

JBoss Transaction Service 4.8.0

Transaction Bridging Guide

Txbridge-9/8/09



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JBoss Transaction Service 4.8.0

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About This Guide

What This Guide Contains

The Transaction Bridging Guide contains information on how to use JBoss Transaction Service 4.8.0. This guide provides information on how to integrate JTA (XA) and XTS (WS-AT) transactions using the transaction bridge.

Audience

This guide is most relevant for application developers working in environments that integrate traditional JEE transactions usage and transactional Web Services.

Prerequisites

JBossTS uses the Java programming language and this manual assumes that you are familiar with programming in Java. In addition, a familiarity with the JTA and XTS components of JBossTS is assumed. You should read the relevant Programmer's Guides before tackling this document.

Organization

This guide contains the following chapters:

1. TODO

Documentation Conventions

The following conventions are used in this guide:

| Convention | Description |
|---------------|--|
| <i>Italic</i> | In paragraph text, italic identifies the titles of documents that are being referenced. When used in conjunction with the Code text described below, italics identify a variable that should be replaced by the user with an actual value. |
| Bold | Emphasizes items of particular importance. |
| Code | Text that represents programming code. |

| | |
|----------------------------|---|
| Function Function | A path to a function or dialog box within an interface. For example, “ Select File Open. ” indicates that you should select the Open function from the File menu. |
| () and | <p>Parentheses enclose optional items in command syntax. The vertical bar separates syntax items in a list of choices. For example, any of the following three items can be entered in this syntax:</p> <pre>persistPolicy (Never OnTimer OnUpdate NoMoreOftenThan)</pre> |
| Note: and | A note highlights important supplemental information. |
| Caution: | A caution highlights procedures or information that is necessary to avoid damage to equipment, damage to software, loss of data, or invalid test results. |

Table 1 **Formatting Conventions**

Additional Documentation

In addition to this guide, the following guides are available in the JBoss Transaction Service 4.8.0 documentation set:

- **JBoss Transaction Service 4.8.0 *Release Notes*:** Provides late-breaking information about JBoss Transaction Service 4.8.0.
- **JBoss Transaction Service 4.8.0 *Installation Guide*:** This guide provides instructions for installing JBoss Transaction Service 4.8.0.
- **JBoss Transaction Service 4.8.0 *Failure Recovery Guide*:** Provides guidance for administering the system.
- **JBoss Transaction Service 4.8.0 *Transactions API Guide*:** Provides guidance for administering the system.
- **JBoss Transaction Service 4.8.0 *Transaction Core Programmers Guide*:** Provides guidance for administering the system.
- **JBoss Transaction Service 4.8.0 *JTS Programmers Guide*:** Provides guidance for administering the system.
- **JBoss Transaction Service 4.8.0 *Administration Guide*:** Provides guidance for administering the system.
- **JBoss Transaction Service 4.8.0 *Web Service Transactions Programmers Guide*:** Provides guidance for using Web Services Transactions.

Contacting Us

Questions or comments about JBoss Transaction Service 4.8.0 should be directed to our support team.

Introduction

Contextual Overview

Transactions provide a structuring mechanism for business logic. Use of transactions allows for grouping of data manipulations into constructs with certain properties. Traditional ACID transactions provide for properties of Atomicity, Consistency, Isolation and Durability.

In JEE applications, transaction support is provided via the Java Transaction API (JTA). The classes and interfaces in the `javax.transaction` and `javax.transaction.xa` packages provide a means by which the programmer may manage transaction demarcation (begin, commit, rollback) and, where necessary, interact with the transaction management system (e.g. `enlistResource`). In many JEE applications, further abstractions are provided on top of the JTA. For example, EJB3 `@TransactionAttribute` annotations may be used for transaction boundary demarcation in preference to explicit calls to the JTA's `UserTransaction` interface.

In distributed applications, the JTA implementation may provide propagation of transaction context and transaction control calls between containers (JVMs) using either a propriety transport or JTS, the Java mapping of the CORBA OTS standard on an RMI/IIOP transport. In JBossTS, both local and distributed (JTS) implementations of the JTA are available.

In Web Services applications, ACID transaction management and interoperable context propagation is provided for by the WS-AT standard. JBossTS XTS provides an implementation of both the 1.0 and 1.1 versions of this standard. Bridging is provided only on the more recent version. At the time of writing the standard covers only the web services API and protocol, not the Java API through which the protocol may be driven. Therefore, XTS provides a custom Java API to users, with characteristics broadly similar to the JTA.

