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Java™

MOVING JAVA FORWARD

ORACLE

EclipseLink: The Evolution of Java Persistence

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About Me

- From Toronto, Canada

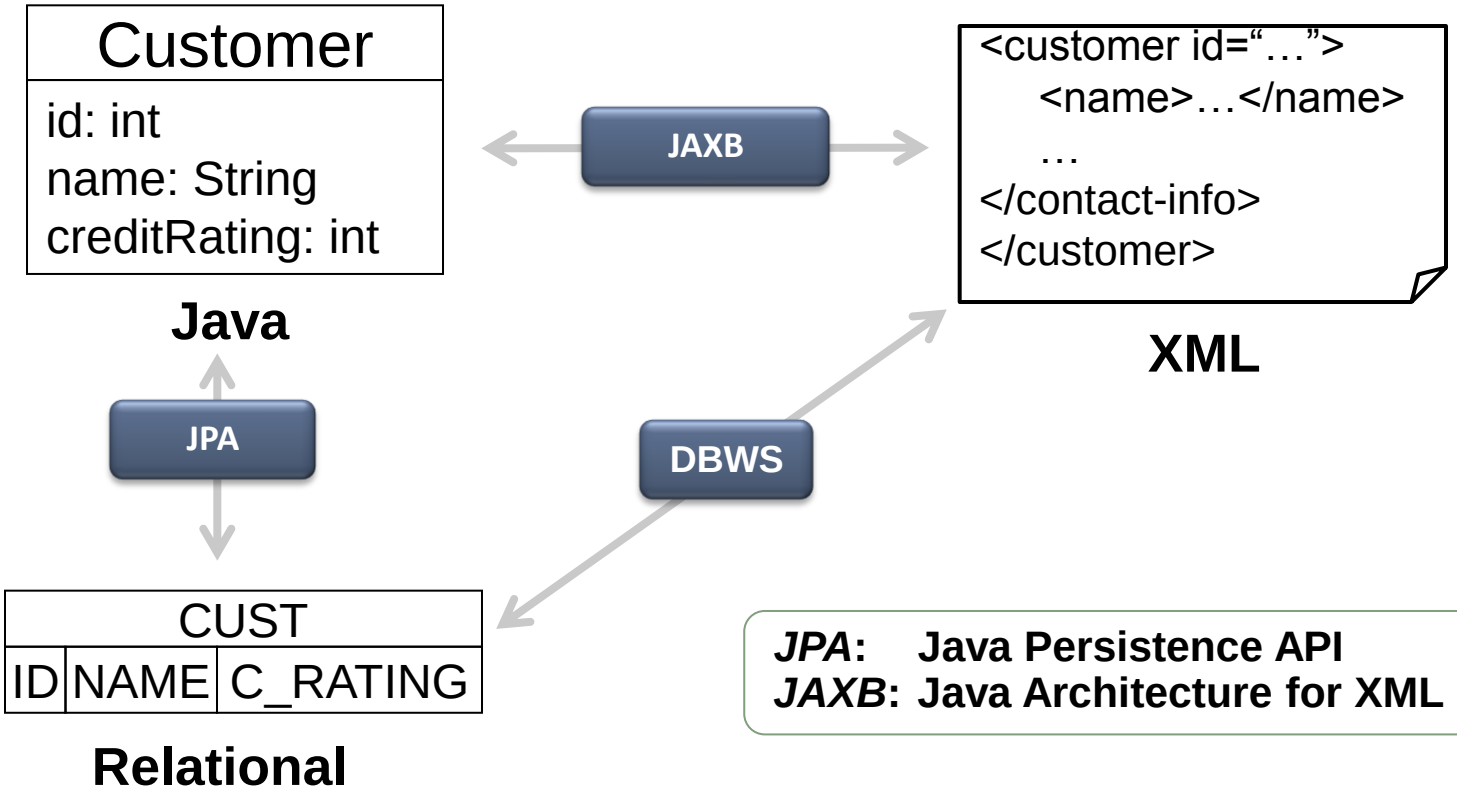
- Product Manager at Oracle for TopLink
- Object-Relational Mapping since ’96!
- Committer on various Eclipse projects including EclipseLink & Gemini
- Presented at many conferences including JavaOne, Devoxx, QCon, EclipseCon, & JAX

Agenda

- Introduction
- Evolutionary Pressures
- New EclipseLink Features
- Conclusion

JAVA PERSISTENCE

Java Persistence: The Problem Space

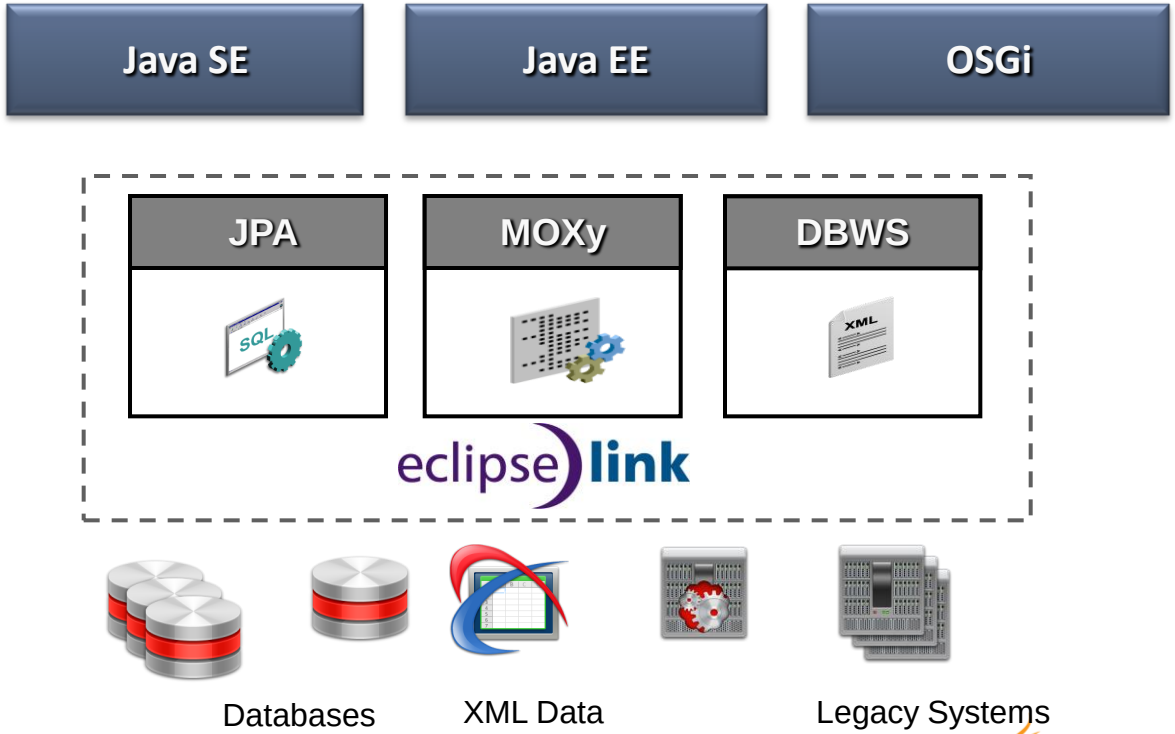


***JPA*: Java Persistence API**
***JAXB*: Java Architecture for XML Binding**

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



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
- EclispeLink 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 – RE**presentational **S**tate **T**ransfer
- **Priniciples:**
  - 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

