Oracle® Agile Product Lifecycle Management for Process

Hierarchy Denormalization Solution Pack

Extensibility Pack 3.5

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Agile Product Lifecycle Management for Process

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Preface

Audience

This guide is intended for client programmers involved with integrating Oracle Agile Product Lifecycle Management for Process. Information about using Oracle Agile PLM for Process resides in application-specific user guides. Information about administering Oracle Agile PLM for Process resides in the *Oracle Agile Product Lifecycle Management for Process Administrator User Guide*.

Variability of Installations

Descriptions and illustrations of the Agile PLM for Process user interface included in this manual may not match your installation. The user interface of Agile PLM for Process applications and the features included can vary greatly depending on such variables as:

- Which applications your organization has purchased and installed
- Configuration settings that may turn features off or on
- Customization specific to your organization
- Security settings as they apply to the system and your user account

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Hierarchy Denormalization

Purpose

This guide describes how to install, configure, and use the Hierarchy Denormalization solution pack.

Solution packs are designed to be pluggable modules that can be added to the Agile PLM for Process application suite without modifying the existing release code base.

Overview

Oracle Agile PLM for Process stores objects, such as specifications, along with the relationships to each other, in a normalized database schema, making inserts, updates and deletes highly efficient while minimizing its size. The challenges with having a normalized schema are that it can make custom SQL queries complex and possibly not optimal for bulk data retrieval. For example, to construct a report that returns the entire hierarchy of a trade specification, would require a deep understanding of many relationship tables and would be extremely difficult to do in SQL alone, due to the varying number of possible layers in the hierarchy. A hierarchy of a specification is defined as that specification plus all descendant specifications as well as other related objects. For example these objects would be considered part of a trade hierarchy:

- The main trade specification
- All lower level trade specifications
- The material specification directly associated to the trade specification
- The formula to create the above material
- All inputs and outputs to the above formula
- All formulas that create the above inputs
- All inputs and outputs to the above formulas
- Etc …

By continuing to drill down into the formula and intermediate formulas that comprise a trade specification, you will have what we are referring to as the Trade Hierarchy. This hierarchy is not limited to the relationships defined above but covers many of the relationships that are defined in PLM for Process.

Hierarchy Denormalization provides a solution to this data access problem by storing the object relationship information in a single table, allowing for simple and performant hierarchy retrieval.

Many solutions can use this table to provide functionality such as hierarchical navigation and reporting.

Installation

Note: A prerequisite for installing Hierarchy Denormalization is Oracle Agile PLM for Process 6.1.1.1.0.

Preparation

1. Unzip the contents of Extensibility Pack 3.5.
2. Unzip the contents of the Utilities\DenormServices\HierarchyDenorm\HierarchyDenorm.zip file and note the location.

Database Setup

1. Create a backup of the PLM for Process database.
2. Apply the database scripts.
    a. SQL Server
        i. Open a command prompt and navigate to the directory where you unzipped the solution pack.
        ii. Change directories (cd) to the Database directory.
        iii. Apply the scripts using the following calls to the ApplyScripts.exe utility:

```
ApplyScripts –c "server=<database_server>;uid=<user>;
password=<password>;database=<database>" –f HierarchyDenorm.xml
```

        iv. After the ApplyScripts call, you can confirm that the database scripts have been applied successfully when the system prompts you with the following message: "Complete – with no errors".

    b. Oracle
        i. Open a command prompt and navigate to the directory where you unzipped the solution pack.
        ii. Change directories (cd) to the Database directory.
        iii. Apply the scripts using the following calls to the ApplyScripts.exe utility:

```
ApplyScripts –c "User Id=<user>;Password=<password>; Data
Source=<datasource>" –dbvendor="orcl" –f HierarchyDenorm-orcl.xml
```

        iv. After the ApplyScripts call, you can confirm that the database scripts have been applied successfully when the system prompts you with the following message: "Complete – with no errors".

Application Installation

1. Run the HierarchyDenormSetup.exe file from the location where you unzipped the solution pack and follow the onscreen instructions to install the necessary files to your specified PLM for Process directory.

   A backup folder called “SolutionPackBackup” is created during the installation to facilitate the uninstall process. Inside of that folder, a new folder called “HierarchyDenorm” is created to hold the files that were changed during the installation.

2. Restart RemotingContainer Service.

Performance Estimation for Initial Denormalization

Hierarchy Denormalization is a background process running on the Remoting Container, which processes updates as needed. After the initial startup of the Remoting Container after installation, all the hierarchies must be denormalized. The amount of time to perform this is dependent on some factors such as hardware performance, number of specifications, depth of hierarchies and Hierarcy Denormalization configuration settings.

For an approximation of how long it will take to complete the initial processing, tests were performed on three data sets. Below are the test details and results.

Testing server (Virtual Machine) information:

- APP server: Xeon 2.93G Dual, 8G RAM, 1000M Intranet, Windows 2008 R2 (64-bit) with IIS7
- DB server A: Xeon 2.93G Dual, 8G RAM, 1000M Intranet, Oracle 11g Release 2 for Windows (64-bit)
- DB server B: Xeon 2.93G Dual, 8G RAM, 1000M Intranet, Oracle 11g Release 2 for Linux

The following is a snapshot of the configuration file “HierarchyDenormConfig.xml” used.

```
<HierarchyDenormConfig>
  <Settings>
    <!-- The interval of the denorm scanning. (unit: seconds) -->
    <PollingIntervalInSeconds_Detector>90</PollingIntervalInSeconds_Detector>
    <PollingIntervalInSeconds_Processor>1</PollingIntervalInSeconds_Processor>

    <!-- The denorm process will stop when CurrentLevel reaches the value. -->
    <DenormMaxLevel>12</DenormMaxLevel>
    <!-- Overwrite current branch's MaxLevel when the processor meets a node which was created by BreakdownComponent resolver. -->
    <DenormMaxLevel_BreakdownComponent>3</DenormMaxLevel_BreakdownComponent>
    <!-- Overwrite current branch's MaxLevel when the processor meets a node which was created by AlternateOutput resolver. -->
    <DenormMaxLevel_AlternateOutput>2</DenormMaxLevel_AlternateOutput>

    <!-- Determinate which type of sub-relationships should be resolved. (TargetOnly, HostOnly, Both) -->
    <DenormMode_AssociatedSpec>TargetOnly</DenormMode_AssociatedSpec>
    <!-- Determinate how many valid requests will be resolved in a denormalization period. -->
    <DenormMode_RequestBatchCount>200</DenormMode_RequestBatchCount>

    <!-- Determinate how many types of logs should be written. (ErrorOnly, WithWarning, WithWarningAndInfo) -->
    <LoggingLevel>WithWarningAndInfo</LoggingLevel>
    <!-- The listed spec types would always skip writing any denorm warning no matter what LoggingLevel is. (Separated by comma) -->
    <LoggingWhiteList_SkipWarning>5816,1004,2147,1009,2280,2121,1006,2076,1010,6500,6501,5002,5001,5012,5019</LoggingWhiteList_SkipWarning>
  </Settings>
```

Four database samples with legacy data have been selected for the estimation. Their involved object types were listed in the below table.