For applications that combine traditional JEE transaction management and Web Service transaction management, it is often desirable to have some mechanism for linking these transaction types, such that a single transaction may span business logic written for either transaction type. Examples include exposing existing JEE transactional business logic (e.g. EJBs) as transactional Web Services, or allowing JEE transactional components to utilize transactional Web Services.

Transaction Bridging

We use the term Transaction Bridging to describe the process of linking the JEE and Web Services transaction domains. The transaction bridge component (`txbridge`) of JBossTS provides bi-directional linkage, such that either type of transaction may encompass business logic designed for use with the other type.

The technique used by the bridge is a combination of interposition and protocol mapping.

Interposition is used in transaction systems to allow a tree of transaction coordinators to be constructed, usually for performance reasons. Interposed coordinators function as transaction managers for nodes below them in the tree, whilst appearing as resources (participants in WS-AT terminology) to the node above them.

Within a single transaction domain, interposition may be used to allow remote nodes to minimize the number of network calls necessary at transaction termination. The top level node is known as the root coordinator, whilst interposed coordinators are termed subordinate. This name indicates that they are not autonomously responsible for determining the transaction outcome, but rather are driven by their parent coordinator. Therefore, whilst a top level coordinator exposes only the commit and rollback methods for transaction termination and handles the 2PC internally, the subordinates additionally expose the prepare method to their parent, behaving much like resources during the termination protocol.

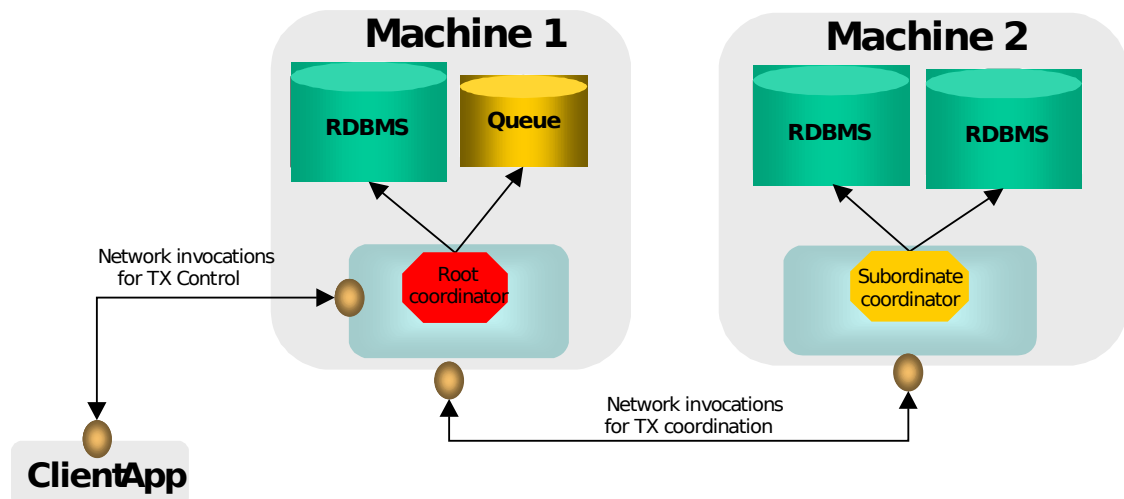


Figure 1: Transaction interposition in a distributed JTA environment

In the transaction bridge, an interposed coordinator is registered into the existing transaction and performs the additional task of protocol mapping. That is, it appears to its parent coordinator to be a resource of its native transaction type, whilst appearing to its children to be a coordinator of their native transaction type, even though these transaction types differ.

TODO: diagram here

The interposed coordinator is responsible for performing mapping between the transaction protocols. There is a strong correspondence between the API and protocol used by the JTA and WS-AT transaction types, which is unsurprising given their common heritage and shared problem domain. However, method signatures, exception types and such do differ. The bridge provides an abstraction layer to mask these distinctions as far as possible.

The net result of this is that existing business logic perceives its expected transaction environment, even though the transaction in which it is executing may be subordinate to one of a different type. No changes are necessary to existing transactional applications to allow them to operate in the scope of foreign transactions. This facilitates reuse of existing business logic components in new environments and increases the possibilities for new architectures and interoperability.

Transaction Bridge Architecture

Overview

The transaction bridge resides in the package `org.jboss.jbossts.txbridge`. It consists of two distinct sets of classes, one for bridging in each direction, as well as a number of shared utility classes.

