



# Web Services Atomic Transaction (WS-AtomicTransaction) Version 1.1

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### Abstract:

The WS-AtomicTransaction specification provides the definition of the Atomic Transaction coordination type that is to be used with the extensible coordination framework described in WS-Coordination. This 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.

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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 "Latest Approved Version" location noted above for possible later revisions of this document.

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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.

WS-Coordination [[WSCOOR](#)] 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. WS-AtomicTransaction 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 WS-Coordination [[WSCOOR](#)] which defines the framework for the Atomic Transaction 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 by a transaction participant prior to commit are only tentative; typically they are neither persistent nor made visible outside the transaction. When an application finishes working on a transaction, 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 directs the participants to make the tentative actions final so they may, for example, be made persistent and be made visible outside the transaction. Abort directs the participants to make the tentative actions appear as if they 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.

This specification defines protocols that govern the outcome of Atomic Transactions. It is expected that existing transaction processing systems will use WS-AtomicTransaction to wrap their proprietary mechanisms and interoperate across different vendor implementations.

## 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 [[WSCOOR](#)], WS-Security [[WSSec](#)]) and application-specific protocols that are able to accommodate a wide variety of coordination protocols related to the coordination actions of distributed applications.

## 1.2 Terminology

The uppercase 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 [[RFC2119](#)].

- 46 This specification uses an informal syntax to describe the XML grammar of the XML fragments below:
- 47 • The syntax appears as an XML instance, but the values indicate the data types instead of values.
  - 48 • Element names ending in "..." (such as <element.../> or <element...>) indicate that
  - 49 elements/attributes irrelevant to the context are being omitted.
  - 50 • Attributed names ending in "..." (such as name=...) indicate that the values are specified below.
  - 51 • Grammar in bold has not been introduced earlier in the document, or is of particular interest in an
  - 52 example.
  - 53 • <!-- description --> is a placeholder for elements from some "other" namespace (like ##other in
  - 54 XSD).
  - 55 • Characters are appended to elements, attributes, and <!-- descriptions --> as follows: "?" (0 or 1),
  - 56 "\*" (0 or more), "+" (1 or more). The characters "[" and "]" are used to indicate that contained
  - 57 items are to be treated as a group with respect to the "?", "\*", or "+" characters.
  - 58 • The XML namespace prefixes (defined below) are used to indicate the namespace of the element
  - 59 being defined.
  - 60 • Examples starting with <?xml contain enough information to conform to this specification; others
  - 61 examples are fragments and require additional information to be specified in order to conform.

## 62 1.3 Namespace

63 The XML namespace [XML-ns] URI that MUST be used by implementations of this specification is:

```
64 http://docs.oasis-open.org/ws-tx/wsat/2006/06
```

65 This MUST also be used as the CoordinationContext type for Atomic Transactions.

### 66 1.3.1 Prefix Namespace

67 The following namespaces are used in this document:

Prefix	Namespace
S11	<a href="http://schemas.xmlsoap.org/soap/envelope">http://schemas.xmlsoap.org/soap/envelope</a>
S12	<a href="http://www.w3.org/2003/05/soap-envelope">http://www.w3.org/2003/05/soap-envelope</a>
wscor	<a href="http://docs.oasis-open.org/ws-tx/wscor/2006/06">http://docs.oasis-open.org/ws-tx/wscor/2006/06</a>
wsat	<a href="http://docs.oasis-open.org/ws-tx/wsat/2006/06">http://docs.oasis-open.org/ws-tx/wsat/2006/06</a>
wsa	<a href="http://www.w3.org/2005/08/addressing">http://www.w3.org/2005/08/addressing</a>

## 68 1.4 XSD and WSDL Files

69 Dereferencing the XML namespace defined in section 1.3 will produce the Resource Directory  
70 Description Language (RDDL) [RDDL] document that describes this namespace, including the XML  
71 schema [XML-Schema1] [XML-Schema2] and WSDL [WSDL] declarations associated with this  
72 specification.

73 SOAP bindings for the WSDL [WSDL], referenced in the RDDL [RDDL] document, MUST use "document"  
74 for the *style* attribute.

## 75 1.5 Protocol Elements

76 The protocol elements define various extensibility points that allow other child or attribute content.  
77 Additional children and/or attributes MAY be added at the indicated extension points but MUST NOT

78 contradict the semantics of the parent and/or owner, respectively. If a receiver does not recognize an  
79 extension, the receiver SHOULD ignore the extension.