Scope	Object	Spec Type	Table Name
GSM	PrintedPackaging	2121	FinishedPackagingSpec
	Menu	6500	FoodServiceMenuItem
	Formulation	5816	formulationSpecification
	Material	1004	MaterialSpec
	Trade	2147	gsmBaseTradeSpec
	Product	6501	FoodServiceProduct
	Delivered Material Packing	1010	PackingSpec
	Label	1006	LabelingSpec
	Packaging	1009	PackagingSpec
	Equipment	2280	gsmEquipmentSpecification
	Packing Configuration	2076	PackingConfigurationSpec
	Activity	2283	SpecActivitySpecification
SCRM	Company	5002	scrmCompany
	Facility	5001	scrmFacility
	SourcingApproval	5012	scrmSourcingApproval
	NonSpecSourcingApproval	5019	scrmSourcingApprovalNonSpec

- Sample A - Oracle for Windows

Total: ~ 26,000 requests

Duration: ~ 173 minutes

Average: ~ 2.5 requests/second

- Sample B - Oracle for Linux

Total: ~ 26,000 requests

Duration: ~ 172 minutes

Average: ~ 2.5 requests/second

- Indicators on Oracle platform:

RemotingContainer CPU usage:

Average: 6%

Peak: 12%

Valley: less than 1%

RemotingContainer Memory usage:

150MB ~ 350MB

Configuration

By default Hierarchy Denormalization will execute without the need to update the configuration settings. The configuration settings can be used to change how often the denormalization process runs as well as what will be denormalized. To understand when data will be denormalized, it's helpful to understand the processes involved.

Hierarchy Denormalization is designed as two endless processing services: Denormalization Detector and Denormalization Processor service. The Detector service checks whether the hierarchy was changed after the last time Denormalization Processor was executed. If changes were detected, it will create denormalization requests. The Processor service will orchestrate the execution of denormalizers which does the actual denormalization work. Both the Detector and Processor service are designed to be triggered in a configurable frequency as shown in the table below. This table also shows the configuration for controlling what is denormalized.

The following are the configurable properties located in the "HierarchyDenormConfig/Settings" section of the configuration file located at "<PLM for Process>\config\Extensions\HierarchyDenormConfig.xml".

Property Name	Acceptable values	Default Value	Description
PollingIntervalInSeconds_Detector	Number in seconds	90	Interval of detector service running frequency.
PollingIntervalInSeconds_Processor	Number in seconds	100	Interval of processor service running frequency.
DenormMaxLevel	Number	12	Denormalized hierarchy tree max depth limitation.
DenormMaxLevel_BreakdownComponent	Number	3	Denormalized hierarchy branch max depth limitation specific for a Breakdown Component. If current branch has a node whose relationship context is "BreakdownComponent" it would perform a level-limited denormalization. The default value indicates the parent will at most have 3-levels children.

Property Name	Acceptable values	Default Value	Description
DenormMaxLevel_AlternateOutput	Number	2	Denormalized hierarchy branch max depth limitation specific for an Alternate Output. If current branch has a node whose relationship context is "AlternateOutput" it would perform a level-limited denormalization. The default value indicates the parent will at most have 2-levels children.
DenormMode_AssociatedSpec	"TargetOnly"; "HostOnly"; "Both"	"TargetOnly"	Determines which type of sub-relationships should be resolved.
DenormMode_RequestBatchCount	Number	200	Determinate how many valid requests will be resolved in a denormalization period.
LoggingLevel	"ErrorOnly"; "WithWarning"; "WithWarningAndInfo"	"ErrorOnly"	Determinate how many types of logs should be written.
LoggingWhiteList_SkipWarning	TypeID string separated by comma	"5816,1004,2147,1009,2280,2121,1006,2076,1010,6500,6501,5002,5001,5012,5019"	The listed spec types would always skip writing any denormalization warning no matter what LoggingLevel is.

Extending Hierarchy Denormalization

Hierarchy Denormalization is designed as a pluggable architecture that enables customers to extend the out of the box functionality by adding other relationships to the denormalized table. The two components necessary to make this possible are Detectors and Denormalizors. Detectors are components that determine what and when a relationship should be denormalized. Denormalizors are components that do the actual work of populating the denormalized table. These are both pluggable components written in C#.

A full reference of how to extend Hierarchy Denormalization can be found below in the Extensibility References section.

Detectors

The purpose of detectors is to find objects that have been modified since the denormalizers last ran. To determine this it compares last updated dates of the objects to the last run dates of the denormalizers. Each object type will have a specific detector that is responsible for performing this operation.

Detector settings were organized in "HierarchyDenormConfig/Detectors" section of the "<PLM for Process>\config\Extensions\HierarchyDenormConfig.xml" file. It can accept a sequence of "Detector" nodes within the section.

Each "detector" should have an "objectURL" and "id" attribute. The value of "id" attribute should be unique across the section. "objectURL" is configured as the full class name of the detector producing factory.

The user can either add new detectors or customize the existing ones. (See more at Extensibility References). Example of Detector settings:

```
<Detectors configChildKey="id">
       <Detector
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDGSMLib.Detectors.RequestArchiveDe
tector,HDGSMLib" id="RequestArchiveDetector"/>
       <Detector
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDGSMLib.Detectors.ActivityDetector
,HDGSMLib" id="ActivityDetector"/>
        …
</Detectors>
```

Denormalizers

The purpose of denormalizers is to actually populate the denormalized table.

Denormalizer settings were organized in "HierarchyDenormConfig/Denormalizers" section of the "<PLM for Process>\config\Extensions\HierarchyDenormConfig.xml" file. It can accept a sequence of "Denormalizer" nodes within the section.

Each "Denormalizer" should have an "objectURL","type" and "dataTable" attribute. The "type" attribute will represent the type id defined in PLM for Process. "objectURL" is configured as the full class name of the denormalizer producing factory. And "dataTable" determinates the table in which the corresponding denormalization results should be saved. Note the available data tables must have been pre-defined in installer scripts. Currently, this solution pack supports the following spec type and repository mappings:

ClassName	Type	DataTable/Repository
IngredientSpecification	1004	DENORM_HD_HIERARCHY_GSM
LabelingSpecification	1006	DENORM_HD_HIERARCHY_GSM
PackagingSpecification	1009	DENORM_HD_HIERARCHY_GSM
PackingSpecification	1010	DENORM_HD_HIERARCHY_GSM
PackingConfigurationSpecification	2076	DENORM_HD_HIERARCHY_GSM

ClassName	Type	DataTable/Repository
FinishedPackagingSpecification	2121	DENORM_HD_HIERARCHY_GSM
GSMTradeSpecDO	2147	DENORM_HD_HIERARCHY_GSM
EquipmentSpecification	2280	DENORM_HD_HIERARCHY_GSM
FormulationSpecification	5816	DENORM_HD_HIERARCHY_GSM
FoodServiceMenuItemDO	6500	DENORM_HD_HIERARCHY_GSM
FoodServiceProductDO	6501	DENORM_HD_HIERARCHY_GSM
SCRMFacilityDO	5001	DENORM_HD_HIERARCHY_SCRM
SCRMCompanyDO	5002	DENORM_HD_HIERARCHY_SCRM
SourcingApproval	5012	DENORM_HD_HIERARCHY_SCRM
SourcingApprovalNonSpec	5019	DENORM_HD_HIERARCHY_SCRM

For example, when a formulation specification, type 5816 is denormalized, the resulting denormalized data will be stored in the "DENORM_HD_HIERARCHY_GSM" table.

For each "Denormalizer", the relationships that should be denormalized should also be defined. The relationships also have attributes of "objectURL" and "id". An expected "RelationshipContext" should be bound with a relationship resolver by adding its unique name to the end of the "objectURL" (Refer to "Relationship Context Definitions").

Customers can create new denormalizers or customize the existing ones. (See more at Extensibility References).

