

IPv6 Ready

Multicast Listener Discovery Version 2
Router Interoperability Test Suite

Technical Document

Revision 0.6

IPv6 Forum
IPv6 Ready Logo Committee
UNH InterOperability Lab (USA)

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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 provide the market a strong signal proving the level of interoperability across various products.

To avoid confusion in the mind of customers, a globally unique logo programme should be defined. The IPv6 logo will give confidence to users that IPv6 is currently operational. It will also be a clear indication that the technology will still be used in the future. To summarize, this logo programme will contribute to the feeling that IPv6 is available and ready to be used.

Abbreviations and Acronyms

HUT: Host Under Test
NUT: Node Under Test
RUT: Router Under Test
TN: Testing Node
TR: Testing Router
QRV: Querier's Robustness Variable
QQIC: Querier Query Interval Code

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Timers and Default Values:

MLDv2 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 RFC3376:

Robustness Variable [RV]:	2
Query Interval [QI]:	125 seconds
Query Response Interval [QRI]:	100 tenths of a second (10 seconds)
Multicast Address Listeners Interval [MALI]:	260 seconds $[RV * QI + QRI]$
Other Querier Present Interval [OQPT]:	255 seconds $[RV] * [QI] + \frac{1}{2} * [QRI]$
Startup Query Interval [SQI]:	31.25 seconds $\frac{1}{4} * [QI]$
Startup Query Count [SQC]:	2 [RV]
Last Listener Query Interval [LLQI]:	10 tenths of a second (1 second)
Last Listener Query Count [LLQC]:	2 [RV]
Unsolicited Report Interval [URI]:	1 seconds
Last Listener Query Time [LLQT]:	2 seconds $[LLQI] * [LLQT]$
Older Version Querier Present Timeout [OVQPT]:	260 seconds $[RV] * [QI] + [QRI]$
Older Version Host Present Interval [OVHPT]:	260 seconds $[RV] * [QI] + [QRI]$

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 by concatenating the short test suite name, the group number, and the test number within the group, separated by periods. The Test Number is the group and test number, also separated by a period.
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.
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 for that parameter.
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 packet 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] Multicast Listener Discovery Version 2 (MLDv2) for IPv6, RFC 3810, June 2004.
- [SSM] Using Internet Group Management Protocol Version 3 (IGMPV3) and Multicast Listener Discovery Protocol 2 (MLDv2) for Source-Specific Multicast, RFC 4604, August 2006.

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Common Test Setup

Test in this test suite may refer common test setup procedure defined for this section.

Common Test Setup

Summary: This basic setup procedure configures the routers with the base MLDv2 setting for use with the Common Topology. Some tests may not utilize all nodes in the Common Test Setup. In those cases, disregard the un-used nodes.

1. Configure TR1 and TR2 Network 0 to have:
 - Robustness Variable of 2
 - Query Interval of 125
 - Query Response Interval of 100 $1/10^{\text{th}}$ of a second (10 seconds)
 - Last Member Query Interval of 10 $1/10^{\text{th}}$ of a second (1 second)

Common Test Cleanup

Summary: The cleanup procedure causes the devices to remove any MLD information.

1. Disable MLD on all devices.
2. Return all timers and variables to their defaults values.
3. The Query Interval of RUT can be shortened to decrease time.

GROUP 1: Listener and Router Interoperability

Scope:

The following tests are designed to verify MLDv2 interoperability between routers and listeners.

Overview:

These tests verify that an MLDv2 router and listener behave correctly when interacting with multicast address records, source records, version compatibility, and source specific multicast.

Test MLDv2_INTEROP.1.1: Multicast Address Membership

Purpose: To verify that an MLDv2 router and listener properly handle Multicast Address membership.

References:

- [MLD] – 6.1

A change of per-interface state causes the node to immediately transmit a State Change Report from that interface. The type and contents of the Multicast Address Record(s) in that Report are determined by comparing the filter mode and source list for the affected multicast address before and after the change, according to the table below. If no per-interface state existed for that multicast address before the change (i.e., the change consisted of creating a new per-interface record), or if no state exists after the change (i.e., the change consisted of deleting a per-interface record), then the "non-existent" state is considered to have an INCLUDE filter mode and an empty source list.

