IPv6 READY

Multicast Listener Discovery
Operations Test Suite

Technical Document

Revision 1.4

IPv6 Forum ***http://www.ipv6forum.org***
Converged Test Specification ***http://www.ipv6ready.org***
TAHI Project (Japan)
UNH InterOperability Lab (USA)

MODIFICATION RECORD

Version 1.1	January 12, 2004
Version 1.2	April 29, 2004
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Version 1.4	February 17, 2004

- Fixed typo in test MLD1.10, Part (A), line 4 – " group FF03::1:3" to "group FF1E::1:3".
- Fixed typos in test MLD1.12: Discussion – " never send" to "never sends"; in Observable Results, Step 2 – "a Reports" to "a Report"
- Fixed wording in test MLD2.1, Possible Problems - " that piece" to "that part".
- Added missing Part D and reorganized the Observable Results section of test MLD2.2 to match the Procedure section.

ACKNOWLEDGMENTS

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TAHI Project

INTRODUCTION

Overview

The IPv6 forum plays a major role to bring together industrial actors, to develop and deploy the new generation of IP protocols. Contrary to IPv4, which started with a small closed group of implementers, the universality of IPv6 leads to a huge number of implementations. Interoperability has always been considered as a critical feature in the Internet community. Due to the large number of IPv6 implementations, it is important to give to the market a strong signal proving the interoperability degree of various products.

To avoid confusion in the mind of customers, a unique logo program has been defined. The IPv6 logo gives confidence to users that IPv6 is currently operational. It is also a clear indication that the technology will still be used in the future. This logo program contributes to the feeling that IPv6 is available and ready to be used.

The IPv6 Logo Program consists of two phases:

Phase I (Short term period)
In a first stage, the Logo will indicate that the product includes IPv6 mandatory core protocols and can interoperate with other IPv6 equipments. The pragmatic approach of the Logo Committee consists in selecting existing relevant interoperability events and conformance and interoperability test suites.

Phase II (Long term period)
The next stage implies proper care, technical consensus and crystal clear technical references. The IPv6 Ready logo will indicates that a product has successfully satisfied strong requirements stated by the v6LC. To avoid confusion, the IPv6 Ready logo will be generic, and the v6LC will identify different categories of products with associated requirements.

Abbreviations and Acronyms

DAD: Duplicate Address Detection
HUT: Host Under Test
MTU: Maximum Transmission Unit
NCE: Neighbor Cache Entry
NUT: Node Under Test
TLLA: Target Link-layer Address
TN: Testing Node
TR: Testing Router

TEST ORGANIZATION

This document organizes tests by group based on related test methodology or goals. Each group begins with a brief set of comments pertaining to all tests within that group. This is followed by a series of description blocks; each block describes a single test. The format of the description block is as follows:

Test Label: The Test Label and Title comprise the first line of the test block. The Test Label is composed of the short test suite name, the group number, and the test number within the group, separated by periods.

Purpose: The Purpose is a short statement describing what the test attempts to achieve. It is usually phrased as a simple assertion of the feature or capability to be tested.

References: The References section lists cross-references to the specifications and documentation that might be helpful in understanding and evaluating the test and results.

Resource Requirements: The Resource Requirements section specifies the software, hardware, and test equipment that will be needed to perform the test.

Discussion: The Discussion is a general discussion of the test and relevant section of the specification, including any assumptions made in the design or implementation of the test as well as known limitations.

Test Setup: The Test Setup section describes the configuration of all devices prior to the start of the test. Different parts of the procedure may involve configuration steps that deviate from what is given in the test setup. If a value is not provided for a protocol parameter, then the protocol's default is used.

Procedure: This section of the test description contains the step-by-step instructions for carrying out the test. These steps include such things as enabling interfaces, unplugging devices from the network, or sending packets from a test station. The test procedure also cues the tester to make observations, which are interpreted in accordance with the observable results given for that test part.

Observable Results: This section lists observable results that can be examined by the tester to verify that the RUT is operating properly. When multiple observable results are possible, this section provides a short discussion on how to interpret them. The determination of a pass or fail for each test is usually based on how the RUT's behavior compares to the results described in this section.

Possible Problems: This section contains a description of known issues with the test procedure, which may affect test results in certain situations.

REFERENCES

The following documents are referenced in this text:

[MLD] S. Deering, W. Fenner, B. Haberman, Multicast Listener Discovery (MLD) for IPv6, RFC 2710, October 1999.

TABLE OF CONTENTS

TIMERS AND DEFAULT VALUES

MLD defines several timers and default values. For the purpose of testing, all configurable timers and values are set to their defaults, unless otherwise noted in the test description. These defaults are given here for reference, taken or calculated from RFC2170:

Robustness Variable:	2
Query Interval:	125 seconds
Query Response Interval:	10 seconds
Multicast Listener Interval:	260 seconds
Other Querier Present Interval	255 seconds
Startup Query Interval	31.25 seconds
Startup Query Count	2
Last Listener Query Interval	1 second
Last Listener Query Count	2
Unsolicited Report Interval	10 seconds

GROUP 1: Multicast Listener Discovery for Nodes

Scope:

These tests are designed to verify a node's MLD behavior.

Overview:

This group will test that a MLD node follows the proper state transitions.

Test MLD.1.1: Receive Gen Query with Zero Max Response Delay

Purpose: Verify that a node processes General Queries and sends reports for Max Response Timers with values set to zero.

References:

- [MLD] – Section 4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: When a node receives a General Query, it sets a delay timer for each multicast address to which it is listening on the interface from which it received the Query. If the node's timer for a particular multicast address on a particular interface expires, the node transmits a Report to that address via that interface; the address being reported is carried in both the IPv6 Destination Address field and the MLD Multicast Address field of the Report packet.

If the Query packet specifies a Maximum Response Delay of zero, each timer is effectively set to zero, and the action for timer expiration is performed immediately.

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.

Procedure:

Part A: One Multicast Group- Max Resp. Delay = 0

1. Configure the NUT to join the multicast group FF1E::1:3.
2. On Link 0, TR1 transmits a General Query with a Max Response Delay of 0.
3. Observe the packets transmitted by the NUT on link 0.

Part B: Multiple Multicast Group – Max Resp. Delay = 0

4. Configure the NUT to join the multicast group FF1E::1:3 and the multicast group FF1E::1:4.
5. On Link 0, TR1 transmits a General Query with a Max Response Delay of 0.
6. Observe the packets transmitted by the NUT on link 0.

Observable Results:

- *Part A*

  Step 3: The NUT should respond to the Query from TR1 immediately (within 1 second) with a Report with the multicast group FF1E::1:3 for the IPv6 Destination Address and the MLD Multicast Address.

- *Part B*

  Step 6: The NUT should respond to the Query from TR2 immediately (within 1 second) with two Reports, one with the multicast group FF1E::1:3 and the second report with the multicast group FF1E::1:4 for the IPv6 Destination Address and the MLD Multicast Address.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.

Test MLD.1.2: Receive Gen Query with Non-Zero Max Response Delay

Purpose: Verify that a node processes General Queries and sends reports for Max Response Timers with values not set to zero.

References:

- [MLD] – Section 4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: When a node receives a General Query, it sets a delay timer for each multicast address to which it is listening on the interface from which it received the Query. If the node's timer for a particular multicast address on a particular interface expires, the node transmits a Report to that address via that interface; the address being reported is carried in both the IPv6 Destination Address field and the MLD Multicast Address field of the Report packet.

Each timer is set to a different random value, using the highest clock granularity available on the node, selected from the range [0, Maximum Response Delay] with Maximum Response Delay as specified in the query packet. If a timer for the address is already running, it is reset to the new random value only if the requested Maximum Response Delay is less than the remaining value of the running timer.

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.

Procedure:

Part A: Max Resp. Delay = 1000

1. Configure the NUT to join the multicast group FF1E::1:3.
2. Configure the NUT to join the multicast group FF1E::1:4.
3. On Link 0, TR1 transmits a General Query with a Max Response Delay of 1000.
4. Observe the packets transmitted by the NUT on link 0.

Part B: Max Resp. Delay < remaining time

5. The NUT should join the multicast group FF1E::1:3.
6. On Link 0, TR1 transmits a General Query with a Max Response Delay of 2000.
7. On Link 0, TR1 transmits a General Query with a Max Response Delay of 1000.
8. Observe the packets transmitted by the NUT on link 0.

Part C: Max Resp. Delay > remaining time

9. The NUT should join the multicast group FF1E::1:3.

10. On Link 0, TR1 transmits a General Query with a Max Response Delay of 1000.
11. On Link 0, TR1 transmits a General Query with a Max Response Delay of 2000.
12. Observe the packets transmitted by the NUT on link 0.

Observable Results:

- *Part A*
  Step 4: The NUT should respond to the General Query from TR1 within 1000 milliseconds with two Reports, one containing the multicast group FF1E::1:3 for the IPv6 Destination Address and the MLD Multicast Address, and the other Report containing FF1E::1:4 for the IPv6 Destination Address and the MLD Multicast Address.
- *Part B*
  Step 6: The NUT should set its Timer for multicast group FF1E::1:3 to between 0 and 2000 milliseconds.
  Step 7: If the NUT's running Timer for multicast group FF1E::1:3 has more than 1000 milliseconds remaining, the NUT should reset it to between 0 and 1000 milliseconds.
  Step 8: The NUT should respond to the General Query from TR1 by sending one Report for multicast group FF1E::1:3 within 1000 milliseconds of receiving the General Query in step 6.
- *Part C*
  Step 10: The NUT should set its Timer for multicast group FF1E::1:3 to between 0 and 1000 milliseconds.
  Step 11: Because the remaining Timer is less than the Max Response Delay (2000), the NUT should not reset its Timer.
  Step 12: The NUT should respond to the General Query from TR1 by sending one Report for multicast group FF1E::1:3 within 1000 milliseconds of receiving the General Query in step 9.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.

Test MLD.1.3: Receive MAS Query with Zero Max Response Delay

Purpose: Verify that a node processes Multicast-Address-Specific Queries and sends reports for Max Response Timers with values set to zero.

References:

- [MLD] – Section 4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: When a node receives a Multicast-Address-Specific Query, if it is listening to the queried Multicast Address on the interface from which the Query was received, it sets a delay timer for that address to a random value selected from the range [0, Maximum Response Delay]. If the node's timer for a particular multicast address on a particular interface expires, the node transmits a Report to that address via that interface; the address being reported is carried in both the IPv6 Destination Address field and the MLD Multicast Address field of the Report packet.

If the Query packet specifies a Maximum Response Delay of zero, the timer value is effectively set to zero, and the action specified below for timer expiration is performed immediately.

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.

Procedure:

Part A: One Multicast Group- Max Resp. Delay = 0

1. Configure the NUT to join the multicast group FF1E::1:3.
2. On Link 0, TR1 transmits a Multicast-Address-Specific Query to group FF1E::1:3 with a Max Response Delay of 0.
3. Observe the packets transmitted by the NUT on link 0.

Part B: Multiple Multicast Group – Max Resp. Delay = 0

4. Configure the NUT to join the multicast group FF1E::1:3 and the multicast group FF1E::1:4.
5. On Link 0, TR1 transmits a Multicast-Address-Specific Query to group FF1E::1:3 with a Max Response Delay of 0.
6. Observe the packets transmitted by the NUT on link 0.
7. On Link 0, TR1 transmits a Multicast-Address-Specific Query to group FF1E::1:4 with a Max Response Delay of 0.
8. Observe the packets transmitted by the NUT on link 0.

Part C: No Multicast Group – Max Resp. Delay = 0

9. Do not configure the NUT to join the multicast group FF1E::1:3.
10. On Link 0, TR1 transmits a Multicast-Address-Specific Query to group FF1E::1:3 with a Max Response Delay of 0.
11. Observe the packets transmitted by the NUT on link 0.

Observable Results:

- *Part A*
  Step 3: The NUT should respond to the Multicast-Address-Specific Query from TR1 immediately (within 1 second) with a Report with the multicast group FF1E::1:3 for the IPv6 Destination Address and the MLD Multicast Address.
- *Part B*
  Step 6: The NUT should respond to the Multicast-Address-Specific Query from TR1 immediately (within 1 second) with a Report containing multicast group FF1E::1:3 for the IPv6 Destination Address and the MLD Multicast Address.
  Step 8: The NUT should respond to the Multicast-Address-Specific Query from TR1 immediately (within 1 second) with a Report containing multicast group FF1E::1:4 for the IPv6 Destination Address and the MLD Multicast Address.
- *Part C*
  Step 13: The NUT should not respond to the Multicast-Address-Specific Query from TR1 with a Report for multicast group FF1E::1:3.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.

Test MLD.1.4: Receive MAS Query with Non-Zero Max Response Delay

Purpose: Verify that a node processes Multicast-Address-Specific Queries and sends reports for Max Response Timers with values not set to zero.

References:

- [MLD] – Section 4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: When a node receives a Multicast-Address-Specific Query, if it is listening to the queried Multicast Address on the interface from which the Query was received, it sets a delay timer for that address to a random value selected from the range [0, Maximum Response Delay]. If the node's timer for a particular multicast address on a particular interface expires, the node transmits a Report to that address via that interface; the address being reported is carried in both the IPv6 Destination Address field and the MLD Multicast Address field of the Report packet.