Example of Denormalizer settings:

```
<Denormalizer
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDGSMLib.Denormalizers.FormulationD
enormalizer,HDGSMLib" type="5816" dataTable="DENORM_HD_HIERARCHY_GSM">
   <Relationships configChildKey="id">
      <Relationship
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDGSMLib.DescendentRelationships.Co
mActivities,HDGSMLib$PrimaryActivity" id="ComActivities"/>
      <Relationship
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDGSMLib.DescendentRelationships.Co
mMasterSpec,HDGSMLib$ExplicitMaster" id="ComMasterSpec"/>
     …
   </Relationships>
</Denormalizer>
```

Relationship Context Definitions

Specifications can be related to each other in different ways. For instance a formulation can have an input BOM item or it can have an alternate BOM item. If that formulation was part of a trade specification then the relationship between the trade and the BOM items would also have certain relationship types. Hierarchy Denormalization captures these relationships types in 2 columns in the DENORM_HD_HIERARCHY_XXXX table, one for the Parent and one for the Ancestor, "fkParentRelationshipContext" and "fkAncestorRelationshipContext". These fields are foreign keys to the "DENORM_HD_RELATIONSHIP_CTX" table and "DENORM_HD_RELATIONSHIP_CTX_ML" table, which both store the readable relationship type, the latter stores the multilingual types. These tables should not be modified.

Example:

```
	SELECT PARENT.Context,ANCESTOR.Context,H.* FROM DENORM_HD_HIERARCHY_XXXX H
	LEFT JOIN DENORM_HD_RELATIONSHIP_CTX PARENT ON
H.fkParentRelationshipContext=PARENT.PKID
	LEFT JOIN DENORM_HD_RELATIONSHIP_CTX ANCESTOR ON
H.fkParentRelationshipContext=ANCESTOR.PKID
WHERE H.fkAncestor='<AncestorPKID>'
```

Column	Data type	Description
PKID	Number	Identifier
Context	Varchar	Relationship context unique name
MaxLevelLimit	Number	Indicate the max allowable level under current relationship type
IsAlternate	Bool	IsAlternate flag

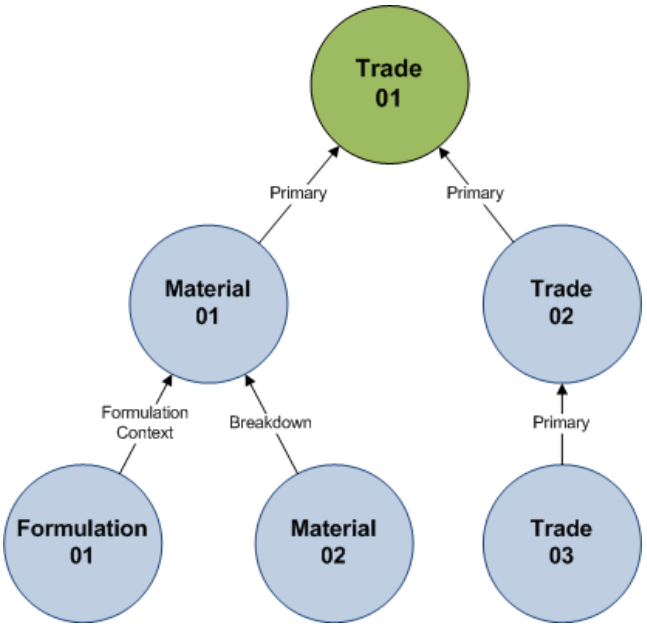
And Table "DENORM_HD_RELATIONSHIP_CTX_ML" is the corresponding translations. Link it for multi-language support.

Column	Data type	Description
PKID	Number	Relationship context identifier
LangID	Number	Language ID. 0: English
Context	Varchar	Relationship context translation.

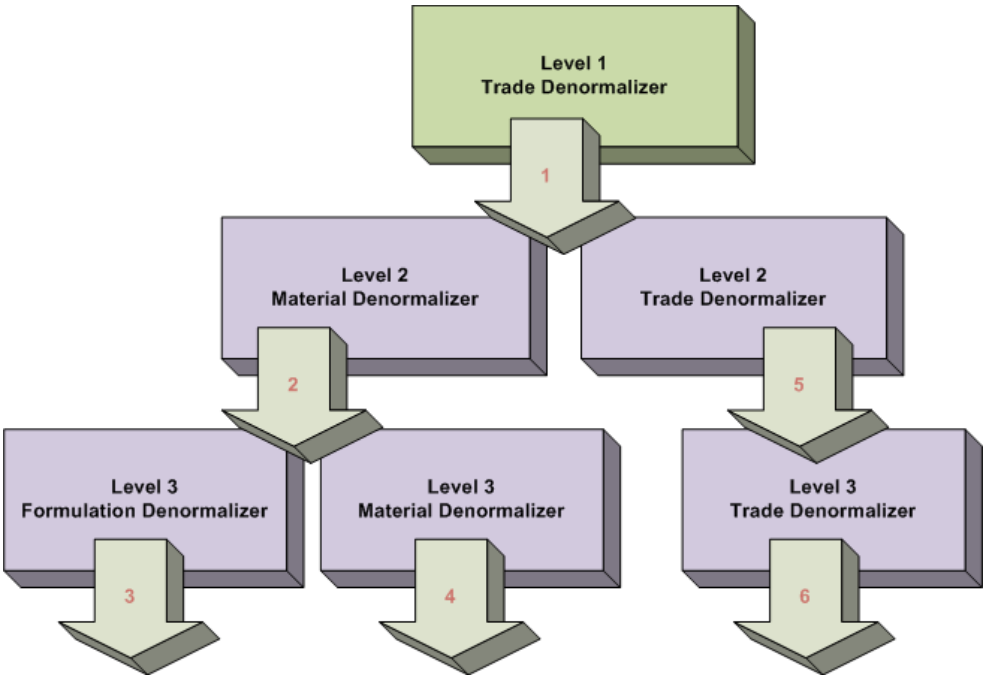
Denormalization Processor

The processor is a background service running in RemotingContainer. The responsibility of this process is to orchestrate the execution of the denormalizers. Each denormalizer is responsible for updating one level of the hierarchy, so the generation of the complete hierarchy will take many denormalizers.

For example, this is an expected tree:



For example, in order to denormalize the above hierarchy, a denormalizer would be executed for each node, according to spec type. The sequence of execution would be similar to the below diagram.



