Middleware and Web Services

Lecture 4: Application Server Services

doc. Ing. Tomáš Vitvar, Ph.D.
tomas@vitvar.com • @TomasVitvar • http://vitvar.com

Czech Technical University in Prague
Faculty of Information Technologies • Software and Web Engineering • http://vitvar.com/courses/mdw

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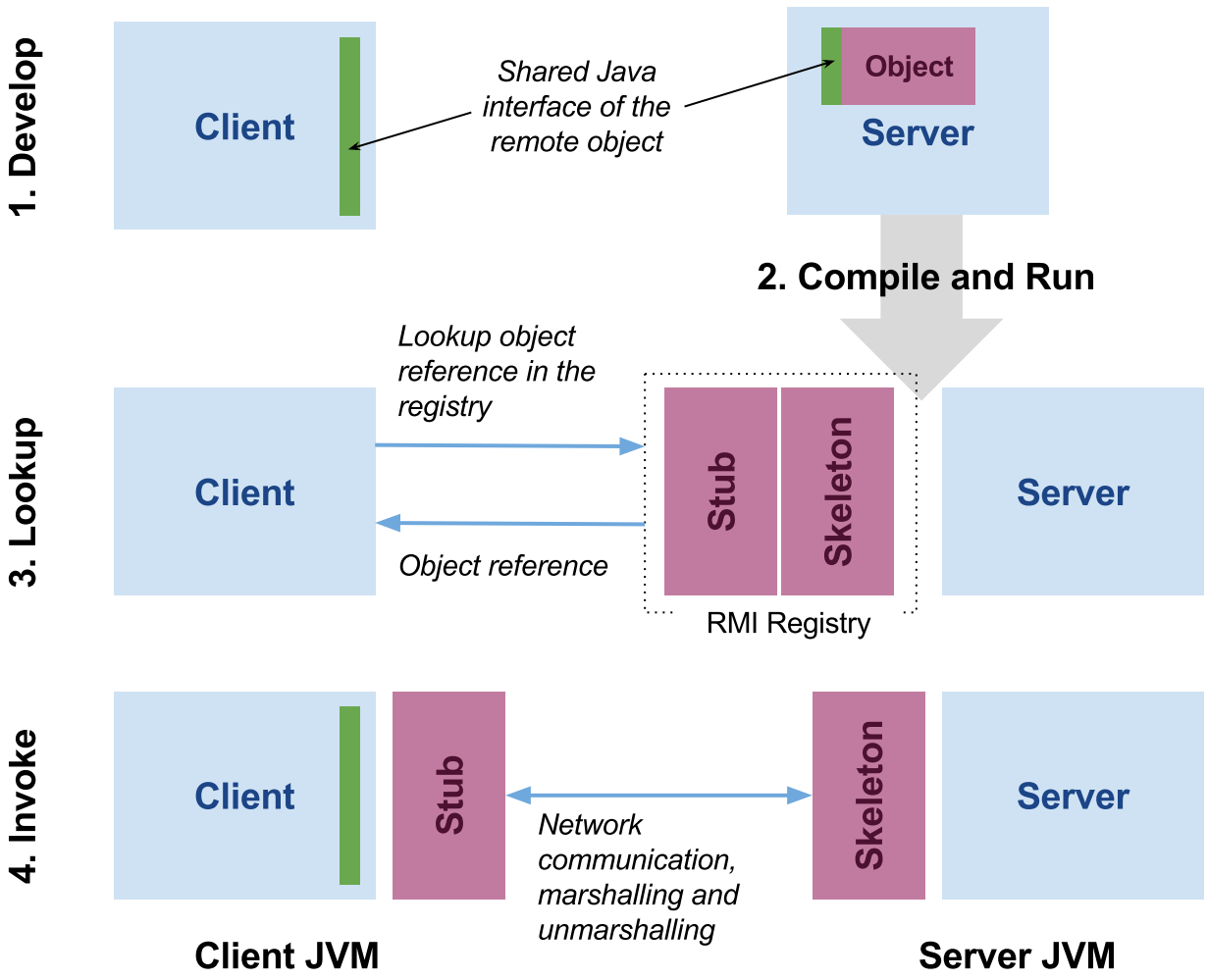
Overview