JAX-RS with JPA Example – GET Invoice

```
public class InvoiceService {...


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

JAX-RS with JPA Example – GET Invoice

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



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

JAX-RS with JPA Example – GET Invoice

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


  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

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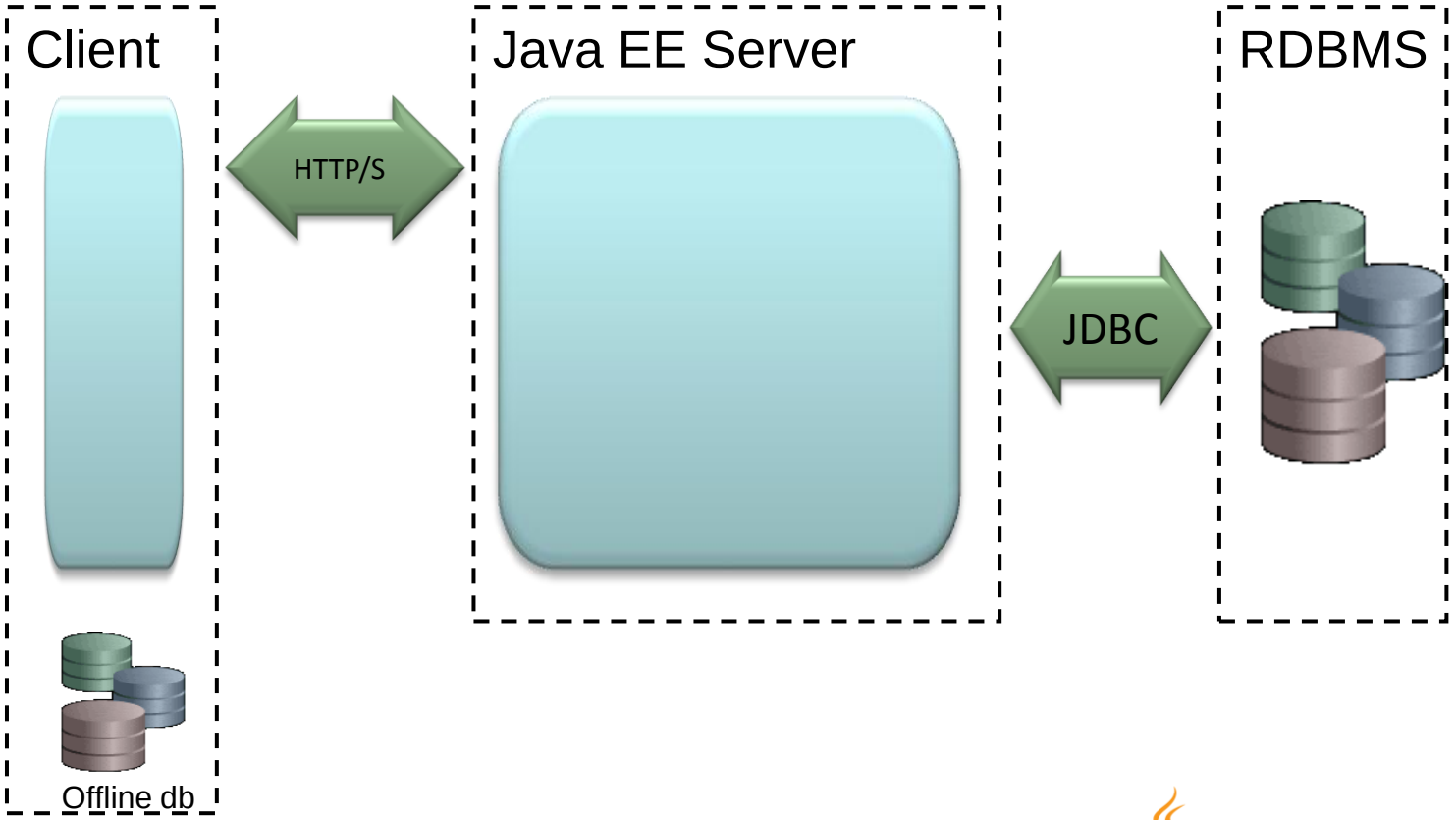