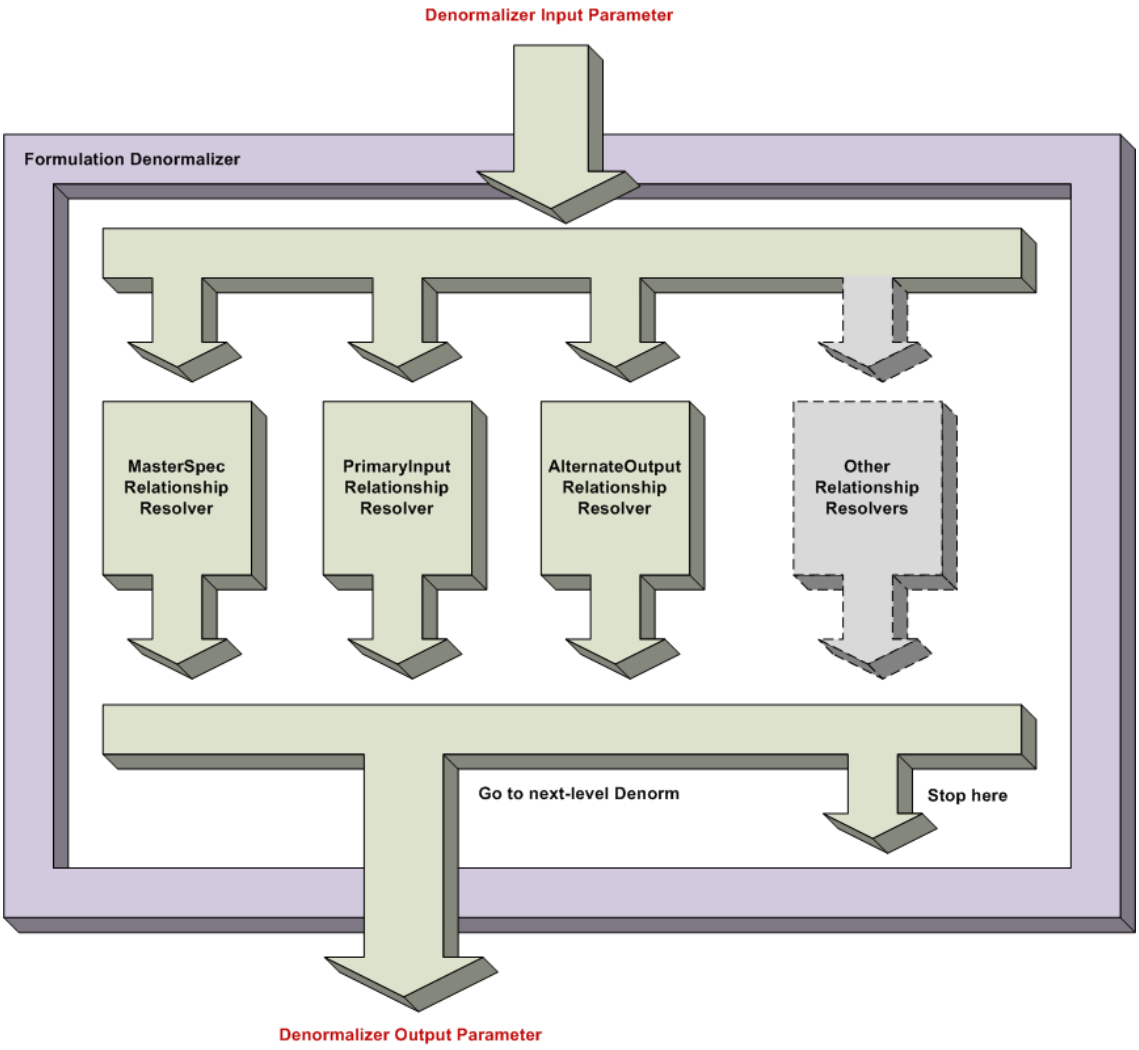
Each denormalizer contains multiple child processes called relationship-resolvers, which are responsible for updating the relationships specific to an object type. For instance if a formulation specification contains a master specification, primary Inputs and an alternate output, within the Formulation Denormalizer, three relationship-resolvers will be executed; the Master Specification relationship-resolver will update the relationships to the master specification, the Primary Input relationship-resolver will update the relationships to the primary inputs and so on.

Customers wanting to add new types of relationships to the denormalized output can add their own relationship resolvers with the runtime context parameters given by the relationship resolver interface.

The input parameter of denormalizer is taking the denormalization context transferred from the previous denormalizer. It includes the parent PKID, the relationship context, some referenced resource entries, and so on. These data ensures the denormalizer finish its work as designed.

Similarly, the output parameter is taking the specific denormalization context that should be transferred to the next denormalizer. Actually, a parent output parameter can be rapidly converted to a child input parameter directly.

This is depicted in the below diagram.



Finally, every denormalizer and its related relationship-resolvers are configurable. The corresponding configuration node for the above FormulationDenormalizer is:

```
<Denormalizer type="5816"
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDGSMLib.Denormalizers.FormulationD
enormalizer,HDGSMLib" dataTable="DENORM_HD_HIERARCHY_GSM">

      <Relationships configChildKey="id">

        <Relationship id="ComMasterSpec"
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDGSMLib.DescendentRelationships.Co
mMasterSpec,HDGSMLib$ExplicitMaster"/>

        <Relationship id="FrmInput"
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDGSMLib.DescendentRelationships.Fr
mInput,HDGSMLib$Input"/>

        <Relationship id="FrmAlternateOutput"
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDGSMLib.DescendentRelationships.Fr
mAlternateOutput,HDGSMLib$AlternateOutput"/>

        <Relationship … />

      </Relationships>
```

```
    </Denormalizer>
```

You can find the full official mappings in the configuration file located in the following path "<PLM for Process>\config\Extensions\HierarchyDenormConfig.xml".

Attention: Each relationship-resolver ObjectURL is taking an additional parameter separated by "$" character. That means this relationship-resolver is binding with a "Relationship Context" so that the resolver's outputs can also take the context as its "ParentRelationshipContext" property. Please refer to Relationship Context Definitions section.

Supported Relationships that are Denormalized in GSM

Object (Parent)	Related Object (Child)	Relationship	Resolver Name in HDGSMLib
Trade	Trade Specifications	Primary	TrdNextLowerLevelItems
	Primary Packaging Specifications	Primary	TrdPackagingMaterials
	Alternate Packaging Specifications	Alternate	TrdAlternatePackaging
	Material	Primary	TrdRelatedMaterial
	Formulation that produces associated Material	FormulationContext	MatFormulationContext
	Breakdown Materials of the associated Material	BreakdownComponent	ComBreakdown
	Nutrient Profiles	Primary	ComNutrientProfile
	Sourcing Approval	Primary	ComSourcingApproval
	Associated Specs	Associated	ComAssociatedSpec
	Activities	PrimaryActivity	ComActivities
	Master Specs	ExplicitMaster	ComMasterSpec
Formulation	Materials	Input, Output	FrmInput, FrmOutput
	Alternate Materials	Alternate, AlternateOutput	FrmAlternateInput, FrmAlternateOutput
	Packaging	Input	FrmInput
	Alternate Packaging	Alternate	FrmAlternateInput
	Formulation context	FormulationContext, AlternateFormulationContext	MatFormulationContext, MatAlternateFormulationContext
	Associated Specs	Associated	ComAssociatedSpec
	Activities	PrimaryActivity	ComActivities
	Master Specs	ExplicitMaster	ComMasterSpec
Menu	Product/Menu	Primary	MenuMenuItemBuild
	Packaging	Primary	MenuPackagingMaterial
	Alternate Pkg	Alternate	MenuAlternatePackaging
	Global/Regional Standard	-	-

Object (Parent)	Related Object (Child)	Relationship	Resolver Name in HDGSMLib
	Alternate Standards	AlternateStandards	ComAlternateStandards
	Nutrient Profile	Primary	ComNutrientProfile
	Associated Specs	Associated	ComAssociatedSpec
	Activities	PrimaryActivity	ComActivities
	Master Specs	ExplicitMaster	ComMasterSpec
Product	Breakdown Materials	BreakdownComponent	ComBreakdown
	Global/Regional Standard	-	-
	Alternate Starndards	AlternateStandards	ComAlternateStandards
	Packing config	Primary	ComPackingConfigurationSpec
	Sourcing Approval	Primary	ComSourcingApproval
	Associated Specs	Associated	ComAssociatedSpec
	Activities	PrimaryActivity	ComActivities
	Master Specs	ExplicitMaster	ComMasterSpec
Material	Breakdown Materials	BreakdownComponent	ComBreakdown
	Substitute Material	Substitute	ComSubstituteMaterial
	Packing config	Primary	ComPackingConfigurationSpec
	Produced By Formulation	Primary	MatProducedBy
	LIO Profile	-	-
	Sourcing Approval	Primary	ComSourcingApproval
	Associated Specs	Associated	ComAssociatedSpec
	Activities	PrimaryActivity	ComActivities
	Master Specs	ExplicitMaster	ComMasterSpec
Packaging	Sub Components	SubComponent	PkgSubComponents
	Packing Config	Primary	ComPackingConfigurationSpec
	Equipment	Primary	PkgEquipmentSpec
	Substitute Material	Substitute	ComSubstituteMaterial
	Sourcing Approval	Primary	ComSourcingApproval
	Associated Specs	Associated	ComAssociatedSpec
	Activities	PrimaryActivity	ComActivities
	Master Specs	ExplicitMaster	ComMasterSpec
Equipment	Sub Components	SubComponent	EquSubComponent
	Sourcing Approval	Primary	ComSourcingApproval
	Associated Specs	Associated	ComAssociatedSpec
	Activities	PrimaryActivity	ComActivities
	Master Specs	ExplicitMaster	ComMasterSpec
Delivered Material	Labeling	Primary	DmatLabelingSpec
	Associated Specs	Associated	ComAssociatedSpec

