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# Configuring and using XA distributed transactions in WebSphere Studio

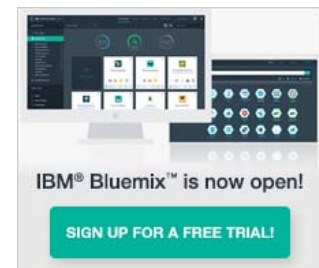
This article describes distributed transactions and shows you how to configure a WebSphere Studio Application Developer test server with XA resources for DB2, Oracle, and JMS that can be used together in a distributed transaction. The article describes an example session bean that updates both databases and sends a JMS message, all in the same transaction. The Oracle database must also be configured to support XA transactions, so the article shows the Java exceptions that occur when it is not configured properly, and how to fix these problems.

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## What are distributed transactions?

Before diving into how to develop applications using distributed transactions, let's review what distributed transactions are and why they're useful. Several terms are often used interchangeably: transaction, distributed transaction, two-phase commit, XA transaction, transaction propagation, and CORBA OTS transaction. But these terms actually have different meanings:



**Transaction** -- a series of actions performed as a single logical unit of work in which either all of the actions are performed or none of them are (also called a *local* or *simple transaction*). A transaction is often described as *ACID* -- atomic, consistent, isolated, and durable. Changes made during a transaction are tentative; to make them permanent, a transaction ends with a *commit* action that finalizes the changes. If any of the changes cannot be committed, the transaction will *roll back*, undoing all of the changes as if the transaction never took place. If the code performing the actions decides not to commit or cannot commit successfully, then it must roll back the transaction to undo the actions. If an application crashes in the middle of a transaction, when it restarts, transaction recovery will roll back the open transaction. In a *write transaction*, all changes must either all commit or all roll back. In a *read transaction*, there are no changes to commit, but the transaction prevents the data being read from changing until all of the reads are complete.

**Distributed transaction** -- An ACID transaction between two or more independent transactional resources (for example, two separate databases). For the transaction to commit successfully, all of the individual resources must commit successfully; if any of them are unsuccessful, the transaction must roll back in all of the resources.

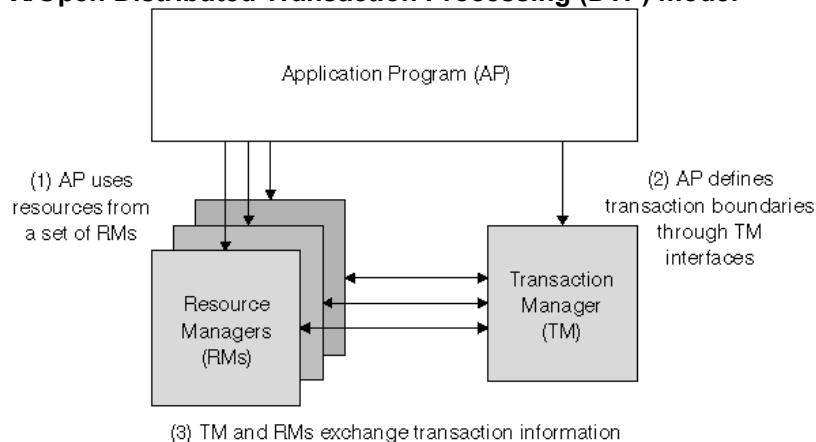
**Two-phase commit** -- An approach for committing a distributed transaction in two steps: *Phase 1, Prepare*: Each of the resources votes on whether it's ready to commit -- usually by going ahead and persisting the new data but not yet deleting the old data. *Phase 2, Commit*: If all of the resources are ready, they all commit -- after which the old data is deleted and the transaction can no longer roll back. Two-phase commit ensures that a distributed transaction can always be committed or always rolled back,

even if parts of the system crash while the transaction is being committed. Many, but not all, distributed transaction implementations use two-phase commit.

**XA specification** -- Documents the Open Group's X/Open Distributed Transaction Processing (DTP) model, which defines how an *application program* uses a *transaction manager* to coordinate a distributed transaction across multiple *resource managers*. Any resource manager that adheres to the XA specification can participate in a transaction coordinated by an XA-compliant transaction manager, thereby enabling different vendors' transactional products to work together. All XA-compliant transactions are distributed transactions; XA supports both single-phase and two-phase commit.

This diagram from the XA specification shows the parts of a distributed transaction:

#### X/Open Distributed Transaction Processing (DTP) model



**Transaction propagation** -- Enables multiple collaborating objects to participate in a single transaction, by passing the transactional context as part of the thread. As the thread passes through the collaborating objects, the transaction manager uses the thread's transaction context to perform all work.

**CORBA OTS specification** -- (Common Object Request Broker Architecture Object Transaction Service, from the Object Management Group) -- Defines how compliant processes propagate a transactional context from one process to the next across multiple process threads. This propagation enables distributed objects to collaborate in a single transaction, even if they're running in containers (e.g., ORBs) from different vendors. The CORBA OTS specification builds on the XA specification

This diagram from the OTS specification shows the parts of a transaction involving distributed objects:

#### Object Transaction Service (OTS) Model

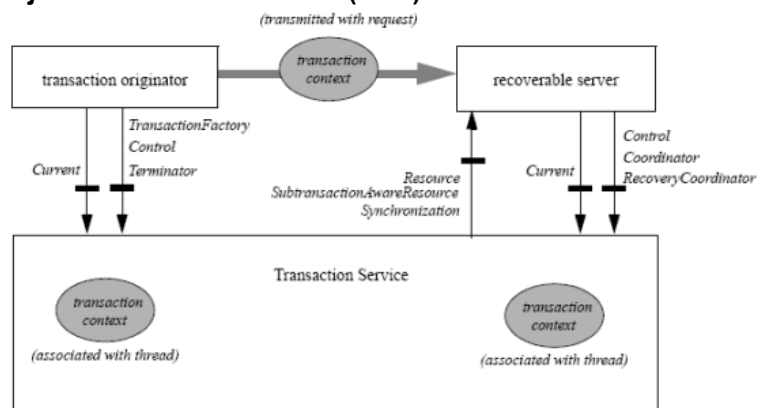


Figure 1-2 Major Components and Interfaces of the Transaction Service

IBM® WebSphere® Application Server V5 provides its applications with a transaction manager that is both XA- and CORBA OTS-compliant. This transaction manager implements two APIs that are part of Java™ 2 Enterprise Edition (J2EE) -- the Java Transaction API (JTA), which provides simplified access to the Java Transaction Service (JTS). The XA part of JTA is capable of coordinating the transactions for any XA-compliant resource (via the interface `javax.transaction.xa.XAResource`). Two resource types in J2EE that support XA are the Java Database Connectivity (JDBC) API (through the interface `javax.sql.XAConnection`) and the Java Message Service (JMS) API (through the interface `javax.jms.XAConnection`). The transaction manager uses CORBA OTS when an EJB in one container calls an EJB in another container.

