

## **Oracle® Fusion Middleware**

Integration Guide for Oracle TopLink with Coherence Grid

11g Release 1 (11.1.1)

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Oracle Fusion Middleware Integration Guide for Oracle TopLink with Coherence Grid, 11g Release 1 (11.1.1)  
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# Preface

Oracle TopLink 11g Release 1 (11.1.1) includes tight integration with Oracle Coherence. This integration, provided through the TopLink Grid feature, blends the standardization and simplicity of application development using the Java Persistence API (JPA) with the scalability and distributed processing power of Oracle Coherence data grid.

## Audience

This guide is intended for developers who build applications using JPA and want to use the power of the data grid for improved scalability and performance.

## Documentation Accessibility

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## Related Documents

For more information about Oracle Coherence and Oracle TopLink, see the following:

- *Oracle Fusion Middleware Developer's Guide for Oracle TopLink*
- *Integration Guide for Oracle Coherence*
- *Getting Started for Oracle Coherence*
- *Developers Guide for Oracle Coherence*
- *Client Guide for Oracle Coherence*
- *Tutorial for Oracle Coherence*
- *User's Guide for Oracle Coherence\*Web*

## Conventions

The following text conventions are used in this guide:

<b>Convention</b>	<b>Meaning</b>
<b>boldface</b>	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
<i>italic</i>	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.
monospace	Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.

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# Introduction to Toplink Grid with Oracle Coherence

Oracle TopLink 11g Release 1 (11.1.1) enables you to scale out JPA applications using Oracle Coherence. TopLink Grid provides applications with a number of options on how they can scale, ranging from using Coherence as a distributed shared (L2) cache up to directing JP QL queries to Coherence for parallel execution across the grid to reduce database load. With TopLink Grid, you do not have to rewrite your applications to scale out. You can use your investment in JPA, and still take advantage of the scalability of Coherence.

TopLink Grid provides the following benefits:

- Simple application configuration using annotations or XML configurations that align with standard JPA.
- The ability to store complex object graphs with relationships in Coherence.
- The ability to selectively choose which entities are stored in the grid and which are stored directly in the backing database.
- Allows you to execute JP QL queries in the Grid or directly against the database.
- Allows you to store entities with both eager and lazy relationships into Coherence.

This document describes how to:

- Configure TopLink Grid to use the Coherence data grid as the primary data store for entities
- Use Coherence as a distributed shared cache
- Employ Coherence parallel processing to perform Java Persistence Query Language (JPQL) queries on cached entities
- Use the cache store and cache loader interfaces, which have been optimized for EclipseLink JPA, in Coherence applications that run on the grid

This chapter contains the following sections:

- [Understanding TopLink Grid Integration](#)
- [Entity Caching](#)
- [Reading and Querying Coherence Caches](#)
- [Writing Entities to the Database](#)

## Understanding TopLink Grid Integration

TopLink Grid integrates the TopLink JPA implementation (EclipseLink) with Oracle Coherence and provides two development approaches:

- You can use the Coherence API with caches backed by TopLink Grid to access relational data with special cache loader and cache store interfaces which have been implemented for JPA.

In this traditional Coherence approach, TopLink Grid provides the `CacheLoader` and `CacheStore` implementations in the `oracle.eclipselink.coherence.standalone` package that are optimized for EclipseLink JPA. This technique is described in the *Integration Guide for Oracle Coherence*.

- You can build applications using JPA and transparently use the power of the data grid for improved scalability and performance.

In this *JPA on the Grid* approach, TopLink Grid provides a set of cache and query configuration options that allow you to control how EclipseLink JPA uses Coherence. These implementations reside in the `oracle.eclipselink.coherence.integrated` package. See [Chapter 2, "JPA on the Grid Configurations"](#) for more information.

- You can build applications with the EclipseLink Native Object Relational Mapping (ORM) framework to take advantage of extended capabilities such as advanced database-specific capabilities, and performance tuning and management options.

The Native ORM approach is very similar to *JPA on the Grid*, however, it does not use annotations to configure how the cache is used. Instead, this approach employs an *amendment method* that defines the appropriate cache behavior. See [Chapter 3, "EclipseLink Native ORM Configurations"](#) for more information.

When integrating JPA applications with the Coherence data grid, note the potential benefits and restrictions. You must understand how the grid works and how it relates to your JPA configurations to realize the full potential.

See the following sections for information about TopLink Grid configuration options:

- [Entity Caching](#)
- [Reading and Querying Coherence Caches](#)
- [Writing Entities to the Database](#)

## Entity Caching

By default, EclipseLink provides an `EntityManagerFactory` managed shared entity cache. This shared cache improves performance for multithreaded and Java EE server hosted applications running in a single JVM.

With TopLink Grid, you can replace the default EclipseLink shared (L2) cache with Oracle Coherence. This is known as *Grid Cache* configuration: the base configuration for TopLink Grid. This configuration applies the Coherence data grid to JPA applications that rely on database hosted data that cannot be entirely pre-loaded into a Coherence cache. You can define very large, shared grid caches that span cluster nodes. You do not have to add special configuration to ensure individual shared caches are coordinated. By defining a Grid Cache configuration for an entity in Coherence, all `EntityManager.find()` calls for that entity will result in a `get` call on the associated Coherence cache. If the Coherence cache does not contain the object, then the database is queried.

See "[Grid Cache Configuration](#)" on page 2-3 for more information.

## Reading and Querying Coherence Caches

In addition to Grid Cache configuration, you can configure TopLink Grid to direct *read* queries to Coherence. By configuring a TopLink JPA cache loader, even when there is no cache hit, the object can be read from the database and then placed in the cache, thereby making it available for subsequent queries. By managing very large numbers of objects, Coherence increases the likelihood of a cache hit, because read operations in one cluster member immediately make the object available to other members.

While using Coherence to spread an entity cache across the grid is useful, support for nonprimary key queries is especially beneficial. When you configure an entity in a *Grid Read* configuration, all *read* operations are directed to Coherence. JPQL queries are automatically translated into Coherence Filters and objects that match the filter are retrieved from the grid. Coherence executes all filters in parallel on each member of a cluster. This results in significantly faster processing for a query, compared to if all the objects resided in a single member. See "[Grid Read Configuration](#)" on page 2-7 for more information.

Because filters apply only to objects in the Coherence cache, the configuration of a cache store or cache loader has no impact on ad hoc query processing. By default, queries are not executed against the database with this configuration. However, you can override this behavior by using the `oracle.eclipselink.coherence.integrated.querying.IgnoreDefaultRedirector` class to issue query hints. For example, the following hint directs the query to the database instead of to the Coherence cache:

```
query.setHint(QueryHints.QUERY_REDIRECTOR, new IgnoreDefaultRedirector());
```

For information about using EclipseLink JPA query hints, see the EclipseLink documentation at this URL:

```
http://wiki.eclipse.org/Using\_EclipseLink\_JPA\_Extensions\_\(ELUG\)#How\_to\_Use\_EclipseLink\_JPA\_Query\_Hints
```

## Writing Entities to the Database

Another key configuration option is specifying how to write entities to the database. You can configure EclipseLink to do either of the following:

- Directly write entities to the database, then put them in Coherence (so that it reflects the database state). See "[Writing Objects in Grid Cache Configuration](#)" on page 2-4 and "[Writing Objects in Grid Read Configuration](#)" on page 2-8 for more information.
- Put entities into Coherence, then have Coherence write to the database using a cache store.

The cache store method, also known as the *Grid Entity* configuration, lets you use the Coherence write-behind feature to enable asynchronous database write operations, which means applications do not have to wait for the database to return in order to proceed.

However, this configuration contains some restrictions, such as the inability to use Java Transaction API (JTA) integration.

See "[Grid Entity Configuration](#)" on page 2-11 for more information.