## 80 1.6 Normative References

- 81 **[RDDL]** Jonathan Borden, Tim Bray, eds. "Resource Directory Description Language  
82 (RDDL) 2.0", <http://www.openhealth.org/RDDL/20040118/rddl-20040118.html>,  
83 January 2004
- 84 **[RFC2119]** S. Bradner, "Key words for use in RFCs to Indicate Requirement Levels",  
85 <http://www.ietf.org/rfc/rfc2119.txt>, IETF RFC2119, March 1997
- 86 **[SOAP11]** W3C Note, "SOAP: Simple Object Access Protocol 1.1",  
87 <http://www.w3.org/TR/2000/NOTE-SOAP-20000508>, 08 May 2000
- 88 **[SOAP12]** W3C Recommendation, "SOAP Version 1.2 Part 1: Messaging Framework",  
89 <http://www.w3.org/TR/soap12-part1>, June 2003
- 90 **[WSADDR]** Web Services Addressing (WS-Addressing) 1.0,  
91 <http://www.w3.org/2005/08/addressing>, W3C Recommendation, May 2006
- 92 **[WSCOOR]** Web Services Coordination (WS-Coordination) 1.1, [http://docs.oasis-  
93 open.org/ws-tx/wscoor/2006/06](http://docs.oasis-open.org/ws-tx/wscoor/2006/06), OASIS, March 2006
- 94 **[WSDL]** Web Services Description Language (WSDL) 1.1,  
95 <http://www.w3.org/TR/2001/NOTE-wsdl-20010315>
- 96 **[WSPOLICY]** Web Services Policy 1.2 – Framework (WS-Policy),  
97 <http://www.w3.org/Submission/2006/SUBM-WS-Policy-20060425/>, W3C  
98 Member Submission, 25 April 2006.
- 99 **[WSPOLICYATTACH]** Web Services Policy 1.2 – Attachment (WS-PolicyAttachment),  
100 <http://www.w3.org/Submission/2006/SUBM-WS-PolicyAttachment-20060425/>,  
101 W3C Member Submission, 25 April 2006.
- 102 **[WSSec]** OASIS Standard 200401, "Web Services Security: SOAP Message Security 1.0  
103 (WS-Security 2004)", [http://docs.oasis-open.org/wss/2004/01/oasis-200401-  
wss-soap-message-security-1.0.pdf](http://docs.oasis-open.org/wss/2004/01/oasis-200401-<br/>104 wss-soap-message-security-1.0.pdf), March 2004
- 105 **[WSSecConv]** Web Services Secure Conversation Language (WS-SecureConversation),  
106 <http://schemas.xmlsoap.org/ws/2005/02/sc>, OpenNetwork, Layer7, Netegrity,  
107 Microsoft, Reactivity, IBM, VeriSign, BEA Systems, Oblix, RSA Security, Ping  
108 Identity, Westbridge, Computer Associates, February 2005
- 109 **[WSSecPolicy]** Web Services Security Policy Language (WS-SecurityPolicy),  
110 <http://schemas.xmlsoap.org/ws/2005/07/securitypolicy>, Microsoft, VeriSign,  
111 IBM, RSA Security, July 2005
- 112 **[WSTrust]** Web Services Trust Language (WS-Trust), ,  
113 <http://schemas.xmlsoap.org/ws/2005/02/trust>, OpenNetwork, Layer7, Netegrity,  
114 Microsoft, Reactivity, VeriSign, IBM, BEA Systems, Oblix, RSA Security, Ping  
115 Identity, Westbridge, Computer Associates, February 2005
- 116 **[XML]** W3C Recommendation, "Extensible Markup Language (XML) 1.0 (Fourth  
117 Edition)", <http://www.w3.org/TR/2006/REC-xml-20060816>, 16 August 2006
- 118 **[XML-ns]** W3C Recommendation, "Namespaces in XML (Second Edition)",  
119 <http://www.w3.org/TR/2006/REC-xml-names-20060816>, 16 August 2006
- 120 **[XML-Schema1]** W3C Recommendation, "XML Schema Part 1: Structures Second Edition",  
121 <http://www.w3.org/TR/2004/REC-xmlschema-1-20041028>, 28 October 2004

122 **[XML-Schema2]**  
123

W3C Recommendation, " XML Schema Part 2: Datatypes Second Edition",  
<http://www.w3.org/TR/2004/REC-xmlschema-2-20041028>, 28 October 2004



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## 2 Atomic Transaction Context

WS-AtomicTransaction builds on WS-Coordination [WSCOOR], which defines an Activation service, a Registration service, and a CoordinationContext type. Example message flows and a complete description of creating and registering for coordinated activities is found in WS-Coordination [WSCOOR].

