



Web Services Atomic Transaction (WS-AtomicTransaction) 1.1

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Abstract:

This specification provides the definition of the atomic transaction coordination type that is to be used with the extensible coordination framework described in the WS-Coordination specification. The specification defines three specific agreement coordination protocols for the atomic transaction coordination type: completion, volatile two-phase commit, and durable two-phase commit. Developers can use any or all of these protocols when building applications that require consistent agreement on the outcome of short-lived distributed activities that have the all-or-nothing property.

Status:

This document is published by the WS-TX TC as a "committee draft".

This document was last revised or approved by the WS-TX TC on the above date. The level of approval is also listed above. Check the current location noted above for possible later revisions of this document. This document is updated periodically on no particular schedule.

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The non-normative errata page for this specification is located at www.oasis-open.org/committees/ws-tx.

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1 Introduction

The current set of Web service specifications [WSDL][SOAP11][SOAP12] defines protocols for Web service interoperability. Web services increasingly tie together a number of participants forming large distributed applications. The resulting activities may have complex structure and relationships.

The WS-Coordination specification defines an extensible framework for defining coordination types. This specification provides the definition of an atomic transaction coordination type used to coordinate activities having an "all or nothing" property. Atomic transactions commonly require a high level of trust between participants and are short in duration. The Atomic Transaction specification defines protocols that enable existing transaction processing systems to wrap their proprietary protocols and interoperate across different hardware and software vendors.

To understand the protocol described in this specification, the following assumptions are made:

- The reader is familiar with existing standards for two-phase commit protocols and with commercially available implementations of such protocols. Therefore this section includes only those details that are essential to understanding the protocols described.
- The reader is familiar with the WS-Coordination [WSCOOR] specification that defines the framework for the WS-AtomicTransaction coordination protocols.
- The reader is familiar with WS-Addressing [WSADDR] and WS-Policy [WSPOLICY].

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Atomic transactions have an all-or-nothing property. The actions taken prior to commit are only tentative (i.e., not persistent and not visible to other activities). When an application finishes, it requests the coordinator to determine the outcome for the transaction. The coordinator determines if there were any processing failures by asking the participants to vote. If the participants all vote that they were able to execute successfully, the coordinator commits all actions taken. If a participant votes that it needs to abort or a participant does not respond at all, the coordinator aborts all actions taken. Commit makes the tentative actions visible to other transactions. Abort makes the tentative actions appear as if the actions never happened. Atomic transactions have proven to be extremely valuable for many applications. They provide consistent failure and recovery semantics, so the applications no longer need to deal with the mechanics of determining a mutually agreed outcome decision or to figure out how to recover from a large number of possible inconsistent states.

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Atomic Transaction defines protocols that govern the outcome of atomic transactions. It is expected that existing transaction processing systems wrap their proprietary mechanisms and interoperate across different vendor implementations.

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The keywords "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC2119 [KEYWORDS].¶
Namespace URIs of the general form <http://example.org> and <http://example.com> represents some application-dependent or context-dependent URI as defined in RFC 2396 [URI].¶

1.1 Composable Architecture

By using the XML [XML], SOAP [SOAP11] [SOAP12] and WSDL [WSDL] extensibility model, SOAP-based and WSDL-based specifications are designed to work together to define a rich Web services environment. As such, WS-AtomicTransaction by itself does not define all features required for a complete solution. WS-AtomicTransaction is a building block used with other specifications of Web services (e.g., WS-Coordination, WS-Security) and application-specific protocols that are able to accommodate a wide variety of coordination protocols related to the coordination actions of distributed applications.

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1.2 Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC2119 [KEYWORDS].

Namespace URIs of the general form "some-URI" represents some application-dependent or context-dependent URI as defined in RFC3986 [URI].

This specification uses an informal syntax to describe the XML grammar of the XML fragments below:

- The syntax appears as an XML instance, but the values indicate the data types instead of values.
- Element names ending in "..." (such as <element.../> or <element...>) indicate that elements/attributes irrelevant to the context are being omitted.
- Attributed names ending in "..." (such as name=...) indicate that the values are specified below.
- Grammar in bold has not been introduced earlier in the document, or is of particular interest in an example.
- <!-- description --> is a placeholder for elements from some "other" namespace (like ##other in XSD).
- Characters are appended to elements, attributes, and <!-- descriptions --> as follows: "?" (0 or 1), "*" (0 or more), "+" (1 or more). The characters "[" and "]" are used to indicate that contained items are to be treated as a group with respect to the "?", "*", or "+" characters.
- The XML namespace prefixes (defined below) are used to indicate the namespace of the element being defined.
- Examples starting with <?xml contain enough information to conform to this specification; others examples are fragments and require additional information to be specified in order to conform.

XSD schemas and WSDL definitions are provided as a formal definition of grammars [XML-Schema1] [WSDL].

1.3 Namespace

The XML namespace URI that MUST be used by implementations of this specification is:

<http://docs.oasis-open.org/ws-tx/ws-sat/2006/06>

This is also used as the CoordinationContext type for atomic transactions.

1.3.1 Prefix Namespace

| Prefix | Namespace |
|--------|---|
| S11 | http://schemas.xmlsoap.org/soap/envelope |
| S12 | http://www.w3.org/2003/05/soap-envelope |
| wscoor | http://docs.oasis-open.org/ws-tx/wscoor/2006/06 |
| wsat | http://docs.oasis-open.org/ws-tx/ws-sat/2006/06 |

If an action URI is used then the action URI MUST consist of the wsat namespace URI concatenated with the "/" character and the element name. For example:

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1.4 XSD and WSDL Files

The following links hold the XML schema and the WSDL declarations defined in this document.

<http://docs.oasis-open.org/ws-tx/wsdl/2006/06/wsdl.xsd>

<http://docs.oasis-open.org/ws-tx/wsdl/2006/06/wsdl.wsdl>

SOAP bindings for the WSDL documents defined in this specification MUST use "document" for the *style* attribute.

