Middleware and Web Services

Lecture 5: Application Server Architecture

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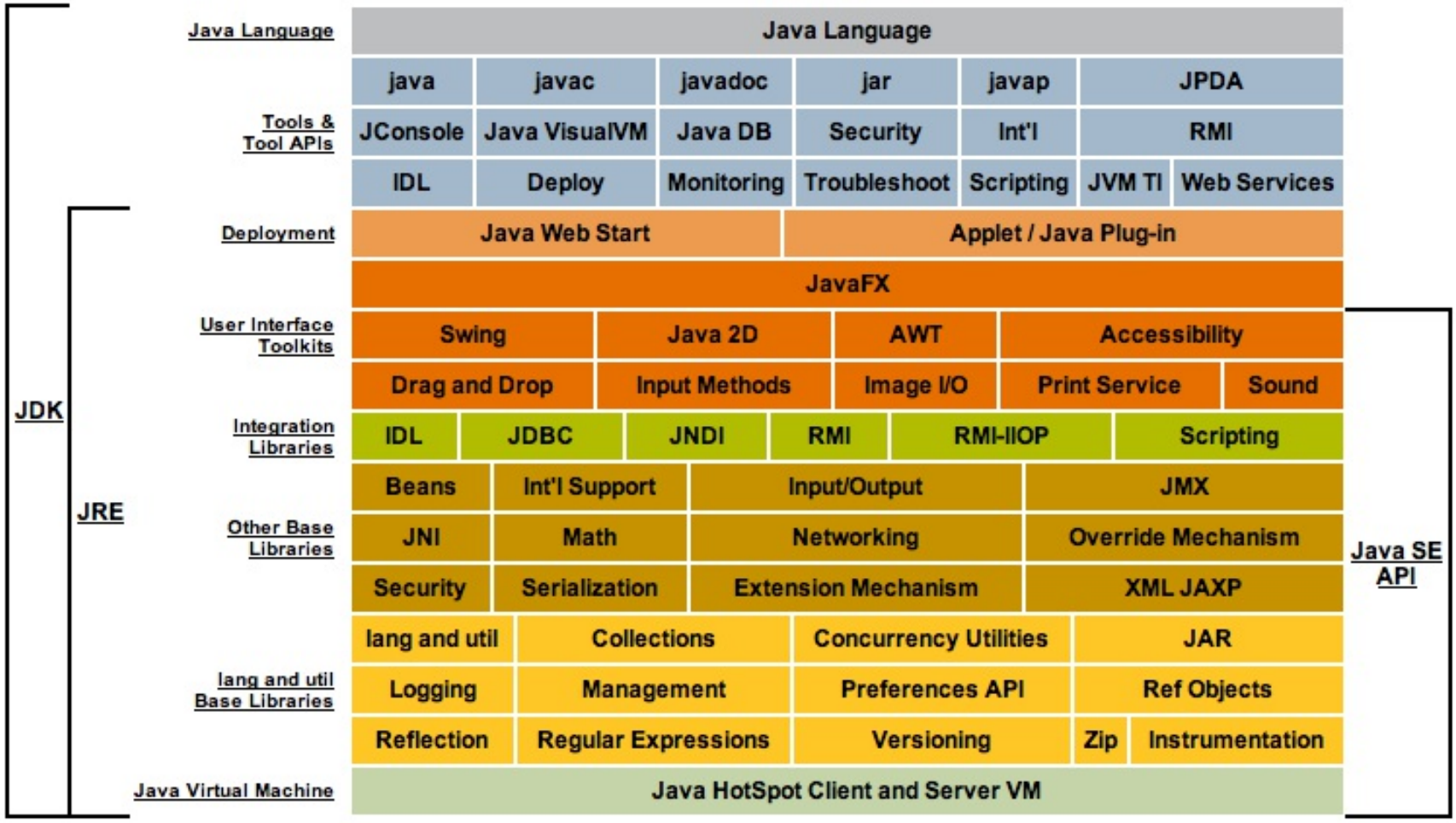
Overview

- Architecture
- Servlet Technology
- Java Technologies and Services

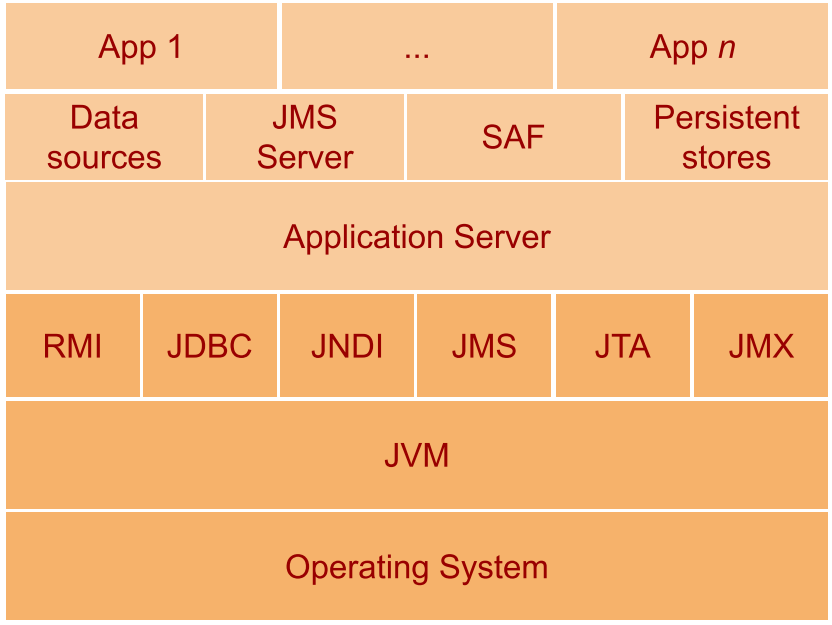
Application Server Overview

- An environment that runs an application logic
  - *A client communicates with the server using an application protocol*
- Application Server
  - *A modular environment*
    - → *provides technology to realize enterprise systems*
    - → *JEE containers – Java technology for AS components*
    - → *Supports a variety of objects such as Servlets, JSPs, JMS*
  - *Provides services such as naming and directory, performance, failover*
  - *Provides Web server capabilities*
  - *Can be a single server or multiple servers*
- Web Tier – HTTP Server
  - *Web Server supports HTTP only*
  - *HTTP request/response, security, proxy, caching*

Standard Java Technology Stack



Application Server Layers



console app, custom-built Web app, middleware apps

shared services used by applications - data sources, JMS queues, JCA adapters

Application Server core libraries, communication management, cluster communication, distributed cache