If a timer for the address is already running, it is reset to the new random value only if the requested Maximum Response Delay is less than the remaining value of the running timer.

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.

Procedure:

Part A: Max Resp. Delay = 1000

1. Configure the NUT to join the multicast group FF1E::1:3.
2. On Link 0, TR1 transmits a Multicast-Address-Specific Query to group FF1E::1:3 with a Max Response Delay of 1000.
3. Observe the packets transmitted by the NUT on link 0.

Part B: Max Resp. Delay < remaining time

4. The NUT should join the multicast group FF1E::1:3.
5. On Link 0, TR1 transmits a Multicast-Address-Specific Query to group FF1E::1:3 with a Max Response Delay of 2000.
6. On Link 0, TR1 transmits a Multicast-Address-Specific Query to group FF1E::1:3 with a Max Response Delay of 1000.
7. Observe the packets transmitted by the NUT on link 0.

Part C: Max Resp. Delay > remaining time

8. The NUT should join the multicast group FF1E::1:3.
9. On Link 0, TR1 transmits a Multicast-Address-Specific Query to group FF1E::1:3 with a Max Response Delay of 1000.
10. On Link 0, TR1 transmits a Multicast-Address-Specific Query to group FF1E::1:3 with a Max Response Delay of 2000.
11. Observe the packets transmitted by the NUT on link 0.

Observable Results:

- *Part A*

  Step 3: The NUT should respond to the Multicast-Address-Specific Query from TR1 within 1000 milliseconds with a Report containing the multicast group FF1E::1:3 for the IPv6 Destination Address and the MLD Multicast Address.
- *Part B*

  Step 5: The NUT should set its Timer for multicast group FF1E::1:3 to between 0 and 2000 milliseconds.

  Step 6: If the NUT's running Timer for multicast group FF1E::1:3 has more than 1000 milliseconds remaining, the NUT should reset it to between 0 and 1000 milliseconds.

  Step 7: The NUT should respond to the Multicast-Address-Specific Query from TR1 by sending one Report for multicast group FF1E::1:3 within 1000 milliseconds of receiving the General Query in step 6.
- *Part C*

  Step 9: The NUT should set its Timer for multicast group FF1E::1:3 to between 0 and 1000 milliseconds.

  Step 10: Because the remaining Timer is less than the Max Response Delay (2000), the NUT should not reset its Timer.

  Step 11: The NUT should respond to the Multicast-Address-Specific Query from TR1 by sending one Report for multicast group FF1E::1:3 within 1000 milliseconds of receiving the General Query in step 9.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.

Test MLD.1.5: Receive Valid Query Message with Unexpected Values

Purpose: To verify that a node processes Queries with unexpected values.

References:

- [MLD] – Section 3.2, 3.5, and 3.7

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. The code field is initialized to zero by the sender; ignored by receivers. The reserved field is initialized to zero by the sender; ignored by receivers.

The length of received MLD message is computed by taking the IPv6 Payload Length value and subtracting the length of any IPv6 extension headers present between the IPv6 header and the MLD message. If that length is greater than 24 octets, that indicates that there are other fields present beyond the fields described above, perhaps belonging to a future backwards-compatible version of MLD. An implementation of this version of MLD MUST NOT send an MLD message longer than 24 octets and MUST ignore anything past the first 24 octets of a received MLD message. The MLD checksum MUST be computed over the entire MLD message, not just the first 24 octets.

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.

Procedure:

Part A: Code field – General Query

1. Configure the NUT to join the multicast group FF1E::1:3.
2. On Link 0, TR1 transmits a General Query message with the code field containing a value of 100.
3. Observe the packets transmitted by the NUT on link 0.

Part B: Code field – Multicast-Address-Specific Query

4. Configure the NUT to join the multicast group FF1E::1:3.
5. On Link 0, TR1 transmits a Multicast-Address-Specific Query for address FF1E::1:3 with the code field containing a value of 100.
6. Observe the packets transmitted by the NUT on link 0.

Part C: Reserved field – General Query

7. Configure the NUT to join the multicast group FF1E::1:3.

8. On Link 0, TR1 transmits a General Query message with the reserved field containing a value of 30.
9. Observe the packets transmitted by the NUT on link 0.

Part D: Reserved field – Multicast-Address-Specific Query

10. Configure the NUT to join the multicast group FF1E::1:3.
11. On Link 0, TR1 transmits a Multicast-Address-Specific Query for address FF1E::1:3 with the reserved field containing a value of 30.
12. Observe the packets transmitted by the NUT on link 0.

Part E: Length of message > 24 octets – General Query

13. Configure the NUT to join the multicast group FF1E::1:3.
14. On Link 0, TR1 transmits a General Query message where the length of the message is 32 octets long.
15. Observe the packets transmitted by the NUT on link 0.

Part F: Length of message > 24 octets – Multicast-Address-Specific Query

16. Configure the NUT to join the multicast group FF1E::1:3.
17. On Link 0, TR1 transmits a Multicast-Address-Specific Query for address FF1E::1:3 where the length of the message is 32 octets long.
18. Observe the packets transmitted by the NUT on link 0.

Observable Results:

Steps 3, 6, 9,12,15 and 18: The NUT should accept the Query, ignore the unexpected values, and transmit a Report for the multicast group FF1E::1:3.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.

Test MLD.1.6: Receive Invalid Query Messages

Purpose: To verify that a node properly ignores invalid Queries.

References:

- [MLD] – Sections 3, 3.3, 5, and 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. All MLD messages described in this document are sent with a link-local IPv6 Source Address, an IPv6 Hop Limit of 1, and an IPv6 Router Alert option in a Hop-by-Hop Options header. The checksum in a Query message is the standard ICMPv6 checksum, covering the entire MLD message plus a "pseudo-header" of IPv6 header fields.

To be valid, a Query message MUST come from a link-local IPv6 source address, be at least 24 octets long, and have a correct MLD checksum. The Multicast Address field in the MLD message must contain either zero (a General Query) or a valid multicast address (a Multicast- Address- Specific Query).

Events such as receiving invalid MLD messages or MLD message types other than Query or Report are ignored in all three node states (Non-Listener, Delaying Listener, Idle Listener).

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.

Procedure:

Part A: Invalid Checksum – General Query

1. Configure the NUT to join the multicast group FF1E::1:3.
2. On Link 0, TR1 transmits a General Query with an invalid checksum.
3. Observe the packet transmitted by the NUT on link 0.

Part B: Invalid Checksum – Multicast Address Specific Query

4. Configure the NUT to join the multicast group FF1E::1:3.
5. On Link 0, TR1 transmits a Multicast-Address-Specific Query for address FF1E::1:3 with an invalid checksum.
6. Observe the packet transmitted by the NUT on link 0.

Part C: Global Source Address – General Query

7. Configure the NUT to join the multicast group FF1E::1:3.

8. On Link 0, TR1 transmits a General Query with TR1's Global Address as the IPv6 Source Address.
9. Observe the packet transmitted by the NUT on link 0.

Part D: Global Source Address – Multicast Address Specific Query

10. Configure the NUT to join the multicast group FF1E::1:3.
11. On Link 0, TR1 transmits a Multicast-Address-Specific Query for address FF1E::1:3 with TR1's Global Address as the IPv6 Source Address.
12. Observe the packet transmitted by the NUT on link 0.

Part E: Length < 24 octets – General Query

13. Configure the NUT to join the multicast group FF1E::1:3.
14. On Link 0, TR1 transmits a General Query with a length of 20 octets.
15. Observe the packet transmitted by the NUT on link 0.

Part F: Length < 24 octets – Multicast Address Specific Query

16. Configure the NUT to join the multicast group FF1E::1:3.
17. On Link 0, TR1 transmits a Multicast-Address-Specific Query for address FF1E::1:3 with a length of 20 octets.
18. Observe the packet transmitted by the NUT on link 0.

Part G: Unicast Address in Multicast Address Field – Multicast Address Specific Query

19. Configure the NUT to join the multicast group FF1E::1:3.
20. On Link 0, TR1 transmits a Multicast-Address-Specific Query for TR1's Link Local address .
21. Observe the packet transmitted by the NUT on link 0.

Observable Results:

Steps 3, 6, 9,12,15, 18 and 21: The NUT should ignore the Queries sent by TR1 and should not transmit a Report in response.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.

Test MLD.1.7: Transmit Report Message

Purpose: To verify that a node properly transmits a Report Message.

References:

- [MLD] – Sections 3, 3.2, 3.4, 3.5, 3.7, and 4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

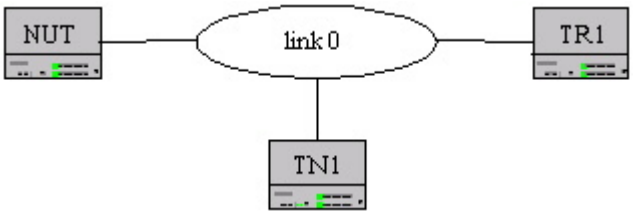
Discussion: MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. All MLD messages described in this document are sent with a link-local IPv6 Source Address, an IPv6 Hop Limit of 1, and an IPv6 Router Alert option in a Hop-by-Hop Options header. The checksum in a Query message is the standard ICMPv6 checksum, covering the entire MLD message plus a "pseudo-header" of IPv6 header fields.

MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. The code field is initialized to zero by the sender; ignored by receivers. The reserved field is initialized to zero by the sender; ignored by receivers.

The length of received MLD message is computed by taking the IPv6 Payload Length value and subtracting the length of any IPv6 extension headers present between the IPv6 header and the MLD message. If that length is greater than 24 octets, that indicates that there are other fields present beyond the fields described above, perhaps belonging to a future backwards-compatible version of MLD. An implementation of this version of MLD MUST NOT send an MLD message longer than 24 octets.

The Maximum Response Delay field is meaningful only in Query messages, and specifies the maximum allowed delay before sending a responding Report. In all other messages it is set to zero by the sender.

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.



Procedure:

1. Configure the NUT to join the multicast group FF1E::1:3.
2. On Link 0, TR1 transmits a Multicast-Address-Specific Query message for group FF1E::1:3 with a Maximum response delay of 2000.
3. Observe the packets transmitted by the NUT on link 0.

Observable Results:

Step 3: The NUT should transmit a Report message with the multicast address field set to FF1E::1:3 to the multicast address FF1E::1:3. The Report message should contain:

- link-local IPv6 Source Address
- IPv6 Hop Limit of 1
- IPv6 Router Alert option in a Hop-by-Hop Options header
- Valid checksum
- Code field value = 0
- Reserved field value = 0
- Maximum Response Delay field value = 0

The Report message must not be longer than 24 octets in length.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.

Test MLD.1.8: Receive Report Message with Unexpected Values

Purpose: To verify that a node properly processes a Report Message that contains unexpected field values.

References:

- [MLD] – Sections 3.2, 3.5, and 3.7

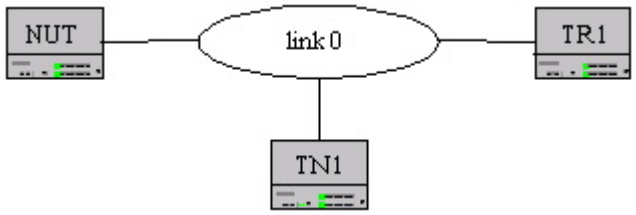
Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. The code field is initialized to zero by the sender; ignored by receivers. The reserved field is initialized to zero by the sender; ignored by receivers.

The length of received MLD message is computed by taking the IPv6 Payload Length value and subtracting the length of any IPv6 extension headers present between the IPv6 header and the MLD message. If that length is greater than 24 octets, that indicates that there are other fields present beyond the fields described above, perhaps belonging to a future backwards-compatible version of MLD. An implementation of this version of MLD MUST NOT send an MLD message longer than 24 octets and MUST ignore anything past the first 24 octets of a received MLD message. The MLD checksum MUST be computed over the entire MLD message, not just the first 24 octets.

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.



Procedure:

Part A: Code field

1. Configure the NUT to join the multicast group FF1E::1:3.
2. On Link 0, TR1 transmits a Multicast-Address-Specific Query for address FF1E::1:3.
3. On Link 0, TN1 immediately transmits a Report Message for FF1E::1:3 with a code field containing a value of 100.
4. Observe the packets transmitted by the NUT on link 0.

Part B: Reserved field

5. Configure the NUT to join the multicast group FF1E::1:3.
6. On Link 0, TR1 transmits a Multicast-Address-Specific Query for address FF1E::1:3.
7. On Link 0, TN1 immediately transmits a Report Message for FF1E::1:3 with a reserved field containing a value of 30.
8. Observe the packets transmitted by the NUT on link 0.

Part C: Length of message > 24 octets

9. Configure the NUT to join the multicast group FF1E::1:3.
10. On Link 0, TR1 transmits a Multicast-Address-Specific Query for address FF1E::1:3.
11. On Link 0, TN1 immediately transmits a Report Message for FF1E::1:3 where the length of the message is 32 octets long.
12. Observe the packets transmitted by the NUT on link 0.