Old State -----	New State -----	State Change Record Sent -----
INCLUDE (A)	INCLUDE (B)	ALLOW (B-A), BLOCK (A-B)
EXCLUDE (A)	EXCLUDE (B)	ALLOW (A-B), BLOCK (B-A)
INCLUDE (A)	EXCLUDE (B)	TO_EX (B)
EXCLUDE (A)	INCLUDE (B)	TO_IN (B)

- [MLD] – 7.2.1

A router is in INCLUDE mode for a specific multicast address on a given interface if all the listeners on the link interested in that address are in INCLUDE mode. The router state is represented through the notation INCLUDE (A), where A is called the "Include List". The Include List is the set of sources that one or more listeners on the link have requested to receive. All the sources from the Include List will be forwarded by the router. Any other source that is not in the Include List will be blocked by the router.

A router is in EXCLUDE mode for a specific multicast address on a given interface if there is at least one listener in EXCLUDE mode interested in that address on the link. Conceptually, when a Multicast Address Record is received, the Router Filter Mode for that multicast address is updated to cover all the requested sources using the least amount of state. As a rule, once a Multicast Address Record with a filter mode of EXCLUDE is received, the Router Filter Mode for that multicast address will be set to EXCLUDE. Nevertheless, if all nodes with a multicast address record having filter mode set to EXCLUDE cease reporting, it is desirable for the Router Filter Mode for that multicast address to transition back to INCLUDE mode. This transition occurs when the Filter Timer expires, and is explained in detail in section 7.5.

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When the router is in EXCLUDE mode, the router state is represented through the notation EXCLUDE (X,Y), where X is called the "Requested List" and Y is called the "Exclude List". All sources, except those from the Exclude List, will be forwarded by the router. The Requested List has no effect on forwarding. Nevertheless, it has to be maintained for several reasons, as explained in section 7.2.3.

- [MLD] – 7.4.1

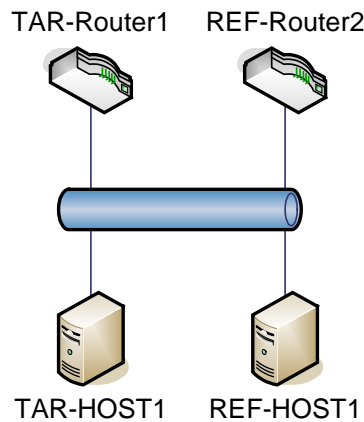
When receiving Current State Records, a router updates both its Filter Timer and its source timers. In some circumstances, the reception of a type of multicast address record will cause the Router Filter Mode for that multicast address to change. The table below describes the actions, with respect to state and timers, that occur to a router's state upon reception of Current State Records.

If the router is in INCLUDE filter mode for a multicast address, we will use the notation INCLUDE (A), where A denotes the associated Include List. If the router is in EXCLUDE filter mode for a multicast address, we will use the notation EXCLUDE (X,Y), where X and Y denote the associated Requested List and Exclude List respectively.

Within the "Actions" section of the router state tables, we use the notation '(A)=J', which means that the set A of source records should have their source timers set to value J. 'Delete (A)' means that the set A of source records should be deleted. 'Filter Timer = J' means that the Filter Timer for the multicast address should be set to value J.

Router State	Report Received	New Router State	Actions
-----	-----	-----	-----
INCLUDE (A)	IS_IN (B)	INCLUDE (A+B)	(B)=MALI
INCLUDE (A)	IS_EX (B)	EXCLUDE (A*B, B-A)	(B-A)=0 Delete (A-B) Filter Timer=MALI
EXCLUDE (X,Y)	IS_IN (A)	EXCLUDE (X+A, Y-A)	(A)=MALI
EXCLUDE (X,Y)	IS_EX (A)	EXCLUDE (A-Y, Y*A)	(A-X-Y)=MALI Delete (X-A) Delete (Y-A) Filter Timer=MALI

Test Setup: For each Part, connect hosts and routers as per the figures below.



Procedure:

Part A: Router Querier, Listener joins multicast group

1. TAR-Host1 joins multicast group M1.
2. Wait for TAR-Router1 transmit a General Query.
3. Observe the packets on all networks.

Part B: Listeners exist, Router Queries

4. Disable MLDv2 on all devices.
5. Enable MLDv2 on TAR-Host1.
6. TAR-Host1 joins multicast group M1.
7. Observe the packets on all networks.
8. Enable MLDv2 on TAR-Router1.
9. Observe the packets on all networks.

Part C: Router Querier, Listener leaves multicast group

10. TAR-Host1 joins multicast group M1.
11. Wait for TAR-Router1 to transmit a General Query.
12. Observe the packets on all networks.
13. TAR-Host1 leaves multicast group M1.
14. Observe the packets on all networks.