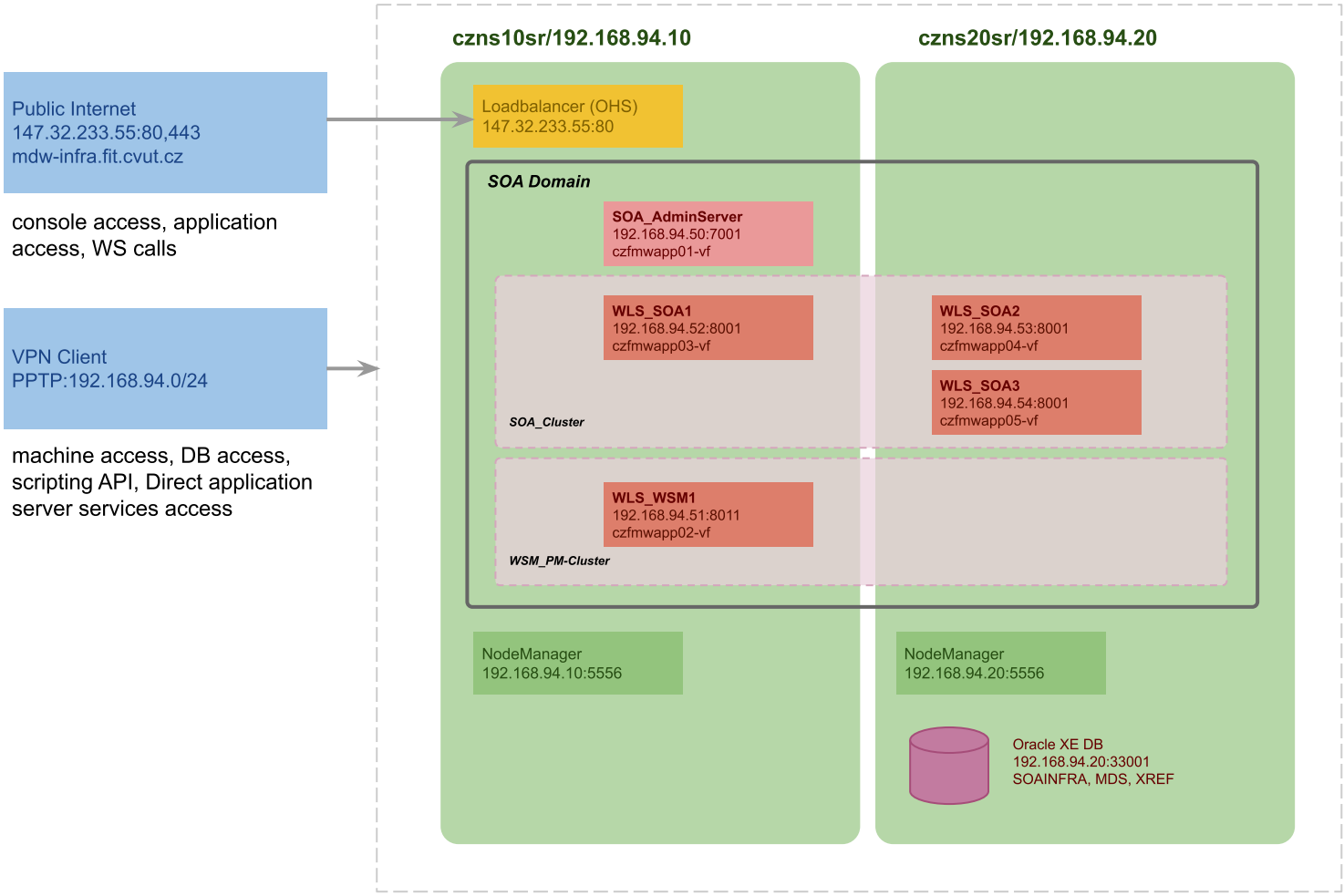
Java Technology

Java environment, memory management, garbage collection

OS services, I/O

- Features
  - *AS instance appears as a single process in the OS*
    - *→ you can use standard OS commands to investigate its operation*
    - *→ AS listens on a single or multipe IPs (VIPs) and a tcp port*
  - *AS is a Java process*
    - *→ you can use Java tools to investigate its operation*
    - *→ Garbage collector stats, thread dumps, memory allocations, etc.*

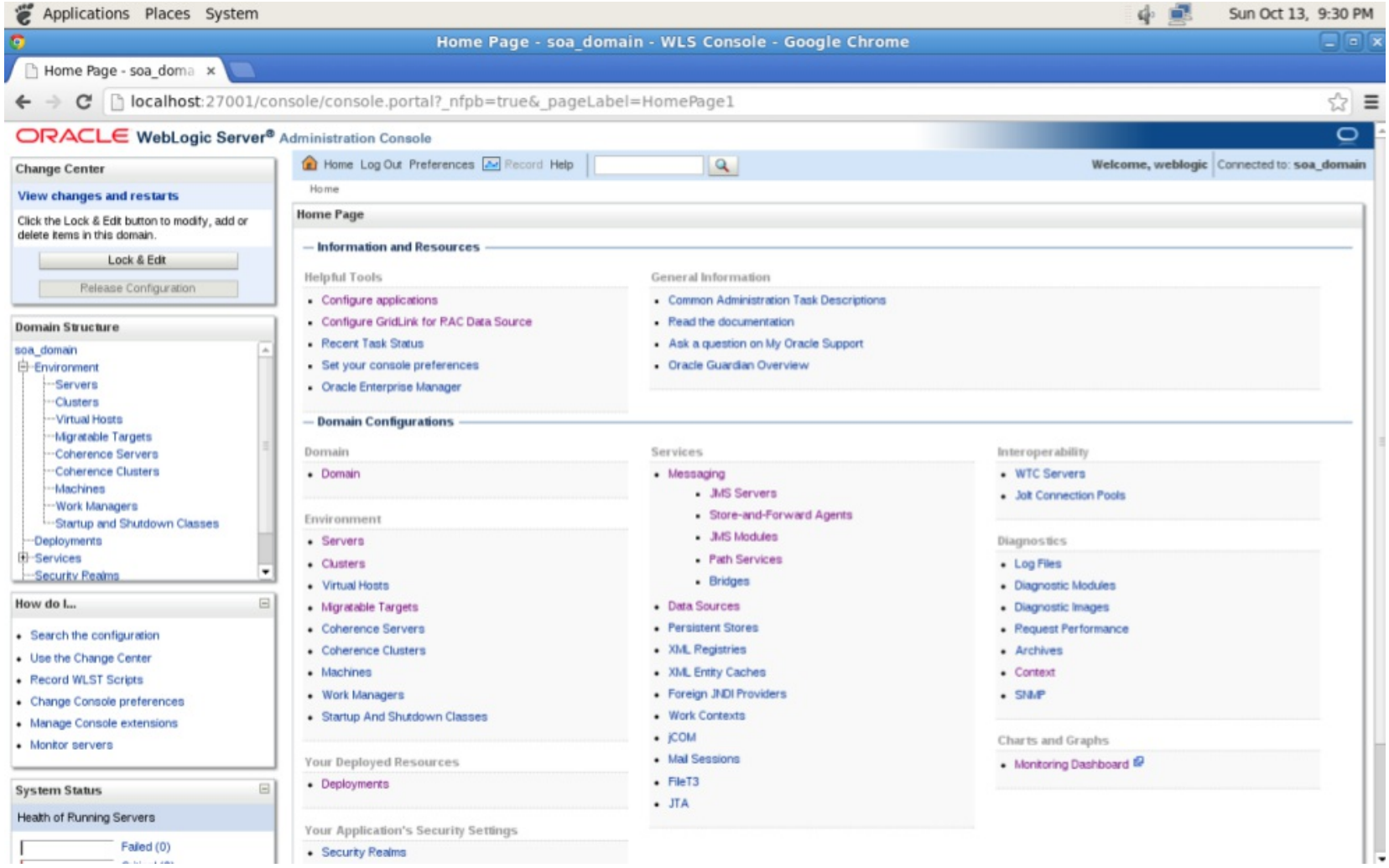
Example Weblogic Infrastructure



Terminology

- Domain
  - *A group of servers with specific configuration of applications and objects*
- Administration Server
  - *An instance of application server that manages the domain*
- Managed Server
  - *An instance of application server running instances of applications and objects*
- Cluster
  - *A group of managed servers; they contain the same copy of applications and objects*
- Machine
  - *A physical machine and OS running one or more servers (Admin or Managed)*
- Node Manager
  - *A process that provides an access to admin and managed servers on the machine*
- Load Balancer
  - *A network element that distributes client requests to managed servers based on a specific algorithm*

Console Example – Weblogic Server



Application Server from the OS View

- Process ID, command line arguments

```
$ ps ax | grep WLS_SOA
 1820 ?        Sl   289:15 /opt/oracle/jrockit/bin/java -jrockit
 -Xms768m -Xmx1536m -Dweblogic.Name=WLS_SOA1 -Djava.security.policy=
 /opt/oracle/11g/fmw/wlserver_10.3/server/lib/weblogic.policy
 -Dweblogic.ProductionModeEnabled=true
 ...
```

- Open files by the process

```
$ ll -l /proc/1820/fd
 lr-x------ 1 oracle oinstall 64 Oct 12 16:53 0 -> /dev/null
 l-wx------ 1 oracle oinstall 64 Oct 12 16:53 1 -> /opt/oracle/11g/domains/soa_domain/serv
 lr-x------ 1 oracle oinstall 64 Oct 12 16:53 10 -> /opt/oracle/11g/fmw/oracle_common/modu
 lr-x------ 1 oracle oinstall 64 Oct 12 16:53 100 -> /opt/oracle/11g/fmw/modules/com.bea.c
 ...
```

- Open sockets by the process

```
$ netstat -anp | grep 1820
tcp  0 0 192.168.94.52:8001      0.0.0.0:*               LISTEN      1820/java
tcp  0 0 192.168.94.10:8088      0.0.0.0:*               LISTEN      1820/java
tcp  0 0 192.168.94.10:39763     192.168.94.20:33001     ESTABLISHED 1820/java
tcp  0 0 192.168.94.52:8001      192.168.94.20:59589     ESTABLISHED 1820/java
tcp  0 0 192.168.94.10:33498     192.168.94.20:33001     ESTABLISHED 1820/java
tcp  0 0 192.168.94.10:33504     192.168.94.20:33001     ESTABLISHED 1820/java
 ...
```