Observable Results:

Steps 4, 8, and 12: The NUT should accept the Report Message from TN1 with unexpected values and not send another Report for multicast group FF1E::1:3.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.
- The NUT may transmit a Report Message before TN1 (if it chooses a Response Delay of 0). In this case, the above behavior cannot be observed.

Test MLD.1.9: Maximum Response Delay in Report Message

Purpose: To verify that a node properly processes a non-zero value for the maximum response delay in a Report Message.

References:

- [MLD] – Sections 3.4 and 4

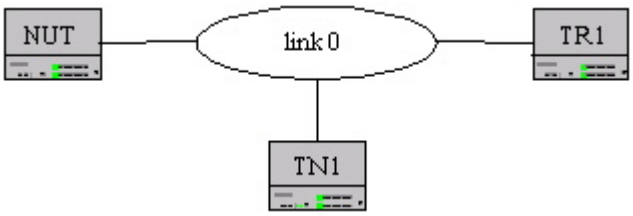
Resource Requirements:

3. Packet Generator
4. Monitor to capture packets

Discussion: The Maximum Response Delay field is meaningful only in Query messages, and specifies the maximum allowed delay before sending a responding Report, in units of milliseconds. In all other messages, it is set to zero by the sender and ignored by receivers.

If a node receives another node's Report from an interface for a multicast address while it has a timer running for that same address on that interface, it stops its timer and does not send a Report for that address, thus suppressing duplicate reports on the link.

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT. TN1 is a listener for multicast group FF1E::1:3.



Procedure:

1. Configure the NUT to join the multicast group FF1E::1:3.
2. On Link 0, TR1 transmits a Multicast-Address-Specific Query message for group FF1E::1:3 with a Maximum response delay of 2000.
3. On Link 0, TN1 immediately transmits a Report message for group FF1E::1:3 with a Maximum response delay of 500.
4. Observe the packets transmitted by the NUT on link 0.

Observable Results:

Step 4: The NUT should ignore the value of 500 for the Maximum Response Delay in the Report sent from TN1. Make sure the NUT does not reset the timer for group FF1E::1:3 to a value between [0, 500]. The NUT should actually stop its timer and not send a report in response to the General Query from TR1 because TN1 already sent one.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.
- The NUT may transmit a Report Message before TN1 (if it chooses a Response Delay of 0). In this case, the above behavior cannot be observed.

Test MLD.1.10: Receive Report

Purpose: To verify that a node properly processes valid MLD Reports from other Nodes.

References:

- [MLD] – Sections 3, 4 and 5

Resource Requirements:

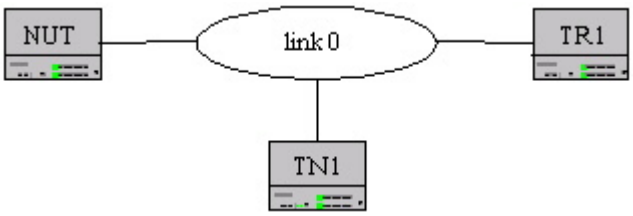
1. Packet Generator
2. Monitor to capture packets

Discussion: The "report received" event occurs when the node receives a valid MLD Report message. To be valid, the Report message MUST come from a link-local IPv6 Source Address, be at least 24 octets long, and have a correct MLD checksum. A Report applies only to the address identified in the Multicast Address field of the Report, on the interface from which the Report is received. It is ignored in the Non-Listener or Idle Listener state.

MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. All MLD messages described in this document are sent with a link-local IPv6 Source Address, an IPv6 Hop Limit of 1, and an IPv6 Router Alert option in a Hop-by-Hop Options header. The checksum in a Query message is the standard ICMPv6 checksum, covering the entire MLD message plus a "pseudo-header" of IPv6 header fields.

If a node receives another node's Report from an interface for a multicast address while it has a timer running for that same address on that interface, it stops its timer and does not send a Report for that address, thus suppressing duplicate reports on the link.

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT. TN1 is a listener for multicast group FF1E::1:3.



Procedure:

Part A: Report with non link-local address

1. Configure the NUT to join the multicast group FF1E::1:3.
2. On Link 0, TR1 transmits a Multicast-Address-Specific Query for FF1E::1:3.
3. On Link 0, TN1 immediately transmits a Report for the multicast group FF1E::1:3. The IPv6 Source Address is set to TN1's Global Address on Link 0.

4. Observe the packets transmitted by the NUT on link 0.

Part B: Report with invalid checksum

5. Configure the NUT to join the multicast group FF1E::1:3.
6. On Link 0, TR1 transmits a Multicast-Address-Specific Query for FF1E::1:3.
7. On Link 0, TN1 immediately transmits a Report for the multicast group FF1E::1:3 with an invalid MLD checksum.
8. Observe the packets transmitted by the NUT on link 0.

Part C: Report less than 24 bytes long

9. Configure the NUT to join the multicast group FF1E::1:3.
10. On Link 0, TR1 transmits a Multicast-Address-Specific Query for FF1E::1:3.
11. On Link 0, TN1 immediately transmits a Report for the multicast group FF1E::1:3 that has a length of 20 bytes. (The last 4 bytes of the Multicast Address are chopped off.)
12. Observe the packets transmitted by the NUT on link 0.

Part D: Report from other node

13. Configure the NUT to join the multicast group FF1E::1:3.
14. On Link 0, TR1 transmits a Multicast-Address-Specific Query for FF1E::1:3.
15. On Link 0, TN1 immediately transmits a Report for the multicast group FF1E::1:3.
16. Observe the packets transmitted by the NUT on link 0.

Observable Results:

- *Parts A, B, C,*
  Steps 4, 8, and 12: Because the Reports sent from TN1 are invalid, the NUT should respond to the Multicast-Address-Specific Query from TR1 with a Report containing the multicast group FF1E::1:3 for the IPv6 Destination Address and the MLD Multicast Address.
- *Part D*
  Step 24: Because the Report sent from TN1 is valid, the NUT should not respond to the Multicast-Address-Specific Query from TR1. It should not transmit a Report Message for multicast group FF1E::1:3.

.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.
- The NUT may transmit a Report Message before TN1 (if it chooses a Response Delay of 0). In this case, the above behavior cannot be observed.

Test MLD.1.11: Transmit Unsolicited Reports

Purpose: To verify that the NUT properly transmits unsolicited Reports when joining a group.

References:

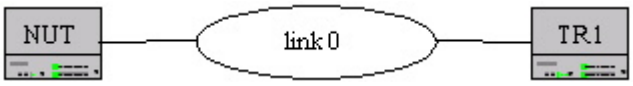
- [MLD] – Section 4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: When a node starts listening to a multicast address on an interface, it should immediately transmit an unsolicited Report for that address on that interface, in case it is the first listener on the link. To cover the possibility of the initial Report being lost or damaged, it is recommended that it be reported once or twice after short delays, [Unsolicited Report Interval].

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.



Procedure:

1. Configure the NUT to join the multicast group FF1E::1:3. Note the NUT's Unsolicited Report Interval. (Should default to 10).
2. Observe the packets transmitted by the NUT on link 0.

Observable Results:

Step 2: The NUT should transmit two Reports [Unsolicited Report Interval] (default 10) seconds apart after joining the multicast group FF1E::1:3.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.

Test MLD.1.12: Link-Scope All-Nodes

Purpose: To verify that the NUT properly handles the Link-Scope All-Nodes Multicast address.

References:

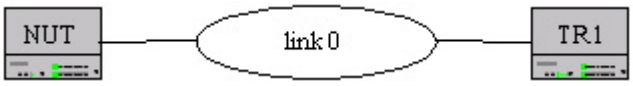
- [MLD] – Section 5

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: The link-scope all-nodes address (FF02::1) is handled as a special case. The node starts in Idle Listener state for that address on every interface, never transitions to another state, and never send a Report or a Done for that address.

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.



Procedure:

1. TR1 transmits a Multicast-Address-Specific Query for address FF02::1 (link-scope all-nodes address).
2. Observe the NUT.

Observable Results:

Step 2: The NUT should not transmit a Report for the link-scope all-nodes address FF02::1.

Possible Problems:

- None.

Test MLD.1.13: Transmit Done Message

Purpose: To verify that a node properly transmits Done Messages.

References:

- [MLD] – Sections 3, 3.2, 3.4, 3.5, 3.7 and 4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: When a node ceases to listen to a multicast address on an interface it should send a single Done message to the link-scope all-routers multicast address (FF02::2), carrying in its multicast Address field the address to which it is ceasing to listen. If the node's most recent Report message was suppressed by hearing another Report message, it MAY send nothing, as it is highly likely that there is another listener for that address still present on the same link. If this optimization is implemented, it MUST be able to be turned off but SHOULD default to on.

MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. All MLD messages described in this document are sent with a link-local IPv6 Source Address, an IPv6 Hop Limit of 1, and an IPv6 Router Alert option in a Hop-by-Hop Options header. The checksum in a Query message is the standard ICMPv6 checksum, covering the entire MLD message plus a "pseudo-header" of IPv6 header fields.

MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. The code field is initialized to zero by the sender; ignored by receivers. The reserved field is initialized to zero by the sender; ignored by receivers.

The length of received MLD message is computed by taking the IPv6 Payload Length value and subtracting the length of any IPv6 extension headers present between the IPv6 header and the MLD message. If that length is greater than 24 octets, that indicates that there are other fields present beyond the fields described above, perhaps belonging to a future backwards-compatible version of MLD. An implementation of this version of MLD MUST NOT send an MLD message longer than 24 octets.

The Maximum Response Delay field is meaningful only in Query messages, and specifies the maximum allowed delay before sending a responding Report. In all other messages it is set to zero by the sender.

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.

Procedure:

Part A: Done Message

1. Configure the NUT to join the multicast group FF1E::1:3.
2. Configure the NUT to leave the multicast group FF1E::1:3.
3. Observe the packets transmitted by the NUT on link 0.

Part B: Done Optimization – Default on

4. Configure the NUT to join the multicast group FF1E::1:3.
5. Enable TN1 on link 0. TN1 is also a listener for multicast group FF1E::1:3.
6. If the optimization is implemented, make sure the NUT is configured to not send Done messages if its report messages for FF1E::1:3 are suppressed.
7. On Link 0, TR1 transmits a Multicast-Address-Specific Query for group FF1E::1:3.
8. On Link 0, TN1 immediately transmits a Report for the multicast group FF1E::1:3.
9. Configure the NUT to leave the multicast group FF1E::1:3.
10. Observe the packets transmitted on link 0.

Part C: Done Optimization – Turn off

11. Configure the NUT to join the multicast group FF1E::1:3.
12. Enable TN1 on link 0. TN1 is also a listener for multicast group FF1E::1:3.
13. If the optimization is implemented, configure the NUT to still send Done messages even if its report messages for FF1E::1:3 are suppressed.
14. On Link 0, TR1 transmits a Multicast-Address-Specific Query for group FF1E::1:3.
15. On Link 0, TN1 immediately transmits a Report for the multicast group FF1E::1:3.
16. Configure the NUT to leave the multicast group FF1E::1:3.
17. Observe the packets transmitted by the NUT on link 0.

Observable Results:

- *Part A*

  Step 3: The NUT should transmit a Done message with the multicast address field set to FF1E::1:3 to the link-scope all-routers multicast address (FF02::2) after leaving the group. The Done message should contain:
  - link-local IPv6 Source Address
  - IPv6 Hop Limit of 1
  - IPv6 Router Alert option in a Hop-by-Hop Options header
  - Valid checksum
  - Code field value = 0
  - Reserved field value = 0
  - Maximum Response Delay field value = 0

  The Done message must not be longer than 24 octets in length.
- *Part B*

  Step 6: If the NUT does not support Done Message optimization then Part B may be skipped. If the NUT supports the Done Message optimization described in the discussion, by default it should be turned on.

  Step 10: The NUT should not transmit a Done message after leaving the multicast group FF1E::1:3.
- *Part C*

Step 13: If the NUT does not support Done Message optimization then Part C may be skipped. If the NUT supports the Done Message optimization described in the discussion, it must be able to be turned off.
Step 17: The NUT should transmit a Done message with the multicast group set to FF1E::1:3 to the link-scope all-routers multicast address (FF02::2) after leaving the multicast group FF1E::1:3. The Done message should contain:

- link-local IPv6 Source Address
- IPv6 Hop Limit of 1
- IPv6 Router Alert option in a Hop-by-Hop Options header
- Valid checksum
- Code field value = 0
- Reserved field value = 0
- Maximum Response Delay field value = 0

The Done message must not be longer than 24 octets in length.

Possible Problems:

- The NUT may not support Done Message optimization.
- The NUT may transmit a Report Message before TN1 (if it chooses a Response Delay of 0). In this case, the above behavior cannot be observed. (Parts B and C).

Test MLD.1.14: Node State Transition – Idle Listener

Purpose: To verify that a node in state Idle Listener correctly handles state transition.

References:

- [MLD] – Section 5

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion:
States
"Idle Listener" state is when the node is listening to the address on the interface and does not have a report delay timer running for that address.

"Non-Listener" state is when the node is not listening to the address on the interface (i.e. no upper-layer protocol or application has requested reception of packets to that multicast address). This is the initial state for all multicast addresses on all interfaces. It requires no storage in the node.