1.5 AT Protocol Elements

The protocol elements define various extensibility points that allow other child or attribute content. Additional children and/or attributes MAY be added at the indicated extension points but MUST NOT contradict the semantics of the parent and/or owner, respectively. If a receiver does not recognize an extension, the receiver SHOULD ignore the extension.

1.6 Normative References

[KEYWORDS]

S. Bradner, "Key words for use in RFCs to Indicate Requirement Levels," RFC 2119, Harvard University, March 1997, <http://www.ietf.org/rfc/rfc2119.txt>

[SOAP11]

W3C Note, "SOAP: Simple Object Access Protocol 1.1," 08 May 2000, <http://www.w3.org/TR/2000/NOTE-SOAP-20000508>

[SOAP12]

W3C Recommendation, "SOAP Version 1.2 Part 1: Messaging Framework", June 2003, <http://www.w3.org/2003/05/soap-envelope>

[URI]

T. Berners-Lee, R. Fielding, L. Masinter, "Uniform Resource Identifiers (URI): Generic Syntax", RFC 3986, <http://www.ietf.org/rfc/rfc3986.txt>, MIT/LCS, Day Software, Adobe Systems, January 2005.

[XML]

W3C Recommendation, "Extensible Markup Language (XML) 1.0 (Fourth Edition)", <http://www.w3.org/TR/2006/REC-xml-20060816>

[XML-ns]

W3C Recommendation, "Namespaces in XML (Second Edition)", 18 August 2006, <http://www.w3.org/TR/2006/REC-xml-names-20060816>

[XML-Schema1]

W3C Recommendation, "XML Schema Part 1: Structures," 2 May 2001, <http://www.w3.org/TR/2001/REC-xmlschema-1-20010502>

[XML-Schema2]

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| 106 | W3C Recommendation, "XML Schema Part 2: Datatypes," 2 May 2001, | Formatted: Default Paragraph Font |
| 107 | http://www.w3.org/TR/2001/REC-xmlschema-2-20010502 | Deleted: / |
| 108 | [WSCOORD] | Formatted: Hyperlink, Font: (Default) Arial, 10 pt |
| 109 | Web Services Coordination (WS-Coordination) 1.1, OASIS, March 2006, http://docs.oasis- | Formatted: Font: (Default) Arial, 10 pt |
| 110 | open.org/ws-tx/wscoord/2006/06 | Formatted: Default Paragraph Font |
| 111 | [WSADDR] | Formatted: Hyperlink, Font: (Default) Arial, 10 pt |
| 112 | Web Services Addressing (WS-Addressing) 1.0, W3C Recommendation, May 2006, | Formatted: Default Paragraph Font |
| 113 | http://www.w3.org/2005/08/addressing | Formatted: Hyperlink, Font: (Default) Arial, 10 pt |
| 114 | [WSPOLICY] | Formatted: Default Paragraph Font |
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| 117 | [WSPOLICYATTACH] | Formatted: Default Paragraph Font |
| 118 | Web Services Policy Attachment (WS-PolicyAttachment), VeriSign, Microsoft, Sonic Software, | Formatted: Hyperlink, Font: (Default) Arial, 10 pt |
| 119 | IBM, BEA Systems, SAP, September 2004, http://schemas.xmlsoap.org/ws/2004/09/policy/ | Deleted: / |
| 120 | [WSDL] | Formatted: Default Paragraph Font |
| 121 | Web Services Description Language (WSDL) 1.1, http://www.w3.org/TR/2001/NOTE-wsdl- | Formatted: Default Paragraph Font |
| 122 | 20010315 | Formatted: Hyperlink, Font: (Default) Arial, 10 pt |
| 123 | [WSSec] | Deleted: ¶ |
| 124 | OASIS Standard 200401, March 2004, "Web Services Security: SOAP Message Security 1.0 | Deleted: " |
| 125 | (WS-Security 2004)", http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-soap-message- | Formatted: Default Paragraph Font |
| 126 | security-1.0.pdf | Formatted: Hyperlink, Font: (Default) Arial, 10 pt |
| 127 | [WSSecPolicy] | Formatted: Default Paragraph Font |
| 128 | Web Services Security Policy Language (WS-SecurityPolicy), Microsoft, VeriSign, IBM, RSA | Formatted: Hyperlink, Font: (Default) Arial, 10 pt |
| 129 | Security, July 2005, http://schemas.xmlsoap.org/ws/2005/07/securitypolicy | Formatted: Default Paragraph Font |
| 130 | [WSSecConv] | Formatted: Hyperlink, Font: (Default) Arial, 10 pt |
| 131 | Web Services Secure Conversation Language (WS-SecureConversation), OpenNetwork, Layer7, | Deleted: / |
| 132 | Netegrity, Microsoft, Reactivity, IBM, VeriSign, BEA Systems, Oblix, RSA Security, Ping Identity, | Formatted: Font: (Default) Arial, 10 pt |
| 133 | Westbridge, Computer Associates, February 2005, http://schemas.xmlsoap.org/ws/2005/02/sc | Formatted: Default Paragraph Font |
| 134 | [WSTrust] | Formatted: Font: (Default) Arial, 10 pt |
| 135 | Web Services Trust Language (WS-Trust), OpenNetwork, Layer7, Netegrity, Microsoft, | Formatted: Default Paragraph Font |
| 136 | Reactivity, VeriSign, IBM, BEA Systems, Oblix, RSA Security, Ping Identity, Westbridge, | Formatted: Font: (Default) Arial, 10 pt |
| 137 | Computer Associates, February 2005, http://schemas.xmlsoap.org/ws/2005/02/trust | Deleted: / |
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2 Atomic Transaction Context

Atomic Transaction builds on WS-Coordination, which defines an activation and a registration service. Example message flows and a complete description of creating and registering for coordinated activities is found in the WS-Coordination specification [WSCOOR].