## Why use distributed transactions?

Whenever an application needs to access or update the data in a transactional resource, it should (and usually must) use a transaction to do so. In standard JDBC code without auto-commit, the application uses a connection to access and update data, then commits the connection to end the transaction (and start another). When a JMS client sends or receives a message, the messaging provider uses a transaction to add the message to or remove the message from the destination. The JMS client can optionally control this transaction explicitly, such as to coordinate receiving a message from one queue with sending a message on another queue in the same messaging system.

Whenever an application has a single function that needs to access or update the data in multiple transactional resources, it should use a distributed transaction. You can use a separate simple transaction on each of the resources, but this approach is error-prone. If the transaction in one resource commits successfully but another fails and must roll back, the first transaction can no longer be rolled back, so the state of the application becomes inconsistent. If one resource commits successfully but the system crashes before the other resource can commit successfully, the application again is inconsistent.

What kinds of functions need to access multiple transactional resources? Here are some examples:

**Moving data between databases** -- An application moving data from one database to another requires a distributed transaction. Otherwise, the data may be duplicated (if the insert completes and the delete fails) or lost (if the delete completes and the insert fails).

**Moving data between a database and a message** -- An application may need to move data from a JMS message to a database table or vice versa. Without a distributed transaction, the data can be either duplicated or lost.

**Logging messages to a database** -- An application may use a database to keep a "paper trail" of messages exchanged with partner applications. To keep the record consistent and accurate, it should log the message in the same distributed transaction that sends or receives the message.

**Moving a message between messaging systems** -- Many messaging scenarios involve receiving one message and sending another as a result. When the two destinations are in the same messaging system, the receive and send can be done in a simple transaction because they involve a single transactional resource. However, when the message is received from a destination in one messaging system and sent to a destination in a separate messaging system, the application should perform the action in a distributed transaction between the two messaging systems to ensure that the message is neither duplicated nor lost.

**Coordinating with an enterprise information system (EIS)** -- The J2EE specification includes the J2EE Connector Architecture for implementing adapters to access enterprise information systems (EIS) such as CICS or SAP. The level of transactional support the adapter provides -- none, local, or XA -- depends on the capabilities of the EIS being adapted. If an adapter supports XA transactions, the application can use distributed transactions to coordinate the EIS resource with JDBC and JMS resources.

Basically, whenever an application is using multiple transactional, persistent resources, it may need distributed transactions. Any function that manipulates more than one resource should use a distributed transaction.

## Transactions and EJBs

Enterprise JavaBeans (EJBs) have many advantages: componentization, remoteness, security, persistence capabilities, messaging capabilities, and so on. While all of these features are useful, perhaps the single greatest advantage of using EJBs is transaction management. EJBs and *container-managed transactions* (CMTs) make transaction management virtually transparent to the bean developer.

Every public method on an EJB defines a transactional boundary between the EJB container and the EJB client, as specified in the deployment descriptor. The result is that all EJB code invoked by a client call typically executes in a single container-managed transaction (unless the deployment descriptor specifies otherwise), such that either all of the code's work is performed, or it all rolls back. Furthermore, the bean developer doesn't actually have to write any code for handling transactions, such as deciding when to invoke the `commit()` method and what to do if it fails. The container infers the transaction model from the method boundaries and deployment descriptor, and controls the transaction commits and rollbacks at runtime.

EJB container-managed transactions work even when multiple EJBs collaborate to perform a task. Once the first EJB in the thread establishes a transactional context, the transaction manager uses transaction propagation to pass the context to the collaborating EJBs so that all work is performed in the same transaction (unless the deployment descriptor specifies otherwise). Even if the collaborating EJBs are in different containers, CORBA OTS enables the containers' transaction managers to coordinate so that the transaction propagates across containers.

EJB container-managed transactions are especially helpful for controlling distributed transactions. This approach allows code to manipulate multiple sets of data without regard to whether the data all comes from a single resource (requiring a simple transaction) or multiple resources (requiring a distributed transaction). The application simply uses EJBs to manipulate the data as needed. The EJB container's transaction manager determines at runtime whether the data comes from one resource -- in which case it lets the resource manager manage the transaction -- or multiple resources -- in which case the transaction manager manages the transaction and coordinates the resource managers. Whether the data comes from one resource or many, the EJB code remains the same, and the EJB container handles the transaction appropriately.

## Developing with distributed transactions

Now we've reviewed what we want to accomplish. We've established what distributed transactions are, scenarios where they're useful and necessary, and how EJB technology makes these scenarios much

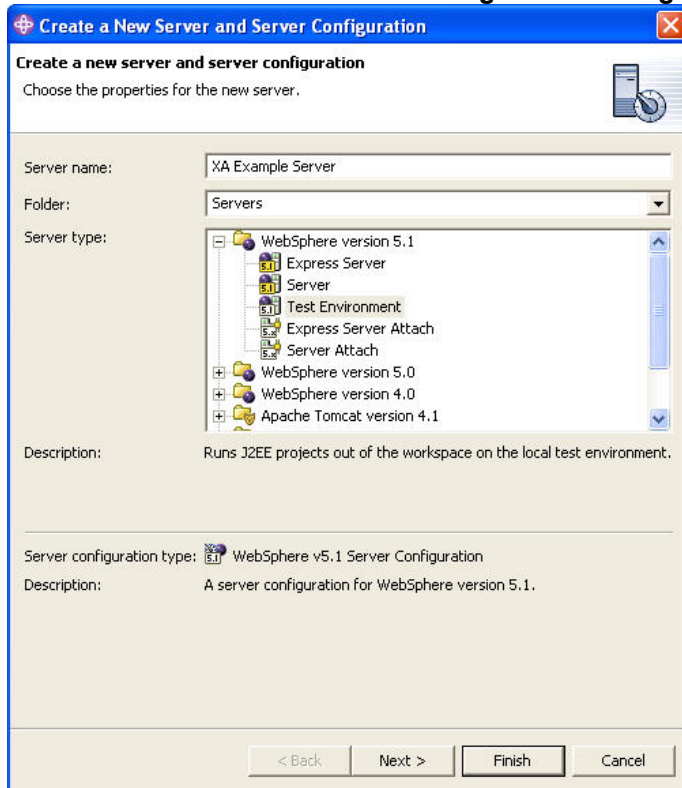
simpler for the bean developer. Now let's use WebSphere Studio Application Developer (hereafter called Application Developer) to create and run a simple example.

These sections show you how to create an Application Developer test server and configure it for JDBC and JMS. It shows you the specific settings to fill in, using values that are specific to this example. The description before each table explains which values are applicable to all applications and which only apply to this example.

This example will show how to configure XA data sources for two common JDBC database products, DB2®, and Oracle. It will also show how to configure a JMS destination with an XA connection.