The Atomic Transaction coordination context is a CoordinationContext type with the coordination type defined in this section. Atomic Transaction application messages that propagate a coordination context MUST use an Atomic Transaction coordination context. If these application messages use a SOAP binding, the Atomic Transaction coordination context MUST flow as a SOAP header in the message.

WS-AtomicTransaction 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/wsat/2006/06>

---

## 3 Atomic Transaction Protocols

145

146 This specification defines the following protocols for Atomic Transactions:

- 147 • **Completion:** The completion protocol initiates commit processing. Based on each protocol's  
148 registered participants, the coordinator begins with Volatile 2PC and then proceeds through  
149 Durable 2PC. The final result is signaled to the initiator.
- 150 • **Two-Phase Commit (2PC):** The 2PC protocol coordinates registered participants to reach a  
151 commit or abort decision, and ensures that all participants are informed of the final result. The  
152 2PC protocol has two variants:
  - 153 ○ **Volatile 2PC:** Participants managing volatile resources such as a cache register for  
154 this protocol.
  - 155 ○ **Durable 2PC:** Participants managing durable resources such as a database register  
156 for this protocol.

157 A participant MAY register for more than one of these protocols.

### 3.1 Preconditions

158

159 The correct operation of the protocols requires that a number of preconditions must be established prior  
160 to the processing:

- 161 1. The source SHOULD have knowledge of the destination's policies, if any, and the source  
162 SHOULD be capable of formulating messages that adhere to this policy.
- 163 2. If a secure exchange of messages is required, then the source and destination MUST have  
164 appropriate security credentials (such as transport-level security credentials or security tokens) in  
165 order to protect the messages.

### 3.2 Completion Protocol

166

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

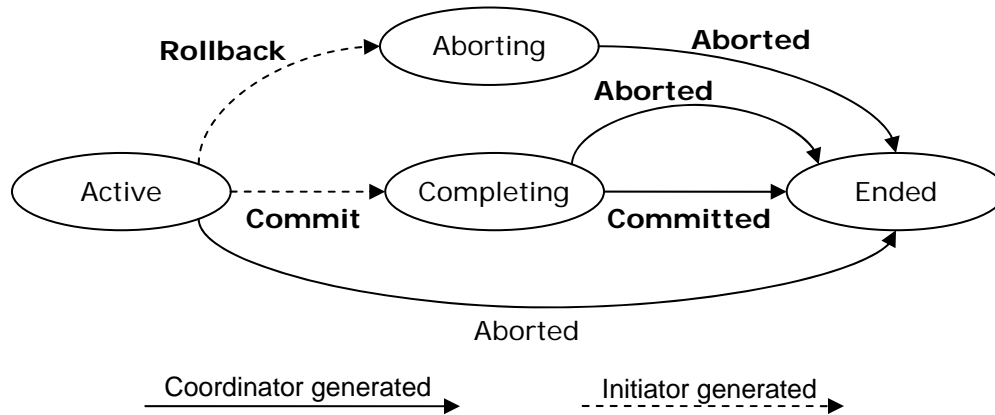
169 An initiator that registers for this protocol MUST use the following protocol identifier:

170

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

171 A Completion protocol coordinator MUST be the root coordinator of an Atomic Transaction. The  
172 Registration service for a subordinate coordinator MUST respond to an attempt to register for this  
173 coordination protocol with the WS-Coordination fault Cannot Register Participant.

174 The diagram below illustrates the protocol abstractly. Refer to section 9 State Tables for a detailed  
175 description of this protocol.



176  
 177 The coordinator accepts:  
 178 Commit  
 179       Upon receipt of this notification, the coordinator knows that the initiator has completed application  
 180       processing. A coordinator that is Active SHOULD attempt to commit the transaction.

181 Rollback  
 182       Upon receipt of this notification, the coordinator knows that the initiator has terminated application  
 183       processing. A coordinator that is Active MUST abort the transaction.