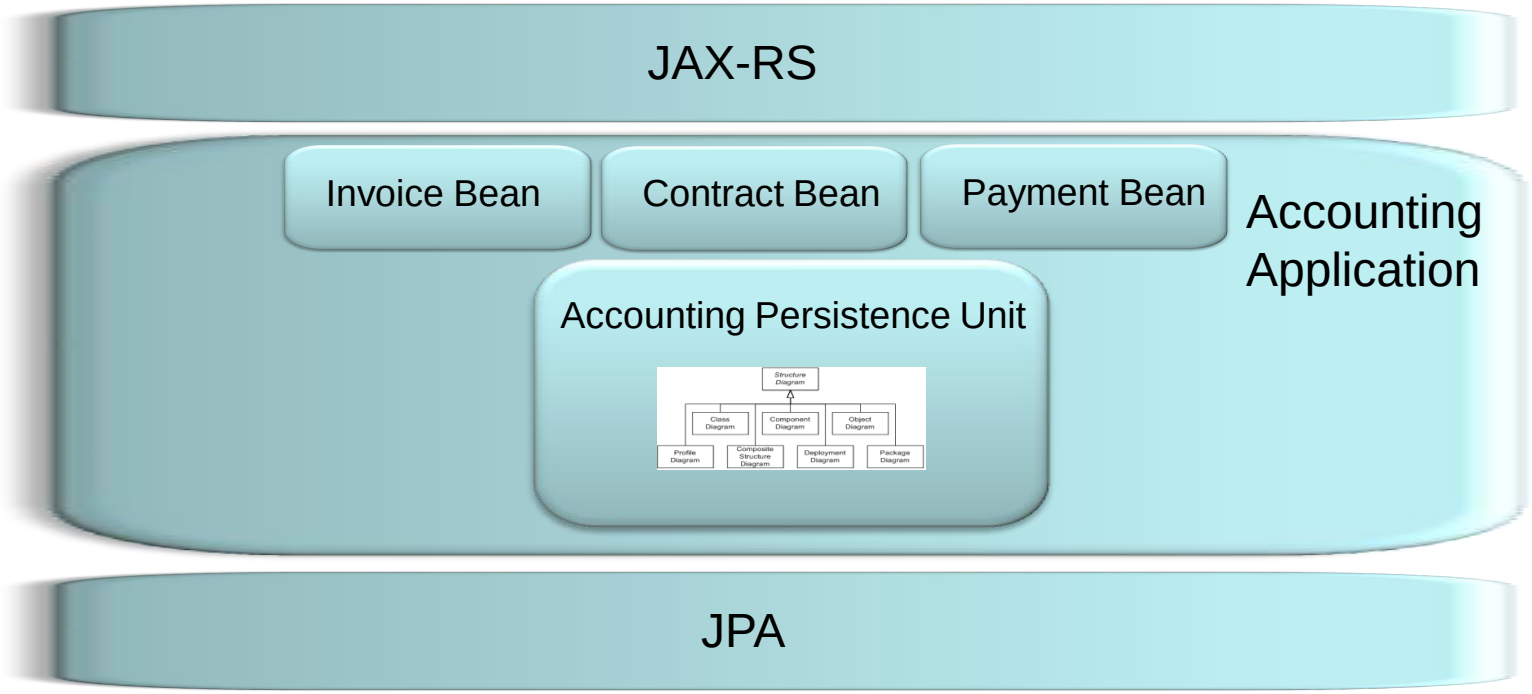
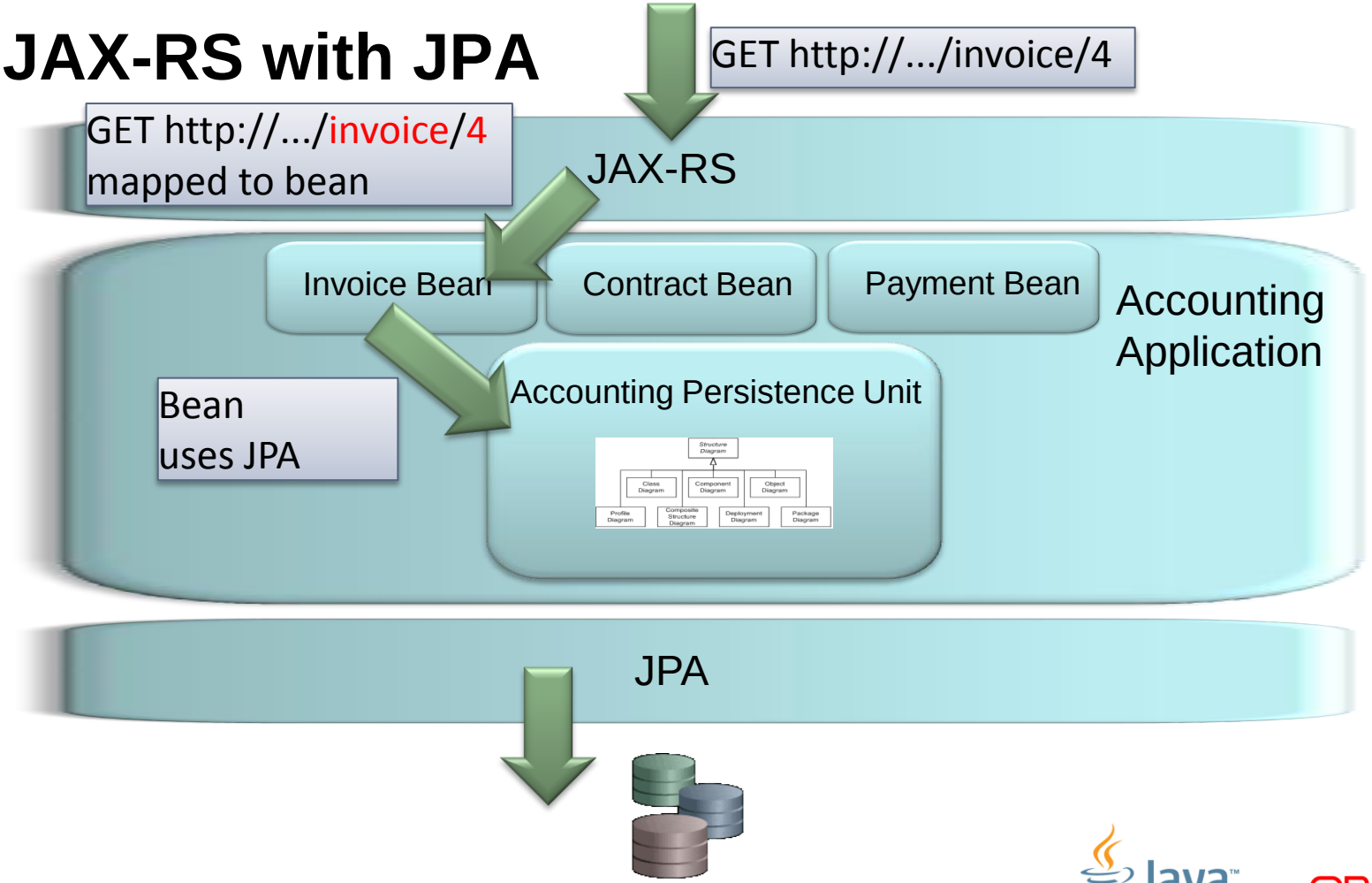
JAX-RS with JPA—High Level Architecture



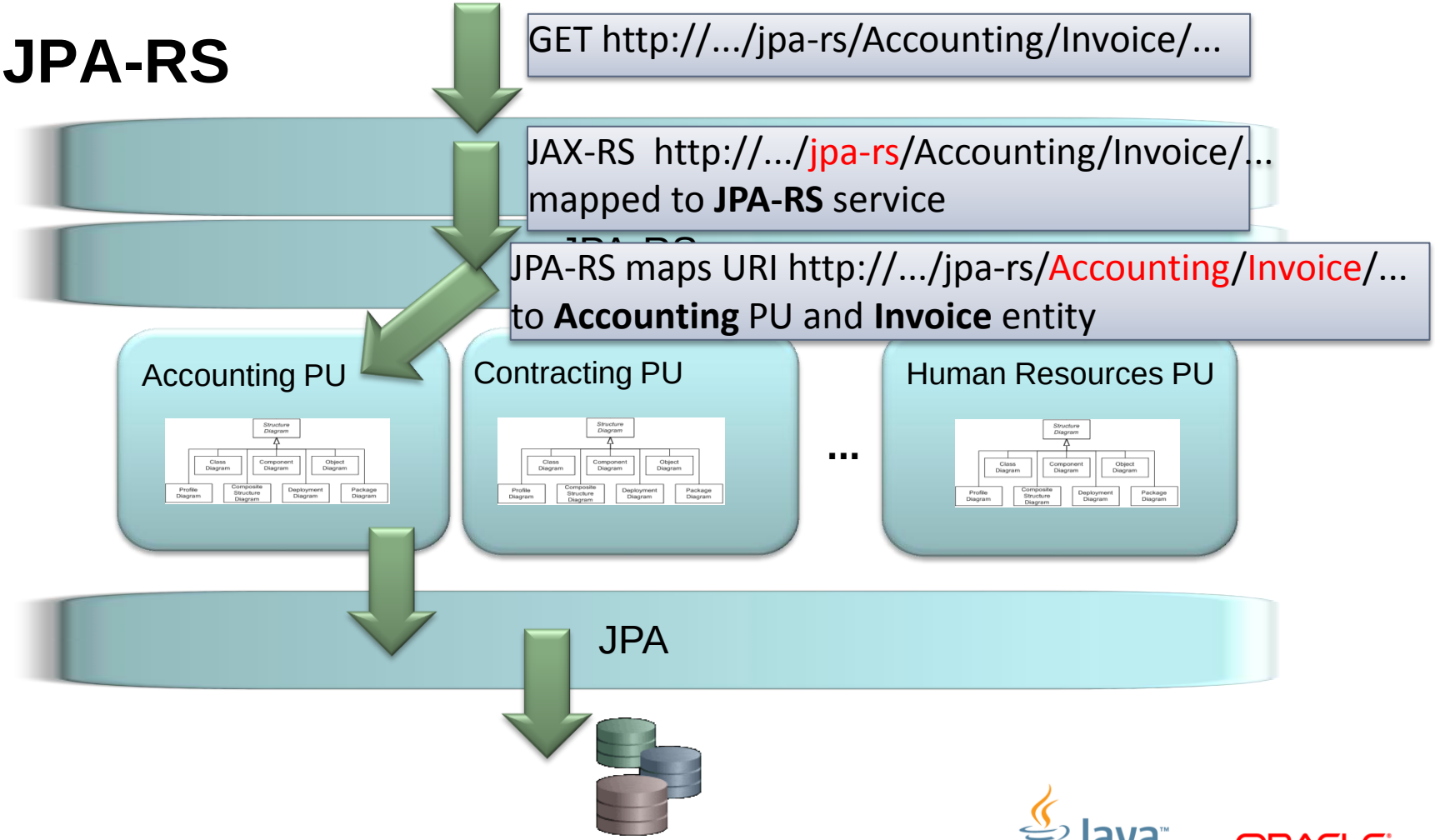
JAX-RS with JPA Example



JAX-RS with JPA



JPA-RS



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/Unmarshaller

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

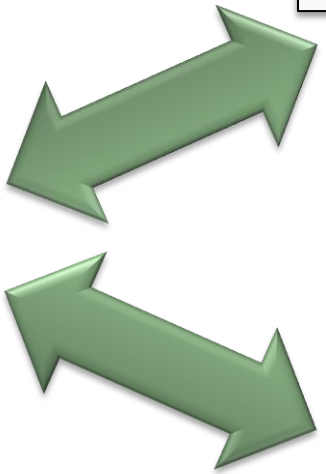
```java
@XmlRootElement(namespace="urn:example")
public class Foo {

