



1 **Web Services Reliable Messaging (WS-**
2 **ReliableMessaging) 1.1**

3 **Committee Draft 05**

4 **1 February 2007**

5 **Specification URIs:**

6 **This Version:**

7 <http://docs.oasis-open.org/ws-rx/wsrn/200702/wsrn-1.1-spec-cd-05.pdf>

8 <http://docs.oasis-open.org/ws-rx/wsrn/200702/wsrn-1.1-spec-cd-05.html>

9 **Previous Version:**

10 <http://docs.oasis-open.org/ws-rx/wsrn/200608/wsrn-1.1-spec-cd-04.pdf>

11 <http://docs.oasis-open.org/ws-rx/wsrn/200608/wsrn-1.1-spec-cd-04.html>

12 **Latest Version:**

13 <http://docs.oasis-open.org/ws-rx/wsrn/200702>

14 **Latest Approved Version:**

15 <http://docs.oasis-open.org/ws-rx/wsrn/200702/wsrn-1.1-spec-cd-05.pdf>

16 <http://docs.oasis-open.org/ws-rx/wsrn/200702/wsrn-1.1-spec-cd-05.html>

17 **Technical Committee:**

18 OASIS Web Services Reliable Exchange (WS-RX) TC

19 **Chairs:**

20 Paul Fremantle <paul@wso2.com>

21 Sanjay Patil <sanjay.patil@sap.com>

22 **Editors:**

23 Doug Davis, IBM <dug@us.ibm.com>

24 Anish Karmarkar, Oracle <Anish.Karmarkar@oracle.com>

25 Gilbert Pilz, BEA <gpilz@bea.com>

26 Steve Winkler, SAP <steve.winkler@sap.com>

27 Ümit Yalçınalp, SAP <umit.yalcinalp@sap.com>

28 **Related Work:**

29 This specification replaces or supercedes:

- 30 ● WS-ReliableMessaging v1.0

31 **Declared XML Namespaces:**

32 <http://docs.oasis-open.org/ws-rx/wsrn/200702>

33 **Abstract:**

34 This specification (WS-ReliableMessaging) describes a protocol that allows messages to be
35 transferred reliably between nodes implementing this protocol in the presence of software
36 component, system, or network failures. The protocol is described in this specification in a
37 transport-independent manner allowing it to be implemented using different network technologies.
38 To support interoperable Web services, a SOAP binding is defined within this specification.

39 The protocol defined in this specification depends upon other Web services specifications for the
40 identification of service endpoint addresses and policies. How these are identified and retrieved
41 are detailed within those specifications and are out of scope for this document.

42 By using the XML [XML], SOAP [SOAP 1.1], [SOAP 1.2] and WSDL [WSDL 1.1] extensibility
43 model, SOAP-based and WSDL-based specifications are designed to be composed with each
44 other to define a rich Web services environment. As such, WS-ReliableMessaging by itself does
45 not define all the features required for a complete messaging solution. WS-ReliableMessaging is
46 a building block that is used in conjunction with other specifications and application-specific
47 protocols to accommodate a wide variety of requirements and scenarios related to the operation
48 of distributed Web services.

49 **Status:**

50 This document was last revised or approved by the WS-RX on the above date. The level of
51 approval is also listed above. Check the "Latest Version" or "Latest Approved Version" location
52 noted above for possible later revisions of this document.

53 Technical Committee members should send comments on this specification to the Technical
54 Committee's email list. Others should send comments to the Technical Committee by using the
55 "Send A Comment" button on the Technical Committee's web page at [http://www.oasis-
56 open.org/committees/ws-rx](http://www.oasis-open.org/committees/ws-rx).

57 For information on whether any patents have been disclosed that may be essential to
58 implementing this specification, and any offers of patent licensing terms, please refer to the
59 Intellectual Property Rights section of the Technical Committee web page ([http://www.oasis-
60 open.org/committees/ws-rx/ipr.php](http://www.oasis-open.org/committees/ws-rx/ipr.php)).

61 The non-normative errata page for this specification is located at [http://www.oasis-
62 open.org/committees/ws-rx](http://www.oasis-open.org/committees/ws-rx).

63 Notices

64 Copyright © OASIS® 1993–2007. All Rights Reserved. OASIS trademark, IPR and other policies apply.

65 All capitalized terms in the following text have the meanings assigned to them in the OASIS Intellectual
66 Property Rights Policy (the "OASIS IPR Policy"). The full Policy may be found at the OASIS website.

67 This document and translations of it may be copied and furnished to others, and derivative works that
68 comment on or otherwise explain it or assist in its implementation may be prepared, copied, published,
69 and distributed, in whole or in part, without restriction of any kind, provided that the above copyright notice
70 and this section are included on all such copies and derivative works. However, this document itself may
71 not be modified in any way, including by removing the copyright notice or references to OASIS, except as
72 needed for the purpose of developing any document or deliverable produced by an OASIS Technical
73 Committee (in which case the rules applicable to copyrights, as set forth in the OASIS IPR Policy, must be
74 followed) or as required to translate it into languages other than English.

75 The limited permissions granted above are perpetual and will not be revoked by OASIS or its successors
76 or assigns.

77 This document and the information contained herein is provided on an "AS IS" basis and OASIS
78 DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY
79 WARRANTY THAT THE USE OF THE INFORMATION HEREIN WILL NOT INFRINGE ANY
80 OWNERSHIP RIGHTS OR ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A
81 PARTICULAR PURPOSE.

82 OASIS requests that any OASIS Party or any other party that believes it has patent claims that would
83 necessarily be infringed by implementations of this OASIS Committee Specification or OASIS Standard, to
84 notify OASIS TC Administrator and provide an indication of its willingness to grant patent licenses to such
85 patent claims in a manner consistent with the IPR Mode of the OASIS Technical Committee that produced
86 this specification.

87 OASIS invites any party to contact the OASIS TC Administrator if it is aware of a claim of ownership of any
88 patent claims that would necessarily be infringed by implementations of this specification by a patent
89 holder that is not willing to provide a license to such patent claims in a manner consistent with the IPR
90 Mode of the OASIS Technical Committee that produced this specification. OASIS may include such
91 claims on its website, but disclaims any obligation to do so.

92 OASIS takes no position regarding the validity or scope of any intellectual property or other rights that
93 might be claimed to pertain to the implementation or use of the technology described in this document or
94 the extent to which any license under such rights might or might not be available; neither does it represent
95 that it has made any effort to identify any such rights. Information on OASIS' procedures with respect to
96 rights in any document or deliverable produced by an OASIS Technical Committee can be found on the
97 OASIS website. Copies of claims of rights made available for publication and any assurances of licenses
98 to be made available, or the result of an attempt made to obtain a general license or permission for the
99 use of such proprietary rights by implementers or users of this OASIS Committee Specification or OASIS
100 Standard, can be obtained from the OASIS TC Administrator. OASIS makes no representation that any
101 information or list of intellectual property rights will at any time be complete, or that any claims in such list
102 are, in fact, Essential Claims.

103 The name "OASIS" is a trademark of [OASIS](#), the owner and developer of this specification, and should be
104 used only to refer to the organization and its official outputs. OASIS welcomes reference to, and
105 implementation and use of, specifications, while reserving the right to enforce its marks against
106 misleading uses. Please see <http://www.oasis-open.org/who/trademark.php> for above guidance.

107 **Table of Contents**

108	1 Introduction.....	7
109	1.1 Terminology.....	7
110	1.2 Namespace.....	8
111	1.3 Conformance.....	8
112	2 Reliable Messaging Model.....	9
113	2.1 Glossary.....	9
114	2.2 Protocol Preconditions.....	10
115	2.3 Protocol Invariants.....	11
116	2.4 Delivery Assurances.....	11
117	2.5 Example Message Exchange.....	12
118	3 RM Protocol Elements.....	14
119	3.1 Considerations on the Use of Extensibility Points.....	14
120	3.2 Considerations on the Use of "Piggy-Backing".....	14
121	3.3 Composition with WS-Addressing.....	14
122	3.4 Sequence Creation.....	15
123	3.5 Closing A Sequence.....	19
124	3.6 Sequence Termination.....	21
125	3.7 Sequences.....	23
126	3.8 Request Acknowledgement.....	24
127	3.9 Sequence Acknowledgement.....	25
128	4 Faults.....	28
129	4.1 SequenceFault Element.....	29
130	4.2 Sequence Terminated.....	30
131	4.3 Unknown Sequence.....	30
132	4.4 Invalid Acknowledgement.....	31
133	4.5 Message Number Rollover.....	31
134	4.6 Create Sequence Refused.....	32
135	4.7 Sequence Closed.....	32
136	4.8 WSRM Required.....	33
137	5 Security Threats and Countermeasures.....	34
138	5.1 Threats and Countermeasures.....	34
139	5.2 Security Solutions and Technologies.....	36
140	6 Securing Sequences.....	40
141	6.1 Securing Sequences Using WS-Security.....	40
142	6.2 Securing Sequences Using SSL/TLS.....	41
143	7 References.....	43
144	7.1 Normative.....	43

145	7.2 Non-Normative	44
146	Appendix A. Schema.....	46
147	Appendix B. WSDL.....	51
148	Appendix C. Message Examples.....	53
149	Appendix C.1 Create Sequence.....	53
150	Appendix C.2 Initial Transmission.....	53
151	Appendix C.3 First Acknowledgement.....	55
152	Appendix C.4 Retransmission.....	55
153	Appendix C.5 Termination.....	56
154	Appendix D. State Tables.....	58
155	Appendix E. Acknowledgments.....	63
156	Appendix F. Revision History.....	64

157 1 Introduction

158 It is often a requirement for two Web services that wish to communicate to do so reliably in the presence
159 of software component, system, or network failures. The primary goal of this specification is to create a
160 modular mechanism for reliable transfer of messages. It defines a messaging protocol to identify, track,
161 and manage the reliable transfer of messages between a source and a destination. It also defines a
162 SOAP binding that is required for interoperability. Additional bindings can be defined.

163 This mechanism is extensible allowing additional functionality, such as security, to be tightly integrated.
164 This specification integrates with and complements the WS-Security [WS-Security], WS-Policy [WS-
165 Policy], and other Web services specifications. Combined, these allow for a broad range of reliable,
166 secure messaging options.

167 1.1 Terminology

168 The keywords "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD
169 NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described
170 in RFC 2119 [KEYWORDS].

171 This specification uses the following syntax to define normative outlines for messages:

- 172 • The syntax appears as an XML instance, but values in italics indicate data types instead of values.
- 173 • Characters are appended to elements and attributes to indicate cardinality:
 - 174 ○ "?" (0 or 1)
 - 175 ○ "*" (0 or more)
 - 176 ○ "+" (1 or more)
- 177 • The character "|" is used to indicate a choice between alternatives.
- 178 • The characters "[" and "]" are used to indicate that contained items are to be treated as a group
179 with respect to cardinality or choice.
- 180 • An ellipsis (i.e. "...") indicates a point of extensibility that allows other child or attribute content
181 specified in this document. Additional children elements and/or attributes MAY be added at the
182 indicated extension points but they MUST NOT contradict the semantics of the parent and/or
183 owner, respectively. If an extension is not recognized it SHOULD be ignored.
- 184 • XML namespace prefixes (See Section 1.2) are used to indicate the namespace of the element
185 being defined.

186 Elements and Attributes defined by this specification are referred to in the text of this document using
187 XPath 1.0 [XPATH 1.0] expressions. Extensibility points are referred to using an extended version of this
188 syntax:

- 189 • An element extensibility point is referred to using {any} in place of the element name. This
190 indicates that any element name can be used, from any namespace other than the wsrn:
191 namespace.
- 192 • An attribute extensibility point is referred to using @{any} in place of the attribute name. This
193 indicates that any attribute name can be used, from any namespace other than the wsrn:
194 namespace.

195 1.2 Namespace

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

197 <http://docs.oasis-open.org/ws-rx/wsrn/200702>

198 Dereferencing the above URI will produce the Resource Directory Description Language [RDDL 2.0]
199 document that describes this namespace.

200 Table 1 lists the XML namespaces that are used in this specification. The choice of any namespace prefix
201 is arbitrary and not semantically significant.

202 Table 1

Prefix	Namespace
S	(Either SOAP 1.1 or 1.2)
S11	http://schemas.xmlsoap.org/soap/envelope/
S12	http://www.w3.org/2003/05/soap-envelope
wsrn	http://docs.oasis-open.org/ws-rx/wsrn/200702
wsa	http://www.w3.org/2005/08/addressing
wsam	http://www.w3.org/2007/02/addressing/metadata
wsse	http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-secext-1.0.xsd
xs	http://www.w3.org/2001/XMLSchema

203 The normative schema for WS-ReliableMessaging can be found linked from the namespace document
204 that is located at the namespace URI specified above.

205 All sections explicitly noted as examples are informational and are not to be considered normative.

206 1.3 Conformance

207 An implementation is not conformant with this specification if it fails to satisfy one or more of the MUST or
208 REQUIRED level requirements defined herein. A SOAP Node MUST NOT use the XML namespace
209 identifier for this specification (listed in Section 1.2) within SOAP Envelopes unless it is conformant with
210 this specification.

211 Normative text within this specification takes precedence over normative outlines, which in turn take
212 precedence over the XML Schema [XML Schema Part 1, Part 2] descriptions.

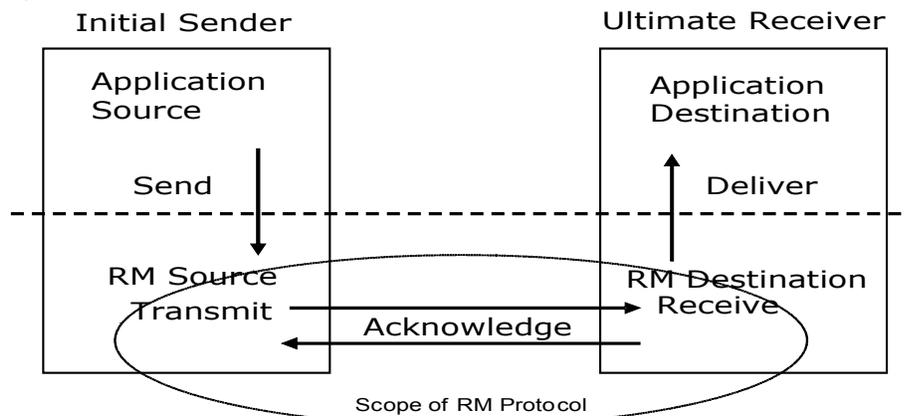
2 Reliable Messaging Model

214 Many errors can interrupt a conversation. Messages can be lost, duplicated or reordered. Further the host
215 systems can experience failures and lose volatile state.

216 The WS-ReliableMessaging specification defines an interoperable protocol that enables a Reliable
217 Messaging (RM) Source to accurately determine the disposition of each message it Transmits as
218 perceived by the RM Destination, so as to allow it to resolve any in-doubt status regarding receipt of the
219 message Transmitted. The protocol also enables an RM Destination to efficiently determine which of
220 those messages it Receives have been previously Received, enabling it to filter out duplicate message
221 transmissions caused by the retransmission, by the RM Source, of an unacknowledged message. It also
222 enables an RM Destination to Deliver the messages it Receives to the Application Destination in the order
223 in which they were sent by an Application Source, in the event that they are Received out of order. Note
224 that this specification places no restriction on the scope of the RM Source or RM Destination entities. For
225 example, either can span multiple WSDL Ports or Endpoints.

226 The protocol enables the implementation of a broad range of reliability features which include ordered
227 Delivery, duplicate elimination, and guaranteed receipt. The protocol can also be implemented with a
228 range of robustness characteristics ranging from in-memory persistence that is scoped to a single process
229 lifetime, to replicated durable storage that is recoverable in all but the most extreme circumstances. It is
230 expected that the Endpoints will implement as many or as few of these reliability characteristics as
231 necessary for the correct operation of the application using the protocol. Regardless of which of the
232 reliability features is enabled, the wire protocol does not change.

233 Figure 1 below illustrates the entities and events in a simple reliable exchange of messages. First, the
234 Application Source Sends a message for reliable transfer. The Reliable Messaging Source accepts the
235 message and Transmits it one or more times. After accepting the message, the RM Destination
236 Acknowledges it. Finally, the RM Destination Delivers the message to the Application Destination. The
237 exact roles the entities play and the complete meaning of the events will be defined throughout this
238 specification.



239 Figure 1: Reliable Messaging Model

240 2.1 Glossary

241 The following definitions are used throughout this specification:

242 **Accept:** The act of qualifying a message by the RM Destination such that it becomes eligible for Delivery
243 and acknowledgement.

244 **Acknowledgement:** The communication from the RM Destination to the RM Source indicating the
245 successful receipt of a message.

246 **Acknowledgement Message:** A message containing a `SequenceAcknowledgement` header block.
247 Acknowledgement Messages may or may not contain a SOAP body.

248 **Acknowledgement Request:** A message containing an `AckRequested` header. Acknowledgement
249 Requests may or may not contain a SOAP body.

250 **Application Destination:** The Endpoint to which a message is Delivered.

251 **Application Source:** The Endpoint that Sends a message.

252 **Back-channel:** When the underlying transport provides a mechanism to return a transport-protocol
253 specific response, capable of carrying a SOAP message, without initiating a new connection, this
254 specification refers to this mechanism as a back-channel.

255 **Deliver:** The act of transferring responsibility for a message from the RM Destination to the Application
256 Destination.

257 **Endpoint:** As defined in the WS-Addressing specification [[WS-Addressing](#)]; a Web service Endpoint is a
258 (referenceable) entity, processor, or resource to which Web service messages can be addressed.
259 Endpoint references (EPRs) convey the information needed to address a Web service Endpoint.

260 **Receive:** The act of reading a message from a network connection and accepting it.

261 **RM Destination:** The Endpoint that Receives messages Transmitted reliably from an RM Source.

262 **RM Protocol Header Block:** One of `Sequence`, `SequenceAcknowledgement`, or `AckRequested`.

263 **RM Source:** The Endpoint that Transmits messages reliably to an RM Destination.

264 **Send:** The act of transferring a message from the Application Source to the RM Source for reliable
265 transfer.

266 **Sequence Lifecycle Message:** A message that contains one of: `CreateSequence`,
267 `CreateSequenceResponse`, `CloseSequence`, `CloseSequenceResponse`, `TerminateSequence`,
268 `TerminateSequenceResponse` as the child element of the SOAP body element.

269 **Sequence Traffic Message:** A message containing a `Sequence` header block.

270 **Transmit:** The act of writing a message to a network connection.

271 **2.2 Protocol Preconditions**

272 The correct operation of the protocol requires that a number of preconditions MUST be established prior
273 to the processing of the initial sequenced message:

- 274 • For any single message exchange the RM Source MUST have an endpoint reference that uniquely
275 identifies the RM Destination Endpoint.
- 276 • The RM Source MUST have successfully created a Sequence with the RM Destination.
- 277 • The RM Source MUST be capable of formulating messages that adhere to the RM Destination's
278 policies.
- 279 • If a secure exchange of messages is REQUIRED, then the RM Source and RM Destination MUST
280 have a security context.