- Java Technologies and Services
  - *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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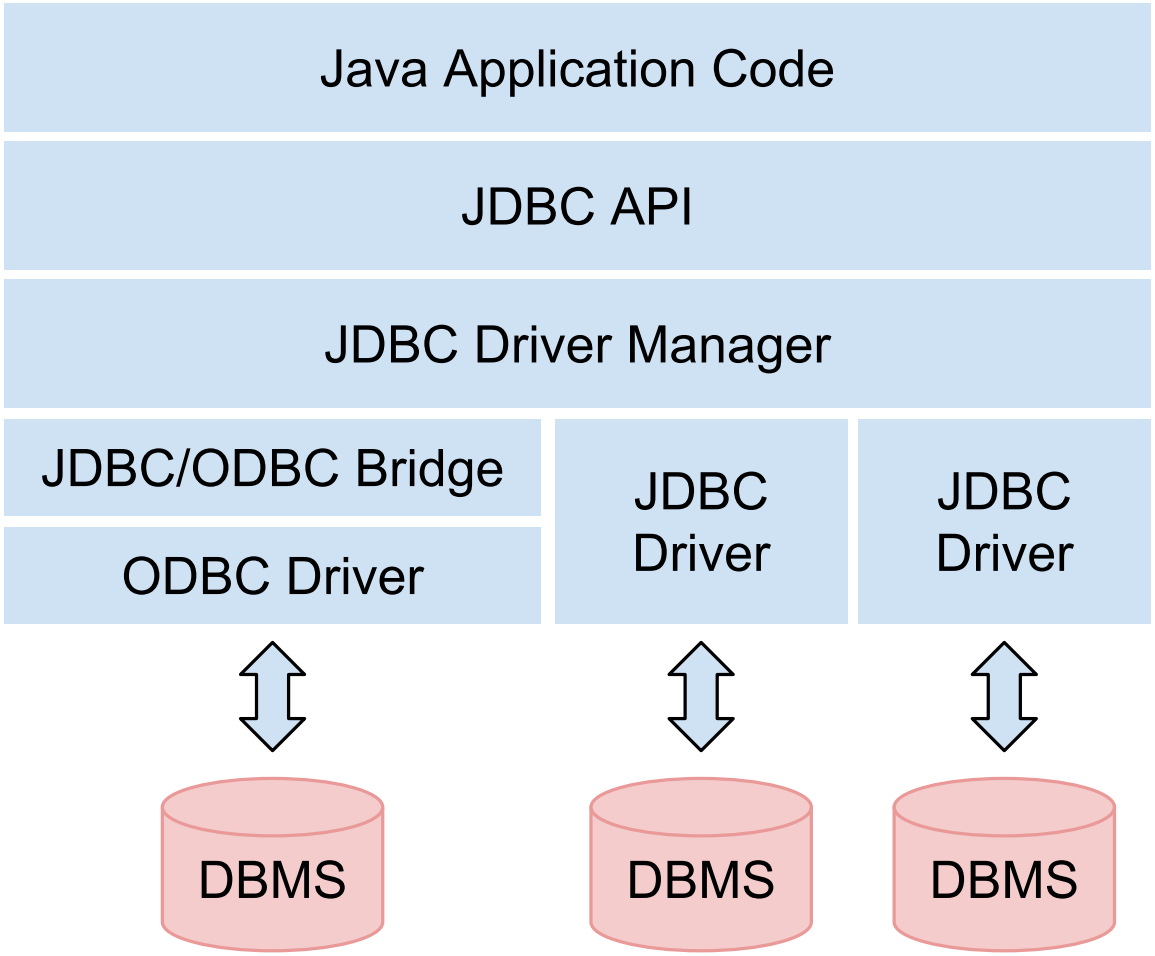
Overview

