for the LogMiner Tables at mult1.net
4. Set Up Users at mult1.net
5. Create the Streams Queue at mult1.net
6. Create the Database Links at mult1.net
7. Prepare the Tables at mult1.net for Latest Time Conflict Resolution

8. Create an Alternate Tablespace for the LogMiner Tables at mult2.net
9. Set Up Users at mult2.net
10. Create the Streams Queue at mult2.net
11. Create the Database Links at mult2.net
12. Drop All of the Tables in the hr Schema at mult2.net
13. Create an Alternate Tablespace for the LogMiner Tables at mult3.net
14. Set Up Users at mult3.net
15. Create the Streams Queue at mult3.net
16. Create the Database Links at mult3.net
17. Drop All of the Tables in the hr Schema at mult3.net
18. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 19-103 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************* BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run SET ECHO ON and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_setup_mult.out

/*
```

Step 2 Alter the hr.countries Table at mult1.net

Connect to `mult1.net` as the `hr` user.

```
*/

CONNECT hr/hr@mult1.net

/*
```

Convert the `hr.countries` table from an index-organized table to a regular table. Currently, the capture process cannot capture changes to index-organized tables.

```
*/

ALTER TABLE countries RENAME TO countries_orig;

CREATE TABLE hr.countries(
  country_id      CHAR(2) CONSTRAINT  country_id_nn_noiot NOT NULL,
  country_name    VARCHAR2(40),
  region_id       NUMBER,
  CONSTRAINT      country_c_id_pk_noiot  PRIMARY KEY (country_id));

ALTER TABLE hr.countries
ADD (CONSTRAINT countr_reg_fk_noiot
         FOREIGN KEY (region_id)
         REFERENCES regions(region_id));

INSERT INTO COUNTRIES (SELECT * FROM hr.countries_orig);

ALTER TABLE locations DROP CONSTRAINT loc_c_id_fk;

ALTER TABLE locations
  ADD (CONSTRAINT loc_c_id_fk
    FOREIGN KEY (country_id)
    REFERENCES countries(country_id));

/*
```

Step 3 Create an Alternate Tablespace for the LogMiner Tables at mult1.net

By default, the LogMiner tables are in the SYSTEM tablespace, but the SYSTEM tablespace may not have enough space for these tables once a capture process starts to capture changes. Therefore, you must create an alternate tablespace for the LogMiner tables.

> **See Also:** "Alternate Tablespace for LogMiner Tables" on page 2-14

Connect to mult1.net as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@mult1.net AS SYSDBA

/*
```

Create an alternate tablespace for the LogMiner tables.

> **Note:** Each ACCEPT command must appear on a single line in the script.

```
*/

ACCEPT tspace_name DEFAULT 'logmnrts' PROMPT 'Enter the name of the tablespace
(for example, logmnrts): '

ACCEPT db_file_directory DEFAULT '' PROMPT 'Enter the complete path to the
datafile directory (for example, /usr/oracle/dbs): '

ACCEPT db_file_name DEFAULT 'logmnrts.dbf' PROMPT 'Enter the name of the
datafile (for example, logmnrts.dbf): '

CREATE TABLESPACE &tspace_name DATAFILE '&db_file_directory/&db_file_name'
  SIZE 25 M REUSE AUTOEXTEND ON MAXSIZE UNLIMITED;

EXECUTE DBMS_LOGMNR_D.SET_TABLESPACE('&tspace_name');

/*
```

Step 4 Set Up Users at mult1.net

Create the Streams administrator named `strmadmin` and grant this user the necessary privileges. These privileges enable the user to manage queues, execute subprograms in packages related to Streams, create rule sets, create rules, and monitor the Streams environment by querying data dictionary views and queue tables. You may choose a different name for this user.

Note:

- To ensure security, use a password other than `strmadminpw` for the Streams administrator.
- The `SELECT_CATALOG_ROLE` is not required for the Streams administrator. It is granted in this example so that the Streams administrator can monitor the environment easily.
- If you plan to use the Streams tool in Oracle Enterprise Manager, then grant the Streams administrator `SELECT ANY DICTIONARY` privilege, in addition to the privileges shown in this step.
- The `ACCEPT` command must appear on a single line in the script.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

GRANT CONNECT, RESOURCE, SELECT_CATALOG_ROLE
  TO strmadmin IDENTIFIED BY strmadminpw;

ACCEPT streams_tbs PROMPT 'Enter the tablespace for the Streams administrator on
mult1.net: '

ALTER USER strmadmin DEFAULT TABLESPACE &streams_tbs
                     QUOTA UNLIMITED ON &streams_tbs;

GRANT EXECUTE ON DBMS_APPLY_ADM        TO strmadmin;
GRANT EXECUTE ON DBMS_AQADM            TO strmadmin;
GRANT EXECUTE ON DBMS_CAPTURE_ADM      TO strmadmin;
GRANT EXECUTE ON DBMS_PROPAGATION_ADM  TO strmadmin;
GRANT EXECUTE ON DBMS_STREAMS_ADM      TO strmadmin;
```

```
BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

/*
```

Step 5 Create the Streams Queue at mult1.net

Connect as the Streams administrator at `mult1.net`.

```
*/

CONNECT strmadmin/strmadminpw@mult1.net

/*
```

Run the `SET_UP_QUEUE` procedure to create a queue named `streams_queue` at `mult1.net`. This queue will function as the Streams queue by holding the changes that will be applied at this database and the changes that will be propagated to other databases.

Running the `SET_UP_QUEUE` procedure performs the following actions:

- Creates a queue table named `streams_queue_table`. This queue table is owned by the Streams administrator (`strmadmin`) and uses the default storage of this user.
- Creates a queue named `streams_queue` owned by the Streams administrator (`strmadmin`).
- Starts the queue.

```
*/

EXEC  DBMS_STREAMS_ADM.SET_UP_QUEUE();

/*
```

Step 6 Create the Database Links at mult1.net

Create database links from the current database to the other databases in the environment.

```
*/

CREATE DATABASE LINK mult2.net CONNECT TO strmadmin
   IDENTIFIED BY strmadminpw USING 'mult2.net';

CREATE DATABASE LINK mult3.net CONNECT TO strmadmin
   IDENTIFIED BY strmadminpw USING 'mult3.net';

/*
```

Step 7 Prepare the Tables at mult1.net for Latest Time Conflict Resolution

This example will configure the tables in the `hr` schema for conflict resolution based on the latest time for a transaction.

Connect to `mult1.net` as the `hr` user.

```
*/

CONNECT hr/hr@mult1.net

/*
```

Add a `time` column to each table in the `hr` schema.

```
*/

ALTER TABLE hr.countries ADD (time TIMESTAMP WITH TIME ZONE);
ALTER TABLE hr.departments ADD (time TIMESTAMP WITH TIME ZONE);
ALTER TABLE hr.employees ADD (time TIMESTAMP WITH TIME ZONE);
ALTER TABLE hr.job_history ADD (time TIMESTAMP WITH TIME ZONE);
ALTER TABLE hr.jobs ADD (time TIMESTAMP WITH TIME ZONE);
ALTER TABLE hr.locations ADD (time TIMESTAMP WITH TIME ZONE);
ALTER TABLE hr.regions ADD (time TIMESTAMP WITH TIME ZONE);

/*
```

Create a trigger for each table in the hr schema to insert the time of a transaction for each row inserted or updated by the transaction.

```
*/

CREATE OR REPLACE TRIGGER hr.insert_time_countries
BEFORE
  INSERT OR UPDATE ON hr.countries FOR EACH ROW
BEGIN
   -- Consider time synchronization problems. The previous update to this
   -- row may have originated from a site with a clock time ahead of the
   -- local clock time.
   IF :OLD.TIME IS NULL OR :OLD.TIME < SYSTIMESTAMP THEN
     :NEW.TIME := SYSTIMESTAMP;
   ELSE
     :NEW.TIME := :OLD.TIME + 1 / 86400;
   END IF;
END;
/

CREATE OR REPLACE TRIGGER hr.insert_time_departments
BEFORE
  INSERT OR UPDATE ON hr.departments FOR EACH ROW
BEGIN
   IF :OLD.TIME IS NULL OR :OLD.TIME < SYSTIMESTAMP THEN
     :NEW.TIME := SYSTIMESTAMP;
   ELSE
     :NEW.TIME := :OLD.TIME + 1 / 86400;
   END IF;
END;
/

CREATE OR REPLACE TRIGGER hr.insert_time_employees
BEFORE
  INSERT OR UPDATE ON hr.employees FOR EACH ROW
BEGIN
   IF :OLD.TIME IS NULL OR :OLD.TIME < SYSTIMESTAMP THEN
     :NEW.TIME := SYSTIMESTAMP;
   ELSE
     :NEW.TIME := :OLD.TIME + 1 / 86400;
   END IF;
END;
/
```

```
CREATE OR REPLACE TRIGGER hr.insert_time_job_history
BEFORE
  INSERT OR UPDATE ON hr.job_history FOR EACH ROW
BEGIN
   IF :OLD.TIME IS NULL OR :OLD.TIME < SYSTIMESTAMP THEN
     :NEW.TIME := SYSTIMESTAMP;
   ELSE
     :NEW.TIME := :OLD.TIME + 1 / 86400;
   END IF;
END;
/

CREATE OR REPLACE TRIGGER hr.insert_time_jobs
BEFORE
  INSERT OR UPDATE ON hr.jobs FOR EACH ROW
BEGIN
   IF :OLD.TIME IS NULL OR :OLD.TIME < SYSTIMESTAMP THEN
     :NEW.TIME := SYSTIMESTAMP;
   ELSE
     :NEW.TIME := :OLD.TIME + 1 / 86400;
   END IF;
END;
/

CREATE OR REPLACE TRIGGER hr.insert_time_locations
BEFORE
  INSERT OR UPDATE ON hr.locations FOR EACH ROW
BEGIN
   IF :OLD.TIME IS NULL OR :OLD.TIME < SYSTIMESTAMP THEN
     :NEW.TIME := SYSTIMESTAMP;
   ELSE
     :NEW.TIME := :OLD.TIME + 1 / 86400;
   END IF;
END;
/
```

```
CREATE OR REPLACE TRIGGER hr.insert_time_regions
BEFORE
  INSERT OR UPDATE ON hr.regions FOR EACH ROW
BEGIN
   IF :OLD.TIME IS NULL OR :OLD.TIME < SYSTIMESTAMP THEN
     :NEW.TIME := SYSTIMESTAMP;
   ELSE
     :NEW.TIME := :OLD.TIME + 1 / 86400;
   END IF;
END;
/

/*
```

Step 8 Create an Alternate Tablespace for the LogMiner Tables at mult2.net

By default, the LogMiner tables are in the SYSTEM tablespace, but the SYSTEM tablespace may not have enough space for these tables once a capture process starts to capture changes. Therefore, you must create an alternate tablespace for the LogMiner tables.

> **See Also:** "Alternate Tablespace for LogMiner Tables" on page 2-14

Connect to `mult2.net` as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@mult2.net AS SYSDBA

/*
```

Create an alternate tablespace for the LogMiner tables.

> **Note:** Each ACCEPT command must appear on a single line in the script.

```
*/

ACCEPT tspace_name DEFAULT 'logmnrts' PROMPT 'Enter the name of the tablespace
(for example, logmnrts): '

ACCEPT db_file_directory DEFAULT '' PROMPT 'Enter the complete path to the
datafile directory (for example, /usr/oracle/dbs): '

ACCEPT db_file_name DEFAULT 'logmnrts.dbf' PROMPT 'Enter the name of the
datafile (for example, logmnrts.dbf): '

CREATE TABLESPACE &tspace_name DATAFILE '&db_file_directory/&db_file_name'
  SIZE 25 M REUSE AUTOEXTEND ON MAXSIZE UNLIMITED;

EXECUTE DBMS_LOGMNR_D.SET_TABLESPACE('&tspace_name');

/*
```

Step 9 Set Up Users at mult2.net

Create the Streams administrator named `strmadmin` and grant this user the necessary privileges. These privileges enable the user to manage queues, execute subprograms in packages related to Streams, create rule sets, create rules, and monitor the Streams environment by querying data dictionary views and queue tables. You may choose a different name for this user.