The process of inflowing a WS-AT transaction context on a Web Service call into the container and converting it to a local JTA transaction context such that existing transactional JEE code (e.g. EJBs) may be called within its scope, is termed **Inbound Transaction Bridging**. When using inbound bridging, a parent WS-AT transaction coordinator has a subordinate JTA coordinator interposed into it via the transaction bridge.

The process of outflowing a WS-AT transaction context on a call to a transactional Web Service from a business logic method operating in a JEE transaction scope, is termed **Outbound Transaction Bridging**. When using outbound bridging, a parent JTA transaction coordinator has a subordinate WS-AT coordinator interposed into it via the transaction bridge.

For the purpose of this naming convention, it is simplest to view the JTA as being local to the container in which it operates, whilst the Web Service protocol provides for transaction context propagation between servers. This is an accurate representation of the situation that exists where the local JTA version of JBossTS is being used alongside JBossTS XTS in an application server. However, it is an oversimplification of the situation where the JTS option is used. We will return to this case later.

TODO: diagram

Shared Design Elements

The design of the inbound and outbound bridges is conceptually very similar. Each provides the following:

A **BridgeManager**, essentially a factory singleton, providing a means of managing **Bridge** and resource/participant instances. The chief role of the **BridgeManager** is to ensure a distinct mapping of a parent transaction context to a single **Bridge** and resource/participant instance.

A **Bridge**, which provides Thread to transaction context association and disassociation functions for the subordinate transaction. The Bridge is usually called from the **Handler**, but may optionally be driven directly.

A **Handler**, which is registered into the JAX-WS processing pipeline to provide minimally invasive management of Thread to transaction context bindings via the **Bridge**, an appropriate instance of which it obtains from the **BridgeManager**. Whilst the bridge provides handlers only for JAX-WS, it's possible to use these as a model for the implementation of JAX-RPC versions if desired.

A **VolatileParticipant** and **DurableParticipant** (in the case of the InboundBridge) or **Synchronization** and **XAResource** (in the case of the OutboundBridge) which are enlisted into the parent transaction and wrap the Subordinate transaction coordinator, providing mapping of the transaction termination protocol operations.

TODO: recovery manager

Inbound Bridging

The process flow when using the inbound bridge is as follows:

A remote client starts a WS-AT transaction and invokes a transactional Web Service in the scope of that transaction. The inbound WS invocation therefore has SOAP headers containing the WS-AT transaction context. The coordinator used for this transaction is the root coordinator. It may be remote from either or both of the client and the service it is invoking. The client needs access to a WS-AT implementation, but not a JTA or the transaction bridge deployed.

The call arrives at a web service container, which must have JBossTS JTA or JTS, XTS and the transaction bridge deployed. The JAX-WS handler chain for the web service should have both the XTS WS-AT transaction header processor and the inbound bridge handler registered, such that they are invoked in that order.

The transaction header processor takes the WS-AT transaction context from XML, creates a corresponding WS-AT TxContext and associates it to the Thread. The bridge handler calls the InboundBridgeManager to obtain a InboundBridge instance corresponding to this TxContext.

As the BridgeManager is seeing the TxContext for the first time, it creates a new Bridge instance. It also creates a new Bridge VolatileParticipant and DurableParticipant and registers them with the WS-AT transaction coordinator. These Participants wrap a subordinate JTA transaction.

The bridge header processor starts the bridge, which associates the JTA subordinate transaction context to the Thread. At this point the Thread has transaction contexts for both WS-AT and JTA.

The JAX-WS pipeline processing continues, eventually calling whatever business logic is exposed. This may be e.g. an EJB using JSR-181 annotations. The business logic may use the JTA transaction in the normal manner e.g. enlisting Synchronizations and XAResources or performing other transactional activity either directly or through the usual JEE abstractions.

On the return path, the bridge header processor disassociates the JTA transaction context from the Thread via the Bridge. The XTS context processor then does likewise for the WS-AT TxContext.

On subsequent web services calls to the same or other web services from the same client, the process is repeated. However, the BridgeManager will, upon seeing the same WS-AT transaction context again, return the existing Bridge instance and not register further Participant instances. This allows substantially better performance than registering one Participant per web service invocation.

Upon transaction termination by the client, the WS-AT transaction coordinator will drive the enlisted bridge Participants through the transaction termination protocol. The Participants maps these calls down to the JTA subtransaction coordinator, which in turn passes them on to any Synchronizations or XAResources enlisted in the transaction. This process is not visible to the business logic, except in so far as it may have registered its own Synchronizations, XAResources or Participants with the transaction.