Part D: Router Querier, Listener rejoins multicast group

15. TAR-Host1 joins multicast group M1.
16. Wait for TAR-Router1 to transmit a General Query.
17. Observe the packets on all networks.
18. TAR-Host1 leaves multicast group M1.
19. Observe the packets on all networks.
20. TAR-Host1 joins multicast group M1.
21. Observe the packets on all networks.

Part E: Router Querier, Multiple Group Join

22. TAR-Host1 joins multicast group M1.
23. Observe the packets on all networks.
24. TAR-Host1 joins multicast group M2.
25. Observe the packets on all networks.

Part F: Router Querier, Multiple Group Leave

26. TAR-Host1 joins multicast group M1.
27. Observe the packets on all networks.
28. TAR-Host1 joins multicast group M2.
29. Observe the packets on all networks.
30. TAR-Host1 leaves multicast group M1.
31. Observe the packets on all networks.
32. TAR-Host1 leaves multicast group M2.
33. Observe the packets on all networks.
34. Wait for TAR-Router1 to transmits a General Query.
35. Observe the packets on all networks.

Part G: Router Querier, Multiple Group Join and Leave

36. TAR-Host1 joins multicast group M1.
37. Observe the packets on all networks.
38. TAR-Host1 joins multicast group M2.
39. Observe the packets on all networks.
40. TAR-Host1 leaves multicast group M1.
41. Observe the packets on all networks.
42. Wait for TAR-Router1 to transmit a General Query.
43. Observe the packets on all networks.

Part H: Router Querier, Other Host Join

44. TAR-Host1 joins multicast group M1.
45. Observe the packets on all networks.
46. REF-Host1 joins multicast group M1.
47. Wait for TAR-Router1 to transmit a General Query.
48. Observe the packets on all networks.

Part I: Router Querier, Other Host Leaves First

49. TAR-Host1 joins multicast group M1.
50. Observe the packets on all networks.
51. REF-Host1 joins multicast group M1.
52. Observe the packets on all networks.
53. REF-Host1 leaves multicast group M1.
54. Observe the packets on all networks.
55. Wait for TAR-Router1 to transmits a General Query.
56. Observe the packets on all networks.

Part J: Router Querier, Other Host Join first, leaves group

57. REF-Host1 joins multicast group M1.
58. Observe the packets on all networks.
59. TAR-Host1 joins multicast group M1.
60. Observe the packets on all networks.
61. REF-Host1 leaves multicast group M1.
62. Observe the packets on all networks.
63. Wait for TAR-Router1 to transmit a General Query.
64. Observe the packets on all networks.

Part K: Router Querier, Leave group

65. TAR-Host1 joins multicast group M1.
66. Observe the packets on all networks.
67. REF-Host1 joins multicast group M1.
68. Observe the packets on all networks.
69. TAR-Host1 leaves multicast group M1.

70. Observe the packets on all networks.
71. Wait for TAR-Router1 to transmit a General Query.
72. Observe the packets on all networks.

Part L: Router Querier, Leave group, Other Host joins first

73. REF-Host1 joins multicast group M1.
74. Observe the packets on all networks.
75. TAR-Host1 joins multicast group M1.
76. Observe the packets on all networks.
77. TAR-Host1 leaves multicast group M1.
78. Observe the packets on all networks.
79. Wait for TAR-Router1 to transmit a General Query.
80. Observe the packets on all networks.

Part M: Joined Group, Change Querier

81. Configure TAR-Router1 to have a higher IPv6 address than REF-Router1.
82. Enable MLDv2 on REF-Router1.
83. TAR-Host1 joins multicast group M1.
84. Wait for REF-Router1 to transmit a General Query.
85. Observe the packets on all networks.
86. REF-Router1 is disabled.
87. Wait for TAR-Router1 to transmits a General Query.
88. Observe the packets on all networks.

Observable Results:

- *Part A*
Step 3: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_EX and a multicast group of M1.
- *Part B*
Step 7: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.
Step 9: TAR-Router1 must transmit 2 Startup General Queries. In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_EX and a multicast group of M1.
- *Part C*
Step 12: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_EX and a multicast group of M1.
Step 14: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router1 transmits 2 Multicast Address Specific Queries with a Multicast Address of M1.
- *Part D*
Step 17: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_EX and a multicast group of M1.
Step 19: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router1 transmit 2 Multicast Address Specific Query with a Multicast Address of M1.
Step 21: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record

type of TO_EX and a multicast group of M1.

- *Part E*

Step 23: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_EX and a multicast group of M1.

Step 25: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_EX and a multicast group of M2.

- *Part F*

Step 27: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 29: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M2.