Note:

- To ensure security, use a password other than `strmadminpw` for the Streams administrator.
- The `SELECT_CATALOG_ROLE` is not required for the Streams administrator. It is granted in this example so that the Streams administrator can monitor the environment easily.
- If you plan to use the Streams tool in Oracle Enterprise Manager, then grant the Streams administrator `SELECT ANY DICTIONARY` privilege, in addition to the privileges shown in this step.
- The `ACCEPT` command must appear on a single line in the script.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

GRANT CONNECT, RESOURCE, SELECT_CATALOG_ROLE
  TO strmadmin IDENTIFIED BY strmadminpw;

ACCEPT streams_tbs PROMPT 'Enter the tablespace for the Streams administrator on
mult2.net: '

ALTER USER strmadmin DEFAULT TABLESPACE &streams_tbs
                     QUOTA UNLIMITED ON &streams_tbs;

GRANT EXECUTE ON DBMS_APPLY_ADM        TO strmadmin;
GRANT EXECUTE ON DBMS_AQADM            TO strmadmin;
GRANT EXECUTE ON DBMS_CAPTURE_ADM      TO strmadmin;
GRANT EXECUTE ON DBMS_FLASHBACK        TO strmadmin;
GRANT EXECUTE ON DBMS_PROPAGATION_ADM  TO strmadmin;
GRANT EXECUTE ON DBMS_STREAMS_ADM      TO strmadmin;

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

/*
```

Step 10 Create the Streams Queue at mult2.net

Connect as the Streams administrator at `mult2.net`.

```
*/

CONNECT strmadmin/strmadminpw@mult2.net

/*
```

Run the SET_UP_QUEUE procedure to create a queue named streams_queue at mult2.net. This queue will function as the Streams queue by holding the changes that will be applied at this database and the changes that will be propagated to other databases.

Running the SET_UP_QUEUE procedure performs the following actions:

- Creates a queue table named streams_queue_table. This queue table is owned by the Streams administrator (strmadmin) and uses the default storage of this user.
- Creates a queue named streams_queue owned by the Streams administrator (strmadmin).
- Starts the queue.

```
*/

EXEC  DBMS_STREAMS_ADM.SET_UP_QUEUE();

/*
```

Step 11 Create the Database Links at mult2.net

Create database links from the current database to the other databases in the environment.

```
*/

CREATE DATABASE LINK mult1.net CONNECT TO strmadmin
   IDENTIFIED BY strmadminpw USING 'mult1.net';

CREATE DATABASE LINK mult3.net CONNECT TO strmadmin
   IDENTIFIED BY strmadminpw USING 'mult3.net';

/*
```

Step 12 Drop All of the Tables in the hr Schema at mult2.net

This example illustrates instantiating the tables in the hr schema at mult2.net by exporting these tables from mult1.net and importing them into mult2.net. You must drop the tables in the hr schema at mult2.net for the instantiation portion of this example to work properly.

Attention: If you complete the following steps and drop the tables in the hr schema at mult2.net, then you should complete the remaining steps of this example to reinstantiate the hr schema. If the hr schema does not exist in an Oracle database, then some examples in the Oracle documentation set may fail.

Connect as hr at mult2.net.

```
*/

CONNECT hr/hr@mult2.net

/*
```

Drop all tables in the hr schema in the mult2.net database.

```
*/

DROP TABLE hr.countries CASCADE CONSTRAINTS;
DROP TABLE hr.departments CASCADE CONSTRAINTS;
DROP TABLE hr.employees CASCADE CONSTRAINTS;
DROP TABLE hr.job_history CASCADE CONSTRAINTS;
DROP TABLE hr.jobs CASCADE CONSTRAINTS;
DROP TABLE hr.locations CASCADE CONSTRAINTS;
DROP TABLE hr.regions CASCADE CONSTRAINTS;

/*
```

Step 13 Create an Alternate Tablespace for the LogMiner Tables at mult3.net

By default, the LogMiner tables are in the SYSTEM tablespace, but the SYSTEM tablespace may not have enough space for these tables once a capture process starts to capture changes. Therefore, you must create an alternate tablespace for the LogMiner tables.

See Also: "Alternate Tablespace for LogMiner Tables" on page 2-14

Connect to `mult3.net` as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@mult3.net AS SYSDBA

/*
```

Create an alternate tablespace for the LogMiner tables.

> **Note:** Each ACCEPT command must appear on a single line in the script.

```
*/

ACCEPT tspace_name DEFAULT 'logmnrts' PROMPT 'Enter the name of the tablespace
(for example, logmnrts): '

ACCEPT db_file_directory DEFAULT '' PROMPT 'Enter the complete path to the
datafile directory (for example, /usr/oracle/dbs): '

ACCEPT db_file_name DEFAULT 'logmnrts.dbf' PROMPT 'Enter the name of the
datafile (for example, logmnrts.dbf): '

CREATE TABLESPACE &tspace_name DATAFILE '&db_file_directory/&db_file_name'
  SIZE 25 M REUSE AUTOEXTEND ON MAXSIZE UNLIMITED;

EXECUTE DBMS_LOGMNR_D.SET_TABLESPACE('&tspace_name');

/*
```

Step 14 Set Up Users at mult3.net

Create the Streams administrator named `strmadmin` and grant this user the necessary privileges. These privileges enable the user to manage queues, execute subprograms in packages related to Streams, create rule sets, create rules, and monitor the Streams environment by querying data dictionary views and queue tables. You may choose a different name for this user.

Note:

- To ensure security, use a password other than `strmadminpw` for the Streams administrator.
- The `SELECT_CATALOG_ROLE` is not required for the Streams administrator. It is granted in this example so that the Streams administrator can monitor the environment easily.
- If you plan to use the Streams tool in Oracle Enterprise Manager, then grant the Streams administrator `SELECT ANY DICTIONARY` privilege, in addition to the privileges shown in this step.
- The `ACCEPT` command must appear on a single line in the script.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

GRANT CONNECT, RESOURCE, SELECT_CATALOG_ROLE
  TO strmadmin IDENTIFIED BY strmadminpw;

ACCEPT streams_tbs PROMPT 'Enter the tablespace for the Streams administrator on
mult3.net: '

ALTER USER strmadmin DEFAULT TABLESPACE &streams_tbs
                     QUOTA UNLIMITED ON &streams_tbs;

GRANT EXECUTE ON DBMS_APPLY_ADM        TO strmadmin;
GRANT EXECUTE ON DBMS_AQADM            TO strmadmin;
GRANT EXECUTE ON DBMS_CAPTURE_ADM      TO strmadmin;
GRANT EXECUTE ON DBMS_FLASHBACK        TO strmadmin;
GRANT EXECUTE ON DBMS_PROPAGATION_ADM  TO strmadmin;
GRANT EXECUTE ON DBMS_STREAMS_ADM      TO strmadmin;
```

```
BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'strmadmin',
    grant_option => FALSE);
END;
/

/*
```

Step 15 Create the Streams Queue at mult3.net

Connect as the Streams administrator at `mult3.net`.

```
*/

CONNECT strmadmin/strmadminpw@mult3.net

/*
```

Run the `SET_UP_QUEUE` procedure to create a queue named `streams_queue` at `mult3.net`. This queue will function as the Streams queue by holding the changes that will be applied at this database and the changes that will be propagated to other databases.

Running the `SET_UP_QUEUE` procedure performs the following actions:

- Creates a queue table named `streams_queue_table`. This queue table is owned by the Streams administrator (`strmadmin`) and uses the default storage of this user.
- Creates a queue named `streams_queue` owned by the Streams administrator (`strmadmin`).
- Starts the queue.

```
*/

EXEC  DBMS_STREAMS_ADM.SET_UP_QUEUE();

/*
```

Step 16 Create the Database Links at mult3.net

Create database links from the current database to the other databases in the environment.

```
*/

CREATE DATABASE LINK mult1.net CONNECT TO strmadmin
   IDENTIFIED BY strmadminpw USING 'mult1.net';

CREATE DATABASE LINK mult2.net CONNECT TO strmadmin
   IDENTIFIED BY strmadminpw USING 'mult2.net';

/*
```

Step 17 Drop All of the Tables in the hr Schema at mult3.net

This example illustrates instantiating the tables in the `hr` schema at `mult3.net` by exporting these tables from `mult1.net` and importing them into `mult3.net`. You must drop the tables in the `hr` schema at `mult3.net` for the instantiation portion of this example to work properly.

> **Attention:** If you complete the following steps and drop the tables in the `hr` schema at `mult3.net`, then you should complete the remaining steps of this example to reinstantiate the `hr` schema. If the `hr` schema does not exist in an Oracle database, then some examples in the Oracle documentation set may fail.

Connect as `hr` at `mult3.net`.

```
*/

CONNECT hr/hr@mult3.net

/*
```

Drop all tables in the hr schema in the mult3.net database.

```
*/

DROP TABLE hr.countries CASCADE CONSTRAINTS;
DROP TABLE hr.departments CASCADE CONSTRAINTS;
DROP TABLE hr.employees CASCADE CONSTRAINTS;
DROP TABLE hr.job_history CASCADE CONSTRAINTS;
DROP TABLE hr.jobs CASCADE CONSTRAINTS;
DROP TABLE hr.locations CASCADE CONSTRAINTS;
DROP TABLE hr.regions CASCADE CONSTRAINTS;

/*
```

Step 18 Check the Spool Results

Check the streams_setup_mult.out spool file to ensure that all actions finished successfully after this script is completed.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT ****************************/
```

Example Script for Sharing Data from Multiple Databases

Complete the following steps to configure a Streams environment that shares information from multiple databases.

1. Show Output and Spool Results
2. Specify Supplemental Logging at mult1.net
3. Create the Capture Process at mult1.net
4. Create One Apply Process at mult1.net for Each Source Database
5. Specify hr as the Apply User for Each Apply Process at mult1.net
6. Grant the hr User Execute Privilege on the Apply Process Rule Set
7. Configure Latest Time Conflict Resolution at mult1.net
8. Configure Propagation at mult1.net
9. Create the Capture Process at mult2.net.
10. Set the Instantiation SCN for mult2.net at the Other Databases
11. Create One Apply Process at mult2.net for Each Source Database
12. Specify hr as the Apply User for Each Apply Process at mult2.net
13. Grant the hr User Execute Privilege on the Apply Process Rule Set
14. Configure Propagation at mult2.net
15. Create the Capture Process at mult3.net
16. Set the Instantiation SCN for mult3.net at the Other Databases
17. Create One Apply Process at mult3.net for Each Source Database
18. Specify hr as the Apply User for Each Apply Process at mult3.net
19. Grant the hr User Execute Privilege on the Apply Process Rule Set
20. Configure Propagation at mult3.net
21. Instantiate the hr Schema at mult2.net and mult3.net
22. Specify Supplemental Logging at mult2.net
23. Specify Supplemental Logging at mult3.net
24. Configure Latest Time Conflict Resolution at mult2.net
25. Start the Apply Processes at mult2.net

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 19-144 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************* BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run `SET ECHO ON` and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL streams_mult.out

/*
```

Step 2 Specify Supplemental Logging at mult1.net

Connect to `mult1.net` as `SYS` user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@mult1.net AS SYSDBA

/*
```

Specify an unconditional supplemental log group that includes the primary key for each table and the column list for each table, as specified in "Configure Latest Time Conflict Resolution at mult1.net" on page 19-110.

Note: For convenience, this example includes the primary key column(s) for each table and the columns used for update conflict resolution in a single unconditional log group. You may choose to place the primary key column(s) for each table in an unconditional log group and the columns used for update conflict resolution in a conditional log group.