The Atomic Transaction coordination context must flow on all application messages involved with the transaction.

Atomic Transaction adds the following semantics to the CreateCoordinationContext operation on the activation service.

- If the request includes the CurrentContext element, the target coordinator is interposed as a subordinate to the coordinator stipulated inside the CurrentContext element.
- If the request does not include a CurrentContext element, the target coordinator creates a new transaction and acts as the root.

A coordination context MAY have an Expires element. This element specifies the period, measured from the point in time at which the context was first created or received, after which a transaction MAY be terminated solely due to its length of operation. From that point forward, the coordinator MAY elect to unilaterally roll back the transaction, so long as it has not made a commit decision. Similarly a 2PC participant MAY elect to abort its work in the transaction so long as it has not already decided to prepare.

The Atomic Transaction protocol is identified by the following coordination type:

<http://docs.oasis-open.org/ws-tx/wsac/2006/06>

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3 Atomic Transaction Protocols

This specification defines the following protocols for atomic transactions.

- **Completion:** The completion protocol initiates commitment processing. Based on each protocol's registered participants, the coordinator begins with Volatile 2PC then proceeds through Durable 2PC. The final result is signaled to the initiator.
- **Two-Phase Commit (2PC):** The 2PC protocol coordinates registered participants to reach a commit or abort decision, and ensures that all participants are informed of the final result. The 2PC protocol has two variants:
 - **Volatile 2PC:** Participants managing volatile resources such as a cache should register for this protocol.
 - **Durable 2PC:** Participants managing durable resources such as a database should register for this protocol.

A participant can register for more than one of these protocols by sending multiple Register messages.

3.1 Preconditions

The correct operation of the protocols requires that a number of preconditions **MUST** be established prior to the processing:

1. The source **MUST** have knowledge of the destination's policies, if any, and the source **MUST** be capable of formulating messages that adhere to this policy.
2. If a secure exchange of messages is required, then the source and destination **MUST** have a security context.

3.2 Completion Protocol

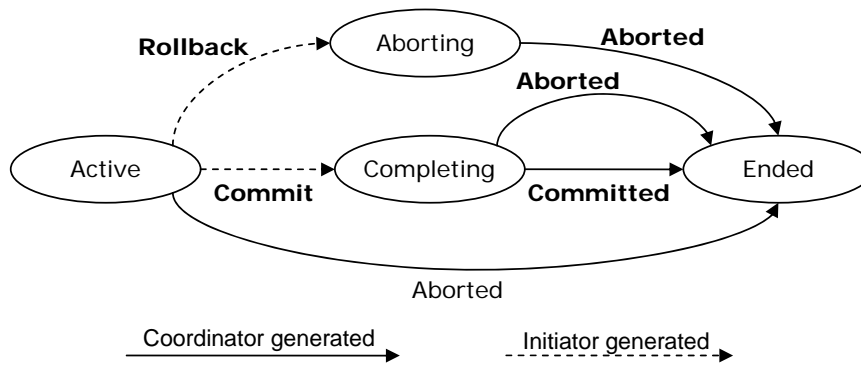
The Completion protocol is used by an application to tell the coordinator to either try to commit or abort an atomic transaction. After the transaction has completed, a status is returned to the application.

An initiator registers for this protocol using the following protocol identifier:

`http://docs.oasis-open.org/ws-tx/wsac/2006/06/Completion`

A Completion protocol coordinator must be the root coordinator of an atomic transaction. The registration service for a subordinate coordinator **MUST** respond to an attempt to register for this coordination protocol with the WS-Coordination fault Cannot Register Participant.

The diagram below illustrates the protocol abstractly. Refer to the section State Tables for a detailed description of this protocol.



189

190 The coordinator accepts:

191 Commit

192 Upon receipt of this notification, the coordinator knows that the participant has completed
193 application processing and that it should attempt to commit the transaction.

194 Rollback

195 Upon receipt of this notification, the coordinator knows that the participant has terminated
196 application processing and that it should abort the transaction.

197 The initiator accepts:

198 Committed

199 Upon receipt of this notification, the initiator knows that the coordinator reached a decision to
200 commit.

201 Aborted

202 Upon receipt of this notification, the initiator knows that the coordinator reached a decision to
203 abort.

204 A coordination service that supports an Activation service MUST support the Completion protocol.

205 **3.3 Two-Phase Commit Protocol**

206 The Two-Phase Commit (2PC) protocol is a Coordination protocol that defines how multiple participants
207 reach agreement on the outcome of an atomic transaction. The 2PC protocol has two variants: Durable
208 2PC and Volatile 2PC.

209 **3.3.1 Volatile Two-Phase Commit Protocol**

210 Upon receiving a Commit notification in the completion protocol, the root coordinator begins the prepare
211 phase of all participants registered for the Volatile 2PC protocol. All participants registered for this
212 protocol must respond before a Prepare is issued to a participant registered for Durable 2PC. Further
213 participants may register with the coordinator until the coordinator issues a Prepare to any durable
214 participant. Once this has happened the Registration Service for the coordinator MUST respond to any
215 further Register requests with a Cannot Register Participant fault message. A volatile recipient is not
216 guaranteed to receive a notification of the transaction's outcome.