281 **2.3 Protocol Invariants**

282 During the lifetime of a Sequence, the following invariants are REQUIRED for correctness:

- 283 • The RM Source MUST assign each message within a Sequence a message number (defined
284 below) beginning at 1 and increasing by exactly 1 for each subsequent message. These numbers
285 MUST be assigned in the same order in which messages are sent by the Application Source.
- 286 • Within every Acknowledgement Message it issues, the RM Destination MUST include one or more
287 AcknowledgementRange child elements that contain, in their collective ranges, the message
288 number of every message accepted by the RM Destination. The RM Destination MUST exclude, in
289 the AcknowledgementRange elements, the message numbers of any messages it has not
290 accepted. If no messages have been received the RM Destination MUST return None instead of an
291 AcknowledgementRange(s). The RM Destination MAY transmit a Nack for a specific message
292 or messages instead of an AcknowledgementRange(s).
- 293 • While the Sequence is not closed or terminated, the RM Source SHOULD retransmit
294 unacknowledged messages.

295 **2.4 Delivery Assurances**

296 This section defines a number of Delivery Assurance assertions, which can be supported by RM Sources
297 and RM Destinations. These assertions can be specified as policy assertions using the WS-Policy
298 framework [[WS-Policy]]. For details on this see the WSRM Policy specification [WS-RM Policy].

299 AtLeastOnce

300 Each message is to be delivered at least once, or else an error MUST be raised by the RM Source and/or
301 RM Destination. The requirement on an RM Source is that it SHOULD retry transmission of every
302 message sent by the Application Source until it receives an acknowledgement from the RM Destination.
303 The requirement on the RM Destination is that it SHOULD retry the transfer to the Application Destination
304 of any message that it accepts from the RM Source, until that message has been successfully delivered.
305 There is no requirement for the RM Destination to apply duplicate message filtering.

306 AtMostOnce

307 Each message is to be delivered at most once. The RM Source MAY retry transmission of
308 unacknowledged messages, but is NOT REQUIRED to do so. The requirement on the RM Destination is
309 that it MUST filter out duplicate messages, i.e. that it MUST NOT deliver a duplicate of a message that
310 has already been delivered.

311 ExactlyOnce

312 Each message is to be delivered exactly once; if a message cannot be delivered then an error MUST be
313 raised by the RM Source and/or RM Destination. The requirement on an RM Source is that it SHOULD
314 retry transmission of every message sent by the Application Source until it receives an acknowledgement
315 from the RM Destination. The requirement on the RM Destination is that it SHOULD retry the transfer to
316 the Application Destination of any message that it accepts from the RM Source until that message has
317 been successfully delivered, and that it MUST NOT deliver a duplicate of a message that has already
318 been delivered.

319 InOrder

320 Messages from each individual sequence are to be delivered in the same order they have been sent by
321 the Application Source. The requirement on an RM Source is that it MUST ensure that the ordinal position
322 of each message in the sequence (as indicated by a message sequence number) is consistent with the

323 order in which the messages have been sent from the Application Source. The requirement on the RM
 324 Destination is that it MUST deliver received messages for each sequence in the order indicated by the
 325 message numbering. This DeliveryAssurance can be used in combination with any of the AtLeastOnce,
 326 AtMostOnce or ExactlyOnce assertions, and the requirements of those assertions MUST also be met. In
 327 particular if the AtLeastOnce or ExactlyOnce assertion applies and the RM Destination detects a gap in
 328 the sequence then the RM Destination MUST NOT deliver any subsequent messages from that sequence
 329 until the missing messages are received or until the sequence is closed.

330 2.5 Example Message Exchange

331 Figure 2 illustrates a possible message exchange between two reliable messaging Endpoints A and B.



Figure 2: The WS-ReliableMessaging Protocol

- 332 1. The protocol preconditions are established. These include policy exchange, endpoint resolution,
- 333 and establishing trust.
- 334 2. The RM Source requests creation of a new Sequence.
- 335 3. The RM Destination creates a new Sequence and returns its unique identifier.
- 336 4. The RM Source begins Transmitting messages in the Sequence beginning with MessageNumber 1.
- 337 In the figure above, the RM Source sends 3 messages in the Sequence.
- 338 5. The 2nd message in the Sequence is lost in transit.

- 339 6. The 3rd message is the last in this Sequence and the RM Source includes an `AckRequested`
340 header to ensure that it gets a timely `SequenceAcknowledgement` for the Sequence.
- 341 7. The RM Destination acknowledges receipt of message numbers 1 and 3 as a result of receiving the
342 RM Source's `AckRequested` header.
- 343 8. The RM Source retransmits the unacknowledged message with `MessageNumber` 2. This is a new
344 message from the perspective of the underlying transport, but it has the same `Sequence Identifier`
345 and `MessageNumber` so the RM Destination can recognize it as a duplicate of the earlier message,
346 in case the original and retransmitted messages are both Received. The RM Source includes an
347 `AckRequested` header in the retransmitted message so the RM Destination will expedite an
348 acknowledgement.
- 349 9. The RM Destination Receives the second transmission of the message with `MessageNumber` 2
350 and acknowledges receipt of message numbers 1, 2, and 3.
- 351 10. The RM Source Receives this Acknowledgement and sends a `TerminateSequence` message to the
352 RM Destination indicating that the Sequence is completed. The `TerminateSequence` message
353 indicates that message number 3 was the last message in the Sequence. The RM Destination then
354 reclaims any resources associated with the Sequence.
- 355 11. The RM Destination Receives the `TerminateSequence` message indicating that the RM Source will
356 not be sending any more messages. The RM Destination sends a `TerminateSequenceResponse`
357 message to the RM Source and reclaims any resources associated with the Sequence.
- 358 The RM Source will expect to Receive Acknowledgements from the RM Destination during the course of a
359 message exchange at occasions described in Section 3 below. Should an Acknowledgement not be
360 Received in a timely fashion, the RM Source MUST re-transmit the message since either the message or
361 the associated Acknowledgement might have been lost. Since the nature and dynamic characteristics of
362 the underlying transport and potential intermediaries are unknown in the general case, the timing of re-
363 transmissions cannot be specified. Additionally, over-aggressive re-transmissions have been
364 demonstrated to cause transport or intermediary flooding which are counterproductive to the intention of
365 providing a reliable exchange of messages. Consequently, implementers are encouraged to utilize
366 adaptive mechanisms that dynamically adjust re-transmission time and the back-off intervals that are
367 appropriate to the nature of the transports and intermediaries envisioned. For the case of TCP/IP
368 transports, a mechanism similar to that described as RTTM in RFC 1323 [[RTTM](#)] SHOULD be
369 considered.
- 370 Now that the basic model has been outlined, the details of the elements used in this protocol are now
371 provided in Section 3.

372 **3 RM Protocol Elements**

373 The following sub-sections define the various RM protocol elements, and prescribe their usage by a
374 conformant implementations.

375 **3.1 Considerations on the Use of Extensibility Points**

376 The following protocol elements define extensibility points at various places. Implementations MAY add
377 child elements and/or attributes at the indicated extension points but MUST NOT contradict the semantics
378 of the parent and/or owner, respectively. If a receiver does not recognize an extension, the receiver
379 SHOULD ignore the extension.

380 **3.2 Considerations on the Use of "Piggy-Backing"**

381 Some RM Protocol Header Blocks may be added to messages that are targeted to the same Endpoint to
382 which those headers are to be sent (a concept often referred to as "piggy-backing"), thus saving the
383 overhead of an additional message exchange. Reference parameters MUST be considered when
384 determining whether two EPRs are targeted to the same Endpoint. The determination of if and when a
385 Header Block will be piggy-backed onto another message is made by the entity (RM Source or RM
386 Destination) that is sending the header. In order to ensure optimal and successful processing of RM
387 Sequences, endpoints that receive RM-related messages SHOULD be prepared to process RM Protocol
388 Header Blocks that are included in any message it receives. See the sections that define each RM
389 Protocol Header Block to know which ones may be considered for piggy-backing.

390 **3.3 Composition with WS-Addressing**

391 When the RM protocol, defined in this specification, is composed with the WS-Addressing specification,
392 the following rules prescribe the constraints on the value of the `wsa:Action` header:

- 393 1. When an Endpoint generates a message that carries an RM protocol element, that is defined in
394 the following sections, in the body of a SOAP envelope that Endpoint MUST include in that
395 envelope a `wsa:Action` SOAP header block whose value is an IRI that is a concatenation of the
396 WS-RM namespace URI, followed by a "/", followed by the value of the local name of the child
397 element of the SOAP body. For example, for a Sequence creation request message as described
398 in section 3.4 below, the value of the `wsa:Action` IRI would be:

```
399 http://docs.oasis-open.org/ws-rx/wsrn/200702/CreateSequence
```

- 400 2. When an Endpoint generates an Acknowledgement Message that has no element content in the
401 SOAP body, then the value of the `wsa:Action` IRI MUST be:

```
402 http://docs.oasis-open.org/ws-rx/wsrn/200702/SequenceAcknowledgement
```

- 403 3. When an Endpoint generates an Acknowledgement Request that has no element content in the
404 SOAP body, then the value of the `wsa:Action` IRI MUST be:

```
405 http://docs.oasis-open.org/ws-rx/wsrn/200702/AckRequested
```

- 406 4. When an Endpoint generates an RM fault as defined in section 4 below, the value of the
407 `wsa:Action` IRI MUST be as defined in section 4 below.

408 3.4 Sequence Creation

409 The RM Source MUST request creation of an outbound Sequence by sending a `CreateSequence`
410 element in the body of a message to the RM Destination which in turn responds either with a message
411 containing `CreateSequenceResponse` or a `CreateSequenceRefused` fault. The RM Source MAY
412 include an offer to create an inbound Sequence within the `CreateSequence` message. This offer is
413 either accepted or rejected by the RM Destination in the `CreateSequenceResponse` message.

414 The SOAP version used for the `CreateSequence` message SHOULD be used for all subsequent
415 messages in or for that Sequence, sent by either the RM Source or the RM Destination.

416 The following exemplar defines the `CreateSequence` syntax:

```
417 <wsrm:CreateSequence ...>
418   <wsrm:AcksTo> wsa:EndpointReferenceType </wsrm:AcksTo>
419   <wsrm:Expires ...> xs:duration </wsrm:Expires> ?
420   <wsrm:Offer ...>
421     <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
422     <wsrm:Endpoint> wsa:EndpointReferenceType </wsrm:Endpoint>
423     <wsrm:Expires ...> xs:duration </wsrm:Expires> ?
424     <wsrm:IncompleteSequenceBehavior>
425       wsrml:IncompleteSequenceBehaviorType
426     </wsrm:IncompleteSequenceBehavior> ?
427     ...
428   </wsrm:Offer> ?
429   ...
430 </wsrm:CreateSequence>
```

431 The following describes the content model of the `CreateSequence` element.

432 `/wsrm:CreateSequence`

433 This element requests creation of a new Sequence between the RM Source that sends it, and the RM
434 Destination to which it is sent. The RM Source MUST NOT send this element as a header block. The RM
435 Destination MUST respond either with a `CreateSequenceResponse` response message or a
436 `CreateSequenceRefused` fault.

437 `/wsrm:CreateSequence/wsrm:AcksTo`

438 The RM Source MUST include this element in any `CreateSequence` message it sends. This element is of
439 type `wsa:EndpointReferenceType` (as specified by WS-Addressing). It specifies the endpoint
440 reference to which messages containing `SequenceAcknowledgement` header blocks and faults related
441 to the created Sequence are to be sent, unless otherwise noted in this specification (for example, see
442 Section 3.5).

443 Implementations MUST NOT use an endpoint reference in the `AcksTo` element that would prevent the
444 sending of Sequence Acknowledgements back to the RM Source. For example, using the WS-Addressing
445 "http://www.w3.org/2005/08/addressing/none" IRI would make it impossible for the RM Destination to ever
446 send Sequence Acknowledgements.

447 `/wsrm:CreateSequence/wsrm:Expires`

448 This element, if present, of type `xs:duration` specifies the RM Source's requested duration for the
449 Sequence. The RM Destination MAY either accept the requested duration or assign a lesser value of its
450 choosing. A value of "PT0S" indicates that the Sequence will never expire. Absence of the element
451 indicates an implied value of "PT0S".

452 `/wsrm:CreateSequence/wsrm:Expires/@{any}`

453 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
454 element.

455 `/wsrm:CreateSequence/wsrm:Offer`

456 This element, if present, enables an RM Source to offer a corresponding Sequence for the reliable
457 exchange of messages Transmitted from RM Destination to RM Source.

458 `/wsrm:CreateSequence/wsrm:Offer/wsrm:Identifier`

459 The RM Source MUST set the value of this element to an absolute URI (conformant with RFC3986 [URI])
460 that uniquely identifies the offered Sequence.

461 `/wsrm:CreateSequence/wsrm:Offer/wsrm:Identifier/@{any}`

462 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
463 element.

464 `/wsrm:CreateSequence/wsrm:Offer/wsrm:Endpoint`

465 An RM Source MUST include this element, of type `wsa:EndpointReferenceType` (as specified by
466 WS-Addressing). This element specifies the endpoint reference to which Sequence Lifecycle Messages,
467 Acknowledgement Requests, and fault messages related to the offered Sequence are to be sent.

468 Implementations MUST NOT use an endpoint reference in the Endpoint element that would prevent the
469 sending of Sequence Lifecycle Message, etc. For example, using the WS-Addressing
470 "http://www.w3.org/2005/08/addressing/none" IRI would make it impossible for the RM Destination to ever
471 send Sequence Lifecycle Messages (e.g. `TerminateSequence`) to the RM Source for the Offered
472 Sequence.

473 The Offer of an Endpoint containing the "http://www.w3.org/2005/08/addressing/anonymous" IRI as its
474 address is problematic due to the inability of a source to connect to this address and retry
475 unacknowledged messages (as described in Section 2.3). Note that this specification does not define any
476 mechanisms for providing this assurance. In the absence of an extension that addresses this issue, an
477 RM Destination MUST NOT accept (via the `/wsrm:CreateSequenceResponse/wsrm:Accept`
478 element described below) an Offer that contains the "http://www.w3.org/2005/08/addressing/anonymous"
479 IRI as its address.

480 `/wsrm:CreateSequence/wsrm:Offer/wsrm:Expires`

481 This element, if present, of type `xs:duration` specifies the duration for the offered Sequence. A value of
482 "PT0S" indicates that the offered Sequence will never expire. Absence of the element indicates an implied
483 value of "PT0S".

484 `/wsrm:CreateSequence/wsrm:Offer/wsrm:Expires/@{any}`

485 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
486 element.

487 `/wsrm:CreateSequence/wsrm:Offer/wsrm:IncompleteSequenceBehavior`

488 This element, if present, specifies the behavior that the destination will exhibit upon the closure or
489 termination of an incomplete Sequence. For the purposes of defining the values used, the term "discard"
490 refers to behavior equivalent to the Application Destination never processing a particular message.

491 A value of "DiscardEntireSequence" indicates that the entire Sequence MUST be discarded if the
492 Sequence is closed, or terminated, when there are one or more gaps in the final
493 `SequenceAcknowledgement`.

494 A value of “DiscardFollowingFirstGap” indicates that messages in the Sequence beyond the first gap
495 MUST be discarded when there are one or more gaps in the final `SequenceAcknowledgement`.

496 The default value of “NoDiscard” indicates that no acknowledged messages in the Sequence will be
497 discarded.

498 `/wsrm:CreateSequence/wsrm:Offer/{any}`

499 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
500 to be passed.

501 `/wsrm:CreateSequence/wsrm:Offer/@{any}`

502 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
503 element.

504 `/wsrm:CreateSequence/{any}`

505 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
506 to be passed.

507 `/wsrm:CreateSequence/@{any}`

508 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
509 element.

510 A `CreateSequenceResponse` is sent in the body of a response message by an RM Destination in
511 response to receipt of a `CreateSequence` request message. It carries the `Identifier` of the created
512 Sequence and indicates that the RM Source can begin sending messages in the context of the identified
513 Sequence.

514 The following exemplar defines the `CreateSequenceResponse` syntax:

```
515 <wsrm:CreateSequenceResponse ...>  
516   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
517   <wsrm:Expires ...> xs:duration </wsrm:Expires> ?  
518   <wsrm:IncompleteSequenceBehavior>  
519     wsrm:IncompleteSequenceBehaviorType  
520   </wsrm:IncompleteSequenceBehavior> ?  
521   <wsrm:Accept ...>  
522     <wsrm:AcksTo wsa:EndpointReferenceType </wsrm:AcksTo>  
523     ...  
524   </wsrm:Accept> ?  
525   ...  
526 </wsrm:CreateSequenceResponse>
```

527 The following describes the content model of the `CreateSequenceResponse` element.

528 `/wsrm:CreateSequenceResponse`

529 This element is sent in the body of the response message in response to a `CreateSequence` request
530 message. It indicates that the RM Destination has created a new Sequence at the request of the RM
531 Source. The RM Destination MUST NOT send this element as a header block.

532 `/wsrm:CreateSequenceResponse/wsrm:Identifier`

533 The RM Destination MUST include this element within any `CreateSequenceResponse` message it sends.
534 The RM Destination MUST set the value of this element to the absolute URI (conformant with RFC3986)
535 that uniquely identifies the Sequence that has been created by the RM Destination.

536 `/wsrm:CreateSequenceResponse/wsrm:Identifier/@{any}`

537 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
538 element.

539 /wsmr:CreateSequenceResponse/wsmr:Expires

540 This element, if present, of type `xs:duration` accepts or refines the RM Source's requested duration for
541 the Sequence. It specifies the amount of time after which any resources associated with the Sequence
542 SHOULD be reclaimed thus causing the Sequence to be silently terminated. At the RM Destination this
543 duration is measured from a point proximate to Sequence creation and at the RM Source this duration is
544 measured from a point approximate to the successful processing of the `CreateSequenceResponse`. A
545 value of "PT0S" indicates that the Sequence will never expire. Absence of the element indicates an
546 implied value of "PT0S". The RM Destination MUST set the value of this element to be equal to or less
547 than the value requested by the RM Source in the corresponding `CreateSequence` message.

548 /wsmr:CreateSequenceResponse/wsmr:Expires/@{any}

549 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
550 element.

551 /wsmr:CreateSequenceResponse/wsmr:IncompleteSequenceBehavior

552 This element, if present, specifies the behavior that the destination will exhibit upon the closure or
553 termination of an incomplete Sequence. For the purposes of defining the values used, the term "discard"
554 refers to behavior equivalent to the Application Destination never processing a particular message.

555 A value of "DiscardEntireSequence" indicates that the entire Sequence MUST be discarded if the
556 Sequence is closed, or terminated, when there are one or more gaps in the final
557 `SequenceAcknowledgement`.

558 A value of "DiscardFollowingFirstGap" indicates that messages in the Sequence beyond the first gap
559 MUST be discarded when there are one or more gaps in the final `SequenceAcknowledgement`.

560 The default value of "NoDiscard" indicates that no acknowledged messages in the Sequence will be
561 discarded.

562 /wsmr:CreateSequenceResponse/wsmr:Accept

563 This element, if present, enables an RM Destination to accept the offer of a corresponding Sequence for
564 the reliable exchange of messages Transmitted from RM Destination to RM Source.

565 **Note:** If a `CreateSequenceResponse` is returned without a child `Accept` in response to a
566 `CreateSequence` that did contain a child `Offer`, then the RM Source MAY immediately reclaim any
567 resources associated with the unused offered Sequence.