See Also:

- "Supplemental Logging" on page 2-9
- "Specifying Supplemental Logging at a Source Database" on page 11-9

```
*/

ALTER TABLE hr.countries ADD SUPPLEMENTAL LOG GROUP log_group_countries
  (country_id, country_name, region_id, time) ALWAYS;

ALTER TABLE hr.departments ADD SUPPLEMENTAL LOG GROUP log_group_departments
  (department_id, department_name, manager_id, location_id, time) ALWAYS;

ALTER TABLE hr.employees ADD SUPPLEMENTAL LOG GROUP log_group_employees
  (employee_id, first_name, last_name, email, phone_number, hire_date, job_id,
   salary, commission_pct, manager_id, department_id, time) ALWAYS;

ALTER TABLE hr.jobs ADD SUPPLEMENTAL LOG GROUP log_group_jobs
  (job_id, job_title, min_salary, max_salary, time) ALWAYS;

ALTER TABLE hr.job_history ADD SUPPLEMENTAL LOG GROUP log_group_job_history
  (employee_id, start_date, end_date, job_id, department_id, time) ALWAYS;

ALTER TABLE hr.locations ADD SUPPLEMENTAL LOG GROUP log_group_locations
  (location_id, street_address, postal_code, city, state_province,
   country_id, time) ALWAYS;
```

```
ALTER TABLE hr.regions ADD SUPPLEMENTAL LOG GROUP log_group_regions
  (region_id, region_name, time) ALWAYS;

ALTER SYSTEM ARCHIVE LOG CURRENT;

/*
```

Step 3 Create the Capture Process at mult1.net

Connect to `mult1.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@mult1.net

/*
```

Create the capture process to capture changes to the entire `hr` schema at `mult1.net`. After this step is complete, users can modify tables in the `hr` schema at `mult1.net`.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name   => 'hr',
    streams_type  => 'capture',
    streams_name  => 'capture_hr',
    queue_name    => 'strmadmin.streams_queue',
    include_dml   =>  true,
    include_ddl   =>  true);
END;
/

/*
```

Step 4 Create One Apply Process at mult1.net for Each Source Database

Configure `mult1.net` to apply changes to the `hr` schema at `mult2.net`.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name     => 'hr',
    streams_type    => 'apply',
    streams_name    => 'apply_from_mult2',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'mult2.net');
END;
/

/*
```

Configure `mult1.net` to apply changes to the `hr` schema at `mult3.net`.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name     => 'hr',
    streams_type    => 'apply',
    streams_name    => 'apply_from_mult3',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'mult3.net');
END;
/

/*
```

Step 5 Specify hr as the Apply User for Each Apply Process at mult1.net

In this example, the hr user owns all of the database objects for which changes are applied by the apply process at this database. Therefore, hr already has the necessary privileges to change these database objects, and it is convenient to make hr the apply user.

When the apply process was created in the previous step, the Streams administrator strmadmin was specified as the apply user by default, because strmadmin ran the procedure that created the apply process. Instead of specifying hr as the apply user, you could retain strmadmin as the apply user, but then you must grant strmadmin privileges on all of the database objects for which changes are applied and privileges to execute all user procedures used by the apply process. In an environment where an apply process applies changes to database objects in multiple schemas, it may be more convenient to use the Streams administrator as the apply user.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name => 'apply_from_mult2',
    apply_user => 'hr');
END;
/

BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name => 'apply_from_mult3',
    apply_user => 'hr');
END;
/

/*
```

Step 6 Grant the hr User Execute Privilege on the Apply Process Rule Set

Because the hr user was specified as the apply user in the previous step, the hr user requires execute privilege on the rule set used by each apply process

```
*/

DECLARE
   rs_name  VARCHAR2(64);   -- Variable to hold rule set name
BEGIN
  SELECT RULE_SET_OWNER||'.'||RULE_SET_NAME
    INTO rs_name
    FROM DBA_APPLY
    WHERE APPLY_NAME='APPLY_FROM_MULT2';
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege   => SYS.DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name => rs_name,
    grantee     => 'hr');
END;
/

DECLARE
   rs_name  VARCHAR2(64);   -- Variable to hold rule set name
BEGIN
  SELECT RULE_SET_OWNER||'.'||RULE_SET_NAME
    INTO rs_name
    FROM DBA_APPLY
    WHERE APPLY_NAME='APPLY_FROM_MULT3';
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege   => SYS.DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name => rs_name,
    grantee     => 'hr');
END;
/

/*
```

Step 7 Configure Latest Time Conflict Resolution at mult1.net

Specify an update conflict handler for each table in the hr schema. For each table, designate the time column as the resolution column for a MAXIMUM conflict handler. When an update conflict occurs, such an update conflict handler applies the transaction with the latest (or greater) time and discards the transaction with the earlier (or lesser) time. The column lists for each table do not include the primary key because this example assumes that primary key values are never updated.

```
*/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'country_name';
  cols(2) := 'region_id';
  cols(3) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.countries',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'department_name';
  cols(2) := 'manager_id';
  cols(3) := 'location_id';
  cols(4) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.departments',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/
```

```
DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1)  := 'first_name';
  cols(2)  := 'last_name';
  cols(3)  := 'email';
  cols(4)  := 'phone_number';
  cols(5)  := 'hire_date';
  cols(6)  := 'job_id';
  cols(7)  := 'salary';
  cols(8)  := 'commission_pct';
  cols(9)  := 'manager_id';
  cols(10) := 'department_id';
  cols(11) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.employees',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'job_title';
  cols(2) := 'min_salary';
  cols(3) := 'max_salary';
  cols(4) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.jobs',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/
```

```
DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'employee_id';
  cols(2) := 'start_date';
  cols(3) := 'end_date';
  cols(4) := 'job_id';
  cols(5) := 'department_id';
  cols(6) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.job_history',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'street_address';
  cols(2) := 'postal_code';
  cols(3) := 'city';
  cols(4) := 'state_province';
  cols(5) := 'country_id';
  cols(6) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.locations',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/
```

```
DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'region_name';
  cols(2) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.regions',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

/*
```

Step 8 Configure Propagation at mult1.net

Configure and schedule propagation of DML and DDL changes in the `hr` schema from the queue at `mult1.net` to the queue at `mult2.net`.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_PROPAGATION_RULES(
    schema_name               => 'hr',
    streams_name              => 'mult1_to_mult2',
    source_queue_name         => 'strmadmin.streams_queue',
    destination_queue_name    => 'strmadmin.streams_queue@mult2.net',
    include_dml               =>  true,
    include_ddl               =>  true,
    source_database           => 'mult1.net');
END;
/

/*
```

Configure and schedule propagation of DML and DDL changes in the hr schema from the queue at mult1.net to the queue at mult3.net.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_PROPAGATION_RULES(
    schema_name                => 'hr',
    streams_name               => 'mult1_to_mult3',
    source_queue_name          => 'strmadmin.streams_queue',
    destination_queue_name     => 'strmadmin.streams_queue@mult3.net',
    include_dml                =>  true,
    include_ddl                =>  true,
    source_database            => 'mult1.net');
END;
/

/*
```

Step 9 Create the Capture Process at mult2.net.

Connect to mult2.net as the strmadmin user.

```
*/

CONNECT strmadmin/strmadminpw@mult2.net

/*
```

Create the capture process to capture changes to the entire hr schema at mult2.net.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name   => 'hr',
    streams_type  => 'capture',
    streams_name  => 'capture_hr',
    queue_name    => 'strmadmin.streams_queue',
    include_dml   =>  true,
    include_ddl   =>  true);
END;
/

/*
```

Step 10 Set the Instantiation SCN for mult2.net at the Other Databases

In this example, the hr schema already exists at all of the databases. The tables in the schema exist only at mult1.net until they are instantiated at mult2.net and mult3.net in Step 21. The instantiation is done using an export of the tables from mult1.net. These export/import operations set the schema instantiation SCNs for mult1.net at mult2.net and mult3.net automatically.

However, the instantiation SCNs for mult2.net and mult3.net are not set automatically at the other sites in the environment. This step sets the schema instantiation SCN for mult2.net manually at mult1.net and mult3.net. The current SCN at mult2.net is obtained by using the GET_SYSTEM_CHANGE_NUMBER function in the DBMS_FLASHBACK package at mult2.net. This SCN is used at mult1.net and mult3.net to run the SET_SCHEMA_INSTANTIATION_SCN procedure in the DBMS_APPLY_ADM package.

The SET_SCHEMA_INSTANTIATION_SCN procedure controls which DDL LCRs for a schema are ignored by an apply process and which DDL LCRs for a schema are applied by an apply process. If the commit SCN of a DDL LCR for a database object in a schema from a source database is less than or equal to the instantiation SCN for that database object at some destination database, then the apply process at the destination database disregards the DDL LCR. Otherwise, the apply process applies the DDL LCR.

Because you are running the SET_SCHEMA_INSTANTIATION_SCN procedure before the tables are instantiated at mult2.net, and because the local capture process is configured already, you do not need to run the SET_TABLE_INSTANTIATION_SCN for each table after the instantiation. In this example, an apply process at both mult1.net and mult3.net will apply transactions to the tables in the hr schema with SCNs that were committed after the SCN obtained in this step.

Note:

- In a case where you are instantiating a schema that does not exist, you can set the global instantiation SCN instead of the schema instantiation SCN.
- In a case where the tables are instantiated before you set the instantiation SCN, you must set the schema instantiation SCN and the instantiation SCN for each table in the schema.

```
*/

DECLARE
  iscn  NUMBER;         -- Variable to hold instantiation SCN value
BEGIN
  iscn := DBMS_FLASHBACK.GET_SYSTEM_CHANGE_NUMBER();
  DBMS_APPLY_ADM.SET_SCHEMA_INSTANTIATION_SCN@MULT1.NET(
    source_schema_name    => 'hr',
    source_database_name  => 'mult2.net',
    instantiation_scn     => iscn);
  DBMS_APPLY_ADM.SET_SCHEMA_INSTANTIATION_SCN@MULT3.NET(
    source_schema_name    => 'hr',
    source_database_name  => 'mult2.net',
    instantiation_scn     => iscn);
END;
/

/*
```

Step 11 Create One Apply Process at mult2.net for Each Source Database

Configure `mult2.net` to apply changes to the `hr` schema at `mult1.net`.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name     => 'hr',
    streams_type    => 'apply',
    streams_name    => 'apply_from_mult1',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'mult1.net');
END;
/

/*
```

Configure mult2.net to apply changes to the hr schema at mult3.net.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name     => 'hr',
    streams_type    => 'apply',
    streams_name    => 'apply_from_mult3',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'mult3.net');
END;
/

/*
```

Step 12 Specify hr as the Apply User for Each Apply Process at mult2.net

In this example, the hr user owns all of the database objects for which changes are applied by the apply process at this database. Therefore, hr already has the necessary privileges to change these database objects, and it is convenient to make hr the apply user.

When the apply process was created in the previous step, the Streams administrator strmadmin was specified as the apply user by default, because strmadmin ran the procedure that created the apply process. Instead of specifying hr as the apply user, you could retain strmadmin as the apply user, but then you must grant strmadmin privileges on all of the database objects for which changes are applied and privileges to execute all user procedures used by the apply process. In an environment where an apply process applies changes to database objects in multiple schemas, it may be more convenient to use the Streams administrator as the apply user.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name => 'apply_from_mult1',
    apply_user => 'hr');
END;
/

BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name => 'apply_from_mult3',
    apply_user => 'hr');
END;
/

/*
```

Step 13 Grant the hr User Execute Privilege on the Apply Process Rule Set

Because the `hr` user was specified as the apply user in the previous step, the `hr` user requires execute privilege on the rule set used by each apply process

```
*/

DECLARE
   rs_name  VARCHAR2(64);   -- Variable to hold rule set name
BEGIN
  SELECT RULE_SET_OWNER||'.'||RULE_SET_NAME
    INTO rs_name
    FROM DBA_APPLY
    WHERE APPLY_NAME='APPLY_FROM_MULT1';
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege   => SYS.DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name => rs_name,
    grantee     => 'hr');
END;
/
```

```
DECLARE
   rs_name  VARCHAR2(64);   -- Variable to hold rule set name
BEGIN
  SELECT RULE_SET_OWNER||'.'||RULE_SET_NAME
    INTO rs_name
    FROM DBA_APPLY
    WHERE APPLY_NAME='APPLY_FROM_MULT3';
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege   => SYS.DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name => rs_name,
    grantee     => 'hr');
END;
/

/*
```

Step 14 Configure Propagation at mult2.net

Configure and schedule propagation of DML and DDL changes in the `hr` schema from the queue at `mult2.net` to the queue at `mult1.net`.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_PROPAGATION_RULES(
    schema_name             => 'hr',
    streams_name            => 'mult2_to_mult1',
    source_queue_name       => 'strmadmin.streams_queue',
    destination_queue_name  => 'strmadmin.streams_queue@mult1.net',
    include_dml             =>  true,
    include_ddl             =>  true,
    source_database         => 'mult2.net');
END;
/

/*
```

Configure and schedule propagation of DML and DDL changes in the hr schema from the queue at mult2.net to the queue at mult3.net.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_PROPAGATION_RULES(
    schema_name              => 'hr',
    streams_name             => 'mult2_to_mult3',
    source_queue_name        => 'strmadmin.streams_queue',
    destination_queue_name   => 'strmadmin.streams_queue@mult3.net',
    include_dml              =>  true,
    include_ddl              =>  true,
    source_database          => 'mult2.net');
END;
/

/*
```

Step 15 Create the Capture Process at mult3.net

Connect to mult3.net as the strmadmin user.