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217 Participants register for this protocol using the following protocol identifier:
218 <http://docs.oasis-open.org/ws-tx/wsac/2006/06/Volatile2PC>

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219 **3.3.2 Durable Two-Phase Commit Protocol**

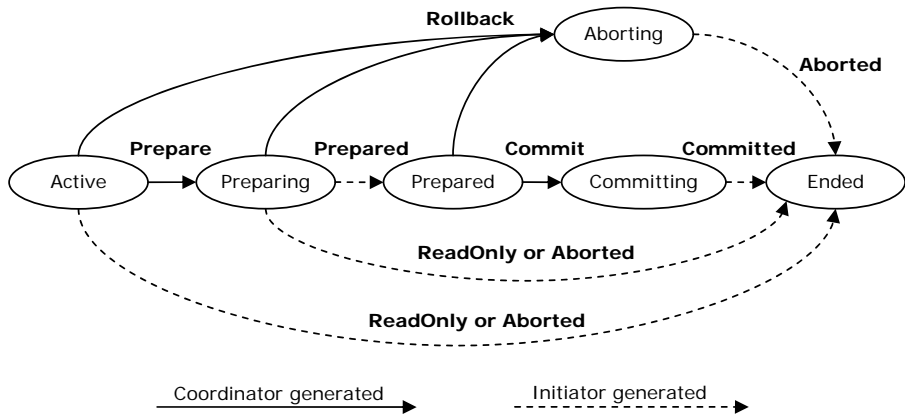
220 After receiving a Commit notification in the completion protocol and upon successfully completing the
221 prepare phase for Volatile 2PC participants, the root coordinator begins the Prepare phase for Durable
222 2PC participants. All participants registered for this protocol must respond Prepared or ReadOnly before
223 a Commit notification is issued to a participant registered for either protocol.

224 Participants register for this protocol using the following protocol identifier:
225 <http://docs.oasis-open.org/ws-tx/wsac/2006/06/Durable2PC>

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226 **3.3.3 2PC Diagram and Notifications**

227 The diagram below illustrates the protocol abstractly. Refer to the section State Tables for a detailed
228 description of this protocol.



229
230 The participant accepts:
231 Prepare
232 Upon receipt of this notification, the participant knows to enter phase 1 and vote on the outcome
233 of the transaction. If the participant does not know of the transaction, it must vote to abort. If the
234 participant has already voted, it should resend the same vote.
235 Rollback
236 Upon receipt of this notification, the participant knows to abort, and forget, the transaction. This
237 notification can be sent in either phase 1 or phase 2. Once sent, the coordinator may forget all
238 knowledge of this transaction.
239 Commit
240 Upon receipt of this notification, the participant knows to commit the transaction. This notification
241 can only be sent after phase 1 and if the participant voted to commit. If the participant does not
242 know of the transaction, it must send a Committed notification to the coordinator.

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243 The coordinator accepts:
244 Prepared
245 Upon receipt of this notification, the coordinator knows the participant is prepared and votes to
246 commit the transaction.
247 ReadOnly
248 Upon receipt of this notification, the coordinator knows the participant votes to commit the
249 transaction, and has forgotten the transaction. The participant does not wish to participate in
250 phase 2.
251 Aborted
252 Upon receipt of this notification, the coordinator knows the participant has aborted, and forgotten,
253 the transaction.
254 Committed
255 Upon receipt of this notification, the coordinator knows the participant has committed the
256 transaction. That participant may be safely forgotten.
257 Conforming implementations MUST implement the 2PC protocol.

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4 AT Policy Assertion

WS-Policy Framework [WSPOLICY] and WS-Policy Attachment [WSPOLICYATTACH] collectively define a framework, model and grammar for expressing the capabilities, requirements, and general characteristics of entities in an XML Web services-based system. To enable a web service to describe transactional capabilities and requirements of a service and its operations, this specification defines a pair of Atomic Transaction policy assertions that leverage the WS-Policy framework.

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4.1 Assertion Model

The AT policy assertion is provided by a web service to qualify the transactional processing of messages associated with the particular operation to which the assertion is scoped. The AT policy assertion indicates whether a requester MAY or MUST include an AtomicTransaction CoordinationContext flowed with the message.

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4.2 Normative Outline

The normative outline for the AT policy assertion is:

```
<wsat:ATAssertion [wsp:Optional="true"]? ... >
...
</wsat:ATAssertion>
```

The following describes additional, normative constraints on the outline listed above:

/wsat:ATAssertion

A policy assertion that specifies that an atomic transaction MUST be flowed inside a requester's message. From the perspective of the requester, the target service that processes the transaction MUST behave as if it had participated in the transaction. The transaction MUST be represented as a SOAP header in CoordinationContext format, as defined in WS-Coordination [WSCOOR].

/wsat:ATAssertion/@wsp:Optional="true"

Per WS-Policy [WSPOLICY], this is compact notation for two policy alternatives, one with and one without the assertion.

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4.3 Assertion Attachment

Because the AT policy assertion indicates atomic transaction behavior for a single operation, the assertion has Operation Policy Subject [WSPOLICYATTACH].

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WS-PolicyAttachment defines two WSDL [WSDL] policy attachment points with Operation Policy Subject:

- wsdl:portType/wsdl:operation – A policy expression containing the AT policy assertion MUST NOT be attached to a wsdl:portType; the AT policy assertion specifies a concrete behavior whereas the wsdl:portType is an abstract construct.
- wsdl:binding/wsdl:operation – A policy expression containing the AT policy assertion SHOULD be attached to a wsdl:binding.