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## *JPA on the Grid* Configurations

This chapter contains the following sections:

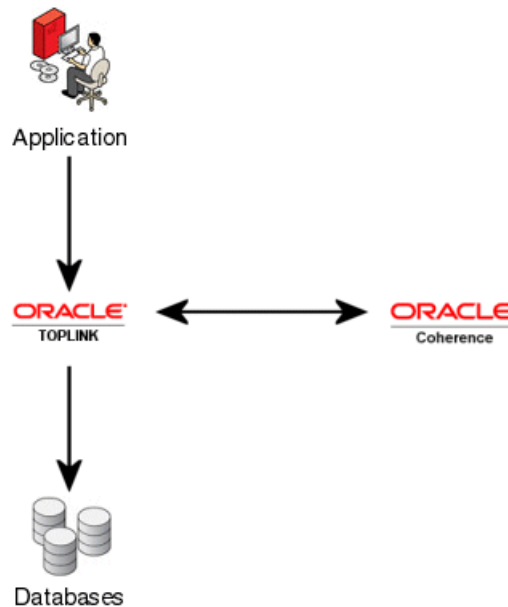
- [Understanding JPA on the Grid](#)
- [JPA on the Grid API](#)
- [Grid Cache Configuration](#)
- [Grid Read Configuration](#)
- [Grid Entity Configuration](#)
- [Handling Grid Read and Grid Entity Failovers](#)
- [Wrapping and Unwrapping Entity Relationships](#)
- [Working with Queries](#)

### Understanding *JPA on the Grid*

The expression *JPA on the Grid* refers to using JPA and the power of the data grid to build applications with improved scalability and performance. In the *JPA on the Grid* approach, TopLink Grid provides a set of cache and query configuration options that allow you to control how EclipseLink JPA uses Coherence.

You can configure Coherence as a distributed shared (L2) cache or use Coherence as the primary data store. You can also configure entities to execute queries in the Coherence data grid instead of the database. This allows clustered application deployments to scale beyond database-bound operations.

[Figure 2-1](#) illustrates the relationship between an application, TopLink, Coherence, and the database.

**Figure 2–1 JPA on the Grid Approach**

## JPA on the Grid API

The API used by *JPA on the Grid* configurations are shipped in the `toplink-grid.jar` file. [Table 2–1](#) lists some of the key classes in the `oracle.eclipselink.coherence.integrated` package that are used in *JPA on the Grid* configurations.

**Table 2–1 TopLink Grid Classes to Build JPA on the Grid Applications**

Class Name	Description
<code>oracle.eclipselink.coherence.integrated.EclipseLinkJPACacheLoader</code>	Provides JPA-aware versions of the Coherence CacheLoader interface.
<code>oracle.eclipselink.coherence.integrated.EclipseLinkJPACacheStore</code>	Provides JPA-aware versions of the Coherence CacheStore interface.
<code>oracle.eclipselink.coherence.integrated.config.CoherenceReadCustomizer</code>	Enables a Coherence read configuration.
<code>oracle.eclipselink.coherence.integrated.config.CoherenceReadWriteCustomizer</code>	Enables a Coherence read/write configuration.
<code>oracle.eclipselink.coherence.integrated.config.GridCacheCustomizer</code>	Enables cache instances to be cached in Coherence instead of in the internal EclipseLink shared cache. All calls to the internal TopLink L2 cache are redirected to Coherence.
<code>oracle.eclipselink.coherence.integrated.querying.IgnoreDefaultRedirector</code>	Allows queries to bypass the Coherence cache and be sent directly to the database.

The configuration also uses the standard JPA run-time configuration file `persistence.xml` and the JPA mapping file `orm.xml`. You must also use the Coherence cache configuration file `coherence-cache-config.xml` to override the default Coherence settings and define the cache store caching scheme.



## Grid Cache Configuration

The Grid Cache configuration can be considered as the base configuration for TopLink Grid. In this configuration, Coherence acts as the TopLink shared (L2) cache. This brings the power of the Coherence data grid to JPA applications that rely on database-hosted data that cannot be entirely preloaded into a Coherence cache. Some reasons why the data might not be able to be preloaded include extremely complex queries that exceed the abilities of Coherence Filters, third-party database updates that create stale caches, and reliance on native SQL queries, stored procedures, or triggers.

By using Coherence as the TopLink Grid cache, you can scale TopLink up into large clusters while avoiding the need to coordinate local shared caches. Updates made to entities are available in all Coherence cluster members immediately, upon committing a transaction.

In general, read and write operations in a Grid Cache configuration have the following characteristics:

- A primary key query will attempt to get entities first from the Coherence cache. If the attempt is unsuccessful, the database will be queried and the Coherence cache will be updated with the query results. See the following section, "[Reading Objects in Grid Cache Configuration](#)".
- A nonprimary key query will be executed against the database and the results will be checked against the Coherence cache. This is to avoid the negative performance impact of constructing entities that are already cached. Newly queried entities are put into the Coherence cache.
- A write operation will update the database and, if successfully committed, will put updated entities into the Coherence cache. See "[Writing Objects in Grid Cache Configuration](#)" on page 2-4.

See "[Grid Cache Configuration Examples](#)" on page 2-5 for detailed examples.

To use Coherence as a distributed cache for an entity, you must enable shared caching in EclipseLink. Shared caching is enabled by default for all entities, but the default can be explicitly set to `true` or `false` by setting the `eclipselink.cache.shared.default` property in the `persistence.xml` file. Specific entities can override the default using the `@Cache` annotation or by specifying the corresponding XML `<cache>` element in the `eclipselink-orm.xml` file. For more information, see:

[http://wiki.eclipse.org/Using\\_EclipseLink\\_JPA\\_Extensions\\_\(ELUG\)#How\\_to\\_Use\\_the\\_.40Cache\\_Annotation](http://wiki.eclipse.org/Using_EclipseLink_JPA_Extensions_(ELUG)#How_to_Use_the_.40Cache_Annotation)

### Reading Objects in Grid Cache Configuration

In the Grid Cache configuration, all read queries are directed to the database *except* primary key queries, which are directed to the Coherence cache first. Any cache misses will result in a database query.

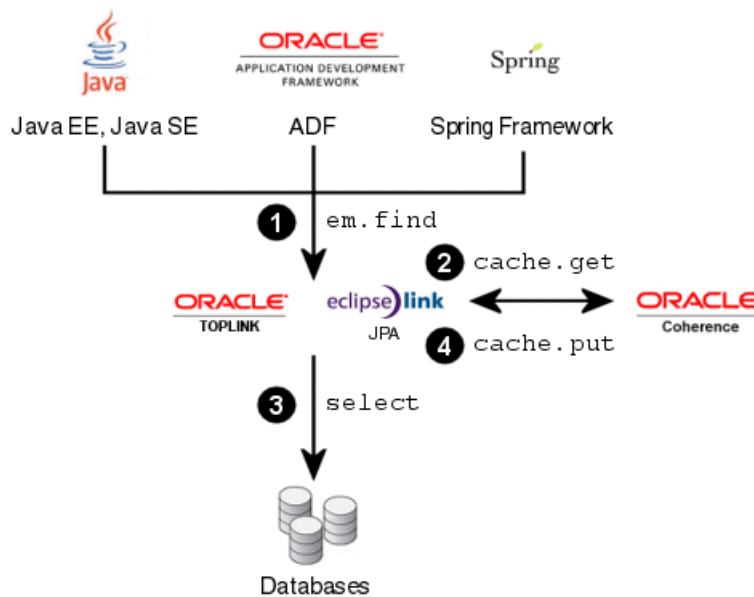
All entities queried from the database are placed in the Coherence cache. This makes the entities immediately available to all members of the cluster. This is valuable because, by default, TopLink uses the cache to avoid constructing new entities from database results.

For each row resulting from a query, TopLink uses the primary key of the result row to query the corresponding entity from the cache. If the cache contains the entity then the entity is used and a new entity is not built. This approach can greatly improve application performance, especially with a warmed cache, because it reduces the cost of a query by eliminating the cost associated with object building.

Figure 2–2 illustrates the path of a read query in the Grid Cache configuration:

1. The application issues a `find` query.
2. For primary key queries, TopLink queries the Coherence cache first.
3. If the object does not exist in the Coherence cache, TopLink queries the database.  
For all read queries *except primary key queries*, TopLink queries the database first.
4. Read objects are `put` into the Coherence cache.

Figure 2–2 Reading Objects in Grid Cache Configuration



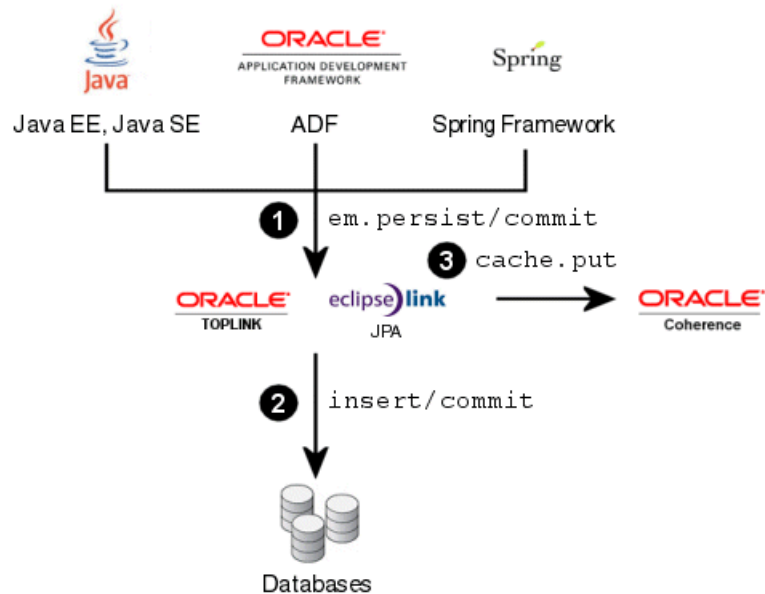
## Writing Objects in Grid Cache Configuration

In the Grid Cache configuration, TopLink performs all database write operations (insert, update, delete). The Coherence cache is then updated to reflect the changes made to the database. TopLink offers a number of performance features when writing large amounts of data including batch writing, parameter binding, stored procedure support, and statement ordering to ensure that database constraints are satisfied.