Object (Parent)	Related Object (Child)	Relationship	Resolver Name in HDGSMLib
	Activities	PrimaryActivity	ComActivities
Packing Config	Delivered Material	Primary	PcfgDeliveredMaterialPackingSpec
	Associated Specs	Associated	ComAssociatedSpec
	Activities	PrimaryActivity	ComActivities
Labeling	Associated Specs	Associated	ComAssociatedSpec
	Activities	PrimaryActivity	ComActivities

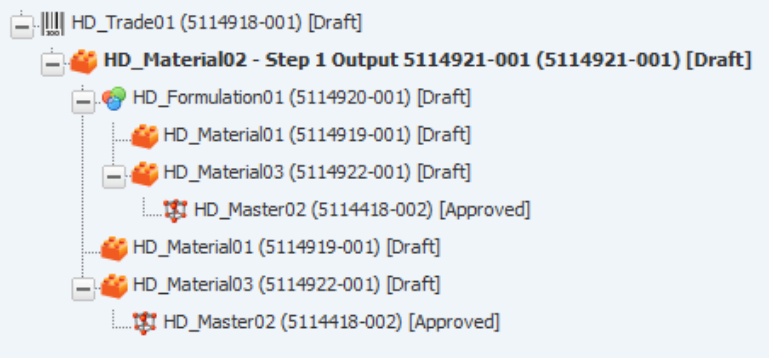
Supported Relationships that are Denormalized in SCRM

Object (Parent)	Related Object (Child)	Relationship	Resolver Name in HDSCRMLib
Company	Company	Primary	CompChildCompany
	Facility	Primary	CompFacility
Facility	Sourcing Approval	Primary	FacNonSAC, FacSAC
Sourcing Approval	Specification	Primary	SACSpec
	Facility	Primary	ComReceivingFacility
Non Sourcing Approval	Facility	Primary	ComReceivingFacility

Understanding the Hierarchy Denormalization Data Model

All hierarchies will be stored in the denormalized table, with each node represented by one row. Each row will contain information such as a reference to the parent object, level in the hierarchy and the type of relationship. These nodes are tied together by a column, fkAncestor, - that references the relative top node of the hierarchy. By using this column as the query criteria all the nodes for a specific hierarchy can be returned.

For Example:



Retrieve the single tree with this script:

```
select * from DENORM_HD_HIERARCHY_GSM
where fkAncestor='21475f5fc62c-1ccb-4067-80f8-4f5810806fb5';
```

And following is the sample data table from above script:

PKID	fkAncestor	fkDescendent	fkDescendentParent	CurrentLevel	fkParentRelationshipContext
2	21475f5fc62c-1ccb-4067-80f8-4f5810806fb5	21475f5fc62c-1ccb-4067-80f8-4f5810806fb5		0	1
3	21475f5fc62c-1ccb-4067-80f8-4f5810806fb5	10044dd5a3b8-0bae-4c93-b711-ecaf8f7b4e6a	21475f5fc62c-1ccb-4067-80f8-4f5810806fb5	1	6
4	21475f5fc62c-1ccb-4067-80f8-4f5810806fb5	10044209f6dc-05d8-4c82-9e11-a54a7bb443c5	10044dd5a3b8-0bae-4c93-b711-ecaf8f7b4e6a	2	14
5	21475f5fc62c-1ccb-4067-80f8-4f5810806fb5	100499340adc-87ec-4fd2-adf6-7c93718e5568	10044dd5a3b8-0bae-4c93-b711-ecaf8f7b4e6a	2	14
6	21475f5fc62c-1ccb-4067-80f8-4f5810806fb5	581603d28db4-0ce2-4b13-be70-ae22f6480079	10044dd5a3b8-0bae-4c93-b711-ecaf8f7b4e6a	2	13
7	21475f5fc62c-1ccb-4067-80f8-4f5810806fb5	1005a6fd6f82-31a9-4ad2-92da-332c504b5f80	10044209f6dc-05d8-4c82-9e11-a54a7bb443c5	3	8
8	21475f5fc62c-1ccb-4067-80f8-4f5810806fb5	10044209f6dc-05d8-4c82-9e11-a54a7bb443c5	581603d28db4-0ce2-4b13-be70-ae22f6480079	3	9
9	21475f5fc62c-1ccb-4067-80f8-4f5810806fb5	100499340adc-87ec-4fd2-adf6-7c93718e5568	581603d28db4-0ce2-4b13-be70-ae22f6480079	3	9
10	21475f5fc62c-1ccb-4067-80f8-4f5810806fb5	1005a6fd6f82-31a9-4ad2-92da-332c504b5f80	10044209f6dc-05d8-4c82-9e11-a54a7bb443c5	4	8

fkAncestorRelationshipContext	ObjectType	fkObjectSubType	fkObjectSubTypeEx	fkRelationshipIdentifier	BoxLft	BoxRgt
1	2147				1	18
6	1004	2210083d0660-b2a6-4256-ad98-3d3dcc2d5d43		5826d5ba6106-6df9-4f97-8dab-8c59a0ed48c3	2	17
6	1004	2210e2704850-c6e1-4c3f-8bd4-7e11bbe862b0		101323a10b8c-45d8-4eb8-8dbf-9f09d138ae24	3	6
6	1004	2210e2704850-c6e1-4c3f-8bd4-7e11bbe862b0		1013fa756721-35a9-4f34-9f68-4a1319b3be7b	7	8
6	5816			5826d5ba6106-6df9-4f97-8dab-8c59a0ed48c3	9	16
6	1005			104058d05bf4-afbe-40ef-bb7e-373aa23217b1	4	5
6	1004	2210e2704850-c6e1-4c3f-8bd4-7e11bbe862b0		5817c375fbf5-b990-42ba-8d7b-b10bfc917303	10	13
6	1004	2210e2704850-c6e1-4c3f-8bd4-7e11bbe862b0		5817d503e570-aa02-4f60-9b58-e67bf550bb1a	14	15
6	1005			104058d05bf4-afbe-40ef-bb7e-373aa23217b1	11	12

The structure definition of the table is shown in below. The current node's primary key is stored in the fkDescendent column.