- 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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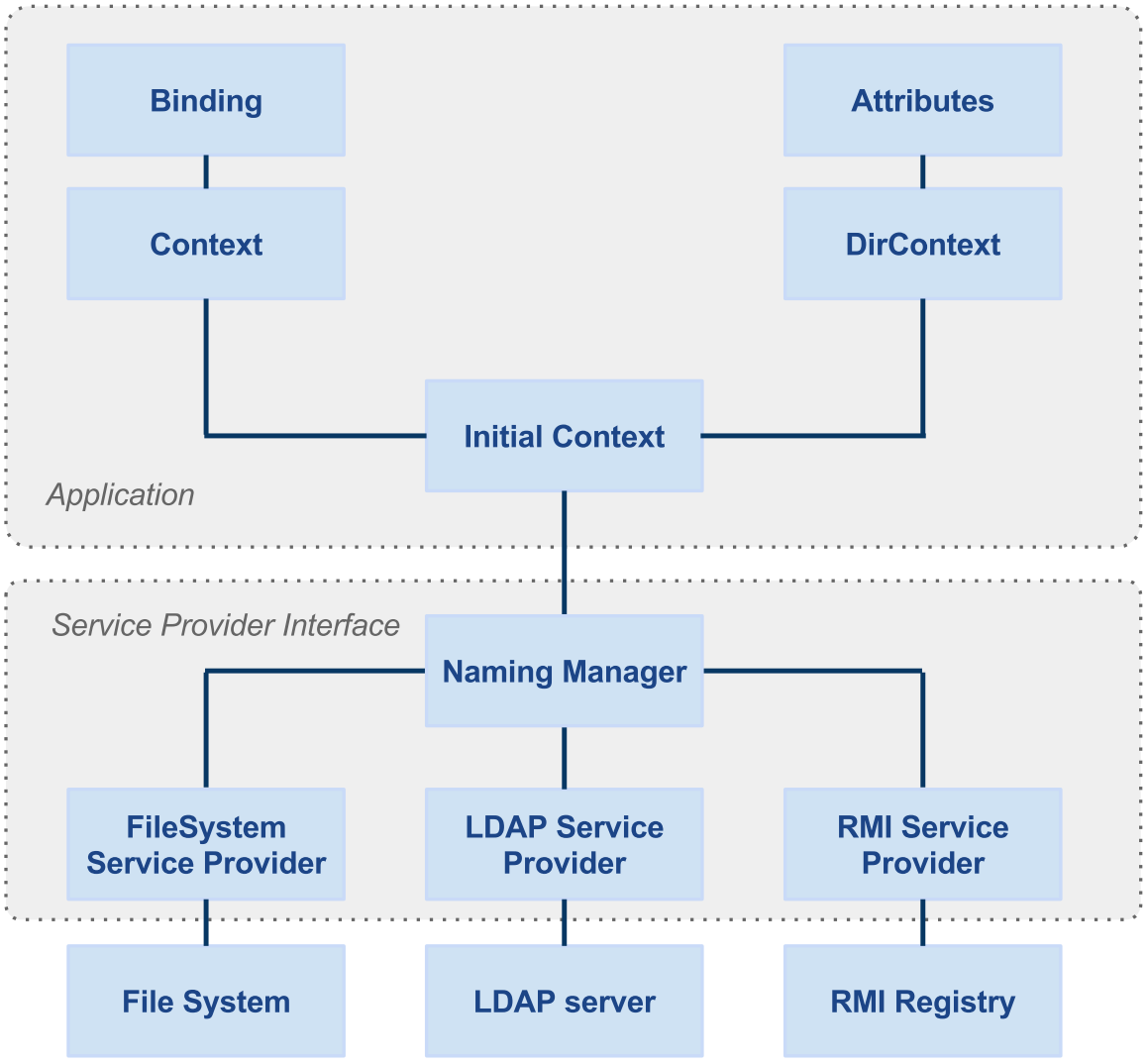
Overview