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292 **4.4 Assertion Example**

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293 An example use of the AT policy assertion follows:

```
294 (01) <wsdl:definitions
295 (02)     targetNamespace="bank.example.com"
296 (03)     xmlns:tns="bank.example.com"
297 (04)     xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
298 (05)     xmlns:wsp="http://schemas.xmlsoap.org/ws/2004/09/policy"
299 (06)     xmlns:wsat="http://docs.oasis-open.org/ws-tx/wsdl/2006/06"
300 (07)     xmlns:wssu="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-
301 wssecurity-utility-1.0.xsd" >
302 (08)     <wsp:Policy wsu:Id="TransactedPolicy" >
303 (09)         <wsat:ATAssertion wsp:optional="true" />
304 (10)         <!-- omitted assertions -->
305 (11)     </wsp:Policy>
306 (12)     <!-- omitted elements -->
307 (13)     <wsdl:binding name="BankBinding" type="tns:BankPortType" >
308 (14)         <!-- omitted elements -->
309 (15)         <wsdl:operation name="TransferFunds" >
310 (16)             <wsp:PolicyReference URI="#TransactedPolicy" wsdl:required="true"
311 />
312 (17)             <!-- omitted elements -->
313 (18)         </wsdl:operation>
314 (19)     </wsdl:binding>
315 (20) </wsdl:definitions>
```

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317 Lines (8-11) are a policy expression that includes an AT policy assertion (Line 10) to indicate that an
318 atomic transaction in WS-Coordination [WSCOOR] format MAY be used.

319 Lines (13-19) are a WSDL [WSDL] binding. Line (17) indicates that the policy in Lines (9-12) applies to
320 this binding, specifically indicating that an atomic transaction MAY flow inside messages.

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5 Transaction Faults

WS-AtomicTransaction faults MUST include as the [action] property the following fault action URI:

`http://docs.oasis-open.org/ws-tx/wsata/2006/06/fault`

The protocol faults defined in this section are generated if the condition stated in the preamble is met. These faults are targeted at a destination endpoint according to the protocol fault handling rules defined for that protocol.

The definitions of faults in this section use the following properties:

[Code] The fault code.

[Subcode] The fault subcode.

[Reason] The English language reason element.

[Detail] The detail element. If absent, no detail element is defined for the fault.

For SOAP 1.2, the [Code] property MUST be either "Sender" or "Receiver". These properties are serialized into text XML as follows:

| SOAP Version | Sender | Receiver |
|--------------|------------|--------------|
| SOAP 1.2 | S12:Sender | S12:Receiver |

The properties above bind to a SOAP 1.2 fault as follows:

```
<S12:Envelope>
  <S12:Header>
    <wsa:Action>
      http://docs.oasis-open.org/ws-tx/wsata/2006/06/fault
    </wsa:Action>
    <!-- Headers elided for clarity. -->
  </S12:Header>
  <S12:Body>
    <S12:Fault>
      <S12:Code>
        <S12:Value>[Code]</S12:Value>
        <S12:Subcode>
          <S12:Value>[Subcode]</S12:Value>
        </S12:Subcode>
      </S12:Code>
      <S12:Reason>
        <S12:Text xml:lang="en">[Reason]</S12:Text>
      </S12:Reason>
      <S12:Detail>
        [Detail]
        ...
      </S12:Detail>
    </S12:Fault>
  </S12:Body>
</S12:Envelope>
```

The properties bind to a SOAP 1.1 fault as follows:

