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EclipseLink: The Evolution of Java Persistence

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About Me

• From Toronto, Canada
• Product Manager at Oracle for TopLink
• Object-Relational Mapping since ’96!
• Committer on various Eclipse projects including EclipseLink & Gemini
• Presented at many conferences including JavaOne, Devoxx, QCon, EclipseCon, & JAX
Agenda

• Introduction
• Evolutionary Pressures
• New EclipseLink Features
• Conclusion
JAVA PERSISTENCE
Java Persistence: The Problem Space

| Customer | <customer id="...">  
| id: int  
| name: String  
| creditRating: int  

Java:

JAXB: Java Architecture for XML Binding

XML:

JPA: Java Persistence API

DBWS

Relational:

| CUST | ID | NAME | C_RATING |

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EclipseLink Project

• Object-Relational: Java Persistence API (JPA)
  – JPA 1.0 part of EJB 3.0 standard (JSR 220)
  – JPA 2.0 standardized in JSR 317
  – EclipseLink is *JPA 2.0 & 2.1 Reference Implementation*

• Object-XML: Java Architecture for XML Binding (JAXB)
  – JAXB 2.2 Certified Implementation

• Object-XML: Service Data Objects
  – SDO 2.1.1 standardized in JSR 235
  – EclipseLink is *SDO 2.1.1 Reference Implementation*
EclipseLink Project

Java SE   Java EE   OSGi

JPA       MOXy      DBWS

Databases  XML Data  Legacy Systems
EclipseLink: Distributions

- Eclipse.org
  - www.eclipse.org/eclipselink/downloads
  - http://download.eclipse.org/rt/eclipselink/updates
- Oracle
  - TopLink 11g & 12c
  - WebLogic Server 11g & 12c
- GlassFish v3
  - Replaces TopLink Essentials
  - JPA 2.0 Reference Implementation
- Spring Source
  - Spring Framework and Bundle Repository
- JOnAS
- JEUS TMaxSoft
EclipseLink History & Future

- EclipseLink 1.0 - July 2008
  - JPA 1.0, simple upgrade from TopLink Essentials (JPA 1.0 RI)
- EclipseLink 1.1 - March 2009
  - JPA 1.0 with some JPA 2.0 capabilities (1.1.2 in Eclipse Galileo)
- EclipseLink 2.0 - December 2009
  - JPA 2.0 reference Implementation
- EclipseLink 2.1 (Helios) – June 2010
- EclipseLink 2.3 (Indigo) – June 2011
- EclipseLink 2.4 (Juno) – June 2012
Software Evolution

• Computing architecture is constantly evolving: Mainframe, client/server, web/thin client, mobile/apps, ...

• Current technologies with increasing adoption include:
  – Cloud computing
  – HTML 5
  – NoSQL databases

• Java EE 7 is evolving to address many of these new requirements

• EclipseLink JPA and JAXB are also evolving!
New Features

• REST—client/server over HTTP with identified resources
• Dynamic Persistence—persistence for web (JavaScript) applications
• Multitenancy—support for multiple customers in single application/server/database
• Customization—customize application instances per customer
JPA-RS
EclipseLink JPA-RS

- Provides a service that exposes JPA mapped entities over REST via JAX-RS
- HTTP message body either XML or JSON
- Client
  - HTML 5 with JavaScript (primary focus)
  - JavaFX
What is REST?

• **REST** – REpresentational **State** Transfer

• **Principles:**
  – Addressable resources (URI per resource)
  – Small set of well-defined methods (i.e. GET, PUT, POST, DELETE)
  – Representation-oriented
  – Communicate statelessly
What is JAX-RS?

• Java API for RESTful Services
  – Java EE specification (Jersey is reference implementation)

• Principles
  – Java EE framework for implementing RESTful services
  – Provides annotations to bind combination of URI and HTTP operation to Java methods.

