BEA WebLogic® Event Server

EPL Reference

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CHAPTER 1

Introduction and Roadmap

This section describes the contents and organization of this guide—*EPL Reference*.

Document Scope and Audience

This document is a resource for software developers who develop event driven real-time applications. It also contains information that is useful for business analysts and system architects who are evaluating WebLogic Event Server or considering the use of WebLogic Event Server for a particular application.

The topics in this document are relevant during the design, development, configuration, deployment, and performance tuning phases of event driven applications. The document also includes topics that are useful in solving application problems that are discovered during test and pre-production phases of a project.

It is assumed that the reader is familiar with the Java programming language and Spring.

WebLogic Event Server Documentation Set

This document is part of a larger WebLogic Event Server documentation set that covers a comprehensive list of topics. The full documentation set includes the following documents:

- *Getting Started With WebLogic Event Server*
- *Creating WebLogic Event Server Applications*
- *WebLogic Event Server Administration and Configuration Guide*
- *EPL Reference Guide*
- *WebLogic Event Server Reference Guide*
- *WebLogic Event Server Release Notes*

See the main WebLogic Event Server documentation page for further details.

Guide to This Document

This document is organized as follows:

- This chapter, Chapter 1, "Introduction and Roadmap," introduces the organization of this guide and the WebLogic Event Server documentation set and samples.
- Chapter 2, "Overview of the Event Processing Language (EPL)," describes the EPL language at a high level, describes event data types, the processing model, and use cases.
- Chapter 3, "EPL Reference: Clauses," provides reference information about the EPL clauses, such as SELECT, RETAIN, and MATCHING.
- Chapter 4, "EPL Reference: Operators," provides reference information about the operators you can use in your EPL statements.
- Chapter 5, "EPL Reference: Functions," provides reference information about the functions you can use in your EPL statements.
- Chapter 6, "Programmatic Interface to EPL," describes at a high-level the Java APIs.

Samples for the WebLogic Event Server Application Developer

In addition to this document, BEA Systems provides a variety of code samples for WebLogic Event Server application developers. The examples illustrate WebLogic Event Server in action, and provide practical instructions on how to perform key development tasks.

BEA recommends that you run some or all of the examples before programming and configuring your own event driven application.

The examples are distributed in two ways:

- Pre-packaged and compiled in their own domain so you can immediately run them after you install the product.
- Separately in a Java source directory so you can see a typical development environment setup.

The following two examples are provided in both their own domain and as Java source in this release of WebLogic Event Server:

- HelloWorld—Example that shows the basic elements of a WebLogic Event Server application. See Hello World Example for additional information.

  The HelloWorld domain is located in *WLEVS_HOME*`\samples\domains\helloworld_domain`, where *WLEVS_HOME* refers to the top-level WebLogic Event Server directory, such as `c:\beahome\wlevs20`.

  The HelloWorld Java source code is located in *WLEVS_HOME*`\samples\source\applications\helloworld`.

- ForeignExchange (FX)—Example that includes multiple adapters, streams, and complex event processor with a variety of EPL rules, all packaged in the same WebLogic Event Server application. See Foreign Exchange (FX) Example for additional information.

  The ForeignExchange domain is located in *WLEVS_HOME*`\samples\domains\fx_domain`, where *WLEVS_HOME* refers to the top-level WebLogic Event Server directory, such as `c:\beahome\wlevs20`.

  The ForeignExchange Java source code is located in *WLEVS_HOME*`\samples\source\applications\fx`.

WebLogic Event Server also includes an algorithmic trading application, pre-assembled and deployed in its own sample domain; the source code for the example, however, is not provided.

The algorithmic trading domain is located in *WLEVS_HOME*\samples\domains\algotrading_domain.

CHAPTER 2

Overview of the Event Processing Language (EPL)

This section contains information on the following subjects:

Overview of the EPL Language

The Complex Event Processor module can be broken down into the following functional components: event representation, processing model, programmatic interface, and language specification.

Events are represented as POJOs following the JavaBeans conventions. Event properties are exposed through getter methods on the POJO. When possible, the results from EPL statement execution are also returned as POJOs. However, there are times when un-typed events are returned such as when event streams are joined. In this case, an instance of the Map collection interface is returned.

The EPL processing model is continuous: results are output as soon as incoming events are received that meet the constraints of the statement. Two types of events are generated during output: *insert events* for new events entering the output window and *remove events* for old events exiting the output window. Listeners may be attached and notified when either or both type of events occur.

Incoming events may be processed through either sliding or batched windows. Sliding windows process events by gradually moving the window over the data in single increments, while batched windows process events by moving the window over data in discrete chunks. The window size may be defined by the maximum number of events contained or by the maximum amount of time to keep an event.

The EPL programmatic interfaces allow statements to be individually compiled or loaded in bulk through a URL. Statements may be iterated over, retrieved, started and stopped. Listeners may be attached to statements and notified when either insert and/or remove events occur.

The Event Processor Language is a SQL-like language with `SELECT`, `FROM`, `WHERE`, `GROUP BY`, `HAVING` and `ORDER BY` clauses. Streams replace tables as the source of data with events replacing rows as the basic unit of data. Since events are composed of data, the SQL concepts of correlation through joins, filtering through sub-queries, and aggregation through grouping may be effectively leveraged. The `INSERT INTO` clause is recast as a means of forwarding events to other streams for further downstream processing. External data accessible through JDBC may be queried and joined with the stream data. Additional clauses such as the `RETAIN`, `MATCHING`, and `OUTPUT` clauses are also available to provide the missing SQL language constructs specific to event processing.

The `RETAIN` clause constraints the amount of data over which the query is run, essentially defining a virtual window over the stream data. Unlike relational database systems in which tables bound the extents of the data, event processing systems must provide an alternative, more dynamic means of limiting the queried data.

The `MATCHING` clause detects sequences of events matching a specific pattern. Temporal and logical operators such as `AND`, `OR`, and `FOLLOWED BY` enable both occurrence of and absence of events to be detected through arbitrarily complex expressions.

The `OUTPUT` clause throttles results of statement execution to prevent overloading downstream processors. Either all or a subset of the first or last resulting events may be passed on in either time or row-based batches.

A series of use cases is presented in the last section to illustrate the language features under realistic scenarios

Event Representation

Event Objects

An event is an immutable record of a past occurrence of an action or state change. Event properties capture the state information for an event object. An event is represented by either a POJO or a `com.bea.wlevs.cep.event.MapEventObject` that extends the `java.util.Map` interface.

Table 2-1 Event Representation

Java Class	Description
java.lang.Object	Any Java POJO with getter methods following JavaBeans conventions.
com.bea.wlevs.ede.api.MapEventObject	Map events are key-values pairs

Plain Old Java Object Events

Plain old Java object (POJO) events are object instances that expose event properties through JavaBeans-style getter methods. Events classes or interfaces do not have to be fully compliant to the JavaBeans specification; however for the EPL engine to obtain event properties, the required JavaBeans getter methods must be present.

EPL supports JavaBeans-style event classes that extend a super class or implement one or more interfaces. Also, EPL statements can refer to Java interface classes and abstract classes.

Classes that represent events should be made immutable. As events are recordings of a state change or action that occurred in the past, the relevant event properties should not be changeable. However this is not a hard requirement and the EPL engine accepts events that are mutable as well.

Map Events

Events can also be represented by objects that implement the `com.bea.wlevs.ede.api.MapEventObject` interface that extends the `java.util.Map` interface. Event properties of `Map` events are the values of each entry accessible through the get method exposed by the `java.util.Map` interface.

Entries in the `Map` represent event properties. Keys must be of type `java.util.String` for the engine to be able to look up event property names specified by EPL statements. Values can be of any type. POJOs may also appear as values in a `Map`.

Event Properties

EPL expressions can include simple as well as indexed, mapped and nested event properties. The table below outlines the different types of properties and their syntax in an event expression. This syntax allows statements to query deep JavaBeans objects graphs, XML structures and Map events.

Table 2-2 Event Properties

Type	Description	Syntax	Example
Simple	A property that has a single value that may be retrieved. The property type may be a primitive type (such as `int`, or `java.lang.String`) or another complex type.	name	sensorId
Nested	A nested property is a property that lives within another property of an event. Events represented as a Map may only nest other POJO events and not other Map events.	name.nestedname	sensor.value
Indexed	An indexed property stores an ordered collection of objects (all of the same type) that can be individually accessed by an integer valued, non-negative index (or subscript). Events represented as a Map do not support Indexed properties.	name[index]	sensor[0]
Mapped	A mapped property stores a keyed collection of objects (all of the same type). As an extension to standard JavaBeans APIs, EPL considers any property that accepts a String-valued key a mapped property. Events represented as a Map do not support Indexed properties.	name('key')	sensor('light')

Assume there is an `EmployeeEvent` event class as shown below. The mapped and indexed properties in this example return Java objects but could also return Java language primitive types (such as `int` or `String`). The `Address` object and `Employee` objects can themselves have properties that are nested within them, such as a street-Name in the `Address` object or a name of the employee in the `Employee` object.

```
public class EmployeeEvent {
    public String getFirstName();
```

```
    public Address getAddress(String type);
    public Employee getSubordinate(int index);
    public Employee[] getAllSubordinates();
}
```

Simple event properties require a getter-method that returns the property value. In the preceding example, the `getFirstName` getter method returns the `firstName` event property of type `String`.

Indexed event properties require either one of the following getter-methods:

- A method that takes an integer type key value and returns the property value, such as the `getSubordinate` method.
- A method returns an array-type such as the `getAllSubordinates` getter method, which returns an array of `Employee`.

In an EPL statement, indexed properties are accessed via the `property[index]` syntax.

Mapped event properties require a getter-method that takes a `String` type key value and returns a property value, such as the `getAddress` method. In an EPL or event pattern statement, mapped properties are accessed via the `property ('key')` syntax.

Nested event properties require a getter-method that returns the nesting object. The `getAddress` and `getSubordinate` methods are mapped and indexed properties that return a nesting object. In an EPL statement, nested properties are accessed via the `property.nestedProperty` syntax.

All EPL statements allow the use of indexed, mapped and nested properties (or a combination of these) at any place where one or more event property names are expected. The example below shows different combinations of indexed, mapped and nested properties.

```
address('home').streetName
subordinate[0].name='anotherName'
allSubordinates[1].name
subordinate[0].address('home').streetName
```

Similarly, the syntax can be used in EPL statements in all places where an event property name is expected, such as in select lists, where clauses or join criteria.

```
SELECT firstName, address('work'), subordinate[0].name, subordinate[1].name
FROM EmployeeEvent RETAIN ALL
WHERE address('work').streetName = 'Park Ave'
```

Event Sinks

Event sinks provide a means of receiving programmatic notifications when events occur that meet the criteria specified in an EPL statement. Sinks may be notified when either:

- New events occur that meet the criteria specified in an EPL statement. These are termed `ISTREAM` events.
- Old events that previously met the criteria specified in an EPL statement are pushed out of the output window due to their expiration or due to new incoming events occurring that take their place. These are termed `RSTREAM` events.

Detailed examples illustrating when each of these notifications occur are provided in "Processing Model" on page 2-6.

To receive `ISTREAM` events, use the `com.bea.wlevs.ede.api.EventSink` interface. Your implementation must provide a single `onEvent` method that the engine invokes when results become available. With this interface, only the new events are sent to the listener.

```
public interface EventSink extends EventListener {
   void onEvent(List<Object> newEvents)
   throws RejectEventException;
}
```

The engine provides statement results to event sinks as a list of POJO or `MapEventObject` instances. For wildcard selects, the result will match the original event object type that was sent into the engine. For joins and select clauses with expressions, the resulting object will implement the `com.bea.wlevs.ede.api.MapEventObject` interface

Processing Model

Event Streams

The EPL processing model is continuous: Listeners to statements receive updated data as soon as the engine processes events for that statement, according to the statement's choice of event streams, retain clause restrictions, filters and output rates.

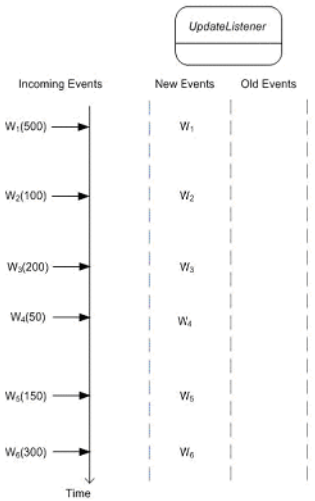
In this section we look at the output of a very simple EPL statement. The statement selects an event stream without using a data window and without applying any filtering, as follows:

```
SELECT * FROM Withdrawal RETAIN ALL
```

This statement selects all `Withdrawal` events. Every time the engine processes an event of type `Withdrawal` or any sub-type of `Withdrawal`, it invokes all update listeners, handing the new event to each of the statement's listeners.

The term insert stream denotes the new events arriving, and entering a data window or aggregation. The insert stream in this example is the stream of arriving `Withdrawal` events, and is posted to update listeners as new events.

The diagram below shows a series of `Withdrawal` events 1 to 6 arriving over time. For this diagram as well as the others in this section, the number in parenthesis is the value of the amount property in the `Withdrawal` event.