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```
<S11:Envelope>
  <S11:Body>
    <S11:Fault>
      <faultcode>[Subcode]</faultcode>
      <faultstring xml:lang="en">[Reason]</faultstring>
    </S11:Fault>
  </S11:Body>
</S11:Envelope>
```

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371

5.1 Inconsistent Internal State

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This fault is sent by a participant or coordinator to indicate that a protocol violation has been detected after it is no longer possible to change the outcome of the transaction. This is indicative of a global consistency failure and is an unrecoverable condition.

375

Properties:

376

[Code] Sender

377

[Subcode] wsat:InconsistentInternalState

378

[Reason] A global consistency failure has occurred. This is an unrecoverable condition.

379

[Detail] unspecified

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380

5.2 Unknown Transaction

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382

This fault is sent by a coordinator to indicate that it has no knowledge of the transaction and consequently cannot convey the outcome.

383

Properties:

384

[Code] Sender

385

[Subcode] wsat:UnknownTransaction

386

[Reason] The coordinator has no knowledge of the transaction. This is an unrecoverable condition.

387

[Detail] unspecified

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6 Security Model

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The security model for atomic transactions builds on the model defined in WS-Coordination [WSCOOR]. That is, services have policies specifying their requirements and requestors provide claims (either implicit or explicit) and the requisite proof of those claims. Coordination context creation establishes a base secret which can be delegated by the creator as appropriate.

390

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393

Because atomic transactions represent a specific use case rather than the general nature of coordination contexts, additional aspects of the security model can be specified.

394

395

All access to atomic transaction protocol instances is on the basis of identity. The nature of transactions, specifically the uncertainty of systems means that the security context established to register for the protocol instance may not be available for the entire duration of the protocol.

396

397

398

Consider for example the scenarios where a participant has committed its part of the transaction, but for some reason the coordinator never receives acknowledgement of the commit. The result is that when communication is re-established in the future, the coordinator will attempt to confirm the commit status of the participant, but the participant, having committed the transaction and forgotten all information associated with it, no longer has access to the special keys associated with the token.

399

400

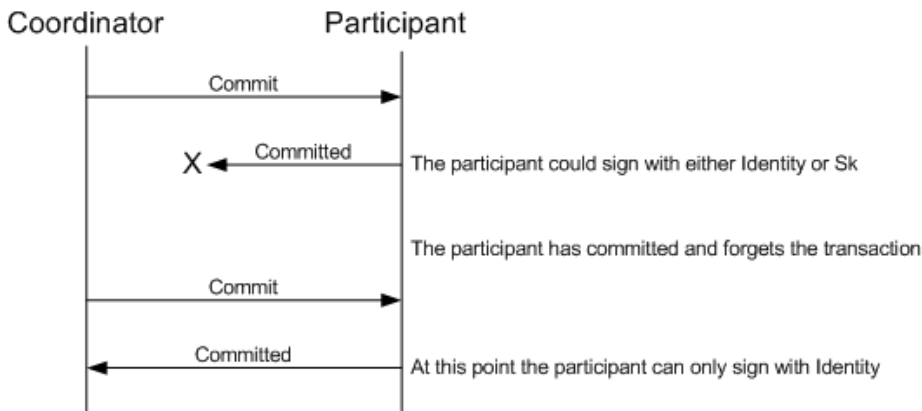
401

402

403

The participant can only prove its identity to the coordinator when it indicates that the specified transaction is not in its log and assumed committed. This is illustrated in the figure below:

404



405

406

There are, of course, techniques to mitigate this situation but such options will not always be successful.

407

Consequently, when dealing with atomic transactions, it is critical that identity claims always be proven to ensure that correct access control is maintained by coordinators.

408

409

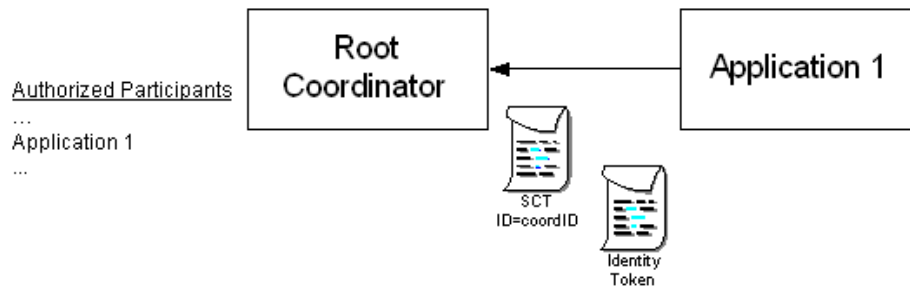
There is still value in coordination context-specific tokens because they offer a bootstrap mechanism so that all participants need not be pre-authorized. As well, it provides additional security because only those instances of an identity with access to the token will be able to securely interact with the coordinator (limiting privileges strategy). This is illustrated in the figure below:

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414 The "list" of authorized participants ensures that application messages having a coordination context are
 415 properly authorized since altering the coordination context ID will not provide additional access unless (1)
 416 the bootstrap key is provided, or (2) the requestor is on the authorized participant "list" of identities.

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7 Security Considerations

It is strongly RECOMMENDED that the communication between services be secured using the mechanisms described in WS-Security [WSSec]. In order to properly secure messages, the body and all relevant headers need to be included in the signature. Specifically, the <wscoor:CoordinationContext> header needs to be signed with the body and other key message headers in order to "bind" the two together.

In the event that a participant communicates frequently with a coordinator, it is RECOMMENDED that a security context be established using the mechanisms described in WS-Trust [WSTrust] and WS-SecureConversation [WSSecConv] allowing for potentially more efficient means of authentication.

It is common for communication with coordinators to exchange multiple messages. As a result, the usage profile is such that it is susceptible to key attacks. For this reason it is strongly RECOMMENDED that the keys be changed frequently. This "re-keying" can be effected a number of ways. The following list outlines four common techniques:

- Attaching a nonce to each message and using it in a derived key function with the shared secret
- Using a derived key sequence and switch "generations"
- Closing and re-establishing a security context (not possible for delegated keys)
- Exchanging new secrets between the parties (not possible for delegated keys)

It should be noted that the mechanisms listed above are independent of the SCT and secret returned when the coordination context is created. That is, the keys used to secure the channel may be independent of the key used to prove the right to register with the activity.

The security context MAY be re-established using the mechanisms described in WS-Trust [WSTrust] and WS-SecureConversation [WSSecConv]. Similarly, secrets can be exchanged using the mechanisms described in WS-Trust. Note, however, that the current shared secret SHOULD NOT be used to encrypt the new shared secret. Derived keys, the preferred solution from this list, can be specified using the mechanisms described in WS-SecureConversation.

The following list summarizes common classes of attacks that apply to this protocol and identifies the mechanism to prevent/mitigate the attacks:

- **Message alteration** – Alteration is prevented by including signatures of the message information using WS-Security [WSSec].
- **Message disclosure** – Confidentiality is preserved by encrypting sensitive data using WS-Security.
- **Key integrity** – Key integrity is maintained by using the strongest algorithms possible (by comparing secured policies – see WS-Policy [WSPOLICY] and WS-SecurityPolicy [WSSecPolicy]).
- **Authentication** – Authentication is established using the mechanisms described in WS-Security and WS-Trust [WSTrust]. Each message is authenticated using the mechanisms described in WS-Security [WSSec].
- **Accountability** – Accountability is a function of the type of and string of the key and algorithms being used. In many cases, a strong symmetric key provides sufficient accountability. However, in some environments, strong PKI signatures are required.