    @XmlAttribute
    private int id;

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

}
```

JAXB mapped Java



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

XML

```
{"foo" : {
    "id" : 123,
    "bar : "Hello World"
}}
```

JSON

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JSON-B DEMO

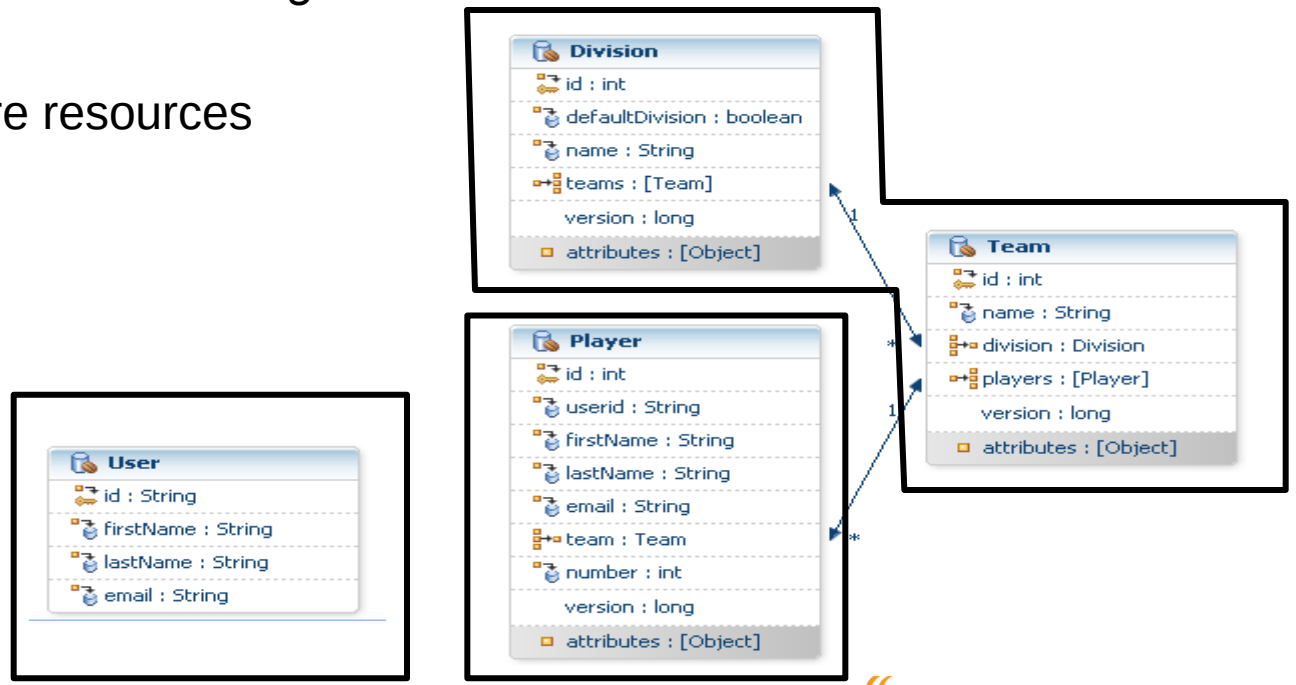
REST RESOURCE MAPPING

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

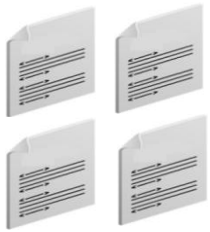
Resource Example

- Team and it's Divisions are a single resource
- User and Player are resources

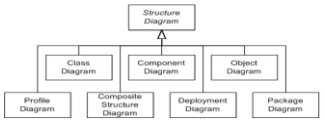


Resource Model

- Maps Java Object Model to REST Resources



Resource Model



Object Model

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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

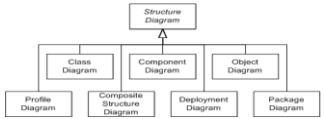
JPA/JAXB FIDELITY

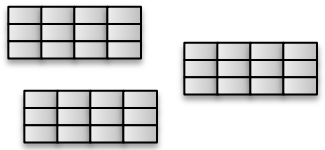
JAXB/JPA Fidelity

- 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

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

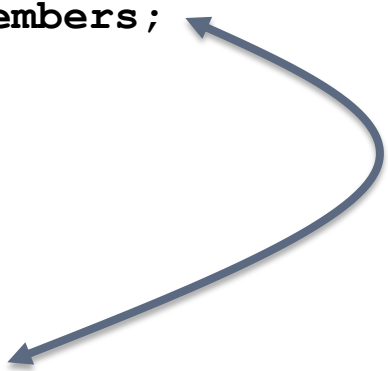




- Bidirectional/Cyclical Relationships
- Composite Keys/Embedded Key Classes
- Byte Code Weaving

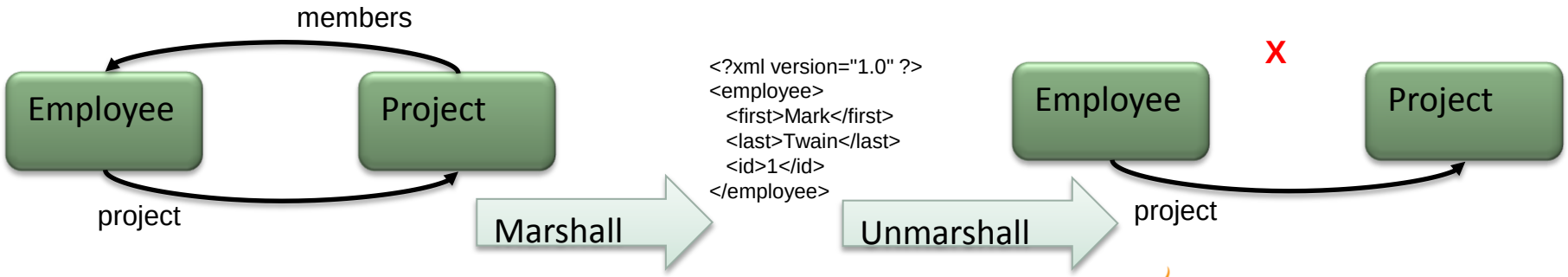
Bidirectional Relationship