184 The initiator accepts:  
 185 Committed  
 186       Upon receipt of this notification, the initiator knows that the coordinator reached a decision to  
 187       commit.

188 Aborted  
 189       Upon receipt of this notification, the initiator knows that the coordinator reached a decision to  
 190       abort.

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

### 192 3.3 Two-Phase Commit Protocol

193 The Two-Phase Commit (2PC) protocol is a Coordination protocol that defines how multiple participants  
 194 reach agreement on the outcome of an Atomic Transaction. The 2PC protocol has two variants: Volatile  
 195 2PC and Durable 2PC.

#### 196 3.3.1 Volatile Two-Phase Commit Protocol

197 Upon receiving a Commit notification in the Completion protocol, the root coordinator begins the prepare  
 198 phase of all participants registered for the Volatile 2PC protocol. All participants registered for this  
 199 protocol MUST respond before a Prepare is issued to a participant registered for Durable 2PC. Further  
 200 participants MAY register with the coordinator until the coordinator issues a Prepare to any durable  
 201 participant. Once this has happened the Registration Service for the coordinator MUST respond to any  
 202 further Register requests with a Cannot Register Participant fault message. A volatile recipient is not  
 203 guaranteed to receive a notification of the transaction's outcome.

204 Participants that register for this protocol MUST use the following protocol identifier:

205 `http://docs.oasis-open.org/ws-tx/wsac/2006/06/Volatile2PC`

206 **3.3.2 Durable Two-Phase Commit Protocol**

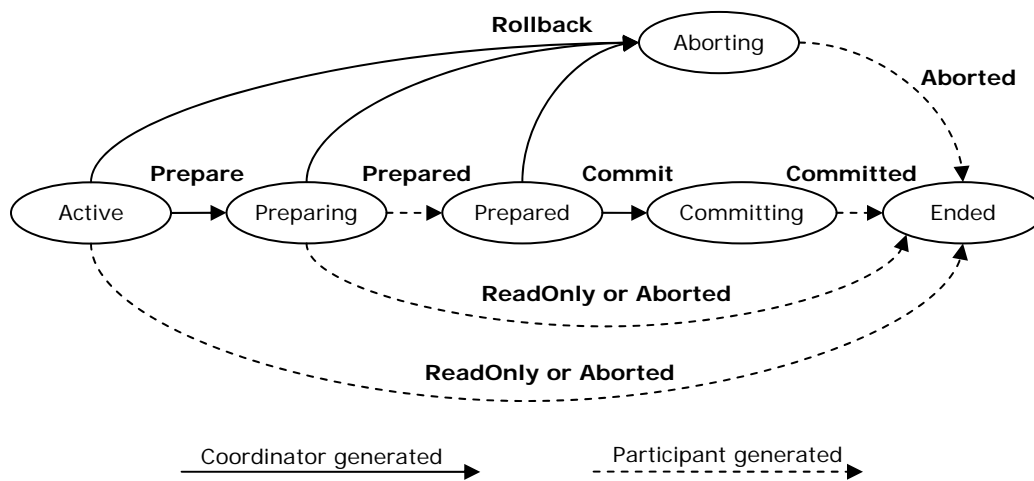
207 Upon successfully completing the prepare phase for Volatile 2PC participants, the root coordinator begins  
208 the prepare phase for Durable 2PC participants. All participants registered for this protocol **MUST**  
209 respond Prepared or ReadOnly before a Commit notification is issued to a participant registered for either  
210 protocol.

211 Participants that register for this protocol **MUST** use the following protocol identifier:

212 <http://docs.oasis-open.org/ws-tx/wsac/2006/06/Durable2PC>

213 **3.3.3 2PC Diagram and Notifications**

214 The diagram below illustrates the protocol abstractly. Refer to section 9 State Tables for a detailed  
215 description of this protocol.



216  
217 The participant accepts:

218 Prepare

219 Upon receipt of this notification, the participant knows to enter phase one and vote on the  
220 outcome of the transaction. A participant that is Active **MUST** respond by sending Aborted,  
221 Prepared, or ReadOnly notification as its vote. If the participant does not know of the transaction,  
222 it **MUST** send an Aborted notification. If the participant knows that it has already voted, it **MUST**  
223 resend the same vote.