The example statement above results in only new events and no old events posted by the engine to the statement's listeners because no `RETAIN` clause is specified.

Sliding Windows

There are two types of sliding windows: row-based and time-based. Each of these is discussed in the following sections.

Row-Based Sliding Windows

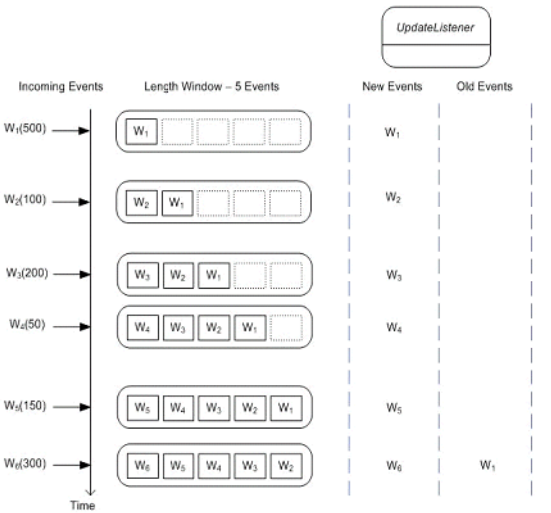
A row-based sliding window instructs the engine to only keep the last N events for a stream. The next statement applies a length window onto the `Withdrawal` event stream. The statement serves to illustrate the concept of data window and events entering and leaving a data window:

```
SELECT * FROM Withdrawal RETAIN 5 EVENTS
```

The size of this statement's window is five events. The engine enters all arriving `Withdrawal` events into the window. When the window is full, the oldest `Withdrawal` event is pushed out the window. The engine indicates to update listeners all events entering the window as new events, and all events leaving the window as old events.

While the term *insert stream* denotes new events arriving, the term `remove stream` denotes events leaving a data window, or changing aggregation values. In this example, the remove stream is the stream of `Withdrawal` events that leave the length window, and such events are posted to update listeners as old events.

The next diagram illustrates how the length window contents change as events arrive and shows the events posted to an update listener.



As before, all arriving events are posted as new events to update listeners. In addition, when event W_1 leaves the length window on arrival of event W_6, it is posted as an old event to update listeners.

Similar to a length window, a time window also keeps the most recent events up to a given time period. A time window of 5 seconds, for example, keeps the last 5 seconds of events. As seconds pass, the time window actively pushes the oldest events out of the window resulting in one or more old events posted to update listeners.

EPL supports optional `ISTREAM` and `RSTREAM` keywords on `SELECT` clauses and on `INSERT INTO` clauses. These instruct the engine to only forward events that enter or leave data windows, or select only current or prior aggregation values, i.e. the insert stream or the remove stream.

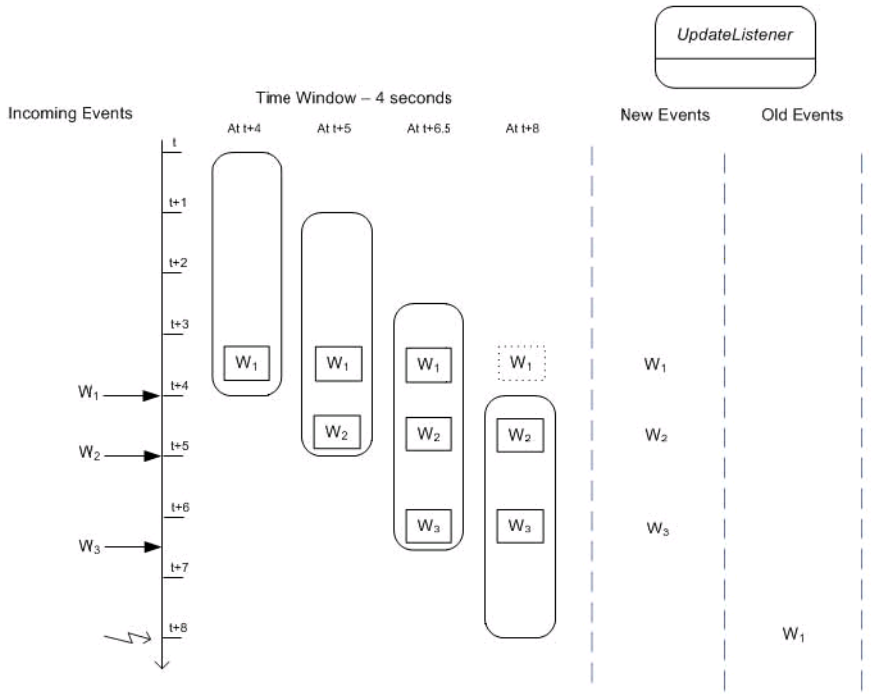
Time-Based Sliding Windows

A time-based sliding window is a moving window extending to the specified time interval into the past based on the system time. Time-based sliding windows enable us to limit the number of events considered by a query, as do row-based sliding windows.

The next diagram serves to illustrate the functioning of a time window. For the diagram, we assume a query that simply selects the event itself and does not group or filter events.

```
SELECT * FROM Withdrawal RETAIN 4 SECONDS
```

The diagram starts at a given time `t` and displays the contents of the time window at `t+4` and `t+5` seconds and so on.



The activity as illustrated by the diagram:

1. At time `t + 4` seconds an event W_1 arrives and enters the time window. The engine reports the new event to update listeners.
2. At time `t + 5` seconds an event W_2 arrives and enters the time window. The engine reports the new event to update listeners.
3. At time `t + 6.5` seconds an event W_3 arrives and enters the time window. The engine reports the new event to update listeners.
4. At time `t + 8` seconds event W_1 leaves the time window. The engine reports the event as an old event to update listeners.

As a practical example, consider the need to determine all accounts where the average withdrawal amount per account for the last 4 seconds of withdrawals is greater then 1000. The statement to solve this problem is shown below.

```
SELECT account, AVG(amount)
FROM Withdrawal RETAIN 4 SECONDS
GROUP BY account
HAVING amount > 1000
```

Batched Windows

Both row-based and time-based windows may be batched. The next sections explain each of these concepts in turn.

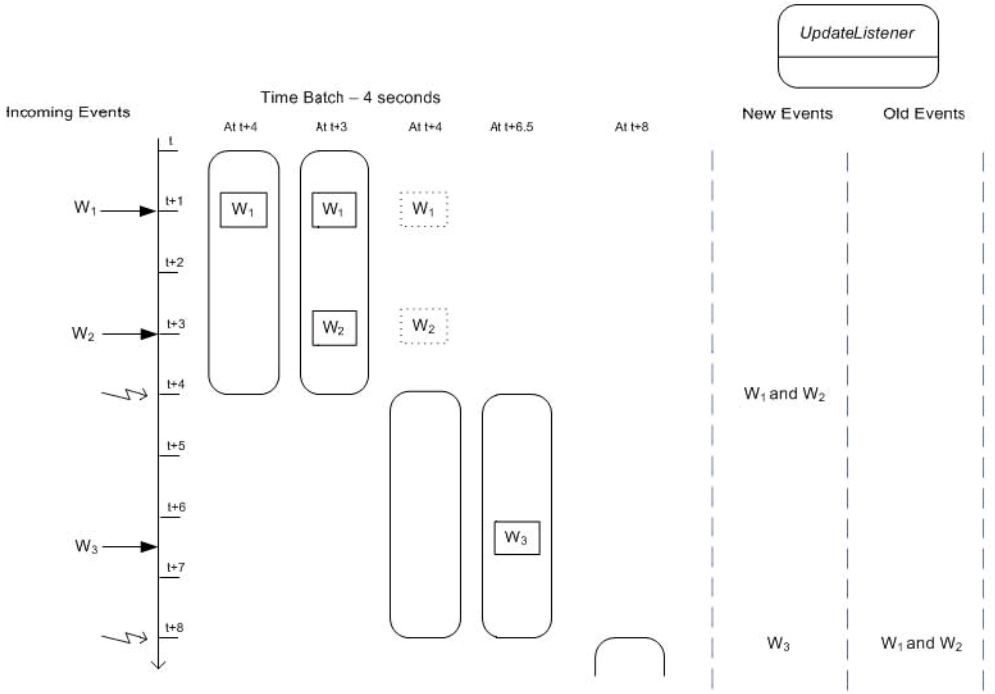
Time-Based Batched Windows

The time-based batch window buffers events and releases them every specified time interval in one update. Time-based batch windows control the evaluation of events, as does the length batch window.

The next diagram serves to illustrate the functioning of a time batch view. For the diagram, we assume a simple query as below:

```
SELECT * FROM Withdrawal RETAIN BATCH OF 4 SECONDS
```

The diagram starts at a given time t and displays the contents of the time window at `t + 4` and t `+ 5` seconds and so on.



The activity as illustrated by the diagram:

1. At time `t + 1` seconds an event W_1 arrives and enters the batch. No call to inform update listeners occurs.
2. At time `t + 3` seconds an event W_2 arrives and enters the batch. No call to inform update listeners occurs.
3. At time `t + 4` seconds the engine processes the batched events and a starts a new batch. The engine reports events W_1 and W_2 to update listeners.
4. At time `t + 6.5` seconds an event W_3 arrives and enters the batch. No call to inform update listeners occurs.

5. At time `t + 8` seconds the engine processes the batched events and a starts a new batch. The engine reports the event W_3 as new data to update listeners. The engine reports the events W_1 and W_2 as old data (prior batch) to update listeners.

Row-Based Batched Windows

A row-based window may be batched as well. For example, the following query would wait to receive five events prior to doing any processing:

```
SELECT * FROM Withdrawal RETAIN BATCH OF 5 EVENTS
```

Once five events were received, the query would run and again wait for a new set of five events prior to processing.

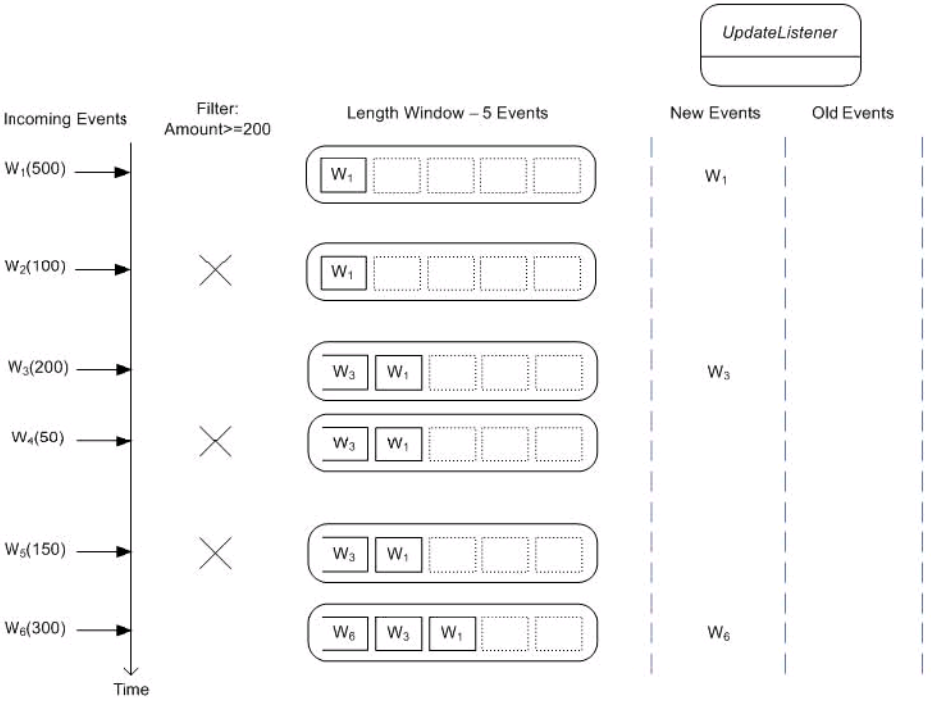
Subqueries and WHERE Clauses

Filters to event streams appear in a subquery expression and allow filtering events out of a given stream before events enter a data window. This filtering occurs prior to the WHERE clause executing. When possible, filtering should be done in a subquery as opposed to the WHERE clause, since this will improve performance by reducing the amount of data seen by the rest of the EPL statement.

The statement below shows a subquery that selects Withdrawal events with an amount value of 200 or more.

```
SELECT * FROM (SELECT * FROM Withdrawal WHERE amount >= 200) RETAIN 5
EVENTS
```

With the subquery, any Withdrawal events that have an amount of less then 200 do not enter the window of the outer query and are therefore not passed to update listeners.