Step 31: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router1 transmit 2 Multicast Address Specific Queries with a Multicast Address of M1.

Step 33: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M2. TAR-Router1 transmit 2 Multicast Address Specific Queries with a Multicast Address of M2.

Step 35: TAR-Host1 must not transmit a Multicast address Record for multicast group M1.

- *Part G*

Step 37: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 39: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M2.

Step 41: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router1 transmit 2 Multicast Address Specific Queries with a Multicast Address of M1.

Step 43: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_EX and a multicast group of M2. TAR-Host1 must not transmit a Multicast address Record for multicast group M1.

- *Part H*

Step 45: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 48: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type of IS_EX and a multicast group of M1.

- *Part I*

Step 50: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 52: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 54: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router1 transmits 2 Multicast Address Specific Queries with a Multicast Address of M1. In response to TAR-Router1 Multicast Address Specific Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type of IS_EX and a multicast group of M1.

Step 56: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must

transmit a Report with a Multicast Address Record with a Record type of IS_EX and a multicast group of M1.

- *Part J*

Step 58: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 60: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 62: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router1 transmits 2 Multicast Address Specific Queries with a Multicast Address of M1. In response to TAR-Router1 Multicast Address Specific Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type of IS_EX and a multicast group of M1.

Step 64: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type of IS_EX and a multicast group of M1.

- *Part K*

Step 66: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 68: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 70: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router1 transmits 2 Multicast Address Specific Queries with a Multicast Address of M1. In response to TAR-Router1 Multicast Address Specific Query, REF-Host1 must transmit a Report with a Multicast Address Record with a Record type of IS_EX and a multicast group of M1. TAR-Host1 must not transmit a Multicast address Record for multicast group M1. TAR-Host1 must not transmit a Multicast address Record for multicast group M1.

Step 72: TAR-Host1 must not transmit a Multicast address Record for multicast group M1.

- *Part L*

Step 74: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 76: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 78: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router1 transmits 2 Multicast Address Specific Queries with a Multicast Address of M1. In response to TAR-Router1 Multicast Address Specific Query, REF-Host1 must transmit a Report with a Multicast Address Record with a Record type of IS_EX and a multicast group of M1. TAR-Host1 must not transmit a Multicast address Record for multicast group M1. TAR-Host1 must not transmit a Multicast address Record for multicast group M1.

Step 80: TAR-Host1 must not transmit a Multicast address Record for multicast group M1.

- *Part M*

Step 85: In response to REF-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_EX and a multicast group of M1.

Step 88: After OQPT TAR-Router1 must transmits a General Query. TAR-Host1 transmits a Report with a Multicast Address Record with a Record type of IS_EX and a multicast group of M1.

Possible Problems:

- None

Test MLDv2_INTEROP.1.2: Multicast and Source Address Membership

Purpose: To verify that an MLDv2 router and listener properly handle Multicast and Source membership.

References:

- [MLD] – 6.1

A change of per-interface state causes the node to immediately transmit a State Change Report from that interface. The type and contents of the Multicast Address Record(s) in that Report are determined by comparing the filter mode and source list for the affected multicast address before and after the change, according to the table below. If no per-interface state existed for that multicast address before the change (i.e., the change consisted of creating a new per-interface record), or if no state exists after the change (i.e., the change consisted of deleting a per-interface record), then the "non-existent" state is considered to have an INCLUDE filter mode and an empty source list.

Old State -----	New State -----	State Change Record Sent -----
INCLUDE (A)	INCLUDE (B)	ALLOW (B-A), BLOCK (A-B)
EXCLUDE (A)	EXCLUDE (B)	ALLOW (A-B), BLOCK (B-A)
INCLUDE (A)	EXCLUDE (B)	TO_EX (B)
EXCLUDE (A)	INCLUDE (B)	TO_IN (B)

- [MLD] – 7.2.1

A router is in INCLUDE mode for a specific multicast address on a given interface if all the listeners on the link interested in that address are in INCLUDE mode. The router state is represented through the notation INCLUDE (A), where A is called the "Include List". The Include List is the set of sources that one or more listeners on the link have requested to receive. All the sources from the Include List will be forwarded by the router. Any other source that is not in the Include List will be blocked by the router.

A router is in EXCLUDE mode for a specific multicast address on a given interface if there is at least one listener in EXCLUDE mode interested in that address on the link. Conceptually, when a Multicast Address Record is received, the Router Filter Mode for that multicast address is updated to cover all the requested sources using the least amount of state. As a rule, once a Multicast Address Record with a filter mode of EXCLUDE is received, the Router Filter Mode for that multicast address will be set to EXCLUDE. Nevertheless, if all nodes with a multicast address record having filter mode set to EXCLUDE cease reporting, it is desirable for the Router Filter Mode for that multicast address to transition back to INCLUDE mode. This transition occurs when the Filter Timer expires, and is explained in detail in section 7.5.