To start, we need to create a new test server. To do so, switch to the Servers perspective. From the Server Configuration view's context (e.g. right mouse button) menu, select **New => Server and Server Configuration**. In the create dialog, enter a server name (such as "XA Example Server"), choose Test Environment (either WebSphere version 5.0 or WebSphere version 5.1 for this example) as the server type, and click finish.

#### Create a new server and server configuration dialog



#### Configure an Oracle XA data source

Before we create the data source, we'll create a JAAS authentication entry, which later we'll associate with the data source so that it can log into the database. In the server configuration editor, switch to the Security page. In the JAAS Authentication Entries list, add an entry. Your entry must be a valid login for your database, one that is able to create tables and add data as shown in this article. For this example, we'll use a sample login that's part of the default Oracle install. You may need to use a different login with your particular install.

#### Oracle JAAS authentication entry settings

<i>Property Name</i>	<i>Property Value</i>	<i>Default?</i>
Alias	Scott	
User ID	scott	
Password	tiger	

### Add JAAS authentication entry dialog



The dialog box titled "Add JAAS Authentication Entry" contains four text input fields: "Alias:" with the value "Scott", "User ID:" with the value "scott", "Password:" with the value "\*\*\*\*\*", and "Description:" which is empty. At the bottom right are "OK" and "Cancel" buttons.

For this example, the server configuration must include a JDBC data source registered in JNDI as `jdbc/OracleXADS`. Its JDBC provider will be accessed as an Oracle XA database.

First, we need to create a JDBC provider that describes how to access an Oracle XA database. In the server configuration editor, switch to the Data Source page. In the JDBC provider list, add a provider with the settings shown below. The name can be anything; we'll use the provider type.

### Oracle JDBC provider settings

<i>Property Name</i>	<i>Property Value</i>	<i>Default?</i>
JDBC Provider type	Oracle JDBC Driver (XA)	
Name	Oracle JDBC Driver (XA)	
Implementation class name	<code>oracle.jdbc.xa.client.OracleXADataSource</code>	default
Class path	<code>\${ORACLE_JDBC_DRIVER_PATH}/ojdbc14.jar</code>	default

## Create a JDBC provider dialog

**Create a JDBC Provider**

Select the type of JDBC provider to create.

Name: Oracle JDBC Driver (XA)

Description: Oracle JDBC Driver (XA)

Implementation class name: oracle.jdbc.xa.client.OracleXADataSource

Class path: ☐ \${ORACLE\_JDBC\_DRIVER\_PATH}/ojdbc14.jar

Native path:

Buttons: Add External JARs..., Add Path..., Remove

Navigation: < Back, Next >, Finish, Cancel

Second, create a JDBC data source that will provide access to our specific Oracle XA database. Select the Oracle provider we just created, and then add a data source with the settings shown below. The name can be anything. The JNDI name is the unique identifier your code will use to lookup the data source; this article's example code uses `jdbc/OracleXADS`. For the container-managed authentication alias, choose the JAAS authentication entry we created earlier. URL is a required resource property; specify the one for accessing your database.

### Oracle JDBC data source settings

<i>Property name</i>	<i>Property value</i>	<i>Default?</i>
JDBC Provider type	Oracle JDBC Driver (XA), version 5.0	
Name	Example Oracle XA Data Source	
JNDI name	jdbc/OracleXADS	
Helper class	com.ibm.websphere.rsadapter.OracleDataStoreHelper	default
Authentication alias	scott	
URL	jdbc:oracle:thin:@localhost:1521:example	

## Create a JDBC data source dialog

The JDBC provider we created earlier looks for its JAR file in the directory specified by the variable `ORACLE_JDBC_DRIVER_PATH`. The variable must be set to the proper directory, but WebSphere Studio does not know where the Oracle client is installed, so you must specify this directory. In the Server Configuration Editor, switch to the Substitution variables page. Under Node settings is a list of defined variables. Find the one for Oracle and set it to the directory containing the `ojdbc14.jar` file.

## Oracle defined variables (for nodes) settings

<i>Property Name</i>	<i>Property Value</i>	<i>Default?</i>
ORACLE_JDBC_DRIVER_PATH	C:\oracle\ora92\jdbc\lib	

## Edit Oracle JDBC driver path variable dialog

You have now configured the server with an Oracle XA JDBC data source. Save the server configuration.

Although you have now configured your test server with an Oracle XA JDBC data source, you may also need to configure the Oracle database itself to support XA transactions. Your Oracle DBA can help you determine if further configuration is necessary and can help you perform the steps. Later in this article, we'll discuss the errors you get if your Oracle database is not configured for XA, and how to configure it.



## Configure a DB2 XA data source

This example also includes a DB2 XA data source. The configuration settings for a DB2 data source are very similar to those for an Oracle data source.

First, define a JAAS identity capable of logging into your database. In this example, we've set up one named DB2.

### DB2 JAAS authentication entry settings

<i>Property name</i>	<i>Property Value</i>	<i>Default?</i>
Alias	DB2	
User ID	db2	
Password	a_password	

Second, we need to create a JDBC provider for DB2 XA data sources.

### DB2 JDBC provider settings

<i>Property Name</i>	<i>Property Value</i>	<i>Default?</i>
JDBC Provider type	DB2 Universal JDBC Driver Provider (XA)	
Name	DB2 Universal JDBC Driver Provider (XA)	
Implementation class name	com.ibm.db2.jcc.DB2XADataSource	default
Class path	\${DB2UNIVERSAL_JDBC_DRIVER_PATH}}/db2jcc.jar \${UNIVERSAL_JDBC_DRIVER_PATH}}/db2jcc_license_cu.jar \${DB2UNIVERSAL_JDBC_DRIVER_PATH}}/db2jcc_license_cisuz.jar	default

Third, we need to create a DB2 XA data source with the JNDI name jdbc/DB2XADS. We'll use the JAAS identity from [step 1](#). Whereas an Oracle data source needs a URL string for accessing the database, a DB2 data source just needs the name of the database, in this case, "sample."

### DB2 JDBC data source settings

<i>Property Name</i>	<i>Property Value</i>	<i>Default?</i>
JDBC Provider type	DB2 Universal JDBC Driver Provider (XA), version 5.0	
Name	Example DB2 XA Data Source	
JNDI name	jdbc/DB2XADS	
Helper class	com.ibm.websphere.rsadapter.DB2UniversalDataStoreHelper	default
Authentication alias	DB2	
databaseName	sample	

Fourth, we need to specify the path where the DB2 drivers are installed, which is the directory that contains the `db2jcc.jar` file. Also, verify the default value of the other variable in the data source's class path.

#### DB2 defined variables (for nodes) settings

<i>Property Name</i>	<i>Property Value</i>	<i>Default?</i>
DB2UNIVERSAL_JDBC_DRIVER_PATH	C:\db2\SQLLIB\java	
UNIVERSAL_JDBC_DRIVER_PATH	\${WAS_INSTALL_ROOT}/universalDriver/lib	default

You have now configured a DB2 XA data source registered as `jdbc/DB2XADS`. Save the server configuration.