Application Server from the JVM View

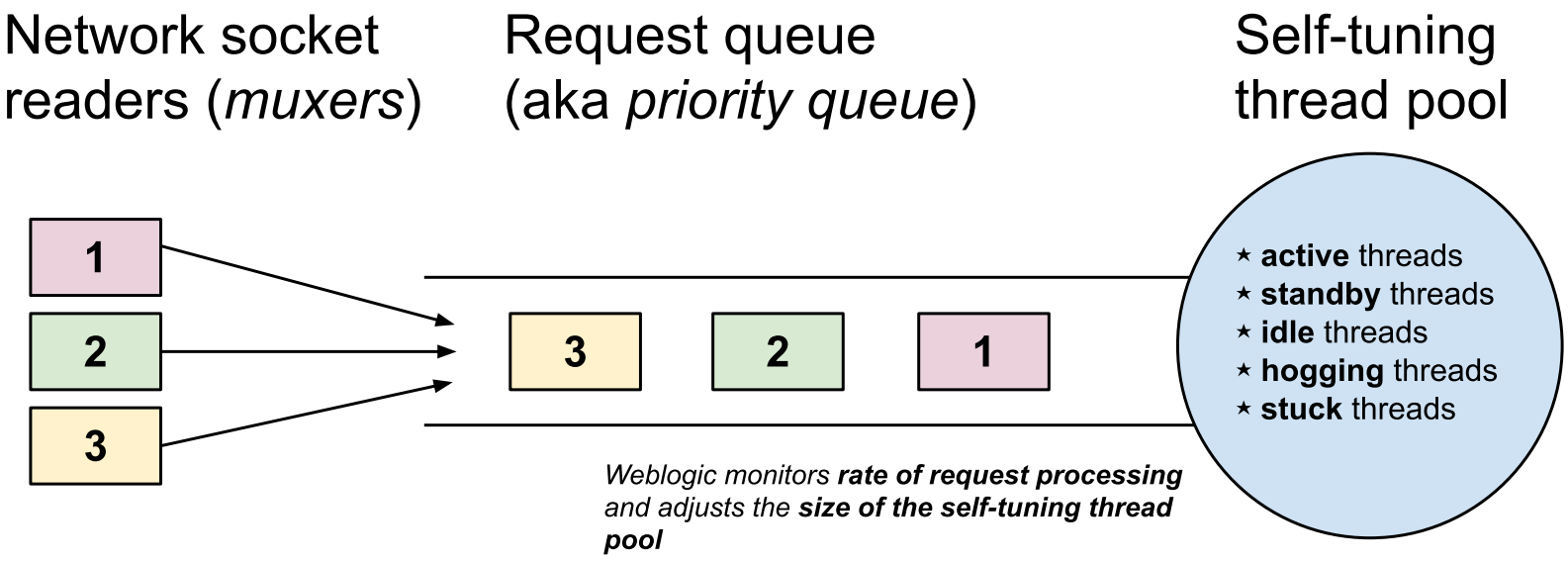
- Thread dumps
  - *All threads that the application server uses, a snapshot on all the threads*
  - *Prints stack trace of currently run threads*

```
5 | $ jrockit 1820 print_threads
```

- Command line arguments
  - *Prints all command line arguments of the JVM process*
    - *→ Memory settings, log file locations, etc.*

```
5 | $ jrockit 1820 command_line
```

Handling Requests in Weblogic



- **Muxer** – component that handles communication via network sockets.
- **Request queue** – queue of requests to be processed.
- **Self-tunning thread pool** – a pool of threads in various states.
- **Work manager** – a configuration of **maximum threads** and a **capacity** that can be used to handle requests for a specific application/service.

Overview

- Architecture
- Servlet Technology
- Java Technologies and Services

Overview

- Technology to extend application server functionalities
  - *A Java class that can respond to any type of requests*
    - → *A servlet defines an interface for a specific protocol*
    - → *Your application implements the servlet's interface*
- Commonly used to respond to HTTP requests
  - *A basis for an application running on an application server*
  - *HTTP Servlet Java classes*
    - → `HttpServlet` – *provides HTTP protocol interface*
    - → `HttpServletRequest` – *represents HTTP request*
    - → `HttpServletResponse` – *represents HTTP response*

Directory Structure

- Your application
  - *collection of documents and libraries your application requires*
  - *packaged in* `war` *or* `ear` *archive*
    - → *JAR that includes not only java classes but also additional resources such as* `.xml`, `.html`, `.js`, `.css`, `.jpg` *files.*
- Content of `war` package

```
# web archive root
war
 |   # directories and documents accessible through the app root /
 |   # such as img, css, js, ...
 |-- (public-directory | public-document)*
 |   # directories and documents internal to your application
 |-- WEB-INF
        |-- (private-directory | private-document)*
        |   # compiled java classes of your application
        |-- classes
        |   # all java libraries your application requires
        |-- lib
        |   # configuration of your application
        |-- web.xml
        |-- # other platform-specific configurations
            # such as app-engineweb.xml for GAE
```

Configuration in web.xml

- `web.xml` defines configuration for
  - *list of servlets, mapping of servlets to URL paths, welcome files, filters, EJB references, authentication mechanism, etc.*
  - *basic configuration example:*

```xml
<?xml version="1.0" encoding="utf-8"?>
<web-app
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns="http://java.sun.com/xml/ns/javaee">

    <servlet>
        <servlet-name>main</servlet-name>
        <servlet-class>com.vitvar.mdw.main</servlet-class>
    </servlet>

    <servlet-mapping>
        <servlet-name>main</servlet-name>
        <url-pattern>/</url-pattern>
    </servlet-mapping>

    <welcome-file-list>
        <welcome-file>index.jsp</welcome-file>
    </welcome-file-list>
</web-app>
```

Handling HTTP Requests

- HTTP Servlets
  - *Servlet is a class that extends capabilities of application servers via a request-response programming model*
  - *HTTP servlets are classes that extend* `HTTPServlet` *abstract class*
  - *Example:*

```java
package com.vitvar.mdw;

import javax.servlet.http.HttpServlet;
import javax.servlet.http.HttpServletRequest;
import javax.servlet.http.HttpServletResponse;

public class Main extends HttpServlet {
    public doGet(HttpServletRequest request, HttpServletResponse response) {
        // GET method implementation here
    }

    public doPost(HttpServletRequest request, HttpServletResponse response) {
        // POST method implementation here
    }

    // other methods such as doPost, doDelete, doOptions
}
```

Support for Sessions

- `HttpSession` interface
  - *Allows to store session data in the memory*
  - *Java API for HTTP State Management*
    - → *Hides details from developers*

```
1  // method doGet in a servlet
2  public doGet(HttpServletRequest request, HttpServletResponse response) {
3      // access the session object through the request
4      HttpSession session = request.getSession();
5
6      // unique identification of the session, the value used for the cookie
7      String id = session.getId();
8
9      // get the value of the attribute
10     Object value = session.getAttribute("data");
11
12     // set the value of the attribute
13     session.setAttribute("data", new String("some data"));
14
15     // this will set a max-age of the session cookie
16     session.setMaxInactiveInterval(3600);
17 }
```

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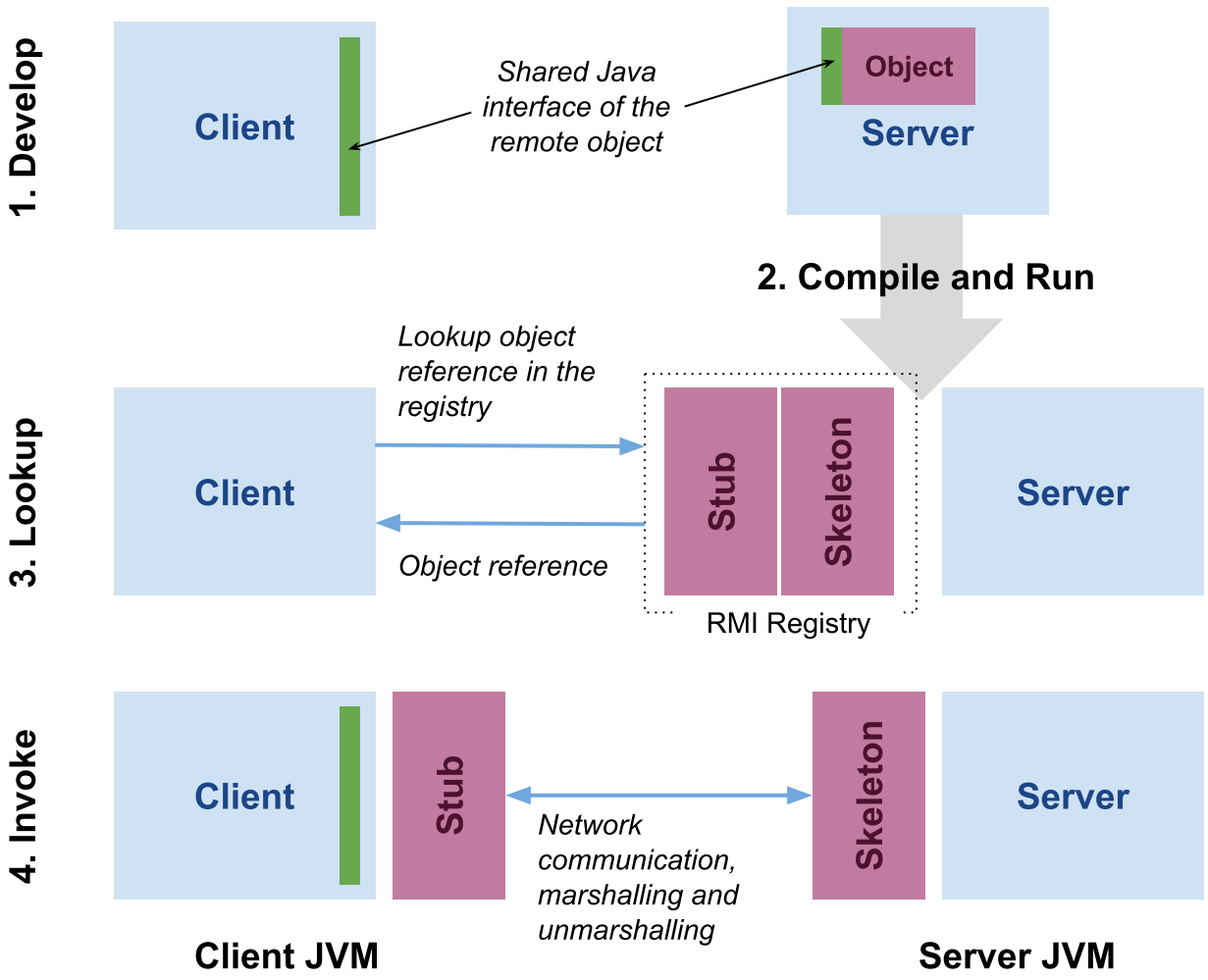
  - *Remote Method Invocation*
  - *Java Database Connectivity*
  - *Java Naming and Directory Interface*
  - *Application Server and JNDI*
  - *Two-phase Commit*