• Specifications
  – JAX-RS 1.0 (JSR 311) – Released October 2008
  – JAX-RS 2.0 (JSR 339) – In Progress
public class InvoiceService {...

    public Invoice read(int id) {
        return null;
    }

    ...

    ...
@Stateless
public class InvoiceService { ... 

public Invoice read(int id) {
    return entityManager.find(Invoice.class, id);
}
...

public Invoice read(int id) {
    return entityManager.find(Invoice.class, id);
}

...
JAX-RS with JPA Example – GET Invoice

@Path("/invoice")
@Stateless
public class InvoiceService {...

@GET
@Path("{id}")
public Invoice read(@PathParam("id") int id) {
    return entityManager.find(Invoice.class, id);
}
...

JAX-RS with JPA Example – GET Invoice

@Path("/invoice")
@Stateless
public class InvoiceService {
    
    @GET
    @Path("{id}")
    @Produces({"application/xml", "application/json"})
    public Invoice read(@PathParam("id") int id) {
        return entityManager.find(Invoice.class, id);
    }
    
    ...
JAX-RS with JPA Example – GET Invoice

@Path("/invoice")
@Stateless
public class InvoiceService {...

    @GET
    @Path("{id}")
    @Produces({"application/xml", "application/json"})
    public Invoice read(@PathParam("id") int id) {
        return entityManager.find(Invoice.class, id);
    }

    ...

    GET http://[machine]:[port]/[web-context]/invoice/4

...
JAX-RS with JPA—High Level Architecture
JAX-RS with JPA Example

JAX-RS

Invoice Bean  Contract Bean  Payment Bean

Accounting Application

Accounting Persistence Unit

JPA
JAX-RS with JPA

GET http://.../invoice/4
mapped to bean

GET http://.../invoice
mapped to bean

JAX-RS

Invoice Bean
Contract Bean
Payment Bean

Bean uses JPA

Accounting Persistence Unit

Accounting Application

JPA

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JPA-RS maps URI http://.../jpa-rs/Accounting/Invoice/... to Accounting PU and Invoice entity
JPA-RS Features

• Access relational data through REST
  – JSON or XML
• Provides REST operations for entities in persistence unit (GET, PUT, POST, DELETE)
• Supports invocation of named queries via HTTP
• Server Caching—EclipseLink clustered cache
• Client offline storage and sync
• Dynamic Persistence also supported
  – Entities defined via metadata—no Java classes required
  – Enables persistence services for HTML 5/JavaScript applications
JAX-RS DEMO
JPA-RS Related Technologies

• JPA-RS—Exposing JPA over RESTful HTTP Services
• Dynamic Provisioning—persistence units defined entirely with metadata—no Java classes.
• JSON Binding—Mapping Java classes/JPA entities to JSON
• REST Resource Mapping—defining mapping from Java model to REST resource model to control XML/JSON marshalling
• JAXB/JPA Fidelity—integration to permit marshalling/unmarshalling of JPA entities to XML (JSON)
DYNAMIC PROVISIONING
Dynamic Provisioning

• Persistence units defined entirely with metadata—no Java classes.
• Ideally suited to HTML 5 client applications
• Clients can dynamically define storage requirements for a set of classes (object types) and EclipseLink will instantiate a full JPA-RS CRUD service for those classes as well as JPQL query support.
DYNAMIC PROVISIONING DEMO
JSON BINDING
JSON Binding / EclipseLink “JSON-B”

• Provides Java/JSON binding similar to EclipseLink JAXB’s Java/XML binding.
• Marshall Java domain model to and from JSON
• Currently no Java standard—EclipseLink interprets JAXB XML bindings for JSON
• Content-type selectable by setting property on Marshaller/Unmarshalller
EclipseLink JSON-B Goals

• Offer the same flexibility as object-to-XML mappings
• Support both XML and JSON with one set of mappings
• No additional compile time dependencies over the JAXB APIs
• Be easy to use with JAX-RS (i.e., MessageBodyReader and MessageBodyWriter)
XML and JSON from JAXB Mappings

```java
@XmlRootElement(namespace="urn:example")
public class Foo {

    @XmlAttribute
    private int id;

    @XmlElement(namespace="urn:example")
    private String bar;
}
```