#### Configure a JMS provider

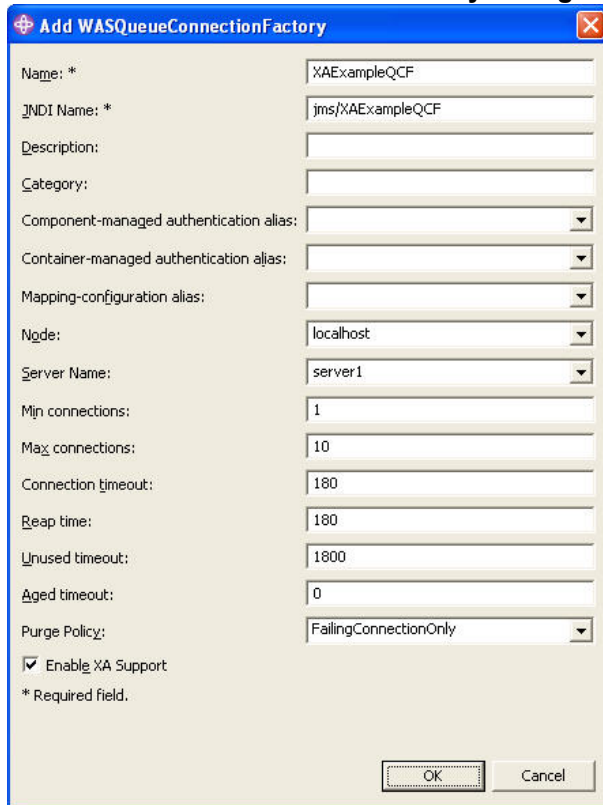
To demonstrate an XA transaction, while we're at it, let's also add in a JMS resource. A simple one to use that also has full XA capabilities is the JMS simulator built in to Application Developer. Your WebSphere applications that use DB2 and or Oracle XA may use resources other than JMS, but it is required for this example.

In the server configuration editor, switch to the JMS page. Under JMS Server Properties, add the queue name `XAExampleQ`. Under JMS Provider, select MQ Simulator for Java Developers.

For this example, the server configuration must include two JMS resources, a queue connection factory named `jms/XAExampleQCF` and a queue named `jms/XAExampleQ`. On the server configuration editor's JMS page, in the `WASQueueConnectionFactories` entries list, add a new queue connection factory with the settings shown below. Be sure that XA support is enabled; that's the whole point of this example.

#### WAS queue connection factory settings

<i>Property Name</i>	<i>Property Value</i>	<i>Default?</i>
Name	XAExampleQCF	
JNDI Name	jms/XAExampleQCF	
Enable XA Support	True (checked)	default

**Add WAS Queue Connection Factory Dialog**


**Add WASQueueConnectionFactory**

Name: \* XAExampleQCF

JNDI Name: \* jms/XAExampleQCF

Description:

Category:

Component-managed authentication alias:

Container-managed authentication alias:

Mapping-configuration alias:

Node: localhost

Server Name: server1

Min connections: 1

Max connections: 10

Connection timeout: 180

Reap time: 180

Unused timeout: 1800

Aged timeout: 0

Purge Policy: FailingConnectionOnly

☒ Enable XA Support

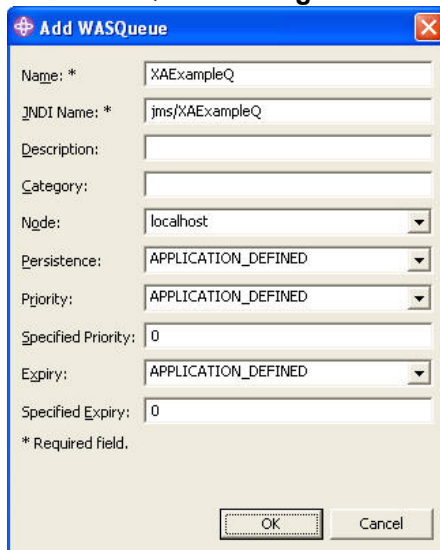
\* Required field.

OK Cancel

In the WASQueue entries list, add a new queue with these settings:

**WAS queue settings**

Property Name	Property Value	Default?
Name	XAExampleQ	
JNDI Name	jms/XAExampleQ	

**Add WAS Queue Dialog**


**Add WASQueue**

Name: \* XAExampleQ

JNDI Name: \* jms/XAExampleQ

Description:

Category:

Node: localhost

Persistence: APPLICATION\_DEFINED

Priority: APPLICATION\_DEFINED

Specified Priority: 0

Expiry: APPLICATION\_DEFINED

Specified Expiry: 0

\* Required field.

OK Cancel

Save the server configuration.

You are now through configuring the server. It has a data source for accessing Oracle through XA, and a JMS queue with a queue connection factory that supports XA transactions. You can even run the server at this point. It doesn't contain any applications, but you can verify that it starts without errors and binds the JDBC and JMS resources in JNDC that we configured for this server. A successful startup will contain JMS- and JDBC-specific messages like these:

```
JMSMQJDPProvid A MSGS0656I: Starting the MQJD JMS Provider
JMSMQJDPProvid A MSGS0650I: MQJD JMS Provider open for business
ResourceMgrIm I WSVR0049I: Binding XAExampleQCF as jms/XAExampleQCF
ResourceMgrIm I WSVR0049I: Binding XAExampleQ as jms/XAExampleQ
ResourceMgrIm I WSVR0049I: Binding Example Oracle XA Data Source as jdbc/OracleXADS
ResourceMgrIm I WSVR0049I: Binding Example DB2 XA Data Source as jdbc/DB2XADS
CacheServiceI I DYNA0048I: WebSphere Dynamic Cache initialized successfully.
```

### Optional: Import the server configuration

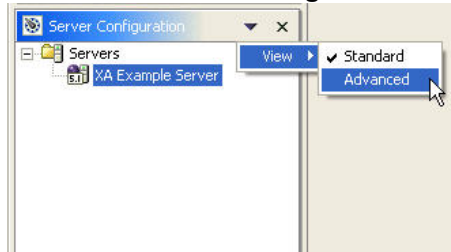
You really should practice setting up the server configuration as described so far. But if you're unsuccessful and still wish to run the example application described below, you can import the configuration instead.

To start, download and unzip the example file. It contains a directory called `XA Example Server.wsc`; this is a `websphere version 5.1` server configuration.

To import a server configuration, you first need to create a server, which is described at the beginning of this article. Make sure it is a WebSphere version 5.1 Test Environment (available in Application Developer version 5.1.1), since the configuration is for version 5.1.

Also, it helps to be able to see both the list of servers and the list of configurations. In the Server Configuration view of the Server perspective, select **View => Advanced** from the Menu (e.g., down triangle) button.