Figure 2–3 illustrates the path for writing and persisting objects in the Grid Cache configuration:

1. The application issues a `commit` query.
2. TopLink updates the database.
3. After a successful transaction, TopLink updates the Coherence cache.

**Figure 2–3 Writing and Persisting Objects in grid Cache Configuration**



## Grid Cache Configuration Examples

You can obtain the code in these examples at the following URL:

[https://toplinkgrid-examples.samplecode.oracle.com/source/browse/\\*checkout\\*/toplinkgrid-examples/trunk/downloads/TLG%20JPA%20Example-Grid%20Cache.zip](https://toplinkgrid-examples.samplecode.oracle.com/source/browse/*checkout*/toplinkgrid-examples/trunk/downloads/TLG%20JPA%20Example-Grid%20Cache.zip)

### Configuring the Cache for the Grid Cache Configuration

The cache configuration file (`coherence-cache-config.xml`) in [Example 2–1](#) defines the cache and configures a wrapper serializer to support serialization of relationships.

#### Example 2–1 Configuring the Cache in Grid Cache Configuration

```
<cache-config>
  <caching-scheme-mapping>
    <cache-mapping>
      <cache-name>*</cache-name>
      <scheme-name>eclipselink-distributed</scheme-name>
    </cache-mapping>
  </caching-scheme-mapping>
  <caching-schemes>
    <distributed-scheme>
      <scheme-name>eclipselink-distributed</scheme-name>
      <service-name>EclipseLinkJPA</service-name>
      <!--
        Configure a wrapper serializer to support serialization of relationships.
      -->
      <serializer>
        <class-name>oracle.eclipselink.coherence.integrated.cache.
WrapperSerializer</class-name>
      </serializer>
    </distributed-scheme>
  </caching-schemes>
</cache-config>
```

```

    <backing-map-scheme>
    <!--
      Backing map scheme with no eviction policy.
    -->
    <local-scheme>
      <scheme-name>unlimited-backing-map</scheme-name>
    </local-scheme>
  </backing-map-scheme>
</backing-map-scheme>
  <autostart>true</autostart>
</distributed-scheme>
</caching-schemes>
</cache-config>

```

### Configuring an Entity for the Grid Cache Configuration

To configure an entity to use Grid Cache, use the `@Customizer` annotation and the `GridCacheCustomizer` class as shown in [Example 2–2](#). This class intercepts all `TopLink` calls to the internal `TopLink` Grid cache and redirects them to the Coherence cache.

#### Example 2–2 Configuring the Entity in Grid Cache Configuration

```

import oracle.eclipselink.coherence.integrated.config.GridCacheCustomizer;
import org.eclipse.persistence.annotations.Customizer;

@Entity
@Customizer(GridCacheCustomizer.class)
public class Employee {
  ...

```

### Inserting Objects for the Grid Cache Configuration

In [Example 2–3](#), `TopLink` performs the insert to create a new employee. Entities are persisted through the `EntityManager` and placed in the database. After a successful transaction, the Coherence cache is updated.

#### Example 2–3 Inserting Objects in Grid Cache Configuration

```

EntityManagerFactory emf = Persistence.createEntityManagerFactory("employee-pu");

// Create an employee with an address and telephone number.
EntityManager em = emf.createEntityManager();
em.getTransaction().begin();
Employee employee = createEmployee();
em.persist(employee);
em.getTransaction().commit();
em.close();

```

### Querying Objects for the Grid Cache Configuration

In [Example 2–4](#), the named JPQL query is directed to the database. Query results are resolved against the Coherence cache to avoid the cost of building objects that have previously been cached.

#### Example 2–4 Querying Objects in Grid Cache Configuration

```

EntityManagerFactory emf = Persistence.createEntityManagerFactory("employee-pu");

EntityManager em = emf.createEntityManager();
List<Employee> employees = em.createQuery("select e from Employee e where e.

```

```

lastName = :lastName").setParameter("lastName", "Smith").getResultList();

for (Employee employee : employees) {
    System.err.println(employee);
    for (PhoneNumber phone : employee.getPhoneNumbers()) {
        System.err.println("\t" + phone);
    }
}

emf.close();

```

## Grid Read Configuration

Use the Grid Read configuration for entities that require fast access to large amounts of (fairly stable) data and write changes synchronously to the database. For these entities, cache warming would typically be used to populate the Coherence cache, but individual queries could be directed to the database if necessary.

In general, read and write operations in a Grid Read configuration have the following characteristics:

- Read operations get objects from the Coherence cache. Configuring a cache loader has no impact on JPQL queries. See the next section, "[Reading Objects in Grid Read Configuration](#)".
- Write operations update the database and, if successfully committed, updated entities are put into the Coherence cache. See "[Writing Objects in Grid Read Configuration](#)" on page 2-8.

See "[Grid Read Configuration Examples](#)" on page 2-9 for detailed examples.

## Reading Objects in Grid Read Configuration

In the Grid Read configuration, all primary key and non-primary key queries are directed to the Coherence cache. To reduce query processing time, TopLink Grid supports parallel processing of queries across the data grid. Coherence contains data already in object form, avoiding the performance impact of database communication and object construction.

With the Grid Read configuration, if Coherence does not contain the entity requested by the `find(...)` method, then `null` is returned. However, if a cache loader is configured for the entity's cache, Coherence will attempt to load the object from the database. This is true only for primary key queries.

Configuring a cache loader has no impact on JPQL queries translated to Coherence filters. When searching with a filter, Coherence will operate *only* on the set of entities in the caches; the database will not be queried. However, it is possible to direct a query, on a query-by-query basis, to the database instead of to Coherence by using the `oracle.eclipselink.coherence.integrated.querying.IgnoreDefaultRedirector` class, as shown in following example:

```
query.setHint(QueryHints.QUERY_REDIRECTOR, new IgnoreDefaultRedirector());
```

Any objects retrieved by a database query will be added to the Coherence cache so that they are available for subsequent queries. Because this configuration resolves all queries for an entity through Coherence by default, the Coherence cache should be warmed with all of the data that is to be queried.

In the Grid Read configuration, projection queries (reports) that extract data from a single entity type will also be directed to Coherence. For example, the following JPQL

query will return the first and last names of all employees contained in the Coherence cache.

```
select e.firstName, e.lastName from Employee e
```

This type of query is useful when the entire entity is not required, for example when populating a drop-down list in a user interface.

A cache store is not compatible with the Grid Read configuration because the EclipseLink JPA will perform all database updates and then propagate the updated objects into Coherence. If you use a cache store, Coherence will attempt to write the objects again.