224 Rollback

225 Upon receipt of this notification, the participant knows to abort and forget the transaction. A  
226 participant that is not Committing **MUST** respond by sending an Aborted notification and  
227 **SHOULD** then forget all knowledge of this transaction. If the participant does not know of the  
228 transaction, it **MUST** send an Aborted notification to the coordinator.

229 Commit

230 Upon receipt of this notification, the participant knows to commit the transaction. This notification  
231 **MUST** only be sent after phase one and if the participant voted to commit. If the participant does  
232 not know of the transaction, it **MUST** send a Committed notification to the coordinator.

233 The coordinator accepts:

234 Prepared

235            Upon receipt of this notification, the coordinator knows the participant is Prepared and votes to  
236            commit the transaction.

237    ReadOnly

238            Upon receipt of this notification, the coordinator knows the participant votes to commit the  
239            transaction, and has forgotten the transaction. The participant does not wish to participate in  
240            phase two.

241    Aborted

242            Upon receipt of this notification, the coordinator knows the participant has aborted and forgotten  
243            the transaction.

244    Committed

245            Upon receipt of this notification, the coordinator knows the participant has committed and  
246            forgotten the transaction.

247    Conforming implementations MUST implement the 2PC protocol.

---

## 248 4 Policy Assertion

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

### 254 4.1 Assertion Model

255 The Atomic Transaction policy assertion is provided by a Web service to qualify the transactional  
256 processing of messages associated with the particular operation to which the assertion is scoped. It  
257 indicates whether a requester MAY or MUST include an Atomic Transaction coordination context flowed  
258 with the message.

### 259 4.2 Normative Outline

260 The normative outline for the Atomic Transaction policy assertion is:

```
261 <wsat:ATAssertion [wsp:Optional="true"]? ... >  
262 ...  
263 </wsat:ATAssertion>
```

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

265 /wsat:ATAssertion

266 A policy assertion that specifies that an Atomic Transaction coordination context MUST be flowed  
267 inside a requester's message. From the perspective of the requester, the target service that  
268 processes the transaction MUST behave as if it had participated in the transaction. For application  
269 messages that use a SOAP binding, the Atomic Transaction coordination context MUST flow as a  
270 SOAP header in the message.

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

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

### 274 4.3 Assertion Attachment

275 Because the Atomic Transaction policy assertion indicates Atomic Transaction behavior for a single  
276 operation, the assertion has an Operation Policy Subject [WSPOLICYATTACH].

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

- 279 • wsdl:portType/wsdl:operation – A policy expression containing the Atomic Transaction policy  
280 assertion MUST NOT be attached to a wsdl:portType; the Atomic Transaction policy assertion  
281 specifies a concrete behavior whereas the wsdl:portType is an abstract construct.
- 282 • wsdl:binding/wsdl:operation – A policy expression containing the Atomic Transaction policy  
283 assertion SHOULD be attached to a wsdl:binding.

### 284 4.4 Assertion Example

285 An example use of the Atomic Transaction policy assertion follows:

```
286 (01) <wsdl:definitions  
287 (02) targetNamespace="bank.example.com"
```

```

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

```

309 Lines 8-11 are a policy expression that includes an Atomic Transaction policy assertion (line 9) to indicate  
310 that an Atomic Transaction in WS-Coordination [WSCOOR] format MAY be used.

311 Lines 13-19 are a WSDL [WSDL] binding. Line 16 indicates that the policy in lines 8-11 applies to this  
312 binding, specifically indicating that an Atomic Transaction MAY flow inside messages.

---

## 313 5 Transaction Faults

314 Atomic Transaction faults MUST include, as the [action] property, the following fault action URI:

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

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

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

320 [Code] The fault code.

321 [Subcode] The fault subcode.

322 [Reason] A human readable explanation of the fault.

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

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

326

SOAP Version	Sender	Receiver
SOAP 1.2	S12:Sender	S12:Receiver

327

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

```
329 <S12:Envelope>
330 <S12:Header>
331   <wsa:Action>
332     http://docs.oasis-open.org/ws-tx/wsat/2006/06/fault
333   </wsa:Action>
334   <!-- Headers elided for clarity. -->
335 </S12:Header>
336 <S12:Body>
337 <S12:Fault>
338   <S12:Code>
339     <S12:Value>[Code]</S12:Value>
340     <S12:Subcode>
341       <S12:Value>[Subcode]</S12:Value>
342     </S12:Subcode>
343   </S12:Code>
344   <S12:Reason>
345     <S12:Text xml:lang="en">[Reason]</S12:Text>
346   </S12:Reason>
347   <S12:Detail>
348     [Detail]
349     ...
350   </S12:Detail>
351 </S12:Fault>
352 </S12:Body>
353 </S12:Envelope>
```