- 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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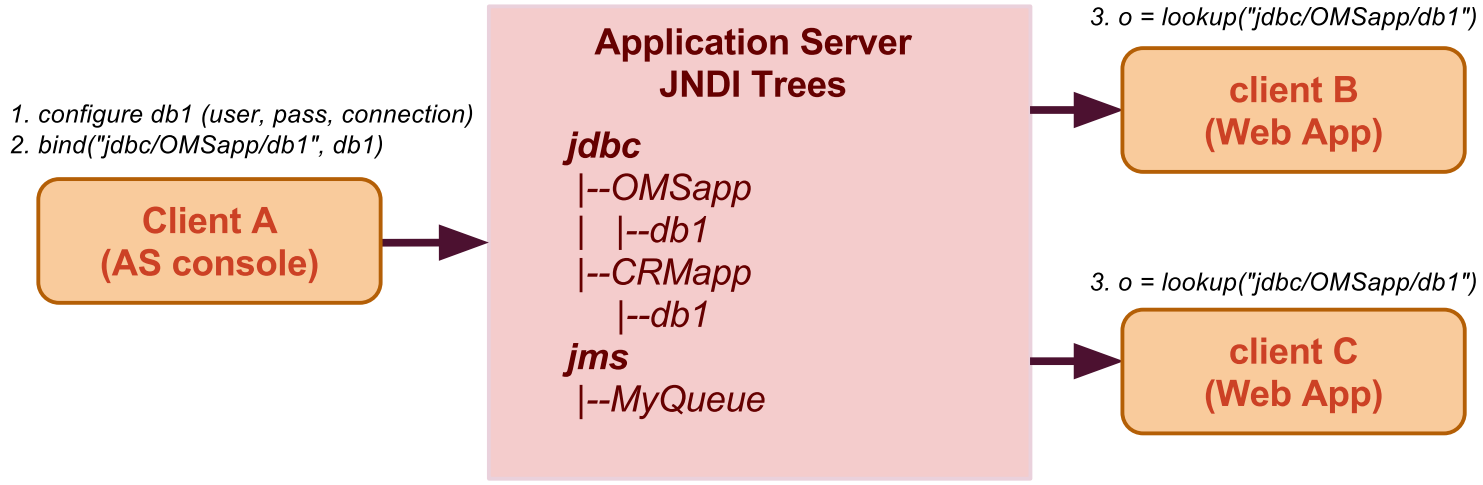
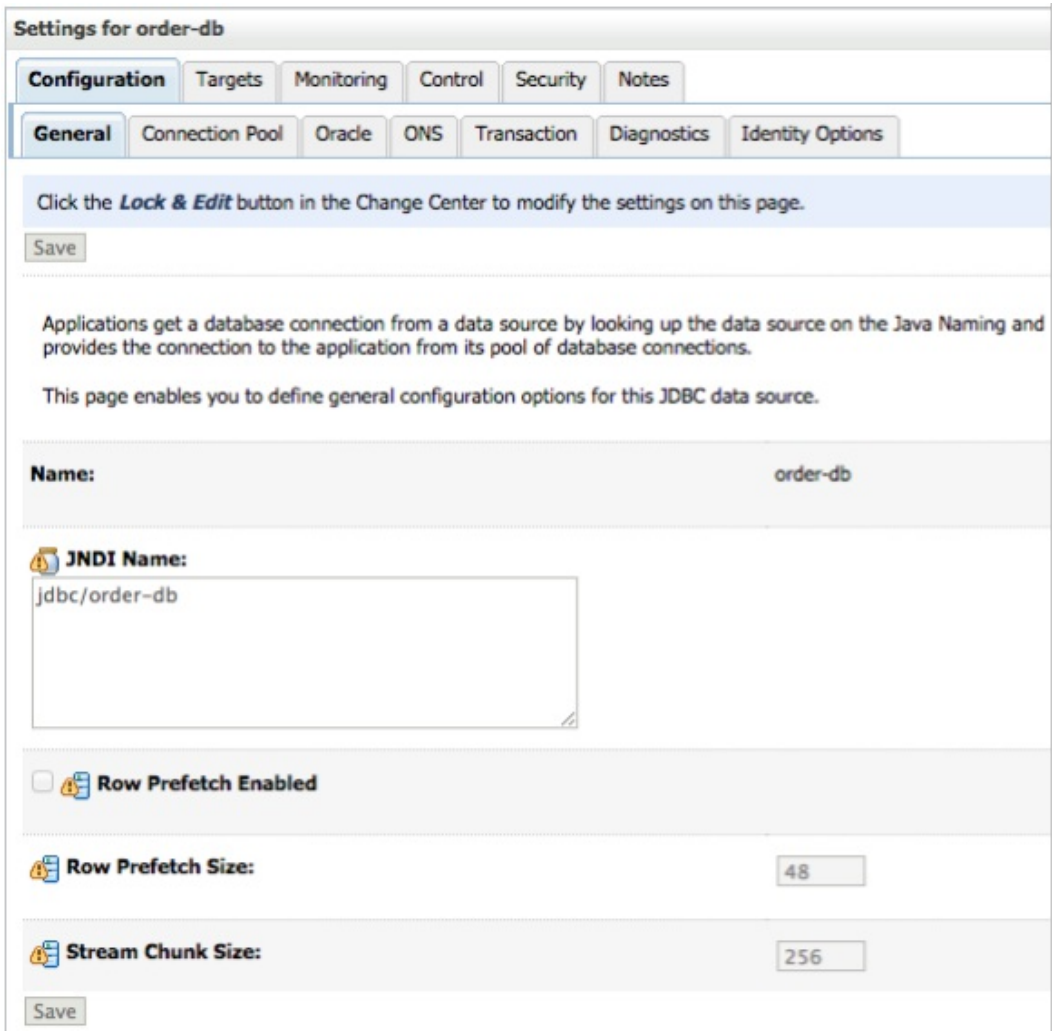
Application Server and JNDI