"Delaying Listener"state is when the node is listening to the address on the interface and has a report delay timer running for that address.

Events
"Stop Listening" occurs when the node stops listening to the address on the interface. It may occur only in the Delaying Listener and Idle Listener states.

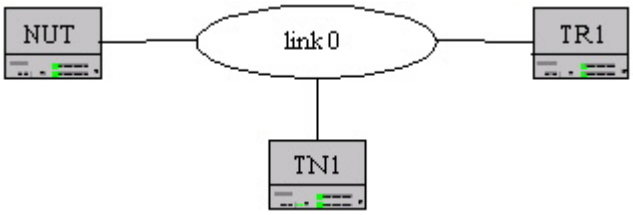
"Query Received" occurs when the node receives either a valid General Query message, or a valid Multicast-Address-Specific Query message. To be valid, the Query message MUST come from a link-local IPv6 Source Address, be at least 24 octets long, and have a correct MLD checksum. The Multicast Address field in the MLD message must contain either zero (a General Query) or a valid multicast address (a Multicast- Address-Specific Query). A General Query applies to all multicast addresses on the interface from which the Query is received. A Multicast-Address-Specific Query applies to a single multicast address on the interface from which the Query is received. Queries are ignored for addresses in the Non-Listener state.

Actions
"Send Done" for the address on the interface. If the flag saying we were the last node to report is cleared, this action MAY be skipped. The Done message is sent to the link-scope all-routers address (FF02::2).

"Start timer" for the address on the interface, using a delay value chosen uniformly from the interval [0, Maximum Response Delay], where Maximum Response Delay is specified in the Query. If this is an

unsolicited Report, the timer is set to a delay value chosen uniformly from the interval [0, [Unsolicited Report Interval].

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.



Procedure:

Part A: Query Received

1. Start with the NUT as a listener for multicast group FF1E::1:3. (The NUT has already joined multicast group FF1E::1:3.)
2. TR1 transmits a Multicast-Address-Specific Query for group FF1E::1:3 with a Maximum Response Delay of 1000.
3. Observe the packets transmitted by the NUT on link 0.

Part B: Stop Listening - Last to Report Flag Set

4. Start with the NUT as a listener for multicast group FF1E::1:3. (The NUT has already joined multicast group FF1E::1:3.)
5. TR1 transmits a Multicast-Address-Specific Query for group FF1E::1:3.
6. Observe the packets transmitted by the NUT on link 0.
7. Wait for the NUT to transition to state Idle Listener again.
8. Configure the NUT to stop listening to multicast group FF1E::1:3.
9. Observe the packets transmitted by the NUT on link 0.

Part C: Stop Listening - Last to Report Flag Clear

10. Start with the NUT as a listener for multicast group FF1E::1:3. (The NUT has already joined multicast group FF1E::1:3.)
11. TR1 transmits a Multicast-Address-Specific Query for group FF1E::1:3.
12. TN1 immediately transmits a Report Message for multicast group FF1E::1:3.
13. Observe the packets transmitted on link 0.
14. Wait for the NUT to transition to state Idle Listener again.
15. Configure the NUT to stop listening to multicast group FF1E::1:3.
16. Observe the packets transmitted by the NUT on link 0.

Observable Results:

- *Part A*

  Step 3: After receiving the Query Message from TR1, the NUT should enter the "Query Received" event. The NUT should start the timer for the multicast address FF1E::1:3 using a delay value between [0, Max Response Delay]. In this case, that is [0, 1000]. Since the NUT

then transitions to “Delaying Listener” state, a report will be sent between 0 and 1000 milliseconds.

- *Part B*

  Step 6: After receiving the Query Message from TR1, the NUT should send a Report message for multicast group FF1E::1:3 and set its flag indicating it was the last to send a report for this group. The NUT should then transition back to “Idle Listener” state.
  Step 9: After the NUT is configured to stop listening to multicast group FF1E::1:3, it should enter “Stop Listening” event. Since the NUT’s flag is set indicating the NUT was the last to send a report for multicast group FF1E::1:3, it should send a Done Message on link 0 for group FF1E::1:3. The NUT should then transition to state “Non-Listener”.

- *Part C*

  Step 13: After seeing the Report Message from TR1, the NUT should not send a Report message for multicast group FF1E::1:3 and should clear its flag indicating it was not the last to send a report for this group. The NUT should then transition back to “Idle Listener” state.
  Step 16: After the NUT is configured to stop listening to multicast group FF1E::1:3, it should enter “Stop Listening” event. The NUT’s flag should be clear indicating the NUT was not the last to send a report for multicast group FF1E::1:3. Therefore, it does not have to send a Done Message on link 0 for group FF1E::1:3. The NUT should then transition to state “Non-Listener”.

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.
- The NUT may transmit a Report Message before TN1 (if it chooses a Response Delay of 0). In this case, the above behavior cannot be observed. (Part C).

Test MLD.1.15: Node State Transition – Delaying Listener

Purpose: To verify that a node in state Delaying Listener correctly handles state transition.

References:

- [MLD] – Section 5

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion:
States
"Delaying Listener" state is when the node is listening to the address on the interface and has a report delay timer running for that address.

"Idle Listener" state is when the node is listening to the address on the interface and does not have a report delay timer running for that address.

"Non-Listener" state is when the node is not listening to the address on the interface (i.e. no upper-layer protocol or application has requested reception of packets to that multicast address). This is the initial state for all multicast addresses on all interfaces. It requires no storage in the node.

Events
"Stop Listening" occurs when the node stops listening to the address on the interface. It may occur only in the Delaying Listener and Idle Listener states.

"Query Received" occurs when the node receives either a valid General Query message, or a valid Multicast-Address-Specific Query message. To be valid, the Query message MUST come from a link-local IPv6 Source Address, be at least 24 octets long, and have a correct MLD checksum. The Multicast Address field in the MLD message must contain either zero (a General Query) or a valid multicast address (a Multicast- Address-Specific Query). A General Query applies to all multicast addresses on the interface from which the Query is received. A Multicast-Address-Specific Query applies to a single multicast address on the interface from which the Query is received. Queries are ignored for addresses in the Non-Listener state.

"Report Received" occurs when the node receives a valid MLD Report message. To be valid, the Report message MUST come from a link-local IPv6 Source Address, be at least 24 octets long, and have a correct MLD checksum. A Report applies only to the address identified in the Multicast Address field of the Report, on the interface from which the Report is received. It is ignored in the Non-Listener or Idle Listener state.

"Timer Expired" occurs when the report delay timer for the address on the interface expires. It may occur only in the Delaying Listener state.

Actions
“Send Done" for the address on the interface. If the flag saying we were the last node to report is cleared, this action MAY be skipped. The Done message is sent to the link-scope all-routers address (FF02::2).

“Send report" for the address on the interface. The Report message is sent to the address being reported.

"Set flag" that we were the last node to send a report for this address.

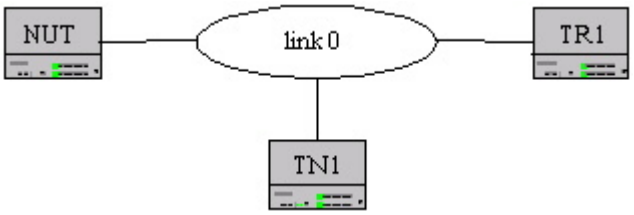
"Stop Timer" for the address on the interface.

"Clear Flag" since we were not the last node to send a report for this address.

"Reset Timer" for the address on the interface to a new value, using a delay value chosen uniformly from the interval [0, Maximum Response Delay], as described in "start timer".

"Start timer" for the address on the interface, using a delay value chosen uniformly from the interval [0, Maximum Response Delay], where Maximum Response Delay is specified in the Query. If this is an unsolicited Report, the timer is set to a delay value chosen uniformly from the interval [0, [Unsolicited Report Interval]].

Test Setup: TR1 is the Querier on link 0. TR1 has a numerically lower IPv6 source address than the NUT.



Procedure:

Part A: Report Received

1. Start with the NUT as a listener for multicast group FF1E::1:3. (The NUT has already joined multicast group FF1E::1:3.)
2. TR1 transmits a Multicast-Address-Specific Query for group FF1E::1:3 with a Maximum Response Delay of 1000.
3. TN1 immediately transmits a Report Message for multicast group FF1E::1:3.
4. Observe the packets transmitted by the NUT on link 0.

Part B: Stop Listening - Last to Report Flag Set

5. Start with the NUT as a listener for multicast group FF1E::1:3. (The NUT has already joined multicast group FF1E::1:3.)

6. TR1 transmits a Multicast-Address-Specific Query for group FF1E::1:3.
7. Observe the packets transmitted by the NUT on link 0.
8. Wait for the NUT to transition to state Idle Listener again.
9. TR1 transmits a Multicast-Address-Specific Query for group FF1E::1:3 with a Maximum Response Delay of 5000.
10. Before the NUT's delay timer expires, configure the NUT to stop listening to multicast group FF1E::1:3.
11. Observe the packets transmitted by the NUT on link 0.

Part C: Stop Listening - Last to Report Flag Clear

12. Start with the NUT as a listener for multicast group FF1E::1:3. (The NUT has already joined multicast group FF1E::1:3.)
13. TR1 transmits a Multicast-Address-Specific Query for group FF1E::1:3.
14. TN1 immediately transmits a Report Message for multicast group FF1E::1:3.
15. Observe the packets transmitted on link 0.
16. Wait for the NUT to transition to state Idle Listener again.
17. TR1 transmits a Multicast-Address-Specific Query for group FF1E::1:3 with a Maximum Response Delay of 5000.
18. Before the NUT's delay timer expires, configure the NUT to stop listening to multicast group FF1E::1:3.
19. Observe the packets transmitted by the NUT on link 0.

Part D: Timer Expired

20. Start with the NUT as a listener for multicast group FF1E::1:3. (The NUT has already joined multicast group FF1E::1:3.)
21. TR1 transmits a Multicast-Address-Specific Query for group FF1E::1:3 with a Maximum Response Delay of 1000.
22. Observe the packets transmitted by the NUT on link 0.

Observable Results:

- *Part A*

  Step 4: After receiving the Report Message from TN1, the NUT should enter the "Report Received" event. The NUT should stop the timer for the multicast address FF1E::1:3 and clear its flag indicating it was not the last to send a report for this group. The NUT should then transition to "Idle Listener" state. The NUT must not send a Report Message for group FF1E::1:3.
- *Part B*

  Step 7: After receiving the Query Message from TR1, the NUT should send a Report message for multicast group FF1E::1:3 and set its flag indicating it was the last to send a report for this group. The NUT should then transition back to "Idle Listener" state.

  Step 9: When the NUT receives the Query Message from TR1, it should transition back to "Delaying Listener" state.

  Step 11: After the NUT is configured to stop listening to multicast group FF1E::1:3, it should enter "Stop Listening" event. Since the NUT's flag is set indicating the NUT was the last to send a report for multicast group FF1E::1:3, it should stop its timer for and send a Done Message on link 0 for group FF1E::1:3. The NUT should then transition to state "Non-Listener".
- *Part C*

Step 15: After seeing the Report Message from TR1, the NUT should not send a Report message for multicast group FF1E::1:3 and should clear its flag indicating it was not the last to send a report for this group. The NUT should then transition back to "Idle Listener" state.
Step 17: When the NUT receives the Query Message from TR1, it should transition back to "Delaying Listener" state.
Step 19: After the NUT is configured to stop listening to multicast group FF1E::1:3, it should enter "Stop Listening" event. The NUT's flag should be clear indicating the NUT was not the last to send a report for multicast group FF1E::1:3. Therefore, it does not have to send a Done Message on link 0 for group FF1E::1:3. The NUT should stop its timer for group FF1E::1:3 and then transition to state "Non-Listener".

- *Part D*

  Step 22: When the NUT's delay timer for group FF1E::1:3 expires, the NUT enters "timer expired" event. The NUT should send a report on link 0 for multicast group FF1E::1:3, and set its flag indicating it was the last to send a report for this group. The NUT should then transition to state "Idle Listener".

Possible Problems:

- It may not be possible to configure the Node to join a multicast group.
- The NUT may transmit a Report Message before TN1 (if it chooses a Response Delay of 0). In this case, the above behavior cannot be observed. (Parts A and C).

GROUP 2: Multicast Listener Discovery for Routers

Scope:

These tests are designed to verify Multicast Listener Discovery protocol operation. This section covers routers.

Overview:

MLD is used by IPv6 hosts to report their host group memberships to any immediately-neighboring multicast routers. MLD allows group membership terminations to be quickly reported to the routing protocol, which is important for high-bandwidth multicast groups and/or subnets with highly volatile group membership.

Test Implementation:

In each test in this section, a test tool is used to transmit and receive MLD packets. This simulates all test routers involved in the test procedure.

Result Determination:

Many tests in this section rely on the tester's ability to determine whether the RUT believes that a certain multicast group has members at a given time. It is presumed that this will be accomplished by enabling some multicast routing protocol, and monitoring routing messages send by the RUT to a neighbor. If this is not possible, it will be necessary for the tester to utilize whatever mechanism is available on the RUT to display a per-network list of multicast groups that presently have members. If none of these methods are available, it will not be possible to determine a pass or fail result for many of the tests in this section.