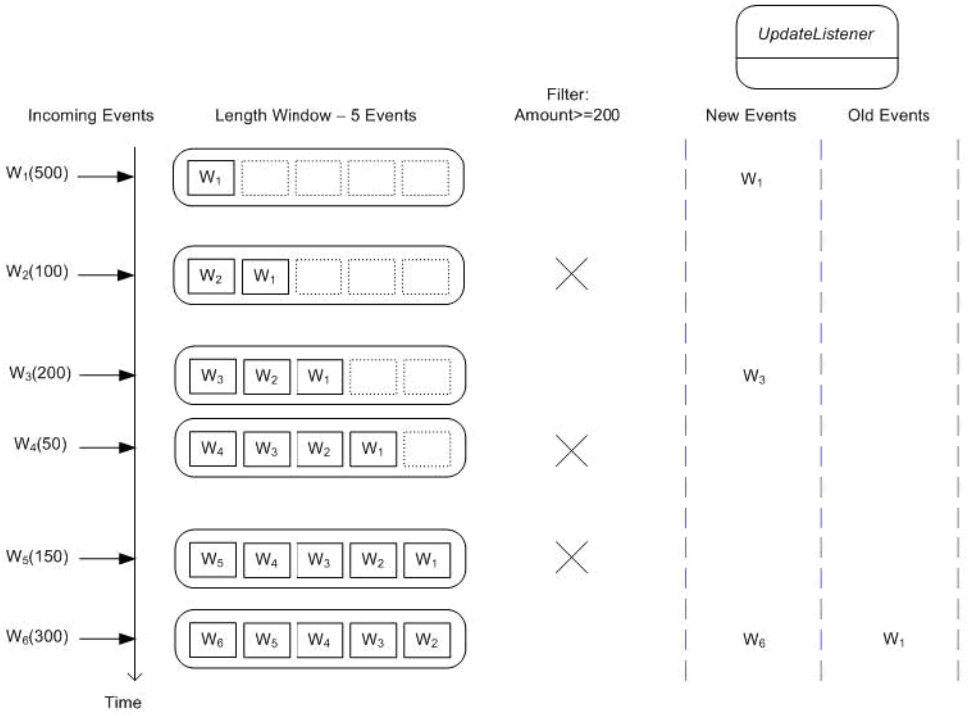


The `WHERE` clause and `HAVING` clause in statements eliminate potential result rows at a later stage in processing, after events have been processed into a statement's data window or other views.

The next statement applies a `WHERE` clause to `Withdrawal` events instead of a subquery.

```
SELECT * FROM Withdrawal RETAIN 5 EVENTS WHERE amount >= 200
```

The `WHERE` clause applies to both new events and old events. As the diagram below shows, arriving events enter the window regardless of the value of the "amount" property. However, only events that pass the `WHERE` clause are handed to update listeners. Also, as events leave the data window, only those events that pass the conditions in the `WHERE` clause are posted to update listeners as old events.



The `WHERE` clause can contain complex conditions while event stream filters are more restrictive in the type of filters that can be specified. The next statement's `WHERE` clause applies the `ceil` function of the `java.lang.Math` Java library class in the where clause. The `INSERT INTO` clause makes the results of the first statement available to the second statement:

```
INSERT INTO BigWithdrawal
  SELECT * FROM Withdrawal RETAIN ALL WHERE Math.ceil(amount) >= 200
SELECT * FROM BigWithdrawal RETAIN ALL
```

Aggregation

Statements that aggregate events via aggregations functions also post remove stream events as aggregated values change. Consider the following statement that alerts when two `Withdrawal` events have been received:

```
SELECT COUNT(*) AS mycount
FROM Withdrawal RETAIN ALL
HAVING COUNT(*) = 2
```

When the engine encounters the second withdrawal event, the engine posts a new event to update listeners. The value of the mycount property on that new event is 2. Additionally, when the engine encounters the third `Withdrawal` event, it posts an old event to update listeners containing the prior value of the count. The value of the mycount property on that old event is also 2.

The `ISTREAM` or `RSTREAM` keyword can be used to eliminate either new events or old events posted to update listeners. The next statement uses the `ISTREAM` keyword causing the engine to call the update listener only once when the second `Withdrawal` event is received:

```
SELECT ISTREAM COUNT(*) AS mycount
FROM Withdrawal RETAIN ALL
HAVING COUNT(*) = 2
```

Use Cases

The use cases below illustrate through examples usage of various language features.

Computing Rates per Feed

For the throughput statistics and to detect rapid fall-off we calculate a ticks per second rate for each market data feed.

We can use an EPL statement that batches together 1 second of events from the market data event stream source. We specify the feed and a count of events per feed as output values. To make this data available for further processing, we insert output events into the TicksPerSecond event stream:

```
INSERT INTO TicksPerSecond
SELECT feed, COUNT(*) AS cnt
  FROM MarketDataEvent
  RETAIN BATCH OF 1 SECOND
  GROUP BY feed
```

Computing Highest Priced Stocks

For computing the highest priced stocks, we define a sliding window that retains 100 events for each unique stock symbol where the block size of the trade is greater than 10. For example, if

there are 5,000 stock symbols, then 5,000 x 100 or 5,000,000 events would be kept. Only `MarketTrade` events with a block size of greater than 10 will enter the window and only the 100 highest priced events will be retained.

The results will be grouped by stock symbol and ordered alphabetically with stock symbols having an average price of less than 100 being filtered from the output.

```
SELECT symbol, AVG(price)
FROM (SELECT * FROM MarketTrade WHERE blockSize > 10)
RETAIN 100 EVENTS WITH LARGEST price PARTITION BY symbol
GROUP BY symbol
HAVING AVG(price) >= 100
ORDER BY symbol
```

Segmenting Location Data

We detect the route a car is taking based on the car location event data that contains information about the location and direction of a car on a highway. We first segment the data by carId to isolate information about a particular car and subsequently segment by expressway, direction and segment to plot its direction. We are then able to calculate the speed of the car based on this information.

The first `PARTITION BY carId` groups car location events by car while the following `PARTITION BY expressway PARTITION BY direction` further segment the data by more detailed location and direction property values. The number of events retained, 4 in this query, applies to the maximum number kept for the last `PARTITION BY` clause. Thus at most 4 events will be kept for each distinct segment property value.

```
SELECT carId, expressway, direction,
  SUM(segment)/(MAX(timestamp)-MIN(timestamp)) AS speed
 FROM CarLocationEvent
 RETAIN 4 events
 PARTITION BY carId PARTITION BY expressway PARTITION BY direction
```

Detecting Rapid Fall-off

We define a rapid fall-off by alerting when the number of ticks per second for any second falls below 75% of the average number of ticks per second over the last 10 seconds.

We can compute the average number of ticks per second over the last 10 seconds simply by using the `TicksPerSecond` events computed by the prior statement and averaging the last 10 seconds.

Next, we compare the current rate with the moving average and filter out any rates that fall below 75% of the average:

```
SELECT feed, AVG(cnt) AS avgCnt, cnt AS feedCnt
  FROM TicksPerSecond
  RETAIN 10 seconds
  GROUP BY feed
  HAVING cnt < AVG(cnt) * 0.75
```

Finding Network Anomalies

A customer may be in the middle of a check-in when the terminal detects a hardware problem or when the network goes down. In that situation we want to alert a team member to help the customer. When the terminal detects a problem, it issues an `OutOfOrder` event. A pattern can find situations where the terminal indicates out-of-order and the customer is in the middle of the check-in process:

```
SELECT ci.term
MATCHING ci:=Checkin FOLLOWED BY
      ( OutOfOrder (term.id=ci.term.id) AND NOT
        (Cancelled (term.id=ci.term.id) OR
         Completed (term.id=ci.term.id) ) WITHIN 3 MINUTES )
```

Each self-service terminal can publish any of the four events below.

- `Checkin` - Indicates a customer started a check-in dialogue.
- `Cancelled` - Indicates a customer cancelled a check-in dialogue.
- `Completed` - Indicates a customer completed a check-in dialogue.
- `OutOfOrder` - Indicates the terminal detected a hardware problem

All events provide information about the terminal that published the event, and a timestamp. The terminal information is held in a property named `term` and provides a terminal `id`. Because all events carry similar information, we model each event as a subtype to a base class `TerminalEvent`, which will provide the terminal information that all events share. This enables us to treat all terminal events polymorphically, which simplifies our queries by allowing us to treat derived event types just like their parent event types.

Detecting Absence of Event

Because `Status` events arrive in regular intervals of 60 seconds, we can make use of temporal pattern matching using the `MATCHING` clause to find events that did not arrive in time. We can use the `WITHIN` operator to keep a 65 second window to account for a possible delay in transmission or processing and the `NOT` operator to detect the absence of a `Status` event with a `term.id` equal to `T1`:

```
SELECT 'terminal 1 is offline'
MATCHING NOT Status(term.id = 'T1') WITHIN 65 SECONDS
OUTPUT FIRST EVERY 5 MINUTES
```

Summarizing Terminal Activity Data

By presenting statistical information about terminal activity to our staff in real-time we enable them to monitor the system and spot problems. The next example query simply gives us a count per event type every 1 minute. We could further use this data, available through the `CountPerType` event stream, to join and compare against a recorded usage pattern, or to just summarize activity in real-time.

```
INSERT INTO CountPerType
SELECT type, COUNT(*) AS countPerType
FROM TerminalEvent
RETAIN 10 MINUTES
GROUP BY type
OUTPUT ALL EVERY 1 MINUTE
```

Reading Sensor Data

In this example an array of RFID readers sense RFID tags as pallets are coming within the range of one of the readers. A reader generates XML documents with observation information such as reader sensor ID, observation time and tags observed. A statement computes the total number of tags per reader sensor ID within the last 60 seconds.

```
SELECT ID AS sensorId, SUM(countTags) AS numTagsPerSensor
FROM AutoIdRFIDExample
RETAIN 60 SECONDS
WHERE Observation[0].Command = 'READ_PALLET_TAGS_ONLY'
GROUP BY ID
```

Combining Transaction Events

In this example we compose an EPL statement to detect combined events in which each component of the transaction is present. We restrict the event matching to the events that arrived within the last 30 minutes. This statement uses the `INSERT INTO` syntax to generate a `CombinedEvent` event stream.

```
INSERT INTO CombinedEvent(transactionId, customerId, supplierId,
  latencyAC, latencyBC, latencyAB)
SELECT C.transactionId, customerId, supplierId,
  C.timestamp - A.timestamp,
  C.timestamp - B.timestamp,
  B.timestamp - A.timestamp
FROM TxnEventA A, TxnEventB B, TxnEventC C
RETAIN 30 MINUTES
WHERE A.transactionId = B.transactionId AND
  B.transactionId = C.transactionId
```

Monitoring Real-time Performance

To derive the minimum, maximum and average total latency from the events (difference in time between A and C) over the past 30 minutes we can use the EPL below. In addition, in order to monitor the event server, a dashboard UI will subscribe to a subset of the events to measure system performance such as server and end-to-end latency. It is not feasible to expect a UI to monitor every event flowing through the system, so there must be a way of rate limiting the output to a subset of the events that can be handled by the monitoring application. Only the single last event or all events can be output.

```
SELECT MIN(latencyAC) as minLatencyAC,
  MAX(latencyAC) as maxLatencyAC,
  AVG(latencyAC) as avgLatencyAC
FROM CombinedEvent
RETAIN 30 MINUTES
GROUP BY customerId
OUTPUT LAST 50 EVERY 1 SECOND
```

Finding Dropped Transaction Events

An `OUTER JOIN` allows us to detect a transaction that did not make it through all three events. When `TxnEventA` or `TxnEventB` events leave their respective time windows consisting of the last 30 minutes of events, EPL filters out rows in which no `EventC` row was found.

```
SELECT *
  FROM TxnEventA A
       FULL OUTER JOIN TxnEventC C ON A.transactionId = C.transactionId
       FULL OUTER JOIN TxnEventB B ON B.transactionId = C.transactionId
  RETAIN 30 MINUTES
WHERE C.transactionId is null
```

CHAPTER 3

EPL Reference: Clauses

This section provides information on the following topics:

Overview of the Clauses You Can Use in an EPL Statement

The top-level BNF for the event processing language (EPL) is as follows:

```
[ INSERT INTO insert_into_def ]
  SELECT select_list
```

```
{ FROM stream_source_list /  MATCHING pattern_expression }
[ WHERE search_conditions ]
[ GROUP BY grouping_expression_list ]
[ HAVING grouping_search_conditions ]
[ ORDER BY order_by_expression_list ]
[ OUTPUT output_specification ]
```

Literal keywords are not case sensitive. Each clause is detailed in the following sections. For information on the built-in operators and functions, see Chapter 4, "EPL Reference: Operators," and Chapter 5, "EPL Reference: Functions."

SELECT

The `SELECT` clause is required in all EPL statements. The `SELECT` clause can be used to select all properties using the wildcard `*`, or to specify a list of event properties and expressions. The `SELECT` clause defines the event type (event property names and types) of the resulting events published by the statement, or pulled from the statement.

The `SELECT` clause also offers optional `ISTREAM` and `RSTREAM` keywords to control how events are posted to update listeners attached to the statement.

The syntax for the `SELECT` clause is summarized below.

```
SELECT [RSTREAM | ISTREAM] ( expression_list | * )
```

The following examples use the `FROM` clause which defines the sources of the event data. The `FROM` clause is described in "FROM" on page 3-4.