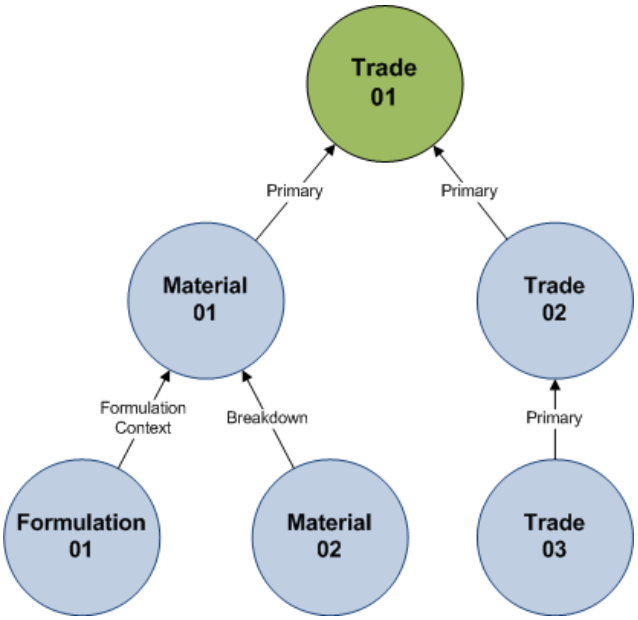
Column	Data type	Description
PKID	Number	Primary key
fkAncestor	Char	PKID of the top node of the hierarchy.

Column	Data type	Description
fkDescendent	Char	PKID of the object for the current node of the hierarchy.
fkDescendentParent	Char	PKID of the parent object of the current node.
CurrentLevel	Number	Level of the hierarchy for the current node. Top node is 0, first level down is 1 and so on.
fkParentRelationshipContext	Number	The relationship type between current node and its parent node. (Refer to "Relationship Context Definitions")
fkAncestorRelationshipContext	Number	The relationship type between current node and the ancestor node. (Refer to Relationship Context Definitions).
ObjectType	Number	The 4 digit object type ID of current node.
fkObjectSubType	Char	The first item type ID for current node if it is a Trade, a Material or a Packaging.
fkObjectSubTypeEx	Char	The second item type ID for current node if it is a Material.
fkRelationshipIdentifier	Char	This is the row PKID when a node exists as one row within in a collection. For example when multiple Materials exist within a Formula as BOM items, this represents the ID that can be tied back to retrieve more row detail such as Quantitiy.
LastEdit	Datetime	Last edit date of the object represented by this node.
Remark	Varchar	(For internal use).
MaxLevel	Number	(For internal use). Indicate the max allowable level for current node's children.
ContextOwner	Char	(For internal use). Keep the formulation context from parent denormalizer.
BoxLft	Number	Nested-set mode LEFT value. Help to identify the tree branch.
BoxRgt	Number	Nested-set model RIGHT value. Help to identify the tree branch.

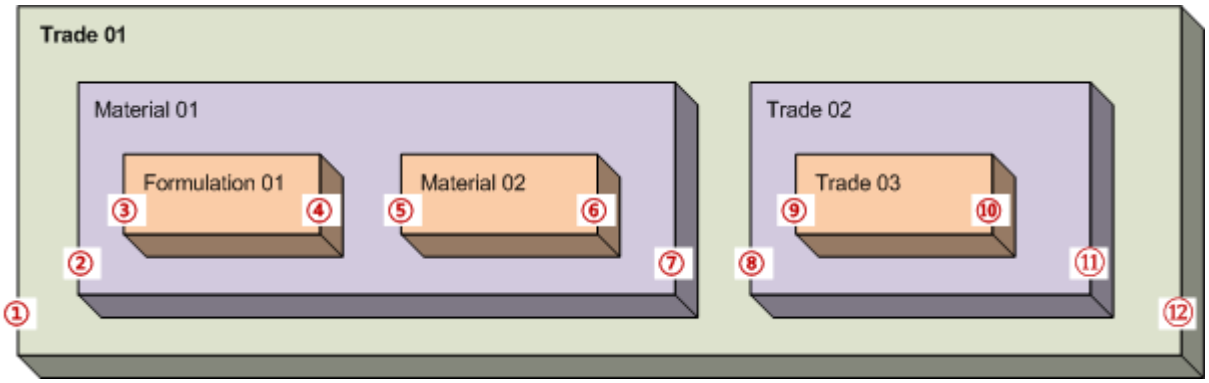
Denormalization Results under Nested-Set Model

The nested-set model is a high efficient model for storing hierarchical data or trees. A metaphor used to describe this model is that each parent node is a box, and all its children are also boxes inside the parent box. For hierarchies greater than two levels there will be boxes inside of boxes. Each box will have 2 numbers, one for each side, box-left and box-right. These numbers facilitate the retrieval and

reconstruction of the hierarchy. The solution guarantees that each box will have two serial numbers (Box-Left and Box-Right). They help to identify each node and facilitate thee retrieval of all parents or all children nodes for a selected node. Example:



The visual nested-set model of the picture is like below:



And this is the corresponding data table:

Object	Level	BoxLft	BoxRgt
Trade 01	0	1	12
Material 01	1	2	7
Formulation 01	2	3	4
Material 02	2	5	6
Trade 02	1	8	11
Trade 03	2	9	10

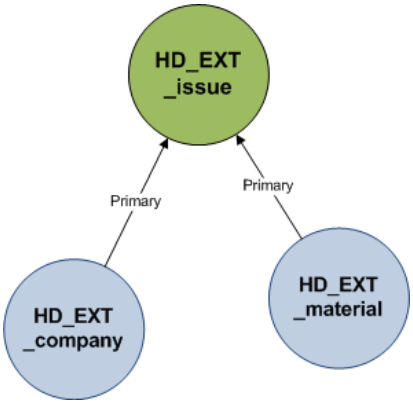
As above shown, those unique numbers (BoxLft and BoxRgt) could help to search or traverse the whole result tree. Assuming there is a node named “X”. Here are some tips:

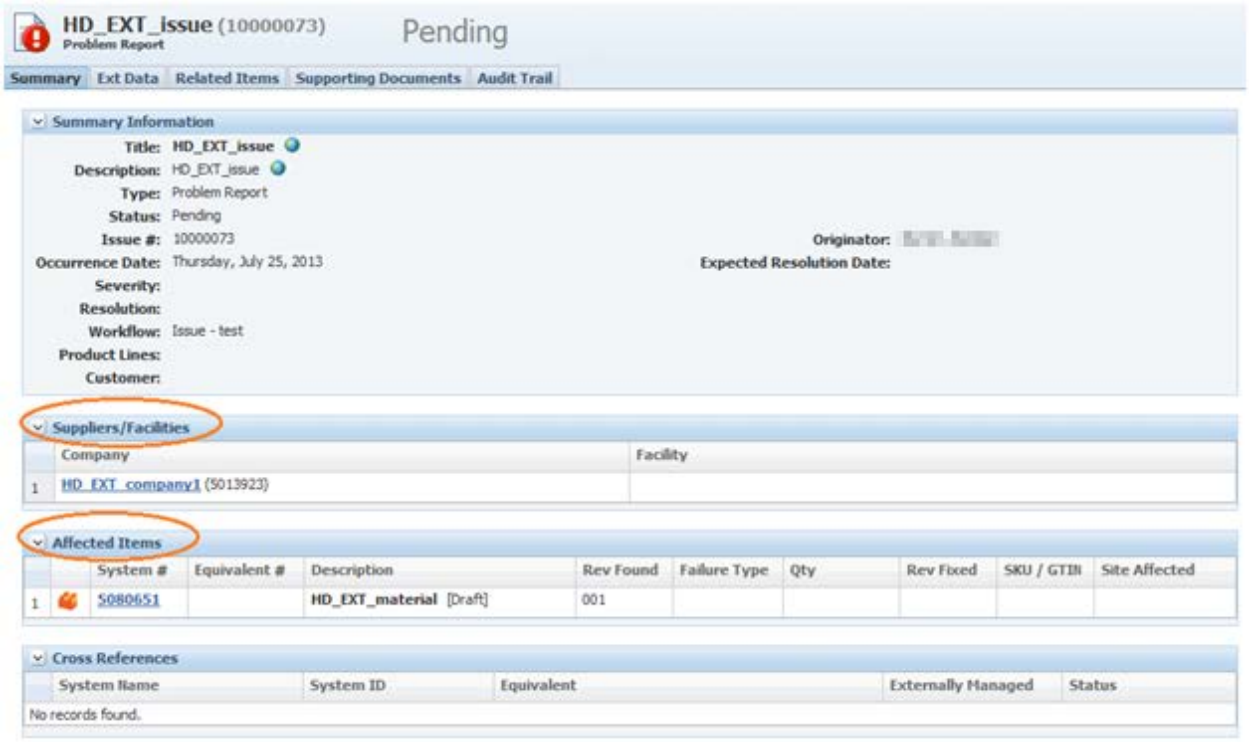
a) When “X.BoxRgt – X.BoxLft == 1”, it must be a leaf node.
b) If “{NODE}.BoxLft < X.BoxLft && {NODE}.BoxRgt > X.BoxRgt”, {NODE} must be X’s parent.
c) If “{NODE}.BoxLft > X.BoxLft && {NODE}.BoxRgt < X.BoxRgt”, {NODE} must be X’s child.
d) With b) and c), it’s convenient to get the direct parent, the direct children or the whole branch members in the tree as well.