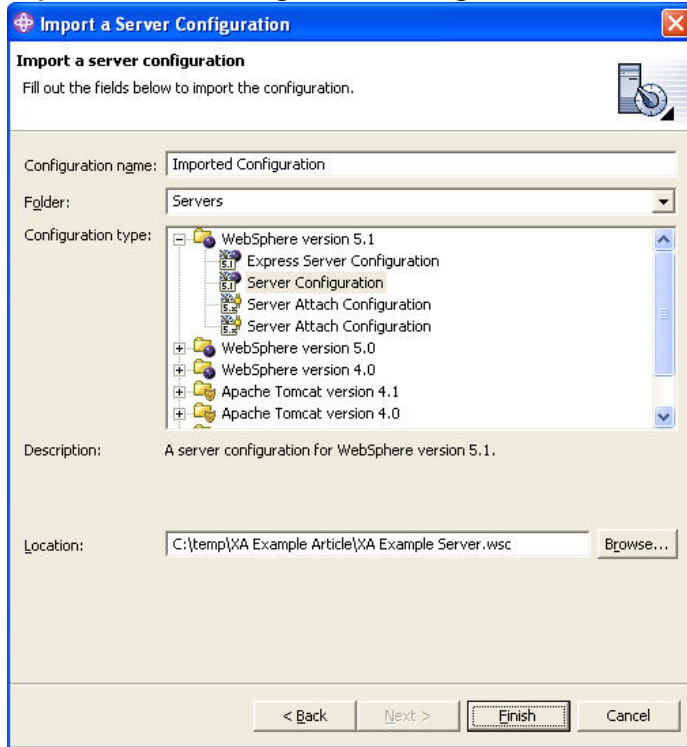
#### Advanced Server Configuration View Menu



Next, import the server configuration by following these steps:

1. From the Studio menu bar, choose **File => Import**.
2. The Import wizard opens on its Select page. Select **Server Configuration** and click **Next**.
3. The wizard switches to its Import a Server Configuration page.
  1. At the Configuration Name field, enter some name that is different from the name of the server you just created, such as "Imported Configuration."
  2. The Folder field will default to the name of your servers project, which is usually called "Servers."
  3. For the Configuration Type, select **WebSphere version 5.1 => Server Configuration**.
  4. In the Location field, click **Browse** and select the `XA Example Server.wsc` file you downloaded.
4. Click **Finish** to import the server configuration. Your Server Configuration view will now list the new configuration with the name you specified.

### Import a server configuration dialog



Now we need to switch the server you created to use the server configuration you just imported. In the Server Configuration view, select the server, pop up the context (e.g., right mouse button) menu, select **Switch configuration**, and select the configuration you imported.

Open the server configuration editor for your server and you'll see that it now has the settings for the JDBC and JMS resources described earlier. (If you don't see these settings, make sure to switch your server to the imported configuration.)

Start the server and you'll see the server startup log shown earlier.

### Set up the example application

This article includes a simple J2EE application that you can download, import into Application Developer, and run. It will execute an XA transaction using the JDBC and JMS resources you configured earlier.

To start, download and unzip the example file. It contains an Enterprise Archive (EAR) file named `XAExampleEAR.ear`. Follow these steps to import it into your WebSphere Studio workspace:

1. From the Studio menu bar, choose **File => Import**.
2. The Import wizard opens on its Select page. Select **EAR file** and click **Next**.
3. The wizard switches to its Enterprise Application Import page. At the EAR File field, click **Browse** and select the `XAExampleEAR.ear` file you downloaded. The project name will default to `XAExampleEAR`.
4. Click **Finish** to import the EAR. Your workspace will now contain three projects named `XAExampleEAR`, `XAExampleEJB`, and `XAExampleweb`.

The `XAExampleEJB` project, not too surprisingly, contains EJBs, so you must generate their deployment code. Select the `XAExampleEJB` project, pop up the context (e.g., right mouse button) menu, and select **Generate => Deployment and RMIC code**. Use the dialog to generate the code for the `XAExampleSession` bean. Application Developer will generate new classes with names like

`EJSLocalStatelessXAExampleSession_5a0991c7`. These are the concrete classes with work with the WebSphere Application Server EJB container to make the example EJBs fulfill all of the qualities defined by the EJB specification.

You must also add the EAR project to the test server. This is analogous to deploying an EAR, but more flexible because as you modify the EAR's code, you don't have to redeploy the EAR to use the new code. Instead, you can simply restart the server or restart the EAR project within the running server and start testing your code changes.

To add the EAR project to the test server, select the server in the Server Configurations view, pop up the context (e.g. right mouse button) menu, and select **Add and remove projects**. In the dialog, add `XAExampleEAR` to the list of configured projects. In the Server Configuration view, expand the imported configuration and you'll now see that the EAR is part of the configuration.

The download contains a file named `XAExampleDB.sql`, which creates a database table named `XA_EXAMPLE`. For Oracle, run this file in SQL\*Plus to create the table:

```
SQL> @C:\temp\XA Example Article\XAExampleDB.sql
DROP TABLE XA_EXAMPLE
*
ERROR at line 1:
ORA-00942: table or view does not exist

Table created.
```

For DB2, run the file in the DB2 command line processor:

```
C:\db2\SQLLIB\BIN>db2 -tvf C:\temp\XA Example Article\XAExampleDB.sql
DROP TABLE XA_EXAMPLE
DB21034E The command was processed as an SQL statement because it was not a
valid Command Line Processor command. During SQL processing it returned:
SQL0204N "DB2.XA_EXAMPLE" is an undefined name.  SQLSTATE=42704

CREATE TABLE XA_EXAMPLE ( TEXT VARCHAR(256) NOT NULL )
DB20000I The SQL command completed successfully.
```

## Example code

The example application is simple and consists of two classes:

1. `XAExampleSessionBean` -- A session EJB that performs an XA transaction.
2. `XAExampleServlet` -- A servlet that invokes the EJB.

The session bean's public method, `persistAndSend(String)`, writes the argument to the two JDBC tables (DB2 and Oracle) and a JMS message. This functionality alone is not a very useful application; however, since JDBC and JMS are transactional resources, performing all three tasks requires an XA transaction. The distributed (two-phase) transaction ensures that all three tasks are performed successfully. If one task cannot commit successfully, the others are rolled back such that none of the tasks are performed. This maintains consistency between the two resources.

```
public void persistAndSend(String data) throws Exception {
    try {
        DataSource oracleDS = getDataSource("java:comp/env/jdbc/OracleXADS");
        persist(data, oracleDS);

        DataSource db2DS = getDataSource("java:comp/env/jdbc/DB2XADS");
        persist(data, db2DS);

        QueueConnectionFactory factory =
            getQueueConnectionFactory("java:comp/env/jms/XAExampleQCF");
        Queue queue = getQueue("java:comp/env/jms/XAExampleQ");
        send(data, factory, queue);
    }
    catch (Exception e) {
        e.printStackTrace();
        this.getSessionContext().setRollbackOnly();
        throw e;
    }
}
```

The method performs three steps:

1. Persists the data using the data source named jdbc/oracleXADS.
2. Persists the data using the data source named jdbc/DB2XADS.
3. Sends the data in a JMS message to a queue named jms/XAExampleQ.