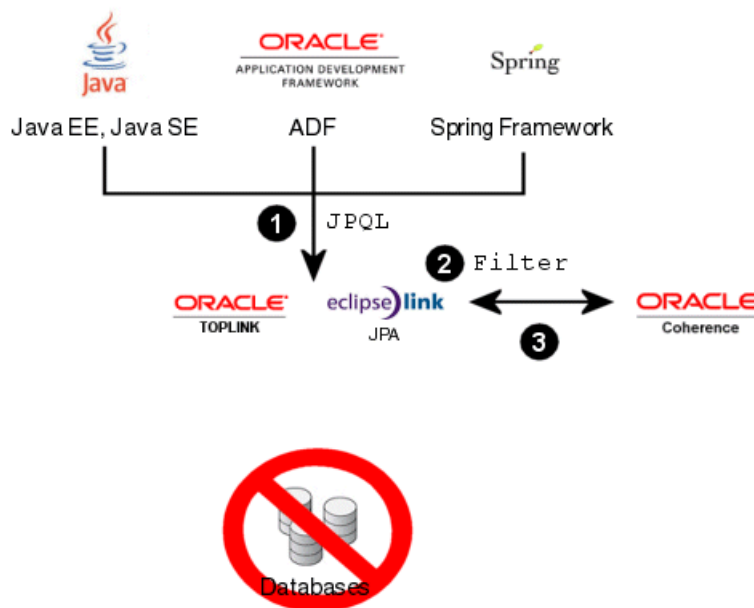
For complete information on using EclipseLink JPA query hints, see the EclipseLink documentation at this URL:

[http://wiki.eclipse.org/Using\\_EclipseLink\\_JPA\\_Extensions\\_\(ELUG\)#How\\_to\\_Use\\_EclipseLink\\_JPA\\_Query\\_Hints](http://wiki.eclipse.org/Using_EclipseLink_JPA_Extensions_(ELUG)#How_to_Use_EclipseLink_JPA_Query_Hints)

Figure 2–4 illustrates the path for a query in the Grid Read configuration:

1. The application issues a JPQL query.
2. TopLink executes a Filter on the Coherence cache.
3. TopLink returns results from the Coherence cache only; the database is not queried.

**Figure 2–4 Reading Objects with a Query**



## Writing Objects in Grid Read Configuration

In the Grid Read configuration, TopLink performs all database write operations (insert, update, delete) directly. The Coherence caches are then updated to reflect the changes made to the database. TopLink offers a number of performance features when writing large amounts of data. These include batch writing, parameter binding, stored

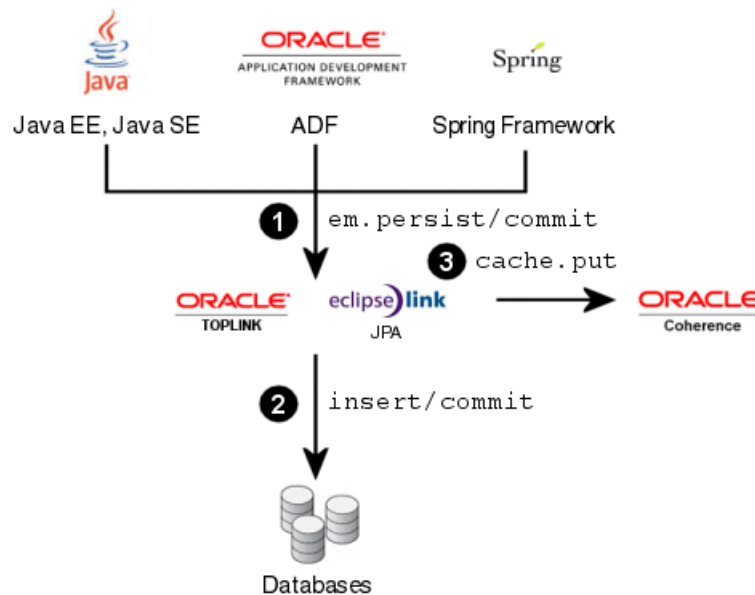
procedure support, and statement ordering to ensure that database constraints are satisfied.

This approach offers the best possibilities: database updates are performed efficiently *and* queries continue to be executed in parallel across the Coherence data grid, with the option of directing individual queries to the database.

Figure 2–5 illustrates the path for writing and persisting objects in the Grid Read configuration:

1. The application issues a `commit` query.
2. TopLink updates the database.
3. After a successful transaction, TopLink updates the Coherence cache.

**Figure 2–5 Writing and Persisting Objects in Grid Read Configuration**



## Grid Read Configuration Examples

You can obtain the code in these examples at the following URL:

[https://toplinkgrid-examples.samplecode.oracle.com/source/browse/\\*checkout\\*/toplinkgrid-examples/trunk/downloads/TLG%20JPA%20Example-Grid%20Read.zip](https://toplinkgrid-examples.samplecode.oracle.com/source/browse/*checkout*/toplinkgrid-examples/trunk/downloads/TLG%20JPA%20Example-Grid%20Read.zip)

### Configuring the Cache in Grid Read Configuration

The cache configuration file (`coherence-cache-config.xml`) in [Example 2–5](#) defines the cache and configures a wrapper serializer to support serialization of relationships. The `oracle.eclipselink.coherence.integrated.EclipseLinkJPACacheLoader` class defines the cache store scheme.

#### **Example 2–5 Configuring the Cache in Grid Read Configuration**

```
<cache-config>
```

```

<caching-scheme-mapping>
  <cache-mapping>
    <cache-name>*</cache-name>
    <scheme-name>eclipselink-distributed-readonly</scheme-name>
  </cache-mapping>
</caching-scheme-mapping>
<caching-schemes>
  <distributed-scheme>
    <scheme-name>eclipselink-distributed-readonly</scheme-name>
    <service-name>EclipseLinkJPAReadOnly</service-name>
    <!--
      Configure a wrapper serializer to support serialization of relationships.
    -->
    <serializer>
      <class-name>oracle.eclipselink.coherence.integrated.cache.
WrapperSerializer</class-name>
    </serializer>
  <backing-map-scheme>
    <read-write-backing-map-scheme>
      <internal-cache-scheme>
        <local-scheme />
      </internal-cache-scheme>
      <!--
        Define the cache scheme.
      -->
      <cachestore-scheme>
        <class-scheme>
          <class-name>oracle.eclipselink.coherence.integrated.
EclipseLinkJPACacheLoader</class-name>
          <init-params>
            <param-type>java.lang.String</param-type>
            <param-value>{cache-name}</param-value>
          </init-param>
          <init-param>
            <param-type>java.lang.String</param-type>
            <param-value>employee-pu</param-value>
          </init-param>
          </init-params>
        </class-scheme>
      </cachestore-scheme>
      <read-only>true</readonly>
    </read-write-backing-map-scheme>
  </backing-map-scheme>
  <autostart>true</autostart>
</distributed-scheme>
</caching-schemes>
</cache-config>

```

## Reading Objects for the Grid Read Configuration

To configure an entity to read through a Coherence cache, use the `@Customizer` annotation and the `CoherenceReadCustomizer` class as shown in [Example 2-6](#):

### Example 2-6 Configuring the Entity in Grid Read Configuration

```

import oracle.eclipselink.coherence.integrated.config.CoherenceReadCustomizer;
import org.eclipse.persistence.annotations.Customizer;

@Entity
@Customizer(CoherenceReadCustomizer.class)

```



```
public class Employee {
    ...
}
```

### Inserting Objects for the Grid Read Configuration

In [Example 2-7](#), TopLink performs an insert to create a new employee. If the transaction is successful, the new object is placed into the Coherence cache under its primary key.

#### *Example 2-7 Inserting Objects in Grid Read Configuration*

```
EntityManagerFactory emf = Persistence.createEntityManagerFactory("employee-pu");
// Create an employee with an address and telephone number
EntityManager em = emf.createEntityManager();
em.getTransaction().begin();
Employee employee = createEmployee();
em.persist(employee);
em.getTransaction().commit();
em.close();

emf.close();
```

### Querying Objects for the Grid Read Configuration

When finding an employee, the read query is directed to the Coherence cache. The JPQL query is translated to Coherence filters, as shown in [Example 2-8](#).

#### *Example 2-8 Querying Objects in Grid Read Configuration*

```
EntityManagerFactory emf = Persistence.createEntityManagerFactory("employee-pu");
EntityManager em = emf.createEntityManager();
List<Employee> employees = em.createQuery("select e from Employee e where e.
lastName = :lastName").setParameter("lastName", "Smith").getResultList();
for (Employee employee : employees) {
    System.err.println(employee);
    for (PhoneNumber phone : employee.getPhoneNumbers()) {
        System.err.println("\t" + phone);
    }
}
emf.close();
```

To retrieve an object from the Coherence cache with a specific ID (key), use the `em.find(Entity.class, ID)` method. You can also configure a Coherence cache loader to query the database to find the object, if the cache does not contain the object with the specified ID.

## Grid Entity Configuration

The Grid Entity configuration should be used by applications that require fast access to large amounts of (fairly stable) data, but perform relatively few updates. This configuration can be combined with a Coherence cache store using write-behind to improve application response time by performing database updates asynchronously.

In general, read and write operations in a Grid Entity configuration have the following characteristics:

- Read operations get objects from the Coherence cache. See ["Reading Objects in Grid Entity Configuration"](#) on page 2-12.

- Write operations put objects into the Coherence cache. If a cache store is configured, TopLink also performs write operations on the database. See ["Writing Objects in Grid Entity Configuration"](#) on page 2-12.

See ["Grid Entity Configuration Examples"](#) on page 2-13 for detailed examples.