Extensibility References

Below is a complete implementation of how to extend Hierarchy Denormalization by identifying a new relationship to denormalized, creating a Detector to determine when a relationship has changed and create a request for processing and creating a Denormalizer which will process the request by adding the appropriate data in the denormalization table.

In this example we will use the PQM Issue relationship with its supplier and affected items (material specification).



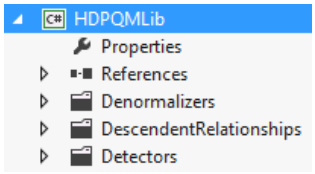


Implementation Example

1. Create Visual Studio Project

   Open Visual Studio 2010 (or above version) and create a class library.

   For this example it is called “HDPQMLib” under .NET Framework 3.5. Normally, it’s strongly recommended to create sub-directories for better organization.



2. Create Detector

   Create a Detector for PQM Issue object so that the Denormalization service would know if an Issue has been changed for any reason.

   The “PQMIssueDetector” is responsibility to detect the edit event in the UI and deliver the related object PKID(s) to Denormalization request queue.

   To add the item to the queue it is possible to use a SQL insert statement to write to the “DENORM_HD_REQUEST” table directly or by using pre-defined HierarchyDenormRequest data object.

   Below is an example of the SQL solution.

```
namespace Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDPQMLib.Detectors
{
    public class PQMIssueDetector : DetectorBase
    {
        private const string DETECTOR_SQL = @"insert into DENORM_HD_REQUEST (PKID, fkSpec)
            select NEWID(), a.SpecPKID
            from
                (
                select distinct fkaffectedObject SpecPKID
                from {0}
                where eventType in (1,2,4) and eventSource in ('PQM.Editor'))
                    and timestamp >= {1} and timestamp < {2}
                ) a
            ";

        [ContainsDynamicSQL]
        public override void Process(DetectorCheckpoint c)
        {
            var sql = string.Format(DETECTOR_SQL, EnumMetaClassInfo.LifecycleEventDO.TableName,
                FormatDateTimeValue(c.LastRunDate), FormatDateTimeValue(c.Now));
            var i = executeNonQuery(sql);
        }
    }
}
```

   The most critical point is the new Detector must inherit from “Oracle.PLM4P.SolutionPack.HierarchyDenorm.DetectorService.DetectorBase” and implement the “Process” method. The delivery work should be done in the designated method.

   In this case, the Detector makes a scan on the “commonLifecycleEventLog” table in which many events are captured and then inserts the appropriate PKIDs in the “DENORM_HD_REQUEST” table.To help understand the “CommonLifecycleEventLog” better, below are some of the details of what this table captures.

Action Category	eventType	eventSource
Create	1	GSM.CreateFromTemplate
	1	GSM.Editor
	1	GSM.SmartIssue
	1	SCRM.Clone
Update	2	GSM.Editor
	2	GSM.GlobalSuccession
	2	GSM.Workflow.Resolve
	2	SCRM.Editor
	2	SCRM.Features.Facility.CompanyChange
	2	SCRM.Workflow.Resolve
Workflow	3	GSM.Workflow.Resolve
	3	GSM.Workflow.Transition
	3	SCRM.Workflow.Resolve
Copy	4	GSM.Clone
	4	GSM.CreateFromTemplate
	4	GSM.NewIssue
	4	GSM.SmartIssue
	4	SCRM.Clone
Get Latest Revision	5	Revision
Substitute	6	GSM.Substitute

Alternatively, the following code shows how to create a request by using the data object.

```
IHierarchyDenormRequest newRequest = new HierarchyDenormRequest("<Target object PKID>");
newRequest.Save();
```

3. Register the Detector

   In order for the RemotingContainer to recognize the new Detector it must be registered properly. To do this, open the "<PLM for Process>\config\Extensions\HierarchyDenormConfig.xml" file with any text editor. Add the following node to the "/HierarchyDenormConfig/Detectors" section.

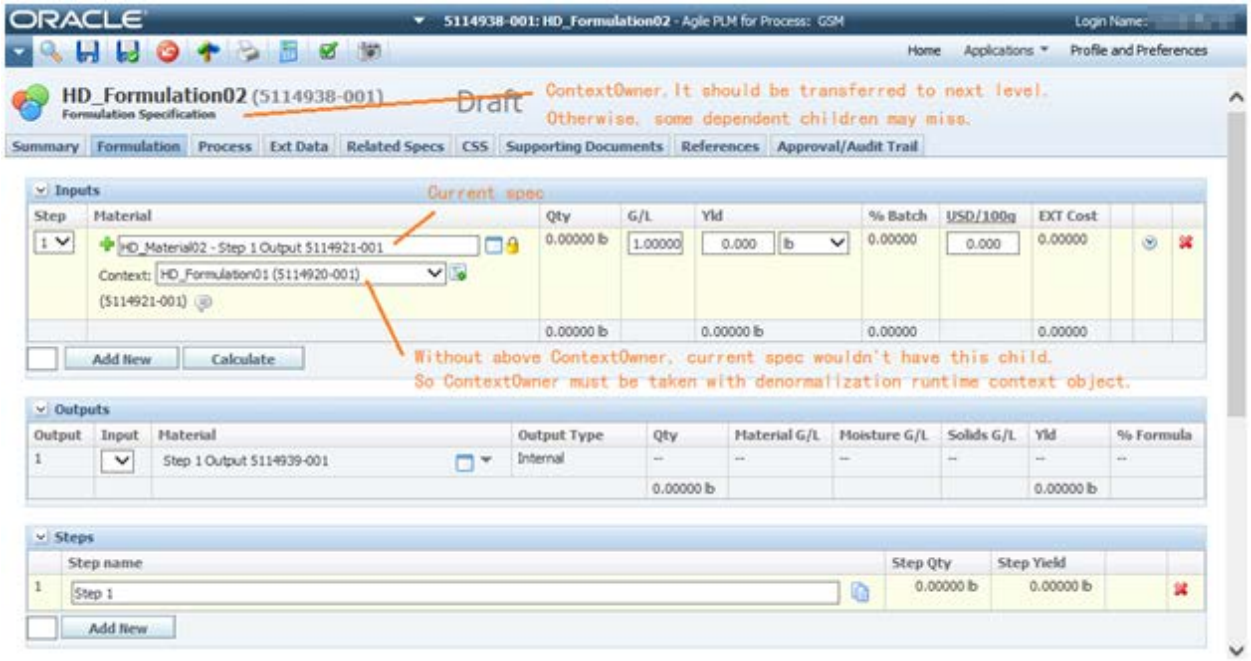
```
<Detector id="PQMIssueDetector"
objectURL="Class:YourCompany.HDPQMLib.Detectors.PQMIssueDetector,HDPQMLib"/>
```