Overview

- Communication among Java-based applications
  - *Methods of a Java class can be invoked by other Java class remotely*
  - *Uses Java Remote Method Protocol (JRMP)*
    → Java-specific application protocol over TCP/IP
  - *Basis for JEE technologies, such as JMS*
- Terminology
  - ***Client*** *– a program that invokes a remote method*
  - ***Server*** *– a program that exports a remote object*
  - ***Stub*** *– a representation of the client-side object for communication*
  - ***Skeleton*** *– a representation of the server-side object for communication*
  - ***Registry*** *– a component that holds a stub*
  - ***Marshalling/Unmarshalling*** *– a process of transforming memory representation of the object to a form suitable for network transmittion and vice-cersa*

Architecture



RMI Implementation in Java – Interface

- Shared interface

```java
import java.rmi.Remote;
import java.rmi.RemoteException;

// shared interface between a client and a server to
// invoke methods on the remote object
public interface HelloRMIInterface extends Remote {
    public String calculate(int a, int b) throws RemoteException;
}
```

- RMI Server

```java
import java.rmi.Naming;
import java.rmi.RemoteException;
import java.rmi.RMISecurityManager;
import java.rmi.server.UnicastRemoteObject;
import java.rmi.registry.LocateRegistry;

public class Server extends UnicastRemoteObject implements HelloRMIInterface {

    // implementation of the interface method
    public int calculate(int a, int b) throws RemoteException {
        return a+b;
    }
```

RMI Implementation in Java – Server

- RMI Server (cont.)

```
1  // start the server and register the object in the rmi registry
2  public static void main(String args[]) {
3      try {
4          // install a security manager (uses a security policy)
5          if (System.getSecurityManager() == null) {
6              RMISecurityManager sm = new RMISecurityManager();
7              System.setSecurityManager(sm);
8          }
9
10         // create rmi registry
11         LocateRegistry.createRegistry(1099);
12
13         // create remote object
14         Server obj = new Server();
15
16         // Bind the object instance to the name "HelloRMI"
17         // 0.0.0.0 denotes the service will listen on all network interfaces
18         Naming.rebind("//0.0.0.0/HelloRMI", obj);
19
20         System.out.println("RMI server started, " +
21             "listening to incoming requests...");
22     } catch (Exception e) {
23         System.out.println("Error occurred: " + e.getLocalizedMessage());
24     }
25 }
```

RMI Implementation in Java – Client

- RMI Client

```
1  import java.rmi.Naming;
2
3  public class Client {
4
5      public static void main(String args[]) throws Exception {
6          // get a reference to the remote object
7          // assuming the server is running on the localhost
8          HelloRMIInterface o = (HelloRMIInterface)
9              Naming.lookup("//localhost/HelloRMI");
10
11         // call the object method
12         System.out.println(o.calculate(6, 4));
13     }
14 }
```

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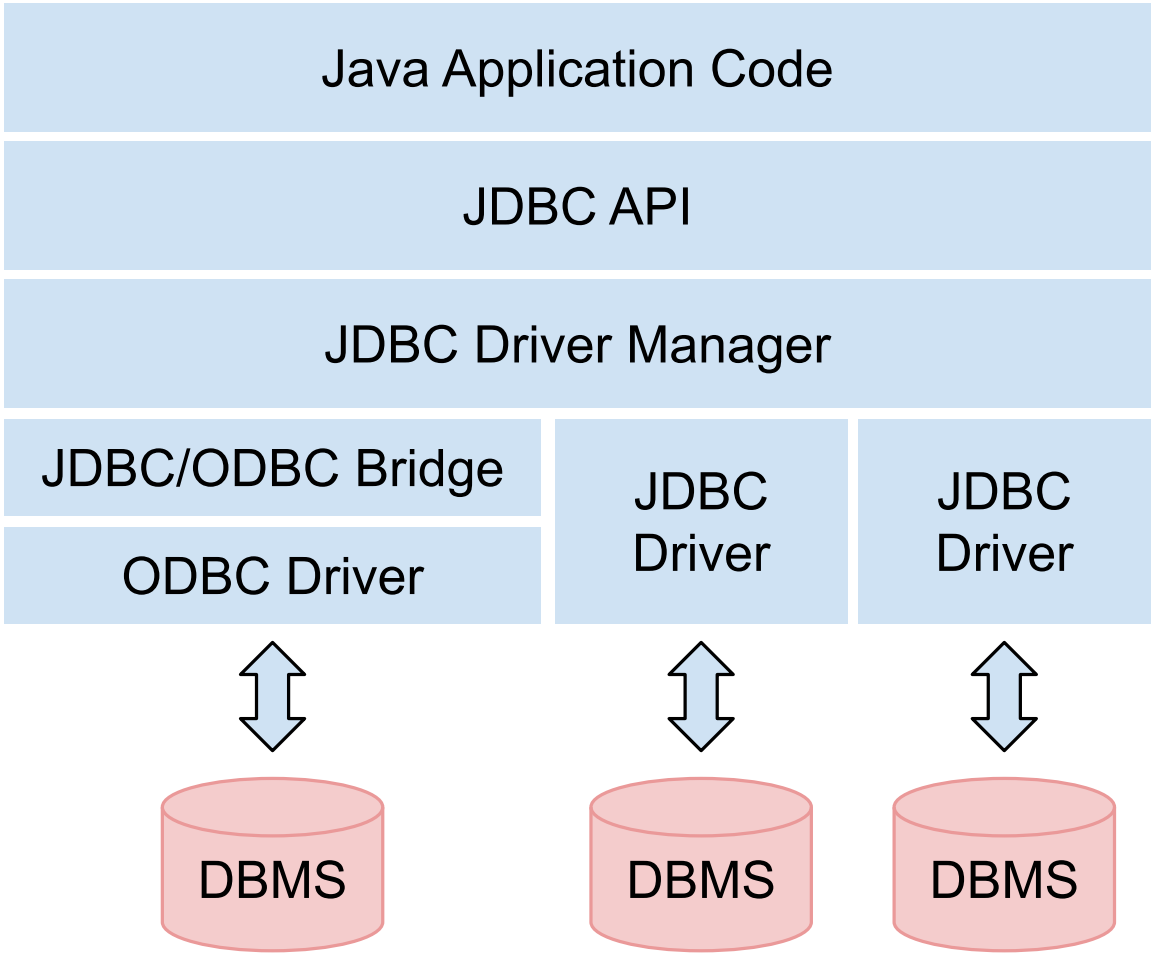
Overview

- Uniform API to access any kind of tabular data
  - *No need to deal with specific APIs of DBMS vendors*
- JDBC components
  - *JDBC API*
    → *defines methods to execute SQL statements and retrieve results*
  - *Driver Manager*
    → *provides drivers that provide access to a specific DBMS*
    → *they implement a specific protocol to access the DBMS*
  - *JDBC-ODBC Bridge*
    → *a software bridge which provides access via ODBC drivers*
    → *ODBC driver is a driver in C for accessing DBMS*