Choosing Specific Event Properties

To choose the particular event properties to return:

```
SELECT event_property [, event_property] [, ...]
FROM stream_def
```

The following statement selects the count and standard deviation of the volume for the last 100 stock tick events.

```
SELECT COUNT, STDDEV(volume)
FROM StockTick RETAIN 100 EVENTS
```

Using Expressions

The SELECT clause can contain one or more expressions.

```
SELECT expression [, expression] [, ...]
FROM stream_def
```

The following statement selects the volume multiplied by price for a time batch of the last 30 seconds of stock tick events.

```
SELECT volume * price
FROM StockTick RETAIN BATCH OF 30 SECONDS
```

Aliasing Event Properties

Event properties and expressions can be aliased using below syntax.

```
SELECT [event_property | expression] AS identifier [,…]
```

The following statement selects volume multiplied by price and specifies the name volPrice for the event property.

```
SELECT volume * price AS volPrice
FROM StockTick RETAIN 100 EVENTS
```

Choosing All Event Properties

The syntax for selecting all event properties in a stream is:

```
SELECT *
FROM stream_def
```

The following statement selects all of the StockTick event properties for the last 30 seconds:

```
SELECT *
FROM StockTick RETAIN 30 SECONDS
```

In a join statement, using the SELECT * syntax selects event properties that contain the events representing the joined streams themselves.

The * wildcard and expressions can also be combined in a SELECT clause. The combination selects all event properties and in addition the computed values as specified by any additional expressions that are part of the SELECT clause. Here is an example that selects all properties of stock tick events plus a computed product of price and volume that the statement names pricevolume:

```
SELECT *, price * volume AS pricevolume
FROM StockTick RETAIN ALL
```

Selecting New and Old Events With ISTREAM and RSTREAM Keywords

The optional `ISTREAM` and `RSTREAM` keywords in the `SELECT` clause define the event stream posted to update listeners to the statement. If neither keyword is specified, the engine posts both insert and remove stream events to statement listeners. The insert stream consists of the events entering the respective window(s) or stream(s) or aggregations, while the remove stream consists of the events leaving the respective window(s) or the changed aggregation result. Insert and remove events are explained in more detail in "Event Sinks" on page 2-6.

By specifying the `ISTREAM` keyword you can instruct the engine to only post insert stream events to update listeners. The engine will then not post any remove stream events. By specifying the `RSTREAM` keyword you can instruct the engine to only post remove stream events to update listeners. The engine will then not post any insert stream events.

The following statement selects only the events that are leaving the 30 second time window.

```
SELECT RSTREAM *
FROM StockTick RETAIN 30 SECONDS
```

The `ISTREAM` and `RSTREAM` keywords in the `SELECT` clause are matched by same-name keywords available in the `INSERT INTO` clause as explained in "INSERT INTO" on page 3-26. While the keywords in the `SELECT` clause control the event stream posted to update listeners to the statement, the same keywords in the insert into clause specify the event stream that the engine makes available to other statements.

FROM

Either the `FROM` or the `MATCHING` clause is required in all EPL statements. The `FROM` clause specifies one or more event streams as the source of the event data. The `MATCHING` clause is discussed in "MATCHING" on page 3-15.

```
FROM stream_expression [ inner_join | outer_join ]
```

with *`inner_join`* specified as a comma separated list of stream expressions:

```
(, stream_expression )*
```

and *`outer_join`* defined as:

```
((LEFT|RIGHT|FULL) OUTER JOIN stream_expression ON prop_name = prop_name)*
```

Inner joins are discussed in detail in "Inner Joins" on page 3-6 while outer joins are discussed in "Outer Joins" on page 3-7.

A *stream_expression* may simply define the name of the event type used as the source of the stream data, or in more complex scenarios define either a subquery expression as a nested EPL statement or a parameterized SQL query to access JDBC data. In all of these cases, the *stream_expression* may optionally include an alias as an identifier to qualify any ambiguous property name references in other expressions and a `RETAIN` clause to define the window of stream data seen by the rest of the query:

```
  (stream_name | subquery_expr | param_sql_query) [[AS] alias]] [RETAIN
retain_expr]
  subquery_expr: ( epl_statement )
  param_sql_query: database_name ('parameterized_sql_query')
```

The *subquery_expr* defines a subquery or nested EPL statement in parenthesis. A subquery is used to pre-filter event stream data seen by the outer EPL statement. For example, the following query would restrict the data seen by the outer EPL statement to only *StockTick* events coming from a Reuters feed.

```
SELECT stockSymbol, AVG(price)
FROM (SELECT * FROM StockTick WHERE feedName = 'Reuters' )
RETAIN 1 MINUTE PARTITION BY stockSymbol
GROUP BY stockSymbol
```

Subqueries may be arbitrarily nested, but may not contain an `INSERT INTO` or an `OUTPUT` clause. Unlike with a top level EPL statement, a `RETAIN` clause is optional within a subquery. Subquery expressions are discussed in more detail in "Subquery Expressions" on page 3-8.

The *param_sql_query* specifies a parameterized SQL query in quotes surrounded by parenthesis that enables reference and historical data accessible through JDBC to be retrieved. The *database_name* identifies the name of the database over which the query will be executed. Configuration information is associated with this database name to establish a database connection, control connection creation and removal, and to setup caching policies for query results. Parameterized SQL queries are discussed in more detail in "Parameterized SQL Queries" on page 3-8.

The `RETAIN` clause defines the quantity of event data read from the streams listed in the `FROM` clause prior to query processing. Each stream may have its own `RETAIN` clause if each require different retain policies. Otherwise, the `RETAIN` clause may appear at the end of the `FROM` clause

for it to apply to all streams. Essentially the RETAIN clause applies to all streams that appear before it in the FROM clause.

For example, in the following EPL statement, five StockTick events will be retained while three News events will be retained:

```
SELECT t.stockSymbol, t.price, n.summary
FROM StockTick t RETAIN 5 EVENTS, News n RETAIN 3 EVENTS
WHERE t.stockSymbol = n.stockSymbol
```

However, in the following statement, four StockTick and four News events will be retained:

```
SELECT t.stockSymbol, t.price, n.summary
FROM StockTick t, News n RETAIN 4 EVENTS
WHERE t.stockSymbol = n.stockSymbol
```

With the exception of subquery expressions, all stream sources must be constrained by a RETAIN clause. Thus at a minimum the FROM clause must contain at least one RETAIN clause at the end for top level EPL statements. The external data from parameterized SQL queries is not affected by the RETAIN clause. The RETAIN clause is discussed in more detail in "RETAIN" on page 3-10.

Inner Joins

Two or more event streams can be part of the FROM clause and thus both streams determine the resulting events. The WHERE clause lists the join conditions that EPL uses to relate events in two or more streams. If the condition is failed to be met, for example if no event data occurs for either of the joined stream source, no output will be produced.

Each point in time that an event arrives to one of the event streams, the two event streams are joined and output events are produced according to the where-clause.

This example joins two event streams. The first event stream consists of fraud warning events for which we keep the last 30 minutes. The second stream is withdrawal events for which we consider the last 30 seconds. The streams are joined on account number.

```
SELECT fraud.accountNumber AS accntNum,
  fraud.warning AS warn, withdraw.amount AS amount,
  MAX(fraud.timestamp, withdraw.timestamp) AS timestamp,
  'withdrawlFraud' AS desc
FROM FraudWarningEvent AS fraud RETAIN 30 MIN,
     WithdrawalEvent AS withdraw RETAIN 30 SEC
WHERE fraud.accountNumber = withdraw.accountNumber
```

Outer Joins

Left outer joins, right outer joins and full outer joins between an unlimited number of event streams are supported by EPL. Depending on the `LEFT`, `RIGHT`, or `FULL` qualifier, in the absence of event data from either stream source, output may still occur.

If the outer join is a left outer join, there will be an output event for each event of the stream on the left-hand side of the clause. For example, in the left outer join shown below we will get output for each event in the stream `RfidEvent`, even if the event does not match any event in the event stream `OrderList`.

```
SELECT *
FROM RfidEvent AS rfid
               LEFT OUTER JOIN
           OrderList AS orderlist
               ON rfid.itemId = orderList.itemId
RETAIN 30 SECONDS
```

Similarly, if the join is a Right Outer Join, then there will be an output event for each event of the stream on the right-hand side of the clause. For example, in the right outer join shown below we will get output for each event in the stream `OrderList`, even if the event does not match any event in the event stream `RfidEvent`.

```
SELECT *
FROM RfidEvent AS rfid
               RIGHT OUTER JOIN
           OrderList AS orderlist
               ON rfid.itemId = orderList.itemId
RETAIN 30 SECONDS
```

For all types of outer joins, if the join condition is not met, the select list is computed with the event properties of the arrived event while all other event properties are considered to be null.

```
SELECT *
FROM RfidEvent AS rfid
               FULL OUTER JOIN
           OrderList AS orderlist
               ON rfid.itemId = orderList.itemId
RETAIN 30 SECONDS
```

The last type of outer join is a full outer join. In a full outer join, each point in time that an event arrives to one of the event streams, one or more output events are produced. In the example

below, when either an RfidEvent or an OrderList event arrive, one or more output event is produced.

Subquery Expressions

A subquery expression is a nested EPL statement that appears in parenthesis in the FROM clause. A subquery may not contain an INSERT INTO clause or an OUTPUT clause, and unlike top level EPL statements, a RETAIN clause is optional.

Subquery expressions execute prior to their containing EPL statement and thus are useful to pre-filter event data seen by the outer statement. For example, the following query would calculate the moving average of a particular stock over the last 100 StockTick events:

```
SELECT AVG(price)
FROM (SELECT * FROM StockTick WHERE stockSymbol = 'ACME' )
RETAIN 100 EVENTS
```

If the WHERE clause had been placed in the outer query, StockTick events for other stock symbols would enter into the window, reducing the number of events used to calculate the average price.

In addition, a subquery may be used to *a)* transform the structure of the inner event source to the structure required by the outer EPL statement or *b)* merge multiple event streams to form a single stream of events. This allows a single EPL statement to be used instead of multiple EPL statements with an INSERT INTO clause connecting them. For example, the following query merges transaction data from EventA and EventB and then uses the combined data in the outer query:

```
SELECT custId, SUM(latency)
FROM (SELECT A.customerId AS custId, A.timestamp -B.timestamp AS latency
              FROM EventA A, EventB B
              WHERE A.txnId = B.txnId)
RETAIN 30 MIN
GROUP BY custId
```

A subquery itself may contain subqueries thus allowing arbitrary levels of nesting.

Parameterized SQL Queries

Parameterized SQL queries enable reference and historical data accessible through JDBC to be queried via SQL within EPL statements. In order for such data sources to become accessible to EPL, some configuration is required.

The following restrictions currently apply:

- Only one event stream and one SQL query may be joined; Joins of two or more event streams with an SQL query are not supported.
- Constraints specified in the `RETAIN` clause are ignored for the stream for the SQL query; that is, one cannot create a time-based or event-based window on an SQL query. However one can use the `INSERT INTO` syntax to make join results available to a further statement.
- Your database software must support JDBC prepared statements that provide statement metadata at compilation time. Most major databases provide this function.

The query string is single or double quoted and surrounded by parentheses. The query may contain one or more substitution parameters. The query string is passed to your database software unchanged, allowing you to write any SQL query syntax that your database understands, including stored procedure calls.

Substitution parameters in the SQL query string take the form `${`*`event_property_name`*`}`. The engine resolves *`event_property_name`* at statement execution time to the actual event property value supplied by the events in the joined event stream.

The engine determines the type of the SQL query output columns by means of the result set metadata that your database software returns for the statement. The actual query results are obtained via the `getObject` on `java.sql.ResultSet`.

The sample EPL statement below joins an event stream consisting of `CustomerCallEvent` events with the results of an SQL query against the database named `MyCustomerDB` and table `Customer`:

```
SELECT custId, cust_name
FROM CustomerCallEvent,
MyCustomerDB (' SELECT cust_name FROM Customer WHERE cust_id = ${custId} ')
RETAIN 10 MINUTES
```

The example above assumes that `CustomerCallEvent` supplies an event property named `custId`. The SQL query selects the customer name from the `Customer` table. The `WHERE` clause in the SQL matches the `Customer` table column `cust_id` with the value of `custId` in each `CustomerCallEvent` event. The engine executes the SQL query for each new `CustomerCallEvent` encountered.

If the SQL query returns no rows for a given customer id, the engine generates no output event. Else the engine generates one output event for each row returned by the SQL query. An outer join as described in the next section can be used to control whether the engine should generate output events even when the SQL query returns no rows.

The next example adds a time window of 30 seconds to the event stream `CustomerCallEvent`. It also renames the selected properties to `customerName` and `customerId` to demonstrate how the naming of columns in an SQL query can be used in the `SELECT` clause in the EQL query. The example uses explicit stream names via the `AS` keyword.

```
SELECT customerId, customerName
FROM CustomerCallEvent AS cce RETAIN 30 SECONDS,
  MyCustomerDB
  ("SELECT cust_id AS customerId, cust_name AS customerName
    FROM Customer WHERE cust_id = ${cce.custId}") AS cq
```

Any window, such as the time window, generates insert events as events enter the window, and remove events as events leave the window. The engine executes the given SQL query for each `CustomerCallEvent` in both the insert stream and the remove stream cases. As a performance optimization, the `ISTREAM` or `RSTREAM` keywords in the `SELECT` clause can be used to instruct the engine to only join insert or remove events, reducing the number of SQL query executions.