```
*/

CONNECT strmadmin/strmadminpw@mult3.net

/*
```

Create the capture process to capture changes to the entire hr schema at mult3.net.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name   => 'hr',
    streams_type  => 'capture',
    streams_name  => 'capture_hr',
    queue_name    => 'strmadmin.streams_queue',
    include_dml   =>  true,
    include_ddl   =>  true);
END;
/

/*
```

Step 16 Set the Instantiation SCN for mult3.net at the Other Databases

In this example, the hr schema already exists at all of the databases. The tables in the schema exist only at mult1.net until they are instantiated at mult2.net and mult3.net in Step 21. The instantiation is done using an export of the tables from mult1.net. These export/import operations set the schema instantiation SCNs for mult1.net at mult2.net and mult3.net automatically.

However, the instantiation SCNs for mult2.net and mult3.net are not set automatically at the other sites in the environment. This step sets the schema instantiation SCN for mult3.net manually at mult1.net and mult2.net. The current SCN at mult3.net is obtained by using the GET_SYSTEM_CHANGE_NUMBER function in the DBMS_FLASHBACK package at mult3.net. This SCN is used at mult1.net and mult2.net to run the SET_SCHEMA_INSTANTIATION_SCN procedure in the DBMS_APPLY_ADM package.

The SET_SCHEMA_INSTANTIATION_SCN procedure controls which DDL LCRs for a schema are ignored by an apply process and which DDL LCRs for a schema are applied by an apply process. If the commit SCN of a DDL LCR for a database object in a schema from a source database is less than or equal to the instantiation SCN for that database object at some destination database, then the apply process at the destination database disregards the DDL LCR. Otherwise, the apply process applies the DDL LCR.

Because you are running the SET_SCHEMA_INSTANTIATION_SCN procedure before the tables are instantiated at mult3.net, and because the local capture process is configured already, you do not need to run the SET_TABLE_INSTANTIATION_SCN for each table after the instantiation. In this example, an apply process at both mult1.net and mult2.net will apply transactions to the tables in the hr schema with SCNs that were committed after the SCN obtained in this step.

Note:

- In a case where you are instantiating a schema that does not exist, you can set the global instantiation SCN instead of the schema instantiation SCN.
- In a case where the tables are instantiated before you set the instantiation SCN, you must set the schema instantiation SCN and the instantiation SCN for each table in the schema.

```
*/

DECLARE
  iscn  NUMBER;         -- Variable to hold instantiation SCN value
BEGIN
  iscn := DBMS_FLASHBACK.GET_SYSTEM_CHANGE_NUMBER();
  DBMS_APPLY_ADM.SET_SCHEMA_INSTANTIATION_SCN@MULT1.NET(
    source_schema_name    => 'hr',
    source_database_name  => 'mult3.net',
    instantiation_scn     => iscn);
  DBMS_APPLY_ADM.SET_SCHEMA_INSTANTIATION_SCN@MULT2.NET(
    source_schema_name    => 'hr',
    source_database_name  => 'mult3.net',
    instantiation_scn     => iscn);
END;
/

/*
```

Step 17 Create One Apply Process at mult3.net for Each Source Database

Configure `mult3.net` to apply changes to the `hr` schema at `mult1.net`.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name     => 'hr',
    streams_type    => 'apply',
    streams_name    => 'apply_from_mult1',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'mult1.net');
END;
/

/*
```

Configure mult3.net to apply changes to the hr schema at mult2.net.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_RULES(
    schema_name     => 'hr',
    streams_type    => 'apply',
    streams_name    => 'apply_from_mult2',
    queue_name      => 'strmadmin.streams_queue',
    include_dml     =>  true,
    include_ddl     =>  true,
    source_database => 'mult2.net');
END;
/

/*
```

Step 18 Specify hr as the Apply User for Each Apply Process at mult3.net

In this example, the hr user owns all of the database objects for which changes are applied by the apply process at this database. Therefore, hr already has the necessary privileges to change these database objects, and it is convenient to make hr the apply user.

When the apply process was created in the previous step, the Streams administrator strmadmin was specified as the apply user by default, because strmadmin ran the procedure that created the apply process. Instead of specifying hr as the apply user, you could retain strmadmin as the apply user, but then you must grant strmadmin privileges on all of the database objects for which changes are applied and privileges to execute all user procedures used by the apply process. In an environment where an apply process applies changes to database objects in multiple schemas, it may be more convenient to use the Streams administrator as the apply user.

See Also: "Configuring a Streams Administrator" on page 10-2

```
*/

BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name => 'apply_from_mult1',
    apply_user => 'hr');
END;
/

BEGIN
  DBMS_APPLY_ADM.ALTER_APPLY(
    apply_name => 'apply_from_mult2',
    apply_user => 'hr');
END;
/

/*
```

Step 19 Grant the hr User Execute Privilege on the Apply Process Rule Set

Because the `hr` user was specified as the apply user in the previous step, the `hr` user requires execute privilege on the rule set used by each apply process

```
*/

DECLARE
   rs_name  VARCHAR2(64);   -- Variable to hold rule set name
BEGIN
  SELECT RULE_SET_OWNER||'.'||RULE_SET_NAME
    INTO rs_name
    FROM DBA_APPLY
    WHERE APPLY_NAME='APPLY_FROM_MULT1';
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege   => SYS.DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name => rs_name,
    grantee     => 'hr');
END;
/
```

```
DECLARE
   rs_name  VARCHAR2(64);   -- Variable to hold rule set name
BEGIN
  SELECT RULE_SET_OWNER||'.'||RULE_SET_NAME
    INTO rs_name
    FROM DBA_APPLY
    WHERE APPLY_NAME='APPLY_FROM_MULT2';
  DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE(
    privilege   => SYS.DBMS_RULE_ADM.EXECUTE_ON_RULE_SET,
    object_name => rs_name,
    grantee     => 'hr');
END;
/

/*
```

Step 20 Configure Propagation at mult3.net

Configure and schedule propagation of DML and DDL changes in the `hr` schema from the queue at `mult3.net` to the queue at `mult1.net`.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_PROPAGATION_RULES(
    schema_name             => 'hr',
    streams_name            => 'mult3_to_mult1',
    source_queue_name       => 'strmadmin.streams_queue',
    destination_queue_name  => 'strmadmin.streams_queue@mult1.net',
    include_dml             =>  true,
    include_ddl             =>  true,
    source_database         => 'mult3.net');
END;
/

/*
```

Configure and schedule propagation of DML and DDL changes in the hr schema from the queue at mult3.net to the queue at mult2.net.

```
*/

BEGIN
  DBMS_STREAMS_ADM.ADD_SCHEMA_PROPAGATION_RULES(
    schema_name              => 'hr',
    streams_name             => 'mult3_to_mult2',
    source_queue_name        => 'strmadmin.streams_queue',
    destination_queue_name   => 'strmadmin.streams_queue@mult2.net',
    include_dml              =>  true,
    include_ddl              =>  true,
    source_database          => 'mult3.net');
END;
/

/*
```

Step 21 Instantiate the hr Schema at mult2.net and mult3.net

Open a different window and export the schema at mult1.net that will be instantiated at mult2.net and mult3.net. Make sure you set the OBJECT_CONSISTENT export parameter to y when you run the export command. Also, make sure no DDL changes are made to the objects being exported during the export.

The following is an example export command:

```
exp hr/hr FILE=hr_schema.dmp OWNER=hr OBJECT_CONSISTENT=y
```

> **See Also:** *Oracle9i Database Utilities* for information about performing an export

```
*/

PAUSE Press <RETURN> to continue when the export is complete in the other window
that you opened.

/*
```

Transfer the export dump file hr_schema.dmp to the destination databases. In this example, the destination databases are mult2.net and mult3.net.

You can use binary FTP or some other method to transfer the export dump file to the destination database. You may need to open a different window to transfer the file.

```
*/

PAUSE Press <RETURN> to continue after transferring the dump file to all of the
other databases in the environment.

/*
```

In a different window, connect to the computer that runs the `mult2.net` database and import the export dump file `hr_schema.dmp` to instantiate the tables in the `mult2.net` database. You can use telnet or remote login to connect to the computer that runs `mult2.net`.

When you run the import command, make sure you set the `STREAMS_INSTANTIATION` import parameter to `y`. This parameter ensures that the import records export SCN information for each object imported.

Also, make sure no changes are made to the tables in the schema being imported at the destination database (`mult2.net`) until the import is complete and the capture process is created.

The following is an example import command:

```
imp hr/hr FILE=hr_schema.dmp FROMUSER=hr IGNORE=y COMMIT=y LOG=import.log
STREAMS_INSTANTIATION=y
```

> **See Also:** *Oracle9i Database Utilities* for information about performing an import

```
*/

PAUSE Press <RETURN> to continue after the import is complete at mult2.net.

/*
```

In a different window, connect to the computer that runs the `mult3.net` database and import the export dump file `hr_schema.dmp` to instantiate the tables in the `mult3.net` database.

After you connect to mult3.net, perform the import in the same way that you did for mult2.net.

```
*/

PAUSE Press <RETURN> to continue after the import is complete at mult3.net.

/*
```

> **Attention:** Make sure no changes are made to the imported tables at mult2.net and mult3.net until you specify supplemental logging at both databases in Step 22 and Step 23.

Step 22 Specify Supplemental Logging at mult2.net

Connect to mult2.net as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@mult2.net AS SYSDBA

/*
```

Set the session tag to a non-NULL value so that the supplemental logging changes are not captured by the capture process at mult2.net.

```
*/

EXEC DBMS_STREAMS.SET_TAG(tag => HEXTORAW('01'));

/*
```

> **See Also:** Chapter 8, "Streams Tags"

Specify an unconditional supplemental log group that includes the primary key for each table and the column list for each table, as specified in "Configure Latest Time Conflict Resolution at mult2.net" on page 19-133. After this step is complete, users can modify tables in the hr schema at mult2.net.

Note: For convenience, this example includes the primary key column(s) for each table and the columns used for update conflict resolution in a single unconditional log group. You may choose to place the primary key column(s) for each table in an unconditional log group and the columns used for update conflict resolution in a conditional log group.

See Also:

- "Supplemental Logging" on page 2-9
- "Specifying Supplemental Logging at a Source Database" on page 11-9

```
*/

ALTER TABLE hr.countries ADD SUPPLEMENTAL LOG GROUP log_group_countries
  (country_id, country_name, region_id, time) ALWAYS;

ALTER TABLE hr.departments ADD SUPPLEMENTAL LOG GROUP log_group_departments
  (department_id, department_name, manager_id, location_id, time) ALWAYS;

ALTER TABLE hr.employees ADD SUPPLEMENTAL LOG GROUP log_group_employees
  (employee_id, first_name, last_name, email, phone_number, hire_date, job_id,
   salary, commission_pct, manager_id, department_id, time) ALWAYS;

ALTER TABLE hr.jobs ADD SUPPLEMENTAL LOG GROUP log_group_jobs
  (job_id, job_title, min_salary, max_salary, time) ALWAYS;

ALTER TABLE hr.job_history ADD SUPPLEMENTAL LOG GROUP log_group_job_history
  (employee_id, start_date, end_date, job_id, department_id, time) ALWAYS;

ALTER TABLE hr.locations ADD SUPPLEMENTAL LOG GROUP log_group_locations
  (location_id, street_address, postal_code, city, state_province,
   country_id, time) ALWAYS;

ALTER TABLE hr.regions ADD SUPPLEMENTAL LOG GROUP log_group_regions
  (region_id, region_name, time) ALWAYS;

ALTER SYSTEM ARCHIVE LOG CURRENT;

/*
```

Set the session tag back to NULL at mult2.net.

```
*/

EXEC DBMS_STREAMS.SET_TAG(tag => NULL);

/*
```

Step 23 Specify Supplemental Logging at mult3.net

Connect to mult3.net as SYS user.

```
*/

CONNECT SYS/CHANGE_ON_INSTALL@mult3.net AS SYSDBA

/*
```

Set the session tag to a non-NULL value so that the supplemental logging changes are not captured by the capture process at mult3.net.

```
*/

EXEC DBMS_STREAMS.SET_TAG(tag => HEXTORAW('01'));

/*
```

See Also: Chapter 8, "Streams Tags"

Specify an unconditional supplemental log group that includes the primary key for each table and the column list for each table, as specified in "Configure Latest Time Conflict Resolution at mult3.net" on page 19-137. After this step is complete, users can modify tables in the hr schema at mult3.net.