Test MLD.2.1: Transmission of Initial and General Queries

Purpose: Verify that the router running MLD properly implements transmission of initial Queries, as well as periodic transmission of General Queries.

References:

- [MLD] – Section 4

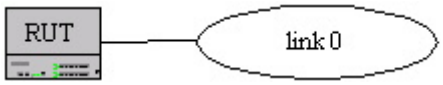
Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: On startup, a router should send [Startup Query Count] General Queries spaced closely together [Startup Query Interval] on all attached links in order to quickly and reliably discover the presence of multicast listeners on those links.

General Queries are sent to the link-scope all-nodes multicast address (FF02::1), with a Multicast Address Field of 0, and a Maximum Response Delay of [Query Response Interval].

Test Setup:



Procedure:

1. Restart MLD on the RUT.

Observable Results:

Step 1: The RUT should transmit [Startup Query Count (2)] General Queries spaced at [Startup Query Interval (31.25)] seconds. After the initialization, the RUT should transition into the Querier state, and transmit one General Query every [Query Interval (125)] seconds. The General Query should be sent to the all-nodes multicast address. The multicast address field should be set to 0, and the Maximum Response Delay should be set to the Query Response Interval (Default 10000).

Possible Problems:

- Transmission of initial queries is only recommended, so a device cannot fail that part of the test.

Test MLD.2.2: Transmit Queries

Purpose: Verify that the router running MLD properly transmits General and Multicast-Address-Specific Queries.

References:

- [MLD] – Section 3, 3.2, 3.4, 3.5, 3.6, 3.7, 4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion:
General Queries are sent to the link-scope all-nodes multicast address (FF02::1), with a Multicast Address Field of 0, and a Maximum Response Delay of [Query Response Interval].

Multicast-Address-Specific Queries are sent to the multicast address being queried, with a Multicast Address Field set to the specific IPv6 multicast address being queried.

MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. All MLD messages described in this document are sent with a link-local IPv6 Source Address, an IPv6 Hop Limit of 1, and an IPv6 Router Alert option in a Hop-by-Hop Options header. The checksum in a Query message is the standard ICMPv6 checksum, covering the entire MLD message plus a "pseudo-header" of IPv6 header fields.

MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. The code field is initialized to zero by the sender; ignored by receivers. The reserved field is initialized to zero by the sender; ignored by receivers.

The length of received MLD message is computed by taking the IPv6 Payload Length value and subtracting the length of any IPv6 extension headers present between the IPv6 header and the MLD message. If that length is greater than 24 octets, that indicates that there are other fields present beyond the fields described above, perhaps belonging to a future backwards-compatible version of MLD. An implementation of this version of MLD MUST NOT send an MLD message longer than 24 octets.

The Maximum Response Delay field is meaningful only in Query messages, and specifies the maximum allowed delay before sending a responding Report. In all other messages it is set to zero by the sender.

Test Setup:

Procedure:

Part A: General Query

1. Wait for the RUT to send a General Query. It should be the Querier on link 0.

Part B: Multicast-Address-Specific Query

2. Connect TN1 to Link 0.
3. TN1 transmits a report for Multicast address FF1E::1:3.
4. After the RUT transitions to state Listeners Present for address FF1E::1:3, TN1 transmits a Done Message for Multicast address FF1E::1:3.
5. Observe the packets transmitted by the RUT on link 0.

Part C: Multiple Multicast-Address-Specific Query

6. Connect TN1 to Link 0.
7. TN1 transmits a report for Multicast address FF1E::1:3.
8. TN1 transmits a report for Multicast address FF1E::1:4.
9. After the RUT transitions to state Listeners Present for address FF1E::1:3, TN1 transmits a Done Message for Multicast address FF1E::1:3.
10. Observe the packets transmitted by the RUT on link 0.
11. After the RUT transitions to state Listeners Present for address FF1E::1:4, TN1 transmits a Done Message for Multicast address FF1E::1:4.
12. Observe the packets transmitted by the RUT on link 0.

Part D: No Multicast-Address-Specific Query

13. Connect TN1 to Link 0.
14. TN1 transmits a report for Multicast address FF1E::1:3.
15. After the RUT transitions to state Listeners Present for address FF1E::1:3, TN1 transmits a Done Message for Multicast address FF1E::1:4.
16. Observe the packets transmitted by the RUT on link 0.

Observable Results:

- *Part A*

  Step 1: The RUT should transmit a General Query message with the Multicast Address Field set to 0 with a destination to the multicast address FF02::1. The General Query message should contain:

  - link-local IPv6 Source Address
  - IPv6 Hop Limit of 1
  - IPv6 Router Alert option in a Hop-by-Hop Options header
  - Valid checksum
  - Code field value = 0
  - Reserved field value = 0
  - Maximum Response Delay field value = Maximum Response Delay

  The General Query message must not be longer than 24 octets in length.

- *Part B*

  Step 5: After the RUT sees the Done Message from TN1, it should send a Multicast-Address-Specific Query for address FF1E::1:3. The Multicast-Address-Specific Query should contain a Multicast Address Field set to FF1E::1:3 with a destination to the multicast address FF1E::1:3. The Multicast-Address-Specific Query should contain:

  - link-local IPv6 Source Address

- IPv6 Hop Limit of 1
- IPv6 Router Alert option in a Hop-by-Hop Options header
- Valid checksum
- Code field value = 0
- Reserved field value = 0
- Maximum Response Delay field value = Maximum Response Delay

The Multicast-Address-Specific Query must not be longer than 24 octets in length.

- *Part C*

  Step 10: After the RUT sees the Done Message from TN1, it should send a Multicast-Address-Specific Query for address FF1E::1:3. The Multicast-Address-Specific Query should contain a Multicast Address Field set to FF1E::1:3 with a destination to the multicast address FF1E::1:3. The Multicast-Address-Specific Query should contain:

  - link-local IPv6 Source Address
  - IPv6 Hop Limit of 1
  - IPv6 Router Alert option in a Hop-by-Hop Options header
  - Valid checksum
  - Code field value = 0
  - Reserved field value = 0
  - Maximum Response Delay field value = Maximum Response Delay

  The Multicast-Address-Specific Query must not be longer than 24 octets in length.

  Step 12: After the RUT sees the Done Message from TN1, it should send a Multicast-Address-Specific Query for address FF1E::1:4. The Multicast-Address-Specific Query should contain a Multicast Address Field set to FF1E::1:4 with a destination to the multicast address FF1E::1:4. The Multicast-Address-Specific Query should contain:

  - link-local IPv6 Source Address
  - IPv6 Hop Limit of 1
  - IPv6 Router Alert option in a Hop-by-Hop Options header
  - Valid checksum
  - Code field value = 0
  - Reserved field value = 0
  - Maximum Response Delay field value = Maximum Response Delay

  The Multicast-Address-Specific Query must not be longer than 24 octets in length.

- *Part D*

  Step 16: After the RUT sees the Done Message from TN1, it should not send a Multicast-Address-Specific Query for address FF1E::1:4.

Possible Problems:

- None.

Test MLD.2.3: Receive Invalid Done Messages

Purpose: To verify that a node properly ignores invalid Done Messages.

References:

- [MLD] – Sections 3, 3.3, 5, and 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. All MLD messages described in this document are sent with a link-local IPv6 Source Address, an IPv6 Hop Limit of 1, and an IPv6 Router Alert option in a Hop-by-Hop Options header. The checksum in a Query message is the standard ICMPv6 checksum, covering the entire MLD message plus a "pseudo-header" of IPv6 header fields.

To be valid, a Done message MUST come from a link-local IPv6 source address, be at least 24 octets long, and have a correct MLD checksum.

Normally, when a Querier in Listeners Present state receives a valid Done message, it should start a timer and send a Multicast-Address-Specific Query in response. In this test, because the Done Messages are invalid, the router under test should not perform these transitions.

Test Setup: RUT is the Querier on Link 0. The RUT has a numerically lower IPv6 source address than TN1.

Procedure:

Part A: Invalid Checksum

1. TN1 transmits a Report for Multicast Address FF1E::1:3. TN1 responds to any queries sent by the RUT for this address.
2. After the RUT transitions to state Listeners Present for address FF1E::1:3, TN1 transmits a Done Message for FF1E::1:3 with an invalid checksum.
3. Wait for [Last Listener Query Interval] * [Last Listener Query Count] (default 2 seconds) but no longer than Multicast Listener Interval.
4. Observe the packets transmitted by the RUT on link 0.

Part B: Global Source Address

5. TN1 transmits a Report for Multicast Address FF1E::1:3. TN1 responds to any queries sent by the RUT for this address.

6. After the RUT transitions to state Listeners Present for address FF1E::1:3, TN1 transmits a Done Message for FF1E::1:3 with TN1's Global Address as the IPv6 Source Address.
7. Wait for [Last Listener Query Interval] * [Last Listener Query Count] (default 2 seconds) but no longer than Multicast Listener Interval.
8. Observe the packets transmitted by the RUT on link 0.

Part C: Length < 24 octets

9. TN1 transmits a Report for Multicast Address FF1E::1:3. TN1 responds to any queries sent by the RUT for this address.
10. After the RUT transitions to state Listeners Present for address FF1E::1:3, TN1 transmits a Done Message for FF1E::1:3 with a length of 20 octets.
11. Wait for [Last Listener Query Interval] * [Last Listener Query Count] (default 2 seconds) but no longer than Multicast Listener Interval.
12. Observe the packets transmitted by the RUT on link 0.

Observable Results:

Steps 4, 8, and 12: The RUT should ignore the Done Messages sent by TN1 and should not transition to state Checking Listeners. A Mutlicast-Address-Specific Query for FF1E::1:3 should not be sent in response to the Invalid Done Messages.

Possible Problems:

- None.

Test MLD.2.4: Receive Done Messages with Unexpected Values

Purpose: To verify that a node properly processes Done Messages with unexpected values.

References:

- [MLD] – Sections 3.2, 3.4, 3.5, and 3.7

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. The code field is initialized to zero by the sender; ignored by receivers. The reserved field is initialized to zero by the sender; ignored by receivers.

The length of received MLD message is computed by taking the IPv6 Payload Length value and subtracting the length of any IPv6 extension headers present between the IPv6 header and the MLD message. If that length is greater than 24 octets, that indicates that there are other fields present beyond the fields described above, perhaps belonging to a future backwards-compatible version of MLD. An implementation of this version of MLD MUST NOT send an MLD message longer than 24 octets and MUST ignore anything past the first 24 octets of a received MLD message. The MLD checksum MUST be computed over the entire MLD message, not just the first 24 octets.

The Maximum Response Delay field is meaningful only in Query messages. In all other messages it is set to zero by the sender and ignored by the receivers.

Test Setup: RUT is the Querier on Link 0. The RUT has a numerically lower IPv6 source address than TN1.

Procedure:

Part A: Code Field

1. TN1 transmits a Report for Multicast Address FF1E::1:3. TN1 responds to any queries sent by the RUT for this address.
2. After the RUT transitions to state Listeners Present for address FF1E::1:3, TN1 transmits a Done Message for FF1E::1:3 with a code field with a value of 100.
3. Observe the packets transmitted by the RUT on link 0.

Part B: Reserved Field

4. TN1 transmits a Report for Multicast Address FF1E::1:3. TN1 responds to any queries sent by the RUT for this address.
5. After the RUT transitions to state Listeners Present for address FF1E::1:3, TN1 transmits a Done Message for FF1E::1:3 without a reserved field with a value of 30.

6. Observe the packets transmitted by the RUT on link 0.

Part C: Length > 24 octets

7. TN1 transmits a Report for Multicast Address FF1E::1:3. TN1 responds to any queries sent by the RUT for this address.
8. After the RUT transitions to state Listeners Present for address FF1E::1:3, TN1 transmits a Done Message for FF1E::1:3 where the length of the message is 32 octets long.
9. Observe the packets transmitted by the RUT on link 0.

Part D: Maximum Response Delay Field

10. TN1 transmits a Report for Multicast Address FF1E::1:3. TN1 responds to any queries sent by the RUT for this address.
11. After the RUT transitions to state Listeners Present for address FF1E::1:3, TN1 transmits a Done Message for FF1E::1:3 with a Maximum Response Delay field with a value of 1000.
12. Observe the packets transmitted by the RUT on link 0.

Observable Results:

Steps 3, 6, 9, and 12: The RUT should accept the Done Messages sent by TN1 and should transition to state Checking Listeners. A Multicast-Address-Specific Query for FF1E::1:3 should be sent in response to the Done Messages.

Possible Problems:

- None.

Test MLD.2.5: Receive Invalid Query Messages

Purpose: To verify that a node properly ignores invalid Query Messages.

References:

- [MLD] – Sections 3, 3.3, 4, and 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. All MLD messages described in this document are sent with a link-local IPv6 Source Address, an IPv6 Hop Limit of 1, and an IPv6 Router Alert option in a Hop-by-Hop Options header. The checksum in a Query message is the standard ICMPv6 checksum, covering the entire MLD message plus a "pseudo-header" of IPv6 header fields.

If a router hears a Query message whose IPv6 Source Address is numerically less than its own selected address for that link, it MUST become a Non-Querier on that link.