Parameterized SQL queries may be used in outer joins as well. Use a left outer join, such as in the next statement, if you need an output event for each event regardless of whether or not the SQL query returns rows. If the SQL query returns no rows, the join result populates null values into the selected properties.

```
SELECT custId, custName
FROM CustomerCallEvent AS cce
  LEFT OUTER JOIN
  MyCustomerDB
    ("SELECT cust_id, cust_name AS custName
      FROM Customer WHERE cust_id = ${cce.custId}") AS cq
  ON cce.custId = cq.cust_id
RETAIN 10 MINUTES
```

The statement above always generates at least one output event for each `CustomerCallEvent`, containing all columns selected by the SQL query, even if the SQL query does not return any rows. Note the `ON` expression that is required for outer joins. The `ON` acts as an additional filter to rows returned by the SQL query.

RETAIN

At least one `RETAIN` clause is a required in the `FROM` clause. The `RETAIN` clause applies to all stream sources listed in the `FROM` clause that precedes it. Conceptually it defines a window of

event data for each stream source over which the query will be executed. The RETAIN clause has the following syntax:

```
RETAIN
( ALL [EVENTS] ) |
( [BATCH OF]
  ( integer (EVENT|EVENTS) ) | ( time_interval (BASED ON prop_name)* )
  ( WITH [n] (LARGEST | SMALLEST | UNIQUE) prop_name )*
  ( PARTITION BY prop_name )* )
```

Each aspect of the RETAIN clause is discussed in detail below.

Keeping All Events

To keep all events for a stream source, specify the ALL [EVENTS] in the RETAIN clause.

```
SELECT AVG(price)
FROM StockTick RETAIN ALL EVENTS
```

In this case, the average price will be calculated based on all StockTick events that occur. Care must be taken with this option, however, since memory may run out when making calculations that require all or part of each event object to be retained under high volume scenarios. One such example would be in calculating a weighted average.

Specifying Window Size

The amount of event data to keep when running the query may be determined in two ways. The first option is to specify the maximum number of events kept. For example, the query below would keep a maximum of 100 StockTick events on which the average price would be computed:

```
SELECT AVG(price)
FROM StockTick RETAIN 100 EVENTS
```

As each new StockTick event comes in, the average price would be computed, with a maximum of 100 events being used for the calculation.

The second option is to specify the time interval in which to collect event data. For example, the query below would keep 1 minute's worth of StockTick events and compute the average price for this data:

```
SELECT AVG(price)
FROM StockTick RETAIN 1 MINUTE
```

In this case, as each new `StockTick` event comes in, again the average price would be computed. However, events that arrived more than one minute ago would be removed from the window with the average price being recalculated based on the remaining events in the window.

Specifying Batched Versus Sliding Windows

By default, the windows holding event data are sliding. With sliding windows, as a new event enters the window, an old events fall off the end of the window once the window is at capacity. Sliding windows cause the query to be re-executed as each new event enters and/or old event leaves the window. An alternative is to specify that the event data should be batched prior to query execution. Only when the window is full, is the query is executed. After this, new event data will again be collected until the window is once again full at which time the query will be re-executed.

For example, the query below would batch together 100 events prior to executing the query to compute the average price:

```
SELECT AVG(price)
FROM StockTick RETAIN BATCH OF 100 EVENTS
```

Once executed, it would batch the next 100 events together prior to re-executing the query.

For more detail on sliding versus batched windows, see "Processing Model" on page 2-6.

Specifying Time Interval

The time interval for the `RETAIN` clause may be specified in days, hours, minutes, seconds, and/or milliseconds:

```
  time_interval:
[day-part][hour-part][minute-part][seconds-part][milliseconds-part]

  day-part: number ("days" | "day")
  hour-part: number ("hours" | "hour" | "hr")
  minute-part: number ("minutes" | "minute" | "min")
  seconds-part: number ("seconds" | "second" | "sec")
 milliseconds-part: number ("milliseconds" | "millisecond" | "msec" | "ms")
```

Some examples of time intervals are:

```
10 seconds
10 minutes 30 seconds
20 sec 100 msec
```

```
0.5 minutes
1 day 2 hours 20 minutes 15 seconds 110 milliseconds
```

BASED ON Clause

By default, the elapse of a time interval is based on the internal system clock. However, in some cases, the time needs to be based on a timestamp value appearing as an event property. In this case, the `BASED ON` clause may be used to specify the property name containing a long-typed timestamp value. In this example, the `StockTick` events would be expected to have a `timestamp` property of type long whose value would control inclusion into and removal from the window:

```
SELECT AVG(price)
FROM StockTick RETAIN 1 MINUTE BASED ON timestamp
```

When using the `BASED ON` clause, each stream source listed in the `FROM` clause must have an associated timestamp property listed or WebLogic Event Server will throw an exception.

Specifying Property Name

A property may be referred to by simply using its property name within the `RETAIN` clause. However, if ambiguities exist because the same property name exists in more than one stream source in the `FROM` clause, it must be prefixed with its alias name followed by a period (similar to the behavior of properties referenced in the `SELECT` clause).

Using PARTION BY Clause to Partition Window

The `PARTITION BY` clause allows a window to be further subdivided into multiple windows based on the unique values contained in the properties listed. For example, the following query would keep 3 events for each unique stock symbol:

```
SELECT stockSymbol, price
FROM StockTick RETAIN 3 EVENTS PARTITION BY stockSymbol
```

Conceptually this is similar to the `GROUP BY` functionality in SQL or EPL. However, the `PARTITION BY` clause only controls the size and subdivision of the window and does not cause event data to be aggregated as with the `GROUP BY` clause. However, in most cases, the `PARTITION BY` clause is used in conjunction with the `GROUP BY` clause with same properties specified in both.

The following examples illustrate the interaction between PARTITION BY and GROUP BY. In the first example, with the absence of the PARTITION BY clause, a total of 10 events will be kept across all stock symbols.

```
SELECT stockSymbol, AVG(price)
FROM StockTick RETAIN 10 EVENTS
GROUP BY stockSymbol
```

The average price for each unique set of stock symbol will be computed based on these 10 events. If a stock symbol of AAA comes into the window, it may cause a different stock symbol such as BBB to leave the window. This would cause the average price for both the AAA group as well as the BBB group to change.

The second example includes the PARTITION BY clause and the GROUP BY clause.

```
SELECT stockSymbol, AVG(price)
FROM StockTick RETAIN 10 EVENTS PARTITION BY stockSymbol
GROUP BY stockSymbol
```

In this case, 10 events will be kept for each unique stock symbol. If a stock symbol of AAA comes into the window, it would only affect the sub-window associated with that symbol and not other windows for different stock symbols. Thus, in this case, only the average price of AAA would be affected.

Using WITH Clause to Keep Largest/Smallest/Unique Values

The WITH clause allows the largest, smallest, and unique property values to be kept in the window. For example, to keep the two highest priced stocks, the following statement would be used:

```
SELECT stockSymbol, price
FROM StockTick RETAIN 2 EVENTS WITH LARGEST price
```

In the case of time-based windows, the [n] qualifier before the LARGEST or SMALLEST keyword determines how many values are kept. For example, the following statement would keep the two smallest prices seen over one minute:

```
SELECT stockSymbol, price
FROM StockTick RETAIN 1 MINUTE WITH 2 SMALLEST price
```

In the absence of this qualifier, the single largest or smallest value is kept.

The UNIQUE qualifier causes the window to include only the most recent among events having the same value for the specified property. For example, the following query would keep only the last stock tick for each unique stock symbol:

```
SELECT *
FROM StockTick RETAIN 1 DAY WITH UNIQUE stockSymbol
```

Prior events of the same property value would be posted as old events by the engine.

MATCHING

Either a MATCHING or a FROM clause must appear in an EPL statement. The MATCHING clause is an alternate mechanism for determining which events are used by the EPL statement. It allows for the detection of a series of one or more events occurring that satisfies a specified pattern. Pattern expressions consist of references to streams separated by logical operators such as AND, OR, and FOLLOWED BY to define the sequence of events that compose the pattern. You may include an optional RETAIN clause, as specified in "RETAIN" on page 3-10, to define the characteristics of the window containing the matched events. The MATCHING clause executes prior to the WHERE or HAVING clauses.

The MATCHING clause syntax is as follows:

```
MATCHING pattern_expression [RETAIN retain_clause]
```

with *pattern_expression* having the following syntax:

```
[NOT|EVERY] stream_expression
    ( ( AND | OR | [NOT] FOLLOWED BY ) stream_expression )*
[WITHIN time_interval]
```

You can use the NOT operator to detect the absence of an event and the EVERY operator to control how pattern matching continues after a match. The *stream_expression* is a stream source name optionally bound to a variable and filtered by a parenthesized expression:

```
stream_expression: [var_name:=]stream_name [( filter_expression )]
```

Alternatively, a *stream_expression* may itself be a *pattern_expression* allowing for arbitrarily complex nesting of expressions:

The *var_name* is bound to the event object occurring that triggers the match. It may be referenced as any other event property in filter expressions that follow as well as in other clauses such as the SELECT and WHERE clauses. The *stream_name* may optionally be followed by a parenthesized expression to filter the matching events of that type. The expression act as a precondition for events to enter the corresponding window and has the same syntax as a WHERE

clause expression. Previously bound variables may be used within the expression to correlate with already matched events.

The *time_interval* is a time interval as specified in "Specifying Time Interval" on page 3-12 that follows the optional WITHIN keyword to determine how long to wait before giving up on the preceding expression to be met.

In the example below we look for RFIDEvent event with a category of "Perishable" followed by an RFIDError within 10 seconds whose id matches the ID of the matched RFIDEvent object.

```
SELECT *
MATCHING a:=RFIDEvent(category="Perishable")
    FOLLOWED BY RFIDError(id=a.id) WITHIN 10 seconds
RETAIN 1 MINUTE
```

The following sections discuss the syntax, semantics, and additional operators available in the MATCHING clause to express temporal constraints for pattern matching.

FOLLOWED BY Operator

The FOLLOWED BY temporal operator matches on the occurrence of several event conditions in a particular order. It specifies that first the left hand expression must turn true and only then will the right hand expression be evaluated for matching events.

For example, the following pattern looks for event A and if encountered, looks for event B:

```
A FOLLOWED BY B
```

This does not mean that event A must immediately be followed by event B. Other events may occur between the event A and the event B and this expression would still evaluate to true. If this is not the desired behavior, used the NOT operator as described in "NOT Operator" on page 3-17.

AND Operator

The AND logical operator requires both nested pattern expressions to turn true before the whole expression returns true. In the context of the MATCHING clause, the operator matches on the occurrence of several event conditions but not necessarily in a particular order.

For example, the following pattern matches when both event A and event B are found:

```
A AND B
```

The pattern matches on any sequence of A followed by B in either order. In addition, it is not required that a B event immediately follow an A event - other events may appear in between the occurrence of an A event and a B event for this expression to return true.

OR Operator

The OR logical operator requires either one of the expressions to turn true before the whole expression returns true. In the context of the MATCHING clause, the operator matches on the occurrence of either of several event conditions but not necessarily in a particular order.

For example, the following pattern matches for either event A or event B:

```
A OR B
```

The following would detect all stock ticks that are either above a certain price or above a certain volume.

```
StockTick(price > 1.0) OR StockTick(volume > 1000)
```

NOT Operator

The NOT operator negates the truth value of an expression. In the context of the MATCHING clause, the operator allows the absence of an event condition to be detected.

The following pattern matches only when an event A is encountered followed by event B but only if no event C was encountered before event B.

```
( A FOLLOWED BY B ) AND NOT C
```

EVERY Operator

The EVERY operator indicates that the pattern sub-expression should restart when the sub-expression qualified by the EVERY keyword evaluates to true or false. In the absence of the EVERY operator, an implicit EVERY operator is inserted as a qualifier to the first event stream source found in the pattern not occurring within a NOT expression.

The EVERY operator works like a factory for the pattern sub-expression contained within. When the pattern sub-expression within it fires and thus quits checking for events, the EVERY causes the start of a new pattern sub-expression listening for more occurrences of the same event or set of events.

Every time a pattern sub-expression within an EVERY operator turns true the engine starts a new active sub-expression looking for more event(s) or timing conditions that match the pattern sub-expression.