JDBC Architecture



JDBC Example Implementation in Java

- JDBC Client

```
1  import java.sql.*;
2
3  public class JDBCClient {
4
5      public static void main(String args[]){
6      // database url
7      String db_url = "jdbc:oracle:thin:@czns20sr:33001:XE";
8
9      // username and password
10     String username = "myUsername";
11     String password = "myPassword";
12
13     try {
14         // Register JDBC driver
15         Class.forName("oracle.jdbc.driver.OracleDriver");
16
17         // Open a connection
18         Connection con = DriverManager.getConnection(
19         db_url, username, password);
20
21         // Create and execute query statement
22         Statement stmt = con.createStatement();
23         String sql = "SELECT id, first, last, age FROM Employees";
24         ResultSet rs = stmt.executeQuery(sql);
25
```

JDBC Example Implementation in Java

- JDBC Client (cont.)

```
25              // Loop and extract received data
26              while (rs.next()) {
27                  int id  = rs.getInt("id");
28                  int age = rs.getInt("age");
29                  String first = rs.getString("first");
30                  String last = rs.getString("last");
31              }
32
33              // Release the connections
34              rs.close();
35              stmt.close();
36              conn.close();
37          }catch(SQLException se){
38
39              //Handle errors for JDBC
40              se.printStackTrace();
41          }catch(Exception e){
42
43              //Handle errors for Class.forName
44              e.printStackTrace();
45          }
46      }
47  }
48
```

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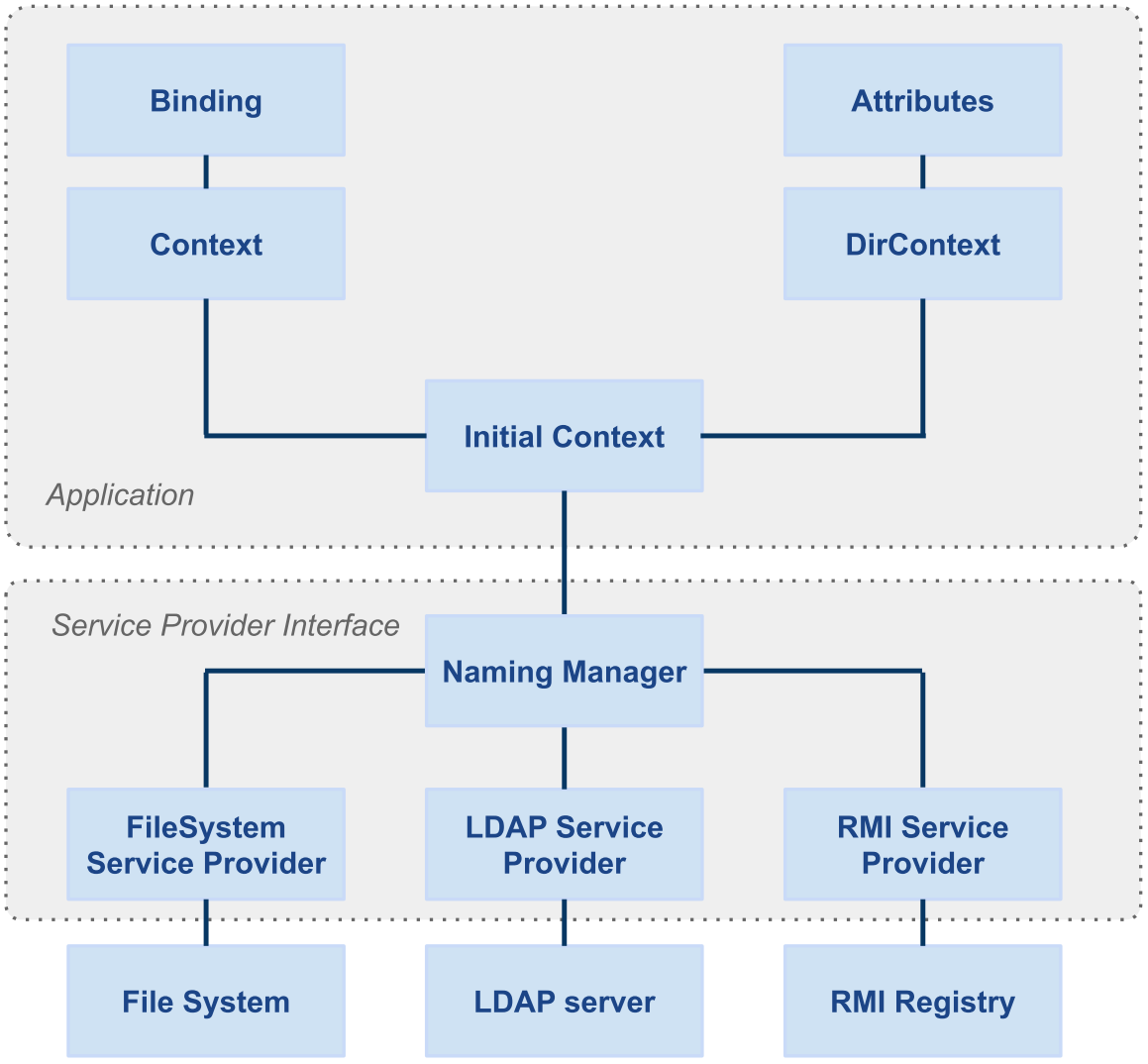
Overview

- Objectives
  - *Allows to access objects by names in various directory systems and their attributes*
  - *Independent of any specific directory service implementation*
  - *Enables to distribute Java objects across various systems in the environment*
- Terminology
  - *Binding – association between a name and a object*
  - *Context – a set of bindings*
- JNDI Provides:
  - *a mechanism to bind an object to a name.*
  - *a directory lookup interface*
  - *a pluggable service provider interface (SPI) – any directory service implmentation can be plugged in*

JNDI Packages

- Naming Package
  - *interfaces to access naming services*
  - *Context: looking up, binding/unbinding, renaming, objects*
- Directory Package
  - *allows to retrieve attributes of objects, and to search for objects*
- Event Package
  - *allows for event notification in naming and directory services*
  - *For example, object was added, object changed, etc.*
- Other packages
  - *LDAP – allows to access LDAP services*
  - *Service Provider Interface – allows to develop various naming/directory services*

JNDI Architecture



Application Server and JNDI

- Distribution of objects
  - *Application Server provides central directory for various kinds of objects*
    → Datasources, JMS queues and topics, etc.
  - *Clients store objects in the central directory*
    → Administrator configures objects using Application Server Console or via AS API
  - *Clients retrieve objects from the central directory*
- Benefits
  - *replication of objects across clients*
  - *central configuration of objects' parameters*
  - *scalability – allowing/disabling connections as required*