354 The properties bind to a SOAP 1.1 fault as follows:

```
355 <S11:Envelope>
356 <S11:Body>
357 <S11:Fault>
358   <faultcode> [Subcode] </faultcode>
```



```
359     <faultstring xml:lang="en">[Reason]</faultstring>
360     </S11:Fault>
361     </S11:Body>
362 </S11:Envelope>
```

## 363 **5.1 Inconsistent Internal State**

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

367 Properties:

368 **[Code]** Sender

369 **[Subcode]** wsat:InconsistentInternalState

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

371 **[Detail]** Unspecified

## 372 **5.2 Unknown Transaction**

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

375 Properties:

376 **[Code]** Sender

377 **[Subcode]** wsat:UnknownTransaction

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

379 **[Detail]** Unspecified

## 380 6 Security Model

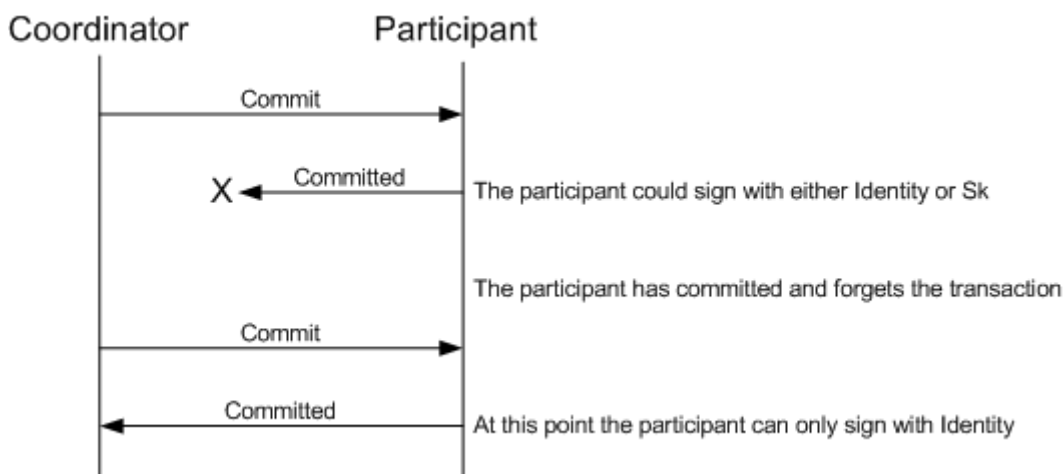
381 The security model for Atomic Transactions builds on the model defined in WS-Coordination [WSCOOR].  
382 That is, services have policies specifying their requirements and requestors provide claims (either implicit  
383 or explicit) and the requisite proof of those claims. Coordination context creation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

385 Because Atomic Transactions represent a specific use case rather than the general nature of  
386 coordination contexts, additional aspects of the security model can be specified.

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

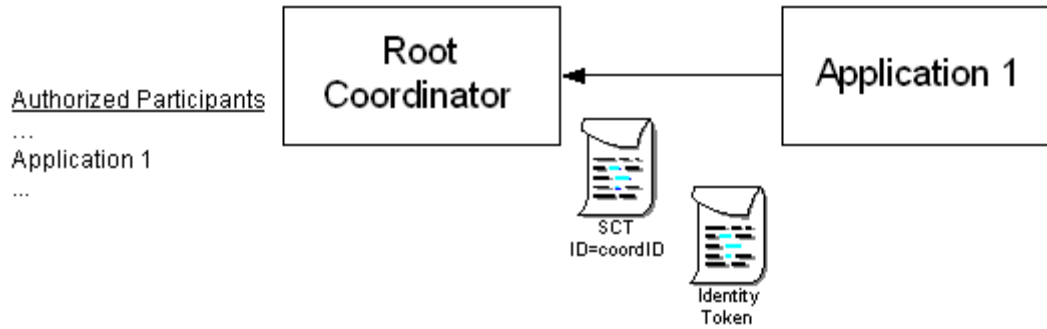
390 Consider, for example, the scenarios where a participant has committed its part of the transaction, but for  
391 some reason the coordinator never receives acknowledgement of the commit. The result is that when  
392 communication is re-established in the future, the coordinator will attempt to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

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



397  
398 There are, of course, techniques to mitigate this situation but such options will not always be successful.  
399 Consequently, when dealing with Atomic Transactions, it is critical that identity claims always be proven to  
400 ensure that correct access control is maintained by coordinators.