Let's consider an example event sequence as follows:

A_1 B_1 C_1 B_2 A_2 D_1 A_3 B_3 E_1 A_4 F_1 B_4

Example	Description
`EVERY ( A FOLLOWED BY B )`	Detect event A followed by event B. At the time when B occurs the pattern matches, then the pattern matcher restarts and looks for event A again. 1. Matches on B_1 for combination $\{A_1, B_1\}$. 2. Matches on B_3 for combination $\{A_2, B_3\}$. 3. Matches on B_4 for combination $\{A_4, B_4\}$
`EVERY A FOLLOWED BY B`	The pattern fires for every event A followed by an event B. 1. Matches on B_1 for combination $\{A_1, B_1\}$ 2. Matches on B_3 for combination $\{A_2, B_3\}$ and $\{A_3, B_3\}$. 3. Matches on B_4 for combination $\{A_4, B_4\}$
`EVERY A FOLLOWED BY EVERY B`	The pattern fires for every event A followed by every event B, in other words, all combinations of A followed by B. 1. Matches on B_1 for combination $\{A_1, B_1\}$. 2. Matches on B_2 for combination $\{A_1, B_2\}$. 3. Matches on B_3 for combination $\{A_1, B_3\}$, $\{A_2, B_3\}$ and $\{A_3, B_3\}$. 4. Matches on B_4 for combination $\{A_1, B_4\}$, $\{A_2, B_4\}$, $\{A_3, B_4\}$, and $\{A_4, B_4\}$

The examples show that it is possible that a pattern fires for multiple combinations of events that match a pattern expression.

Let's consider the EVERY operator in conjunction with a sub-expression that matches three events that follow each other:

```
EVERY (A FOLLOWED BY B FOLLOWED BY C)
```

The pattern first looks for event A. When event A arrives, it looks for event B. After event B arrives, the pattern looks for event C. Finally, when event C arrives the pattern matches. The engine then starts looking for event A again.

Assume that between event B and event C a second event A_2 arrives. The pattern would ignore the A_2 entirely since it's then looking for event C. As observed in the prior example, the `EVERY` operator restarts the sub-expression `A FOLLOWED BY B FOLLOWED BY C` only when the sub-expression fires.

In the next statement the every operator applies only to the A event, not the whole sub-expression:

```
EVERY A FOLLOWED BY B FOLLOWED BY C
```

This pattern now matches for any event A that is followed by an event B and then event C, regardless of when the event A arrives. This can often be impractical unless used in combination with the `AND NOT` syntax or the `RETAIN` syntax to constrain how long an event remains in the window.

WITHIN Operator

The `WITHIN` qualifier acts like a stopwatch. If the associated pattern expression does not become true within the specified time period it is evaluated by the engine as false. The `WITHIN` qualifier takes a time period as a parameter as specified in "Specifying Time Interval" on page 3-12.

This pattern fires if an A event arrives within 5 seconds after statement creation.

```
A WITHIN 5 SECONDS
```

This pattern fires for all A events that arrive within 5 second intervals.

This pattern matches for any one A or B event in the next 5 seconds.

```
(A or B) WITHIN 5 SECONDS
```

This pattern matches for any two errors that happen 10 seconds within each other.

```
A(status='ERROR') FOLLOWED BY B(status='ERROR') WITHIN 10 SECONDS
```

This pattern matches when a Status event does not occur within 10 seconds:

```
NOT Status WITHIN 10 SECONDS
```

Event Structure for Matched Pattern

The structure of the events produced when a pattern matches is determined by the structure of the union of the variables bound within the `MATCHING` clause. Thus variable bindings must be present in order to retrieve data from the matched events.

For example, given the following pattern:

```
tick:=StockTick FOLLOWED BY news:=News(stockSymbol = tick.stockSymbol)
```

Events that match would have a composite event type with two properties: a tick property with a type of `StockTick` and a `news` property with a type of `News`.

WHERE

The `WHERE` clause is an optional clause in EPL statements. Using the `WHERE` clause event streams can be joined and events can be filtered. Aggregate functions may not appear in a `WHERE` clause. To filter using aggregate functions, the `HAVING` clause should be used.

```
WHERE aggregate_free_expression
```

Comparison operators =, <, >, >=, <=, `!=`, <>, `IS NULL`, `IS NOT NULL` and logical combinations using `AND` and `OR` are supported in the `WHERE` clause. Some examples are listed below.

```
...WHERE fraud.severity = 5 AND amount > 500

... WHERE (orderItem.orderId IS NULL) OR (orderItem.class != 10)

... WHERE (orderItem.orderId = NULL) OR (orderItem.class <> 10)

... WHERE itemCount / packageCount > 10
```

GROUP BY

The `GROUP BY` clause is optional in EPL statements. The `GROUP BY` clause divides the output of an EPL statement into groups. You can group by one or more event property names, or by the result of computed expressions. When used with aggregate functions, `GROUP BY` retrieves the calculations in each subgroup. You can use `GROUP BY` without aggregate functions, but generally this can produce confusing results.

For example, the below statement returns the total price per symbol for all `StockTickEvents` in the last 30 seconds:

```
SELECT symbol, SUM(price)
FROM StockTickEvent RETAIN 30 SEC
GROUP BY symbol
```

The syntax of the `GROUP BY` clause is:

```
GROUP BY arregate_free_expression [, arregate_free_expression] [, …]
```

EPL places the following restrictions on expressions in the `GROUP BY` clause:

- Expressions in the `GROUP BY` clause cannot contain aggregate functions

- Event properties that are used within aggregate functions in the `SELECT` clause cannot also be used in a `GROUP BY` expression

You can list more then one expression in the `GROUP BY` clause to nest groups. Once the sets are established with `GROUP BY`, the aggregation functions are applied. This statement posts the median volume for all stock tick events in the last 30 seconds grouped by symbol and tick data feed. EPL posts one event for each group to statement update listeners:

```
SELECT symbol, tickDataFeed, MEDIAN(volume)
FROM StockTickEvent RETAIN 30 SECONDS
GROUP BY symbol, tickDataFeed
```

In the statement above the event properties in the select list (`symbol` and `tickDataFeed`) are also listed in the `GROUP BY` clause. The statement thus follows the SQL standard which prescribes that non-aggregated event properties in the select list must match the `GROUP BY` columns.

EPL also supports statements in which one or more event properties in the select list are not listed in the `GROUP BY` clause. The statement below demonstrates this case. It calculates the standard deviation for the last 30 seconds of stock ticks aggregating by symbol and posting for each event the `symbol`, `tickDataFeed` and the standard deviation on `price`.

```
SELECT symbol, tickDataFeed, STDDEV(price)
FROM StockTickEvent RETAIN 30 SECONDS
GROUP BY symbol
```

The above example still aggregates the price event property based on the symbol, but produces one event per incoming event, not one event per group.

Additionally, EPL supports statements in which one or more event properties in the `GROUP BY` clause are not listed in the select list. This is an example that calculates the mean deviation per `symbol` and `tickDataFeed` and posts one event per group with `symbol` and mean deviation of `price` in the generated events. Since `tickDataFeed` is not in the posted results, this can potentially be confusing.

```
SELECT symbol, AVEDEV(price)
FROM StockTickEvent RETAIN 30 SECONDS
GROUP BY symbol, tickDataFeed
```

Expressions are also allowed in the `GROUP BY` list:

```
SELECT symbol * price, count(*)
FROM StockTickEvent RETAIN 30 SECONDS
GROUP BY symbol * price
```

If the GROUP BY expression results in a null value, the null value becomes its own group. All null values are aggregated into the same group. The COUNT(expression) aggregate function does not count null values and the COUNT returns zero if only null values are encountered.

You can use a WHERE clause in a statement with GROUP BY. Events that do not satisfy the conditions in the WHERE clause are eliminated before any grouping is done. For example, the statement below posts the number of stock ticks in the last 30 seconds with a volume larger then 100, posting one event per group (symbol).

```
SELECT symbol, count(*)
FROM StockTickEvent RETAIN 30 SECONDS
WHERE volume > 100
GROUP BY symbol
```

HAVING

The HAVING clause is optional in EPL statements. Use the HAVING clause to pass or reject events defined by the GROUP BY clause. The HAVING clause sets conditions for the GROUP BY clause in the same way WHERE sets conditions for the SELECT clause, except the WHERE clause cannot include aggregate functions, while HAVING often does.

```
HAVING expression
```

This statement is an example of a HAVING clause with an aggregate function. It posts the total price per symbol for the last 30 seconds of stock tick events for only those symbols in which the total price exceeds 1000. The HAVING clause eliminates all symbols where the total price is equal or less then 1000.

```
SELECT symbol, SUM(price)
FROM StockTickEvent RETAIN 30 SEC
GROUP BY symbol
HAVING SUM(price) > 1000
```

To include more than one condition in the HAVING clause combine the conditions with AND, OR or NOT. This is shown in the statement below which selects only groups with a total price greater then 1000 and an average volume less then 500.

```
SELECT symbol, SUM(price), AVG(volume)
FROM StockTickEvent RETAIN 30 SEC
GROUP BY symbol
HAVING SUM(price) > 1000 AND AVG(volume) < 500
```

EPL places the following restrictions on expressions in the HAVING clause:

- Any expressions that contain aggregate functions must also occur in the SELECT clause

A statement with the HAVING clause should also have a GROUP BY clause. If you omit GROUP BY, all the events not excluded by the WHERE clause return as a single group. In that case HAVING acts like a WHERE except that HAVING can have aggregate functions.

The HAVING clause can also be used without GROUP BY clause as the below example shows. The example below posts events where the price is less then the current running average price of all stock tick events in the last 30 seconds.

```
SELECT symbol, price, AVG(price)
FROM StockTickEvent RETAIN 30 SEC
HAVING price < AVG(price)
```

Interaction With MATCHING, WHERE and GROUP BY Clauses

When an EPL statement includes subqueries, a MATCHING clause, WHERE conditions, a GROUP BY clause, and HAVING conditions, the sequence in which each clause executes determines the final result:

1. Any subqueries present in the statement run first. The subqueries act as a filter for events to enter the window of the outer query
2. The event stream's filter conditions in the MATCHING clause, if present, dictates which events enter a window. The filter discards any events not meeting filter criteria.
3. The WHERE clause excludes events that do not meet its search condition.
4. Aggregate functions in the SELECT list calculate summary values for each group.
5. The HAVING clause excludes events from the final results that do not meet its search condition.

The following query illustrates the use of filter, WHERE, GROUP BY and HAVING clauses in one statement with a SELECT clause containing an aggregate function.

```
SELECT tickDataFeed, STDDEV(price)
FROM (SELECT * FROM StockTickEvent WHERE symbol='ACME')
RETAIN 10 EVENTS
WHERE volume > 1000
GROUP BY tickDataFeed
HAVING STDDEV(price) > 0.8
```

EPL filters events using the subquery for the event stream StockTickEvent. In the example above, only events with symbol ACME enter the window over the last 10 events, all other events

are simply discarded. The WHERE clause removes any events posted into the window (events entering the window and event leaving the window) that do not match the condition of volume greater then 1000. Remaining events are applied to the STDDEV standard deviation aggregate function for each tick data feed as specified in the GROUP BY clause. Each tickDataFeed value generates one event. EPL applies the HAVING clause and only lets events pass for tickDataFeed groups with a standard deviation of price greater then 0.8.

ORDER BY

The ORDER BY clause is optional in EPL. It is used for ordering output events by their properties, or by expressions involving those properties. For example, the following statement batches 1 minute of stock tick events sorting them first by price and then by volume.

```
SELECT symbol
FROM StockTickEvent RETAIN BATCH OF 1 MINUTE
ORDER BY price, volume
```

Here is the syntax for the ORDER BY clause:

```
ORDER BY expression [ASC | DESC] [, expression [ASC | DESC] [,…]]
```

EPL places the following restrictions on the expressions in the ORDER BY clause:

- All aggregate functions that appear in the ORDER BY clause must also appear in the SELECT expression.

Otherwise, any kind of expression that can appear in the SELECT clause, as well as any alias defined in the SELECT clause, is also valid in the ORDER BY clause.

OUTPUT

The OUTPUT clause is optional in EPL and is used to control or stabilize the rate at which events are output. For example, the following statement batches old and new events and outputs them at the end of every 90 second interval.

```
SELECT *
FROM StockTickEvent RETAIN 5 EVENTS
OUTPUT EVERY 90 SECONDS
```

Here is the syntax for output rate limiting:

```
OUTPUT [ALL | ( (FIRST | LAST) [number]] EVERY number [EVENTS | time_unit]
```

where

```
  time_unit: MIN | MINUTE | MINUTES | SEC | SECOND | SECONDS | MILLISECONDS
| MS
```

The ALL keyword is the default and specifies that all events in a batch should be output. The batch size can be specified in terms of time or number of events.

The FIRST keyword specifies that only the first event in an output batch is to be output. The optional number qualifier allows more than one event to be output. The FIRST keyword instructs the engine to output the first matching event(s) as soon as they arrive, and then ignore matching events for the time interval or number of events specified. After the time interval elapsed, or the number of matching events has been reached, the same cycle starts again.

The LAST keyword specifies to only output the last event at the end of the given time interval or after the given number of matching events have been accumulated. The optional number qualifier allows more than one event to be output.