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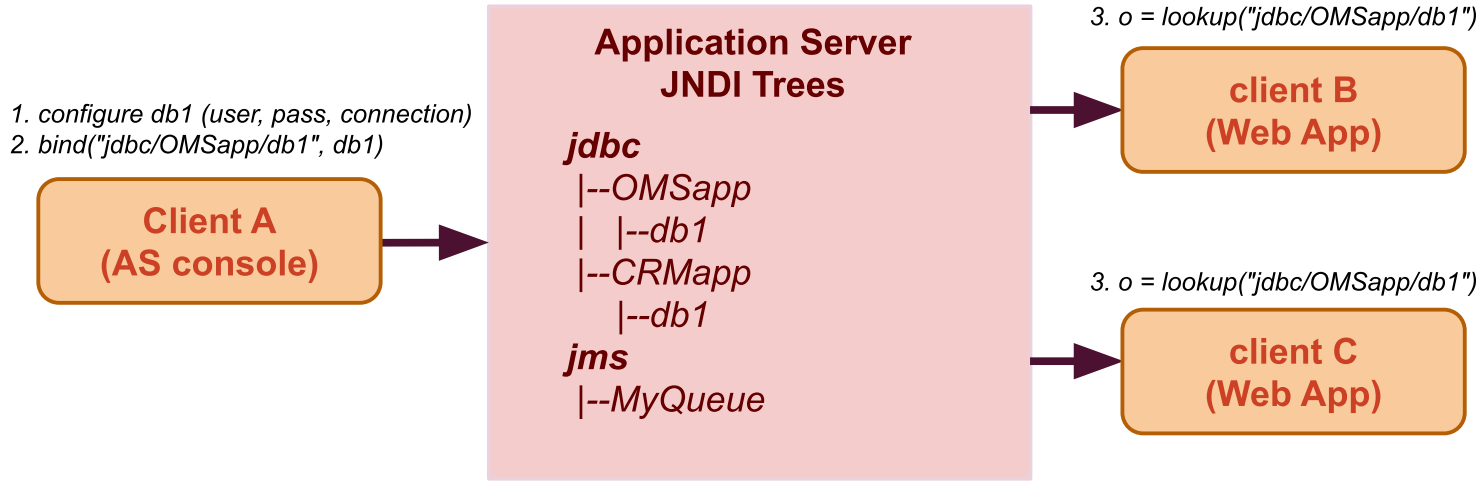
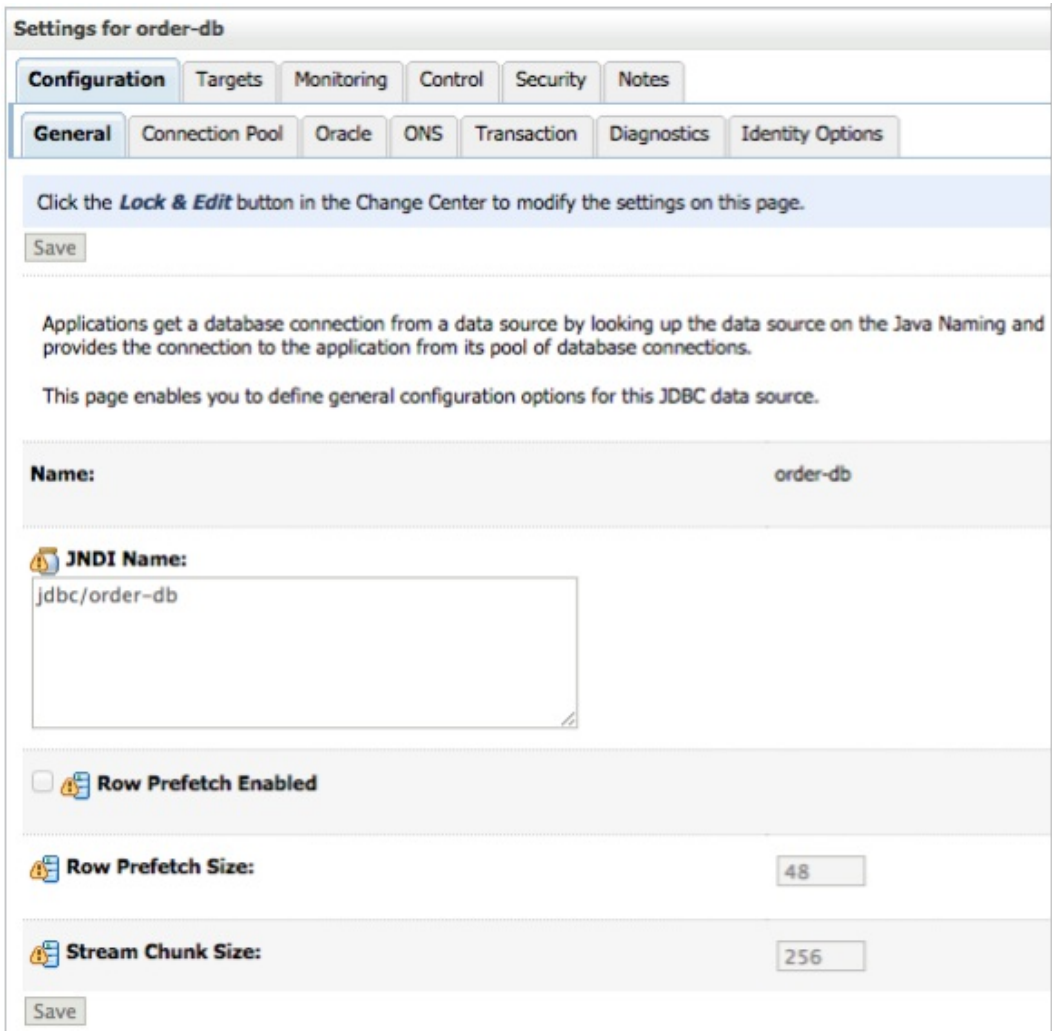
Application Server and JNDI



- Example Scenario
  - *Client A creates a datasource, configures it and registeres it in the JNDI tree*
    - → *Client A is a Admin server console app; this task is performed by the administrator*
  - *Client B and C lookup the object under specific JNDI name and retrieves the object from the tree*
    - → *They get the object from the tree and use it to connect to the DB*
    - → *They do not need to know any DB specific details, the object is pre-configured from the server*