568 /wsmr:CreateSequenceResponse/wsmr:Accept/wsmr:AcksTo

569 The RM Destination MUST include this element, of type `wsa:EndpointReferenceType` (as specified
570 by WS-Addressing). It specifies the endpoint reference to which messages containing
571 `SequenceAcknowledgement` header blocks and faults related to the created Sequence are to be sent,
572 unless otherwise noted in this specification (for example, see Section 3.5).

573 Implementations MUST NOT use an endpoint reference in the `AcksTo` element that would prevent the
574 sending of Sequence Acknowledgements back to the RM Source. For example, using the WS-Addressing
575 "http://www.w3.org/2005/08/addressing/none" IRI would make it impossible for the RM Destination to ever
576 send Sequence Acknowledgements.

577 /wsmr:CreateSequenceResponse/wsmr:Accept/{any}

578 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
579 to be passed.

580 `/wsmr:CreateSequenceResponse/wsmr:Accept/@{any}`

581 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
582 element.

583 `/wsmr:CreateSequenceResponse/{any}`

584 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
585 to be passed.

586 `/wsmr:CreateSequenceResponse/@{any}`

587 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
588 element.

589 **3.5 Closing A Sequence**

590 There are times during the use of an RM Sequence that the RM Source or RM Destination will wish to
591 discontinue using a Sequence. Simply terminating the Sequence discards the state managed by the RM
592 Destination, leaving the RM Source unaware of the final ranges of messages that were successfully
593 transferred to the RM Destination. To ensure that the Sequence ends with a known final state either the
594 RM Source or RM Destination MAY choose to close the Sequence before terminating it.

595 If the RM Source wishes to close the Sequence, then it sends a `CloseSequence` element, in the body of
596 a message, to the RM Destination. This message indicates that the RM Destination MUST NOT accept
597 any new messages for the specified Sequence, other than those already accepted at the time the
598 `CloseSequence` element is interpreted by the RM Destination. Upon receipt of this message, or
599 subsequent to the RM Destination closing the Sequence of its own volition, the RM Destination MUST
600 include a final `SequenceAcknowledgement` (within which the RM Destination MUST include the `Final`
601 element) header block on any messages associated with the Sequence destined to the RM Source,
602 including the `CloseSequenceResponse` message or on any Sequence fault Transmitted to the RM
603 Source.

604 To allow the RM Destination to determine if it has received all of the messages in a Sequence, the RM
605 Source SHOULD include the `LastMsgNumber` element in any `CloseSequence` messages it sends. The
606 RM Destination can use this information, for example, to implement the behavior indicated by
607 `/wsmr:CreateSequenceResponse/wsmr:IncompleteSequenceBehavior`. The value of the
608 `LastMsgNumber` element MUST be the same in all the `CloseSequence` messages for the closing
609 Sequence.

610 If the RM Destination decides to close a Sequence of its own volition, it MAY inform the RM Source of this
611 event by sending a `CloseSequence` element, in the body of a message, to the `AcksTo` EPR of that
612 Sequence. The RM Destination MUST include a final `SequenceAcknowledgement` (within which the RM
613 Destination MUST include the `Final` element) header block in this message and any subsequent
614 messages associated with the Sequence destined to the RM Source.

615 While the RM Destination MUST NOT accept any new messages for the specified Sequence it MUST still
616 process Sequence Lifecycle Messages and Acknowledgement Requests. For example, it MUST respond to
617 `AckRequested`, `TerminateSequence` as well as `CloseSequence` messages. Note, subsequent
618 `CloseSequence` messages have no effect on the state of the Sequence.

619 In the case where the RM Destination wishes to discontinue use of a Sequence it is RECOMMENDED
620 that it close the Sequence. Please see `Final` and the `SequenceClosed` fault. Whenever possible the
621 `SequenceClosed` fault SHOULD be used in place of the `SequenceTerminated` fault to allow the RM
622 Source to still Receive Acknowledgements.

623 The following exemplar defines the `CloseSequence` syntax:

```
624 <wsrm:CloseSequence ...>  
625   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
626   <wsrm:LastMsgNumber> wsrm:MessageNumberType </wsrm:LastMsgNumber> ?  
627   ...  
628 </wsrm:CloseSequence>
```

629 The following describes the content model of the `CloseSequence` element.

630 `/wsrm:CloseSequence`

631 This element MAY be sent by an RM Source to indicate that the RM Destination MUST NOT accept any
632 new messages for this Sequence This element MAY also be sent by an RM Destination to indicate that it
633 will not accept any new messages for this Sequence.

634 `/wsrm:CloseSequence/wsrm:Identifier`

635 The RM Source or RM Destination MUST include this element in any `CloseSequence` messages it sends.
636 The RM Source or RM Destination MUST set the value of this element to the absolute URI (conformant
637 with RFC3986) of the closing Sequence.

638 `/wsrm:CloseSequence/wsrm:LastMessageNumber`

639 The RM Source SHOULD include this element in any `CloseSequence` message it sends. The
640 `LastMsgNumber` element specifies the highest assigned message number of all the Sequence Traffic
641 Messages for the closing Sequence.

642 `/wsrm:CloseSequence/wsrm:Identifier/@{any}`

643 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
644 element.

645 `/wsrm:CloseSequence/{any}`

646 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
647 to be passed.

648 `/wsrm:CloseSequence@{any}`

649 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
650 element.

651 A `CloseSequenceResponse` is sent in the body of a message in response to receipt of a
652 `CloseSequence` request message. It indicates that the responder has closed the Sequence.

653 The following exemplar defines the `CloseSequenceResponse` syntax:

```
654 <wsrm:CloseSequenceResponse ...>  
655   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
656   ...  
657 </wsrm:CloseSequenceResponse>
```

658 The following describes the content model of the `CloseSequenceResponse` element.

659 `/wsrm:CloseSequenceResponse`

660 This element is sent in the body of a message in response to receipt of a `CloseSequence` request
661 message. It indicates that the responder has closed the Sequence.

662 `/wsrm:CloseSequenceResponse/wsrm:Identifier`

663 The responder (RM Source or RM Destination) MUST include this element in any
664 `CloseSequenceResponse` message it sends. The responder MUST set the value of this element to the
665 absolute URI (conformant with RFC3986) of the closing Sequence.

666 `/wsrm:CloseSequenceResponse/wsrm:Identifier/@{any}`

667 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
668 element.

669 `/wsrm:CloseSequenceResponse/{any}`

670 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
671 to be passed.

672 `/wsrm:CloseSequenceResponse@{any}`

673 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
674 element.

675 **3.6 Sequence Termination**

676 When the RM Source has completed its use of the Sequence it sends a `TerminateSequence` element,
677 in the body of a message, to the RM Destination to indicate that the Sequence is complete and that it will
678 not be sending any further messages related to the Sequence. The RM Destination can safely reclaim any
679 resources associated with the Sequence upon receipt of the `TerminateSequence` message. Under
680 normal usage the RM Source will complete its use of the Sequence when all of the messages in the
681 Sequence have been acknowledged. However, the RM Source is free to Terminate or Close a Sequence
682 at any time regardless of the acknowledgement state of the messages.

683 To allow the RM Destination to determine if it has received all of the messages in a Sequence, the RM
684 Source SHOULD include the `LastMsgNumber` element in any `TerminateSequence` messages it sends.
685 The RM Destination can use this information, for example, to implement the behavior indicated by
686 `/wsrm:CreateSequenceResponse/wsrm:IncompleteSequenceBehavior`. The value of the
687 `LastMsgNumber` element in the `TerminateSequence` message MUST be equal to the value of the
688 `LastMsgNumber` element in any `CloseSequence` message(s) sent by the RM Source for the same
689 Sequence.

690 If the RM Destination decides to terminate a Sequence of its own volition, it MAY inform the RM Source of
691 this event by sending a `TerminateSequence` element, in the body of a message, to the `AcksTo` EPR for
692 that Sequence. The RM Destination MUST include a final `SequenceAcknowledgement` (within which
693 the RM Destination MUST include the `Final` element) header block in this message.

694 The following exemplar defines the `TerminateSequence` syntax:

```
695 <wsrm:TerminateSequence ...>  
696   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
697   <wsrm>LastMsgNumber> wsrm:MessageNumberType </wsrm>LastMsgNumber> ?  
698   ...  
699 </wsrm:TerminateSequence>
```

700 The following describes the content model of the `TerminateSequence` element.

701 `/wsrm:TerminateSequence`

702 This element MAY be sent by an RM Source to indicate it has completed its use of the Sequence. It
703 indicates that the RM Destination can safely reclaim any resources related to the identified Sequence. The
704 RM Source MUST NOT send this element as a header block. The RM Source MAY retransmit this
705 element. Once this element is sent, other than this element, the RM Source MUST NOT send any
706 additional message to the RM Destination referencing this Sequence.

707 This element MAY also be sent by the RM Destination to indicate that it has unilaterally terminated the
708 Sequence. Upon sending this message the RM Destination MUST NOT accept any additional messages
709 (with the exception of the corresponding `TerminateSequenceResponse`) for this Sequence. Upon
710 receipt of a `TerminateSequence` the RM Source MUST NOT send any additional messages (with the
711 exception of the corresponding `TerminateSequenceResponse`) for this Sequence.

712 `/wsrm:TerminateSequence/wsrm:Identifier`

713 The RM Source or RM Destination MUST include this element in any `TerminateSequence` message it
714 sends. The RM Source or RM Destination MUST set the value of this element to the absolute URI
715 (conformant with RFC3986) of the terminating Sequence.

716 `/wsrm:TerminateSequence/wsrm:LastMsgNumber`

717 The RM Source SHOULD include this element in any `TerminateSequence` message it sends. The
718 `LastMsgNumber` element specifies the highest assigned message number of all the Sequence Traffic
719 Messages for the closing Sequence.

720 `/wsrm:TerminateSequence/wsrm:Identifier/@{any}`

721 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
722 element.

723 `/wsrm:TerminateSequence/{any}`

724 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
725 to be passed.

726 `/wsrm:TerminateSequence/@{any}`

727 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
728 element.

729 A `TerminateSequenceResponse` is sent in the body of a message in response to receipt of a
730 `TerminateSequence` request message. It indicates that responder has terminated the Sequence.

731 The following exemplar defines the `TerminateSequenceResponse` syntax:

```
732 <wsrm:TerminateSequenceResponse ...>  
733   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
734   ...  
735 </wsrm:TerminateSequenceResponse>
```

736 The following describes the content model of the `TerminateSequence` element.

737 `/wsrm:TerminateSequenceResponse`

738 This element is sent in the body of a message in response to receipt of a `TerminateSequence` request
739 message. It indicates that the responder has terminated the Sequence. The responder MUST NOT send
740 this element as a header block.

741 `/wsrm:TerminateSequenceResponse/wsrm:Identifier`

742 The responder (RM Source or RM Destination) MUST include this element in any
743 `TerminateSequenceResponse` message it sends. The responder MUST set the value of this element
744 to the absolute URI (conformant with RFC3986) of the terminating Sequence.

745 `/wsrm:TerminateSequenceResponse/wsrm:Identifier/@{any}`

746 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
747 element.

748 `/wsrm:TerminateSequenceResponse/{any}`

749 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
750 to be passed.

751 `/wsrm:TerminateSequenceResponse/@{any}`

752 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
753 element.

754 On receipt of a `TerminateSequence` message the receiver (RM Source or RM Destination) MUST
755 respond with a corresponding `TerminateSequenceResponse` message or generate a fault
756 `UnknownSequenceFault` if the Sequence is not known.

757 **3.7 Sequences**

758 The RM protocol uses a Sequence header block to track and manage the reliable transfer of messages.
759 The RM Source MUST include a `Sequence` header block in all messages for which reliable transfer is
760 REQUIRED. The RM Source MUST identify Sequences with unique Identifier elements and the RM
761 Source MUST assign each message within a Sequence a `MessageNumber` element that increments by 1
762 from an initial value of 1. These values are contained within a `Sequence` header block accompanying
763 each message being transferred in the context of a Sequence.

764 The RM Source MUST NOT include more than one `Sequence` header block in any message.

765 A following exemplar defines its syntax:

```
766 <wsrm:Sequence ...>  
767   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
768   <wsrm:MessageNumber> wsrm:MessageNumberType </wsrm:MessageNumber>  
769   ...  
770 </wsrm:Sequence>
```

771 The following describes the content model of the `Sequence` header block.

772 `/wsrm:Sequence`

773 This protocol element associates the message in which it is contained with a previously established RM
774 Sequence. It contains the Sequence's unique identifier and the containing message's ordinal position
775 within that Sequence. The RM Destination MUST understand the `Sequence` header block. The RM
776 Source MUST assign a `mustUnderstand` attribute with a value 1/true (from the namespace
777 corresponding to the version of SOAP to which the `Sequence` SOAP header block is bound) to the
778 `Sequence` header block element.

779 `/wsrm:Sequence/wsrm:Identifier`

780 An RM Source that includes a `Sequence` header block in a SOAP envelope MUST include this element in
781 that header block. The RM Source MUST set the value of this element to the absolute URI (conformant
782 with RFC3986) that uniquely identifies the Sequence.

783 /wsmr:Sequence/wsmr:Identifier/@{any}

784 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
785 element.

786 /wsmr:Sequence/wsmr:MessageNumber

787 The RM Source **MUST** include this element within any Sequence headers it creates. This element is of
788 type `MessageNumberType`. It represents the ordinal position of the message within a Sequence.
789 Sequence message numbers start at 1 and monotonically increase by 1 throughout the Sequence. See
790 Section 4.5 for Message Number Rollover fault.

791 /wsmr:Sequence/{any}

792 This is an extensibility mechanism to allow different types of information, based on a schema, to be
793 passed.

794 /wsmr:Sequence/@{any}

795 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
796 element.

797 The following example illustrates a Sequence header block.

```
798 <wsmr:Sequence>  
799   <wsmr:Identifier>http://example.com/abc</wsmr:Identifier>  
800   <wsmr:MessageNumber>10</wsmr:MessageNumber>  
801 </wsmr:Sequence>
```

802 3.8 Request Acknowledgement

803 The purpose of the `AckRequested` header block is to signal to the RM Destination that the RM Source is
804 requesting that a `SequenceAcknowledgement` be sent.

805 The RM Source **MAY** request an Acknowledgement Message from the RM Destination at any time by
806 independently transmitting an `AckRequested` header block (i.e. as a header of a SOAP envelope with an
807 empty body). Alternatively the RM Source **MAY** include an `AckRequested` header block in any message
808 targeted to the RM Destination. The RM Destination **SHOULD** process `AckRequested` header blocks
809 that are included in any message it receives. If a non-mustUnderstand fault occurs when processing an
810 `AckRequested` header block that was piggy-backed, a fault **MUST** be generated, but the processing of
811 the original message **MUST NOT** be affected.

812 An RM Destination that Receives a message that contains an `AckRequested` header block **MUST** send
813 a message containing a `SequenceAcknowledgement` header block to the `AcksTo` endpoint reference
814 (see Section 3.4) for a known Sequence or else generate an `UnknownSequence` fault. It is
815 **RECOMMENDED** that the RM Destination return a `AcknowledgementRange` or `None` element instead
816 of a `Nack` element (see Section 3.9).

817 The following exemplar defines its syntax:

```
818 <wsmr:AckRequested ...>  
819   <wsmr:Identifier ...> xs:anyURI </wsmr:Identifier>  
820   ...  
821 </wsmr:AckRequested>
```

822 The following describes the content model of the `AckRequested` header block.

823 /wsmr:AckRequested

824 This element requests an Acknowledgement for the identified Sequence.

825 /wsmr:AckRequested/wsmr:Identifier
826 An RM Source that includes an `AckRequested` header block in a SOAP envelope MUST include this
827 element in that header block. The RM Source MUST set the value of this element to the absolute URI,
828 (conformant with RFC3986), that uniquely identifies the Sequence to which the request applies.

829 /wsmr:AckRequested/wsmr:Identifier/@{any}
830 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
831 element.

832 /wsmr:AckRequested/{any}
833 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
834 to be passed.

835 /wsmr:AckRequested/@{any}
836 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
837 element.

838 **3.9 Sequence Acknowledgement**

839 The RM Destination informs the RM Source of successful message receipt using a
840 `SequenceAcknowledgement` header block. Acknowledgements can be explicitly requested using the
841 `AckRequested` directive (see Section 3.8).

842 The RM Destination MAY Transmit the `SequenceAcknowledgement` header block independently (i.e.
843 As a header of a SOAP envelope with an empty body). Alternatively, an RM Destination MAY include a
844 `SequenceAcknowledgement` header block on any SOAP envelope targeted to the endpoint referenced
845 by the `AcksTo` EPR. The RM Source SHOULD process `SequenceAcknowledgement` header blocks
846 that are included in any message it receives. If a non-mustUnderstand fault occurs when processing a
847 `SequenceAcknowledgement` header that was piggy-backed, a fault MUST be generated, but the
848 processing of the original message MUST NOT be affected.

849 During creation of a Sequence the RM Source MAY specify the WS-Addressing anonymous IRI as the
850 address of the `AcksTo` EPR for that Sequence. When the RM Source specifies the WS-Addressing
851 anonymous IRI as the address of the `AcksTo` EPR, the RM Destination MUST Transmit any
852 `SequenceAcknowledgement` headers for the created Sequence in a SOAP envelope to be Transmitted
853 on the protocol binding-specific back-channel. Such a channel is provided by the context of a Received
854 message containing a SOAP envelope that contains a `Sequence` header block and/or an `AckRequested`
855 header block for that same Sequence identifier. When the RM Destination receives an `AckRequested`
856 header, and the `AckTo` EPR for that sequence is the WS-Addressing anonymous IRI, the RM Destination
857 SHOULD respond on the protocol binding-specific back-channel provided by the Received message
858 containing the `AckRequested` header block.

859 The following exemplar defines its syntax:

```
860 <wsmr:SequenceAcknowledgement ...>  
861   <wsmr:Identifier ...> xs:anyURI </wsmr:Identifier>  
862   [ [ [ <wsmr:AcknowledgementRange ...  
863     Upper="wsmr:MessageNumberType"  
864     Lower="wsmr:MessageNumberType" /> +  
865     | <wsmr:None/> ]  
866     <wsmr:Final/> ? ]  
867   | <wsmr:Nack> wsmr:MessageNumberType </wsmr:Nack> + ]  
868  
869   ...
```

870 `</wsrm:SequenceAcknowledgement>`

871 The following describes the content model of the `SequenceAcknowledgement` header block.

872 `/wsrm:SequenceAcknowledgement`

873 This element contains the Sequence Acknowledgement information.

874 `/wsrm:SequenceAcknowledgement/wsrm:Identifier`

875 An RM Destination that includes a `SequenceAcknowledgement` header block in a SOAP envelope
876 MUST include this element in that header block. The RM Destination MUST set the value of this element
877 to the absolute URI (conformant with RFC3986) that uniquely identifies the Sequence. The RM
878 Destination MUST NOT include multiple `SequenceAcknowledgement` header blocks that share the
879 same value for `Identifier` within the same SOAP envelope.

880 `/wsrm:SequenceAcknowledgement/wsrm:Identifier/@{any}`

881 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
882 element.

883 `/wsrm:SequenceAcknowledgement/wsrm:AcknowledgementRange`

884 The RM Destination MAY include one or more instances of this element within a
885 `SequenceAcknowledgement` header block. It contains a range of Sequence message numbers
886 successfully accepted by the RM Destination. The ranges MUST NOT overlap. The RM Destination
887 MUST NOT include this element if a sibling `Nack` or `None` element is also present as a child of
888 `SequenceAcknowledgement`.