The time interval can also be specified in terms of minutes or milliseconds; the following statement is identical to the first one.

```
SELECT *
FROM StockTickEvent RETAIN 5 EVENTS
OUTPUT EVERY 1.5 MINUTES
```

A second way that output can be stabilized is by batching events until a certain number of events have been collected. The next statement only outputs when either 5 (or more) new or 5 (or more) old events have been batched.

```
SELECT *
FROM StockTickEvent RETAIN 30 SECONDS
OUTPUT EVERY 5 EVENTS
```

Additionally, event output can be further modified by the optional LAST keyword, which causes output of only the last event(s) to arrive into an output batch. For the example below, the last five events would be output every three minutes.

```
SELECT *
FROM StockTickEvent RETAIN 30 SECONDS
OUTPUT LAST 5 EVERY 3 MINUTES
```

Using the FIRST keyword you can be notified at the start of the interval. This allows one to be immediately notified each time a rate falls below a threshold.

```
SELECT *
FROM TickRate RETAIN 30 SECONDS
```

```
WHERE rate < 100
OUTPUT FIRST EVERY 60 SECONDS
```

Interaction With GROUP BY and HAVING Clauses

The `OUTPUT` clause interacts in two ways with the `GROUP BY` and `HAVING` clauses. First, in the `OUTPUT EVERY n EVENTS` case, the number n refers to the number of events arriving into the `GROUP BY` clause. That is, if the `GROUP BY` clause outputs only 1 event per group, or if the arriving events do not satisfy the `HAVING` clause, then the actual number of events output by the statement could be fewer than `n`.

Second, the `LAST` and `ALL` keywords have special meanings when used in a statement with aggregate functions and the `GROUP BY` clause. The `LAST` keyword specifies that only groups whose aggregate values have been updated with the most recent batch of events should be output. The `ALL` keyword (the default) specifies that the most recent data for all groups seen so far should be output, whether or not these groups' aggregate values have just been updated.

INSERT INTO

The `INSERT INTO` clause is optional in EPL. This clause can be specified to make the results of a statement available as an event stream for use in further statements. The clause can also be used to merge multiple event streams to form a single stream of events.

```
INSERT INTO CombinedEvent
SELECT A.customerId AS custId, A.timestamp - B.timestamp AS latency
FROM EventA A, EventB B RETAIN 30 MIN
WHERE A.txnId = B.txnId
```

The `INSERT INTO` clause in the above statement generates events of type `CombinedEvent`. Each generated `CombinedEvent` event has two event properties named `custId` and `latency`. The events generated by the above statement can be used in further statements. For example, the statement below uses the generated events.

```
SELECT custId, SUM(latency)
FROM CombinedEvent RETAIN 30 MIN
GROUP BY custId
```

The `INSERT INTO` clause can consist of just an event type alias, or of an event type alias and one or more event property names. The syntax for the `INSERT INTO` clause is as follows:

```
INSERT [ISTREAM | RSTREAM] INTO event_type_alias [(prop_name [,prop_name, [,…]] ) ]
```

The ISTREAM (default) and RSTREAM keywords are optional. If neither keyword is specified, the engine supplies the insert stream events generated by the statement to attached update listeners. The insert stream consists of the events entering the respective window(s) or stream(s). If the RSTREAM keyword is specified, the engine supplies the remove stream events generated by the statement. The remove stream consists of the events leaving the respective window(s).

The *event_type_alias* is an identifier that names the events generated by the engine. The identifier can be used in statements to filter and process events of the given name.

The engine also allows update listeners to be attached to a statement that contain an INSERT INTO clause.

To merge event streams, simply use the same *event_type_alias* identifier in any EPL statements that you would like to be merged. Make sure to use the same number and names of event properties and that event property types match up.

EPL places the following restrictions on the INSERT INTO clause:

- The number of elements in the SELECT clause must match the number of elements in the INSERT INTO clause if the clause specifies a list of event property names
- If the event type alias has already been defined by a prior statement and the event property names and types do not match, an exception is thrown at statement creation time.

The example statement below shows the alternative form of the INSERT INTO clause that explicitly defines the property names to use.

```
INSERT INTO CombinedEvent (custId, latency)
SELECT A.customerId, A.timestamp - B.timestamp
FROM EventA A, EventB B RETAIN 30 MIN
WHERE A.txnId = B.txnId
```

The RSTREAM keyword is used to indicate to the engine to generate only remove stream events. This can be useful if we want to trigger actions when events leave a window rather then when events enter a window. The statement below generates CombinedEvent events when EventA and EventB leave the window after 30 minutes.

```
INSERT RSTREAM INTO CombinedEvent
SELECT A.customerId AS custId, A.timestamp - B.timestamp AS latency
FROM EventA A, EventB B RETAIN 30 MIN
WHERE A.txnId = B.txnId
```

CHAPTER 4

EPL Reference: Operators

This section contains information on the following subjects:

Overview of EPL Operators

The precedence of arithmetic and logical operators in EPL follows Java standard arithmetic and logical operator precedence.

Arithmetic Operators

The table below outlines the arithmetic operators available.

Table 4-1 Arithmetic Operators

Operator	Description
+, -	As unary operators they denote a positive or negative expression. As binary operators they add or subtract.
*, /	Multiplication and division are binary operators.
%	Modulo binary operator.

Logical and Comparison Operators

The table below outlines the logical and comparison operators available.

Table 4-2 Logical and Comparison Operators

Operator	Description
NOT	Returns `true` if the following condition is false, returns `false` if it is true.
OR	Returns `true` if either component condition is true, `returns` false if both are false
AND	Returns `true` if both component conditions are true, returns `false` if either is false
=, !=, <, >, <=, >=,<>	Comparison operators

Concatenation Operators

The table below outlines the concatenation operators available.

Table 4-3 Concatenation Operators

Operator	Description
||	Concatenates character strings

Binary Operators

The table below outlines the binary operators available.

Table 4-4 Binary Operators

Operator	Description
&	Bitwise AND if both operands are numbers; conditional AND if both operands are Boolean.
|	Bitwise OR if both operands are numbers; conditional OR if both operands are Boolean.
^	Bitwise exclusive OR (XOR)

Array Definition Operator

The { and } curly braces are array definition operators following the Java array initialization syntax. Arrays can be useful to pass to user-defined functions or to select array data in a SELECT clause.

Array definitions consist of zero or more expressions within curly braces. Any type of expression is allowed within array definitions including constants, arithmetic expressions or event properties. This is the syntax of an array definition:

```
{ [expression [,expression [,…]]] }
```

Consider the next statement that returns an event property named actions. The engine populates the `actions` property as an array of `java.lang.String` values with a length of 2 elements. The first element of the array contains the observation property value and the second element the command property value of `RFIDEvent` events.

```
SELECT {observation, command} AS actions
FROM RFIDEvent RETAIN ALL
```

The engine determines the array type based on the types returned by the expressions in the array definition. For example, if all expressions in the array definition return integer values then the type of the array is `java.lang.Integer[]`. If the types returned by all expressions are a compatible number types, such as integer and double values, the engine coerces the array element values and returns a suitable type, `java.lang.Double[]` in this example. The type of the array returned is `Object[]` if the types of expressions cannot be coerced or return object values. Null values can also be used in an array definition.

Arrays can come in handy for use as parameters to user-defined functions:

```
SELECT *
FROM RFIDEvent RETAIN ALL
WHERE Filter.myFilter(zone, {1,2,3})
```

List and Range Operators

This section describes the following two operations:

- "IN Operator" on page 4-4
- "BETWEEN Operator" on page 4-5

IN Operator

The `IN` operator determines if a given value matches any value in a list. The syntax of the operator is:

`test_expression` `[NOT] IN (`*`expression`* `[,`*`expression`* `[,…]] )`

The *`test_expression`* is any valid expression. The `IN` keyword is followed by a list of expressions to test for a match. The optional `NOT` keyword specifies that the result of the predicate be negated.

The result of an `IN` expression is of type `Boolean`. If the value of *`test_expression`* is equal to any expression from the comma-separated list, the result value is `true`. Otherwise, the result value is `false`. All expressions must be of the same type or a type compatible with *`test_expression`*.

The next example shows how the `IN` keyword can be applied to select certain command types of `RFIDEvents`:

```
SELECT *
FROM RFIDEvent RETAIN ALL
WHERE command IN ('OBSERVATION', 'SIGNAL')
```

The statement is equivalent to:

```
SELECT *
FROM RFIDEvent RETAIN ALL
WHERE command = 'OBSERVATION' OR symbol = 'SIGNAL'
```

BETWEEN Operator

The `BETWEEN` operator specifies a range to test. The syntax of the operator is:

```
test_expression [NOT] BETWEEN begin_expression AND end_expression
```

The *`test_expression`* is any valid expression and is the expression to test for the range being inclusively within the expressions defined by *`begin_expression`* and *`end_expression`*. The `NOT` keyword specifies that the result of the predicate be negated.

The result of a `BETWEEN` expression is of type `Boolean`. If the value of *`test_expression`* is greater then or equal to the value of *`begin_expression`* and less than or equal to the value of *`end_expression`*, the result is `true`.

The next example shows how the `BETWEEN` keyword can be used to select events with a price between 55 and 60 (inclusive).

```
SELECT *
FROM StockTickEvent RETAIN ALL
WHERE price BETWEEN 55 AND 60
```

The equivalent expression without using the `BETWEEN` keyword is:

```
SELECT *
FROM StockTickEvent RETAIN ALL
WHERE price >= 55 AND price <= 60
```

The *`begin_expression`* and *`end_expression`* may occur in either order without affecting the query. For example, the following is equivalent to the above example:

```
SELECT *
FROM StockTickEvent RETAIN ALL
WHERE price BETWEEN 60 AND 55
```

String Operators

This section describes the following string operators:

LIKE Operator

The `LIKE` operator provides standard SQL pattern matching. SQL pattern matching allows you to use _ to match any single character and `%` to match an arbitrary number of characters (including zero characters). In EPL, SQL patterns are case-sensitive by default. The syntax of `LIKE` is:

```
test_expression [NOT] LIKE pattern_expression [ESCAPE string_literal]
```

The *`test_expression`* is any valid expression yielding a String type or a numeric result. The optional *`NOT`* keyword specifies that the result of the predicate be negated. The *`LIKE`* keyword is followed by any valid standard SQL *`pattern_expression`* yielding a String-typed result. The optional `ESCAPE` keyword signals the escape character used to escape the _ and `%` values in the pattern.

The result of a `LIKE` expression is of type `Boolean`. If the value of *`test_expression`* matches the *`pattern_expression`*, the result value is `true`. Otherwise, the result value is `false`. An example for the `LIKE` keyword is shown below.

```
SELECT *
FROM PersonLocationEvent RETAIN ALL
WHERE name LIKE '%Jack%'
```

In this example the `WHERE` clause matches events where the `suffix` property is a single _ character.

```
SELECT *
FROM PersonLocationEvent RETAIN ALL
WHERE suffix LIKE '!_' ESCAPE '!'
```

REGEXP Operator

The `REGEXP` operator is a form of pattern matching based on regular expressions implemented through the Java `java.util.regex` package. The syntax of `REGEXP` is:

```
test_expression [NOT] REGEXP pattern_expression
```

The *test_expression* is any valid expression yielding a String type or a numeric result. The optional NOT keyword specifies that the result of the predicate be negated. The REGEXP keyword is followed by any valid regular expression *pattern_expression* yielding a String-typed result.

The result of a REGEXP expression is of type Boolean. If the value of *test_expression* matches the regular expression *pattern_expression*, the result value is true. Otherwise, the result value is false.

An example for the REGEXP operator is below.

```
SELECT *
FROM PersonLocationEvent RETAIN ALL
WHERE name REGEXP '*Jack*'
```

Temporal Operators

This section describes the following temporal operations:

FOLLOWED BY Operator

The FOLLOWED BY operator specifies that first the left hand expression must turn true and only then is the right hand expression evaluated for matching events.

For example, the following pattern looks for event A and if encountered, looks for event B:

```
A FOLLOWED BY B
```

This does not mean that event A must *immediately* be followed by event B. Other events may occur between the event A and the event B and this expression would still evaluate to true. If this is not the desired behavior, the NOT operator can be used.

WITHIN Operator

The WITHIN qualifier acts like a stopwatch. If the associated pattern expression does not become true within the specified time period it is evaluated by the engine as false. The WITHIN qualifier takes a time period as a parameter as specified in "Specifying Time Interval" on page 3-12.

This pattern fires if an A event arrives within 5 seconds after statement creation.

```
A WITHIN 5 seconds
```

This pattern fires for all A events that arrive within 5 second intervals.

EVERY Operator

The EVERY operator indicates that the pattern sub-expression should restart when the sub-expression qualified by the EVERY keyword evaluates to true or false. In the absence of the EVERY operator, an implicit EVERY operator is inserted as a qualifier to the first event stream source found in the pattern not occurring within a NOT expression.

The EVERY operator works like a factory for the pattern sub-expression contained within. When the pattern sub-expression within it fires and thus quits checking for events, the EVERY causes the start of a new pattern sub-expression listening for more occurrences of the same event or set of events.

Every time a pattern sub-expression within an EVERY operator turns true the engine starts a new active sub-expression looking for more event(s) or timing conditions that match the pattern sub-expression.

This pattern fires when an A event is followed by a B event and continues attempting to match again after the B event:

```
EVERY (A FOLLOWED BY B)
```

This pattern also fires when an A event is followed by a B event, but continues attempting to match again after the A event:

```
EVERY A FOLLOWED BY B
```

The EVERY in this pattern is optional, since it would implicitly be placed here if it was absent.