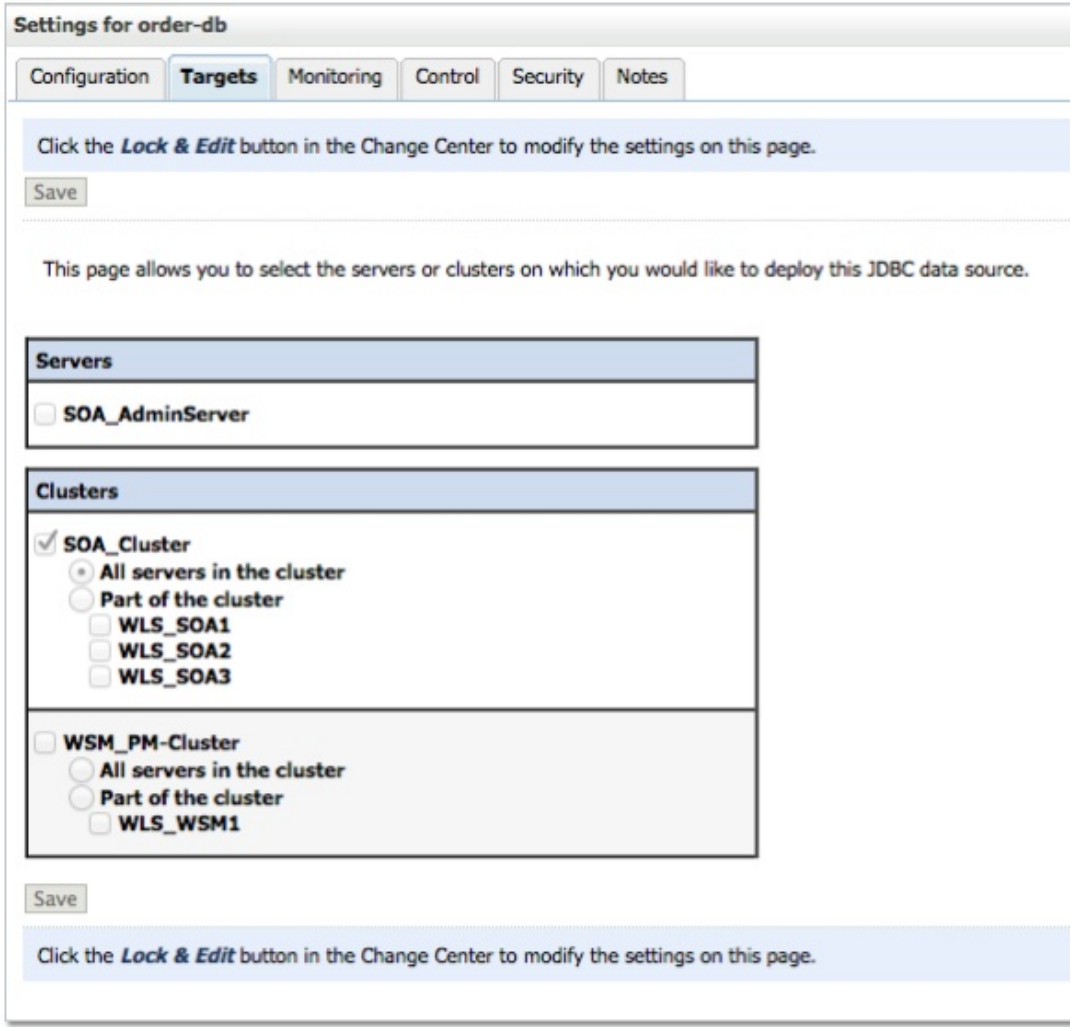
Example Datasource in Weblogic



Targets

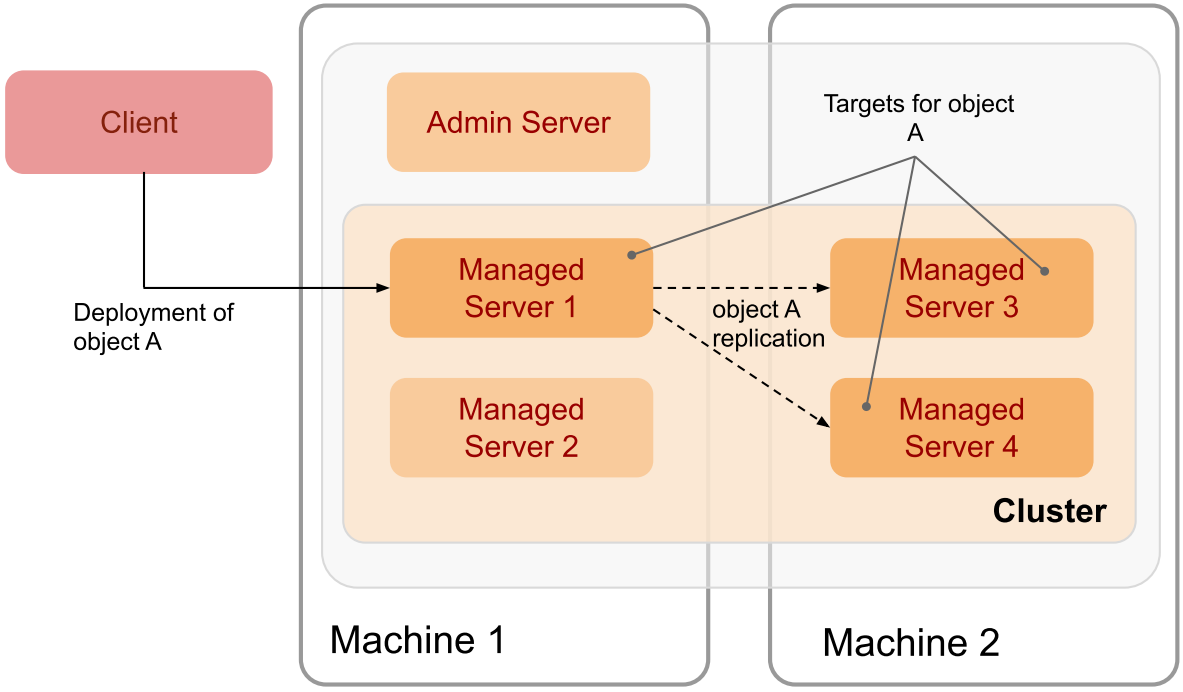
- Object
  - *A service provided by the applicaton server, e.g. datasources, JMS queue, SAF*
- Types of services
  - *Pinned services*
    → *Objects targeted to a single server only*
  - *Cluster services*
    → *Objects targeted to all servers in the cluster*

Example Target Configuration



Deployment to Cluster

- Deployment of an object
  - *Client deploys to one managed server in the cluster*
  - *Object gets replicated to its targets*
    - → *Targets can be configured for the object, usually all servers but can be selected servers*

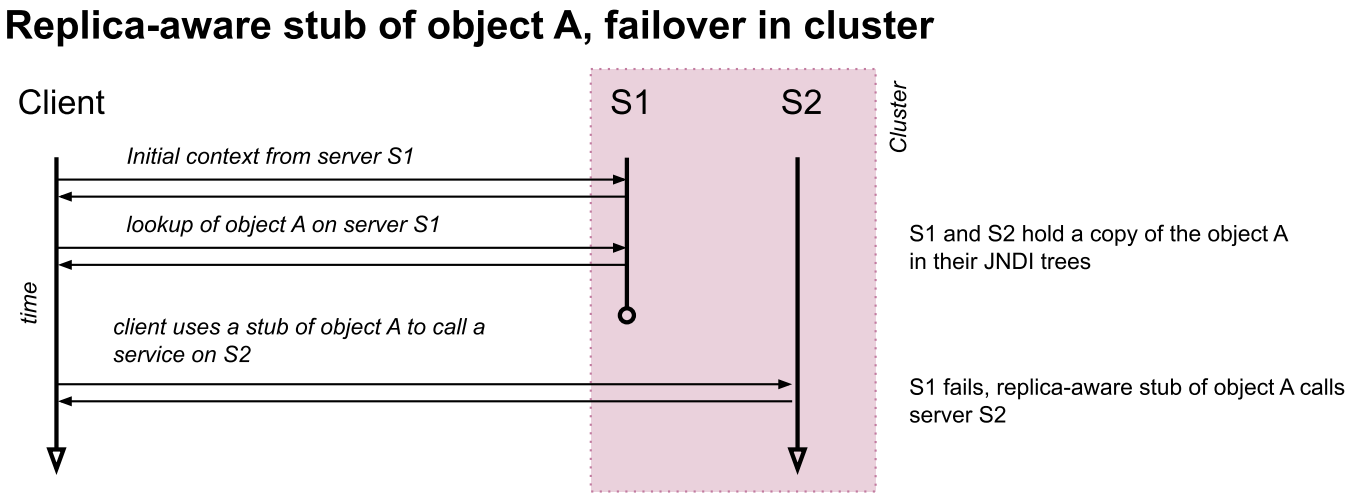


Cluster-wide JNDI Tree

- Cluster
  - *Every managed server has its own JNDI tree*
  - *Servers in a cluster sync up their JNDI trees as per the target configuration*
    - *→ A stub of the object appears in every managed server's JNDI tree*
    - *→ They use JNDI replication service (see Lecture 6)*
- When a client retrieves an object from the tree
  1. *Client connects to the cluster using the cluster address*
  2. *Client creates an initial context (represents a naming service)*
  3. *Client uses the initial context to lookup objects*
  4. *Client uses the stub of the object to call the service*

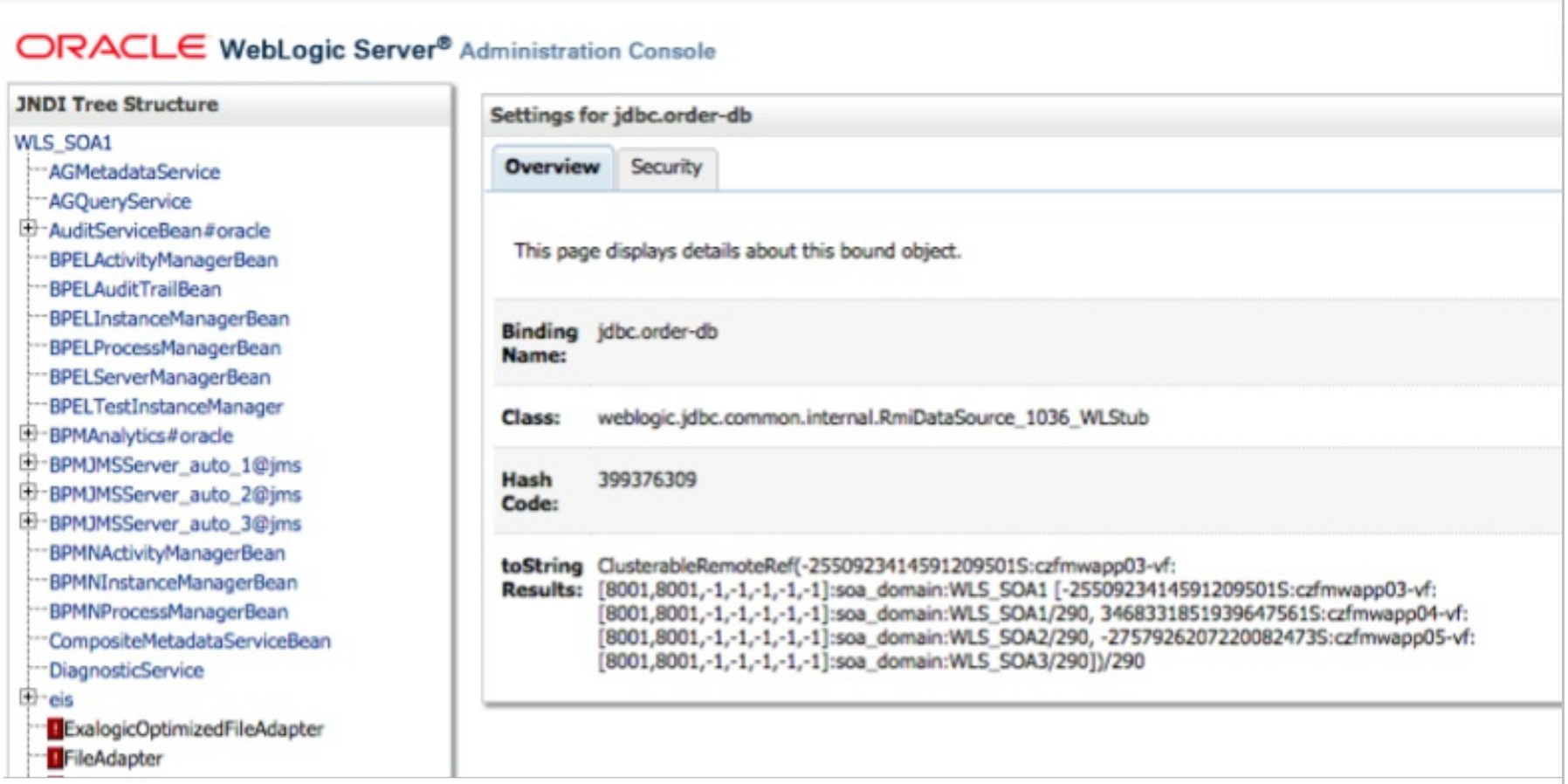
Object Failover

- Failover
  - *Failover = ability to locate an object on another server that holds a copy of the object without impact on the performace and configuration*