4. Create Denormalizer

   Find the specification type ID for the main object, in this example it is the PQM Issue, 7002. This can be done by querying the "ORClassMetaInfo" table.

```
select * from orclassmetainfo where classname = 'PQMIssueDO'
```

   Normally, there is no need to create a new specific denormalizer for each object type. Use "Oracle.PLM4P.SolutionPack.HierarchyDenorm.ProcessorService.DenormalizerBase" instead if the current target object doesn't have to overwrite some denormalization runtime Context.
   In current release version, only FormulationSpecification uses this feature. This screenshot helps to explain the concept.



As a result, this configuration node should be added to "/HierarchyDenormConfig/Denormalizers" section.

```
<Denormalizer type="7002"
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.ProcessorService.DenormalizerBase,H
ierarchyDenormProcessorService" dataTable="DENORM_HD_HIERARCHY_PQM">
     <Relationships configChildKey="id">
     </Relationships>
</Denormalizer>
```

Please note the marked "dataTable" property here. This property determines the repository of the data generated by this Denormalizer. The direct table name should be given there; however, the user must ensure the target data table exists. If not, use following scripts to create a new repository for the new customized denormalization.

```
-- SQL Server
IF EXISTS(SELECT 1 FROM INFORMATION_SCHEMA.TABLES WHERE TABLE_NAME = 'DENORM_HD_HIERARCHY_PQM')
       DROP TABLE DENORM_HD_HIERARCHY_PQM
GO
CREATE TABLE DENORM_HD_HIERARCHY_PQM(
       PKID int NOT NULL,
       fkAncestor char(40) NOT NULL,
       fkDescendent char(40) NOT NULL,
       fkDescendentParent char(40) NULL,
       CurrentLevel int NOT NULL,
       fkParentRelationshipContext int NOT NULL,
       fkAncestorRelationshipContext int NOT NULL,
```

```
	ObjectType int NOT NULL,
	fkObjectSubType char(40) NULL,
	fkObjectSubTypeEx char(40) NULL,
	fkRelationshipIdentifier char(40) NULL,
	LastEdit datetime NOT NULL CONSTRAINT DF_DENORM_HD_HIERARCHY_PQM_LastEdit  DEFAULT
(getdate()),
	Remark nvarchar(512) NULL,
	MaxLevel int NOT NULL,
	ContextOwner char(40) NULL,
	BoxLft int NOT NULL,
	BoxRgt int NOT NULL,
	CONSTRAINT PK_DENORM_HD_HIERARCHY_PQM PRIMARY KEY CLUSTERED
	(
		PKID ASC
	)
)
GO


-- Oracle
DECLARE cnt NUMBER;
BEGIN
  cnt:=0;
  Select count(*) into cnt from user_tables where table_name =
upper('DENORM_HD_HIERARCHY_PQM');
  If(cnt>0) then
      execute immediate ('DROP TABLE DENORM_HD_HIERARCHY_PQM');
  End if;
  execute immediate ('
    CREATE TABLE DENORM_HD_HIERARCHY_PQM(
	PKID number(10,0) NOT NULL,
	fkAncestor char(40) NOT NULL,
	fkDescendent char(40) NOT NULL,
	fkDescendentParent char(40) NULL,
	CurrentLevel number(10,0) NOT NULL,
	fkParentRelationshipContext number(10,0) NOT NULL,
	fkAncestorRelationshipContext number(10,0) NOT NULL,
	ObjectType number(10,0) NOT NULL,
	fkObjectSubType char(40) NULL,
	fkObjectSubTypeEx char(40) NULL,
	fkRelationshipIdentifier char(40) NULL,
```

```
        LastEdit timestamp DEFAULT CURRENT_TIMESTAMP,
        Remark nvarchar2(512) NULL,
        MaxLevel number(10,0) NOT NULL,
        ContextOwner char(40) NULL,
        BoxLft number(10,0) NOT NULL,
        BoxRgt number(10,0) NOT NULL,
        CONSTRAINT PK_DENORM_HD_HIERARCHY_PQM PRIMARY KEY
        (
                PKID
        )
    )
  ');
END;
```

5. Create Relationship Resolvers

   Next create two relationship resolvers for “Suppliers” and “AffectedItems”.

   This will be similar to the Detector development. The user should create two classes named “IssueAffectedItem” and “IssueSupplier” under the DescendentRelationships directory of the project. Both of them must inherit from “Oracle.PLM4P.SolutionPack.HierarchyDenorm.ProcessorService.DescendentRelationshipBase” and implement the “GetDescendents” method. In the implementation of the method, with the input parameter (packaging the denormalization context of current scenario), “IssueAffectedItem” resolver should retrieve the AffectedItem relationship children of current PQM Issue whose PKID was being assigned in “input.fkDescendentParent”. And “IssueSupplier” resolver should retrieve the Supplier relationship children of current PQM Issue specification whose PKID was being assigned in “input.fkDescendentParent” as well. In fact, the input parameter should have provided whatever the task needs.

   This is the demo code:

```
namespace Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDPQMLib.DescendentRelationships
{
    public class IssueAffectedItem : DescendentRelationshipBase
    {
        public override ICollection<IRelationshipOutput> GetDescendents(IRelationshipInput input)
        {
            var r = new ReferencedObjectPropertyCollectionRetriever(
                input.fkDescendentParent,
                "AffectedItems",
                "ItemInternalID"
            );
            return r.Retrieve();
        }
    }
}
```

```
namespace Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDPQMLib.DescendentRelationships
{
    public class IssueSupplier : DescendentRelationshipBase
    {
        public override ICollection<IRelationshipOutput> GetDescendents(IRelationshipInput input)
        {
            var r = new ReferencedObjectPropertyCollectionRetriever(
                input.fkDescendentParent,
                "PQMSummary.Suppliers",
                "ItemInternalID"
            );
            return r.Retrieve();
        }
    }
}
```

The solution relies on the reflection feature provided by PLM for Process core. It will be helpful to make a basic understanding of the PLM for Process objects.

Then the object property retrievers provided by this solution pack would help to get the direct PKIDs, and then wrap them as an output for next phase. The actual code is not complex.

6. Register the Resolvers

   The new resolvers should be registered in configuration.

   Add the two nodes to "/HierarchyDenormConfig/Denormalizers/Denormalizer/Relationships" section. Put them under the "7002" one.

```
<Relationship id="ComAffectedItem"
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDPQMLib.DescendentRelationships.IssueAffectedItem,HDPQMLib$PrimaryXApp"/>

<Relationship id="ComCompany"
objectURL="Class:Oracle.PLM4P.SolutionPack.HierarchyDenorm.HDPQMLib.DescendentRelationships.IssueSupplier,HDPQMLib$PrimaryXApp"/>
```

   Meanwhile, the expected relationship context for current resolver will be assigned here. Refer to Relationship Context Definitions for more detail about the additional parameter at the end of "objectURL" value.

7. Create DLL

   Finally, compile the new project to be a DLL file and put it to "<PLM for Process>\RemotingContainer\dependentAssemblies".