```
@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!

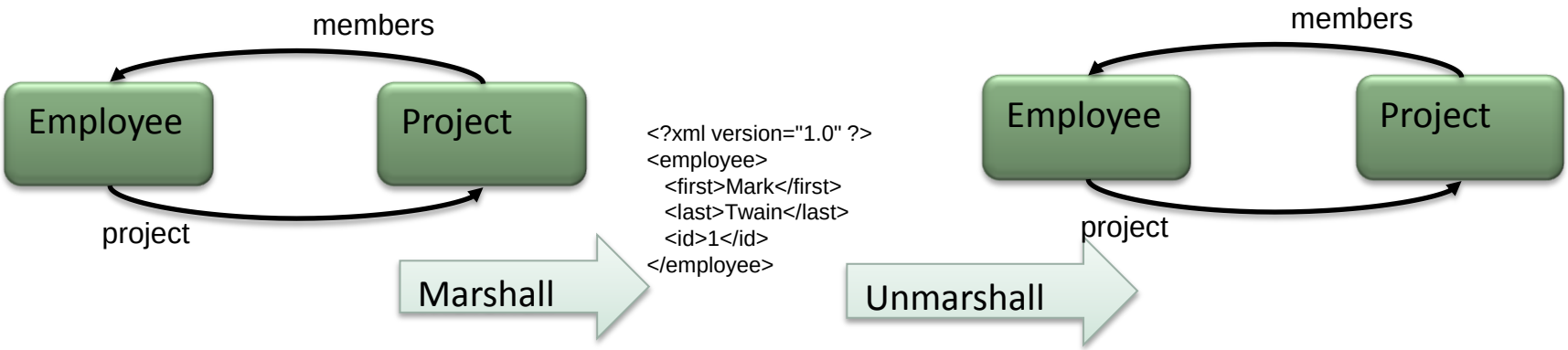


EclipseLink XmlInverseReference

```
@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!



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)

```
@Entity
@NoSql(dataFormat=DataFormatType.MAPPED)
public class Order {
  @Id
  @Column(name="Id")
  public long id;
  public String orderedBy;
  @Field(name="address")
  public Address address;

  @OneToOne
  @JoinField(name="customerId",
      referencedFieldName="ID")
  public Customer customer;
  ...
}
```