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When the router is in EXCLUDE mode, the router state is represented through the notation EXCLUDE (X,Y), where X is called the "Requested List" and Y is called the "Exclude List". All sources, except those from the Exclude List, will be forwarded by the router. The Requested List has no effect on forwarding. Nevertheless, it has to be maintained for several reasons, as explained in section 7.2.3.

- [MLD] – 7.4.1

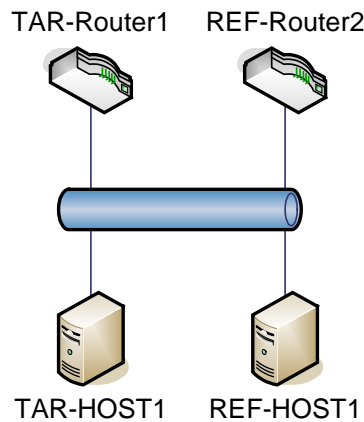
When receiving Current State Records, a router updates both its Filter Timer and its source timers. In some circumstances, the reception of a type of multicast address record will cause the Router Filter Mode for that multicast address to change. The table below describes the actions, with respect to state and timers, that occur to a router's state upon reception of Current State Records.

If the router is in INCLUDE filter mode for a multicast address, we will use the notation INCLUDE (A), where A denotes the associated Include List. If the router is in EXCLUDE filter mode for a multicast address, we will use the notation EXCLUDE (X,Y), where X and Y denote the associated Requested List and Exclude List respectively.

Within the "Actions" section of the router state tables, we use the notation '(A)=J', which means that the set A of source records should have their source timers set to value J. 'Delete (A)' means that the set A of source records should be deleted. 'Filter Timer = J' means that the Filter Timer for the multicast address should be set to value J.

Router State	Report Received	New Router State	Actions
-----	-----	-----	-----
INCLUDE (A)	IS_IN (B)	INCLUDE (A+B)	(B)=MALI
INCLUDE (A)	IS_EX (B)	EXCLUDE (A*B, B-A)	(B-A)=0 Delete (A-B) Filter Timer=MALI
EXCLUDE (X,Y)	IS_IN (A)	EXCLUDE (X+A, Y-A)	(A)=MALI
EXCLUDE (X,Y)	IS_EX (A)	EXCLUDE (A-Y, Y*A)	(A-X-Y)=MALI Delete (X-A) Delete (Y-A) Filter Timer=MALI

Test Setup: For each Part, connect hosts and routers as per the figures below.



Procedure:

Part A: Router Querier, Listener joins multicast group

1. TAR-Host1 joins multicast group M1 with a source address of S1.
2. Wait for TAR-Router1 transmit a General Query.
3. Observe the packets on all networks.

Part B: Listeners exist, Router Queries

4. Disable MLDv2 on all devices.
5. Enable MLDv2 on TAR-Host1.
6. TAR-Host1 joins multicast group M1 with a source address of S1.
7. Observe the packets on all networks.
8. Enable MLDv2 on TAR-Router1.
9. Observe the packets on all networks.

Part C: Router Querier, Listener leaves multicast group

10. TAR-Host1 joins multicast group M1 with a source address of S1.
11. Wait for TAR-Router1 to transmit a General Query.
12. Observe the packets on all networks.
13. TAR-Host1 leaves multicast group M1 with a source address of S1.
14. Observe the packets on all networks.

Part D: Router Querier, Listener rejoins multicast group

15. TAR-Host1 joins multicast group M1 with a source address of S1.
16. Wait for TAR-Router1 to transmit a General Query.
17. Observe the packets on all networks.
18. TAR-Host1 leaves multicast group M1 with a source address of S1.
19. Observe the packets on all networks.
20. TAR-Host1 joins multicast group M1 with a source address of S1.
21. Observe the packets on all networks.

Part E: Router Querier, Multiple Group Join

22. TAR-Host1 joins multicast group M1 with a source address of S1.
23. Observe the packets on all networks.
24. TAR-Host1 joins multicast group M1 with a source address of S2.