Note: For convenience, this example includes the primary key column(s) for each table and the columns used for update conflict resolution in a single unconditional log group. You may choose to place the primary key column(s) for each table in an unconditional log group and the columns used for update conflict resolution in a conditional log group.

See Also:

- "Supplemental Logging" on page 2-9
- "Specifying Supplemental Logging at a Source Database" on page 11-9

```
*/

ALTER TABLE hr.countries ADD SUPPLEMENTAL LOG GROUP log_group_countries
  (country_id, country_name, region_id, time) ALWAYS;

ALTER TABLE hr.departments ADD SUPPLEMENTAL LOG GROUP log_group_departments
  (department_id, department_name, manager_id, location_id, time) ALWAYS;

ALTER TABLE hr.employees ADD SUPPLEMENTAL LOG GROUP log_group_employees
  (employee_id, first_name, last_name, email, phone_number, hire_date, job_id,
   salary, commission_pct, manager_id, department_id, time) ALWAYS;

ALTER TABLE hr.jobs ADD SUPPLEMENTAL LOG GROUP log_group_jobs
  (job_id, job_title, min_salary, max_salary, time) ALWAYS;

ALTER TABLE hr.job_history ADD SUPPLEMENTAL LOG GROUP log_group_job_history
  (employee_id, start_date, end_date, job_id, department_id, time) ALWAYS;

ALTER TABLE hr.locations ADD SUPPLEMENTAL LOG GROUP log_group_locations
  (location_id, street_address, postal_code, city, state_province,
   country_id, time) ALWAYS;

ALTER TABLE hr.regions ADD SUPPLEMENTAL LOG GROUP log_group_regions
  (region_id, region_name, time) ALWAYS;

ALTER SYSTEM ARCHIVE LOG CURRENT;

/*
```

Set the session tag back to `NULL` at `mult2.net`.

```
*/

EXEC DBMS_STREAMS.SET_TAG(tag => NULL);

/*
```

Step 24 Configure Latest Time Conflict Resolution at mult2.net

Connect to `mult2.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@mult2.net

/*
```

Specify an update conflict handler for each table in the `hr` schema. For each table, designate the `time` column as the resolution column for a `MAXIMUM` conflict handler. When an update conflict occurs, such an update conflict handler applies the transaction with the latest (or greater) time and discards the transaction with the earlier (or lesser) time.

```
*/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'country_name';
  cols(2) := 'region_id';
  cols(3) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.countries',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'department_name';
  cols(2) := 'manager_id';
  cols(3) := 'location_id';
  cols(4) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.departments',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/
```

```
DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1)  := 'first_name';
  cols(2)  := 'last_name';
  cols(3)  := 'email';
  cols(4)  := 'phone_number';
  cols(5)  := 'hire_date';
  cols(6)  := 'job_id';
  cols(7)  := 'salary';
  cols(8)  := 'commission_pct';
  cols(9)  := 'manager_id';
  cols(10) := 'department_id';
  cols(11) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.employees',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'job_title';
  cols(2) := 'min_salary';
  cols(3) := 'max_salary';
  cols(4) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.jobs',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/
```

```
DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'employee_id';
  cols(2) := 'start_date';
  cols(3) := 'end_date';
  cols(4) := 'job_id';
  cols(5) := 'department_id';
  cols(6) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.job_history',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'street_address';
  cols(2) := 'postal_code';
  cols(3) := 'city';
  cols(4) := 'state_province';
  cols(5) := 'country_id';
  cols(6) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.locations',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/
```

```
DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'region_name';
  cols(2) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.regions',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

/*
```

Step 25 Start the Apply Processes at mult2.net

Set the `disable_on_error` parameter to `n` for both apply processes so that they will not be not disabled if they encounter an error, and start both of the apply processes at `mult2.net`.

```
*/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply_from_mult1',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply_from_mult1');
END;
/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply_from_mult3',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/
```

```
BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply_from_mult3');
END;
/

/*
```

Step 26 Configure Latest Time Conflict Resolution at mult3.net

Connect to `mult3.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@mult3.net

/*
```

Specify an update conflict handler for each table in the `hr` schema. For each table, designate the `time` column as the resolution column for a `MAXIMUM` conflict handler. When an update conflict occurs, such an update conflict handler applies the transaction with the latest (or greater) time and discards the transaction with the earlier (or lesser) time.

```
*/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'country_name';
  cols(2) := 'region_id';
  cols(3) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.countries',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/
```

```
DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'department_name';
  cols(2) := 'manager_id';
  cols(3) := 'location_id';
  cols(4) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.departments',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1)  := 'first_name';
  cols(2)  := 'last_name';
  cols(3)  := 'email';
  cols(4)  := 'phone_number';
  cols(5)  := 'hire_date';
  cols(6)  := 'job_id';
  cols(7)  := 'salary';
  cols(8)  := 'commission_pct';
  cols(9)  := 'manager_id';
  cols(10) := 'department_id';
  cols(11) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.employees',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/
```

```
DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'job_title';
  cols(2) := 'min_salary';
  cols(3) := 'max_salary';
  cols(4) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.jobs',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'employee_id';
  cols(2) := 'start_date';
  cols(3) := 'end_date';
  cols(4) := 'job_id';
  cols(5) := 'department_id';
  cols(6) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.job_history',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/
```

```
DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'street_address';
  cols(2) := 'postal_code';
  cols(3) := 'city';
  cols(4) := 'state_province';
  cols(5) := 'country_id';
  cols(6) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.locations',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

DECLARE
  cols  DBMS_UTILITY.NAME_ARRAY;
BEGIN
  cols(1) := 'region_name';
  cols(2) := 'time';
  DBMS_APPLY_ADM.SET_UPDATE_CONFLICT_HANDLER(
    object_name           =>  'hr.regions',
    method_name           =>  'MAXIMUM',
    resolution_column     =>  'time',
    column_list           =>  cols);
END;
/

/*
```

Step 27 Start the Apply Processes at mult3.net

Set the `disable_on_error` parameter to `n` for both apply processes so that they will not be disabled if they encounter an error, and start both of the apply processes at `mult3.net`.

```
*/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply_from_mult1',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply_from_mult1');
END;
/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply_from_mult2',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply_from_mult2');
END;
/

/*
```

Step 28 Start the Apply Processes at mult1.net

Connect to `mult1.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@mult1.net

/*
```

Set the `disable_on_error` parameter to `n` for both apply processes so that they will not be disabled if they encounter an error, and start both of the apply processes at `mult1.net`.

```
*/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply_from_mult2',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply_from_mult2');
END;
/

BEGIN
  DBMS_APPLY_ADM.SET_PARAMETER(
    apply_name  => 'apply_from_mult3',
    parameter   => 'disable_on_error',
    value       => 'n');
END;
/

BEGIN
  DBMS_APPLY_ADM.START_APPLY(
    apply_name  => 'apply_from_mult3');
END;
/

/*
```

Step 29 Start the Capture Process at mult1.net

Start the capture process at `mult1.net`.

```
*/

BEGIN
  DBMS_CAPTURE_ADM.START_CAPTURE(
    capture_name  => 'capture_hr');
END;
/

/*
```

Step 30 Start the Capture Process at mult2.net

Connect to `mult2.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@mult2.net

/*
```

Start the capture process at `mult2.net`.

```
*/

BEGIN
  DBMS_CAPTURE_ADM.START_CAPTURE(
    capture_name  => 'capture_hr');
END;
/

/*
```

Step 31 Start the Capture Process at mult3.net

Connect to `mult3.net` as the `strmadmin` user.

```
*/

CONNECT strmadmin/strmadminpw@mult3.net

/*
```

Start the capture process at `mult3.net`.

```
*/

BEGIN
  DBMS_CAPTURE_ADM.START_CAPTURE(
    capture_name  => 'capture_hr');
END;
/

SET ECHO OFF

/*
```

Step 32 Check the Spool Results

Check the `streams_mult.out` spool file to ensure that all actions finished successfully after this script is completed.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT ******************************/
```

20

Example Rule-Based Application

This chapter illustrates a rule-based application that uses the Oracle rules engine.

This chapter contains these topics:

- Overview of the Rule-Based Application
- Using Rules on Non-Table Data Stored in Explicit Variables
- Using Rules on Data Stored in a Table
- Using Rules on Both Explicit Variables and Table Data
- Using Rules on Implicit Variables and Table Data

Note: The examples in this chapter are independent of Streams. That is, no Streams processes or jobs are clients of the rules engine in these examples, and no queues are used.

See Also:

- Chapter 5, "Rules"
- Chapter 14, "Managing Rules and Rule-Based Transformations"
- "Monitoring Rules and Rule-Based Transformations" on page 16-41

Overview of the Rule-Based Application

Each example in this chapter creates a rule-based application that handles customer problems. The application uses rules to determine actions that must be completed based on the problem priority when a new problem is reported. For example, the application assigns each problem to a particular company center based on the problem priority.

The application enforces these rules using the rules engine. An evaluation context named `evalctx` is created to define the information surrounding a support problem. Rules are created based on the requirements described previously, and they are added to a rule set named `rs`.

The task of assigning problems is done by a user defined procedure named `problem_dispatch`, which calls the rules engine to evaluate rules in the rule set `rs` and then takes appropriate action based on the rules that evaluate to `TRUE`.

Note: To complete these examples, the `COMPATIBLE` initialization parameter must be set to `9.2.0` or higher.

Using Rules on Non-Table Data Stored in Explicit Variables

This example illustrates using rules to evaluate data stored in explicit variables. This example handles customer problems based on priority and uses the following rules for handling customer problems:

- Assign all problems with priority greater than 2 to the San Jose Center
- Assign all problems with priority less than or equal to 2 to the New York Center
- Send an alert to the vice president of support for a problem with priority equal to 1

The evaluation context only contains one explicit variable named `priority`, which refers to the priority of the problem being dispatched. The value for this variable is passed to `DBMS_RULE.EVALUATE` procedure by the `problem_dispatch` procedure.

Complete the following steps:

1. Show Output and Spool Results
2. Create the support User
3. Grant the support User the Necessary System Privileges on Rules
4. Create the evalctx Evaluation Context
5. Create the Rules that Correspond to Problem Priority
6. Create the rs Rule Set
7. Add the Rules to the Rule Set
8. Query the Data Dictionary
9. Create the problem_dispatch PL/SQL Procedure
10. Dispatch Sample Problems
11. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 20-9 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************ BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run SET ECHO ON and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL rules_stored_variables.out

/*
```

Step 2 Create the support User

```
*/

CONNECT SYS/CHANGE_ON_INSTALL AS SYSDBA;

GRANT CONNECT, RESOURCE TO support IDENTIFIED BY support;

/*
```

Step 3 Grant the support User the Necessary System Privileges on Rules

```
*/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
END;
/

/*
```

Step 4 Create the evalctx Evaluation Context

```
*/

CONNECT support/support

SET FEEDBACK 1
SET NUMWIDTH 10
SET LINESIZE 80
SET TRIMSPOOL ON
SET TAB OFF
SET PAGESIZE 100
SET SERVEROUTPUT ON;
DECLARE
  vt SYS.RE$VARIABLE_TYPE_LIST;
BEGIN
  vt := SYS.RE$VARIABLE_TYPE_LIST(
    SYS.RE$VARIABLE_TYPE('priority', 'NUMBER', NULL, NULL));
  DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT(
    evaluation_context_name    => 'evalctx',
    variable_types             => vt,
    evaluation_context_comment => 'support problem definition');
END;
/
```

```
/*
```

Step 5 Create the Rules that Correspond to Problem Priority

```
*/

DECLARE
  ac  SYS.RE$NV_LIST;
BEGIN
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('CENTER', SYS.AnyData.CONVERTVARCHAR2('San Jose'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r1',
    condition      => ':priority > 2',
    action_context => ac,
    rule_comment   => 'Low priority problems');
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('CENTER', SYS.AnyData.CONVERTVARCHAR2('New York'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r2',
    condition      => ':priority <= 2',
    action_context => ac,
    rule_comment   => 'High priority problems');
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('ALERT', SYS.AnyData.CONVERTVARCHAR2('John Doe'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r3',
    condition      => ':priority = 1',
    action_context => ac,
    rule_comment   => 'Urgent problems');
END;
/

/*
```