889 `/wsrm:SequenceAcknowledgement/wsrm:AcknowledgementRange/@Upper`

890 The RM Destination MUST set the value of this attribute equal to the message number of the highest
891 contiguous message in a Sequence range accepted by the RM Destination.

892 `/wsrm:SequenceAcknowledgement/wsrm:AcknowledgementRange/@Lower`

893 The RM Destination MUST set the value of this attribute equal to the message number of the lowest
894 contiguous message in a Sequence range accepted by the RM Destination.

895 `/wsrm:SequenceAcknowledgement/wsrm:AcknowledgementRange/@{any}`

896 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
897 element.

898 `/wsrm:SequenceAcknowledgement/wsrm:None`

899 The RM Destination MUST include this element within a `SequenceAcknowledgement` header block if
900 the RM Destination has not accepted any messages for the specified Sequence. The RM Destination
901 MUST NOT include this element if a sibling `AcknowledgementRange` or `Nack` element is also present
902 as a child of the `SequenceAcknowledgement`.

903 `/wsrm:SequenceAcknowledgement/wsrm:Final`

904 The RM Destination MAY include this element within a `SequenceAcknowledgement` header block. This
905 element indicates that the RM Destination is not receiving new messages for the specified Sequence. The
906 RM Source can be assured that the ranges of messages acknowledged by this
907 `SequenceAcknowledgement` header block will not change in the future. The RM Destination MUST
908 include this element when the Sequence is closed. The RM Destination MUST NOT include this element
909 when sending a `Nack`; it can only be used when sending `AcknowledgementRange` elements or a `None`.

910 /wsmr:SequenceAcknowledgement/wsmr:Nack

911 The RM Destination MAY include this element within a `SequenceAcknowledgement` header block. If
912 used, the RM Destination MUST set the value of this element to a `MessageNumberType` representing
913 the `MessageNumber` of an unreceived message in a Sequence. The RM Destination MUST NOT include
914 a `Nack` element if a sibling `AcknowledgementRange` or `None` element is also present as a child of
915 `SequenceAcknowledgement`. Upon the receipt of a `Nack`, an RM Source SHOULD retransmit the
916 message identified by the `Nack`. The RM Destination MUST NOT issue a `SequenceAcknowledgement`
917 containing a `Nack` for a message that it has previously acknowledged within an
918 `AcknowledgementRange`. The RM Source SHOULD ignore a `SequenceAcknowledgement` containing
919 a `Nack` for a message that has previously been acknowledged within an `AcknowledgementRange`.

920 /wsmr:SequenceAcknowledgement/{any}

921 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
922 to be passed.

923 /wsmr:SequenceAcknowledgement/@{any}

924 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
925 element.

926 The following examples illustrate `SequenceAcknowledgement` elements:

- 927 • Message numbers 1..10 inclusive in a Sequence have been accepted by the RM Destination.

```
928 <wsmr:SequenceAcknowledgement>  
929   <wsmr:Identifier>http://example.com/abc</wsmr:Identifier>  
930   <wsmr:AcknowledgementRange Upper="10" Lower="1"/>  
931 </wsmr:SequenceAcknowledgement>
```

- 932 • Message numbers 1..2, 4..6, and 8..10 inclusive in a Sequence have been accepted by the RM
933 Destination, messages 3 and 7 have not been accepted.

```
934 <wsmr:SequenceAcknowledgement>  
935   <wsmr:Identifier>http://example.com/abc</wsmr:Identifier>  
936   <wsmr:AcknowledgementRange Upper="2" Lower="1"/>  
937   <wsmr:AcknowledgementRange Upper="6" Lower="4"/>  
938   <wsmr:AcknowledgementRange Upper="10" Lower="8"/>  
939 </wsmr:SequenceAcknowledgement>
```

- 940 • Message number 3 in a Sequence has not been accepted by the RM Destination.

```
941 <wsmr:SequenceAcknowledgement>  
942   <wsmr:Identifier>http://example.com/abc</wsmr:Identifier>  
943   <wsmr:Nack>3</wsmr:Nack>  
944 </wsmr:SequenceAcknowledgement>
```

945 4 Faults

946 Faults for the `CreateSequence` message exchange are treated as defined in WS-Addressing. `Create`
947 `Sequence Refused` is a possible fault reply for this operation. `Unknown Sequence` is a fault generated by
948 Endpoints when messages carrying RM header blocks targeted at unrecognized or terminated Sequences
949 are detected. `WSRMRequired` is a fault generated an RM Destination that requires the use of WS-RM on
950 a Received message that did not use the protocol. All other faults in this section relate to known
951 Sequences. Destinations that generate faults related to known sequences SHOULD transmit those faults.
952 If transmitted, such faults MUST be transmitted to the same [destination] as Acknowledgement
953 messages.

954 Entities that generate WS-ReliableMessaging faults MUST include as the [action] property the default fault
955 action IRI defined below. The value from the W3C Recommendation is below for informational purposes:

```
956 http://docs.oasis-open.org/ws-rx/wsrn/200702/fault
```

957 The faults defined in this section are generated if the condition stated in the preamble is met. Fault
958 handling rules are defined in section 6 of WS-Addressing SOAP Binding.

959 The definitions of faults use the following properties:

960 [Code] The fault code.

961 [Subcode] The fault subcode.

962 [Reason] The English language reason element.

963 [Detail] The detail element(s). If absent, no detail element is defined for the fault. If more than one detail
964 element is defined for a fault, implementations MUST include the elements in the order that they are
965 specified.

966 Entities that generate WS-ReliableMessaging faults MUST set the [Code] property to either "Sender" or
967 "Receiver". These properties are serialized into text XML as follows:

SOAP Version	Sender	Receiver
SOAP 1.1	S11:Client	S11:Server
SOAP 1.2	S:Sender	S:Receiver

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

```
969 <S:Envelope>  
970 <S:Header>  
971 <wsa:Action>  
972 http://docs.oasis-open.org/ws-rx/wsrn/200702/fault  
973 </wsa:Action>  
974 <!-- Headers elided for brevity. -->  
975 </S:Header>  
976 <S:Body>  
977 <S:Fault>  
978 <S:Code>  
979 <S:Value> [Code] </S:Value>  
980 <S:Subcode>  
981 <S:Value> [Subcode] </S:Value>  
982 </S:Subcode>  
983 </S:Code>  
984 <S:Reason>  
985 <S:Text xml:lang="en"> [Reason] </S:Text>  
986 </S:Reason>  
987 <S:Detail>
```

```

988     [Detail]
989     ...
990     </S:Detail>
991     </S:Fault>
992     </S:Body>
993     </S:Envelope>

```

994 The properties above bind to a SOAP 1.1 fault as follows when the fault is triggered by processing an RM
995 header block:

```

996 <S11:Envelope>
997   <S11:Header>
998     <wsrm:SequenceFault>
999       <wsrm:FaultCode> wsrm:FaultCodes </wsrm:FaultCode>
1000       <wsrm:Detail> [Detail] </wsrm:Detail>
1001       ...
1002     </wsrm:SequenceFault>
1003     <!-- Headers elided for brevity. -->
1004   </S11:Header>
1005   <S11:Body>
1006     <S11:Fault>
1007       <faultcode> [Code] </faultcode>
1008       <faultstring> [Reason] </faultstring>
1009     </S11:Fault>
1010   </S11:Body>
1011 </S11:Envelope>

```

1012 The properties bind to a SOAP 1.1 fault as follows when the fault is generated as a result of processing a
1013 `CreateSequence` request message:

```

1014 <S11:Envelope>
1015   <S11:Body>
1016     <S11:Fault>
1017       <faultcode> [Subcode] </faultcode>
1018       <faultstring> [Reason] </faultstring>
1019     </S11:Fault>
1020   </S11:Body>
1021 </S11:Envelope>

```

1022 4.1 SequenceFault Element

1023 The purpose of the `SequenceFault` element is to carry the specific details of a fault generated during
1024 the reliable messaging specific processing of a message belonging to a Sequence. WS-
1025 ReliableMessaging nodes MUST use the `SequenceFault` container only in conjunction with the SOAP
1026 1.1 fault mechanism. WS-ReliableMessaging nodes MUST NOT use the `SequenceFault` container in
1027 conjunction with the SOAP 1.2 binding.

1028 The following exemplar defines its syntax:

```

1029 <wsrm:SequenceFault ...>
1030   <wsrm:FaultCode> wsrm:FaultCodes </wsrm:FaultCode>
1031   <wsrm:Detail> ... </wsrm:Detail> ?
1032   ...
1033 </wsrm:SequenceFault>

```

1034 The following describes the content model of the `SequenceFault` element.

1035 `/wsrm:SequenceFault`

1036 This is the element containing Sequence information for WS-ReliableMessaging

1037 /wsm:SequenceFault/wsm:FaultCode
 1038 WS-ReliableMessaging nodes that generate a `SequenceFault` MUST set the value of this element to a
 1039 qualified name from the set of fault [Subcodes] defined below.

1040 /wsm:SequenceFault/wsm:Detail
 1041 This element, if present, carries application specific error information related to the fault being described.

1042 /wsm:SequenceFault/wsm:Detail/{any}
 1043 The application specific error information related to the fault being described.

1044 /wsm:SequenceFault/wsm:Detail/@{any}
 1045 The application specific error information related to the fault being described.

1046 /wsm:SequenceFault/{any}
 1047 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
 1048 to be passed.

1049 /wsm:SequenceFault/@{any}
 1050 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
 1051 element.

1052 4.2 Sequence Terminated

1053 The Endpoint that generates this fault SHOULD make every reasonable effort to notify the corresponding
 1054 Endpoint of this decision.

1055 Properties:

1056 [Code] Sender or Receiver
 1057 [Subcode] wsm:SequenceTerminated
 1058 [Reason] The Sequence has been terminated due to an unrecoverable error.
 1059 [Detail]

1060 `<wsm:Identifier ...> xs:anyURI </wsm:Identifier>`

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Source or RM Destination.	Encountering an unrecoverable condition or detection of violation of the protocol.	Sequence termination.	MUST terminate the Sequence if not otherwise terminated.

1061 4.3 Unknown Sequence

1062 Properties:

1063 [Code] Sender
 1064 [Subcode] wsm:UnknownSequence

1065 [Reason] The value of wsrn:Identifier is not a known Sequence identifier.

1066 [Detail]

1067 `<wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>`

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Source or RM Destination.	In response to a message containing an unknown or terminated Sequence identifier.	None.	MUST terminate the Sequence if not otherwise terminated.

1068 **4.4 Invalid Acknowledgement**

1069 An example of when this fault is generated is when a message is Received by the RM Source containing
1070 a SequenceAcknowledgement covering messages that have not been sent.

1071 [Code] Sender

1072 [Subcode] wsrn:InvalidAcknowledgement

1073 [Reason] The SequenceAcknowledgement violates the cumulative Acknowledgement invariant.

1074 [Detail]

1075 `<wsrm:SequenceAcknowledgement ...> ... </wsrm:SequenceAcknowledgement>`

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Source.	In response to a SequenceAcknowledgement that violate the invariants stated in 2.3 or any of the requirements in 3.9 about valid combinations of AckRange, Nack and None in a single SequenceAcknowledgement element or with respect to already Received such elements.	Unspecified.	Unspecified.

1076 **4.5 Message Number Rollover**

1077 If the condition listed below is reached, the RM Destination MUST generate this fault.

1078 Properties:

1079 [Code] Sender

1080 [Subcode] wsrn:MessageNumberRollover

1081 [Reason] The maximum value for wsrn:MessageNumber has been exceeded.

1082 [Detail]

```
1083 <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
1084 <wsrm:MaxMessageNumber> wsrm:MessageNumberType </wsrm:MaxMessageNumber>
```

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Destination.	Message number in /wsrm:Sequence/wsrm:MessageNumber of a Received message exceeds the internal limitations of an RM Destination or reaches the maximum value of 9,223,372,036,854,775,807.	RM Destination SHOULD continue to accept undelivered messages until the Sequence is closed or terminated.	RM Source SHOULD continue to retransmit undelivered messages until the Sequence is closed or terminated.

1085 4.6 Create Sequence Refused

1086 Properties:

1087 [Code] Sender or Receiver

1088 [Subcode] wsrm:CreateSequenceRefused

1089 [Reason] The Create Sequence request has been refused by the RM Destination.

1090 [Detail]

```
1091 xs:any
```

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Destination.	In response to a CreateSequence message when the RM Destination does not wish to create a new Sequence.	Unspecified.	Sequence terminated.

1092 4.7 Sequence Closed

1093 This fault is generated by an RM Destination to indicate that the specified Sequence has been closed.

1094 This fault MUST be generated when an RM Destination is asked to accept a message for a Sequence that
1095 is closed.

1096 Properties:

1097 [Code] Sender

1098 [Subcode] wsrm:SequenceClosed

1099 [Reason] The Sequence is closed and cannot accept new messages.

1100 [Detail]

1101 `<wsrm:Identifier...> xs:anyURI </wsrm:Identifier>`

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Destination.	In response to a message that belongs to a Sequence that is already closed.	Unspecified.	Sequence closed.

1102 **4.8 WSRM Required**

1103 If an RM Destination requires the use of WS-RM, this fault is generated when it Receives an incoming
1104 message that did not use this protocol.

1105 Properties:

1106 [Code] Sender

1107 [Subcode] wsrm:WSRMRequired

1108 [Reason] The RM Destination requires the use of WSRM.

1109 [Detail]

1110 `xs:any`

1111 **5 Security Threats and Countermeasures**

1112 This specification considers two sets of security requirements, those of the applications that use the WS-
1113 RM protocol and those of the protocol itself.

1114 This specification makes no assumptions about the security requirements of the applications that use WS-
1115 RM. However, once those requirements have been satisfied within a given operational context, the
1116 addition of WS-RM to this operational context should not undermine the fulfillment of those requirements;
1117 the use of WS-RM should not create additional attack vectors within an otherwise secure system.

1118 There are many other security concerns that one may need to consider when implementing or using this
1119 protocol. The material below should not be considered as a "check list". Implementers and users of this
1120 protocol are urged to perform a security analysis to determine their particular threat profile and the
1121 appropriate responses to those threats.

1122 Implementers are also advised that there is a core tension between security and reliable messaging that
1123 can be problematic if not addressed by implementations; one aspect of security is to prevent message
1124 replay but one of the invariants of this protocol is to resend messages until they are acknowledged.
1125 Consequently, if the security sub-system processes a message but a failure occurs before the reliable
1126 messaging sub-system Receives that message, then it is possible (and likely) that the security sub-system
1127 will treat subsequent copies as replays and discard them. At the same time, the reliable messaging sub-
1128 system will likely continue to expect and even solicit the missing message(s). Care should be taken to
1129 avoid and prevent this condition.

1130 **5.1 Threats and Countermeasures**

1131 The primary security requirement of this protocol is to protect the specified semantics and protocol
1132 invariants against various threats. The following sections describe several threats to the integrity and
1133 operation of this protocol and provide some general outlines of countermeasures to those threats.
1134 Implementers and users of this protocol should keep in mind that all threats are not necessarily applicable
1135 to all operational contexts.

1136 **5.1.1 Integrity Threats**

1137 In general, any mechanism which allows an attacker to alter the information in a Sequence Traffic
1138 Message, Sequence Lifecycle Message, Acknowledgement Messages, Acknowledgement Request, or
1139 Sequence-related fault, or which allows an attacker to alter the correlation of a RM Protocol Header Block
1140 to its intended message represents a threat to the WS-RM protocol.

1141 For example, if an attacker is able to swap `Sequence` headers on messages in transit between the RM
1142 Source and RM Destination then they have undermined the implementation's ability to guarantee the first
1143 invariant described in Section 2.3. The result is that there is no way of guaranteeing that messages will be
1144 Delivered to the Application Destination in the same order that they were sent by the Application Source.

1145 **5.1.1.1 Countermeasures**

1146 Integrity threats are generally countered via the use of digital signatures some level of the communication
1147 protocol stack. Note that, in order to counter header swapping attacks, the signature SHOULD include
1148 both the SOAP body and any relevant SOAP headers (e.g. `Sequence` header). Because some headers
1149 (`AckRequested`, `SequenceAcknowledgement`) are independent of the body of the SOAP message in which
1150 they occur, implementations MUST allow for signatures that cover only these headers.

1151 **5.1.2 Resource Consumption Threats**

1152 The creation of a Sequence with an RM Destination consumes various resources on the systems used to
1153 implement that RM Destination. These resources can include network connections, database tables,
1154 message queues, etc. This behavior can be exploited to conduct denial of service attacks against an RM
1155 Destination. For example, a simple attack is to repeatedly send `CreateSequence` messages to an RM
1156 Destination. Another attack is to create a Sequence for a service that is known to require in-order
1157 message Delivery and use this Sequence to send a stream of very large messages to that service,
1158 making sure to omit message number “1” from that stream.

1159 **5.1.2.1 Countermeasures**

1160 There are a number of countermeasures against the described resource consumption threats. The
1161 technique advocated by this specification is for the RM Destination to restrict the ability to create a
1162 Sequence to a specific set of entities/principals. This reduces the number of potential attackers and, in
1163 some cases, allows the identity of any attackers to be determined.

1164 The ability to restrict Sequence creation depends, in turn, upon the RM Destination's ability identify and
1165 authenticate the RM Source that issued the `CreateSequence` message.

1166 **5.1.3 Sequence Spoofing Threats**

1167 Sequence spoofing is a class of threats in which the attacker uses knowledge of the `Identifier` for a
1168 particular Sequence to forge Sequence Lifecycle or Traffic Messages. For example the attacker creates a
1169 fake `TerminateSequence` message that references the target Sequence and sends this message to the
1170 appropriate RM Destination. Some sequence spoofing attacks also require up-to-date knowledge of the
1171 current `MessageNumber` for their target Sequence.

1172 In general any Sequence Lifecycle Message, RM Protocol Header Block, or sequence-correlated SOAP
1173 fault (e.g. `InvalidAcknowledgement`) can be used by someone with knowledge of the Sequence identifier
1174 to attack the Sequence. These attacks are “two-way” in that an attacker may choose to target the RM
1175 Source by, for example, inserting a fake `SequenceAcknowledgement` header into a message that it sends
1176 to the `AcksTo` EPR of an RM Source.

1177 **5.1.3.1 Sequence Hijacking**

1178 Sequence hijacking is a specific case of a sequence spoofing attack. The attacker attempts to inject
1179 Sequence Traffic Messages into an existing Sequence by inserting fake `Sequence` headers into those
1180 messages.

1181 Note that “sequence hijacking” should not be equated with “security session hijacking”. Although a
1182 Sequence may be bound to some form of a security session in order to counter the threats described in
1183 this section, applications MUST NOT rely on WS-RM-related information to make determinations about
1184 the identity of the entity that created a message; applications SHOULD rely only upon information that is
1185 established by the security infrastructure to make such determinations. Failure to observe this rule
1186 creates, among other problems, a situation in which the absence of WS-RM may deprive an application of
1187 the ability to authenticate its peers even though the necessary security processing has taken place.