25. Observe the packets on all networks.

Part F: Router Querier, Multiple Group Leave

26. TAR-Host1 joins multicast group M1 with a source address of S1.

27. Observe the packets on all networks.

28. TAR-Host1 joins multicast group M1 with a source address of S2.

29. Observe the packets on all networks.

30. TAR-Host1 leaves multicast group M1 with a source address of S1.

31. Observe the packets on all networks.

32. TAR-Host1 leaves multicast group M1 with a source address of S2.

33. Observe the packets on all networks.

34. Wait for TAR-Router1 to transmit a General Query.

35. Observe the packets on all networks.

Part G: Router Querier, Multiple Group Join and Leave

36. TAR-Host1 joins multicast group M1 with a source address of S1.

37. Observe the packets on all networks.

38. TAR-Host1 joins multicast group M1 with a source address of S2.

39. Observe the packets on all networks.

40. TAR-Host1 leaves multicast group M1 with a source address of S1.

41. Observe the packets on all networks.

42. Wait for TAR-Router1 to transmit a General Query.

43. Observe the packets on all networks.

Part H: Router Querier, Other Host Join

44. TAR-Host1 joins multicast group M1 with a source address of S1.

45. Observe the packets on all networks.

46. REF-Host1 joins multicast group M1 with a source address of S2.

47. Wait for TAR-Router1 to transmit a General Query.

48. Observe the packets on all networks.

Part I: Router Querier, Other Host Leaves First

49. TAR-Host1 joins multicast group M1 with a source address of S1.

50. Observe the packets on all networks.

51. REF-Host1 joins multicast group M1 with a source address of S1.

52. Observe the packets on all networks.

53. REF-Host1 leaves multicast group M1 with a source address of S1.

54. Observe the packets on all networks.

55. Wait for TAR-Router1 to transmit a General Query.

56. Observe the packets on all networks.

Part J: Router Querier, Other Host Join first, leaves group

57. REF-Host1 joins multicast group M1 with a source address of S1.

58. Observe the packets on all networks.

59. TAR-Host1 joins multicast group M1 with a source address of S1.

60. Observe the packets on all networks.

61. REF-Host1 leaves multicast group M1 with a source address of S1.

62. Observe the packets on all networks.

63. Wait for TAR-Router1 to transmit a General Query.

64. Observe the packets on all networks.

Part K: Router Querier, Leave group

65. TAR-Host1 joins multicast group M1 with a source address of S1.

66. Observe the packets on all networks.

67. REF-Host1 joins multicast group M1 with a source address of S1.

68. Observe the packets on all networks.
69. TAR-Host1 leaves multicast group M1 with a source address of S1.
70. Observe the packets on all networks.
71. Wait for TAR-Router1 to transmit a General Query.
72. Observe the packets on all networks.

Part L: Router Querier, Leave group, Other Host joins first

73. REF-Host1 joins multicast group M1 with a source address of S1.
74. Observe the packets on all networks.
75. TAR-Host1 joins multicast group M1 with a source address of S1.
76. Observe the packets on all networks.
77. TAR-Host1 leaves multicast group M1 with a source address of S1.
78. Observe the packets on all networks.
79. Wait for TAR-Router1 to transmit a General Query.
80. Observe the packets on all networks.

Part M: Joined Group, Change Querier

81. Configure TAR-Router1 to have a higher IPv6 address than REF-Router1.
82. Enable MLDv2 on REF-Router1.
83. TAR-Host1 joins multicast group M1 with a source address of S1.
84. Wait for REF-Router1 to transmit a General Query.
85. Observe the packets on all networks.
86. REF-Router1 is disabled.
87. Wait for TAR-Router1 to transmits a General Query.
88. Observe the packets on all networks.

Observable Results:

- *Part A*
Step 3: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_IN and a multicast group of M1 with a source address of S1.
- *Part B*
Step 7: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of M1 with a source address of S1.
Step 9: TAR-Router1 must transmit 2 Startup General Queries. In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_IN and a multicast group of M1 with a source address of S1.
- *Part C*
Step 12: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_IN and a multicast group of M1 with a source address of S1.
Step 14: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 with a source address of S1. TAR-Router1 transmits 2 Multicast Address and Source Specific Queries with a Multicast Address of M1 with a source address of S1.
- *Part D*
Step 17: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_IN and a multicast group of M1 with a source address of S1.
Step 19: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record

type of BLOCK and a multicast group of M1 with a source address of S1. TAR-Router1 transmits 2 Multicast Address and Source Specific Queries with a Multicast Address of M1 with a source address of S1.

Step 21: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of M1 with a source address of S1.

- *Part E*

Step 23: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of M1 with a source address of S1.

Step 25: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of M1 with a source address of S2.

- *Part F*

Step 27: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of M1 with a source address of S1.