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



405

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

409

## 7 Security Considerations

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

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

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

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

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

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

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

- 436 • **Message alteration** – Alteration is prevented by including signatures of the message information  
437 using WS-Security [WSSec].
- 438 • **Message disclosure** – Confidentiality is preserved by encrypting sensitive data using WS-  
439 Security [WSSec].
- 440 • **Key integrity** – Key integrity is maintained by using the strongest algorithms possible (by  
441 comparing secured policies – see WS-Policy [WSPOLICY] and WS-SecurityPolicy  
442 [WSSecPolicy]).
- 443 • **Authentication** – Authentication is established using the mechanisms described in WS-Security  
444 and WS-Trust [WSTrust]. Each message is authenticated using the mechanisms described in  
445 WS-Security [WSSec].
- 446 • **Accountability** – Accountability is a function of the type of and string of the key and algorithms  
447 being used. In many cases, a strong symmetric key provides sufficient accountability. However, in  
448 some environments, strong PKI signatures are required.
- 449 • **Availability** – Many services are subject to a variety of availability attacks. Replay is a common  
450 attack and it is RECOMMENDED that this be addressed as described in the next bullet. Other  
451 attacks, such as network-level denial of service attacks are harder to avoid and are outside the  
452 scope of this specification. That said, care should be taken to ensure that minimal processing be  
453 performed prior to any authenticating sequences.

- 454
- 455
- 456
- 457
- **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.

---

## 458 8 Use of WS-Addressing Headers

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

- 462 • A notification message is a terminal message when it indicates the end of a  
463 coordinator/participant relationship. **Committed**, **Aborted** and **ReadOnly** are terminal  
464 messages, as are the protocol faults defined in this specification and in WS-Coordination  
465 [[WSCOOR](#)].
- 466 • A notification message is a non-terminal message when it does not indicate the end of a  
467 coordinator/participant relationship. **Commit**, **Rollback**, **Prepare** and **Prepared** are non-  
468 terminal messages.

469 The following statements define addressing interoperability requirements for the Atomic Transaction  
470 message types:

471 Non-terminal notification messages:

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

475 Both terminal and non-terminal notification messages:

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

478 Notification messages used in WS-AtomicTransaction protocols MUST include as the [action] property an  
479 action URI that consists of the wsat namespace URI concatenated with the "/" character and the element  
480 name of the message. For example:

481 `http://docs.oasis-open.org/ws-tx/wsat/2006/06/Commit`

482 Notification messages are normally addressed according to section 3.3 of WS-Addressing 1.0 – Core  
483 [[WSADDR](#)] by both coordinators and participants using the Endpoint References initially obtained during  
484 the Register-RegisterResponse exchange. If a [source endpoint] property is present in a notification  
485 message, it MAY be used by the recipient. Cases exist where a Coordinator or Participant has forgotten a  
486 transaction that is completed and needs to respond to a resent protocol message. In such cases, the  
487 [source endpoint] property SHOULD be used as described in section 3.3 of WS-Addressing 1.0 – Core  
488 [[WSADDR](#)]. Permanent loss of connectivity between a coordinator and a participant in an in-doubt state  
489 can result in data corruption.

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

493 All messages are delivered using connections initiated by the sender.

494 **9 State Tables**

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

497 Each cell in the tables uses the following convention:

498

Legend
<i>Action to take</i>
Next state

499

500 Each state supports a number of possible events. Expected events are processed by taking the  
 501 prescribed action and transitioning to the next state. Unexpected protocol messages MUST result in a  
 502 fault message as defined in the state tables. These faults use standard fault codes as defined in either  
 503 WS-Coordination [WSCOOR] or in section 5 Transaction Faults. Events that may not occur in a given  
 504 state are labeled as N/A.

505 Notes:

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

510 **9.1 Completion Protocol**

511

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

512

513 **9.2 2PC Protocol**

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

517

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

518

519 “Forget” implies that the subordinate’s participation is removed from the coordinator (if necessary), and  
 520 otherwise the message is ignored



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

521

---

522

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