Step 6 Create the rs Rule Set

```
*/

BEGIN
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name      => 'rs',
    evaluation_context => 'evalctx',
    rule_set_comment   => 'support rules');
END;
/

/*
```

Step 7 Add the Rules to the Rule Set

```
*/

BEGIN
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r1',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r2',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r3',
    rule_set_name => 'rs');
END;
/

/*
```

Step 8 Query the Data Dictionary

At this point, you can view the evaluation context, rules, and rule set you created in the previous steps.

```
*/

SELECT * FROM USER_EVALUATION_CONTEXTS;

SELECT * FROM USER_RULES;

SELECT * FROM USER_RULE_SETS;

/*
```

Step 9 Create the problem_dispatch PL/SQL Procedure

```
*/

CREATE OR REPLACE PROCEDURE problem_dispatch (priority NUMBER)
IS
    vv        SYS.RE$VARIABLE_VALUE;
    vvl       SYS.RE$VARIABLE_VALUE_LIST;
    truehits  SYS.RE$RULE_HIT_LIST;
    maybehits SYS.RE$RULE_HIT_LIST;
    ac        SYS.RE$NV_LIST;
    namearray SYS.RE$NAME_ARRAY;
    name      VARCHAR2(30);
    cval      VARCHAR2(100);
    rnum      INTEGER;
    i         INTEGER;
    status    PLS_INTEGER;
BEGIN
  vv  := SYS.RE$VARIABLE_VALUE('priority',
                               SYS.AnyData.CONVERTNUMBER(priority));
  vvl := SYS.RE$VARIABLE_VALUE_LIST(vv);
  truehits := SYS.RE$RULE_HIT_LIST();
  maybehits := SYS.RE$RULE_HIT_LIST();
  DBMS_RULE.EVALUATE(
      rule_set_name        => 'support.rs',
      evaluation_context   => 'evalctx',
      variable_values      => vvl,
      true_rules           => truehits,
      maybe_rules          => maybehits);
  FOR rnum IN 1..truehits.COUNT LOOP
    DBMS_OUTPUT.PUT_LINE('Using rule '|| truehits(rnum).rule_name);
    ac := truehits(rnum).rule_action_context;
    namearray := ac.GET_ALL_NAMES;
      FOR i IN 1..namearray.count loop
        name := namearray(i);
        status := ac.GET_VALUE(name).GETVARCHAR2(cval);
        IF (name = 'CENTER') then
          DBMS_OUTPUT.PUT_LINE('Assigning problem to ' || cval);
        ELSIF (name = 'ALERT') THEN
          DBMS_OUTPUT.PUT_LINE('Sending alert to: '|| cval);
        END IF;
      END LOOP;
  END LOOP;
END;
/
```

```
/*

Step 10  Dispatch Sample Problems
*/

EXECUTE problem_dispatch(1);
EXECUTE problem_dispatch(2);
EXECUTE problem_dispatch(3);
EXECUTE problem_dispatch(5);

/*

Step 11  Check the Spool Results
```

Check the `rules_stored_variables.out` spool file to ensure that all actions completed successfully after this script completes.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT ****************************/
```

Using Rules on Data Stored in a Table

This example illustrates using rules to evaluate data stored in a table. This example is similar to the example described in "Using Rules on Non-Table Data Stored in Explicit Variables" on page 20-3. In both examples, the application routes customer problems based on priority. However, in this example, the problems are stored in a table instead of variables.

The application uses `problems` table in the `support` schema, into which customer problems are inserted. This example uses the following rules for handling customer problems:

- Assign all problems with priority greater than 2 to the San Jose Center
- Assign all problems with priority less than or equal to 2 to the New York Center
- Send an alert to the vice president of support for a problem with priority equal to 1

The evaluation context consists of the `problems` table. The relevant row of the table, which corresponds to the problem being routed, is passed to the `DBMS_RULE.EVALUATE` procedure as a table value.

Complete the following steps:

1. Show Output and Spool Results
2. Drop and Recreate the support User
3. Grant the support User the Necessary System Privileges on Rules
4. Create the problems Table
5. Create the evalctx Evaluation Context
6. Create the Rules that Correspond to Problem Priority
7. Create the rs Rule Set
8. Add the Rules to the Rule Set
9. Query the Data Dictionary
10. Create the problem_dispatch PL/SQL Procedure
11. Log Problems
12. List the Problems in the problems Table
13. Dispatch the Problems by Running the problem_dispatch Procedure
14. List the Problems in the problems Table
15. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 20-17 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************ BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run SET ECHO ON and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL rules_table.out

/*
```

Step 2 Drop and Recreate the support User

```
*/

CONNECT SYS/CHANGE_ON_INSTALL AS SYSDBA;

DROP USER support CASCADE;

GRANT CONNECT, RESOURCE TO support IDENTIFIED BY support;

/*
```

Step 3 Grant the support User the Necessary System Privileges on Rules

```
*/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
END;
/

/*
```

Step 4 Create the problems Table

```
*/

CONNECT support/support

SET FEEDBACK 1
SET NUMWIDTH 10
SET LINESIZE 80
SET TRIMSPOOL ON
SET TAB OFF
SET PAGESIZE 100
SET SERVEROUTPUT ON;

CREATE TABLE problems(
  probid          NUMBER PRIMARY KEY,
  custid          NUMBER,
  priority        NUMBER,
  description     VARCHAR2(4000),
  center          VARCHAR2(100));

/*
```

Step 5 Create the evalctx Evaluation Context

```
*/

DECLARE
  ta  SYS.RE$TABLE_ALIAS_LIST;
BEGIN
  ta := SYS.RE$TABLE_ALIAS_LIST(SYS.RE$TABLE_ALIAS('prob', 'problems'));
  DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT(
    evaluation_context_name    => 'evalctx',
    table_aliases              => ta,
    evaluation_context_comment => 'support problem definition');
END;
/

/*
```

Step 6 Create the Rules that Correspond to Problem Priority

```
*/

DECLARE
  ac  SYS.RE$NV_LIST;
BEGIN
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('CENTER', SYS.AnyData.CONVERTVARCHAR2('San Jose'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r1',
    condition      => 'prob.priority > 2',
    action_context => ac,
    rule_comment   => 'Low priority problems');
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('CENTER', SYS.AnyData.CONVERTVARCHAR2('New York'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r2',
    condition      => 'prob.priority <= 2',
    action_context => ac,
    rule_comment   => 'High priority problems');
  ac := sys.RE$NV_LIST(NULL);
  ac.ADD_PAIR('ALERT', SYS.AnyData.CONVERTVARCHAR2('John Doe'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r3',
    condition      => 'prob.priority = 1',
    action_context => ac,
    rule_comment   => 'Urgent problems');
END;
/

/*
```

Step 7 Create the rs Rule Set

```
*/

BEGIN
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name      => 'rs',
    evaluation_context => 'evalctx',
    rule_set_comment   => 'support rules');
END;
/

/*
```

Step 8 Add the Rules to the Rule Set

```
*/

BEGIN
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r1',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r2',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r3',
    rule_set_name => 'rs');
END;
/

/*
```

Step 9 Query the Data Dictionary

At this point, you can view the evaluation context, rules, and rule set you created in the previous steps.

```
*/

SELECT * FROM USER_EVALUATION_CONTEXTS;

SELECT * FROM USER_RULES;

SELECT * FROM USER_RULE_SETS;

/*
```

Step 10 Create the problem_dispatch PL/SQL Procedure

```
*/
```

```
CREATE OR REPLACE PROCEDURE problem_dispatch
IS
    cursor c IS SELECT probid, rowid FROM problems WHERE center IS NULL;
    tv        SYS.RE$TABLE_VALUE;
    tvl       SYS.RE$TABLE_VALUE_LIST;
    truehits  SYS.RE$RULE_HIT_LIST;
    maybehits SYS.RE$RULE_HIT_LIST;
    ac        SYS.RE$NV_LIST;
    namearray SYS.RE$NAME_ARRAY;
    name      VARCHAR2(30);
    cval      VARCHAR2(100);
    rnum      INTEGER;
    i         INTEGER;
    status    PLS_INTEGER;
BEGIN
  FOR r IN c LOOP
    tv  := SYS.RE$TABLE_VALUE('prob', rowidtochar(r.rowid));
    tvl := SYS.RE$TABLE_VALUE_LIST(tv);
    truehits := SYS.RE$RULE_HIT_LIST();
    maybehits := SYS.RE$RULE_HIT_LIST();
    DBMS_RULE.EVALUATE(
      rule_set_name        => 'support.rs',
      evaluation_context   => 'evalctx',
      table_values         => tvl,
      true_rules           => truehits,
      maybe_rules          => maybehits);
    FOR rnum IN 1..truehits.COUNT LOOP
      DBMS_OUTPUT.PUT_LINE('Using rule '|| truehits(rnum).rule_name);
      ac := truehits(rnum).rule_action_context;
      namearray := ac.get_all_names;
      FOR i IN 1..namearray.COUNT LOOP
        name := namearray(i);
        status := ac.GET_VALUE(name).GETVARCHAR2(cval);
        IF (name = 'CENTER') THEN
          UPDATE PROBLEMS SET center = cval WHERE rowid = r.rowid;
          DBMS_OUTPUT.PUT_LINE('Assigning '|| r.probid || ' to ' || cval);
        ELSIF (name = 'ALERT') THEN
          DBMS_OUTPUT.PUT_LINE('Alert: '|| cval || ' Problem:' || r.probid);
        END IF;
       END LOOP;
    END LOOP;
  END LOOP;
END;
/
```

```
/*
```

Step 11 Log Problems

```
*/

INSERT INTO problems(probid, custid, priority, description)
  VALUES(10101, 11, 1, 'no dial tone');

INSERT INTO problems(probid, custid, priority, description)
  VALUES(10102, 21, 2, 'noise on local calls');

INSERT INTO problems(probid, custid, priority, description)
  VALUES(10103, 31, 3, 'noise on long distance calls');

COMMIT;

/*
```

Step 12 List the Problems in the problems Table

This `SELECT` statement should show the problems logged in Step 11. Notice that the `center` column is `NULL` for each new row inserted.

```
*/

SELECT * FROM problems;

/*
```

Step 13 Dispatch the Problems by Running the problem_dispatch Procedure

```
*/

EXECUTE problem_dispatch;

/*
```

Step 14 List the Problems in the problems Table

If the problems were dispatched successfully in Step 13, then this SELECT statement should show the center to which each problem was dispatched in the center column.

```
*/

SELECT * FROM problems;

/*
```

Step 15 Check the Spool Results

Check the rules_table.out spool file to ensure that all actions completed successfully after this script completes.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT ****************************/
```

Using Rules on Both Explicit Variables and Table Data

This example illustrates using rules to evaluate data stored in explicit variables and in a table. The application uses `problems` table in the `support` schema, into which customer problems are inserted. This example uses the following rules for handling customer problems:

- Assign all problems with priority greater than 2 to the San Jose Center
- Assign all problems with priority equal to 2 to the New York Center
- Assign all problems with priority equal to 1 to the Tampa Center from 8 AM to 8 PM
- Assign all problems with priority equal to 1 to the Bangalore Center from 8 PM to 8 AM
- Send an alert to the vice president of support for a problem with priority equal to 1

The evaluation context consists of the `problems` table. The relevant row of the table, which corresponds to the problem being routed, is passed to the `DBMS_RULE.EVALUATE` procedure as a table value.

Some of the rules in this example refer to the current time, which is represented as an explicit variable named `current_time`. The current time is treated as additional data in the evaluation context. It is represented as a variable for the following reasons:

- It is not practical to store the current time in a table since it would have to be updated very often.
- The current time can be accessed by inserting calls to `SYSDATE` in every rule that requires it, but that would cause repeated invocations of the same SQL function `SYSDATE`, which may slow down rule evaluation. Different values of the current time in different rules may lead to incorrect behavior.

Complete the following steps:

1. Show Output and Spool Results
2. Drop and Recreate the support User
3. Grant the support User the Necessary System Privileges on Rules
4. Create the problems Table
5. Create the evalctx Evaluation Context

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 20-27 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************ BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run SET ECHO ON and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL rules_var_tab.out

/*
```

```
Step 2  Drop and Recreate the support User
*/

CONNECT SYS/CHANGE_ON_INSTALL AS SYSDBA;

DROP USER support CASCADE;

GRANT CONNECT, RESOURCE TO support IDENTIFIED BY support;

/*

Step 3  Grant the support User the Necessary System Privileges on Rules
*/

BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
END;
/

/*

Step 4  Create the problems Table
*/

CONNECT support/support

SET FEEDBACK 1
SET NUMWIDTH 10
SET LINESIZE 80
SET TRIMSPOOL ON
SET TAB OFF
SET PAGESIZE 100
SET SERVEROUTPUT ON;
```

```
CREATE TABLE problems(
  probid          NUMBER PRIMARY KEY,
  custid          NUMBER,
  priority        NUMBER,
  description     VARCHAR2(4000),
  center          VARCHAR2(100));

/*
```