EPL Reference: Functions

This section contains information on the following subjects:

Single-row Functions

Single-row functions return a single value for every single result row generated by your statement. These functions can appear anywhere where expressions are allowed.

EPL allows static Java library methods as single-row functions, and also features built-in single-row functions.

EPL auto-imports the following Java library packages:

- `java.lang.*`
- `java.math.*`
- `java.text.*`
- `java.util.*`

Thus Java static library methods can be used in all expressions as shown in below example:

```
SELECT symbol, Math.round(volume/1000)
FROM StockTickEvent RETAIN 30 SECONDS
```

Other arbitrary Java classes may also be used, however their names must be fully qualified or configured to be imported. For more information, see "User-Defined functions" on page 5-8.

The table below outlines the built-in single-row functions available.

Table 5-1 Built-In Single-Row Functions

Single-row Function	Result
`MAX(expression, expression [, expression [,…])`	Returns the highest numeric value among the two or more comma-separated expressions.
`MIN(expression, expression [, expression [,…])`	Returns the lowest numeric value among the two or more comma-separated expressions.
`COALESCE(expression, expression [, expression [,…])`	Returns the first non-null value in the list, or null if there are no non-null values.

`CASE value`
`  WHEN compare_value THEN result`
`  [WHEN compare_value THEN result …]`
`  [ELSE result]`
`END`
	Returns result where the first value equals *compare_value*.

`CASE value`
`  WHEN condition THEN result`
`  [WHEN condition THEN result …]`
`  [ELSE result]`
`END`
	Returns the result for the first condition that is true.

`PREV(expression, event_property)`	Returns a property value of a previous event, relative to the event order within a data window.
`PRIOR(integer, event_property)`	Returns a property value of a prior event, relative to the natural order of arrival of events

The MIN and MAX Functions

The MIN and MAX functions take two or more expression parameters. The min function returns the lowest numeric value among these comma-separated expressions, while the MAX function returns the highest numeric value. The return type is the compatible aggregated type of all return values.

The next example shows the MAX function that has a Double return type and returns the value 1.1.

```
SELECT MAX(1, 1.1, 2 * 0.5)
FROM ...
```

The MIN function returns the lowest value. The statement below uses the function to determine the smaller of two timestamp values.

```
SELECT symbol, MIN(ticks.timestamp, news.timestamp) AS minT
FROM StockTickEvent AS ticks, NewsEvent AS news RETAIN 30 SECONDS
WHERE ticks.symbol = news.symbol
```

The MIN and MAX functions are also available as aggregate functions. See "Aggregate functions" on page 5-6 for a description of this usage.

The COALESCE Function

The result of the COALESCE function is the first expression in a list of expressions that returns a non-null value. The return type is the compatible aggregated type of all return values.

This example returns a String type result with a value of foo.

```
SELECT COALESCE(NULL, 'foo')
FROM …
```

The CASE Control Flow Function

The CASE control flow function has two versions. The first version takes a value and a list of compare values to compare against, and returns the result where the first value equals the compare value. The second version takes a list of conditions and returns the result for the first condition that is true.

The return type of a CASE expression is the compatible aggregated type of all return values.

The example below shows the first version of a CASE statement. It has a String return type and returns the value one.

```
SELECT CASE 1 WHEN 1 THEN 'one' WHEN 2 THEN 'two' ELSE 'more' END
FROM …
```

The second version of the CASE function takes a list of conditions. The next example has a Boolean return type and returns the Boolean value true.

```
SELECT CASE WHEN 1>0 THEN true ELSE false END
FROM …
```

The PREV Function

The PREV function returns the property value of a previous event. The first parameter denotes the i^{th} previous event in the order established by the data window. The second parameter is a property name for which the function returns the value for the previous event.

This example selects the value of the price property of the second previous event from the current Trade event.

```
SELECT PREV(2, price)
FROM Trade RETAIN 10 EVENTS
```

Because the PREV function takes the order established by the data window into account, the function works well with sorted windows. In the following example the statement selects the symbol of the three Trade events that had the largest, second-largest and third-largest volume.

```
SELECT PREV(0, symbol), PREV(1, symbol), PREV(2, symbol)
FROM Trade RETAIN 10 EVENTS WITH LARGEST volume
```

The i^{th} previous event parameter can also be an expression returning an Integer type value. The next statement joins the Trade data window with a RankSelectionEvent event that provides a rank property used to look up a certain position in the sorted Trade data window:

```
SELECT PREV(rank, symbol)
FROM Trade, RankSelectionEvent RETAIN 10 EVENTS WITH LARGEST volume
```

The PREV function returns a NULL value if the data window does not currently hold the i^{th} previous event. The example below illustrates this using a time batch window. Here the PREV function returns a null value for any events in which the previous event is not in the same batch of events. The PRIOR function as discussed below can be used if a null value is not the desired result.

```
SELECT PREV(1, symbol)
FROM Trade RETAIN BATCH OF 1 MINUTE
```

Previous Event Per Group

The combination of the PREV function and the PARTITION BY clause returns the property value for a previous event in the given group.

For example, assume we want to obtain the price of the previous event of the same symbol as the current event.

The statement that follows solves this problem. It partitions the window on the symbol property over a time window of one minute. As a result, when the engine encounters a new symbol value that it hasn't seen before, it creates a new window specifically to hold events for that symbol. Consequently, the PREV function returns the previous event within the respective time window for that event's symbol value.

```
SELECT PREV(1, price) AS prevPrice
FROM Trade RETAIN 1 MIN PARTITION BY symbol
```

Restrictions

The following restrictions apply to the PREV functions and its results:

- The function always returns a null value for remove stream (old data) events.
- The function may only be used on streams that are constrained by a RETAIN clause.

The PRIOR Function

The PRIOR function returns the property value of a prior event. The first parameter is an integer value that denotes the ith prior event in the natural order of arrival. The second parameter is a property name for which the function returns the value for the prior event.

This example selects the value of the price property of the second prior event to the current Trade event.

```
SELECT PRIOR(2, price)
FROM Trade RETAIN ALL
```

The PRIOR function can be used on any event stream or view and does not require a stream to be constrained by a RETAIN clause as with the PREV function. The function operates based on the order of arrival of events in the event stream that provides the events.

The next statement uses a time batch window to compute an average volume for 1 minute of Trade events, posting results every minute. The SELECT clause employs the PRIOR function to select the current average and the average before the current average:

```
SELECT AVG(volume) AS avgVolume, PRIOR(1, avgVolume)
FROM TradeAverages RETAIN BATCH OF 1 MINUTE
```

Comparison to the PREV Function

The PRIOR function is similar to the PREV function. The key differences between the two functions are as follows:

- The PREV function returns previous events in the order provided by the window, while the PRIOR function returns prior events in the order of arrival in the stream.
- The PREV function requires a RETAIN clause while the PRIOR function does not.
- The PREV function returns the previous event taking into account any grouping. The PRIOR function returns prior events regardless of any grouping.
- The PREV function returns a null value for remove stream events, i.e. for events leaving a data window. The PRIOR function does not have this restriction.

Aggregate functions

The aggregate functions are SUM, AVG, COUNT, MAX, MIN, MEDIAN, STDDEV, AVEDEV. You can use aggregate functions to calculate and summarize data from event properties. For example, to find out the total price for all stock tick events in the last 30 seconds:

```
SELECT SUM(price)
FROM StockTickEvent RETAIN 30 SECONDS
```

Here is the syntax for aggregate functions:

```
aggregate_function( [ALL | DISTINCT] expression)
```

You can apply aggregate functions to all events in an event stream window or other view, or to one or more groups of events. From each set of events to which an aggregate function is applied, EPL generates a single value.

The expression is usually an event property name. However it can also be a constant, function, or any combination of event property names, constants, and functions connected by arithmetic operators.

For example, to find out the average price for all stock tick events in the last 30 seconds if the price was doubled:

```
SELECT AVG(price * 2)
FROM StockTickEvent RETAIN 30 SECONDS
```

You can use the optional keyword `DISTINCT` with all aggregate functions to eliminate duplicate values before the aggregate function is applied. The optional keyword `ALL` which performs the operation on all events is the default.

The `MIN` and `MAX` aggregate functions are also available as single row functions. See "The MIN and MAX Functions" on page 5-3 for a description of this usage.

The syntax of the aggregation functions and the results they produce are shown in table below.

Table 5-2 Aggregate Functions

Aggregate Function	Result
`SUM([ALL|DISTINCT] expression)`	Totals the (distinct) values in the *`expression`*, returning a value of `long`, `double`, `float` or `integer` type depending on the expression.
`AVG([ALL|DISTINCT] expression)`	Average of the (distinct) values in the *`expression`*, returning a value of `double` type.
`COUNT([ALL|DISTINCT] expression)`	Number of the (distinct) non-null values in the *`expression`*, returning a value of `long` type.
`COUNT(*)`	Number of events, returning a value of `long` type.
`MAX([ALL|DISTINCT] expression)`	Highest (distinct) value in the *`expression`*, returning a value of the same type as the expression itself returns.
`MIN([ALL|DISTINCT] expression)`	Lowest (distinct) value in the *`expression`*, returning a value of the same type as the expression itself returns.
`MEDIAN([ALL|DISTINCT] expression)`	Median (distinct) value in the *`expression`*, returning a value of `double` type.
`STDDEV([ALL|DISTINCT] expression)`	Standard deviation of the (distinct) values in the *`expression`*, returning a value of `double` type.
`AVEDEV([ALL|DISTINCT] expression)`	Mean deviation of the (distinct) values in the *`expression`*, returning a value of `double` type.
`TREND(expression)`	Number of consecutive up ticks (as positive number), down ticks (as negative number), or no change (as zero) for *`expression`*.

You can use aggregation functions in a `SELECT` clause and in a `HAVING` clause. You cannot use aggregate functions in a `WHERE` clause, but you can use the `WHERE` clause to restrict the events to

which the aggregate is applied. The next query computes the average and sum of the price of stock tick events for the symbol ACME only, for the last 10 stock tick events regardless of their symbol.

```
  SELECT 'ACME stats' AS title, AVG(price) AS avgPrice, SUM(price) AS
sumPrice
  FROM StockTickEvent RETAIN 10 EVENTS
  WHERE symbol='ACME'
```

In the preceding example the length window of 10 elements is not affected by the WHERE clause, in other words, all events enter and leave the length window regardless of their symbol. If we only care about the last 10 ACME events, we need to add a MATCHING clause as shown below.

```
  SELECT 'ACME stats' AS title, AVG(price) AS avgPrice, SUM(price) AS
sumPrice
  FROM (SELECT * FROM StockTickEvent WHERE symbol='ACME')
  RETAIN 10 EVENT
```

You can use aggregate functions with any type of event property or expression, with the following restriction:

- You can use SUM, AVG, MEDIAN, STDDEV, AVEDEV with numeric event properties only

EPL ignores any null values returned by the event property or expression on which the aggregate function is operating, except for the COUNT(*) function, which counts null values as well. All aggregate functions return null if the data set contains no events, or if all events in the data set contain only null values for the aggregated expression.

User-Defined functions

A user-defined function can be invoked anywhere as an expression itself or within an expression. The function must simply be a public static method that the class loader can resolve at statement creation time. The engine resolves the function reference at statement creation time and verifies parameter types.

The example below assumes a class MyClass that exposes a public static method myFunction accepting two parameters, and returning a numeric type such as double.

```
  SELECT 3 * MyClass.myFunction(price, volume) as myValue
  FROM StockTick RETAIN 30 SECONDS
```

User-defined functions also take array parameters as this example shows. “Array Definition Operator” on page 4-3 outlines in more detail the types of arrays produced.

```
SELECT *
FROM RFIDEvent RETAIN 10 MINUTES
WHERE com.mycompany.rfid.MyChecker.isInZone(zone, {10, 20, 30})
```

CHAPTER 6

Programmatic Interface to EPL

This section contains information on the following subjects:

Java Programming Interfaces

The Java programmatic interface for the EPL is rooted at the `com.bea.wlevs.ede.api.Processor` interface. This interface provides methods to load, compile, start, stop, and retrieve EPL statements.

EPL statements are loaded and compiled individually through the following method:

```
Statement createStatement(String query) throws StatementException;
```

If the query fails to compile, a `StatementException` will be thrown. Alternatively, multiple statements may be loaded from a URL using the following method:

```
List<Statement> loadStatements (URL location) throws
MultiStatementException;
```

If the queries fail to compile, a `MultiStatementException` will be thrown. The structure of the rules file is explained in the section Configuring the Complex Event Processor Rules. Individual queries compiled through the `createStatement` are not persisted and have no effect on the rule files located at the URL location.

The `com.bea.wlevs.ede.api.Statement` interface allows event sinks to be attached to an EPL statement using the following method:

```
void addEventSink (EventSink listener);
```

The engine calls the following method on the `ccom.bea.wlevs.ede.api.EventSink` interface when events are added to the output window as a result of executing the statement:

```
void onEvent (List newEvents);
```

For more information, see the complete WebLogic Event Server Javadocs.