1188 **5.1.3.2 Countermeasures**

1189 There are a number of countermeasures against sequence spoofing threats. The technique advocated by
1190 this specification is to consider the Sequence to be a shared resource that is jointly owned by the RM

1191 Source that initiated its creation (i.e. that sent the `CreateSequence` message) and the RM Destination that
1192 serves as its terminus (i.e. that sent the `CreateSequenceResponse` message). To counter sequence
1193 spoofing attempts the RM Destination SHOULD ensure that every message or fault that it Receives that
1194 refers to a particular Sequence originated from the RM Source that jointly owns the referenced Sequence.
1195 For its part the RM Source SHOULD ensure that every message or fault that it Receives that refers to a
1196 particular Sequence originated from the RM Destination that jointly owns the referenced Sequence.

1197 For the RM Destination to be able to identify its sequence peer it MUST be able to identify and
1198 authenticate the entity that sent the `CreateSequence` message. Similarly for the RM Source to identify its
1199 sequence peer it MUST be able to identify and authenticate the entity that sent the
1200 `CreateSequenceResponse` message. For either the RM Destination or the RM Source to determine if a
1201 message was sent by its sequence peer it MUST be able to identify and authenticate the initiator of that
1202 message and, if necessary, correlate this identity with the sequence peer identity established at sequence
1203 creation time.

1204 **5.2 Security Solutions and Technologies**

1205 The security threats described in the previous sections are neither new nor unique. The solutions that
1206 have been developed to secure other SOAP-based protocols can be used to secure WS-RM as well. This
1207 section maps the facilities provided by common web services security solutions against countermeasures
1208 described in the previous sections.

1209 Before continuing this discussion, however, some examination of the underlying requirements of the
1210 previously described countermeasures is necessary. Specifically it should be noted that the technique
1211 described in Section 5.1.2.1 has two components. Firstly, the RM Destination identifies and authenticates
1212 the issuer of a `CreateSequence` message. Secondly, the RM Destination performs an authorization check
1213 against this authenticated identity and determines if the RM Source is permitted to create Sequences with
1214 the RM Destination. Since the facilities for performing this authorization check (runtime infrastructure,
1215 policy frameworks, etc.) lie completely within the domain of individual implementations, any discussion of
1216 such facilities is considered to be beyond the scope of this specification.

1217 **5.2.1 Transport Layer Security**

1218 This section describes how the facilities provided by SSL/TLS [RFC 4346] can be used to implement the
1219 countermeasures described in the previous sections. The use of SSL/TLS is subject to the constraints
1220 defined in Section 4 of the Basic Security Profile 1.0 [BSP 1.0].

1221 The description provided here is general in nature and is not intended to serve as a complete definition on
1222 the use of SSL/TLS to protect WS-RM. In order to interoperate implementations need to agree on the
1223 choice of features as well as the manner in which they will be used. The mechanisms described in the
1224 Web Services Security Policy Language [SecurityPolicy] MAY be used by services to describe the
1225 requirements and constraints of the use of SSL/TLS.

1226 **5.2.1.1 Model**

1227 The basic model for using SSL/TLS is as follows:

- 1228 1. The RM Source establishes an SSL/TLS session with the RM Destination.
- 1229 2. The RM Source uses this SSL/TLS session to send a `CreateSequence` message to the RM
1230 Destination.

- 1231 3. The RM Destination establishes an SSL/TLS session with the RM Source and sends an
1232 asynchronous `CreateSequenceResponse` using this session. Alternately it may respond with a
1233 synchronous `CreateSequenceResponse` using the session established in (1).
- 1234 4. For the lifetime of the Sequence the RM Source uses the SSL/TLS session from (1) to Transmit
1235 any and all messages or faults that refer to that Sequence.
- 1236 5. For the lifetime of the Sequence the RM Destination either uses the SSL/TLS session established
1237 in (3) to Transmit any and all messages or faults that refer to that Sequence or, for synchronous
1238 exchanges, the RM Destination uses the SSL/TLS session established in (1).

1239 5.2.1.2 Countermeasure Implementation

1240 Used in its simplest fashion (without relying upon any authentication mechanisms), SSL/TLS provides the
1241 necessary integrity qualities to counter the threats described in Section 5.1.1. Note, however, that the
1242 nature of SSL/TLS limits the scope of this integrity protection to a single transport level session. If
1243 SSL/TLS is the only mechanism used to provide integrity, any intermediaries between the RM Source and
1244 the RM Destination MUST be trusted to preserve the integrity of the messages that flow through them.

1245 As noted, the technique described in Sections 5.1.2.1 involves the use of authentication. This specification
1246 advocates either of two mechanisms for authenticating entities using SSL/TLS. In both of these methods
1247 the SSL/TLS server (the party accepting the SSL/TLS connection) authenticates itself to the SSL/TLS
1248 client using an X.509 certificate that is exchanged during the SSL/TLS handshake.

- 1249 • **HTTP Basic Authentication:** This method of authentication presupposes that a SOAP/HTTP
1250 binding is being used as part of the protocol stack beneath WS-RM. Subsequent to the
1251 establishment of the SSL/TLS session, the sending party authenticates itself to the receiving party
1252 using HTTP Basic Authentication [RFC 2617]. For example, a RM Source might authenticate itself
1253 to a RM Destination (e.g. when transmitting a Sequence Traffic Message) using BasicAuth.
1254 Similarly the RM Destination might authenticate itself to the RM Source (e.g. when sending an
1255 Acknowledgement) using BasicAuth.
- 1256 • **SSL/TLS Client Authentication:** In this method of authentication, the party initiating the
1257 connection authenticates itself to the party accepting the connection using an X.509 certificate
1258 that is exchanged during the SSL/TLS handshake.

1259 To implement the countermeasures described in section 5.1.2.1 the RM Source must authenticate itself
1260 using one the above mechanisms. The authenticated identity can then be used to determine if the RM
1261 Source is authorized to create a Sequence with the RM Destination.

1262 This specification advocates implementing the countermeasures described in section 5.1.3.2 by requiring
1263 an RM node's Sequence peer to be equivalent to their SSL/TLS session peer. This allows the
1264 authorization decisions described in section 5.1.3.2 to be based on SSL/TLS session identity rather than
1265 on authentication information. For example, an RM Destination can determine that a Sequence Traffic
1266 Message rightfully belongs to its referenced Sequence if that message arrived over the same SSL/TLS
1267 session that was used to carry the `CreateSequence` message for that Sequence. Note that requiring a
1268 one-to-one relationship between SSL/TLS session peer and Sequence peer constrains the lifetime of a
1269 SSL/TLS-protected Sequence to be less than or equal to the lifetime of the SSL/TLS session that is used
1270 to protect that Sequence.

1271 This specification does not preclude the use of other methods of using SSL/TLS to implement the
1272 countermeasures (such as associating specific authentication information with a Sequence) although such
1273 methods are not covered by this document.

1274 Issues specific to the life-cycle management of SSL/TLS sessions (such as the resumption of a SSL/TLS
1275 session) are outside the scope of this specification.

1276 **5.2.2 SOAP Message Security**

1277 The mechanisms described in WS-Security may be used in various ways to implement the
1278 countermeasures described in the previous sections. This specification advocates using the protocol
1279 described by WS-SecureConversation [[SecureConversation](#)] (optionally in conjunction with WS-Trust
1280 [[Trust](#)]) as a mechanism for protecting Sequences. The use of WS-Security (as an underlying component
1281 of WS-SecureConversation) is subject to the constraints defined in the Basic Security Profile 1.0.

1282 The description provided here is general in nature and is not intended to serve as a complete definition on
1283 the use of WS-SecureConversation/WS-Trust to protect WS-RM. In order to interoperate implementations
1284 need to agree on the choice of features as well as the manner in which they will be used. The
1285 mechanisms described in the Web Services Security Policy Language MAY be used by services to
1286 describe the requirements and constraints of the use of WS-SecureConversation.

1287 **5.2.2.1 Model**

1288 The basic model for using WS-SecureConversation is as follows:

- 1289 1. The RM Source and the RM Destination create a WS-SecureConversation security context. This
1290 may involve the participation of third parties such as a security token service. The tokens
1291 exchanged may contain authentication claims (e.g. X.509 certificates or Kerberos service tickets).
- 1292 2. During the `CreateSequence` exchange, the RM Source SHOULD explicitly identify the security
1293 context that will be used to protect the Sequence. This is done so that, in cases where the
1294 `CreateSequence` message is signed by more than one security context, the RM Source can
1295 indicate which security context should be used to protect the newly created Sequence.
- 1296 3. For the lifetime of the Sequence the RM Source and the RM Destination use the session key(s)
1297 associated with the security context to sign (as defined by WS-Security) at least the body and any
1298 relevant WS-RM-defined headers of any and all messages or faults that refer to that Sequence.

1299 **5.2.2.2 Countermeasure Implementation**

1300 Without relying upon any authentication information, the per-message signatures provide the necessary
1301 integrity qualities to counter the threats described in Section 5.1.1.

1302 To implement the countermeasures described in section 5.1.2.1 some mutually agreed upon form of
1303 authentication claims must be provided by the RM Source to the RM Destination during the establishment
1304 of the Security Context. These claims can then be used to determine if the RM Source is authorized to
1305 create a Sequence with the RM Destination.

1306 This specification advocates implementing the countermeasures described in section 5.1.3.2 by requiring
1307 an RM node's Sequence peer to be equivalent to their security context session peer. This allows the
1308 authorization decisions described in section 5.1.3.2 to be based on the identity of the message's security
1309 context rather than on any authentication claims that may have been established during security context
1310 initiation. Note that other methods of using WS-SecureConversation to implement the countermeasures
1311 (such as associating specific authentication claims to a Sequence) are possible but not covered by this
1312 document.

1313 As with transport security, the requisite equivalence of a security context peer and with a Sequence peer
1314 limits the lifetime of a Sequence to the lifetime of the protecting security context. Unlike transport security,

1315 the association between a Sequence and its protecting security context cannot always be established
1316 implicitly at Sequence creation time. This is due to the fact that the `CreateSequence` and
1317 `CreateSequenceResponse` messages may be signed by more than one security context.

1318 Issues specific to the life-cycle management of WS-SecureConversation security contexts (such as
1319 amending or renewing contexts) are outside the scope of this specification.

1320 6 Securing Sequences

1321 As noted in Section 5, the RM Source and RM Destination should be able to protect their shared
1322 Sequences against the threat of Sequence Spoofing attacks. There are a number of OPTIONAL means of
1323 achieving this objective depending upon the underlying security infrastructure.

1324 6.1 Securing Sequences Using WS-Security

1325 One mechanism for protecting a Sequence is to include a security token using a
1326 `wsse:SecurityTokenReference` element from WS-Security (see section 9 in WS-
1327 SecureConversation) in the `CreateSequence` element. This establishes an association between the
1328 created (and, if present, offered) Sequence(s) and the referenced security token, such that the RM Source
1329 and Destination MUST use the security token as the basis for authorization of all subsequent interactions
1330 related to the Sequence(s). The `wsse:SecurityTokenReference` explicitly identifies the token as
1331 there may be more than one token on a `CreateSequence` message or inferred from the communication
1332 context (e.g. transport protection).

1333 It is RECOMMENDED that a message independent referencing mechanism be used to identify the token,
1334 if the token being referenced supports such mechanism.

1335 The following exemplar defines the `CreateSequence` syntax when extended to include a
1336 `wsse:SecurityTokenReference`:

```
1337 <wsrm:CreateSequence ...>  
1338   <wsrm:AcksTo> wsa:EndpointReferenceType </wsrm:AcksTo>  
1339   <wsrm:Expires ...> xs:duration </wsrm:Expires> ?  
1340   <wsrm:Offer ...>  
1341     <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
1342     <wsrm:Endpoint> wsa:EndpointReferenceType </wsrm:Endpoint>  
1343     <wsrm:Expires ...> xs:duration </wsrm:Expires> ?  
1344     <wsrm:IncompleteSequenceBehavior>  
1345       wsrml:IncompleteSequenceBehaviorType  
1346     </wsrm:IncompleteSequenceBehavior> ?  
1347     ...  
1348   </wsrm:Offer> ?  
1349   ...  
1350   <wsse:SecurityTokenReference>  
1351     ...  
1352   </wsse:SecurityTokenReference> ?  
1353   ...  
1354 </wsrm:CreateSequence>
```

1355 The following describes the content model of the additional `CreateSequence` elements.

1356 `/wsrm:CreateSequence/wsse:SecurityTokenReference`

1357 This element uses the extensibility mechanism defined for the `CreateSequence` element (defined in
1358 section 3.4) to communicate an explicit reference to the security token, using a
1359 `wsse:SecurityTokenReference` as documented in WS-Security, that the RM Source and Destination
1360 MUST use to authorize messages for the created (and, if present, the offered) Sequence(s). All
1361 subsequent messages related to the created (and, if present, the offered) Sequence(s) MUST
1362 demonstrate proof-of-possession of the secret associated with the token (e.g., by using or deriving from a
1363 private or secret key).

1364 When a RM Source transmits a `CreateSequence` that has been extended to include a
1365 `wsse:SecurityTokenReference` it SHOULD ensure that the RM Destination both understands and
1366 will conform to the requirements listed above. In order to achieve this, the RM Source SHOULD include

1367 the `UsesSequenceSTR` element as a SOAP header block within the `CreateSequence` message. This
1368 element MUST include a `soap:mustUnderstand` attribute with a value of 'true'. Thus the RM Source
1369 can be assured that a RM Destination that responds with a `CreateSequenceResponse` understands
1370 and conforms with the requirements listed above. Note that an RM Destination understanding this header
1371 does not mean that it has processed and understood any WS-Security headers, the fault behavior defined
1372 in WS-Security still applies.

1373 The following exemplar defines the `UsesSequenceSTR` syntax:

```
1374 <wsm:UsesSequenceSTR ... />
```

1375 The following describes the content model of the `UsesSequenceSTR` header block.

1376 `/wsm:UsesSequenceSTR`

1377 This element SHOULD be included as a SOAP header block in `CreateSequence` messages that use the
1378 extensibility mechanism described above in this section. The `soap:mustUnderstand` attribute value
1379 MUST be 'true'. The receiving RM Destination MUST understand and correctly implement the extension
1380 described above or else generate a `soap:MustUnderstand` fault, thus aborting the requested
1381 Sequence creation.

1382 The following is an example of a `CreateSequence` message using the

1383 `wsse:SecurityTokenReference` extension and the `UsesSequenceSTR` header block:

```
1384 <soap:Envelope ...>  
1385   <soap:Header>  
1386     ...  
1387     <wsm:UsesSequenceSTR soap:mustUnderstand='true' />  
1388     ...  
1389   </soap:Header>  
1390   <soap:Body>  
1391     <wsm:CreateSequence>  
1392       <wsm:AcksTo>  
1393         <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>  
1394       </wsm:AcksTo>  
1395       <wsse:SecurityTokenReference>  
1396         ...  
1397       </wsse:SecurityTokenReference>  
1398     </wsm:CreateSequence>  
1399   </soap:Body>  
1400 </soap:Envelope>
```

1401 6.2 Securing Sequences Using SSL/TLS

1402 One mechanism for protecting a Sequence is to bind the Sequence to the underlying SSL/TLS session(s).
1403 The RM Source indicates to the RM Destination that a Sequence is to be bound to the underlying
1404 SSL/TLS session(s) via the `UsesSequenceSSL` header block. If the RM Source wishes to bind a
1405 Sequence to the underlying SSL/TLS sessions(s) it MUST include the `UsesSequenceSSL` element as a
1406 SOAP header block within the `CreateSequence` message.

1407 The following exemplar defines the `UsesSequenceSSL` syntax:

```
1408 <wsm:UsesSequenceSSL soap:mustUnderstand="true" ... />
```

1409 The following describes the content model of the `UsesSequenceSSL` header block.

1410 `/wsm:UsesSequenceSSL`

1411 The RM Source MAY include this element as a SOAP header block of a `CreateSequence` message to
1412 indicate to the RM Destination that the resulting Sequence is to be bound to the SSL/TLS session that was

1413 used to carry the `CreateSequence` message. If included, the RM Source MUST mark this header with a
1414 `soap:mustUnderstand` attribute with a value of 'true'. The receiving RM Destination MUST understand
1415 and correctly implement the functionality described in Section 5.2.1 or else generate a
1416 `soap:MustUnderstand` fault, thus aborting the requested Sequence creation.

1417 Note that the use inclusion of the above header by the RM Source implies that all Sequence-related
1418 information (Sequence Lifecycle or Acknowledgment messages or Sequence-related faults) flowing from
1419 the RM Destination to the RM Source will be bound to the SSL/TLS session that is used to carry the
1420 `CreateSequenceResponse` message.

1421 **7 References**

1422 **7.1 Normative**

1423 **[KEYWORDS]**

1424 S. Bradner, "Key words for use in RFCs to Indicate Requirement Levels," RFC 2119, Harvard University,
1425 March 1997

1426 <http://www.ietf.org/rfc/rfc2119.txt>

1427 **[WS-RM Policy]**

1428 OASIS WS-RX Technical Committee Draft, "Web Services ReliableMessaging Policy Assertion(WS-RM
1429 Policy)" February 2007

1430 <http://docs.oasis-open.org/ws-rx/wsrmp/200702/wsrmp-1.1-spec-cd-05.pdf>

1431 **[SOAP 1.1]**

1432 W3C Note, "SOAP: Simple Object Access Protocol 1.1," 08 May 2000.

1433 <http://www.w3.org/TR/2000/NOTE-SOAP-20000508/>

1434 **[SOAP 1.2]**

1435 W3C Recommendation, "SOAP Version 1.2 Part 1: Messaging Framework" June 2003.

1436 <http://www.w3.org/TR/2003/REC-soap12-part1-20030624/>

1437 **[URI]**

1438 T. Berners-Lee, R. Fielding, L. Masinter, "Uniform Resource Identifiers (URI): Generic Syntax," RFC 3986,
1439 MIT/LCS, U.C. Irvine, Xerox Corporation, January 2005.

1440 <http://ietf.org/rfc/rfc3986>

1441 **[UUID]**

1442 P. Leach, M. Mealling, R. Salz, "A Universally Unique Identifier (UUID) URN Namespace," RFC 4122,
1443 Microsoft, Refactored Networks - LLC, DataPower Technology Inc, July 2005

1444 <http://www.ietf.org/rfc/rfc4122.txt>

1445 **[XML]**

1446 W3C Recommendation, "Extensible Markup Language (XML) 1.0 (Fourth Edition)", September 2006.

1447 <http://www.w3.org/TR/REC-xml/>

1448 **[XML-ns]**

1449 W3C Recommendation, "Namespaces in XML," 14 January 1999.

1450 <http://www.w3.org/TR/1999/REC-xml-names-19990114/>

1451 **[XML-Schema Part1]**

1452 W3C Recommendation, "XML Schema Part 1: Structures," October 2004.

1453 <http://www.w3.org/TR/xmlschema-1/>

1454 **[XML-Schema Part2]**

1455 W3C Recommendation, "XML Schema Part 2: Datatypes," October 2004.

1456 <http://www.w3.org/TR/xmlschema-2/>

1457 **[XPath 1.0]**

1458 W3C Recommendation, "XML Path Language (XPath) Version 1.0," 16 November 1999.

1459 <http://www.w3.org/TR/xpath>

1460 **[WSDL 1.1]**

1461 W3C Note, "Web Services Description Language (WSDL 1.1)," 15 March 2001.

1462 <http://www.w3.org/TR/2001/NOTE-wsdl-20010315>

1463 **[WS-Addressing]**

1464 W3C Recommendation, "Web Services Addressing 1.0 - Core", May 2006.

1465 <http://www.w3.org/TR/2006/REC-ws-addr-core-20060509/>

1466 W3C Recommendation, "Web Services Addressing 1.0 – SOAP Binding", May 2006.

1467 <http://www.w3.org/TR/2006/REC-ws-addr-soap-20060509/>

1468 **7.2 Non-Normative**

1469 **[BSP 1.0]**

1470 WS-I Working Group Draft. "Basic Security Profile Version 1.0," August 2006

1471 <http://www.ws-i.org/Profiles/BasicSecurityProfile-1.0.html>

1472 **[RDDL 2.0]**

1473 Jonathan Borden, Tim Bray, eds. "Resource Directory Description Language (RDDL) 2.0," January 2004

1474 <http://www.openhealth.org/RDDL/20040118/rddl-20040118.html>

1475 **[RFC 2617]**

1476 J. Franks, P. Hallam-Baker, J. Hostetler, S. Lawrence, P. Leach, A. Loutonen, L. Stewart, "HTTP Authentication: Basic and Digest Access Authentication," June 1999.