Step 5 Create the evalctx Evaluation Context

```
*/

DECLARE
  ta SYS.RE$TABLE_ALIAS_LIST;
  vt SYS.RE$VARIABLE_TYPE_LIST;
BEGIN
  ta := SYS.RE$TABLE_ALIAS_LIST(SYS.RE$TABLE_ALIAS('prob', 'problems'));
  vt := SYS.RE$VARIABLE_TYPE_LIST(
          SYS.RE$VARIABLE_TYPE('current_time', 'DATE', NULL, NULL));
  DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT(
    evaluation_context_name    => 'evalctx',
    table_aliases              => ta,
    variable_types             => vt,
    evaluation_context_comment => 'support problem definition');
END;
/

/*
```

Step 6 Create the Rules that Correspond to Problem Priority

```
*/
```

```
DECLARE
  ac SYS.RE$NV_LIST;
BEGIN
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('CENTER', SYS.AnyData.CONVERTVARCHAR2('San Jose'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r1',
    condition      => 'prob.priority > 2',
    action_context => ac,
    rule_comment   => 'Low priority problems');
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('CENTER', SYS.AnyData.CONVERTVARCHAR2('New York'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r2',
    condition      => 'prob.priority = 2',
    action_context => ac,
    rule_comment   => 'High priority problems');
  ac := SYS.RE$NV_LIST(NULL);
  ac.add_pair('ALERT', SYS.AnyData.CONVERTVARCHAR2('John Doe'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r3',
    condition      => 'prob.priority = 1',
    action_context => ac,
    rule_comment   => 'Urgent problems');
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('CENTER', SYS.AnyData.CONVERTVARCHAR2('Tampa'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name => 'r4',
    condition => '(prob.priority = 1) and ' ||
                 '(TO_NUMBER(TO_CHAR(:current_time, ''HH24'')) >= 8) and ' ||
                 '(TO_NUMBER(TO_CHAR(:current_time, ''HH24'')) <= 20)',
    action_context => ac,
    rule_comment => 'Urgent daytime problems');
  ac := sys.RE$NV_LIST(NULL);
  ac.add_pair('CENTER', SYS.Anydata.CONVERTVARCHAR2('Bangalore'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name => 'r5',
    condition => '(prob.priority = 1) and ' ||
                 '((TO_NUMBER(TO_CHAR(:current_time, ''HH24'')) < 8) or ' ||
                 ' (TO_NUMBER(TO_CHAR(:current_time, ''HH24'')) > 20))',
    action_context => ac,
    rule_comment => 'Urgent nighttime problems');
END;
/
```

```
/*

Step 7  Create the rs Rule Set
*/

BEGIN
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name      => 'rs',
    evaluation_context => 'evalctx',
    rule_set_comment   => 'support rules');
END;
/

/*

Step 8  Add the Rules to the Rule Set
*/

BEGIN
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r1',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r2',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r3',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r4',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r5',
    rule_set_name => 'rs');
END;
/

/*
```

Step 9 Query the Data Dictionary

At this point, you can view the evaluation context, rules, and rule set you created in the previous steps.

```
*/

SELECT * FROM USER_EVALUATION_CONTEXTS;

SELECT * FROM USER_RULES;

SELECT * FROM USER_RULE_SETS;

/*
```

Step 10 Create the problem_dispatch PL/SQL Procedure

```
*/

CREATE OR REPLACE PROCEDURE problem_dispatch
IS
    cursor c  is SELECT probid, rowid FROM PROBLEMS WHERE center IS NULL;
    tv        SYS.RE$TABLE_VALUE;
    tvl       SYS.RE$TABLE_VALUE_LIST;
    vv1       SYS.RE$VARIABLE_VALUE;
    vvl       SYS.RE$VARIABLE_VALUE_LIST;
    truehits  SYS.RE$RULE_HIT_LIST;
    maybehits SYS.RE$RULE_HIT_LIST;
    ac        SYS.RE$NV_LIST;
    namearray SYS.RE$NAME_ARRAY;
    name      VARCHAR2(30);
    cval      VARCHAR2(100);
    rnum      INTEGER;
    i         INTEGER;
    status    PLS_INTEGER;
```

```
BEGIN
  FOR r IN c LOOP
    tv  := sYS.RE$TABLE_VALUE('prob', ROWIDTOCHAR(r.rowid));
    tvl := SYS.RE$TABLE_VALUE_LIST(tv);
    vv1 := SYS.RE$VARIABLE_VALUE('current_time',
                                 SYS.AnyData.CONVERTDATE(SYSDATE));
    vvl := SYS.RE$VARIABLE_VALUE_LIST(vv1);
    truehits := SYS.RE$RULE_HIT_LIST();
    maybehits := SYS.RE$RULE_HIT_LIST();
    DBMS_RULE.EVALUATE(
        rule_set_name        => 'support.rs',
        evaluation_context   => 'evalctx',
        table_values         => tvl,
        variable_values      => vvl,
        true_rules           => truehits,
        maybe_rules          => maybehits);
    FOR rnum IN 1..truehits.COUNT loop
      DBMS_OUTPUT.PUT_LINE('Using rule '|| truehits(rnum).rule_name);
      ac := truehits(rnum).rule_action_context;
      namearray := ac.GET_ALL_NAMES;
      FOR i in 1..namearray.COUNT LOOP
        name := namearray(i);
        status := ac.GET_VALUE(name).GETVARCHAR2(cval);
        IF (name = 'CENTER') THEN
          UPDATE problems SET center = cval
          WHERE rowid = r.rowid;
          DBMS_OUTPUT.PUT_LINE('Assigning '|| r.probid || ' to ' || cval);
        ELSIF (name = 'ALERT') THEN
          DBMS_OUTPUT.PUT_LINE('Alert: '|| cval || ' Problem:' || r.probid);
        END IF;
      END LOOP;
    END LOOP;
  END LOOP;
END;
/

/*
```

Step 11 Log Problems

```
*/

INSERT INTO problems(probid, custid, priority, description)
  VALUES(10201, 12, 1, 'no dial tone');

INSERT INTO problems(probid, custid, priority, description)
  VALUES(10202, 22, 2, 'noise on local calls');

INSERT INTO PROBLEMS(probid, custid, priority, description)
  VALUES(10203, 32, 3, 'noise on long distance calls');

COMMIT;

/*
```

Step 12 List the Problems in the problems Table

This `SELECT` statement should show the problems logged in Step 11. Notice that the `center` column is `NULL` for each new row inserted.

```
*/

SELECT * FROM problems;

/*
```

Step 13 Dispatch the Problems by Running the problem_dispatch Procedure

```
*/

EXECUTE problem_dispatch;

/*
```

Step 14 List the Problems in the problems Table

If the problems were dispatched successfully in Step 13, then this `SELECT` statement should show the center to which each problem was dispatched in the `center` column.

```
*/

SELECT * FROM problems;

/*
```

Step 15 Check the Spool Results

Check the `rules_var_tab.out` spool file to ensure that all actions completed successfully after this script completes.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT *****************************/
```

Using Rules on Implicit Variables and Table Data

This example illustrates using rules to evaluate implicit variables and data stored in a table. The application uses the `problems` table in the `support` schema, into which customer problems are inserted. This example uses the following rules for handling customer problems:

- Assign all problems with priority greater than 2 to the San Jose Center
- Assign all problems with priority equal to 2 to the New York Center
- Assign all problems with priority equal to 1 to the Tampa Center from 8 AM to 8 PM
- Assign all problems with priority equal to 1 to the Bangalore Center from 8 PM to 8 AM
- Send an alert to the vice president of support for a problem with priority equal to 1

The evaluation context consists of the `problems` table. The relevant row of the table, which corresponds to the problem being routed, is passed to the `DBMS_RULE.EVALUATE` procedure as a table value.

As in the example illustrated in "Using Rules on Both Explicit Variables and Table Data" on page 20-18, the current time is represented as a variable named `current_time`. However, this variable's value is not specified during evaluation by the caller. That is, `current_time` is an implicit variable in this example. A PL/SQL function named `timefunc` is specified for `current_time`, and this function is invoked once during evaluation to get its value.

Using implicit variables can be useful in other cases if one of the following conditions is true:

- The caller does not have access to the variable value
- The variable is referenced infrequently in rules. Because it is implicit, its value can be retrieved only when necessary, and does not need to be passed in for every evaluation.

Complete the following steps:

1. Show Output and Spool Results
2. Drop and Recreate the support User
3. Grant the support User the Necessary System Privileges on Rules
4. Create the problems Table
5. Create the timefunc Function to Return the Value of current_time
6. Create the evalctx Evaluation Context
7. Create the Rules that Correspond to Problem Priority
8. Create the rs Rule Set
9. Add the Rules to the Rule Set
10. Query the Data Dictionary
11. Create the problem_dispatch PL/SQL Procedure
12. Log Problems
13. List the Problems in the problems Table
14. Dispatch the Problems by Running the problem_dispatch Procedure
15. List the Problems in the problems Table
16. Check the Spool Results

Note: If you are viewing this document online, then you can copy the text from the "BEGINNING OF SCRIPT" line on this page to the next "END OF SCRIPT" line on page 20-36 into a text editor and then edit the text to create a script for your environment. Run the script with SQL*Plus on a computer that can connect to all of the databases in the environment.

```
/************************* BEGINNING OF SCRIPT ******************************
```

Step 1 Show Output and Spool Results

Run SET ECHO ON and specify the spool file for the script. Check the spool file for errors after you run this script.

```
*/

SET ECHO ON
SPOOL rules_implicit_var.out

/*
```

Step 2 Drop and Recreate the support User

```
*/

CONNECT SYS/CHANGE_ON_INSTALL AS SYSDBA;

DROP USER support CASCADE;

GRANT CONNECT, RESOURCE TO support IDENTIFIED BY support;

/*
```

Step 3 Grant the support User the Necessary System Privileges on Rules

```
*/
```

```
BEGIN
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_SET_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_RULE_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
  DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(
    privilege    => DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT_OBJ,
    grantee      => 'support',
    grant_option => FALSE);
END;
/

/*
```

Step 4 Create the problems Table

```
*/

CONNECT support/support

SET FEEDBACK 1
SET NUMWIDTH 10
SET LINESIZE 80
SET TRIMSPOOL ON
SET TAB OFF
SET PAGESIZE 100
SET SERVEROUTPUT ON;

CREATE TABLE problems(
  probid          NUMBER PRIMARY KEY,
  custid          NUMBER,
  priority        NUMBER,
  description     VARCHAR2(4000),
  center          VARCHAR2(100));

/*
```

Step 5 Create the timefunc Function to Return the Value of current_time

```
*/
```

```
CREATE OR REPLACE FUNCTION timefunc(
  eco    VARCHAR2,
  ecn    VARCHAR2,
  var    VARCHAR2,
  evctx  SYS.RE$NV_LIST)
RETURN SYS.RE$VARIABLE_VALUE
IS
BEGIN
  IF (var = 'CURRENT_TIME') THEN
    RETURN(SYS.RE$VARIABLE_VALUE('CURRENT_TIME',
                                 SYS.AnyData.CONVERTDATE(sysdate)));
  ELSE
    RETURN(NULL);
  END IF;
END;
/