Step 29: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of M1 with a source address of S2.

Step 31: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 with a source address of S1. TAR-Router1 transmits 2 Multicast Address and Source Specific Queries with a multicast address of M1 with a source address of S1.

Step 33: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 with a source address of S2. TAR-Router1 transmits 2 Multicast Address and Source Specific Queries with a multicast address of M1 with a source address of S2.

Step 35: TAR-Host1 must not transmit a Multicast address Record for multicast group M1.

- *Part G*

Step 37: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of M1 with a source address of S1.

Step 39: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of M1 with a source address of S2.

Step 41: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 with a source address of S1. TAR-Router1 transmits 2 Multicast Address and Source Specific Queries with a multicast address of M1 with a source address of S1.

Step 43: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_IN and a multicast group of M1 with a source address of S2.

- *Part H*

Step 45: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of M1 with a source address of S1.

Step 48: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_IN and a multicast group of M1 with a source address of S1.

- *Part I*

Step 50: TAR-Host1 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 and a source address of S1.

Step 52: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of M1 and a source address of S1.

Step 54: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 with a source address of S1. TAR-Router1

transmits 2 Multicast Address and Source Specific Queries with a multicast address of M1 with a source address of S1. Upon receiving a Multicast Address and Source Specific Query from TAR-Router1, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type of IS_IN and a multicast group of M1 and a source address of S1.

Step 56: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_IN and a multicast group of M1 with a source address of S1.

- *Part J*

Step 58: REF-Host1 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 and a source address of S1.

Step 60: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of M1 and a source address of S1.

Step 62: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 with a source address of S1. TAR-Router1 transmits 2 Multicast Address and Source Specific Queries with a multicast address of M1 with a source address of S1. Upon receiving a Multicast Address and Source Specific Query from TAR-Router1, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type of IS_IN and a multicast group of M1 and a source address of S1.

Step 64: In response to TAR-Router1 transmitting a General Query, TAR-Host1 must transmit a Report with a Multicast Address Record with a Record type IS_IN and a multicast group of M1 with a source address of S1.

- *Part K*

Step 66: TAR-Host1 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 with a source address of S1.

Step 68: REF-Host1 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 with a source address of S1.

Step 70: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 with a source address of S1. TAR-Router1 transmits 2 Multicast Address and Source Address Specific Queries with a multicast address of M1 and a source address of S1. In response to TAR-Router1 Multicast Address and Source Specific Query, REF-Host1 must transmit a Report with a Multicast Address Record with a Record type of IS_IN and a multicast group of M1 and a source address of S1. TAR-Host1 must not transmit a Multicast address Record for multicast group M1.

Step 72: TAR-Host1 must not transmit a Multicast address Record for multicast group M1.

- *Part L*

Step 74: REF-Host1 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 with a source address of S1.

Step 76: TAR-Host1 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 with a source address of S1.

Step 78: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 with a source address of S1. TAR-Router1 transmits 2 Multicast Address and Source Address Specific Queries with a multicast address of M1 and a source address of S1. In response to TAR-Router1 Multicast Address and Source Specific Query, REF-Host1 must transmit a Report with a Multicast Address Record with a Record type of IS_IN and a multicast group of M1 and a source address of S1. TAR-Host1 must not transmit a Multicast address Record for multicast group M1.

Step 80: TAR-Host1 must not transmit a Multicast address Record for multicast group M1.

- *Part M*

Step 85: In response to REF-Router1 transmitting a General Query, TAR-Host1 must

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transmit a Report with a Multicast Address Record with a Record type IS_IN and a multicast group of M1 with a source address of S1.

Step 88: After [OQPT] REF-Router1 must transmit a General Query. TAR-Host1 transmits a Report with a Multicast Address Record with a Record type of IS_IN and a multicast group of M1 and a source address of S1.

Possible Problems:

- None

Test MLDv2_INTEROP.1.3: MLDv1 Compatibility Mode

Purpose: To verify that a router and listener properly interoperate in MLDv1 compatible mode.

References:

- [MLD] – 8.2.1

In order to be compatible with MLDv1 routers, MLDv2 hosts **MUST** operate in version 1 compatibility mode. MLDv2 hosts **MUST** keep state per local interface regarding the compatibility mode of each attached link. A host's compatibility mode is determined from the Host Compatibility Mode variable which can be in one of the two states: MLDv1 or MLDv2.