1478 <http://www.ietf.org/rfc/rfc2617.txt>

1479 **[RFC 4346]**

1480 T. Dierks, E. Rescorla, "The Transport Layer Security (TLS) Protocol Version 1.1," April 2006.

1481 <http://www.ietf.org/rfc/rfc4346.txt>

1482 **[WS-Policy]**

1483 W3C Member Submission, "Web Services Policy Framework (WS-Policy)," April 2006.

1484 <http://www.w3.org/Submission/2006/SUBM-WS-Policy-20060425/>

1485 **[WS-PolicyAttachment]**

1486 W3C Member Submission, "Web Services Policy Attachment (WS-PolicyAttachment)," April 2006.

1487 <http://www.w3.org/Submission/2006/SUBM-WS-PolicyAttachment-20060425/>

1489 **[WS-Security]**

1490 Anthony Nadalin, Chris Kaler, Phillip Hallam-Baker, Ronald Monzillo, eds. "OASIS Web Services Security:
1491 SOAP Message Security 1.0 (WS-Security 2004)", OASIS Standard 200401, March 2004.

1492 <http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-soap-message-security-1.0.pdf>

1493 Anthony Nadalin, Chris Kaler, Phillip Hallam-Baker, Ronald Monzillo, eds. "OASIS Web Services Security:
1494 SOAP Message Security 1.1 (WS-Security 2004)", OASIS Standard 200602, February 2006.

1495 <http://www.oasis-open.org/committees/download.php/16790/wss-v1.1-spec-os-SOAPMessageSecurity.pdf>

1496 **[RTTM]**

1497 V. Jacobson, R. Braden, D. Borman, "TCP Extensions for High Performance", RFC 1323, May
1498 1992.

1499 <http://www.rfc-editor.org/rfc/rfc1323.txt>

1500 **[SecurityPolicy]**

1501 G. Della-Libra, et. al. "Web Services Security Policy Language (WS-SecurityPolicy)", July 2005

1502 <http://specs.xmlsoap.org/ws/2005/07/securitypolicy/ws-securitypolicy.pdf>

1503 **[SecureConversation]**

1504 S. Anderson, et al, "Web Services Secure Conversation Language (WS-SecureConversation)," February
1505 2005.

1506 <http://schemas.xmlsoap.org/ws/2004/04/sc/>

1507 **[Trust]**

1508 S. Anderson, et al, "Web Services Trust Language (WS-Trust)," February 2005.

1509 <http://schemas.xmlsoap.org/ws/2005/02/trust>

1510 Appendix A. Schema

1511 The normative schema that is defined for WS-ReliableMessaging using [XML-Schema Part1] and [XML-
1512 Schema Part2] is located at:

1513 <http://docs.oasis-open.org/ws-rx/wsrn/200702/wsrn-1.1-schema-200702.xsd>

1514 The following copy is provided for reference.

```
1515 <?xml version="1.0" encoding="UTF-8"?>
1516 <!-- Copyright (C) OASIS (R) 1993-2007. All Rights Reserved.
1517 OASIS trademark, IPR and other policies apply. -->
1518 <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
1519 xmlns:wsa="http://www.w3.org/2005/08/addressing"
1520 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
1521 targetNamespace="http://docs.oasis-open.org/ws-rx/wsrn/200702"
1522 elementFormDefault="qualified" attributeFormDefault="unqualified">
1523 <xs:import namespace="http://www.w3.org/2005/08/addressing"
1524 schemaLocation="http://www.w3.org/2006/03/addressing/ws-addr.xsd"/>
1525 <!-- Protocol Elements -->
1526 <xs:complexType name="SequenceType">
1527 <xs:sequence>
1528 <xs:element ref="wsrm:Identifier"/>
1529 <xs:element name="MessageNumber" type="wsrm:MessageNumberType"/>
1530 <xs:any namespace="##other" processContents="lax" minOccurs="0"
1531 maxOccurs="unbounded"/>
1532 </xs:sequence>
1533 <xs:anyAttribute namespace="##other" processContents="lax"/>
1534 </xs:complexType>
1535 <xs:element name="Sequence" type="wsrm:SequenceType"/>
1536 <xs:element name="SequenceAcknowledgement">
1537 <xs:complexType>
1538 <xs:sequence>
1539 <xs:element ref="wsrm:Identifier"/>
1540 <xs:choice>
1541 <xs:sequence>
1542 <xs:choice>
1543 <xs:element name="AcknowledgementRange" maxOccurs="unbounded">
1544 <xs:complexType>
1545 <xs:sequence/>
1546 <xs:attribute name="Upper" type="xs:unsignedLong"
1547 use="required"/>
1548 <xs:attribute name="Lower" type="xs:unsignedLong"
1549 use="required"/>
1550 <xs:anyAttribute namespace="##other" processContents="lax"/>
1551 </xs:complexType>
1552 </xs:element>
1553 <xs:element name="None">
1554 <xs:complexType>
1555 <xs:sequence/>
1556 </xs:complexType>
1557 </xs:element>
1558 </xs:choice>
1559 <xs:element name="Final" minOccurs="0">
1560 <xs:complexType>
1561 <xs:sequence/>
1562 </xs:complexType>
1563 </xs:element>
1564 </xs:sequence>
1565 <xs:element name="Nack" type="xs:unsignedLong"
```

```

1566 maxOccurs="unbounded"/>
1567     </xs:choice>
1568     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1569 maxOccurs="unbounded"/>
1570 </xs:sequence>
1571 <xs:anyAttribute namespace="##other" processContents="lax"/>
1572 </xs:complexType>
1573 </xs:element>
1574 <xs:complexType name="AckRequestedType">
1575     <xs:sequence>
1576         <xs:element ref="wsrm:Identifier"/>
1577         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1578 maxOccurs="unbounded"/>
1579     </xs:sequence>
1580     <xs:anyAttribute namespace="##other" processContents="lax"/>
1581 </xs:complexType>
1582 <xs:element name="AckRequested" type="wsrm:AckRequestedType"/>
1583 <xs:element name="Identifier">
1584     <xs:complexType>
1585         <xs:annotation>
1586             <xs:documentation>
1587                 This type is for elements whose [children] is an anyURI and can have
1588 arbitrary attributes.
1589             </xs:documentation>
1590         </xs:annotation>
1591         <xs:simpleContent>
1592             <xs:extension base="xs:anyURI">
1593                 <xs:anyAttribute namespace="##other" processContents="lax"/>
1594             </xs:extension>
1595         </xs:simpleContent>
1596     </xs:complexType>
1597 </xs:element>
1598 <xs:element name="Address">
1599     <xs:complexType>
1600         <xs:simpleContent>
1601             <xs:extension base="xs:anyURI">
1602                 <xs:anyAttribute namespace="##other" processContents="lax"/>
1603             </xs:extension>
1604         </xs:simpleContent>
1605     </xs:complexType>
1606 </xs:element>
1607 <xs:simpleType name="MessageNumberType">
1608     <xs:restriction base="xs:unsignedLong">
1609         <xs:minInclusive value="1"/>
1610         <xs:maxInclusive value="9223372036854775807"/>
1611     </xs:restriction>
1612 </xs:simpleType>
1613 <!-- Fault Container and Codes -->
1614 <xs:simpleType name="FaultCodes">
1615     <xs:restriction base="xs:QName">
1616         <xs:enumeration value="wsrm:SequenceTerminated"/>
1617         <xs:enumeration value="wsrm:UnknownSequence"/>
1618         <xs:enumeration value="wsrm:InvalidAcknowledgement"/>
1619         <xs:enumeration value="wsrm:MessageNumberRollover"/>
1620         <xs:enumeration value="wsrm:CreateSequenceRefused"/>
1621         <xs:enumeration value="wsrm:SequenceClosed"/>
1622         <xs:enumeration value="wsrm:WSRMRequired"/>
1623         <xs:enumeration value="wsrm:UnsupportedSelection"/>
1624     </xs:restriction>
1625 </xs:simpleType>
1626 <xs:complexType name="SequenceFaultType">
1627     <xs:sequence>
1628         <xs:element name="FaultCode" type="wsrm:FaultCodes"/>

```

```

1629     <xs:element name="Detail" type="wsrm:DetailType" minOccurs="0"/>
1630     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1631 maxOccurs="unbounded"/>
1632   </xs:sequence>
1633   <xs:anyAttribute namespace="##other" processContents="lax"/>
1634 </xs:complexType>
1635 <xs:complexType name="DetailType">
1636   <xs:sequence>
1637     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1638 maxOccurs="unbounded"/>
1639   </xs:sequence>
1640   <xs:anyAttribute namespace="##other" processContents="lax"/>
1641 </xs:complexType>
1642 <xs:element name="SequenceFault" type="wsrm:SequenceFaultType"/>
1643 <xs:element name="CreateSequence" type="wsrm:CreateSequenceType"/>
1644 <xs:element name="CreateSequenceResponse"
1645 type="wsrm:CreateSequenceResponseType"/>
1646 <xs:element name="CloseSequence" type="wsrm:CloseSequenceType"/>
1647 <xs:element name="CloseSequenceResponse"
1648 type="wsrm:CloseSequenceResponseType"/>
1649 <xs:element name="TerminateSequence" type="wsrm:TerminateSequenceType"/>
1650 <xs:element name="TerminateSequenceResponse"
1651 type="wsrm:TerminateSequenceResponseType"/>
1652 <xs:complexType name="CreateSequenceType">
1653   <xs:sequence>
1654     <xs:element ref="wsrm:AcksTo"/>
1655     <xs:element ref="wsrm:Expires" minOccurs="0"/>
1656     <xs:element name="Offer" type="wsrm:OfferType" minOccurs="0"/>
1657     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1658 maxOccurs="unbounded"/>
1659     <xs:annotation>
1660       <xs:documentation>
1661         It is the authors intent that this extensibility be used to
1662 transfer a Security Token Reference as defined in WS-Security.
1663       </xs:documentation>
1664     </xs:annotation>
1665   </xs:sequence>
1666 </xs:complexType>
1667 <xs:complexType name="CreateSequenceResponseType">
1668   <xs:sequence>
1669     <xs:element ref="wsrm:Identifier"/>
1670     <xs:element ref="wsrm:Expires" minOccurs="0"/>
1671     <xs:element name="IncompleteSequenceBehavior"
1672 type="wsrm:IncompleteSequenceBehaviorType" minOccurs="0"/>
1673     <xs:element name="Accept" type="wsrm:AcceptType" minOccurs="0"/>
1674     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1675 maxOccurs="unbounded"/>
1676   </xs:sequence>
1677 </xs:complexType>
1678 <xs:complexType name="CloseSequenceType">
1679   <xs:sequence>
1680     <xs:element ref="wsrm:Identifier"/>
1681     <xs:element name="LastMsgNumber" type="wsrm:MessageNumberType"
1682 minOccurs="0"/>
1683     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1684 maxOccurs="unbounded"/>
1685   </xs:sequence>
1686 </xs:complexType>
1687 <xs:complexType name="CloseSequenceResponseType">

```

```

1692     <xs:sequence>
1693         <xs:element ref="wsrm:Identifier"/>
1694         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1695 maxOccurs="unbounded"/>
1696     </xs:sequence>
1697     <xs:anyAttribute namespace="##other" processContents="lax"/>
1698 </xs:complexType>
1699 <xs:complexType name="TerminateSequenceType">
1700     <xs:sequence>
1701         <xs:element ref="wsrm:Identifier"/>
1702         <xs:element name="LastMsgNumber" type="wsrm:MessageNumberType"
1703 minOccurs="0"/>
1704         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1705 maxOccurs="unbounded"/>
1706     </xs:sequence>
1707     <xs:anyAttribute namespace="##other" processContents="lax"/>
1708 </xs:complexType>
1709 <xs:complexType name="TerminateSequenceResponseType">
1710     <xs:sequence>
1711         <xs:element ref="wsrm:Identifier"/>
1712         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1713 maxOccurs="unbounded"/>
1714     </xs:sequence>
1715     <xs:anyAttribute namespace="##other" processContents="lax"/>
1716 </xs:complexType>
1717 <xs:element name="AcksTo" type="wsa:EndpointReferenceType"/>
1718 <xs:complexType name="OfferType">
1719     <xs:sequence>
1720         <xs:element ref="wsrm:Identifier"/>
1721         <xs:element name="Endpoint" type="wsa:EndpointReferenceType"/>
1722         <xs:element ref="wsrm:Expires" minOccurs="0"/>
1723         <xs:element name="IncompleteSequenceBehavior"
1724 type="wsrm:IncompleteSequenceBehaviorType" minOccurs="0"/>
1725         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1726 maxOccurs="unbounded"/>
1727     </xs:sequence>
1728     <xs:anyAttribute namespace="##other" processContents="lax"/>
1729 </xs:complexType>
1730 <xs:complexType name="AcceptType">
1731     <xs:sequence>
1732         <xs:element ref="wsrm:AcksTo"/>
1733         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1734 maxOccurs="unbounded"/>
1735     </xs:sequence>
1736     <xs:anyAttribute namespace="##other" processContents="lax"/>
1737 </xs:complexType>
1738 <xs:element name="Expires">
1739     <xs:complexType>
1740         <xs:simpleContent>
1741             <xs:extension base="xs:duration">
1742                 <xs:anyAttribute namespace="##other" processContents="lax"/>
1743             </xs:extension>
1744         </xs:simpleContent>
1745     </xs:complexType>
1746 </xs:element>
1747 <xs:simpleType name="IncompleteSequenceBehaviorType">
1748     <xs:restriction base="xs:string">
1749         <xs:enumeration value="DiscardEntireSequence"/>
1750         <xs:enumeration value="DiscardFollowingFirstGap"/>
1751         <xs:enumeration value="NoDiscard"/>
1752     </xs:restriction>
1753 </xs:simpleType>
1754 <xs:element name="UsesSequenceSTR">

```

```
1755     <xs:complexType>
1756         <xs:sequence/>
1757         <xs:anyAttribute namespace="##other" processContents="lax"/>
1758     </xs:complexType>
1759 </xs:element>
1760 <xs:element name="UsesSequenceSSL">
1761     <xs:complexType>
1762         <xs:sequence/>
1763         <xs:anyAttribute namespace="##other" processContents="lax"/>
1764     </xs:complexType>
1765 </xs:element>
1766 <xs:element name="UnsupportedElement">
1767     <xs:simpleType>
1768         <xs:restriction base="xs:QName"/>
1769     </xs:simpleType>
1770 </xs:element>
1771 </xs:schema>
```

1772 Appendix B. WSDL

1773 This WSDL describes the WS-RM protocol from the point of view of an RM Destination. In the case where
1774 an endpoint acts both as an RM Destination and an RM Source, note that additional messages may be
1775 present in exchanges with that endpoint.

1776 Also note that this WSDL is intended to describe the internal structure of the WS-RM protocol, and will not
1777 generally appear in a description of a WS-RM-capable Web service. See WS-RM Policy [WS-RM Policy]
1778 for a higher-level mechanism to indicate that WS-RM is engaged.

1779 The normative WSDL 1.1 definition for WS-ReliableMessaging is located at:

1780 <http://docs.oasis-open.org/ws-rx/wsrn/200702/wsd/wsrn-1.1-wsd-200702.wsd>

1781 The following non-normative copy is provided for reference.

```
1782 <?xml version="1.0" encoding="utf-8"?>
1783 <!-- Copyright(C) OASIS(R) 1993-2007. All Rights Reserved.
1784 OASIS trademark, IPR and other policies apply. -->
1785 <wSDL:definitions xmlns:wSDL="http://schemas.xmlsoap.org/wSDL/"
1786 xmlns:xs="http://www.w3.org/2001/XMLSchema"
1787 xmlns:wsa="http://www.w3.org/2005/08/addressing"
1788 xmlns:wsam="http://www.w3.org/2007/02/addressing/metadata"
1789 xmlns:rm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
1790 xmlns:tns="http://docs.oasis-open.org/ws-rx/wsrn/200702/wsd"
1791 targetNamespace="http://docs.oasis-open.org/ws-rx/wsrn/200702/wsd">
1792
1793   <wSDL:types>
1794     <xs:schema
1795       <xs:import namespace="http://docs.oasis-open.org/ws-rx/wsrn/200702"
1796       schemaLocation="http://docs.oasis-open.org/ws-rx/wsrn/200702/wsrn-1.1-schema-
1797       200702.xsd"/>
1798     </xs:schema>
1799   </wSDL:types>
1800
1801   <wSDL:message name="CreateSequence">
1802     <wSDL:part name="create" element="rm:CreateSequence"/>
1803   </wSDL:message>
1804   <wSDL:message name="CreateSequenceResponse">
1805     <wSDL:part name="createResponse" element="rm:CreateSequenceResponse"/>
1806   </wSDL:message>
1807   <wSDL:message name="CloseSequence">
1808     <wSDL:part name="close" element="rm:CloseSequence"/>
1809   </wSDL:message>
1810   <wSDL:message name="CloseSequenceResponse">
1811     <wSDL:part name="closeResponse" element="rm:CloseSequenceResponse"/>
1812   </wSDL:message>
1813   <wSDL:message name="TerminateSequence">
1814     <wSDL:part name="terminate" element="rm:TerminateSequence"/>
1815   </wSDL:message>
1816   <wSDL:message name="TerminateSequenceResponse">
1817     <wSDL:part name="terminateResponse"
1818     element="rm:TerminateSequenceResponse"/>
1819   </wSDL:message>
1820
1821   <wSDL:portType name="SequenceAbstractPortType">
1822     <wSDL:operation name="CreateSequence">
1823       <wSDL:input message="tns:CreateSequence" wsam:Action="http://docs.oasis-
1824       open.org/ws-rx/wsrn/200702/CreateSequence"/>
1825       <wSDL:output message="tns:CreateSequenceResponse"
```

```
1823 wsam:Action="http://docs.oasis-open.org/ws-
1824 rx/wsrn/200702/CreateSequenceResponse"/>
1825 </wsdl:operation>
1826 <wsdl:operation name="CloseSequence">
1827 <wsdl:input message="tns:CloseSequence" wsam:Action="http://docs.oasis-
1828 open.org/ws-rx/wsrn/200702/CloseSequence"/>
1829 <wsdl:output message="tns:CloseSequenceResponse"
1830 wsam:Action="http://docs.oasis-open.org/ws-
1831 rx/wsrn/200702/CloseSequenceResponse"/>
1832 </wsdl:operation>
1833 <wsdl:operation name="TerminateSequence">
1834 <wsdl:input message="tns:TerminateSequence"
1835 wsam:Action="http://docs.oasis-open.org/ws-rx/wsrn/200702/TerminateSequence"/>
1836 <wsdl:output message="tns:TerminateSequenceResponse"
1837 wsam:Action="http://docs.oasis-open.org/ws-
1838 rx/wsrn/200702/TerminateSequenceResponse"/>
1839 </wsdl:operation>
1840 </wsdl:portType>
1841 </wsdl:definitions>
```