If anything goes wrong, the catch block will catch the exception, mark the transaction for rollback, and rethrow the exception. Just for completeness, here's the rest of the code for implementing the session bean:

```
private void persist(String data, DataSource datasource)
    throws SQLException {
    System.out.println("Adding a new database row containing: " + data);
    Connection connection = null;
    try {
        connection = datasource.getConnection();
        PreparedStatement statement =
            connection.prepareStatement(
                "INSERT INTO XA_EXAMPLE (TEXT) VALUES (?)");
        statement.setString(1, data);
        statement.execute();
        System.out.println("Successfully added row: " + data);
    }
    finally {
        if (connection != null)
            connection.close();
    }
}

private void send(String data, QueueConnectionFactory factory, Queue queue)
    throws JMSException {
    System.out.println("Sending a message containing: " + data);
    QueueConnection connection = null;
    try {
        connection = factory.createQueueConnection();
        QueueSession session =
            connection.createQueueSession(false, Session.AUTO_ACKNOWLEDGE);
        QueueSender sender = session.createSender(queue);
        TextMessage message = session.createTextMessage(data);
        sender.send(message);
        System.out.println("Successfully sent message: " + data);
    }
    finally {
        if (connection != null)
            connection.close();
    }
}

private DataSource getDataSource(String jndiName) throws NamingException {
    return (DataSource) this.getJNDIObject(jndiName);
}

private QueueConnectionFactory getQueueConnectionFactory(String jndiName)
    throws NamingException {
    return (QueueConnectionFactory) this.getJNDIObject(jndiName);
}

private Queue getQueue(String jndiName) throws NamingException {
    return (Queue) this.getJNDIObject(jndiName);
}

private Object getJNDIObject(String jndiName) throws NamingException {
    Context root = new InitialContext();
    return root.lookup(jndiName);
}
```

This is standard code for using JDBC and JMS. There isn't even any code to define a transaction or make it XA. But because the code is invoked by the WebSphere Application Server's EJB container as a single public EJB method, the container automatically runs the code in a transaction. The container would normally use a simple (e.g. single phase) transaction, but it automatically detects when the second transactional resource is updated and converts the transaction to an XA transaction. As part of doing so, the container informs the resources that it is coordinating an XA transaction for them and to participate accordingly. All of this behavior is achieved automatically, without any additional code for the developer to write, simply by implementing the code in an EJB.

## Run the example application

Ideally, while you're reading this article, you should also be performing these steps in Application Developer. If you have been, you have now configured a test server and installed the example EAR.

You can now start the server to run the application. In the Server perspective, go to the Servers view. Select your server and click Start to run it. If the server starts correctly, you'll see a startup log in the console similar to this:

```
JMSMQJDPProv A MSGS0656I: Starting the MQJD JMS Provider
JMSMQJDPProv A MSGS0650I: MQJD JMS Provider open for business
ResourceMgrIm I WSVR0049I: Binding XAExampleQCF as jms/XAExampleQCF
ResourceMgrIm I WSVR0049I: Binding XAExampleQ as jms/XAExampleQ
ResourceMgrIm I WSVR0049I: Binding Example Oracle XA Data Source as jdbc/OracleXADS
ResourceMgrIm I WSVR0049I: Binding Example DB2 XA Data Source as jdbc/DB2XADS
CacheServiceI I DYNA0048I: WebSphere Dynamic Cache initialized successfully.
. . .
ApplicationMg A WSVR0200I: Starting application: XAExampleEAR
EJBContainerI I WSVR0207I: Preparing to start EJB jar: XAExampleEJB.jar
EJBContainerI I WSVR0037I: Starting EJB jar: XAExampleEJB.jar
WebContainer A SRVE0169I: Loading Web Module: XAExampleWeb.
WebGroup      I SRVE0180I: [XAExampleWeb] [/XAExampleWeb] [Servlet.LOG]: JSP 1.2 Processor: init
WebGroup      I SRVE0180I: [XAExampleWeb] [/XAExampleWeb] [Servlet.LOG]: SimpleFileServlet: init
WebGroup      I SRVE0180I: [XAExampleWeb] [/XAExampleWeb] [Servlet.LOG]: InvokerServlet: init
ApplicationMg A WSVR0221I: Application started: XAExampleEAR
```

Now we can run the application. In your favorite web browser, invoke this URL:

```
http://localhost:9080/XAExampleWeb/XAExampleServlet?data=hello%20world
```

This invokes our `XAExampleServlet` servlet with a single parameter whose name is `data` and whose value is "hello world." If everything runs successfully, the browser will display this result:

```
Just persisted and sent data: hello world
```

Likewise, in the server console, you'll see some status messages like these:

```
SystemOut      0 Adding a new database row containing: hello world
SystemOut      0 Successfully added row: hello world
SystemOut      0 Adding a new database row containing: hello world
SystemOut      0 Successfully added row: hello world
SystemOut      0 Sending a message containing: hello world
SystemOut      0 Successfully sent message: hello world
```

If all of this works for you, congratulations, you've successfully run an application that uses an XA transaction spanning JDBC and JMS resources.

## Troubleshooting the example application

Several potential problems can prevent you from running the example successfully. Two of them are common mistakes in deploying the example and are easy to fix. Two others have to do with configuration problems in the Oracle database and require an Oracle DBA to fix.

The following sections list the problems that can occur, show the exceptions displayed in the Application Developer console, give a brief description of why the problem occurred, and explain what to do to fix each problem.

### ClassNotFoundException: EJSSStatelessXAExampleSessionHomeBean

When starting the server, when the application starts successfully, you get these messages:

```
ApplicationMg A WSVR0200I: Starting application: XAExampleEAR
EJBContainerI I WSVR0207I: Preparing to start EJB jar: XAExampleEJB.jar
EJBContainerI I WSVR0037I: Starting EJB jar: XAExampleEJB.jar
WebContainer A SRVE0169I: Loading Web Module: XAExampleWeb.
WebGroup      I SRVE0180I: [XAExampleWeb] [/XAExampleWeb] [Servlet.LOG]: JSP 1.2 Processor: init
WebGroup      I SRVE0180I: [XAExampleWeb] [/XAExampleWeb] [Servlet.LOG]: SimpleFileServlet: init
WebGroup      I SRVE0180I: [XAExampleWeb] [/XAExampleWeb] [Servlet.LOG]: InvokerServlet: init
ApplicationMg A WSVR0221I: Application started: XAExampleEAR
```