"query received from a router with a lower IP address" occurs when a valid MLD Query is received from a router on the same link with a lower IPv6 Source Address. To be valid, the Query message MUST come from a link-local IPv6 Source Address, be at least 24 octets long, and have a correct MLD checksum.

Test Setup: RUT is the Querier on link 0. The RUT has a numerically lower IPv6 source address than TR1.

Procedure:

Part A: Invalid Checksum

1. TR1 has a lower IPv6 source address than the RUT.
2. TR1 transmits a General Query sent to the all-nodes multicast address (FF02::1), with an invalid checksum.
3. Observe the RUT.

Part B: Global Source Address

4. TR1 has a lower IPv6 source address than the RUT.
5. TR1 transmits a General Query sent to the all-nodes multicast address (FF02::1), with TN1's Global Address as the IPv6 Source Address.
6. Observe the RUT.

Part C: Length < 24 octets

7. TR1 has a lower IPv6 source address than the RUT.

8. TR1 transmits a General Query sent to the all-nodes multicast address (FF02::1), with a length of 20 octets.
9. Observe the RUT.

Observable Results:

Steps 3, 6, and 9: The RUT should ignore the General Query Messages sent by TR1 and should not transition to state "Non-Querier". The RUT should remain as Querier periodically [Query Interval] sending General Queries on link 0. All queries from the RUT should be sent with a link-local IPv6 Source Address, an IPv6 Hop Limit of 1, and an IPv6 Router Alert option in a Hop-by-Hop Options header.

Possible Problems:

- None.

Test MLD.2.6: Receive Query Messages with Unexpected Values

Purpose: To verify that a node properly processes Query Messages with unexpected values.

References:

- [MLD] – Sections 3.2, 3.5, 3.7, 4 and 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. The code field is initialized to zero by the sender; ignored by receivers. The reserved field is initialized to zero by the sender; ignored by receivers.

The length of received MLD message is computed by taking the IPv6 Payload Length value and subtracting the length of any IPv6 extension headers present between the IPv6 header and the MLD message. If that length is greater than 24 octets, that indicates that there are other fields present beyond the fields described above, perhaps belonging to a future backwards-compatible version of MLD. An implementation of this version of MLD MUST NOT send an MLD message longer than 24 octets and MUST ignore anything past the first 24 octets of a received MLD message. The MLD checksum MUST be computed over the entire MLD message, not just the first 24 octets.

If a router hears a Query message whose IPv6 Source Address is numerically less than its own selected address for that link, it MUST become a Non-Querier on that link.

"query received from a router with a lower IP address" occurs when a valid MLD Query is received from a router on the same link with a lower IPv6 Source Address. To be valid, the Query message MUST come from a link-local IPv6 Source Address, be at least 24 octets long, and have a correct MLD checksum.

Test Setup: RUT is the Querier on link 0. The RUT has a numerically lower IPv6 source address than TR1.

Procedure:

Part A: Code Field

1. TR1 has a lower IPv6 source address than the RUT.
2. TR1 transmits a General Query sent to the all-nodes multicast address (FF02::1), with the code field set to 100.
3. Observe the packets transmitted by the RUT on link 0.

Part B: Reserved Field

4. TR1 has a lower IPv6 source address than the RUT.

5. TR1 transmits a General Query sent to the all-nodes multicast address (FF02::1), with a reserved field with a value of 30.
6. Observe the packets transmitted by the RUT on link 0.

Part C: Length > 24 octets

7. TR1 has a lower IPv6 source address than the RUT.
8. TR1 transmits a General Query sent to the all-nodes multicast address (FF02::1), where the length of the message is 32 octets long.
9. Observe the packets transmitted by the RUT on link 0.

Observable Results:

Steps 3, 6, and 9: The RUT should process the General Query Messages sent by TR1 and should transition to state Non Querier. The RUT should not send periodic General Queries on link 0.

Possible Problems:

- None.

Test MLD.2.7: Receive Invalid Report Messages

Purpose: To verify that a node properly ignores invalid Report Messages.

References:

- [MLD] – Sections 3, 3.3, 5, and 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. All MLD messages described in this document are sent with a link-local IPv6 Source Address, an IPv6 Hop Limit of 1, and an IPv6 Router Alert option in a Hop-by-Hop Options header. The checksum in a Query message is the standard ICMPv6 checksum, covering the entire MLD message plus a "pseudo-header" of IPv6 header fields.

To be valid, a Query message MUST come from a link-local IPv6 source address, be at least 24 octets long, and have a correct MLD checksum.

Normally, when a router receives a valid Report, and it is in Listener's Present state, it restarts a timer and stays in Listeners Present state. If that timer [Multicast Listener Interval] (default 260 seconds) expires without further valid reports, then the router assumes there are no listeners for this address and transitions to No Listeners Present.

Test Setup: RUT is the Querier on Link 0. The RUT has a numerically lower IPv6 source address than TN1.

Procedure:

Part A: Invalid Checksum

1. TN1 transmits a Report for Multicast Address FF1E::1:3.
2. After 200 seconds, TN1 transmits a Report for address FF1E::1:3 with an invalid checksum.
3. Wait for 60 seconds (the rest of Multicast Listener Interval).
4. TN1 transmits a Done Message for Multicast Address FF1E::1:3.
5. Observe the RUT.

Part B: Global Source Address

6. TN1 transmits a Report for Multicast Address FF1E::1:3.
7. After 200 seconds, TN1 transmits a Report for address FF1E::1:3 with a source address set to TN1's Global Address on link 0.
8. Wait for 60 seconds (the rest of Multicast Listener Interval).

9. TN1 transmits a Done Message for Multicast Address FF1E::1:3.
10. Observe the RUT.

Part C: Length < 24 octets

11. TN1 transmits a Report for Multicast Address FF1E::1:3.
12. After 200 seconds, TN1 transmits a Report for address FF1E::1:3 with a length of 20 octets.
13. Wait for 60 seconds (the rest of Multicast Listener Interval).
14. TN1 transmits a Done Message for Multicast Address FF1E::1:3.
15. Observe the RUT.

Observable Results:

Steps 5, 10, and 15: The RUT should ignore the Report Messages sent by TN1 and should not stay in state Listeners Present. After the rest of Multicast Listener Interval Expires from when the first and valid report was received, the RUT should no longer show listeners for address FF1E::1:3 and should transition to state No Listeners Present. When TN1 transmits a Done Message, because the RUT no longer has any listeners for address FF1E::1:3, it must not transmit a Multicast Address Specific Query for address FF1E::1:3.

Possible Problems:

- None.

Test MLD.2.8: Receive Report Messages with Unexpected Values

Purpose: To verify that a node properly processes Report Messages with unexpected values.

References:

- [MLD] – Sections 3.2, 3.4, 3.5, 3.7 and 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: MLD is a subset of the set of ICMPv6 messages, and MLD messages are identified in IPv6 packets by a preceding Next Header value of 58. The code field is initialized to zero by the sender; ignored by receivers. The reserved field is initialized to zero by the sender; ignored by receivers.

The length of received MLD message is computed by taking the IPv6 Payload Length value and subtracting the length of any IPv6 extension headers present between the IPv6 header and the MLD message. If that length is greater than 24 octets, that indicates that there are other fields present beyond the fields described above, perhaps belonging to a future backwards-compatible version of MLD. An implementation of this version of MLD MUST NOT send an MLD message longer than 24 octets and MUST ignore anything past the first 24 octets of a received MLD message. The MLD checksum MUST be computed over the entire MLD message, not just the first 24 octets.

When a router receives a valid Report, and it is in Listener's Present state, it restarts a timer and stays in Listeners Present state. If that timer [Multicast Listener Interval] (default 260 seconds) expires without further valid reports, then the router assumes there are no listeners for this address and transitions to No Listeners Present.

The Maximum Response Delay field is meaningful only in Query messages. In all other messages it is set to zero by the sender and ignored by the receivers.

Test Setup: RUT is the Querier on Link 0. The RUT has a numerically lower IPv6 source address than TN1.

Procedure:

Part A: Code Field

1. TN1 transmits a Report for Multicast Address FF1E::1:3.
2. After 200 seconds, TN1 transmits a Report for address FF1E::1:3 with a code field value of 100.
3. Wait for 60 seconds (the rest of Multicast Listener Interval).
4. TN1 transmits a Done Message for Multicast Address FF1E::1:3.
5. Observe the RUT.

Part B: Reserved Field

6. TN1 transmits a Report for Multicast Address FF1E::1:3.
7. After 200 seconds, TN1 transmits a Report for address FF1E::1:3 with a reserved field value of 30.
8. Wait for 60 seconds (the rest of Multicast Listener Interval).
9. TN1 transmits a Done Message for Multicast Address FF1E::1:3.
10. Observe the RUT.

Part C: Length > 24 octets

11. TN1 transmits a Report for Multicast Address FF1E::1:3.
12. After 200 seconds, TN1 transmits a Report for address FF1E::1:3 where the length of the message is 32 octets long.
13. Wait for 60 seconds (the rest of Multicast Listener Interval).
14. TN1 transmits a Done Message for Multicast Address FF1E::1:3.
15. Observe the RUT.

Part D: Maximum Response Delay Field

16. TN1 transmits a Report for Multicast Address FF1E::1:3.
17. After 200 seconds, TN1 transmits a Report for address FF1E::1:3 with a Maximum Response Delay field with a value of 1000.
18. Wait for 60 seconds (the rest of Multicast Listener Interval).
19. TN1 transmits a Done Message for Multicast Address FF1E::1:3.
20. Observe the RUT.

Observable Results:

Steps 5, 10, 15 and 20: The RUT should accept the Report sent by TN1 and should stay in state Listeners Present after 60 seconds. Because the RUT should still list address FF1E::1:3 as having listeners, when it receives the Done message from TN1, the RUT should send a Multicast Address Specific Query for address FF1E::1:3.

Possible Problems:

- None.

Test MLD.2.9: Other Querier Present Interval

Purpose: To verify that a router running MLD properly implements Other Querier Present Interval.

References:

- [MLD] – Section 4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: All routers start up as a Querier on each of their attached links. If a router hears a Query message whose IPv6 Source Address is numerically less than its own selected address for that link, it must become a Non-Querier on that link. If [Other Querier Present Interval] passes without receiving, from a particular attached link, any Queries from a router with an address less than its own, a router resumes the role of Querier on that link.

Test Setup: Configure TR1 to have a lower IPv6 source address than that of the RUT.

Procedure:

Part A: Other Querier Present Timer Set

1. On Link 0, the TR1 transmits a general query to the all-systems multicast group every (Query Interval) 125 seconds.
2. TR1 ceases transmission of General Queries.
3. Observe the time from when the TR1 sent its last General Query to when the RUT transitions to the Querier state and transmits a Query.

Part B: Other Querier Present Timer Reset

4. On Link 0, the TR1 transmits a general query to the all-systems multicast group every (Query Interval) 125 seconds.
5. TR1 ceases transmission of General Queries for a time that is greater than Query Interval, 125 seconds, and less than Other Querier Present Interval, 255 seconds.
6. TR1 resumes transmission of general queries as in step 4.
7. Observe the packets transmitted by the RUT.

Observable Results:

- *Part A*

  Step 1: After receiving a Query from TR1 the RUT must transition to Non Querier.

Step 3: The Time from when TR1 sends its last General Query to when the RUT transitions to the Querier state and transmits a Query should be equal to Other Querier Present Interval.

- *Part B*

  Step 4: After receiving a Query from TR1 the RUT must transition to Non Querier.

  Step 7: When the RUT receives the General Queries from TR1 on link 0, it should restart its Other Query Present Timer. The RUT must not become the Querier on link 0 and must not transmit any Query messages.

Possible Problems:

- None

Test MLD.2.10: Multicast Listener Interval

Purpose: To verify that a router properly implements the Members Present state for a multicast group when it is in Querier state.

References:

- [MLD] – Section 4, 6 and 7.4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: The MLD Querier sends periodic MLD Queries to the network to determine the group membership. All multicast routers start up as a Querier on each attached network and initialize in the No Listeners Present state.

When a router receives a Report message from a link, if the reported address is not already present on that link, the reported address is added to the list, its timer set to [Multicast Listener Interval], and its appearance is made known to the router's multicast routing component.

If a report is received for a multicast address that is already present in the router's list, the timer for that address is reset to [Multicast Listener Interval].

If an address expires, it is assumed that there are no longer any listeners for that address present on the link, so it is deleted from the list and its disappearance is made known to the multicast routing component.

Multicast Listener Interval MUST be ((the Robustness Variable) * (the Query Interval)) + (one Query Response Interval).

Test Setup:

Procedure:

Part A: Multicast Listener Timer Set

1. Restart MLD on the RUT.
2. TN1 transmits an MLD Report for the multicast group FF1E::1:3.
3. On link 1, TN2 transmits a multicast data packet with a destination address of FF1E::1:3.

Part B: Multicast Listener Timer Reset

4. Continue from Part A (do not restart MLD on the RUT).
5. Wait 30 seconds.

6. TN1 transmits valid MLD Reports for the multicast group FF1E::1:3 in response to each General Query sent by the RUT.
7. Wait 250 seconds.
8. On link 1, TN2 transmits a multicast data packet with a destination address of FF1E::1:3.