```
@Embeddable
@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

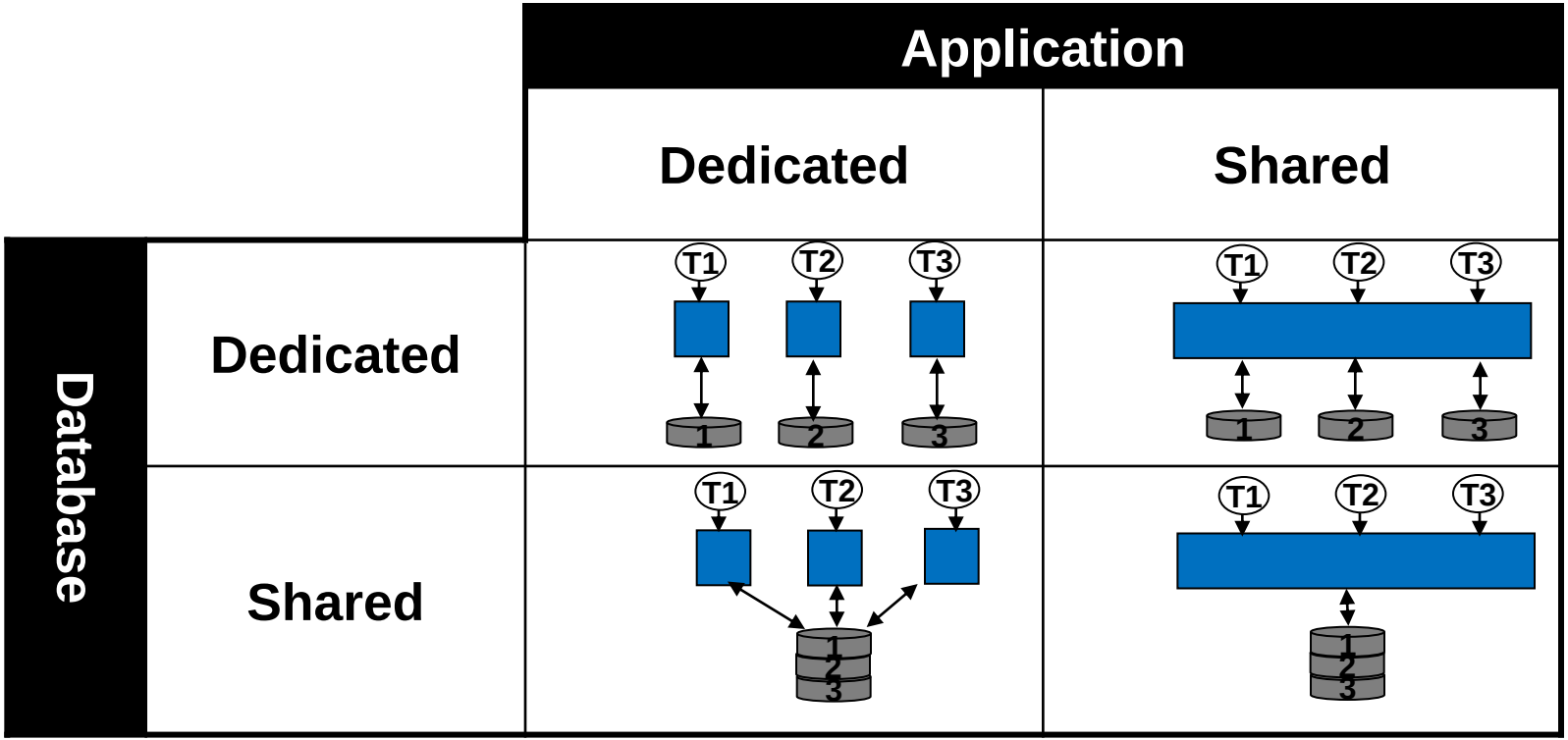
Application Development and the Cloud

- 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

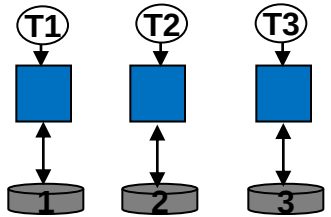
Multitenant Topologies



Note: Single application deployed to support various MT architectures

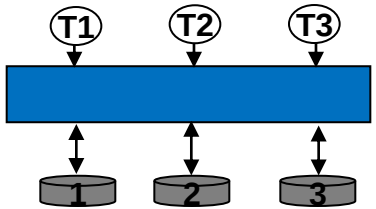
Multitenant: Dedicated Application Dedicated DB

- 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



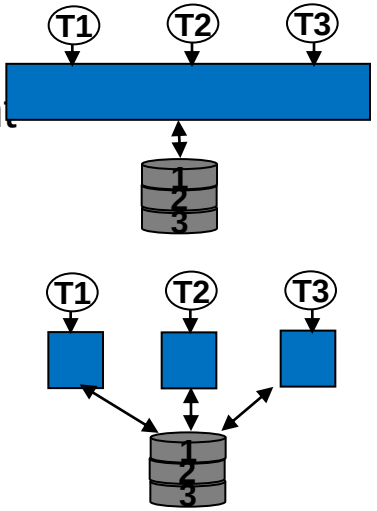
Multitenant: Shared App Dedicated DB

- 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

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

PLAYER

ID	VERSION	F_NAME	L_NAME	LEAGUE
1	1	John	Doe	HTHL
2	3	Jane	Doe	OSL

DEMO—JPA SINGLE (NO) TENANCY

Multitenant: SINGLE_TABLE

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

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

PLAYER

ID	VERSION	F_NAME	L_NAME	LEAGUE
1	1	John	Doe	HTHL
2	3	Jane	Doe	OSL

DEMO—SINGLE TABLE MULTITENANCY

Multitenant using Oracle VPD

- Leverage the Oracle Database

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

PLAYER

ID	VERSION	F_NAME	L_NAME	LEAGUE
1	1	John	Doe	HTHL
2	3	Jane	Doe	OSL

Multitenant: TENANT_PER_TABLE

- Planned Feature

```
@Entity
@Multitenant(TABLE_PER_TENANT)
public class Player {
```