## Reading Objects in Grid Entity Configuration

In the Grid Entity configuration, querying objects is identical to the Grid Read configuration. See ["Reading Objects in Grid Cache Configuration"](#) on page 2-3 for more information.

## Writing Objects in Grid Entity Configuration

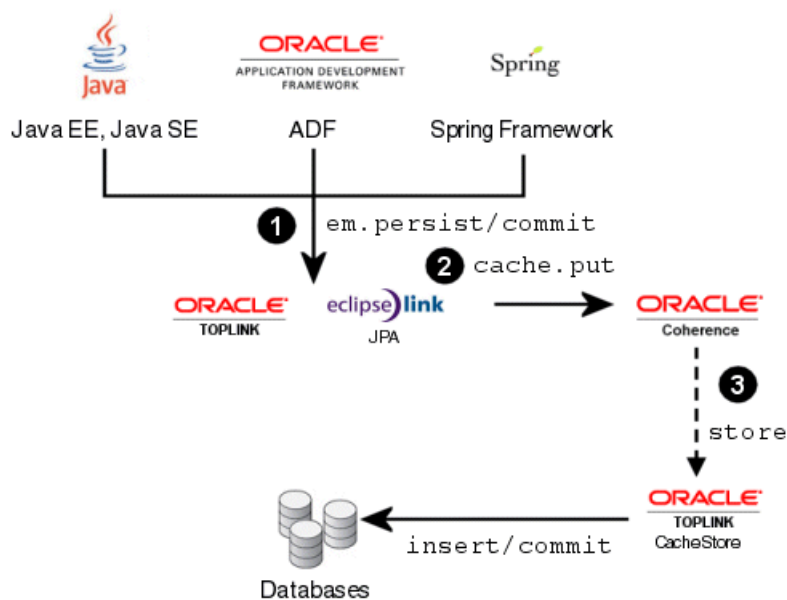
In the Grid Entity configuration, all objects that are persisted, updated, or merged through an `EntityManager` instance will be put in the appropriate Coherence cache. To persist objects in a Coherence cache to the database, an EclipseLink JPA cache store (`oracle.eclipselink.coherence.integrated.EclipseLinkJPACacheStore`) must be configured for each cache.

You can also configure the cache store to use write-behind to asynchronously batch-write updated objects. See *Coherence Developer's Guide* for more information.

[Figure 2-6](#) illustrates the path for writing and persisting objects in the Grid Entity configuration.

- The application issues a `commit` call.
- TopLink directs all queries to update the Coherence cache.
- By configuring a Coherence cache store (optional), TopLink will also update the database.

**Figure 2-6 Writing and Persisting Objects in Grid Entity Configuration**



## Limitations on Writing Objects in Grid Entity Configuration

When using a cache store, Coherence assumes that all write operations succeed and will not inform TopLink of a failure. This could result in the Coherence cache differing from the database. You cannot use optimistic locking to protect against data corruption that may occur if the database is concurrently modified by Coherence and a third-party application.

Because the order in which Coherence cache members write updates to the database is unpredictable, referential integrity cannot be guaranteed. Referential integrity constraints must be removed from the database. If they are not, write operations could fail with the following error:

```
org.eclipse.persistence.exceptions.DatabaseException
Internal Exception: java.sql.BatchUpdateException: ORA-02292: integrity constraint
violated - child record found
Error Code: 2292
```

## Grid Entity Configuration Examples

You can obtain the code in these examples at the following URL:

[https://toplinkgrid-examples.samplecode.oracle.com/source/browse/\\*checkout\\*/toplinkgrid-examples/trunk/downloads/TLG%20JPA%20Example-Grid%20Entity.zip](https://toplinkgrid-examples.samplecode.oracle.com/source/browse/*checkout*/toplinkgrid-examples/trunk/downloads/TLG%20JPA%20Example-Grid%20Entity.zip)

### Configuring the Cache for the Grid Entity Configuration

The cache configuration file (`coherence-cache-config.xml`) in [Example 2-9](#) configures a wrapper serializer to support serialization of relationships. The `oracle.eclipselink.coherence.integrated.EclipseLinkJPACacheStore` class defines the cache store scheme.

#### *Example 2-9 Configuring the Cache in Grid Entity Configuration*

```
<cache-config>
  <caching-scheme-mapping>
    <cache-mapping>
      <cache-name>*/</cache-name>
      <scheme-name>eclipselink-distributed-readwrite</scheme-name>
    </cache-mapping>
  </caching-scheme-mapping>
  <caching-schemes>
    <distributed-scheme>
      <scheme-name>eclipselink-distributed-readwrite</scheme-name>
      <service-name>EclipseLinkJPACacheStore</service-name>
      <!--
        Configure a wrapper serializer to support serialization of relationships.
      -->
      <serializer>
        <class-name>oracle.eclipselink.coherence.integrated.cache.
WrapperSerializer</class-name>
      </serializer>
    </distributed-scheme>
    <backing-map-scheme>
      <read-write-backing-map-scheme>
        <internal-cache-scheme>
          <local-scheme />
        </internal-cache-scheme>
      <!--
        Define the cache scheme
      -->
```

```

    <cachestore-scheme>
      <class-scheme>
        <class-name>oracle.eclipselink.coherence.integrated.
EclipseLinkJPACacheStore</class-name>
        <init-params>
          <init-param>
            <param-type>java.lang.String</param-type>
            <param-value>{cache-name}</param-value>
          </init-param>
          <init-param>
            <param-type>java.lang.String</param-type>
            <param-value>employee-pu</param-value>
          </init-param>
        </init-params>
      </class-scheme>
    </cachestore-scheme>
  </read-write-backing-map-scheme>
</backing-map-scheme>
<autostart>true</autostart>
</distributed-scheme>
</caching-schemes>
</cache-config>

```

## Configuring an Entity for the Grid Entity Configuration

To configure an entity to read through Coherence, use the `@Customizer` annotation and the `CoherenceReadWriteCustomizer` class as shown [Example 2-10](#):

### Example 2-10 Configuring an Entity in Grid Entity Configuration

```

import oracle.eclipselink.coherence.integrated.config.
CoherenceReadWriteCustomizer;
import org.eclipse.persistence.annotations.Customizer;

@Entity
@Customizer(CoherenceReadWriteCustomizer.class)
public class Employee {
    ...
}

```

## Persisting Objects for the Grid Entity Configuration

In [Example 2-11](#), TopLink performs the insert to create a new employee. Entities persist through the `EntityManager` instance and are placed in the appropriate Coherence cache.

### Example 2-11 Persisting Objects in Grid Entity Configuration

```

EntityManagerFactory emf = Persistence.createEntityManagerFactory("employee-pu");

// Create an employee with an address and telephone number.
EntityManager em = emf.createEntityManager();
em.getTransaction().begin();
Employee employee = createEmployee();
em.persist(employee);
em.getTransaction().commit();
em.close();

```

## Querying Objects for the Grid Entity Configuration

When finding an employee, the read query is directed to the Coherence cache, as shown in [Example 2-12](#).

### Example 2-12 Querying Objects in Grid Entity Configuration

```
EntityManagerFactory emf = Persistence.createEntityManagerFactory("employee-pu");

EntityManager em = emf.createEntityManager();
List<Employee> employees = em.createQuery("select e from Employee e where e.
lastName = :lastName").setParameter("lastName", "Smith").getResultList();

for (Employee employee : employees) {
    System.err.println(employee);
    for (PhoneNumber phone : employee.getPhoneNumbers()) {
        System.err.println("\t" + phone);
    }
}

emf.close();
```

To get an object from the Coherence cache with a specific ID (key), use the `em.find(Entity.class, ID)` method. You can also configure a Coherence cache store to query the database to find the object, if the cache does not contain the object with the specified ID.

## Handling Grid Read and Grid Entity Failovers

In the Grid Read and Grid Entity configurations, TopLink Grid will attempt to translate JPQL queries into Coherence Filters and execute the query in the grid. However some queries cannot be translated into filters. When TopLink Grid encounters such a query, it automatically fails over to the database to execute the query. In TopLink, you can specify a user-defined translation failure delegate object that will be called if the JPQL-to-filter translation fails. You configure the translation failure delegate by declaring the `eclipselink.coherence.query.translation-failure-delegate` persistence unit property. For example:

```
<property name="eclipselink.coherence.query.translation-failure-delegate"
value="org.example.ExceptionFailoverPolicy"/>
```

A translation failure delegate must implement `oracle.eclipselink.coherence.integrated.querying.TranslationFailureDelegate` class which defines the single method `translationFailed(DatabaseQuery query, Record arguments, Session session)`.