However, you may instead get an error like this:

```
ApplicationMg A WSVR0200I: Starting application: XAExampleEAR
EJBContainerI I WSVR0207I: Preparing to start EJB jar: XAExampleEJB.jar
```



```

BeanMetaData E CNTR0075E: The user-provided class
"com.ibm.example.xa.EJSStatelessXAExampleSessionHomeBean_5a0991c7"
needed by the EnterpriseBean could not be found or loaded.
EJBContainer I E WSVR0209E: Unable to prepare EJB jar XAExampleEJB.jar
[class com.ibm.ws.runtime.component.DeployedModuleImpl],
enterprise bean com.ibm.etools.ejb.impl.SessionImpl(XAExampleSession)
(transactionType: Container, sessionType: Stateless)
java.lang.ClassNotFoundException:
com.ibm.example.xa.EJSStatelessXAExampleSessionHomeBean_5a0991c7
at com.ibm.ws.classloader.CompoundClassLoader.findClass(CompoundClassLoader.java:351)
at com.ibm.ws.classloader.CompoundClassLoader.loadClass(CompoundClassLoader.java:261)
at java.lang.ClassLoader.loadClass(ClassLoader.java:Compiled Code)
at com.ibm.ejs.container.BeanMetaData.loadExistedClass(BeanMetaData.java:2573)
at com.ibm.ejs.container.BeanMetaData.<init>(BeanMetaData.java:888)
at com.ibm.ws.runtime.component.EJBContainerImpl.createBeanMetaData(EJBContainerImpl.java:980)
. . .

DeployedAppli W WSVR0206E: Module, XAExampleEJB.jar, of application,
XAExampleEAR.ear/deployments/XAExampleEAR, failed to start
ApplicationMg W WSVR0101W: An error occurred starting, XAExampleEAR
ApplicationMg A WSVR0217I: Stopping application: XAExampleEAR
ApplicationMg A WSVR0220I: Application stopped: XAExampleEAR

```

The error is `ClassNotFoundException`, where the missing class is `com.ibm.example.xa.EJSStatelessXAExampleSessionHomeBean_5a0991c7`. It occurred while attempting to start the EJB jar `XAExampleEJB.jar`.

What this indicates is that you forgot to generate the EJB code, so the container cannot find the generated Home class for the `XAExampleSession` bean. To fix this problem, generate the **Deployment and RMIC code** for all of the beans in the indicated EJB project, then restart the server.

## SQLException: Table or view does not exist

When running the example for the first time, you may get an error that looks like this:

```

WSRdbDataSou I DSR8203I: Database product name: Oracle
WSRdbDataSou I DSR8204I: Database product version:
Personal Oracle9i Release 9.2.0.1.0 - Production
With the Partitioning, OLAP and Oracle Data Mining options
JServer Release 9.2.0.1.0 - Production
WSRdbDataSou I DSR8205I: JDBC driver name : Oracle JDBC driver
WSRdbDataSou I DSR8206I: JDBC driver version : 9.2.0.1.0
WebGroup E SRVE0026E: [Servlet Error]-[ORA-00942: table or view does not exist
]: java.sql.SQLException: ORA-00942: table or view does not exist

at oracle.jdbc.dbaccess.DBError.throwSQLException(DBError.java:134)
at oracle.jdbc.ttc7.TTIoer.processError(TTIoer.java:289)
at oracle.jdbc.ttc7.Oall17.receive(Oall17.java:573)
at oracle.jdbc.ttc7.TTC7Protocol.doOall17(TTC7Protocol.java:1891)
at oracle.jdbc.ttc7.TTC7Protocol.parseExecuteFetch(TTC7Protocol.java:1093)
at oracle.jdbc.driver.OracleStatement.executeNonQuery(OracleStatement.java:2047)
at oracle.jdbc.driver.OracleStatement.doExecuteOther(OracleStatement.java:1940)
at oracle.jdbc.driver.OracleStatement.doExecuteWithTimeout(OracleStatement.java:2709)
at oracle.jdbc.driver.OraclePreparedStatement.executeUpdate(OraclePreparedStatement.java:589)
at oracle.jdbc.driver.OraclePreparedStatement.execute(OraclePreparedStatement.java:656)
at com.ibm.ws.rsadapter.jdbc.WSJdbcPreparedStatement.execute(WSJdbcPreparedStatement.java:386)
at com.ibm.example.xa.XAExampleSessionBean.persist(XAExampleSessionBean.java:45)
at com.ibm.example.xa.XAExampleSessionBean.persistAndSend(XAExampleSessionBean.java:30)
at com.ibm.example.xa.EJSLocalStatelessXAExampleSession_5a0991c7.persistAndSend
(EJSLocalStatelessXAExampleSession_5a0991c7.java:23)
at XAExampleServlet.persistAndSend(XAExampleServlet.java:44)
at XAExampleServlet.doGet(XAExampleServlet.java:28)
at javax.servlet.http.HttpServlet.service(HttpServlet.java:740)
at javax.servlet.http.HttpServlet.service(HttpServlet.java:853)
. . .

```

The error is `SQLException`, error code `ORA-00942`; specifically, an expected database table or view does not exist. However, the error does not tell you which table or view is missing. The stack trace does show that the error occurred in the method `XAExampleSessionBean.persist`, in line 45 of the `.java` file. Click on that line of the stack trace and the editor takes you to the execute line of this code:

```

PreparedStatement statement =
    connection.prepareStatement("INSERT INTO XA_EXAMPLE VALUES (?)");
statement.setString(1, data);
statement.execute();

```

So the problem occurred while inserting a row into the `XA_EXAMPLE` table. What this indicates is that you forgot to run the SQL file that creates the database tables. To fix this problem, run the SQL file:

```
SQL> @:\workspace\XAExampleEJB\XAExampleDB.sql
```

Now run the example again.

## OracleXAException: XAER\_RMERR (Internal XA Error)

When running the example for the first time, you may get an error that looks like this:

```
WSRdbDataSou I DSRA8203I: Database product name : Oracle
WSRdbDataSou I DSRA8204I: Database product version :
    Personal Oracle9i Release 9.2.0.1.0 - Production
With the Partitioning, OLAP and Oracle Data Mining options
JServer Release 9.2.0.1.0 - Production
WSRdbDataSou I DSRA8205I: JDBC driver name : Oracle JDBC driver
WSRdbDataSou I DSRA8206I: JDBC driver version : 9.2.0.1.0
WSRdbXAResour E DSRA0304E: XAException occurred. XAException contents and details are:
The XA Error is : -3
The XA Error message is : A resource manager error has occurred in the transaction branch.
The Oracle Error code is : 65535
The Oracle Error message is: Internal XA Error
The cause is : null.
WSRdbXAResour E DSRA0302E: XAException occurred. Error code is: XAER_RMERR.
Exception is: <null>
RegisteredRes E WTRN0078E: An attempt by the transaction manager to call start
on a transactional resource has resulted in an error.
The error code was XAER_RMERR. The exception stack trace follows:
oracle.jdbc.xa.OracleXAException
at oracle.jdbc.xa.OracleXAResource.checkError(OracleXAResource.java:1157)
at oracle.jdbc.xa.client.OracleXAResource.start(OracleXAResource.java:295)
at com.ibm.ws.rsadapter.spi.WSRdbXAResourceImpl.start(WSRdbXAResourceImpl.java:927)
at com.ibm.ejs.j2c.XATransactionWrapper.start(XATransactionWrapper.java:1267)
at com.ibm.ws.Transaction.JTA.JTAResourceBase.start(JTAResourceBase.java:164)
at com.ibm.ws.Transaction.JTA.RegisteredResources.startRes(RegisteredResources.java:389)
at com.ibm.ws.Transaction.JTA.TransactionImpl.enlistResource(TransactionImpl.java:1903)
at com.ibm.ws.Transaction.JTA.TransactionManagerSet.enlist(TransactionManagerSet.java:494)
. . .
```