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- **Availability** – Many services are subject to a variety of availability attacks. Replay is a common attack and it is RECOMMENDED that this be addressed as described in the next bullet. Other attacks, such as network-level denial of service attacks are harder to avoid and are outside the scope of this specification. That said, care should be taken to ensure that minimal processing be performed prior to any authenticating sequences.
- 462
- 463
- 464
- 465
- **Replay** – Messages may be replayed for a variety of reasons. To detect and eliminate this attack, mechanisms should be used to identify replayed messages such as the timestamp/nonce outlined in WS-Security [WSSec]. Alternatively, and optionally, other technologies, such as sequencing, can also be used to prevent replay of application messages.

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8 Use of WS-Addressing Headers

The protocols defined in WS-AtomicTransaction use a "one way" message exchange pattern consisting of a sequence of notification messages between a Coordinator and a Participant. There are two types of notification messages used in these protocols:

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- A notification message is a terminal message when it indicates the end of a coordinator/participant relationship. **Committed**, **Aborted** and **ReadOnly** are terminal messages, as are the protocol faults defined in this specification and in **WSCOORD**.
- A notification message is a non-terminal message when it does not indicate the end of a coordinator/participant relationship. **Commit**, **Rollback**, **Prepare** and **Prepared** are non-terminal messages.

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The following statements define addressing interoperability requirements for the WS-AtomicTransaction message types:

Non-terminal notification messages

- MUST** include a [source endpoint] property whose [address] property is not set to 'http://www.w3.org/2005/08/addressing/anonymous' or 'http://www.w3.org/2005/08/addressing/none'.

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Both terminal and non-terminal notification messages

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- MUST** include a [reply endpoint] property whose [address] property is set to 'http://www.w3.org/2005/08/addressing/none'.

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Notification messages are addressed by both coordinators and participants using the Endpoint References initially obtained during the Register-RegisterResponse exchange. If a [source endpoint] property is present in a notification message, it MAY be used by the recipient. For example, in cases where a Coordinator or Participant has forgotten a transaction that is completed and needs to respond to a resent protocol message, the [source endpoint] property should be used as described in section 3.3 of WS-Addressing 1.0 – Core **WSADDR**. Permanent loss of connectivity between a coordinator and a participant in an in-doubt state can result in data corruption.

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Protocol faults raised by a Coordinator or Participant during the processing of a notification message are terminal notifications and **MUST** be composed using the same mechanisms as other terminal notification messages.

All messages are delivered using connections initiated by the sender.

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9 State Tables

The following state tables specify the behavior of coordinators and participants when presented with protocol messages or internal events.

Each cell in the tables uses the following convention:

| Legend |
|----------------|
| Action to take |
| Next state |

Deleted: These tables present the view of a coordinator or participant with respect to a single partner. A coordinator with multiple participants can be understood as a collection of independent coordinator state machines, each with its own state.

Each state supports a number of possible events. Expected events are processed by taking the prescribed action and transitioning to the next state. Unexpected protocol messages will result in a fault message, with a standard fault code such as Invalid State or Inconsistent Internal State. Events that may not occur in a given state are labeled as N/A.

Notes:

1. Transitions with a "N/A" as their action are inexpressible. A TM should view these transitions as serious internal consistency issues, and probably fatal.
2. The "Internal events" shown are those events, created either within a TM itself or on its local system, that cause state changes and/or trigger the sending of a protocol message.

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9.1 Completion Protocol

| Completion Protocol (Coordinator View) | | | |
|---|-----------------------------|--|-----------------------------|
| Inbound Events | States | | |
| | None | Active | Completing |
| Commit | Unknown Transaction None | Initiate user commit Completing | Ignore Completing |
| Rollback | Unknown Transaction None | Initiate user rollback, send aborted None | Invalid State Completing |
| Internal Events | | | |
| Commit Decision | N/A | N/A | Send committed None |
| Abort Decision | N/A | Send aborted None | Send aborted None |

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9.2 2PC Protocol

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These tables present the view of a coordinator or participant with respect to a single partner. A coordinator with multiple participants can be understood as a collection of independent coordinator state machines, each with its own state.

| Atomic Transaction 2PC Protocol (Coordinator View) | | | | | | | |
|---|---|---------------------------|-----------------------------|--|--|---|---|
| Inbound Events | States | | | | | | |
| | None | Active | Preparing | Prepared | PreparedSuccess | Committing | Aborting |
| Prepared | Durable: Send Rollback Volatile: Unknown Transaction None | Invalid State Aborting | Record Vote Prepared | Ignore PreparedSuccess | Ignore PreparedSuccess | Resend Commit Committing | Resend Rollback Aborting |
| ReadOnly | Ignore None | Forget None | Forget None | Inconsistent Internal State PreparedSuccess | Inconsistent Internal State PreparedSuccess | Inconsistent Internal State Committing | Forget None |
| Aborted | Ignore None | Forget None | Forget None | Inconsistent Internal State PreparedSuccess | Inconsistent Internal State PreparedSuccess | Inconsistent Internal State Committing | Forget None |
| Committed | Ignore None | Invalid State Aborting | Invalid State Aborting | Inconsistent Internal State PreparedSuccess | Inconsistent Internal State PreparedSuccess | Forget None | Inconsistent Internal State Aborting |
| Internal Events | | | | | | | |
| User Commit | N/A | Send Prepare Preparing | N/A | N/A | N/A | N/A | N/A |
| User Rollback | N/A | Send Rollback Aborting | N/A | N/A | N/A | N/A | N/A |
| Expires Times Out | N/A | Send Rollback Aborting | Send Rollback Aborting | Send Rollback Aborting | Ignore PreparedSuccess | Ignore Committing | Ignore Aborting |
| Comms Times Out | N/A | N/A | Resend Prepare Preparing | N/A | N/A | Resend Commit Committing | N/A |