## Wrapping and Unwrapping Entity Relationships

When storing entities with relationships in the Coherence cache, TopLink Grid generates a wrapper class that maintains the relationship information. In this way, when the object is read from the Coherence cache (eager or lazy), the relationships can be resolved.

If you read entities directly from the Coherence cache using the Coherence API, the wrappers are not automatically removed. You can configure automatic unwrapping programmatically by calling the `setNotEclipseLink(true)` method on the serializer, as shown in [Example 2-13](#). You can also set the system property as `eclipselink.coherence.not-eclipselink` to automatically unwrap an entity.

When configured properly, a cache `get` operation will return the unwrapped entity.

**Example 2–13 Unwrapping an Entity**

```
WrapperSerializer wrapperSerializer = (WrapperSerializer)myCache.  
getCacheService().getSerializer();  
wrapperSerializer.setNotEclipseLink(true); // So the Serializer will unwrap an  
Entity when clients use a get() call from the cache.
```

## Working with Queries

This section includes information on the following topics:

- [Querying Objects by ID](#)
- [Querying Objects with Criteria](#)
- [Using Indexes in Queries](#)
- [Limitations on Queries](#)

### Querying Objects by ID

To get an entity from the Coherence cache with a specific ID (key), use the `em.find(Entity.class, ID)` method. For example, the following code will get the entity with key 8, from the Coherence `Employee` cache.

```
em.find(Employee.class, 8)
```

If the entity is not found in the Coherence cache, TopLink executes a `SELECT` statement against the database. If a result is found, then the entity is constructed and placed into the Coherence cache. The query's specific behavior will depend on your Coherence cache configuration:

- calling the `find` method with a [Grid Cache Configuration](#) performs a `SELECT` statement against the database on a cache miss and then updates the cache.
- calling the `find` method with a [Grid Read Configuration](#) or a [Grid Entity Configuration](#) performs a `get` operation on the Coherence cache. A cache miss results in a `SELECT` statement against the database by using a `CacheLoader` instance, if it is configured.

### Querying Objects with Criteria

To retrieve an entity that matches a specific selection criterion, use the `em.createQuery("...")` method. The query's specific behavior will depend on your Coherence cache configuration:

- For the [Grid Cache Configuration](#), the query will always execute a `SELECT` statement against the database. For example, the following code will execute a `SELECT` statement to find employees named John.

```
em.createQuery("select e from Employee e where e.name='John'")
```

- For the [Grid Read Configuration](#) and [Grid Entity Configuration](#), the query will be executed against the Coherence cache. If the cache does not contain any entities that match the selection criteria, then nothing will be returned. This is an example of why the cache should be warmed before performing the query.
- For the cache store and cache loader, queries are performed only on primary keys

## Using Indexes in Queries

Indexes allow values (or attributes of those values) and corresponding keys to be correlated within a cache to improve query performance. TopLink Grid allows you to declare indexes with the `@Property` annotation. The `IntegrationProperties` class provides the `INDEXED` property.

In [Example 2-14](#), the `@Property` annotation declares that the `name` attribute is to be indexed. TopLink Grid will define an index for that attribute in the `Publisher` cache.

### **Example 2-14 Exposing a Coherence Query Index to TopLink Grid**

```
import static oracle.eclipselink.coherence.IntegrationProperties.INDEXED;
import oracle.eclipselink.coherence.integrated.config.CoherenceReadCustomizer;

@Customizer(CoherenceReadCustomizer.class)
public class Publisher implements Serializable {
    ...
    @Property(name=INDEXED, value="true")
    private String name;
    ...
}
```

With an index in place, you can issue a JPQL query, such as the following, to return all the `Publishers` in the cache with a name beginning with `S`.

```
SELECT Publisher p WHERE p.name like 'S%'
```

Internally, Coherence will process the query by consulting the name index to find matches rather than by deserializing and examining every `Publisher` object stored in the grid. By avoiding deserialization, you achieve a significant positive improvement on query execution time, eliminate garbage collection of the temporarily deserialized objects, and reduce CPU usage.

## Limitations on Queries

The following are limitations on querying Coherence caches:

- Because the Coherence Filter framework is limited to a single cache, JPQL `join` queries cannot be translated to Filters. All `join` queries will execute on the database.
- This release of TopLink Grid does not provide support for JPQL bulk updates and deletions.





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## EclipseLink Native ORM Configurations

This chapter contains the following sections:

- [Understanding EclipseLink Native ORM](#)
- [API for EclipseLink Native ORM](#)
- [Configuring an Amendment Method](#)
- [Configuring the EclipseLink Native ORM Cache Store and Cache Loader](#)

### Understanding EclipseLink Native ORM

EclipseLink Native Object Relational Mapping (ORM) provides an extensible object-relational mapping framework. It provides high-performance object persistence with extended capabilities configured declaratively through XML. These extended capabilities include caching (including support for clustered caching), advanced database-specific capabilities, and performance tuning and management options.

Like *JPA on the Grid* configurations, applications that employ EclipseLink ORM can access Coherence caches. However, unlike *JPA on the grid* configurations, EclipseLink ORM applications do not use the `@Customizer` annotation to configure how the cache is used. Instead, they typically call an *amendment method* that defines the appropriate cache behavior.

### API for EclipseLink Native ORM

The cache store and cache loader API used in EclipseLink Native ORM configurations are shipped in the `toplink-grid.jar` file. [Table 3-1](#) describes the API for EclipseLink Native ORM. These classes can be found in the `oracle.eclipselink.coherence.integrated` package.

**Table 3-1** *EclipseLink Classes for Native ORM Configurations*

Class Name	Description
<code>EclipseLinkNativeCacheStore(String cacheName, String sessionName)</code>	Coherence cache store that should be used with native EclipseLink configuration ( <code>sessions.xml</code> ).
<code>EclipseLinkNativeCacheLoader(String cacheName, String sessionName)</code>	Coherence cache loader that should be used with native EclipseLink configuration ( <code>sessions.xml</code> ).

**Table 3–1 (Cont.) EclipseLink Classes for Native ORM Configurations**

Class Name	Description
<code>oracle.eclipselink.coherence.integrated.config.CoherenceReadCustomizer</code>	Enables a Coherence read configuration.
<code>oracle.eclipselink.coherence.integrated.config.CoherenceReadWriteCustomizer</code>	Enables a Coherence read/write configuration.
<code>oracle.eclipselink.coherence.integrated.config.GridCacheCustomizer</code>	Enables entity instances to be cached in Coherence instead of in the internal EclipseLink shared cache

Note that the second initialization parameter in the signatures, `sessionName`, represents the name of the mapping project that must be listed in the native EclipseLink configuration file, `META-INF/sessions.xml`.

The `EclipseLinkNativeCacheStore` and `EclipseLinkNativeCacheLoader` classes allow applications that use EclipseLink Native ORM to access Coherence caches. Use these classes when Coherence cache behavior has been configured through an amendment method. These classes can be used to configure a cache store or cache loader for each persistent class in the same way as described in [Chapter 2, "JPA on the Grid Configurations"](#).

Use the Coherence cache configuration file `coherence-cache-config.xml` to define the cache store caching scheme and to override any default Coherence settings.

The configuration uses the native EclipseLink `sessions.xml` file and the `project.xml` file. The `sessions.xml` file, and all of the deployment XML files (which have user-defined names) listed in it, must be available on the classpath or packaged within a JAR file within the `META-INF` directory.

You must also configure an amendment method to define the appropriate cache behavior. See ["Configuring an Amendment Method"](#) for more information.

## Configuring an Amendment Method

An *amendment method* is a method that uses the EclipseLink descriptor API to customize the ORM mapping metadata for a class. The method is called when the descriptor is loaded at runtime. The purpose of the amendment methods provided by TopLink Grid is to define how the Coherence cache is going to be used. Amendment methods are the TopLink native ORM alternative to the `@Customizer` annotation; they produce the same configuration.

The TopLink Grid customizer classes in the `toplink-grid.jar` file (`CoherenceReadCustomizer`, `CoherenceReadWriteCustomizer`, and `GridCacheCustomizer`) provide an `afterLoad` amendment method that can be selected to enable the appropriate Coherence cache behavior.