Part C: Group Membership Timer Expired

9. Continue from Part B (do not restart MLD on the RUT).
10. TN1 ceases transmission of Reports.
11. Wait 265 seconds.
12. On link 1, TN1 transmits a multicast data packet with a destination address of FF1E::1:3.

Observable Results:

- *Part A*

  Step 3: After restarting the RUT, it should be the Querier on link 0. As soon as it receives a report from TN1 for multicast group FF1E::1:3, it should start a timer for that group to [Multicast Listener Interval]. (Default 260 seconds). The RUT must forward the multicast data packets onto link 0.
- *Part B*

  Step 8: Each time the RUT receives a report from TN1 for multicast group FF1E::1:3, it should reset its timer for that group to [Multicast Listener Interval]. (Default 260 seconds). The RUT must forward the multicast data packets onto link 0.
- *Part C*

  Step 6: The RUT should stop showing members in the FF1E::1:3 group [Multicast Listener Interval] seconds after the TN1 sends its last Report. (Default 260 seconds). The RUT must not forward the multicast data packets onto link 0.

Possible Problems:

- The results of this test may not be observable if there is no multicast routing protocol available on the RUT.

Test MLD.2.11: Querier State Transitions

Purpose: To verify that a router properly implements Querier state transition.

References:

- [MLD] – Section 6

Resource Requirements:

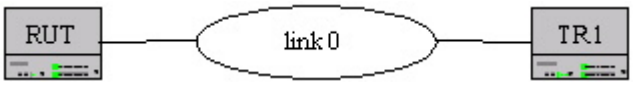
1. Packet Generator
2. Monitor to capture packets

Discussion: When an MLD router starts up, it sends a general query and starts its initial General Query Timer. This causes an immediate transition to state "Querier".

While in state "Querier", if a router receives a query from a router with a lower IP address, it should start its Other Querier Present Timer and transition to state "Non Querier".

While in state "Querier", if a router's General Query Timer expires, it should send a General Query, start its General Query Timer and stay in state "Querier".

Test Setup:



Procedure:

Part A: Query from Lower IP Address

1. Wait for the RUT to become Querier on link 0.
2. TR1 has a lower IP Address than the RUT, and transmits a General Query on link 0.
3. Observe the packets transmitted on link 0.

Part B: General Query Timer Expires

4. Wait for the RUT to become Querier on link 0.
5. TR1 has a higher IP Address than the RUT, and transmits a General Query on link 0.
6. Observe the packets transmitted by the RUT on link 0.

Observable Results:

- *Part A*

  Step 3: When the RUT receives the Query from TR1, it should start its Other Querier Present Timer. The RUT should then transition to state "Non-Querier". The RUT therefore, should not send any General Queries on link 0.
- *Part B*

Step 6: When the RUT receives the Query from TR1, because the IP address is not lower, the RUT should remain the Querier on link 0. Query Response Interval seconds after the RUT sends its General Query, its General Query Timer expires. The RUT should sent a General Query and restart its General Query Timer. It stays in state "Querier".

Possible Problems:

- None.

Test MLD.2.12: Non-Querier State Transitions

Purpose: To verify that a router properly implements Non-Querier state transition.

References:

- [MLD] – Section 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion:

While in state "Non-Querier", if a router receives a query from a router with a lower IP address, it should start its Other Querier Present Timer and stay in state "Non Querier".

While in state "Non-Querier", if a router's Other Querier Present Timer expires, it should send a General Query, start its General Query Timer and transition to state "Querier".

Test Setup:

Procedure:

Part A: Query from Lower IP Address

1. TR1 has a lower IP address than the RUT.
2. Wait for the RUT to become Non-Querier on link 0.
3. TR1 transmits another General Query on link 0.
4. Observe the packets transmitted on link 0.

Part B: Other Querier Present Timer Expires

5. TR1 has a lower IP address than the RUT.
6. TR1 transmits a General Query on link 0.
7. Wait Other Querier Present Interval seconds. (Default 255 seconds).
8. Observe the packets transmitted by the RUT on link 0.

Observable Results:

- *Part A*

  Step 4: When the RUT receives the Query from TR1, it should restart its Other Querier Present Timer. The RUT should stay in state "Non-Querier". Therefore, the RUT should not send General Queries on link 0.

- *Part B*

  Step 8: After Other Querier Present Interval seconds, the RUT should send a General Query, start its General Query Timer and transition to state “Querier”.

Possible Problems:

- None.

Test MLD.2.13: Querier State Transitions– No Listeners Present

Purpose: To verify that a router properly implements Querier state transitions with respect to a single multicast address on a link while in state No Listeners Present.

References:

- [MLD] – Section 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: To keep track of which multicast addresses have listeners, a router may be in one of three possible states with respect to any single IPv6 multicast address on any single attached link: “No Listeners Present”, “Listeners Present”, and “Checking Listeners”.

While in state “No Listeners Present”, if a router receives a report, it should notify the routing protocol that there is a Listener for the address, start the Timer for the address, and transition to state “Listeners Present”.

Test Setup:

Procedure:

1. Configure the RUT to be Querier on link 0. Initially, there are no listeners for multicast group FF1E::1:3.
2. TN1 transmits a Report Message for multicast group FF1E::1:3.
3. On link 1, TN2 transmits a multicast data packets with a destination address of FF1E::1:3.
4. Observe the RUT.

Observable Results:

Step 4: When the RUT receives the Report from TN1, it should create an entry for the address FF1E::1:3 and start its timer to [Multicast Listener Interval]. The RUT must forward the multicast data packets onto link 0.

Possible Problems:

- The results of this test may not be observable if there is no multicast routing protocol available on the RUT.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Test MLD.2.14: Querier State Transitions– Listeners Present

Purpose: To verify that a router properly implements Querier state transitions with respect to a single multicast address on a link while in state Listeners Present.

References:

- [MLD] – Section 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: To keep track of which multicast addresses have listeners, a router may be in one of three possible states with respect to any single IPv6 multicast address on any single attached link: "No Listeners Present", "Listeners Present", and "Checking Listeners".

While in state "Listeners Present", if a router receives a report, restart the Timer for the address, and remain in state "Listeners Present".

While in state "Listeners Present", if a router's Timer for the address expires, the router should notify the routing protocol that there are no listeners for this address and transition to state "No Listeners Present".

While in state "Listeners Present", if a router receives a Done Message for the address, the router should start its timer to [Last Listener Query Interval] * [Last Listener Query Count]. It should start its retransmit timer for the address to [Last Listener Query Interval], send a Multicast-Address-Specific Query for the address, and transition to state "Checking Listeners".

Test Setup: RUT is Querier on Link 0. The RUT has a numerically lower IPv6 source address than TN1.

Procedure:

Part A: Receives Report

1. TN1 transmits a Report Message for multicast group FF1E::1:3.
2. On link 1, TN2 transmits multicast data packets with a destination address of FF1E::1:3.
3. Observe the RUT.
4. Within [Maximum Listener Interval], TN1 transmits the same Report Message as in step 1.
5. On link 1, TN2 transmits multicast data packets with a destination address of FF1E::1:3.
6. Observe the RUT.

Part B: Address Timer Expires

7. TN1 transmits a Report Message for multicast group FF1E::1:3.
8. Wait for [Multicast Listener Inteval] (default 260 seconds).
9. On link 1, TN2 transmits multicast data packets with a destination address of FF1E::1:3.
10. Observe the RUT.

Part C: Receives Done Message

11. TN1 transmits a Report Message for multicast group FF1E::1:3.
12. After 10 seconds, TN1 transmits a Done Message to the RUT for multicast group FF1E::1:3.
13. On link 1, TN2 transmits multicast data packets with a destination address of FF1E::1:3.
14. Observe the packets transmitted on link 0.

Observable Results:

- *Part A*

  Step 3: When the RUT receives the Report from TN1, it transition to "Listeners Present" state and should have an entry for multicast address FF1E::1:3. The RUT must forward the multicast data packets onto link 0.

  Step 6: When the RUT receives the second Report from TR1, it should restart its Timer for address FF1E::1:3. The RUT should stay in state "Listeners Present". The RUT must forward the multicast data packets onto link 0.
- *Part B*

  Step 10: When the RUT receives the Report from TN1, it transition to "Listeners Present" state and should have an entry for multicast address FF1E::1:3. After Multicast Listener Interval passes, however, and TN1 does not send any more Report Messages, the RUT should delete its entry for address FF1E::1:3 and notify the routing protocol that there are no listeners for that address. The RUT then transitions to "No Listeners Present" state. The RUT must not forward the multicast data packets onto link 0.
- *Part C*

  Step 14: When the RUT receives a Done Message for FF1E::1:3, it should start its address timer to [Last Listener Query Interval] * [Last Listener Query Count]. (Default 2 seconds). It should start its retransmit timer for the address to [Last Listener Query Interval] (Default 1 second), send a Multicast-Address-Specific Query for FF1E::1:3, and transition to state "Checking Listeners". The RUT must not forward the multicast data packets onto link 0.

Possible Problems:

- The results of this test may not be observable if there is no multicast routing protocol available on the RUT.

Test MLD.2.15: Querier State Transitions– Checking Listeners

Purpose: To verify that a router properly implements Querier state transitions with respect to a single multicast address on a link while in state Checking Listeners.

References:

- [MLD] – Section 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: To keep track of which multicast addresses have listeners, a router may be in one of three possible states with respect to any single IPv6 multicast address on any single attached link: "No Listeners Present", "Listeners Present", and "Checking Listeners".

While in state "Checking Listeners", if a router receives a report, start the Timer for the address, clear the Retransmit Timer and transition to state "Listeners Present".

While in state "Checking Listeners", if a router's Retransmit Timer for the address expires, the router should send a Multicast-Address-Specific Query for this address, restart its Retransmit Timer to [Last Listener Query Interval] and remain in state "Checking Listeners".

While in state "Checking Listeners", if a router's Address Timer for the address expires, it should notify the routing protocol that there are no listeners for that address, clear its Retransmit Timer and transition to state "No Listeners Present".

Test Setup: RUT is Querier on link 0. The RUT has a numerically lower IPv6 source address than TN1. TN1 transmits a Report Message for multicast group FF1E::1:3. The RUT should be in "Listeners Present" state for multicast group FF1E::1:3.

Procedure:

Part A: Receives Report

1. TN1 transmits a Done Message for multicast group FF1E::1:3.
2. After 5 seconds, TN1 transmits a Report Message for multicast group FF1E::1:3.
3. On link 1, TN2 transmits multicast data packets with a destination address of FF1E::1:3.
4. Observe the RUT.

Part B: Retransmit Timer Expires

5. TN1 transmits a Done Message for multicast group FF1E::1:3.

6. Wait for [Last Listener Query Interval] to pass.
7. On link 1, TN2 transmits multicast data packets with a destination address of FF1E::1:3.
8. Observe the packets transmitted by the RUT on link 0.

Part C: Address Timer Expires

9. TN1 transmits a Done Message for multicast group FF1E::1:3.
10. Wait for the RUT's Address Timer for address FF1E::1:3 to expire.
11. On link 1, TN2 transmits multicast data packets with a destination address of FF1E::1:3.
12. Observe the packets transmitted on link 0.

Observable Results:

- *Part A*

  Step 4: When the RUT receives the Report from TN1, it starts a timer for the address FF1E::1:3, clears its Retransmit Timer, and transition to state "Listeners Present". The RUT must forward the multicast data packets onto link 0.
- *Part B*

  Step 8: After Retransmit Timer Expires, the RUT should send a Multicast-Address-Specific Query for address FF1E::1:3, restart its Retransmit Timer to [Last Listener Query Interval] and remain in state "Checking Listeners". The RUT must not forward the multicast data packets onto link 0.
- *Part C*

  Step 12: After the RUT's Address Timer for FF1E::1:3 expires, it should notify the routing protocol that there are no listeners for that address, delete its entry for address FF1E::1:3, clear its Retransmit Timer and transition to state "No Listeners Present". The RUT must not forward the multicast data packets onto link 0.

Possible Problems:

- The results of this test may not be observable if there is no multicast routing protocol available on the RUT.

Test MLD.2.16: Non-Querier State Transitions– No Listeners Present

Purpose: To verify that a router properly implements Non-Querier state transitions with respect to a single multicast address on a link while in state No Listeners Present.

References:

- [MLD] – Section 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: To keep track of which multicast addresses have listeners, a router may be in one of three possible states with respect to any single IPv6 multicast address on any single attached link: "No Listeners Present", "Listeners Present", and "Checking Listeners".

While in state "No Listeners Present", if a router receives a report, it should notify the routing protocol that there is a Listener for the address, start the Timer for the address, and transition to state "Listeners Present".

Test Setup:

Procedure:

1. Configure the RUT to not be Querier on link 0. Initially, there are no listeners for multicast group FF1E::1:3.
2. TN1 transmits a Report Message for multicast group FF1E::1:3.
3. On link 1, TN2 transmits multicast data packets with a destination address of FF1E::1:3.
4. Observe the RUT.

Observable Results:

Step 4: When the RUT receives the Report from TN1, it should create an entry for the address FF1E::1:3 and start its timer to [Multicast Listener Interval]. The RUT should transition to state "Listeners Present". The RUT must forward the multicast data packets onto link 0.