| Commit Decision | N/A | N/A | N/A | Record Outcome PreparedSuccess | N/A | N/A | N/A |
| Rollback Decision | N/A | Send Rollback Aborting | Send Rollback Aborting | Send Rollback Aborting | N/A | N/A | N/A |
| Write Done | N/A | N/A | N/A | N/A | Send Commit Committing | N/A | N/A |
| Write Failed | N/A | N/A | N/A | N/A | Send Rollback Aborting | N/A | N/A |
| Participant Abandoned | N/A | N/A | N/A | N/A | N/A | Durable: N/A Volatile: None | None |

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Prepared Success

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"Forget" implies that the subordinate's participation is removed from the coordinator (if necessary), and otherwise the message is ignored

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| Atomic Transaction 2PC Protocol (Participant View) | | | | | | | |
|---|------------------------|---|--|--|--|--|---|
| Inbound Events | States | | | | | | |
| | None | Active | Preparing | Prepared | PreparedSuccess | Committing | Aborting |
| Prepare | Send Aborted None | Gather Vote Decision Preparing | Ignore Preparing | Ignore Prepared | Resend Prepared PreparedSuccess | Ignore Committing | Resend Aborted, and Forget Aborting |
| Commit | Send Committed None | Invalid State Aborting | Invalid State Aborting | Invalid State Aborting | Initiate Commit Decision Committing | Ignore Committing | Inconsistent Internal State Aborting |
| Rollback | Send Aborted None | Initiate Rollback, Send Aborted, and Forget Aborting | Initiate Rollback, Send Aborted, and Forget Aborting | Initiate Rollback, Send Aborted, and Forget Aborting | Initiate Rollback, Send Aborted, and Forget Aborting | Inconsistent Internal State Committing | Send Aborted, and Forget Aborting |
| Internal Events | | | | | | | |
| Expires Times Out | N/A | Initiate Rollback, Send Aborted, and Forget Aborting | Initiate Rollback, Send Aborted, and Forget Aborting | Ignore Prepared | Ignore PreparedSuccess | Ignore Committing | Ignore Aborting |
| Comms Times Out | N/A | N/A | N/A | N/A | Resend Prepared PreparedSuccess | N/A | N/A |
| Commit Decision | N/A | N/A | Record Commit Prepared | N/A | N/A | Send Committed and Forget Committing | N/A |
| Rollback Decision | N/A | Send Aborted Aborting | Send Aborted Aborting | N/A | N/A | N/A | N/A |
| Write Done | N/A | N/A | N/A | Send Prepared PreparedSuccess | N/A | N/A | N/A |
| Write Failed | N/A | N/A | N/A | Initiate Rollback, Send Aborted, and Forget Aborting | N/A | N/A | N/A |
| All Forgotten | None | Send ReadOnly None | Send ReadOnly None | N/A | N/A | None | None |

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Appendix B. Revision History

| Revision | yy-mm-dd | Editor | Changes Made |
|--------------|-----------------|---------------------------------|---|
| 01 | 05-11-22 | Mark Little Andrew Wilkinson | Initial Working Draft |
| 02 | 06-02-12 | Mark Little | Updated for issue i017 |
| 03 | 06-03-02 | Andrew Wilkinson | Updated for issue i015 |
| 04 | 06-03-10 | Andrew Wilkinson | Updated for issue i009 |
| cd-01 | 06-03-15 | Andrew Wilkinson | Updates to produce CD-01 |
| 05 | 06-05-23 | Mark Little | Updates for i023, i026, i027, i028, i030 |
| 06 | 06-06-01 | Andrew Wilkinson | Updates for i039, i043, i045, i052, i053, i055 |
| cd-02 | 06-06-13 | Andrew Wilkinson | Updates to produce CD-02 |
| 07 | 06-07-13 | Mark Little | Editorial changes. |
| 08 | 06-07-24 | Andrew Wilkinson | Updates for i036, i037. Update namespace to 2006/06 |
| 09 | 06-08-18 | Mark Little Andrew Wilkinson | Updates for i038, i041, i047, i049, i050, i056, i057, i062, i083, i084. |
| 10 | 06-08-25 | Andrew Wilkinson | Updates for i061, i065, i078, i080, i081, i089 |
| <u>cd-03</u> | <u>06-08-30</u> | <u>Andrew Wilkinson</u> | <u>Editorial changes</u> <u>Updates for i090, i091</u> |

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| Definition,d, Don't adjust space between Latin and Asian text | | |
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| Page 6: [3] Deleted | Andy Wilkinson | 8/29/2006 1:26 PM |
| W3C Note, "SOAP: Simple Object Access Protocol 1.1," 08 May 2000, | | |
| Page 6: [4] Formatted | Andy Wilkinson | 8/29/2006 1:16 PM |
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| Page 6: [5] Deleted | Andy Wilkinson | 8/29/2006 1:14 PM |
| [URI] T. Berners-Lee, R. Fielding, L. Masinter, "Uniform Resource Identifiers (URI): Generic Syntax," RFC 2396, MIT/LCS, U.C. Irvine, Xerox Corporation, August 1998, http://www.ietf.org/rfc/rfc2396.txt | | |
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Introduction

The current set of Web service specifications [WSDL] [SOAP11][SOAP12] defines protocols for Web service interoperability. Web services increasingly tie together a number of participants forming large distributed applications. The resulting activities may have complex structure and relationships.

The WS-Coordination specification defines an extensible framework for defining coordination types. This specification provides the definition of an atomic transaction coordination type used to coordinate activities having an "all or nothing" property. Atomic transactions commonly require a high level of trust between participants and are short in duration. The Atomic Transaction specification defines protocols that enable existing transaction processing systems to wrap their proprietary protocols and interoperate across different hardware and software vendors.

To understand the protocol described in this specification, the following assumptions are made:

The reader is familiar with existing standards for two-phase commit protocols and with commercially available implementations of such protocols. Therefore this section includes only those details that are essential to understanding the protocols described.

The reader is familiar with the WS-Coordination [WSCOOR] specification that defines the framework for the WS-AtomicTransaction coordination protocols.

The reader is familiar with WS-Addressing [WSADDR] and WS-Policy [WSPOLICY].

Atomic transactions have an all-or-nothing property. The actions taken prior to commit are only tentative (i.e., not persistent and not visible to other activities). When an application finishes, it requests the coordinator to determine the outcome for the transaction. The coordinator determines if there were any processing failures by asking the participants to vote. If the participants all vote that they were able to execute successfully, the coordinator commits all actions taken. If a participant votes that it needs to abort or a participant does not respond at all, the coordinator aborts all actions taken. Commit makes the tentative actions visible to other transactions. Abort makes the tentative actions appear as if the actions never happened. Atomic transactions have proven to be extremely valuable for many applications. They provide consistent failure and recovery semantics, so the applications no longer need to deal with the mechanics of determining a mutually agreed outcome decision or to figure out how to recover from a large number of possible inconsistent states.

Atomic Transaction defines protocols that govern the outcome of atomic transactions. It is expected that existing transaction processing systems wrap their proprietary mechanisms and interoperate across different vendor implementations.