- 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*

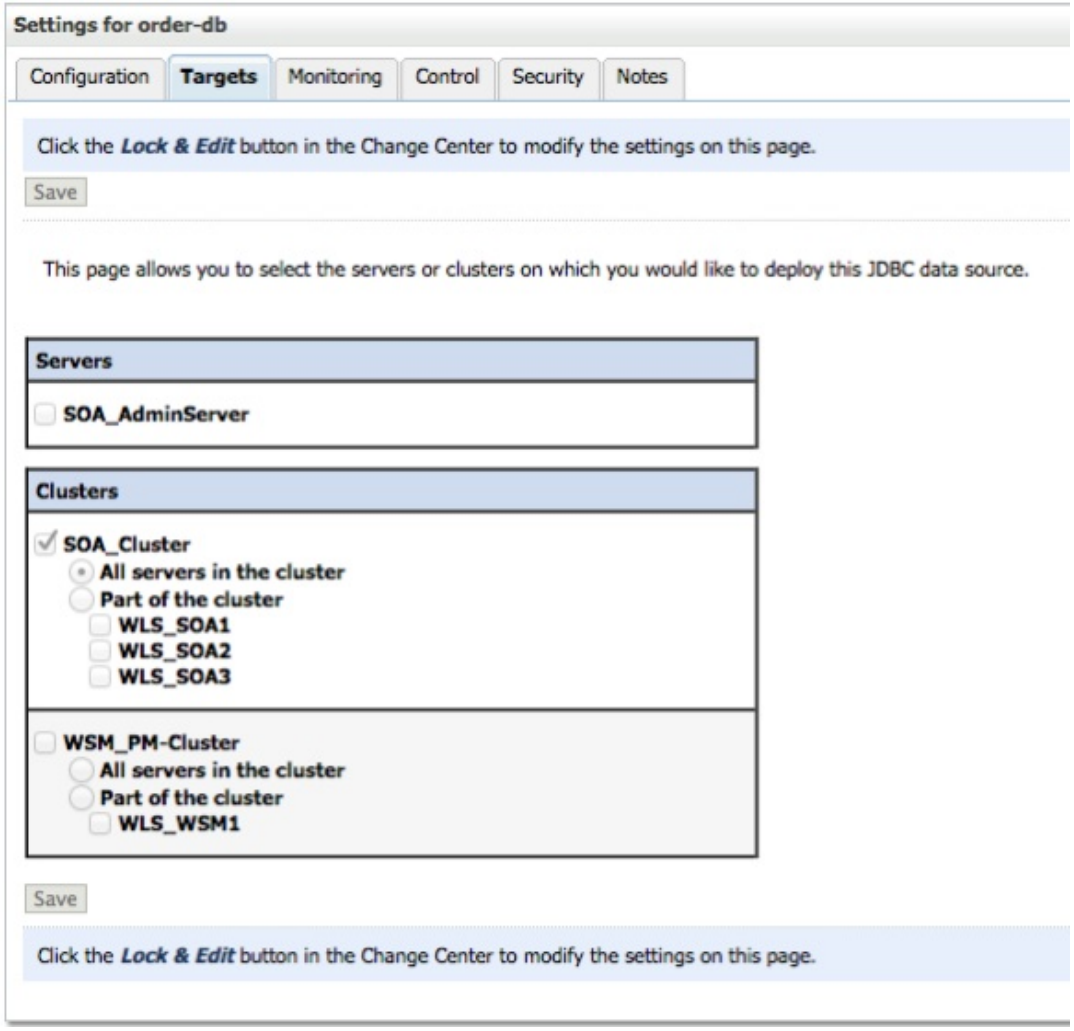
Example Datasource in Weblogic



Targets

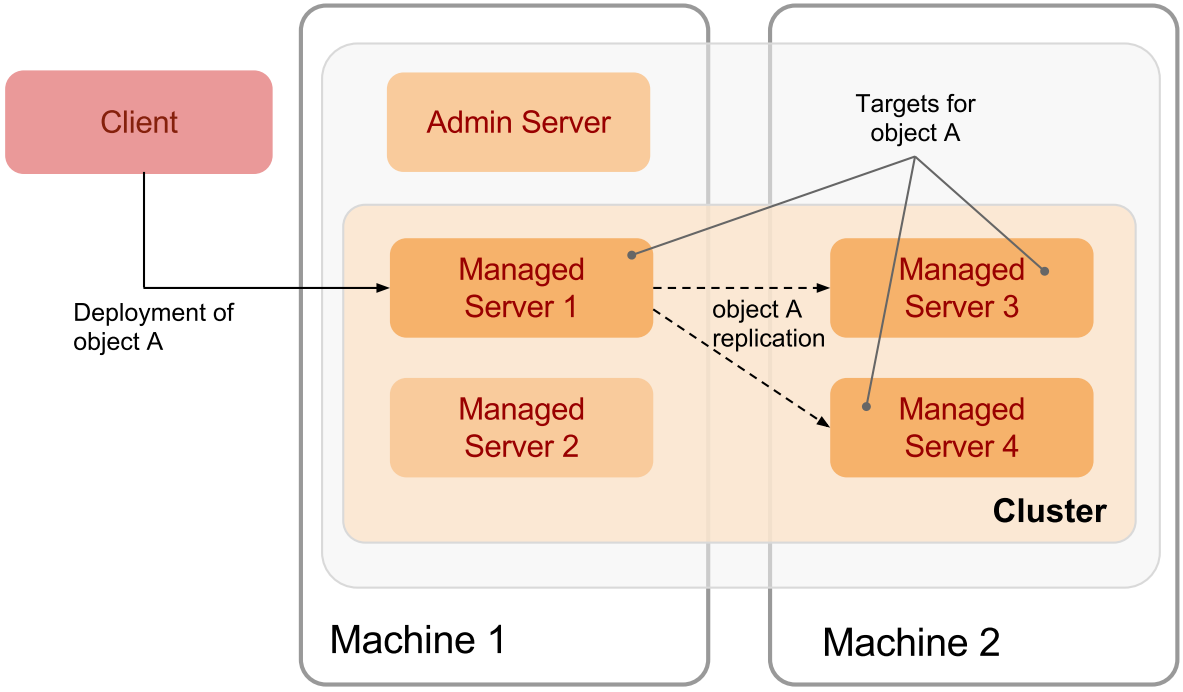
- Object
  - *A service provided by the applicaton server, e.g. datasources, JMS queue, SAF*
- Types of services
  - *Pinned services*
    → *Objects targeted to a single server only*
  - *Cluster services*
    → *Objects targeted to all servers in the cluster*