/*
```

Step 6 Create the evalctx Evaluation Context

```
*/

DECLARE
  ta SYS.RE$TABLE_ALIAS_LIST;
  vt SYS.RE$VARIABLE_TYPE_LIST;
BEGIN
  ta := SYS.RE$TABLE_ALIAS_LIST(SYS.RE$TABLE_ALIAS('prob', 'problems'));
  vt := SYS.RE$VARIABLE_TYPE_LIST(
          SYS.RE$VARIABLE_TYPE('current_time', 'DATE', 'timefunc', NULL));
  DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT(
    evaluation_context_name    => 'evalctx',
    table_aliases              => ta,
    variable_types             => vt,
    evaluation_context_comment => 'support problem definition');
END;
/

/*
```

Step 7 Create the Rules that Correspond to Problem Priority

```
*/
```

```
DECLARE
  ac SYS.RE$NV_LIST;
BEGIN
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('CENTER', SYS.AnyData.CONVERTVARCHAR2('San Jose'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r1',
    condition      => 'prob.priority > 2',
    action_context => ac,
    rule_comment   => 'Low priority problems');
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('CENTER', SYS.AnyData.CONVERTVARCHAR2('New York'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r2',
    condition      => 'prob.priority = 2',
    action_context => ac,
    rule_comment   => 'High priority problems');
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('ALERT', SYS.AnyData.CONVERTVARCHAR2('John Doe'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name      => 'r3',
    condition      => 'prob.priority = 1',
    action_context => ac,
    rule_comment   => 'Urgent problems');
  ac := SYS.RE$NV_LIST(NULL);
  ac.ADD_PAIR('CENTER', SYS.AnyData.CONVERTVARCHAR2('Tampa'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name => 'r4',
    condition => '(prob.priority = 1) and ' ||
                 '(TO_NUMBER(TO_CHAR(:current_time, ''HH24'')) >= 8) and ' ||
                 '(TO_NUMBER(TO_CHAR(:current_time, ''HH24'')) <= 20)',
    action_context => ac,
    rule_comment   => 'Urgent daytime problems');
  ac := SYS.RE$NV_LIST(NULL);
  ac.add_pair('CENTER', sys.anydata.convertvarchar2('Bangalore'));
  DBMS_RULE_ADM.CREATE_RULE(
    rule_name => 'r5',
    condition => '(prob.priority = 1) and ' ||
                 '((TO_NUMBER(TO_CHAR(:current_time, ''HH24'')) < 8) or ' ||
                 ' (TO_NUMBER(TO_CHAR(:current_time, ''HH24'')) > 20))',
    action_context => ac,
    rule_comment => 'Urgent nighttime problems');
END;
/
```

```
/*

Step 8  Create the rs Rule Set
*/

BEGIN
  DBMS_RULE_ADM.CREATE_RULE_SET(
    rule_set_name      => 'rs',
    evaluation_context => 'evalctx',
    rule_set_comment   => 'support rules');
END;
/

/*

Step 9  Add the Rules to the Rule Set
*/

BEGIN
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r1',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r2',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r3',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r4',
    rule_set_name => 'rs');
  DBMS_RULE_ADM.ADD_RULE(
    rule_name     => 'r5',
    rule_set_name => 'rs');
END;
/

/*
```

Step 10 Query the Data Dictionary

At this point, you can view the evaluation context, rules, and rule set you created in the previous steps.

```
*/

SELECT * FROM USER_EVALUATION_CONTEXTS;

SELECT * FROM USER_RULES;

SELECT * FROM USER_RULE_SETS;

/*
```

Step 11 Create the problem_dispatch PL/SQL Procedure

```
*/

CREATE OR REPLACE PROCEDURE problem_dispatch
IS
    cursor c  IS SELECT probid, rowid FROM problems WHERE center IS NULL;
    tv        SYS.RE$TABLE_VALUE;
    tvl       SYS.RE$TABLE_VALUE_LIST;
    truehits  SYS.RE$RULE_HIT_LIST;
    maybehits SYS.RE$RULE_HIT_LIST;
    ac        SYS.RE$NV_LIST;
    namearray SYS.RE$NAME_ARRAY;
    name      VARCHAR2(30);
    cval      VARCHAR2(100);
    rnum      INTEGER;
    i         INTEGER;
    status    PLS_INTEGER;
BEGIN
  FOR r IN c LOOP
    tv  := SYS.RE$TABLE_VALUE('prob', rowidtochar(r.rowid));
    tvl := SYS.RE$TABLE_VALUE_LIST(tv);
    truehits := SYS.RE$RULE_HIT_LIST();
    maybehits := SYS.RE$RULE_HIT_LIST();
    DBMS_RULE.EVALUATE(
        rule_set_name        => 'support.rs',
        evaluation_context   => 'evalctx',
        table_values         => tvl,
        true_rules           => truehits,
        maybe_rules          => maybehits);
```

```
    FOR rnum IN 1..truehits.COUNT LOOP
      DBMS_OUTPUT.PUT_LINE('Using rule '|| truehits(rnum).rule_name);
      ac := truehits(rnum).rule_action_context;
      namearray := ac.GET_ALL_NAMES;
      FOR i IN 1..namearray.COUNT LOOP
        name := namearray(i);
        status := ac.GET_VALUE(name).GETVARCHAR2(cval);
        IF (name = 'CENTER') THEN
          UPDATE problems SET center = cval
            WHERE rowid = r.rowid;
          DBMS_OUTPUT.PUT_LINE('Assigning '|| r.probid || ' to ' || cval);
        ELSIF (name = 'ALERT') THEN
          DBMS_OUTPUT.PUT_LINE('Alert: '|| cval || ' Problem:' || r.probid);
        END IF;
      END LOOP;
    END LOOP;
  END LOOP;
END;
/

/*
```

Step 12 Log Problems

```
*/

INSERT INTO problems(probid, custid, priority, description)
  VALUES(10301, 13, 1, 'no dial tone');

INSERT INTO problems(probid, custid, priority, description)
  VALUES(10302, 23, 2, 'noise on local calls');

INSERT INTO problems(probid, custid, priority, description)
  VALUES(10303, 33, 3, 'noise on long distance calls');

COMMIT;

/*
```

Step 13 List the Problems in the problems Table

This SELECT statement should show the problems logged in Step 12. Notice that the center column is NULL for each new row inserted.

```
*/

SELECT * FROM problems;

/*
```

Step 14 Dispatch the Problems by Running the problem_dispatch Procedure

```
*/

EXECUTE problem_dispatch;

/*
```

Step 15 List the Problems in the problems Table

If the problems were dispatched successfully in Step 13, then this SELECT statement should show the center to which each problem was dispatched in the center column.

```
*/

SELECT * FROM problems;

/*
```

Step 16 Check the Spool Results

Check the rules_implicit_var.out spool file to ensure that all actions completed successfully after this script completes.

```
*/

SET ECHO OFF
SPOOL OFF

/************************** END OF SCRIPT *****************************/
```

Part IV

Appendices

This part includes the following appendix:

- Appendix A, "XML Schema for LCRs"

A

XML Schema for LCRs

The XML schema described in this appendix defines the format of a logical change record (LCR).

This appendix contains this topic:

- Definition of the XML Schema for LCRs

The namespace for this schema is the following:

`http://xmlns.oracle.com/streams/schemas/lcr`

The schema is the following:

`http://xmlns.oracle.com/streams/schemas/lcr/streamslcr.xsd`

This schema definition can be loaded into the database by connecting as SYS in SQL*Plus and executing the following file:

`rdbms/admin/catxlcr.sql`

The `rdbms` directory is in your Oracle home.

Definition of the XML Schema for LCRs

The following is the XML schema definition for LCRs:

```
schema xmlns="http://www.w3.org/2001/XMLSchema"
        targetNamespace="http://xmlns.oracle.com/streams/schemas/lcr"
        xmlns:lcr="http://xmlns.oracle.com/streams/schemas/lcr"
        xmlns:xdb="http://xmlns.oracle.com/xdb"
          version="1.0">

  <simpleType name = "short_name">
    <restriction base = "string">
      <maxLength value="30"/>
    </restriction>
  </simpleType>

  <simpleType name = "long_name">
    <restriction base = "string">
      <maxLength value="4000"/>
    </restriction>
  </simpleType>

  <simpleType name = "db_name">
    <restriction base = "string">
      <maxLength value="128"/>
    </restriction>
  </simpleType>

  <!-- Default session parameter is used if format is not specified -->
  <complexType name="datetime_format">
    <sequence>
      <element name = "value" type = "string"/>
      <element name = "format" type = "string" minOccurs="0"/>
    </sequence>
  </complexType>

  <complexType name="anydata">
    <choice>
      <element name="varchar2" type = "string" xdb:SQLType="VARCHAR2"/>

      <!-- Represent char as varchar2. xdb:CHAR blank pads upto 2000 bytes! -->
      <element name="char" type = "string" xdb:SQLType="VARCHAR2"/>
      <element name="nchar" type = "string" xdb:SQLType="NVARCHAR2"/>
```

```
    <element name="nvarchar2" type = "string" xdb:SQLType="NVARCHAR2"/>
    <element name="number" type = "double" xdb:SQLType="NUMBER"/>
    <element name="raw" type = "hexBinary" xdb:SQLType="RAW"/>
    <element name="date" type = "lcr:datetime_format"/>
    <element name="timestamp" type = "lcr:datetime_format"/>
    <element name="timestamp_tz" type = "lcr:datetime_format"/>
    <element name="timestamp_ltz" type = "lcr:datetime_format"/>

    <!-- Interval YM should be according to format allowed by SQL -->
    <element name="interval_ym" type = "string"/>

    <!-- Interval DS should be according to format allowed by SQL -->
    <element name="interval_ds" type = "string"/>
  </choice>
</complexType>

<complexType name="column_value">
  <sequence>
    <element name = "column_name" type = "lcr:long_name"/>
    <element name = "data" type = "lcr:anydata"/>
    <element name = "lob_information" type = "string" minOccurs="0"/>
    <element name = "lob_offset" type = "nonNegativeInteger" minOccurs="0"/>
    <element name = "lob_operation_size" type = "nonNegativeInteger"
                                                          minOccurs="0"/>
  </sequence>
</complexType>

<element name = "ROW_LCR">
  <complexType>
    <sequence>
      <element name = "source_database_name" type = "lcr:db_name"/>
      <element name = "command_type" type = "string"/>
      <element name = "object_owner" type = "lcr:short_name"/>
      <element name = "object_name" type = "lcr:short_name"/>
      <element name = "tag" type = "hexBinary" xdb:SQLType="RAW"
                                                        minOccurs="0"/>
      <element name = "transaction_id" type = "string" minOccurs="0"/>
      <element name = "scn" type = "double" xdb:SQLType="NUMBER"
                                                        minOccurs="0"/>
      <element name = "old_values" minOccurs = "0">
        <complexType>
          <sequence>
            <element name = "old_value" type="lcr:column_value"
                                                 maxOccurs = "unbounded"/>
          </sequence>
```

```
        </complexType>
      </element>
      <element name = "new_values" minOccurs = "0">
        <complexType>
          <sequence>
            <element name = "new_value" type="lcr:column_value"
                                                  maxOccurs = "unbounded"/>
          </sequence>
        </complexType>
      </element>
    </sequence>
  </complexType>
</element>

<element name = "DDL_LCR">
  <complexType>
    <sequence>
      <element name = "source_database_name" type = "lcr:db_name"/>
      <element name = "command_type" type = "string"/>
      <element name = "current_schema" type = "lcr:short_name"/>
      <element name = "ddl_text" type = "string"/>
      <element name = "object_type" type = "string"
                                              minOccurs = "0"/>
      <element name = "object_owner" type = "lcr:short_name"
                                              minOccurs = "0"/>
      <element name = "object_name" type = "lcr:short_name"
                                              minOccurs = "0"/>
      <element name = "logon_user" type = "lcr:short_name"
                                              minOccurs = "0"/>
      <element name = "base_table_owner" type = "lcr:short_name"
                                              minOccurs = "0"/>
      <element name = "base_table_name" type = "lcr:short_name"
                                              minOccurs = "0"/>
      <element name = "tag" type = "hexBinary" xdb:SQLType="RAW"
                                              minOccurs = "0"/>
      <element name = "transaction_id" type = "string"
                                              minOccurs = "0"/>
      <element name = "scn" type = "double" xdb:SQLType="NUMBER"
                                              minOccurs = "0"/>
    </sequence>
  </complexType>
</element>
</schema>
```

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