You can select the amendment method using either JDeveloper or EclipseLink Workbench. How to configure amendment methods in EclipseLink Workbench is beyond the scope of this document. You can find information on this topic in "Amendment and After-Load Methods" at Eclipsepedia:

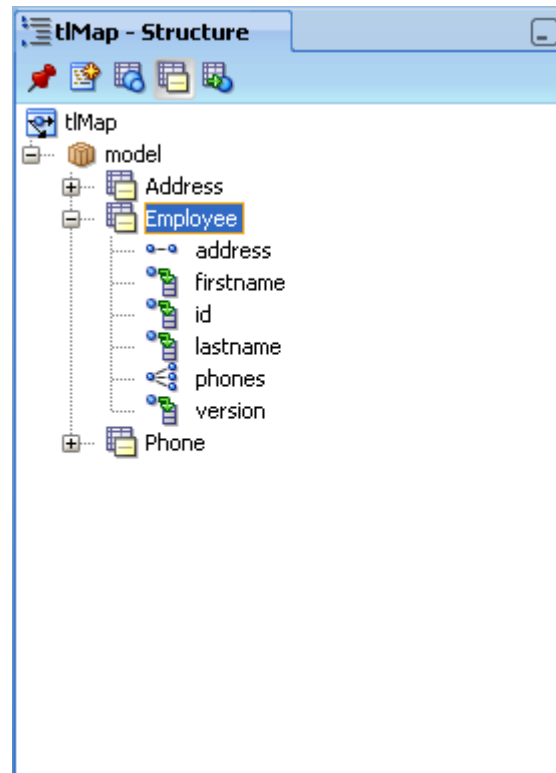
[http://wiki.eclipse.org/Introduction\\_to\\_Descriptors\\_\(ELUG\)#Amendment\\_and\\_After-Load\\_Methods](http://wiki.eclipse.org/Introduction_to_Descriptors_(ELUG)#Amendment_and_After-Load_Methods)

## Configuring the Amendment Method in JDeveloper

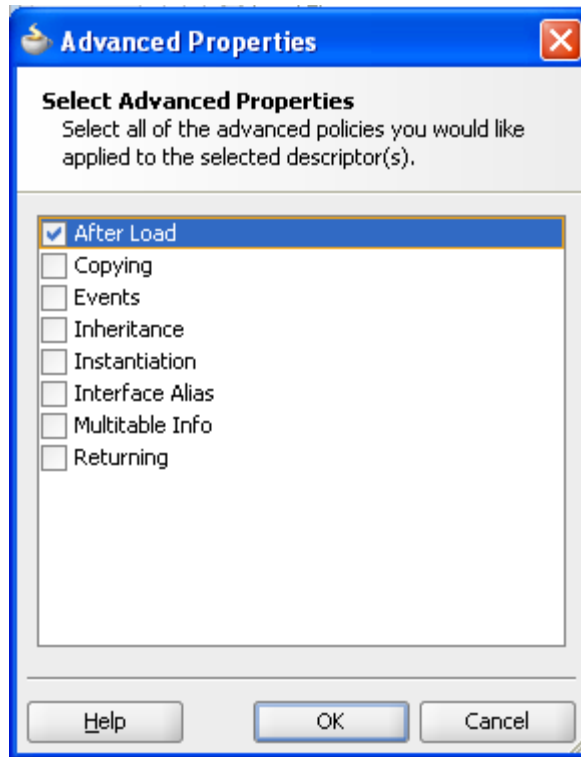
To configure an amendment method:

1. In the JDeveloper Structure pane, expand the desired **tIMap** descriptor name.

**Figure 3-1** *tIMap Descriptors in the JDeveloper Structure Pane*



2. Right-click the desired TopLink descriptor element. Select **Advanced Properties** to open the **Advanced Properties** dialog box. Select the **After Loading** check box and click **OK**.

**Figure 3–2 Advanced Properties Dialog Box**

3. In the **After Load** tab of the **tlMap** configuration window, enter the name of the class containing the `afterLoad` amendment method you want to use for the selected TopLink descriptor. You can also use the class browser to search for the class. [Figure 3–3](#) illustrates the After Load tab of the **tlMap** configuration window.

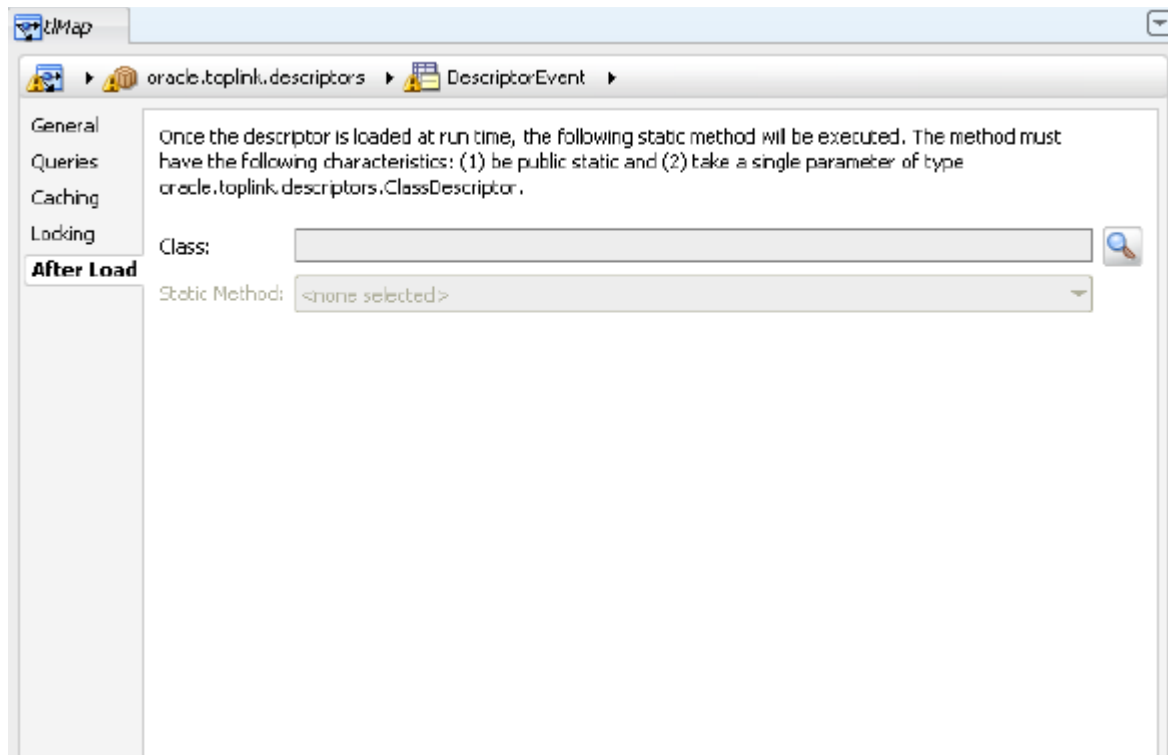
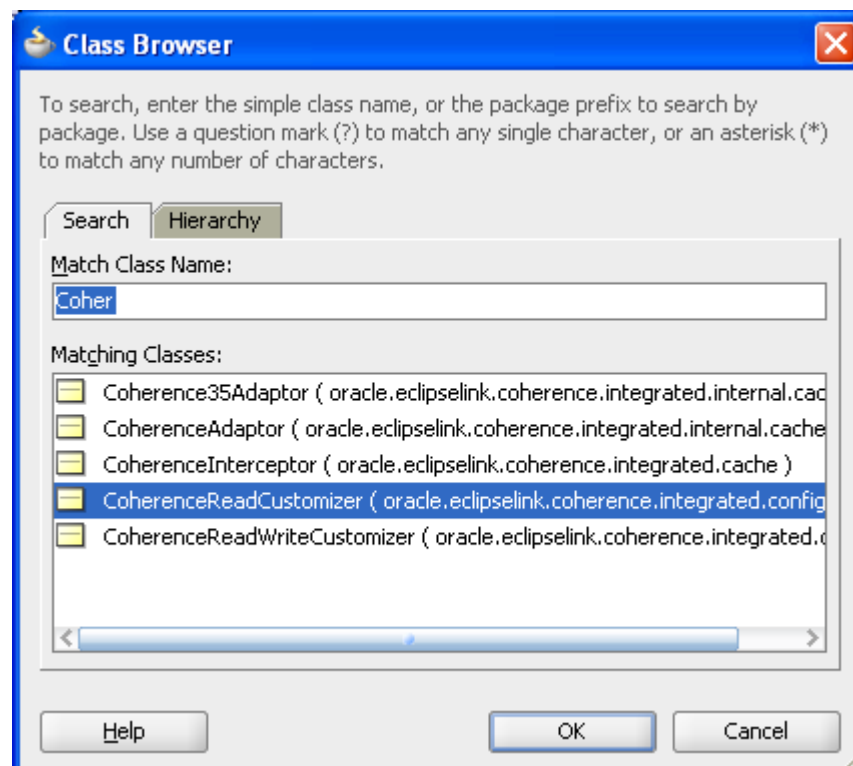
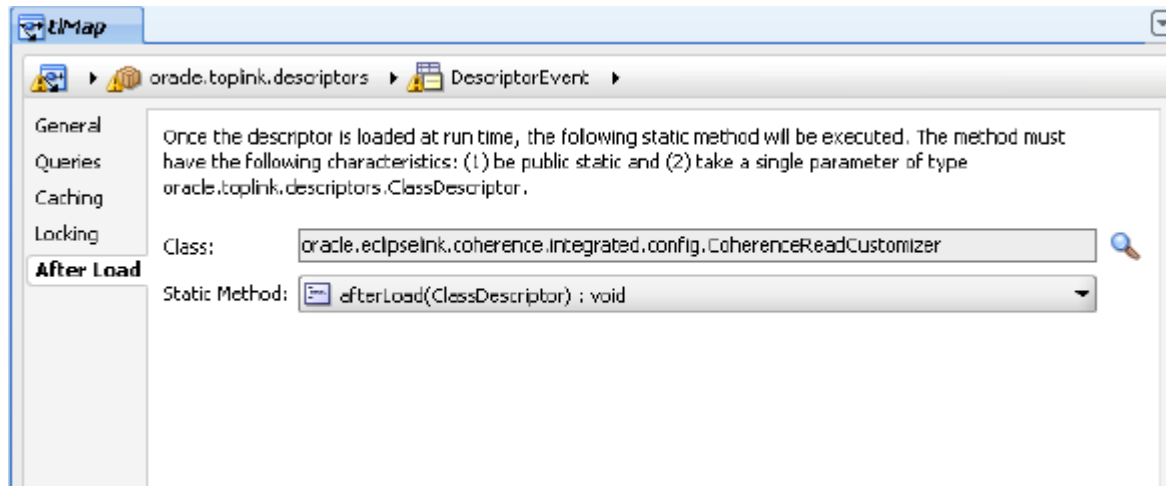
**Figure 3–3** After Load Tab for a TopLink Descriptor