The error is that the transaction manager was unable to convert the transaction to an XA transaction. Specifically, Oracle returned an error XAER\_RMERR, error code number 65535. ORA-65535 is not a valid error code and XAER\_RMERR essentially means that something went wrong with XA. What this indicates is that your Oracle database is not configured to support XA transactions. Therefore, when the WebSphere Application Server transaction manager instructs the Oracle transaction manager to participate in this XA transaction, Oracle cannot comply and throws this exception.

The solution is to run two scripts that are included in the Oracle install. This will likely need to be performed by your Oracle DBA, since you must be logged into Oracle as SYSOPER or SYSDBA in order to have the necessary permissions for these scripts to work. The scripts are:

directory: <ORACLE\_HOME>\javavm\install

file: initxa.sql

file: initjvm.sql

The initxa.sql script configures the database for XA. Once it runs successfully, your database is configured for XA. The script may run successfully the first time you try. Unfortunately, it probably will not run successfully because some of the database's memory spaces are too small. To fix this, run the initjvm.sql script. It will probably fail too, but in doing so it will indicate which parameters need to be adjusted. The parameters are stored in this file:

directory: <ORACLE\_HOME>\database

file: init<DATABASE\_SID>.ora

This table shows two parameters that typically need to be increased. Your particular database configuration may require adjusting different parameters.

### Oracle Initialization Values

Parameter Name	Minimum Value
java_pool_size	12000000

<i>Parameter Name</i>	<i>Minimum Value</i>
shared_pool_size	24000000

Once `initjvm.sql` runs successfully, then `initxa.sql` should run successfully. The Oracle database will need to be restarted for the changes to take effect. You can then restart the WebSphere Studio test server and retry running the example.

### **XAException: XAER\_RMERR (xa\_recover)**

You may be able to run the example just fine, at least after fixing a few problems. You may develop an application that uses XA transactions with Oracle and be able to run it fine. But one day you may find that you cannot start your WebSphere Application Server. This will probably occur after crashing WebSphere and/or Oracle without shutting down the servers properly. The WebSphere startup error looks like this:

```
SecurityCompo I SECJ0243I: Security service started successfully
SecurityCompo I SECJ0210I: Security enabled false
WSRdbxaResour E DSRA0304E: XAException occurred.
XAException contents and details are: The cause is          : null.
36185510 WSRdbxaResour E DSRA0302E: XAException occurred.
Error code is: XAER_RMERR. Exception is: <null>
XARminst E WTRN0037W: The transaction service encountered an error
on an xa_recover operation. The resource was J2CXAResourceInfo :
cfName = XA Example Data Source
configProps = [Deployed Resource Adapter Properties]
OptionC_authDataAlias java.lang.String scott
UserName java.lang.String scott
Password java.lang.String *****
TransactionResourceRegistration java.lang.String dynamic
InactiveConnectionSupport java.lang.Boolean true
secureMode boolean true
. . .
The error code was XAER_RMERR. The exception stack trace follows:
javax.transaction.xa.XAException
at oracle.jdbc.xa.OracleXAResource.recover(OracleXAResource.java:626)
at com.ibm.ws.rsadapter.spi.WSRdbxaResourceImpl.recover(WSRdbxaResourceImpl.java:672)
at com.ibm.ws.Transaction.JTA.XARminst.recover(XARminst.java:130)
at com.ibm.ws.Transaction.JTA.XARcoveryData.recover(XARcoveryData.java:673)
at com.ibm.ws.Transaction.JTA.RecoveryManager.resync(RecoveryManager.java:1369)
at com.ibm.ws.Transaction.JTA.ResyncThread.run(RecoveryManager.java:1440)

ApplicationMg A WSVR0200I: Starting application: IBMUTC
```

The error is that the transaction manager was unable to perform an XA recover operation. Specifically, Oracle returned an error `XAER_RMERR`. As with the last error, `XAER_RMERR` indicates that something went wrong with XA. What this indicates is that WebSphere did not close its connection with Oracle properly, probably because either or both servers were not shut down properly; they crashed. Now that WebSphere Application Server is attempting to reestablish the connection, Oracle needs to rollback any transactions that were in progress, but the Oracle user that WebSphere is using to log into the database (scott, in this example) cannot perform the recovery.

The solution is to give the Oracle user permission to perform the recovery, specifically to access the internal Oracle tables used to manage recovery. In SQL Plus as `SYSOPER` or `SYSDBA`, run this command:

```
grant select on DBA_PENDING_TRANSACTIONS to PUBLIC
```

If you don't want to grant this permission to all users, specify only the user listed in the error (in this example, scott). Then restart the database, and this time you should be able to successfully restart the WebSphere server.

## **Conclusions**

This article has shown you how to create a WebSphere Studio Application Developer test server configured with a JDBC data source for Oracle XA, a data source for DB2 XA, and a JMS queue connection factory and queue. It described a simple session EJB method that updates both JDBC and

JMS data, necessitating an XA transaction. You've seen what this simple application looks like when it runs correctly, as well as some of the errors that can occur and how to fix them. With this knowledge, you can now write WebSphere Java applications that use XA transactions.

## Acknowledgements

The author would like to thank Tom Alcott, Keys Botzum, Roland Barcia, Bill Hines, and Paul Ilchko for their help in developing this article.

## Questions from users

**Question 1:** Hi Bobby -- your article is very useful and I was looking desperately to some information it contains a few months ago when I tried to make this work with Oracle. I just wanted to mention that in our case, it didn't work without the property "transactionBranchesLooselyCoupled" set to "true" in the datasource. Best regards, Daniel

**Response from author:** Daniel -- you are correct xxxxxxxxxxxxxxxx

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[WebSphere Studio Application Developer V5 Programming Guide](#), by Ueli Wahli, et. al., IBM Redbook SG246957

["Transactions in J2EE"](#) by Jan Smolenski and Peter Kovari, IBM Redpaper REDP3659

["Distributed Transaction Processing: The XA Specification"](#) by The Open Group, February 1992, UK ISBN 1-872630-24-3

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