Outbound Bridging

The process flow when using the outbound bridge is as follows:

A client starts a JTA transaction and invokes a remote transactional Web Service in the scope of that transaction. The client must have JBossTS JTA (or JTS) and XTS deployed, as well as the transaction bridge. The coordinator used for the JTA transaction is the root coordinator. The server hosting the target web service needs a WS-AT transaction implementation but not a JTA or the transaction bridge.

The outbound WS invocation flows through a handler chain that has the outbound transaction bridge handler and XTS header context processor registered, such that they are invoked in that order.

The bridge handler calls the outbound bridge manager to obtain an outbound bridge instance corresponding to the JTA transaction context. As the BridgeManager is seeing the context for the first time, it creates a new Bridge instance. It also creates a Synchronization and XAResource instance to wrap the subordinate WS-AT transaction and registers these with the JTA transaction.

The bridge handler starts the bridge, which associates the subordinate WS-AT transaction context to the Thread. The WS-AT header context processor then serializes this into XML in the headers of the outbound Web Services call.

The receiving Web Service sees a WS-AT context and can work with it in the normal manner, without knowing it is a subordinate context.

On the return path, the bridge handler disassociates the WS-AT TxContext from the Thread via the Bridge.

On subsequent calls to the same or other transactional Web Services in the scope of the same JTA transaction, the process is repeated. However, the BridgeManager will, upon seeing the same JTA transaction context again, return the existing Bridge and not register another Synchronization or XAResource with the parent JTA transaction. This allows substantially better performance than registering once per web service invocation.

Upon transaction termination by the client, the JTA transaction coordinator will drive the enlisted bridge Synchronization and XAResource through the transaction termination protocol. The XAResource maps these calls down to the WS-AT subtransaction coordinator, which in turn passes them on to any Volatile or Durable Participants enlisted in the transaction. This process is not visible to the business logic, except in so far as it may have registered its own Participants, XAResources or Synchronizatons with the transaction.

Crash Recovery

TODO

Using the Transaction Bridge

Introduction

This section describes how to use the transaction bridge in your applications. It is recommended you first read the preceding chapters for a theoretical background in the way the bridge functions.

Deployment

The txbridge.sar file should be placed in JBossAS server/<config>/deploy directory. The server must also be running JBossTS JTA (the default transaction manager) or JTS, and also JBossTS XTS. The versions of all these components must be consistent.

Inbound Bridging

To use the inbound bridge, register the JAX-WS handler into the handler chain of any Web Service as follows:

```
<handler-chain>
  <protocol-bindings>##SOAP11_HTTP</protocol-bindings>
  <handler>
    <handler-name>TransactionBridgeHandler</handler-name>
    <handler-
class>org.jboss.jbossts.txbridge.JaxWSTxInboundBridgeHandler</handler-class>
  </handler>

  <handler>
    <handler-name>WebServicesTxContextHandler</handler-name>
    <handler-
class>com.arjuna.mw.wst11.service.JaxWSHeaderContextProcessor</handler-
class>
  </handler>
</handler-chain>
```

The web service may then operate as though running in the scope of a JTA transaction, as indeed it is. For example, it can call (or indeed simply be) an EJB3 business logic method annotated with `@TransactionAttribute(TransactionAttributeType.MANDATORY)`.

Note that the handlers expect a WS-AT transaction context to be present on all inbound invocations. If you wish deploy your service in such a way as to make transactional invocation optional, you must expose it though two different endpoints, one transactional and one not, with the handlers registered only on the former. This limitation may be addressed in future versions.

Outbound Bridging

To use the outbound bridge, register the JAX-WS handler into the handler chain of any Web Service client application as follows:

```
<handler-chain>
  <protocol-bindings>##SOAP11_HTTP</protocol-bindings>
  <handler>
    <handler-name>TransactionBridgeHandler</handler-name>
    <handler-
class>org.jboss.jbossts.txbridge.JaxWSTxOutboundBridgeHandler</handler-
class>
  </handler>

  <handler>
    <handler-name>WebServicesTxContextHandler</handler-name>
    <handler-
class>com.arjuna.mw.wst11.client.JaxWSHeaderContextProcessor</handler-class>
  </handler>
</handler-chain>
```

The web service client may then make calls to web service implementations that expect to be invoked in the scope of a WS-AT transaction.