1842 Appendix C. Message Examples

1843 Appendix C.1 Create Sequence

1844 Create Sequence

```
1845 <?xml version="1.0" encoding="UTF-8"?>
1846 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1847 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200702"
1848 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1849   <S:Header>
1850     <wsa:MessageID>
1851       http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546817
1852     </wsa:MessageID>
1853     <wsa:To>http://example.com/serviceB/123</wsa:To>
1854     <wsa:Action>http://docs.oasis-open.org/ws-
1855 rx/wsmr/200702/CreateSequence</wsa:Action>
1856     <wsa:ReplyTo>
1857       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
1858     </wsa:ReplyTo>
1859   </S:Header>
1860   <S:Body>
1861     <wsmr:CreateSequence>
1862       <wsmr:AcksTo>
1863         <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
1864       </wsmr:AcksTo>
1865     </wsmr:CreateSequence>
1866   </S:Body>
1867 </S:Envelope>
```

1868 Create Sequence Response

```
1869 <?xml version="1.0" encoding="UTF-8"?>
1870 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1871 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200702"
1872 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1873   <S:Header>
1874     <wsa:To>http://Business456.com/serviceA/789</wsa:To>
1875     <wsa:RelatesTo>
1876       http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8a7c2eb546817
1877     </wsa:RelatesTo>
1878     <wsa:Action>
1879       http://docs.oasis-open.org/ws-rx/wsmr/200702/CreateSequenceResponse
1880     </wsa:Action>
1881   </S:Header>
1882   <S:Body>
1883     <wsmr:CreateSequenceResponse>
1884       <wsmr:Identifier>http://Business456.com/RM/ABC</wsmr:Identifier>
1885     </wsmr:CreateSequenceResponse>
1886   </S:Body>
1887 </S:Envelope>
```

1888 Appendix C.2 Initial Transmission

1889 The following example WS-ReliableMessaging headers illustrate the message exchange in the above
1890 figure. The three messages have the following headers; the third message is identified as the last
1891 message in the Sequence:

1892 Message 1

```
1893 <?xml version="1.0" encoding="UTF-8"?>
1894 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1895 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200702"
1896 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1897   <S:Header>
1898     <wsa:MessageID>
1899       http://Business456.com/guid/71e0654e-5ce8-477b-bb9d-34f05cfc9e
1900     </wsa:MessageID>
1901     <wsa:To>http://example.com/serviceB/123</wsa:To>
1902     <wsa:From>
1903       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
1904     </wsa:From>
1905     <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
1906     <wsmr:Sequence>
1907       <wsmr:Identifier>http://Business456.com/RM/ABC</wsmr:Identifier>
1908       <wsmr:MessageNumber>1</wsmr:MessageNumber>
1909     </wsmr:Sequence>
1910   </S:Header>
1911   <S:Body>
1912     <!-- Some Application Data -->
1913   </S:Body>
1914 </S:Envelope>
```

1915 Message 2

```
1916 <?xml version="1.0" encoding="UTF-8"?>
1917 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1918 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200702"
1919 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1920   <S:Header>
1921     <wsa:MessageID>
1922       http://Business456.com/guid/daa7d0b2-c8e0-476e-a9a4-d164154e38de
1923     </wsa:MessageID>
1924     <wsa:To>http://example.com/serviceB/123</wsa:To>
1925     <wsa:From>
1926       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
1927     </wsa:From>
1928     <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
1929     <wsmr:Sequence>
1930       <wsmr:Identifier>http://Business456.com/RM/ABC</wsmr:Identifier>
1931       <wsmr:MessageNumber>2</wsmr:MessageNumber>
1932     </wsmr:Sequence>
1933   </S:Header>
1934   <S:Body>
1935     <!-- Some Application Data -->
1936   </S:Body>
1937 </S:Envelope>
```

1938 Message 3

```
1939 <?xml version="1.0" encoding="UTF-8"?>
1940 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1941 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200702"
1942 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1943   <S:Header>
1944     <wsa:MessageID>
1945       http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546819
1946     </wsa:MessageID>
1947     <wsa:To>http://example.com/serviceB/123</wsa:To>
1948     <wsa:From>
1949       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
```

```

1950 </wsa:From>
1951 <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
1952 <wsrm:Sequence>
1953 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
1954 <wsrm:MessageNumber>3</wsrm:MessageNumber>
1955 </wsrm:Sequence>
1956 <wsrm:AckRequested>
1957 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
1958 </wsrm:AckRequested>
1959 </S:Header>
1960 <S:Body>
1961 <!-- Some Application Data -->
1962 </S:Body>
1963 </S:Envelope>

```

1964 **Appendix C.3 First Acknowledgement**

1965 Message number 2 has not been accepted by the RM Destination due to some transmission error so it
1966 responds with an Acknowledgement for messages 1 and 3:

```

1967 <?xml version="1.0" encoding="UTF-8"?>
1968 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1969 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
1970 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1971 <S:Header>
1972 <wsa:MessageID>
1973 http://example.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546810
1974 </wsa:MessageID>
1975 <wsa:To>http://Business456.com/serviceA/789</wsa:To>
1976 <wsa:From>
1977 <wsa:Address>http://example.com/serviceB/123</wsa:Address>
1978 </wsa:From>
1979 <wsa:Action>
1980 http://docs.oasis-open.org/ws-rx/wsrn/200702/SequenceAcknowledgement
1981 </wsa:Action>
1982 <wsrm:SequenceAcknowledgement>
1983 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
1984 <wsrm:AcknowledgementRange Upper="1" Lower="1"/>
1985 <wsrm:AcknowledgementRange Upper="3" Lower="3"/>
1986 </wsrm:SequenceAcknowledgement>
1987 </S:Header>
1988 <S:Body/>
1989 </S:Envelope>

```

1990 **Appendix C.4 Retransmission**

1991 The RM Sourcediscovers that message number 2 was not accepted so it resends the message and
1992 requests an Acknowledgement:

```

1993 <?xml version="1.0" encoding="UTF-8"?>
1994 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1995 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
1996 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1997 <S:Header>
1998 <wsa:MessageID>
1999 http://Business456.com/guid/daa7d0b2-c8e0-476e-a9a4-d164154e38de
2000 </wsa:MessageID>
2001 <wsa:To>http://example.com/serviceB/123</wsa:To>
2002 <wsa:From>
2003 <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
2004 </wsa:From>

```

```

2005 <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
2006 <wsrm:Sequence>
2007 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2008 <wsrm:MessageNumber>2</wsrm:MessageNumber>
2009 </wsrm:Sequence>
2010 <wsrm:AckRequested>
2011 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2012 </wsrm:AckRequested>
2013 </S:Header>
2014 <S:Body>
2015 <!-- Some Application Data -->
2016 </S:Body>
2017 </S:Envelope>

```

2018 Appendix C.5 Termination

2019 The RM Destination now responds with an Acknowledgement for the complete Sequence which can then
2020 be terminated:

```

2021 <?xml version="1.0" encoding="UTF-8"?>
2022 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2023 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
2024 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2025 <S:Header>
2026 <wsa:MessageID>
2027 http://example.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546811
2028 </wsa:MessageID>
2029 <wsa:To>http://Business456.com/serviceA/789</wsa:To>
2030 <wsa:From>
2031 <wsa:Address>http://example.com/serviceB/123</wsa:Address>
2032 </wsa:From>
2033 <wsa:Action>
2034 http://docs.oasis-open.org/ws-rx/wsrn/200702/SequenceAcknowledgement
2035 </wsa:Action>
2036 <wsrm:SequenceAcknowledgement>
2037 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2038 <wsrm:AcknowledgementRange Upper="3" Lower="1"/>
2039 </wsrm:SequenceAcknowledgement>
2040 </S:Header>
2041 <S:Body/>
2042 </S:Envelope>

```

2043 Terminate Sequence

```

2044 <?xml version="1.0" encoding="UTF-8"?>
2045 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2046 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
2047 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2048 <S:Header>
2049 <wsa:MessageID>
2050 http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546812
2051 </wsa:MessageID>
2052 <wsa:To>http://example.com/serviceB/123</wsa:To>
2053 <wsa:Action>
2054 http://docs.oasis-open.org/ws-rx/wsrn/200702/TerminateSequence
2055 </wsa:Action>
2056 <wsa:From>
2057 <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
2058 </wsa:From>
2059 </S:Header>
2060 <S:Body>
2061 <wsrm:TerminateSequence>

```

```
2062     <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2063     <wsrm:LastMsgNumber> 3 </wsrm:LastMsgNumber>
2064     </wsrm:TerminateSequence>
2065     </S:Body>
2066 </S:Envelope>
```

2067 Terminate Sequence Response

```
2068 <?xml version="1.0" encoding="UTF-8"?>
2069 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2070 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200702"
2071 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2072   <S:Header>
2073     <wsa:MessageID>
2074       http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546813
2075     </wsa:MessageID>
2076     <wsa:To>http://example.com/serviceA/789</wsa:To>
2077     <wsa:Action>
2078       http://docs.oasis-open.org/ws-rx/wsmr/200702/TerminateSequenceResponse
2079     </wsa:Action>
2080     <wsa:RelatesTo>
2081       http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546812
2082     </wsa:RelatesTo>
2083     <wsa:From>
2084       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
2085     </wsa:From>
2086   </S:Header>
2087   <S:Body>
2088     <wsmr:TerminateSequenceResponse>
2089       <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2090     </wsmr:TerminateSequenceResponse>
2091   </S:Body>
2092 </S:Envelope>
```

2093 Appendix D. State Tables

2094 This appendix specifies the non-normative state transition tables for RM Source and RM Destination.

2095 The state tables describe the lifetime of a sequence in both the RM Source and the RM Destination

2096 Legend:

2097 The first column of these tables contains the motivating event and has the following format:

Event
<i>Event name</i> [source] {ref}

2098 Where:

- 2099 ● Event Name: indicates the name of the event. Event Names surrounded by "<>" are optional as
2100 described by the specification.
- 2101 ● [source]: indicates the source of the event; one of:
 - 2102 ● [msg] a Received message
 - 2103 ● [int]: an internal event such as the firing of a timer
 - 2104 ● [app]: the application
 - 2105 ● [unspec]: the source is unspecified

2106 Each event / state combination cell in the tables in this appendix has the following format:

State Name
<i>Action to take</i> [next state] {ref}

2107 Where:

- 2108 ● action to take: indicates that the state machine performs the following action. Actions surrounded
2109 by "<>" are optional as described by the specification. "Xmit" is used as a short form for the word
2110 "Transmit"
 - 2111 ● [next state]: indicates the state to which the state machine will advance upon the performance of
2112 the action. For ease of reading the next state "same" indicates that the state does not change.
 - 2113 ● {ref} is a reference to the document section describing the behavior in this cell
- 2114 "N/A" in a cell indicates a state / event combination self-inconsistent with the state machine; should these
2115 conditions occur, it would indicate an implementation error. A blank cell indicates that the behavior is not
2116 described in this specification and does not indicate normal protocol operation. Implementations MAY
2117 generate a Sequence Terminated fault (see section 4.2) in these circumstances. Robust implementations
2118 MUST be able to operate in a stable manner despite the occurrence of unspecified event / state
2119 combinations.

2120 Table 1 RM Source Sequence State Transition Table

Events	Sequence States					
	None	Creating	Created	Closing	Closed	Terminating
Create Sequence [unspec] {3.4}	Xmit Create Sequence [Creating] {3.4}	N/A	N/A	N/A	N/A	N/A
Create Sequence Response [msg] {3.4}		Process Create Sequence Response [Created] {3.4}				
Create Sequence Refused Fault [msg] {3.4}		No action [None] {4.6}				
Send message [app] {2.1}	N/A	N/A	Xmit message [Same] {2}	No action [Same] {2}	N/A	N/A
Retransmit of un-ack'd message [int]	N/A	N/A	Xmit message [Same] {2.3}	Xmit message [Same] {2.3}	N/A	N/A
SeqAck (non-final) [msg] {3.9}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Process Ack ranges [Same] {3.9}			
Nack [msg] {3.9}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	<Xmit message(s)> [Same] {3.9}	<Xmit message(s)> [Same] {3.9}	No action [Same]	No action [Same]
Message Number Rollover Fault [msg]	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	No action [Rollover]	No action [Same]	No action [Same]	No action [Same]
CloseSequence [msg] {3.5}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Xmit CloseSequence Response [Closed] {3.5}	Xmit CloseSequence Response [Closed] {3.5}	Xmit CloseSequence Response [Closed] {3.5}	Generate Unknown Sequence Fault [Same] {4.3}
<Close Sequence> [int] {3.5}	N/A		Xmit Close Sequence [Closing] {3.5}	N/A	N/A	N/A
Close Sequence Response [msg] {3.5}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}		No action [Closed] {3.5}	No action [Same] {3.5}	No action [Same] {3.5}

Events	Sequence States					
	None	Creating	Created	Closing	Closed	Terminating
SeqAck (final) [msg] {3.9}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Process Ack ranges [Closed] {3.9}	Process Ack ranges [Closed] {3.9}	Process Ack ranges [Same]	Process Ack ranges [Same]
Sequence Closed Fault [msg] {4.7}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	No action [Closed] {4.7}	No action [Closed] {4.7}	No action [Same]	No action [Same]
Unknown Sequence Fault [msg] {4.3}			Terminate Sequence [None] {4.3}			
Sequence Terminated Fault [msg] {4.2}	N/A		Terminate Sequence [None] {4.2}			
TerminateSequence [msg] {3.6}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Xmit Terminate Sequence Response [None] {3.6}	Xmit Terminate Sequence Response [None] {3.6}	Xmit Terminate Sequence Response [None] {3.6}	Generate Unknown Sequence Fault [Same] {4.3}
Terminate Sequence [int]	N/A	No action [None] {unspec}	Xmit Terminate Sequence [Terminating]	Xmit Terminate Sequence [Terminating]	Xmit Terminate Sequence [Terminating]	N/A
Terminate Sequence Response [msg]	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}				Terminate Sequence [None] {3.6}
Expires exceeded [int]	N/A	Terminate Sequence [None] {3.7}	Terminate Sequence [None] {3.7}	Terminate Sequence [None] {3.7}	Terminate Sequence [None] {3.7}	Terminate Sequence [None] {3.7}
Invalid Acknowledgement [msg] {4.4}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Invalid Acknowledgement Fault [Same] {4.4}			

2121 Table 2 RM Destination Sequence State Transition Table

Events	Sequence States			
	None	Created	Closed	Terminating
CreateSequence (successful) [msg/int] {3.4}	Xmit Create Sequence Response [Created] {3.4}	N/A	N/A	

Events	Sequence States			
	None	Created	Closed	Terminating
CreateSequence (unsuccessful) [msg/int] {3.4}	Generate Create Sequence Refused Fault [None] {3.4}	N/A	N/A	
Message (with message number within range) [msg]	Generate Unknown Sequence Fault [Same] {4.3}	Accept Message; <Xmit SeqAck> [Same]	Generate Sequence Closed Fault (with SeqAck+Final) [Same] {3.5}	Generate Sequence Terminated Fault [Same] {4.2}
Message (with message number outside of range) [msg]	Generate Unknown Sequence Fault [Same] {4.3}	Xmit Message Number Rollover Fault [Same] {3.7}{4.5}	Generate Sequence Closed Fault (with SeqAck+Final) [Same] {3.5}	Generate Sequence Terminated Fault [Same] {4.2}
<AckRequested> [msg] {3.8}	Generate Unknown Seq Fault [Same] {4.3}	Xmit SeqAck [Same] {3.8}	Xmit SeqAck+Final [Same] {3.9}	Generate Sequence Terminated Fault [Same] {4.2}
CloseSequence [msg] {3.5}	Generate Unknown Sequence Fault [Same] {4.3}	Xmit CloseSequence Response with SeqAck+Final [Closed] {3.5}	Xmit CloseSequence Response with SeqAck+Final [Closed] {3.5}	Generate Sequence Terminated Fault [Same] {4.2}
<CloseSequence autonomously> [int]		Xmit CloseSequence with SeqAck+Final [Closed] {3.5}	Xmit CloseSequence with SeqAck+Final [Same] {3.5}	
CloseSequenceResponse [msg] {3.5}	Generate Unknown Sequence Fault [Same] {4.3}		No Action [Closed] {3.5}	Generate Sequence Terminated Fault [Same] {4.2}
TerminateSequence [msg] {3.6}	Generate Unknown Sequence Fault [Same] {4.3}	Xmit Terminate Sequence Response [None] {3.6}	Xmit Terminate Sequence Response [None] {3.6}	Xmit Terminate Sequence Response [None] {3.6}
<TerminateSequence autonomously> [int]		Xmit TerminateSequence with SeqAck+Final [Terminating] {3.6}	Xmit TerminateSequence with SeqAck+Final [Terminating] {3.6}	Xmit TerminateSequence with SeqAck+Final [Terminating] {3.6}
TerminateSequenceResponse [msg]	Generate Unknown Sequence Fault [Same] {4.3}			Terminate Sequence [None]
UnknownSequence Fault [msg] {4.3}		Terminate Sequence [None] {4.3}	Terminate Sequence [None] {4.3}	Terminate Sequence [None] {4.3}
SequenceTerminated Fault [msg] {4.2}		Terminate Sequence [None] {4.2}	Terminate Sequence [None] {4.2}	Terminate Sequence [None] {4.3}
Invalid Acknowledgement Fault [msg] {4.4}	N/A			
Expires exceeded	N/A	Terminate Sequence	Terminate Sequence	

Events	Sequence States			
	None	Created	Closed	Terminating
[int]		[None] {3.4}	[None] {3.4}	
<Seq Acknowledgement autonomously> [int] {3.9}	N/A	Xmit SeqAck [Same] {3.9}	Xmit SeqAck+Final [Same] {3.9}	
Non WSRM message when WSRM required [msg] {4.8}	Generate WSRMRequired Fault [Same] {4.8}	Generate WSRMRequired Fault [Same] {4.8}	Generate WSRMRequired Fault [Same] {4.8}	

2122 **Appendix E. Acknowledgments**

2123 This document is based on initial contribution to OASIS WS-RX Technical Committee by the following
2124 authors:

2125 Ruslan Bilorusets(BEA), Don Box(Microsoft), Luis Felipe Cabrera(Microsoft), Doug Davis(IBM),
2126 Donald Ferguson(IBM), Christopher Ferris(IBM), Tom Freund(IBM), Mary Ann Hondo(IBM), John
2127 Ibbotson(IBM), Lei Jin(BEA), Chris Kaler(Microsoft), David Langworthy-Editor(Microsoft), Amelia
2128 Lewis(TIBCO Software), Rodney Limprecht(Microsoft), Steve Lucco(Microsoft), Don
2129 Mullen(TIBCO Software), Anthony Nadalin(IBM), Mark Nottingham(BEA), David Orchard(BEA),
2130 Jamie Roots(IBM), Shivajee Samdarshi(TIBCO Software), John Shewchuk(Microsoft), Tony
2131 Storey(IBM).