HTHL.PLAYER

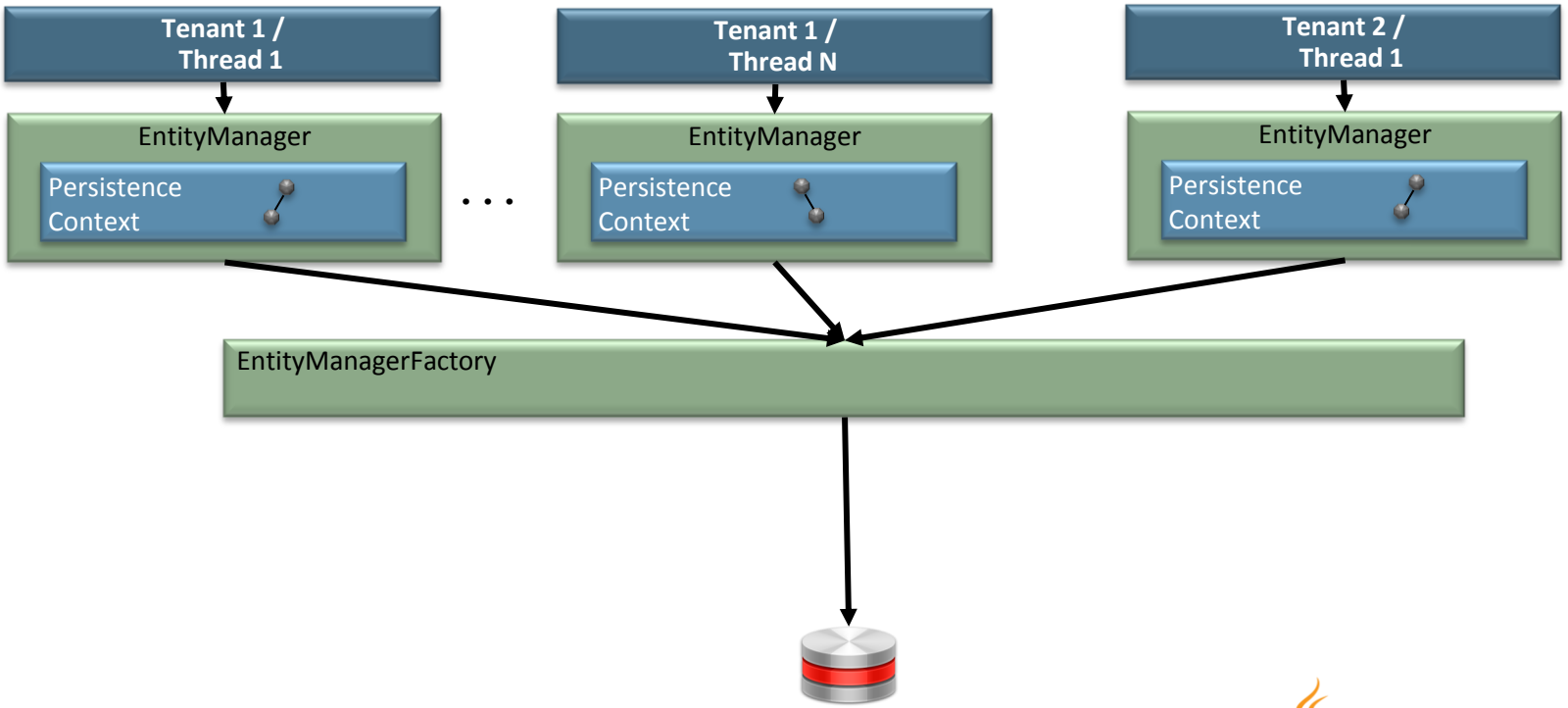
ID	VERSION	F_NAME	L_NAME
1	1	John	Doe

OSL.PLAYER

ID	VERSION	F_NAME	L_NAME
2	3	Jane	Doe

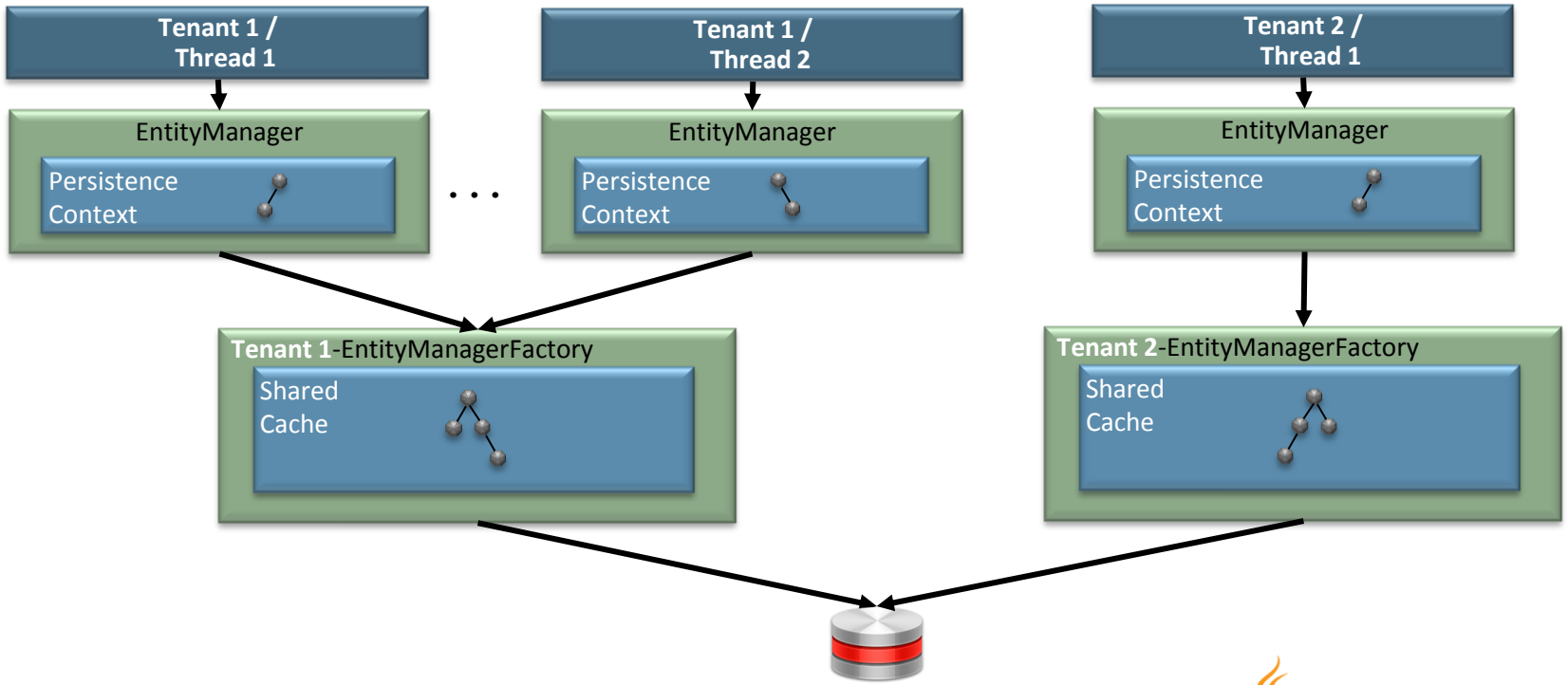
Caching & Multitenancy

- EntityManager/Tenant—Shared Cache Disabled



Caching & Multitenancy

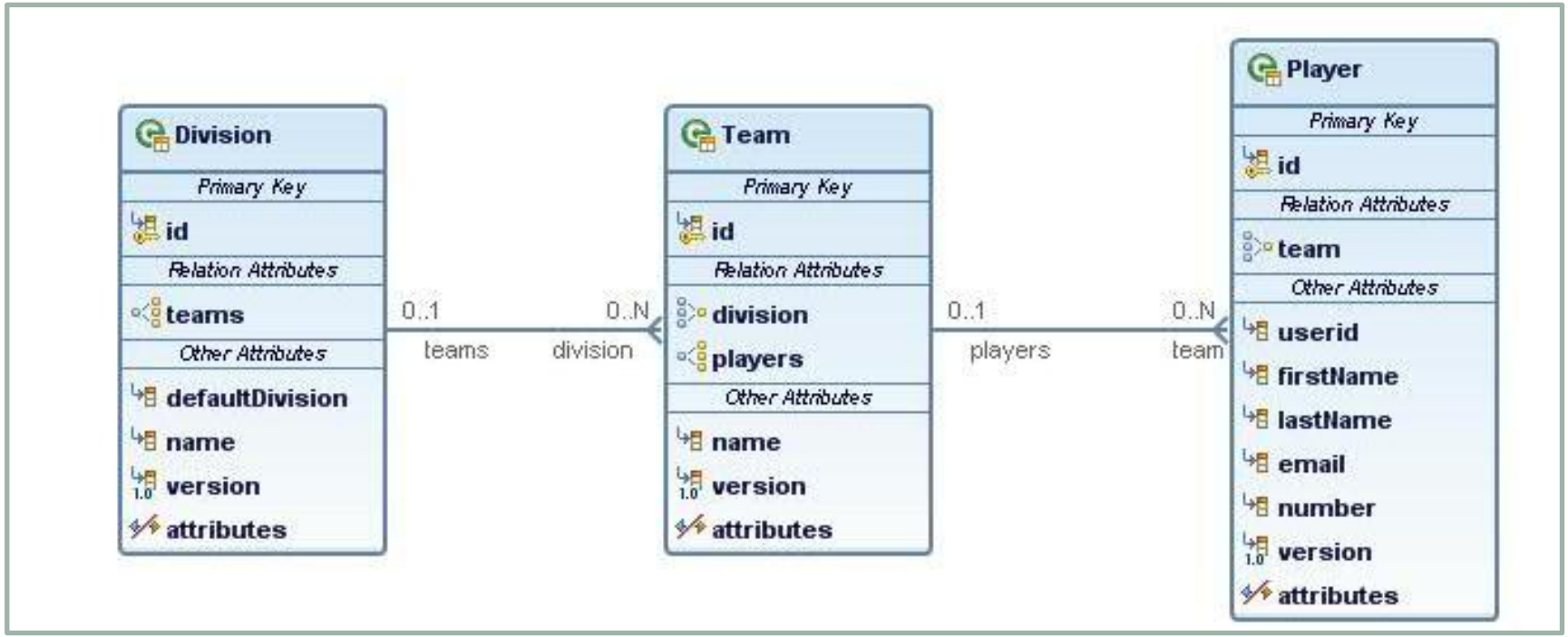
- EntityManagerFactory/Tenant—Shared Cache