Note that the handlers expect a JTA transaction context to be present on the client thread used to make the outbound web service invocation. If the context is not always present, different stubs must be used for the transactional and non-transactional cases and the handler chain registered only on the former. This limitation may be addressed in future versions.

Demonstration Application

A simple demonstration application is available to show usage of the bridge. It is modeled to some extent on the XTS 'Night Out' demonstrator application, with which readers are assumed to be familiar.

Since transactions mostly run without visible effect, the demo is useful mainly as an example of how to utilize the bridge. The bridge implementation does however contain trace level logging for most functions. Used in conjunction with verbose logging from XTS, the transaction manager, the Web Service stack and the EJB container, this can be used to gain a detailed understanding of the flow of events in the system. Alternatively, stepping through the demo using a source debugger can be instructive.

To deploy and run the demo application, edit demo/build.xml to ensure the jbossas.home and jbossas.server properties are set correctly, then execute 'ant dist' to build the application artifacts. Start the application server, then deploy the service side of the demo using 'ant deploy-service'. Once it has deployed, the client app can be similarly installed using 'ant deploy-client'. Depending on your server configuration, the client will then be accessible from e.g. <http://localhost:8080/txbridge-demo-client/>

Inbound Bridge

The demonstrator exposes a EJB3 SLSB as a transactional web service ('Bistro') via the inbound bridge. Note that the code implementing this service is standard EJB with JSR-181 annotations and has no compile time dependency on XTS or the txbridge. The only point of linkage is the usage of the `@HandlerChain(file = "jaxws-handlers-server.xml")` annotation to reference a xml file containing the XTS and txbridge handlers, as detailed above. Other than this the service side of the application uses only standard JEE elements and has no direct knowledge of WS-AT transactions.

A client starts a WS-AT transaction and makes an invocation on the web service. The client does not use JTA (XA) transactions. It uses `@HandlerChain(file = "jaxws-handlers-client.xml")` to register the XTS header context processor, but is otherwise similar to the XTS demo client.

In this demo, the inbound bridge converts the WS-AT context to a JTA one and invokes the EJB in that scope. By default the EJB is backed by the hsqldb embedded in JBossAS, for ease of deployment. This database does not support XA, so the resource registered for it uses LRCO. However, this point is not significant to the demo. Curious users can readily use a true XA database by deploying it into JBossAS via the usual `<xa-datasource>` in a -ds.xml file, then alter the demo's dd/persistence.xml to reference it.

Outbound Bridge

The demonstrator client application can also be used to invoke the XTS Night Out demo Restaurant Service via the outbound bridge. Deploy the XTS demo application services, then select the 'JTA' transaction type in the client. In this scenario the client uses a JTA transaction only, whilst the service understands WS-AT type transactions only. Note that the client has it's own copy of the service API, annotated with `@HandlerChain(file = "jaxws-handlers-client.xml")`, which is the only point of linkage with the transaction bridge. Once again neither the client nor server have any compile time dependency on the bridge.

Loops and Diamonds

In distributed environments that utilize transaction bridging, it is possible to construct arrangements of servers such that a transaction context passes through more than one interposition. These can give rise to some undesirable issues, including locking and performance problems.

A simple case would be a loop in which a JTA transaction context is bridged outbound to a WS-AT context, passed through one or more remote servers and inflowed back to the original server through an inbound bridge. This may result in a new subordinate JTA context, rather than reuse of the existing parent context in the original server.

This situation has two main observable effects. Firstly, the parent JTA transaction and indirectly subordinate JTA transaction are considered distinct and XAResources may not be shared between them. In most cases this will cause isolation between the transactions, such that they do not share locks or see each other's changes. This may cause deadlocks in the application. Secondly, performance will be poor relative to reuse of the original context, particularly if the interposition chain becomes long.

A similar problem exists where a transaction context is propagated from a single source to a single destination server via two or more separate routes, the paths forming a diamond shape. In such case the intermediate nodes operate independently and will bridge the original context to two separate interposed contexts. To the destination server these will appear unrelated, rather than as representations of the same transaction. Thus instead of recombining into a single shared transaction context at the destination, they will behave as different transactions, giving rise once again to potential deadlock and performance issues.

These problems may be partially addressed by having a shared context mapping service available on the network, which each bridge consults when working with a previously unseen transaction context for the first time. Using such a mechanism, bridge instances may identify transactions for which an established mapping already exists and reuse that relationship rather than creating a new one.