  - *A client gets a stub of the object by calling* `lookup` *on the context*
  - *A client uses the stub of the object to access the object on the server*
  - *When a server fails, replicate-aware stub calls the next server that holds the object copy*

Example JNDI Tree on Weblogic Server



JNDI Implementation in Java

- Lookup for bound object

```
1  import javax.naming.InitialContext;
2  import java.util.*;
3  import javax.sql.*;
4
5  ...
6
7  Properties p = new Properties();
8
9  // configure the service provider url: "t3://localhost:7001"
10 p.put(Context.PROVIDER_URL,
11     "t3://czfmwapp03-vf:8001,czfmwapp04-vf:8001,czfmwapp05-vf:8001");
12
13 // configure the initial context factory.
14 // we use WebLogic context factory
15 p.put(Context.INITIAL_CONTEXT_FACTORY,
16         "weblogic.jndi.WLInitialContextFactory");
17 InitialContext ctx = new InitialContext(p);
18
19 dataSource =
20     (DataSource) ctx.lookup("jdbc/order-db");
21
22 // invoke the object method
23 Connection c = dataSource.getConnection();
24
```

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Overview

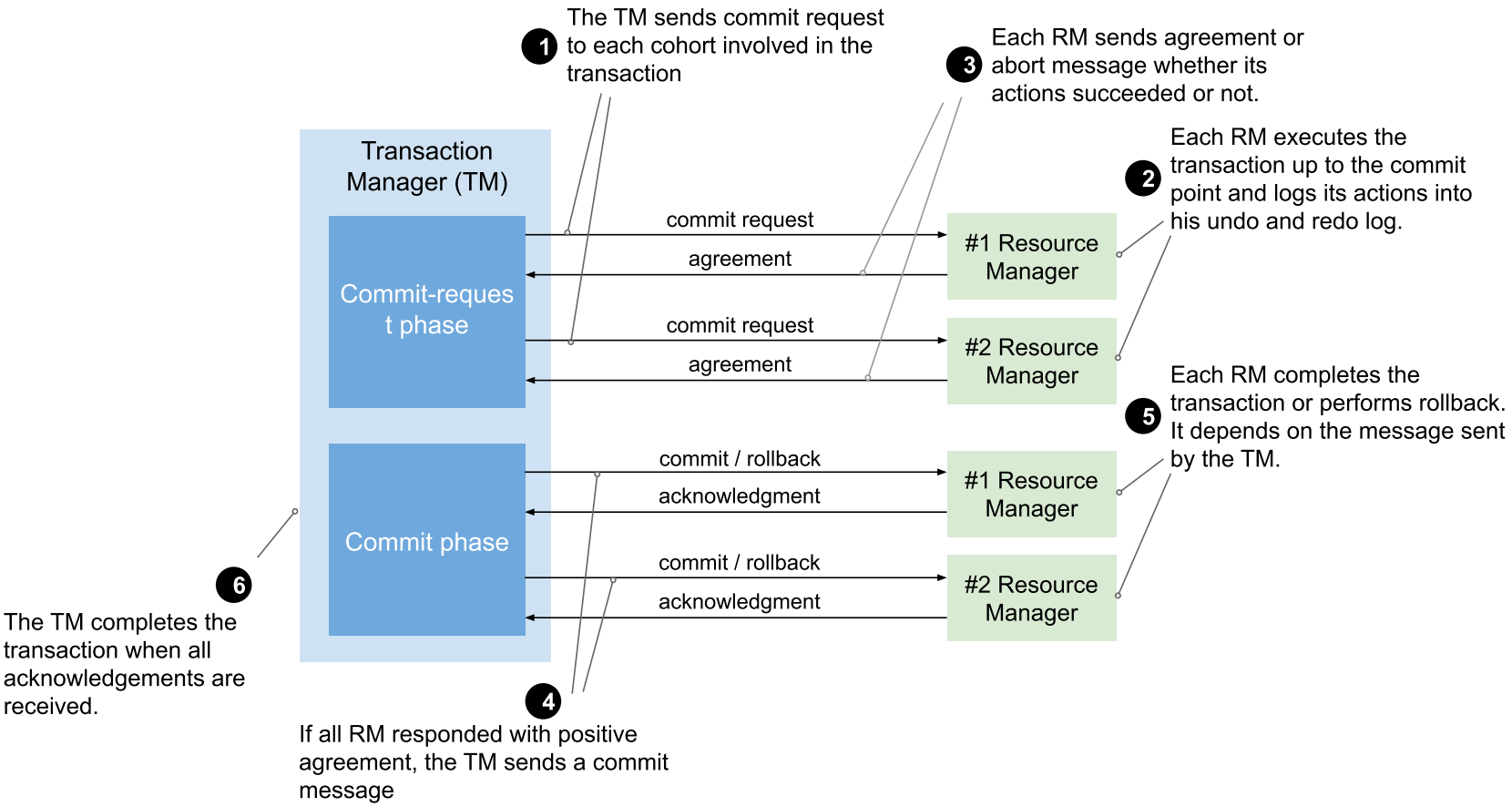
- Coordination of a distributed transaction
  - *All transaction operations are completed across multiple resources; or none is completed*
  - *Able to deal with many types of failures (process, network, communication)*
- Terminology
  - ***Transaction Manager*** *– manages transactions, coordinates decisions for commit or rollback, and coordinates failure recovery*
  - ***Resource Manager*** *– manages an access to a resource that participates in the transacction, e.g. DBMS, JMS*
  - ***Agreement*** *– an agreement message send by the Resource Manager, whether the operation was processed successfuly*
  - ***Acknowledgment*** *– a message about a status of the operation execution*
  - ***Rollback*** *– operation that returns the Resource Manager state to its pre-transaction state.*

X/Open – eXtended Architecture (XA)

- Standard for executing distrubuted transactions
  - *Specifies how the coordinator will roll up the transaction against involved different systems.*
  - *Based on the Two-phase Commit protocol.*
  - *Defines interface between the coordinator and each system node.*
  - *Single transaction access to multiple resources (e.g. message queues, databases, etc.)*
  - *Defined in the eXtended Architecture Specification*
- Wide technological support
  - *Java Transaction API (JTA) – distributed transactions in a Java environment.*
  - *Supported in the Oracle Service Bus through a JMS queue.*
  - *MySQL Relational Database Management System (since v5.0)*

Two-phase Commit

- Two-phase commit scenario



XA Example Implementation in Java

- Distributed Transaction

```
1  import java.sql.*;
2  import javax.sql.*;
3  import javax.naming.*;
4  import java.util.*;
5
6  public class Server {
7
8      public static void main(String args[]) {
9
10       // Initialize context
11       Hashtable parms = new Hashtable();
12       parms.put(Context.INITIAL_CONTEXT_FACTORY,
13             "weblogic.jndi.WLInitialContextFactory");
14       parms.put(Context.PROVIDER_URL, "t3://localhost:7001");
15       InitialContext ctx = new InitialContext(parms);
16
17       // Perform a naming service lookup to get UserTransaction object
18       javax.transaction.UserTransaction usertx;
19       usertx = (UserTransaction) ctx.lookup("java:comp/UserTransaction");
20
21       try {
22           //Start a new user transaction.
23           usertx.begin();
```

XA Example Implementation in Java

- Distributed Transaction (cont.)

```
24  // Establish a connection with the first database
25  javax.sql.DataSource data1;
26  data1=(javax.sql.DataSource)ctx.lookup("java:comp/env/jdbc/DataBase1");
27  java.sql.Connection conn1 = data1.getConnection();
28  java.sql.Statement stat1 = conn1.getStatement();
29  // Establish a connection with the second database
30  javax.sql.DataSource data2;
31  data2=(javax.sql.DataSource)ctx.lookup("java:comp/env/jdbc/DataBase2");
32  java.sql.Connection conn2 = data2.getConnection();
33  java.sql.Statement stat2 = conn2.getStatement();
34
35  // Execute update query to both databases
36  stat1.executeUpdate(...);
37  stat2.executeUpdate(...);
38
39  // Commit the transaction
40  // Apply the changes to the participating databases
41  usertx.commit();
42
43  //Release all connections and statements.
44  stat1.close();
45  stat2.close();
46  conn1.close();
47  conn2.close();
```

XA Example Implementation in Java

- Distributed Transaction (cont.)

```
48          // Catch any type of exception
49          catch (java.lang.Exception e) {
50              try {
51                  e.printStackTrace();
52
53                  // Rollback the transaction
54                  usertx.rollback();
55                  System.out.println("The transaction is rolled back.");
56              } catch(java.lang.Exception ex) {
57                  e.printStackTrace();
58                  System.out.println("Exception is caught. Check stack trace.");
59              }
60          }
61      }
```