XML

```xml
<foo xmlns="urn:examle" id="123">
   <bar>Hello World</bar>
</foo>
```

JSON

```json
{"foo": {
    "id": 123,
    "bar": "Hello World"
}}
```
REST RESOURCE MAPPING
REST Resource Mapping

• REST requires URIs for identifiable resources
• Resources not 1:1 with classes
  – may be a graph of closely related objects
• Resources are connected via links
• Need a way to define Resource Model that can be leveraged by JAXB/JSON Binding
Resource Example

- Team and it’s Divisions are a single resource
- User and Player are resources
Resource Model

• Maps Java Object Model to REST Resources
EclipseLink Resource Model Status

- In development
- Resources (sub-graphs of domain graph) can be marshalled and unmarshalled (and reconnected)
- Links are being automatically generated
  - Currently requires use of JAXB annotations
- Future: simplify metadata declaration of resources
REST RESOURCE DEMO
JPA/JAXB FIDELITY
JAXB/JPA Fidelity

- JAXB and JPA specifications defined in relative isolation
- Have conflicting / differing semantics
- Enhancements required to permit marshalling/unmarshalling of JPA entities to/from XML (JSON)
Challenges – Mapping Java Objects (JPA Entities) to XML

- Bidirectional/Cyclical Relationships
- Composite Keys/Embedded Key Classes
- Byte Code Weaving
Bidirectional Relationship

```java
@Entity
public class Project{
    ...
    @OneToMany(mappedBy="project")
    private List<Employee> members;
}

@Entity
public class Employee{
    ...
    @ManyToOne
    private Project project;
}
```
Bidirectional Relationships in JAXB

- JAXB specification does not support bidirectional relationships. One side must be marked `@XmlTransient`.
- But that loses the relationship!
EclipseLink XmlInverseReference

```java
@Entity
public class Project{
    ...
    @OneToMany(mappedBy="project")
    private List<Employee> members;
}

@Entity
public class Employee{
    ...
    @ManyToOne
    @XmlInverseReference(mappedBy="members")
    private Project project;
}
```
EclipseLink XmlInverseReference

• EclipseLink restores relationships on unmarshall!

```xml
<?xml version="1.0" ?>
<employee>
  <first>Mark</first>
  <last>Twain</last>
  <id>1</id>
</employee>
```

Marshall

```xml
<employee>
  <first>Mark</first>
  <last>Twain</last>
  <id>1</id>
</employee>
```

Unmarshall
JAXB/JPA FIDELITY DEMO
NOSQL PERSISTENCE
NoSQL Databases

- NoSQL (i.e., non-relational) database are increasingly popular
- No standards
- Differing APIs and feature sets
- Some offer query language/API—some not
EclipseLink NoSQL

• Support JPA access to NoSQL databases
  – Leverage non-relational database support for JCA (and JDBC when available)

• Define annotations and XML to identify NoSQL stored entities (e.g., @NoSQL)

• Support JPQL subset for each
  – Key principal: leverage what’s available

• Initial support for MongoDB and Oracle NoSQL.

• Support mixing relational and non-relational data in single composite persistence unit
Example NoSQL Mapped Entities (not final)

```java
@Entity
@NoSql(dataFormat=DataFormatType.MAPPED)
public class Order {
    @Id
    @Column(name="Id")
    public long id;
    public String orderedBy;
    @Field(name="address")
    public Address address;
    @OneToMany
    @JoinColumn(name="customerId",
        referencedColumnName="ID")
    public Customer customer;
    ...
}

@Entity
@NoSql(dataFormat=DataFormatType.MAPPED)
public class Address {
    @Field(name="addressee")
    public String addressee;
    public String street;
    ...
}

@Entity
@NoSql(dataFormat=DataFormatType.MAPPED)
public class Customer {
    @Id
    public String id;
    public String name;
    public String toString() {
        return "Customer(" + name + ")";
    }
    ...
}
```
MULTITENANCY
Multitenancy

• Multitenancy refers to a principle in software architecture where a single instance of the software runs on a server, serving multiple client organizations (tenants).