Figure 3–4 illustrates the class browser with the with the CoherenceReadCustomizer class selected.

**Figure 3–4** Searching for the Class containing the Amendment Method

4. In the **After Load** tab of the **tIMap** configuration window, select the amendment method from the **Static Method** dropdown list. For the Coherence Customizer classes, this will be the `afterLoad` method.

**Figure 3–5** Selecting the Amendment Method



## Configuring the EclipseLink Native ORM Cache Store and Cache Loader

The `coherence-cache-config.xml` file must specify the cache loader or cache store class and provide parameters for the cache name and session name (that is, *project name*). The following examples illustrate that aside from changing the class name (`EclipseLinkNativeCacheStore` or `EclipseLinkNativeCacheLoader`), you do not have to make any changes to the Coherence cache configuration depending on whether you are using the cache loader or cache store.

[Example 3–1](#) illustrates a configuration in the `coherence-cache-config.xml` file for a cache that can communicate with EclipseLink Native ORM applications. The `class-name` element identifies the `EclipseLinkNativeCacheStore` class as the cache store scheme. The `param-value` elements specify the cache name and the session (project) name that are passed to the class.

### **Example 3–1** Configuration for an Integrated `EclipseLinkNativeCacheStore`

```
...
<distributed-scheme>
  <scheme-name>eclipselink-native-distributed-store</scheme-name>
  <service-name>EclipseLinkNative</service-name>
  <serializer>
    <class-name>oracle.eclipselink.coherence.integrated.cache.
WrapperSerializer</class-name>
  </serializer>
  <backing-map-scheme>
    <read-write-backing-map-scheme>
      <internal-cache-scheme>
        <local-scheme/>
      </internal-cache-scheme>
      <!-- Define the cache scheme -->
      <cachestore-scheme>
        <class-scheme>
          <class-name>oracle.eclipselink.coherence.integrated.
EclipseLinkNativeCacheStore</class-name>
```

```

    <init-params>
      <init-param>
        <param-type>java.lang.String</param-type>
        <param-value>{cache-name}</param-value>
      </init-param>
      <init-param>
        <param-type>java.lang.String</param-type>
        <param-value>coherence-native-project</param-value>
      </init-param>
    </init-params>
  </class-scheme>
</cachestore-scheme>
</read-write-backing-map-scheme>
</backing-map-scheme>
<autostart>>true</autostart>
</distributed-scheme>
...

```

**Example 3-2** illustrates an integrated `EclipseLinkNativeCacheLoader` instance configuration in the `coherence-cache-config.xml` file. The cache name (`{cache-name}`) and session name (`coherence-native-project`) parameter values are passed to the class.

**Example 3-2 Configuration for an Integrated `EclipseLinkNativeCacheLoader`**

```

...
<cachestore-scheme>
  <class-scheme>
    <class-name>oracle.eclipselink.coherence.integrated.
EclipseLinkNativeCacheLoader</class-name>
    <init-params>
      <init-param>
        <param-type>java.lang.String</param-type>
        <param-value>{cache-name}</param-value>
      </init-param>
      <init-param>
        <param-type>java.lang.String</param-type>
        <param-value>coherence-native-project</param-value>
      </init-param>
    </init-params>
  </class-scheme>
</cachestore-scheme>
...

```





This chapter contains recommendations of how to use TopLink Grid with byte code weaving and lazy loading:

- [Changing Compiled Java Classes with Byte Code Weaving](#)
- [Deferring Database Queries with Lazy Loading](#)

## Changing Compiled Java Classes with Byte Code Weaving

*Byte code weaving* is a technique for changing the byte code of compiled Java classes. You can configure byte code weaving to enable a number of EclipseLink JPA performance optimizations, including support for the lazy loading of one-to-one and many-to-one relationships, attribute-level change tracking, and fetch groups.

Weaving can be performed either dynamically when entity classes are loaded, or statically as part of the build process. Static byte code weaving can be incorporated into an Ant build using the `weaver` task provided by EclipseLink.

Dynamic byte code weaving is automatically enabled in Java EE 5-compliant application servers such as Oracle WebLogic. However, in Java SE it must be explicitly enabled by using the JRE 1.5 `javaagent` JVM command line argument. See "How to Configure Dynamic Weaving for JPA Entities Using the EclipseLink Agent" at the following URL for more information about dynamic byte code weaving for JRE 1.5.

[http://wiki.eclipse.org/Using\\_EclipseLink\\_JPA\\_Extensions\\_\(ELUG\)#How\\_to\\_Configure\\_Dynamic\\_Weaving\\_for\\_JPA\\_Entities\\_Using\\_the\\_EclipseLink\\_Agent](http://wiki.eclipse.org/Using_EclipseLink_JPA_Extensions_(ELUG)#How_to_Configure_Dynamic_Weaving_for_JPA_Entities_Using_the_EclipseLink_Agent)

To enable byte code weaving in a Coherence cache server, the Java VM should be invoked with `-javaagent:<PATH>\eclipselink.jar`. Java SE client applications should be run with the `-javaagent` argument.

See "Using EclipseLink JPA Weaving" at Eclipsepedia for more information on configuring and disabling static and dynamic byte code weaving.

[http://wiki.eclipse.org/Using\\_EclipseLink\\_JPA\\_Extensions\\_\(ELUG\)#Using\\_EclipseLink\\_JPA\\_Weaving](http://wiki.eclipse.org/Using_EclipseLink_JPA_Extensions_(ELUG)#Using_EclipseLink_JPA_Weaving)

## Deferring Database Queries with Lazy Loading

Lazy loading is a technique used to defer the querying of objects from the database until they are required. This can reduce the amount of data loaded by an application and improve throughput. A TopLink Grid JPA or native ORM application should lazily load all relationships. Lazy loading is the default for one-to-many and many-to-many relationships in JPA, but is eager for one-to-one and many-to-one

relationships. You must explicitly select lazy loading on these relationship types. For example, you can specify lazy loading as an attribute for many of the relationship annotations:

```
...
@ManyToOne(fetch=FetchType.LAZY)
private Publisher parent
...
```

For maximum efficiency, lazy loading should be specified for all one-to-one and many-to-one entity relationships that TopLink Grid stores in the Coherence cache. Lazy loading is implemented through byte code weaving in EclipseLink and must be enabled explicitly if not running in a Java EE 5-compliant application server. For more information, see "[Changing Compiled Java Classes with Byte Code Weaving](#)" on page 4-1.

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