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
  - http://wiki.eclipse.org/EclipseLink/Examples/MySports

MySports Demo Model

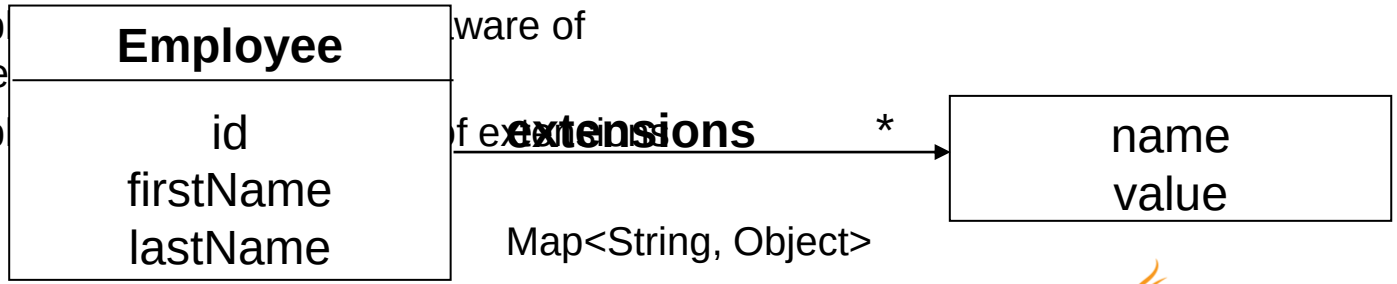


DEMO—MYSPORTS MULTITENANCY

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
  - App ware of exte
  - App f extensions



Flex Extensions

```
@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);
}
```

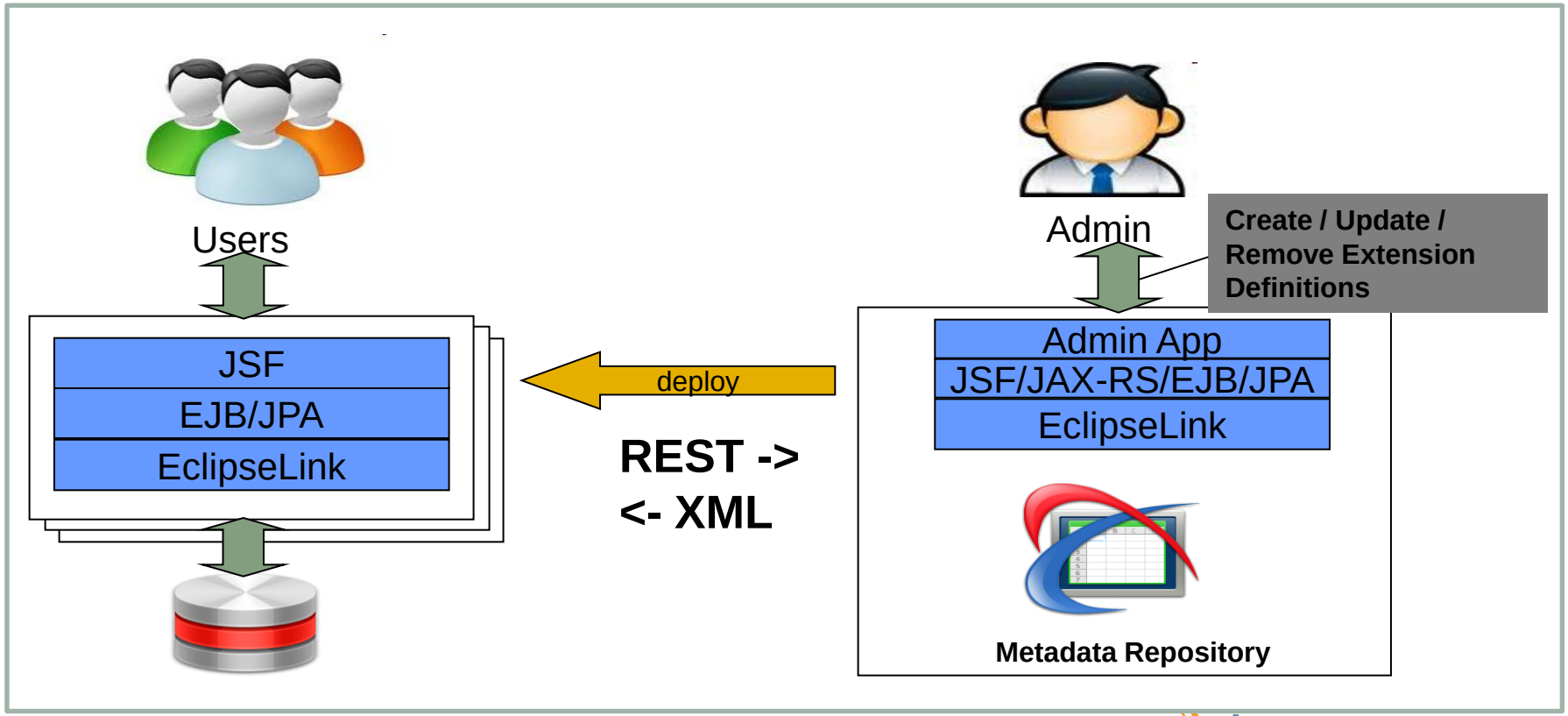
PLAYER

ID	F_NAME	L_NAME	FLEX_1	FLEX_2
1	John	Doe	‘R’	’22’
2	Jane	Smith	‘NONE’	

Virtual Access Mappings

```
<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>
```

MySports Architecture



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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


Java™