• Multitenancy is contrasted with a multi-instance architecture where separate software instances (or hardware systems) are set up for different client organizations.

• Wikipedia http://en.wikipedia.org/wiki/Multitenancy
Application Development and the Cloud

• Today
  – Single Tenant or non-Tenant Applications
  – Dedicated application instance and database

• Future
  – Support multiple tenants
  – Support extensibility (custom fields per tenant)
  – Support various deployment architectures
    • Dedicated or shared application instances
    • Dedicated or shared databases
So Many Clouds

- **Infrastructure - IaaS**
  - E.g., Amazon Web Services

- **Platform – PaaS**
  - E.g., Oracle Public Cloud, Cloud Bees, Google App Engine

- **Software – SaaS**
  - E.g., Google Mail
Multitenant Topologies

<table>
<thead>
<tr>
<th></th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dedicated</strong></td>
<td><img src="diagram1.png" alt="Diagram" /></td>
</tr>
<tr>
<td><strong>Shared</strong></td>
<td><img src="diagram3.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

**Note:** Single application deployed to support various MT architectures
Multitenant: Dedicated Application

- Dedicated application instance
  - Application instance per tenant
    - unique container or application class-loader
  - Caching supported

- Dedicated database
  - Unique tables (tablespace/schema/db) per tenant
  - Tenant specific data source required
Multitenant:  

- **Shared Application Instance**
  - Application instances handle multiple tenants
  - Caching must isolate by tenant

- **Dedicated Database**
  - Common data source
    - Unique schema/tablespace per tenant
    - Common schema with table per tenant (partitioning)
    - Proxy Authentication
  - Data source per tenant
Shared Database

• **@Multitenant**
  – Application’s persistence layer manages access
  – Row data includes tenant identifier values
  – Queries augmented to limit results based on current tenant
  – Database vendor independent

• **@Multitenant(VPD)**
  – Row data includes tenant identifier values
  – Database provides client limited view of database tables
    • Shared solution for all database clients
    • Native queries (SQL) supported
Multitenant Entity Strategies

• GOAL: support storage of entities from multiple tenants in a single shared schema

• @Multitenant Strategies
  – @Multitenant(SINGLE_TABLE) - default
  – @Multitenant(VPD)
    • SINGLE_TABLE + includeCriteria=false
    • SET_IDENTIFIER(property) & CLEAR_IDENTIFIER
    • DDL Gen of predicate function and ADD_POLICY
  – Future:
    @Multitenant(TABLE_PER_TENANT)
In the beginning…

- Application dedicated for single tenant
- All rows available to all queries

```java
@Entity
public class Player {
```

<table>
<thead>
<tr>
<th>ID</th>
<th>VERSION</th>
<th>F_NAME</th>
<th>L_NAME</th>
<th>LEAGUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>John</td>
<td>Doe</td>
<td>HTHL</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Jane</td>
<td>Doe</td>
<td>OSL</td>
</tr>
</tbody>
</table>
DEMO—JPA SINGLE (NO) TENANCY
Multitenant: SINGLE_TABLE

- Simple configuration: Annotation or XML
- Flexible tenant identifier support
- EclipseLink augments generated SQL

```java
@Entity
@Multitenant
@TenantDiscriminatorColumn(name="league-id", columnName="LEAGUE")
public class Player {

    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private Long id;

    @Version
    private Integer version;

    @Column
    private String firstName;

    @Column
    private String lastName;

    @Column
    private String league;

    // Getters and setters
}
```