This shared service model does however cause some issues of its own with regard to performance and availability. It is not currently implemented. Therefore, users are urged to be cautious when constructing distributed applications. Whilst location abstraction is sometimes desirable, it is important to maintain a clear understanding of the deployment relationships between transactional components in the system.

Distributed JTA and the JTS

The JEE transaction engine in JBossTS comes in two varieties. These are the local only JTA, which does not support propagation of transaction context or transaction control calls between JVMs and the JTAX, which provides the JTA API implemented by a JTS engine that does support distributed usage.

JBossAS uses the local JTA implementation by default, but can be reconfigured to use the JTS via the JTA API, such that it supports distributed transactions without requiring any changes to business applications.

In environments requiring transaction propagation of JTA transactions, it is feasible to use either the JTS or an outbound and inbound bridge pair to achieve this. In the former case the transport is RMI/IIOP for the transaction control and RMI/IIOP or JRMP for the transactional business logic calls. In the latter case the transport is Web Services for both transaction control and business logic.

From a transaction management perspective the JTS solution is preferred, due to simplicity (no protocol mapping is needed), maturity (JBossTS JTS was the world's first JTS implementation and has been extensively used and tested in production environments), reliability (JTS does not suffer the crash recovery limitations of the current bridge implementation) and performance (binary vs. xml).

It is possible to use transactions that propagate context on some calls via JTS and on others via Web Services, such as a client invoking both EJBs via RMI/IIOP and Web services with

WS-AT context. In such cases it's possible for a transaction to have multiple representations that the infrastructure cannot determine are related, even if they actually represent different contexts in the same interposition hierarchy. Care must therefore be taken to avoid the problems described previously in 'Loops and Diamonds'.

Logging

The transaction bridge uses the log4j logging system. When running inside JBossAS, logging is configured via the server's `conf/jboss-log4j.xml` file. To enable full logging for the transaction bridge, which may be useful for debug purposes, the following should be used:

```
<category name="org.jboss.jbossts.txbridge">
    <priority value="ALL"/>
</category>
```

Note that the transaction bridge is a thin layer on top of the XTS and JTA/JTS components of JBossTS, and that it also interacts with other parts of the application server. To gain a comprehensive understanding of the system's operation, it may be necessary to enable verbose logging for some of these other components also. The JBossTS logging system is discussed in detail in the documentation set, but for ease of reference the following settings are used to enable verbose logging: In `conf/jbossts-properties.xml`, change the `DebugLevel` to

```
<property name="com.arjuna.common.util.logging.DebugLevel"
    type="System" value="0xffffffff"/>
```

and in `conf/jboss-log4j.xml`, ensure that the `com.arjuna` category is at ALL or TRACE.

Known Limitations

The current transaction bridge release has the following limitations:

The bridge operates only on WS-AT 1.1, not 1.0, although XTS includes implementations of both versions of WS-AT. Care must therefore be taken to deploy and configure the system correctly.

The bridge provides JAX-WS handlers only, not JAX-RPC, although it is possible to create such if required.

Long running activities that occur during the transaction termination process may cause timeouts in the transaction system, which can in turn cause inconsistent transaction outcomes or incomplete transaction termination. To minimize this problem, it is advised to manually flush data that would otherwise be flushed by Synchronizations during termination, such as hibernate session state.

A transaction context must always be present on the Thread in order for the context processors to operate correctly, as detailed previously in 'Using the Transaction Bridge'.

A subordinate transaction context will be created and registered into parent transaction unconditionally, which can cause unnecessary overhead in situations where no transactional activity takes place in the scope of the subordinate. Care should be taken to register the bridge handlers only on methods that do require them. In future releases this may be addressed by the use of WS-Policy or lazy initialization techniques.

Transaction mappings are local to BridgeManagers, which are singletons. This means mappings are classloader scoped and not shared across JVMs. This gives rise to issues where transactional resources are accessed indirectly through multiple bridges or transaction context transports, as described in 'Loops and Diamonds'.

Crash recovery is subject to certain timing issues, due to the interaction between recovery of the JTA/XA and XTS sides of the transaction. It may take longer than usual for a bridged transaction to recover and in certain cases misleading error messages may be printed during this interval. With the exception of the case detailed below, recovery should eventually occur.

If a transaction crashes in the time window between prepare of the subordinate and prepare of the parent, automated crash recovery may not occur. The subordinate will recover, but remain in a wait state pending instructions from its parent. The parent, having crashed before writing a log, will not recover. Such cases currently require manual recovery.