Possible Problems:

- The results of this test may not be observable if there is no multicast routing protocol available on the RUT.

Test MLD.2.17: Non-Querier State Transitions– Listeners Present

Purpose: To verify that a router properly implements Non-Querier state transitions with respect to a single multicast address on a link while in state Listeners Present.

References:

- [MLD] – Section 6

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

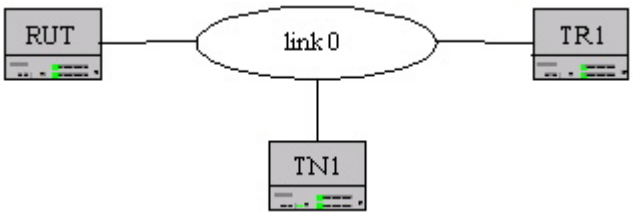
Discussion: To keep track of which multicast addresses have listeners, a router may be in one of three possible states with respect to any single IPv6 multicast address on any single attached link: “No Listeners Present”, “Listeners Present”, and “Checking Listeners”.

While in state “Listeners Present”, if a router receives a report, restart the Timer for the address and remain in state “Listeners Present”.

While in state “Listeners Present”, if a router’s Timer for the address expires, the router should notify the routing protocol that there are no listeners for this address and transition to state “No Listeners Present”.

While in state “Listeners Present”, if a router receives a Multicast-Address-Specific Query for the address, the router should start its timer to the Maximum Response Delay in the Query message * [Last Listener Query Count] and transition to state “Checking Listeners”.

Test Setup: TR1 is Querier on link 0. TR1 has a numerically lower IPv6 source address than the RUT.



Procedure:

Part A: Receives Report

1. TN1 transmits a Report Message for multicast group FF1E::1:3.
2. Observe the RUT.
3. Within [Maximum Listener Interval], TN1 transmits the same Report Message as in step 1.
4. Observe the RUT.

Part B: Address Timer Expires

5. TN1 transmits a Report Message to the RUT for multicast group FF1E::1:3.
6. Wait for [Multicast Listener Inteval] (default 260 seconds).
7. Observe the RUT.

Part C: Receives Done Message

8. TN1 transmits a Report Message to the RUT for multicast group FF1E::1:3.
9. After the RUT transitions to state Listeners Present for address FF1E::1:3, TN1 transmits a Done Message to the RUT for multicast group FF1E::1:3.
10. Observe the packets transmitted on link 0.

Observable Results:

- *Part A*

  Step 2: When the RUT receives the Report from TN1, it transition to "Listeners Present" state and should have an entry for multicast address FF1E::1:3.

  Step 4: When the RUT receives the second Report from TR1, it should restart its Timer for address FF1E::1:3. The RUT should stay in state "Listeners Present".
- *Part B*

  Step 7: When the RUT receives the Report from TN1, it transition to "Listeners Present" state and should have an entry for multicast address FF1E::1:3. After Multicast Listener Interval passes, however, and TN1 does not send any more Report Messages, the RUT should delete its entry for address FF1E::1:3 and notify the routing protocol that there are no listeners for that address. The RUT then transitions to "No Listeners Present" state.
- *Part C*

  Step 10: When the RUT receives a Multicast-Address-Specific Query for FF1E::1:3, it should start its address timer to the Maximum Response Delay in the Query message * [Last Listener Query Count] and transition to state "Checking Listeners". The RUT must not send a MAS Query for FF1E::1:3.

Possible Problems:

- None.

Test MLD.2.18: Non-Querier State Transitions– Checking Listeners

Purpose: To verify that a router properly implements Non-Querier state transitions with respect to a single multicast address on a link while in state Checking Listeners.

References:

- [MLD] – Section 6

Resource Requirements:

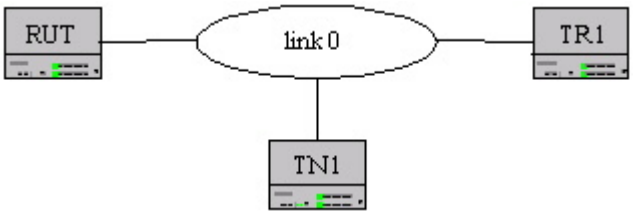
1. Packet Generator
2. Monitor to capture packets

Discussion: To keep track of which multicast addresses have listeners, a router may be in one of three possible states with respect to any single IPv6 multicast address on any single attached link: "No Listeners Present", "Listeners Present", and "Checking Listeners".

While in state "Checking Listeners", if a router receives a report, start the Timer for the address and transition to state "Listeners Present".

While in state "Checking Listeners", if a router's Address Timer for the address expires, it should notify the routing protocol that there are no listeners for that address and transition to state "No Listeners Present".

Test Setup: TR1 is Querier on link 0. TR1 has a numerically lower IPv6 source address than the RUT. TN1 transmits a Report Message for multicast group FF1E::1:3. The RUT should be in "Listeners Present" state for multicast group FF1E::1:3.



Procedure:

Part A: Receives Report

1. TR1 transmits a Multicast-Address-Specific Query for multicast group FF1E::1:3.
2. Before the Address Timer for FF1E::1:3 expires, TN1 transmits a Report Message for multicast group FF1E::1:3.
3. Observe the RUT.

Part B: Address Timer Expires

4. TN1 transmits a Multicast-Address-Specific Query for multicast group FF1E::1:3.

5. Wait for the RUT's Address Timer for address FF1E::1:3 to expire.
6. Observe the packets transmitted on link 0.

Observable Results:

- *Part A*
  Step 3: When the RUT receives the Report from TN1, it starts a timer for the address FF1E::1:3 and transition to state "Listeners Present". It should list an entry for address FF1E::1:3.
- *Part B*
  Step 6: After the RUT's Address Timer for FF1E::1:3 expires, it should notify the routing protocol that there are no listeners for that address, delete its entry for address FF1E::1:3 and transition to state "No Listeners Present".

Possible Problems:

- None.

Test MLD.2.19: Non-Querier Done Message Reception

Purpose: To verify that a router that is Non-Querier for a link properly ignores the reception of Done Message.

References:

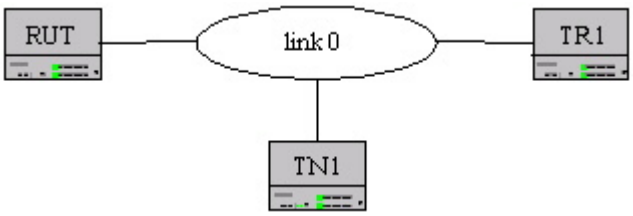
- [MLD] – Section 4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: Routers in Non-Querier state MUST ignore Done messages.

Test Setup: TR1 is Querier on link 0. TR1 has a numerically lower IPv6 source address than the RUT. TN1 transmits a Report Message for multicast group FF1E::1:3. The RUT should be in "Listeners Present" state for multicast group FF1E::1:3.



Procedure:

1. TN1 transmits a Done message on Link 0.
2. Observe the RUT.

Observable Results:

Step 3: When the RUT receives the Done Message from TN1, it must ignore it. After Maximum Response Delay * [Last Listener Query Count], the RUT must not notify the multicast routing protocol that there are no listeners present for address FF1E::1:3. The RUT must still list an entry for address FF1E::1:3.

Possible Problems:

- The results for some sections of this test may not be observable if there is no multicast routing protocol available on the RUT.

Test MLD.2.20: Non-Querier MAS Query Reception

Purpose: To verify that a router that is Non-Querier for a link properly processes the reception of a Multicast-Address-Specific Query.

References:

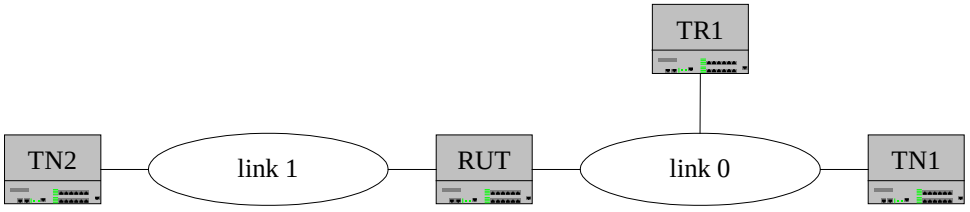
- [MLD] – Section 4

Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: When a router in Non-Querier state receives a Multicast-Address-Specific Query, if its timer value for the identified multicast address is greater than [Last Listener Query Count] times the Maximum Response Delay (Default 2*Max Resp Delay) specified in the message, it sets the address's timer to that latter value.

Test Setup: TR1 is Querier on link 0. TR1 has a numerically lower IPv6 source address than the RUT. TN1 transmits a Report Message for multicast group FF1E::1:3. The RUT should be in "Listeners Present" state for multicast group FF1E::1:3.



Procedure:

1. TR1 transmits a General Query for address FF1E::1:3 with a Maximum Response Delay value of 10000 milliseconds.
2. TR1 transmits a Multicast-Address-Specific Query for address FF1E::1:3 with a Maximum Response Delay value of 500 milliseconds.
3. On link 1, TN2 transmits multicast data packets with a destination address of FF1E::1:3.
4. Observe the RUT.

Observable Results:

Step 4: When the RUT receives the Multicast-Address-Specific Query for address FF1E::1:3, if its timer for this address is greater than 2*500 (If 2 is the Last Listener Query Count for the RUT), it should set the timer's new value to 1000. Within 1 second, the RUT should not list address FF1E::1:3 as having listeners. The RUT should forward the multicast data packets on link 0.

Possible Problems:

- The results for some sections of this test may not be observable if the RUT sets its timer for address FF1E::1:3 to less than [Last Listener Query Count] * Maximum Response Delay. The results of this test may not be observable if there is no multicast routing protocol available on the RUT.

Test MLD.2.21: Querier to Non-Querier while in Checking Listeners

Purpose: To verify that a router that is Querier for a link properly handles the transition to Non-Querier while in Checking Listeners state.

References:

- [MLD] – Section 4 and 6

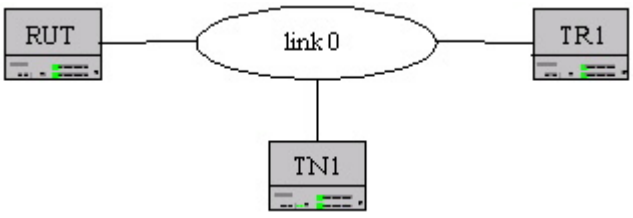
Resource Requirements:

1. Packet Generator
2. Monitor to capture packets

Discussion: If no reports for the address are received from the link after the response delay of the last query has passed, the routers on the link assume that the address no longer has any listeners there; the address is therefore deleted from the list and its disappearance is made known to the multicast routing component. This process is continued to its resolution (i.e. until a Report is received or the last Multicast-Address-Specific Query is sent with no response) despite any transition from Querier to Non-Querier on this link.

The transition between Querier and Non-Querier state on a link is handled specially. Any groups in "Checking Listeners" state continue with the same state transition diagram until the "Checking Listeners" state is exited. E.g. a router that starts as a Querier, receives a Done message for a group and then receives a Query from a router with a lower address (causing a transition to the Non-Querier state) continues to send multicast-address-specific queries for the group in question until it either receives a Report or its timer expires, at which time it starts performing the actions of a Non-Querier for this group.

Test Setup: RUT is Querier on link 0. The RUT has a numerically lower IPv6 source address than TR1.



Procedure:

Part A: Timer Expired

1. TN1 transmits a Report for address FF1E::1:3 on link 0.
2. After the RUT enters Listener's Present state, TN1 transmits a Done Message for FF1E::1:3.
3. Immediately after the TN1 transmits a Done Message for FF1E::1:3, TR1 transmits a Query on link 0 with a lower IP address than that of the RUT.

4. TN1 does not respond to any queries for address FF1E::1:3.
5. Observe the RUT.

Part B: Report Received

6. TN1 transmits a Report for address FF1E::1:3 on link 0.
7. After the RUT enters Listener's Present state, TN1 transmits a Done Message for FF1E::1:3.
8. Immediately after the TN1 transmits a Done Message for FF1E::1:3, TR1 transmits a Query on link 0 with a lower IP address than that of the RUT.
9. After 1 second, TN1 responds to the query for address FF1E::1:3.
10. Observe the RUT.

Observable Results:

- *Part A*

  Step 5: When the RUT receives the Done from TN1, it should send a Multicast-Address-Specific Query for address FF1E::1:3 and start a timer for the address (Last Listener Query Interval * List Listener Query Count) default 2 seconds. The RUT should send out Multicast-Address-Specific Queries until the timer expires, even though it is not the Querier after receiving TR1's Query. After the timer expires, the RUT should not send any more Queries on link 0.

- *Part B*

  Step 10: When the RUT receives the Done from TN1, it should send a Multicast-Address-Specific Query for address FF1E::1:3 and start a timer for the address (Last Listener Query Interval * List Listener Query Count) default 2 seconds. The RUT should send out Multicast-Address-Specific Queries until it receives the report in step 9, even though it is not the Querier after receiving TR1's Query. After receiving the report, the RUT should not send any more Queries on link 0.

Possible Problems:

- None.