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*

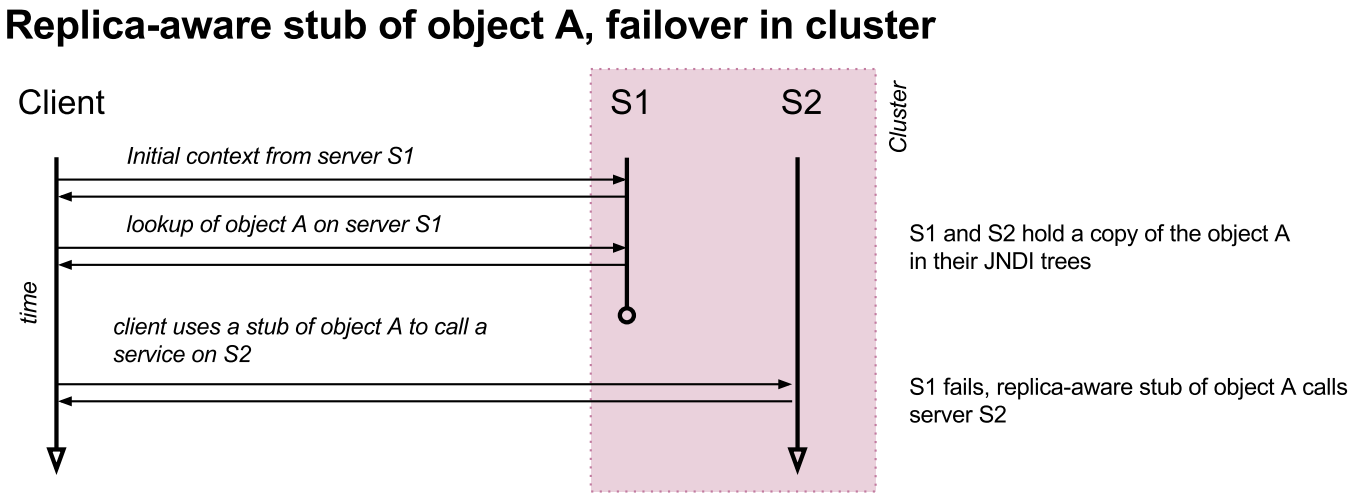


Cluster-wide JNDI Tree

- 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*

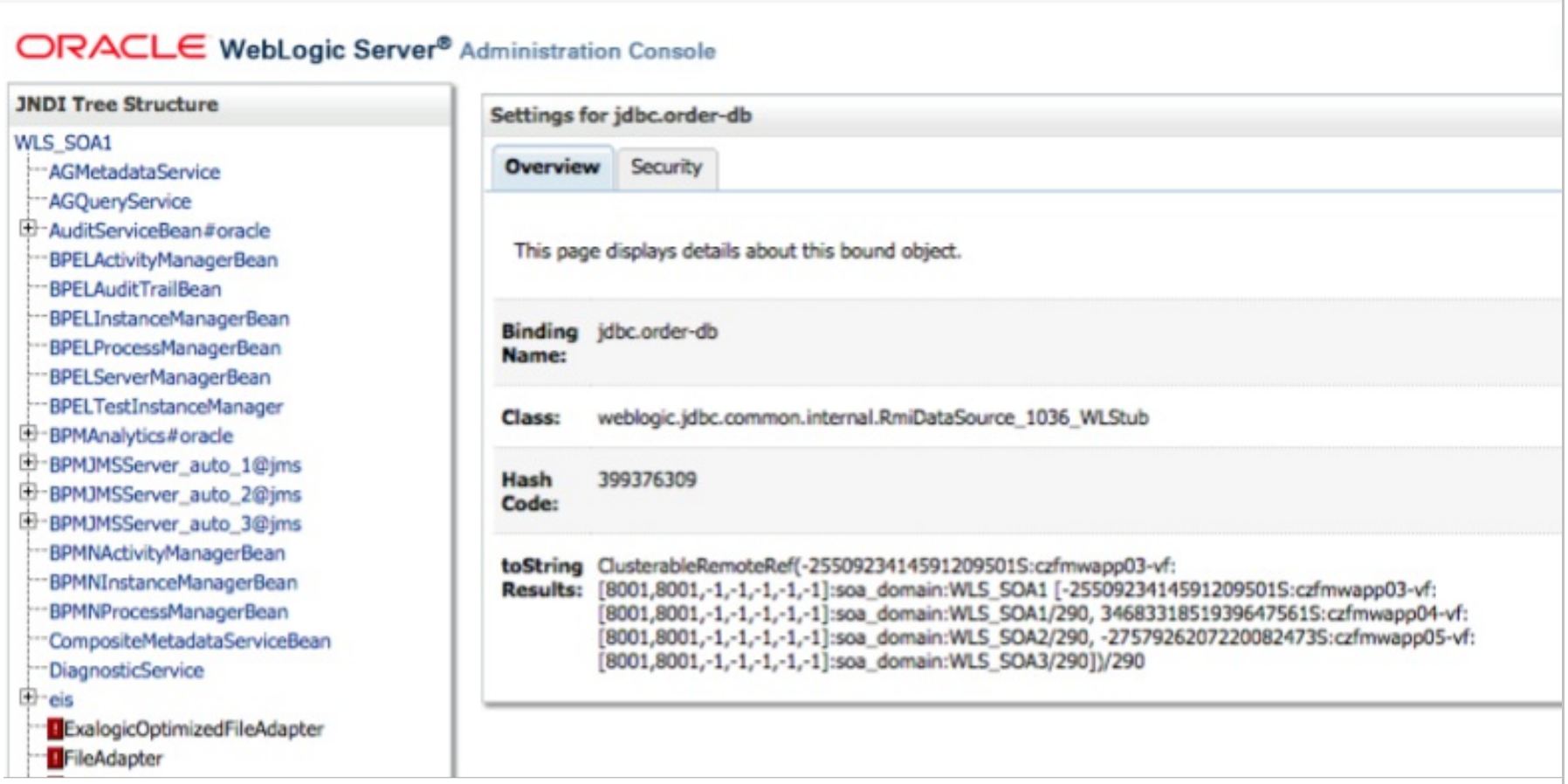
Object Failover

- 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

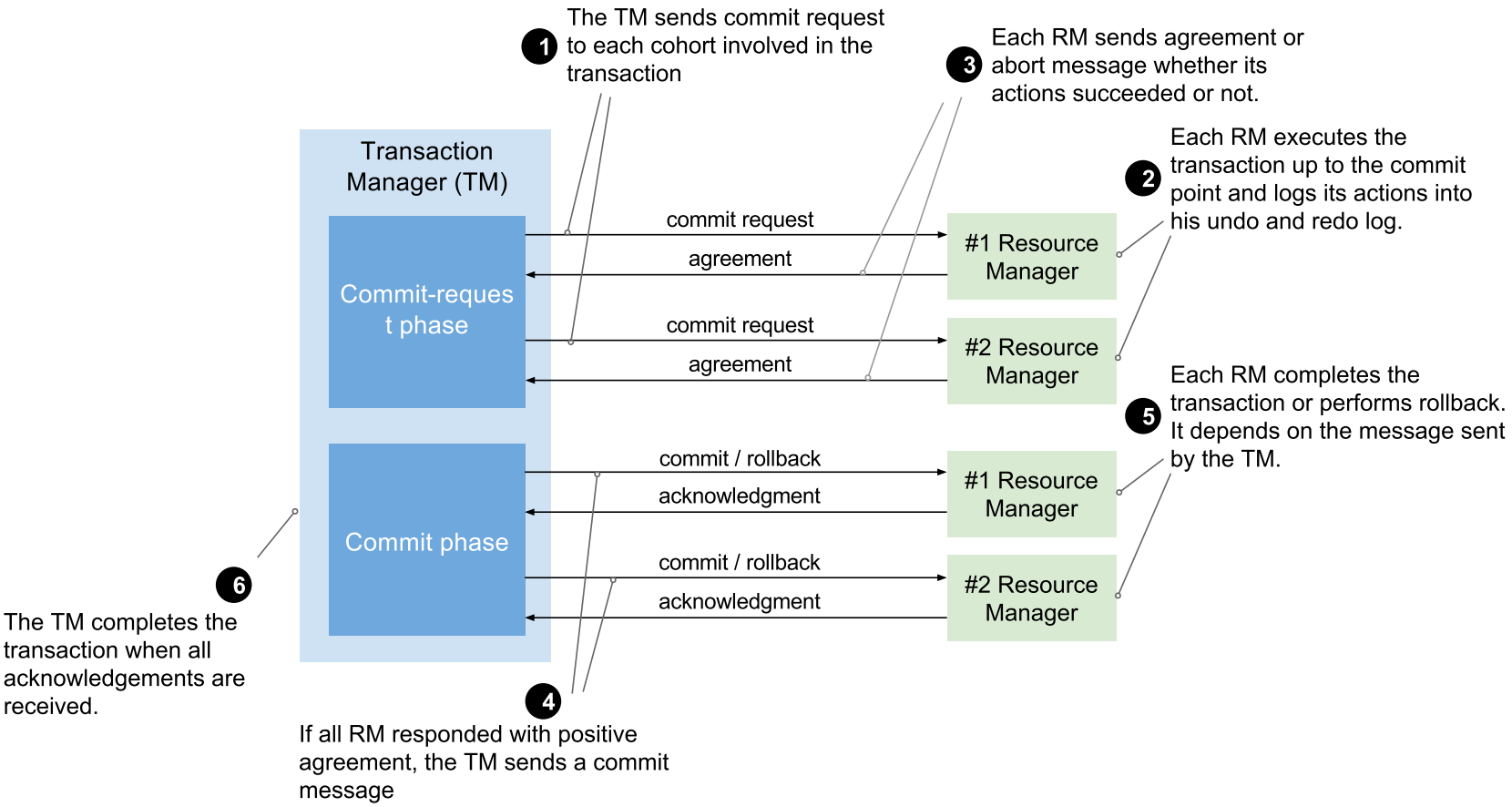
- Coordination of a distributed transaction
  - *All transaction operations are completed across multiple resources; or none is completed*
  - *Able to deal with many types of failures (process, network, communication)*
- Terminology
  - ***Transaction Manager*** *– manages transactions, coordinates 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      }
```