<table>
<thead>
<tr>
<th>ID</th>
<th>VERSION</th>
<th>F_NAME</th>
<th>L_NAME</th>
<th>LEAGUE</th>
</tr>
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<td>2</td>
<td>3</td>
<td>Jane</td>
<td>Doe</td>
<td>OSL</td>
</tr>
</tbody>
</table>
DEMO—SINGLE TABLE MULTITENANCY
Multitenant using Oracle VPD

• Leverage the Oracle Database

```java
@Entity
@Multitenant(VPD)
@TenantDiscriminatorColumn(name="league-id", columnName="LEAGUE")
public class Player {

    // Table data
    ID | VERSION | F_NAME | L_NAME | LEAGUE
    -- | ------- | ------ | ------ |-------
    1  | 1       | John   | Doe    | HTHL  
    2  | 3       | Jane   | Doe    | OSL   
```
Multitenant: TENANT_PER_TABLE

• Planned Feature

```java
@Entity
@Multitenant(TABLE_PER_TENANT)
public class Player {
    // Class implementation
}
```

<table>
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<th>F_NAME</th>
<th>L_NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>John</td>
<td>Doe</td>
</tr>
</tbody>
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<th>ID</th>
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<th>F_NAME</th>
<th>L_NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3</td>
<td>Jane</td>
<td>Doe</td>
</tr>
</tbody>
</table>
Caching & Multitenancy

- EntityManager/Tenant—Shared Cache Disabled
Caching & Multitenancy

- `EntityManagerFactory/Tenant`—Shared Cache
MySports Demo

• Introduced in EclipseLink Indigo (2.3)

• Features
  – @Multitenant
    • EntityManagerFactory per tenant (shared cache enabled)
  – @VirtualAccessMethods (Extensions per Tenant)
  – External Metadata Sources
  – JSF, EJB, JPA
  – Admin: JSF + JAX-RS + JPA

• Wiki
MySports Demo Model
DEMO—MYSPORTS MULTITENANCY
DOMAIN MODEL EXTENSIONS
Domain Model Extensions

- Storage and querying of extended properties
  - Application developer enables extensions in entity
  - Schema created with extension columns/table(s)
  - Application Admin stores extension definitions
  - Application instances made aware of extension definitions
  - Application users make use of extensions

```
Employee
  id
  firstName
  lastName
```

```
extensions
  * 
  Map<String, Object>
```

```
name
value
```
Flex Extensions

```java
@VirtualAccessMethods
public class Player{
  ...  
  @Transient
  private Map<String, Object> attributes;

  public <T> T get(String attributeName) {
    return (T) this.attributes.get(attributeName);
  }

  public Object set(String attributeName, Object value) {
    return this.attributes.put(attributeName, value);
  }
}
```

<table>
<thead>
<tr>
<th>ID</th>
<th>F_NAME</th>
<th>L_NAME</th>
<th>FLEX_1</th>
<th>FLEX_2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>John</td>
<td>Doe</td>
<td>‘R’</td>
<td>’22’</td>
</tr>
<tr>
<td>2</td>
<td>Jane</td>
<td>Smith</td>
<td>‘NONE’</td>
<td></td>
</tr>
</tbody>
</table>
Virtual Access Mappings

```xml
<entity class="example.mysports.model.Player">
  <attributes>
    <basic name="penaltyMinutes" access="VIRTUAL"
      attribute-type="java.lang.Integer">
      <column name="flex_1"/>
    </basic>
    <basic name="position" access="VIRTUAL"
      attribute-type="java.lang.String">
      <column name="flex_2"/>
    </basic>
  </attributes>
</entity>
```
DEMO—MYSports Extensible Entities
Summary

• Java is evolving—and EclipseLink is evolving too!
  – JPA-RS
  – JSON Binding
  – REST Resource Mapping
  – Dynamic Provisioning
  – NoSQL
  – Multitenancy
  – Extensible entities

• EclipseLink is the center of innovation in Java persistence
Q & A

Provide Feedback, Get Involved!
User forums and lists at http://eclipse.org/eclipselink