2132 The following individuals have provided invaluable input into the initial contribution:

2133 Keith Ballinger(Microsoft), Stefan Batres(Microsoft), Rebecca Bergersen(Iona), Allen
2134 Brown(Microsoft), Michael Conner(IBM), George Copeland(Microsoft), Francisco Curbera(IBM),
2135 Paul Fremantle(IBM), Steve Graham(IBM), Pat Helland(Microsoft), Rick Hill(Microsoft), Scott
2136 Hinkelman(IBM), Tim Holloway(IBM), Efim Hudis(Microsoft), David Ingham(Microsoft), Gopal
2137 Kakivaya(Microsoft), Johannes Klein(Microsoft), Frank Leymann(IBM), Martin Nally(IBM), Peter
2138 Niblett(IBM), Jeffrey Schlimmer(Microsoft), James Snell(IBM), Keith Stobie(Microsoft), Satish
2139 Thatte(Microsoft), Stephen Todd(IBM), Sanjiva Weerawarana(IBM), Roger Wolter(Microsoft).

2140 The following individuals were members of the committee during the development of this specification:

2141 Abbie Barbir(Nortel), Charlton Barreto(Adobe), Stefan Batres(Microsoft), Hamid Ben
2142 Malek(Fujitsu), Andreas Bjarlestam(Ericsson), Toufic Boubez(Layer 7), Doug Bunting(Sun), Lloyd
2143 Burch(Novell), Steve Carter(Novell), Martin Chapman(Oracle), Dave Chappell(Sonic), Paul
2144 Cotton(Microsoft), Glen Daniels(Sonic), Doug Davis(IBM), Blake Dournaee(Intel), Jacques
2145 Durand(Fujitsu), Colleen Evans(Microsoft), Christopher Ferris(IBM), Paul Fremantle(WSO2),
2146 Robert Freund(Hitachi), Peter Furniss(Erebor), Marc Goodner(Microsoft), Alastair
2147 Green(Choreology), Mike Grogan(Sun), Ondrej Hrebicek(Microsoft), Kazunori Iwasa(Fujitsu),
2148 Chamikara Jayalath(WSO2), Lei Jin(BEA), Ian Jones(BTplc), Anish Karmarkar(Oracle), Paul
2149 Knight(Nortel), Dan Leshchiner(Tibco), Mark Little(JBoss), Lily Liu(webMethods), Matt
2150 Lovett(IBM), Ashok Malhotra(Oracle), Jonathan Marsh(Microsoft), Daniel Millwood(IBM), Jeff
2151 Mischkinsky(Oracle), Nilo Mitra(Ericsson), Peter Niblett(IBM), Duane Nickull(Adobe), Eisaku
2152 Nishiyama(Hitachi), Dave Orchard(BEA), Chouthri Palanisamy(NEC), Sanjay Patil(SAP), Gilbert
2153 Pilz(BEA), Martin Raeppele(SAP), Eric Rajkovic(Oracle), Stefan Rossmannith(SAP), Tom
2154 Rutt(Fujitsu), Rich Salz(IBM), Shivajee Samdarshi(Tibco), Vladimir Videlov(SAP), Claus von
2155 Riegen(SAP), Pete Wenzel(Sun), Steve Winkler(SAP), Ümit Yalçinalp(SAP), Nobuyuki
2156 Yamamoto(Hitachi).

Appendix F. Revision History

Rev	Date	By Whom	What
wd-01	2005-07-07	Christopher Ferris	Initial version created based on submission by the authors.
ws-02	2005-07-21	Doug Davis	I011 (PT0S) added
wd-02	2005-08-16	Anish Karmarkar	Trivial editorial changes
ws-03	2005-09-15	Doug Davis	I019 and i028 (CloseSeq) added
wd-05	2005-09-26	Gilbert Pilz	i005 (Source resend of nacks messages when ack already received) added.
wd-05	2005-09-27	Doug Davis	i027 (InOrder delivery assurance spanning multiple sequences) added
wd-05	2005-09-27	Doug Davis	i020 (Semantics of "At most once" Delivery Assurance) added
wd-05	2005-09-27	Doug Davis	i034 (Fault while processing a piggy-backed RM header) added
wd-05	2005-09-27	Doug Davis	i033 (Processing model of NACKs) added
wd-05	2005-09-27	Doug Davis	i031 (AckRequested schema inconsistency) added
wd-05	2005-09-27	Doug Davis	i025 (SeqAck/None) added
wd-05	2005-09-27	Doug Davis	i029 (Remove dependency on WS-Security) added
wd-05	2005-09-27	Doug Davis	i039 (What does 'have a mU attribute' mean) added
wd-05	2005-09-27	Doug Davis	i040 (Change 'optiona'/'required' to 'OPTIONAL'/'REQUIRED') added
wd-05	2005-09-30	Anish Karmarkar	i017 (Change NS to http://docs.oasis-open.org/wsrn/200510/)
wd-05	2005-09-30	Anish Karmarkar	i045 (Include SecureConversation as a reference and move it to non-normative citation)
wd-05	2005-09-30	Anish Karmarkar	i046 (change the type of wsrn:FaultCode element)
wd-06	2005-11-02	Gilbert Pilz	Start wd-06 by changing title page from cd-01.
wd-06	2005-11-03	Gilbert Pilz	i047 (Reorder spec sections)
wd-07	2005-11-17	Gilbert Pilz	Start wd-07
wd-07	2005-11-28	Doug Davis	i071 – except for period in Appendix headings
wd-07	2005-11-28	Doug Davis	i10
wd-07	2005-11-28	Doug Davis	i030
wd-07	2005-11-28	Doug Davis	i037
wd-07	2005-11-28	Doug Davis	i038
wd-07	2005-11-28	Doug Davis	i041
wd-07	2005-11-28	Doug Davis	i043
wd-07	2005-11-28	Doug Davis	i044

Rev	Date	By Whom	What
wd-07	2005-11-28	Doug Davis	i048
wd-07	2005-11-28	Doug Davis	i051
wd-07	2005-11-28	Doug Davis	i053
wd-07	2005-11-28	Doug Davis	i059
wd-07	2005-11-28	Doug Davis	i062
wd-07	2005-11-28	Doug Davis	i063
wd-07	2005-11-28	Doug Davis	i065
wd-07	2005-11-28	Doug Davis	i067
wd-07	2005-11-28	Doug Davis	i068
wd-07	2005-11-28	Doug Davis	i069
wd-07	2005-11-28	Doug Davis	Fix bulleted list (#2) in section 2.3
wd-07	2005-11-29	Gilbert Pilz	i074 (Use of [tcShortName] in artifact locations namespaces, etc)
wd-07	2005-11-29	Gilbert Pilz	i071 – Fixed styles and formatting for TOC. Fixed styles of the appendix headings.
wd-07	2005-11-30	Doug Davis	Removed dup definition of "Receive"
wd-07	2005-11-30	Gilbert Pilz	Fixed lost formatting from heading for Namespace section. Fixed style of text body elements to match OASIS example documents. Fixed tables to match OASIS example documents.
wd-07	2005-12-01	Gilbert Pilz	Updated fix for i074 to eliminate trailing '/'. Added corresponding text around action IRI composition.
wd-07	2005-12-01	Gilbert Pilz	Use non-fixed fields for date values on both title page and body footers.
wd-07	2005-12-01	Doug Davis	Alphabetize the glossary
wd-07	2005-12-02	Doug Davis	i064
wd-07	2005-12-02	Doug Davis	i066
wd-08	2005-12-15	Doug Davis	Add back in RM Source to glossary
wd-08	2005-12-15	Steve Winkler	Doug added Steve's editorial nits
wd-08	2005-12-21	Doug Davis	i050
wd-08	2005-12-21	Doug Davis	i081
wd-08	2005-12-21	Doug Davis	i080 – but i050 negates the need for any changes
wd-08	2005-12-21	Doug Davis	i079
wd-08	2005-12-21	Doug Davis	i076 – didn't add text about "replies" since the RMD to RMS sequence could be used for any message not just replies
wd-08	2005-12-21	Umit Yalcinalp	Action Su03: removed wsse from Table 1
wd-08	2005-12-21	Umit Yalcinalp	i057 per Sunnyvale F2F 2005, Cleaned up some formatting errors in contributors
wd-08	2005-12-27	Doug Davis	i060
wd-08	2005-12-27	Gilbert Pilz	Moved schema and WSDL files to their own artifacts. Converted source document to

Rev	Date	By Whom	What
			OpenDocument Text format. Changed line numbers to be a single style.
wd-08	2005-12-28	Anish Karmarkar	Included a section link to c:\temp\wsrm-1.1-schema-200510.xsd and to c:\temp\wsrm-1.1-wsdl-200510.wsdl
wd-08	2006-01-04	Gilbert Pilz	Fixed formatting for included sections.
wd-08	2006-01-05	Gilbert Pilz	Created links for unused references. Fixed exemplars for CloseSequence and CloseSequenceResponse.
wd-09	2006-01-11	Doug Davis	Minor tweaks to text/typos.
wd-10	2006-01-23	Doug Davis	Accept all changes from wd-09 Make some minor editorial tweaks from Marc's comments.
wd-10	2006-02-14	Doug Davis	Issue 082 resolution
wd-10	2006-02-14	Doug Davis	Issue 083 resolution
wd-10	2006-02-14	Doug Davis	Issue 085 resolution
wd-10	2006-02-14	Doug Davis	Issues 086, 087 resolutions Defined MessageNumberType
wd-10	2006-02-15	Doug Davis	Issue 078 resolution
wd-10	2006-02-15	Doug Davis	Issue 094 resolution
wd-10	2006-02-15	Doug Davis	Issue 095 resolution
wd-10	2006-02-15	Gilbert Pilz	Issue 088 – added namespace URI link to namespace URI; added text explaining that this URI could be dereferenced to produce the RDDDL doc; added non-normative reference to RDDDL 2.0
wd-10	2006-02-17	Anish Karmarkar	Namespace changed to 200602 for both WSDL and XSD docs.
wd-10	2006-02-17	Anish Karmarkar	Issue i087 as it applies to WSRM spec.
wd-10	2006-02-17	Anish Karmarkar	Added titles and minor text for state table (issue i058).
wd-11	2006-02-22	Doug Davis	Accept all changes for new WD Minor typos fixed
wd-11	2006-02-23	Doug Davis	s'/close'/close/g – per Marc Goodner Added first ref to [URI] – per Marc G again
wd-11	2006-02-27	Doug Davis	Issue i061 applied
wd-11	2006-02-28	Doug Davis	Fixed typo around the use of "above" and "below"
wd-11	2006-03-01	Doug Davis	Minor typos found by Marc Goodner
wd-11	2006-03-02	Doug Davis	Minor typos found by Matt Lovett
wd-11	2006-03-08	Doug Davis	Issue 091 applied
wd-11	2006-03-08	Doug Davis	Issue 092 applied
wd-11	2006-03-08	Doug Davis	Issue 100 applied

Rev	Date	By Whom	What
wd-12	2006-03-20	Doug Davis	Added space in "SOAP1.x" – PaulCotton
wd-12	2006-04-11	Doug Davis	Issue 007 applied
wd-12	2006-04-11	Doug Davis	Issue 090 applied
wd-12	2006-04-11	Doug Davis	Issue 098 applied
wd-12	2006-04-11	Doug Davis	Issue 099 applied
wd-12	2006-04-11	Doug Davis	Issue 101 applied
wd-12	2006-04-11	Doug Davis	Issue 103 applied
wd-12	2006-04-11	Doug Davis	Issue 104 applied
wd-12	2006-04-11	Doug Davis	Issue 105 applied
wd-12	2006-04-11	Doug Davis	Issue 107 applied
wd-12	2006-04-11	Doug Davis	Issue 109 applied
wd-12	2006-04-11	Doug Davis	Issue 110 applied
wd-12	2006-04-12	Doug Davis	Used "generated" instead of "issue" or "send" when talking about faults.
wd-12	2006-04-24	Gilbert Pilz	Update references to WS-Addressing to the Proposed Recommendations; update WS-RM namespace to "200604".
wd-13	2006-05-08	Gilbert Pilz	i093 part 1; more work needed
wd-13	2006-05-10	Doug Davis	Issue 096 applied
wd-13	2006-05-26	Gilbert Pilz	i093 part 2; reflects decisions from 2006-05-25 meeting
wd-13	2006-05-28	Gilbert Pilz	Issue 106 applied
wd-13	2006-05-29	Gilbert Pilz	Issue 118 applied
wd-13	2006-05-29	Gilbert Pilz	Issue 120 applied
wd-13	2006-05-30	Gilbert Pilz	Issue 114 applied
wd-13	2006-05-30	Gilbert Pilz	Issue 116 applied
wd-14	2006-06-05	Gilbert Pilz	Accept all changes; bump WD number
wd-14	2006-06-07	Doug Davis	Applied lots of minor edits from Marc Goodner
wd-14	2006-06-07	Doug Davis	Change a couple of period/sp/sp to period/sp
wd-14	2006-06-07	Doug Davis	Added a space in "URI]of" – per Marc Goodner
wd-14	2006-06-07	Doug Davis	Issue 131 applied
wd-14	2006-06-07	Doug Davis	Issue 132 applied
wd-14	2006-06-07	Doug Davis	Issue 119 applied
wd-14	2006-06-07	Doug Davis	Applied lots of minor edits from Doug Davis
wd-14	2006-06-07	Doug Davis	s/"none"/"full-uri"/ - per Marc Goodner
wd-14	2006-06-12	Doug Davis	Complete i106
wd-14	2006-06-12	Doug Davis	Issues 089 applied
wd-14	2006-06-12	Doug Davis	Fix for several RFC2119 keywords – per Anish
wd-15	2006-06-12	Doug Davis	Accept all changed, dump WD number
wd-15	2006-06-12	Doug Davis	Move WSDL after Schema
wd-15	2006-06-12	Doug Davis	Nits – remove tabs, extra [yyy]'s ...
wd-15	2006-06-14	Doug Davis	Remove extra "OPTIONAL"s – Matt Lovett

Rev	Date	By Whom	What
wd-15	2006-06-14	Doug Davis	Remove blank rows/columns from state table. Fix italics in state table
wd-15	2006-06-15	Doug Davis	Typo – section D was empty
wd-15	2006-06-16	Doug Davis	Issue 125 applied
wd-15	2006-06-16	Doug Davis	Issue 126 applied
wd-15	2006-06-16	Doug Davis	Issue 127 applied
wd-15	2006-06-16	Doug Davis	Issue 133 applied
wd-15	2006-06-16	Doug Davis	Issue 136 applied
wd-15	2006-06-16	Doug Davis	Issue 138 applied
wd-15	2006-06-16	Doug Davis	Issue 135 applied
wd-15	2006-06-20	Doug Davis	Added all TC members to the ack list
wd-15	2006-06-22	Doug Davis	Issue 129 applied
wd-15	2006-06-22	Doug Davis	Issue 130 applied
wd-15	2006-06-22	Doug Davis	Issue 137 applied
wd-15	2006-06-26	Doug Davis	Issue 111 applied
wd-15	2006-06-26	Doug Davis	Missed a part of issue 129
wd-15	2006-06-30	Doug Davis	Fixed a typo in schema
wd-15	2006-06-30	Doug Davis	Issue 141 applied
wd-15	2006-06-30	Doug Davis	Issue 142 applied
wd-15	2006-06-30	Doug Davis	Issue 148 applied
wd-15	2006-06-30	Doug Davis	Issue 149 applied
wd-15	2006-06-30	Doug Davis	Issue 150 applied
wd-15	2006-07-06	Doug Davis	Issue 121 applied
wd-15	2006-07-21	Doug Davis	Issue 139 applied
wd-15	2006-07-21	Doug Davis	Issue 144 applied
wd-15	2006-07-21	Doug Davis	Issue 147 applied
wd-15	2006-07-21	Doug Davis	Issues 122-124 applied
wd-15	2006-07-27	Doug Davis	Updated list of oasis TC members (i134)
wd-15	2006-07-27	Doug Davis	Issue 140 applied
wd-15	2006-07-27	Doug Davis	Issue 145 applied
wd-15	2006-07-27	Doug Davis	Issue 143 applied
wd-15	2006-07-28	Doug Davis	Lots of minor typos found by Matt L.
wd-15	2006-07-28	Doug Davis	Issue 113 applied
wd-15	2006-08-04	Doug Davis	Update old namespaces – found by PaulC
wd-15	2006-08-04	Doug Davis	Issue 150 applied
wd-15	2006-08-04	Doug Davis	Minor typos – found by PeterN
wd-15	2006-08-04	Doug Davis	Verify all [refs]
wd-15	2006-08-04	Doug Davis	Change namespace to 2006/08
wd-15	2006-08-04	Doug Davis	Issue 148 applied
wd-15	2006-08-07	Doug Davis	Add some new glossary terms – per GilP
cd-04	2006-08-10	Gilbert Pilz	Formatting changes for better HTML rendering.

Rev	Date	By Whom	What
cd-04	2006-08-11	Doug Davis	Issue 158 applied
cd-04	2006-08-11	Doug Davis	Issue 153 applied
cd-04	2006-08-11	Doug Davis	Issue 156 applied
cd-04	2006-08-15	Gilbert Pilz	More formatting changes for better HTML rendering.
wd-16	2006-10-25	Doug Davis	Accept all changes, update to wd16
wd-16	2006-10-26	Doug Davis	PR002 applied
wd-16	2006-10-26	Doug Davis	PR003 applied
wd-16	2006-10-26	Doug Davis	PR004 applied
wd-16	2006-10-27	Doug Davis	PR005 applied
wd-16	2006-10-27	Doug Davis	PR006 applied
wd-16	2006-10-27	Doug Davis	PR024 applied
wd-16	2006-11-13	Doug Davis	PR010 applied
wd-16	2006-11-13	Doug Davis	PR011 applied (technically as part of PR004)
wd-16	2006-11-13	Doug Davis	PR016 applied
wd-16	2006-11-13	Doug Davis	PR032 applied
wd-16	2006-11-20	Doug Davis	PR025 applied
wd-16	2006-11-20	Doug Davis	PR023 applied
wd-16	2006-12-03	Doug Davis	PR036 applied
wd-16	2006-12-03	Doug Davis	PR017 applied
wd-16	2006-12-11	Doug Davis	PR012 applied (and PR013)
wd-16	2006-12-14	Doug Davis	PR033 applied – changed a 'return' to 'generate' when talking about a fault
wd-16	2007-01-04	Doug Davis	PR018 applied
wd-16	2007-01-05	Doug Davis	Moved MakeConnection to new spec
wd-16	2007-01-17	Doug Davis	PR026 applied
wd-16	2007-01-18	Doug Davis	PR021 applied
wd-16	2007-01-18	Doug Davis	PR022 applied
wd-16	2007-01-18	Doug Davis	Fixed a few typos (Doug,Gil)
wd-16	2007-01-18	Gilbert Pilz	PR007 applied
wd-16	2007-01-25	Doug Davis	PR039 applied
wd-17	2007-01-31	Doug Davis	Lots of typos from MarcG Updated WD number and date
wd-17	2007-02-01	Doug Davis	PR038 applied
wd-17	2007-02-01	Doug Davis	PR035 (009,020 dups) applied Fixed typo in state table