The Host Compatibility Mode of an interface is set to MLDv1 whenever an MLDv1 Multicast Address Listener Query is received on that interface. At the same time, the Older Version Querier Present timer for the interface is set to Older Version Querier Present Timeout seconds. The timer is re-set whenever a new MLDv1 Query is received on that interface. If the Older Version Querier Present timer expires, the host switches back to Host Compatibility Mode of MLDv2.

When Host Compatibility Mode is MLDv2, a host acts using the MLDv2 protocol on that interface. When Host Compatibility Mode is MLDv1, a host acts in MLDv1 compatibility mode, using only the MLDv1 protocol, on that interface.

An MLDv1 Querier will send General Queries with the Maximum Response Code set to the desired Maximum Response Delay, i.e., the full range of this field is linear and the exponential algorithm described in section 5.1.3. is not used.

Whenever a host changes its compatibility mode, it cancels all its pending responses and retransmission timers.

- [MLD] – 8.3.2

MLDv2 routers may be placed on a network where there are hosts that have not yet been upgraded to MLDv2. In order to be compatible with MLDv1 hosts, MLDv2 routers **MUST** operate in version 1 compatibility mode. MLDv2 routers keep a compatibility mode per multicast address record. The compatibility mode of a multicast address is determined from the Multicast Address Compatibility Mode variable, which can be in one of the two following states: MLDv1 or MLDv2.

The Multicast Address Compatibility Mode of a multicast address record is set to MLDv1 whenever an MLDv1 Multicast Listener Report is received for that multicast address. At the same time, the Older Version Host Present timer for the multicast address is set to Older Version Host Present Timeout seconds. The timer is re-set whenever a new MLDv1 Report

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is received for that multicast address. If the Older Version Host Present timer expires, the router switches back to Multicast Address Compatibility Mode of MLDv2 for that multicast address.

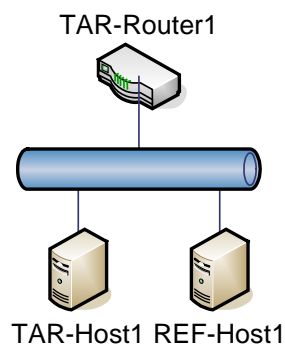
Note that when a router switches back to MLDv2 Multicast Address Compatibility Mode for a multicast address, it takes some time to regain source-specific state information. Source-specific information will be learned during the next General Query, but sources that should be blocked will not be blocked until [Multicast Address Listening Interval] after that.

When Multicast Address Compatibility Mode is MLDv2, a router acts using the MLDv2 protocol for that multicast address. When Multicast Address Compatibility Mode is MLDv1, a router internally translates the following MLDv1 messages for that multicast address to their MLDv2 equivalents:

MLDv1 Message	MLDv2 Equivalent
-----	-----
Report	IS_EX({ })
Done	TO_IN({ })

MLDv2 BLOCK messages are ignored, as are source-lists in TO_EX() messages (i.e., any TO_EX() message is treated as TO_EX({ })). On the other hand, the Querier continues to send MLDv2 queries, regardless of its Multicast Address Compatibility Mode.

Test Setup: For each Part, connect hosts and routers as per the figures below.



Procedure:

Part A: MLDv1 and MLDv2 Listener leaves

1. Configure REF-Host1 to MLDv1 mode.
2. REF-Host1 joins multicast group M1.
3. Observe the packets on all networks.
4. TAR-Host1 joins multicast group M1 with Source Addresses of S1.

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5. Observe the packets on all networks.
6. TAR-Host1 leaves the multicast group M1 with a Source Address of S1.
7. Observe the packets on all networks.

Part B: MLDv2 Listener and MLDv1 Listener leaves

8. Configure REF-Host1 to MLDv1 mode.
9. REF-Host1 joins multicast group M1.
10. Observe the packets on all networks.
11. TAR-Host1 joins multicast group M1 with a Source Address of S1.
12. Observe the packets on all networks.
13. REF-Host1 leaves the multicast group M1.
14. Observe the packets on all networks.

Part C: MLDv1 Router, MLDv2 Listener joins

15. Enable MLDv1 on TAR-Router1.
16. Observe the packets on all networks.
17. TAR-Host1 joins multicast group M1.
18. Observe the packets on all networks.

Part D: MLDv1 Router, MLDv2 Listener Leaves

19. Enable MLDv1 on TAR-Router1.
20. Observe the packets on all networks.
21. TAR-Host1 joins multicast group M1.
22. Observe the packets on all networks.
23. TAR-Host1 leaves multicast group M1.
24. Observe the packets on all networks.

Part E: Switch version Listener

25. Disable MLD on all Devices.
26. Enable MLDv1 on TAR-Router1.
27. Enable MLDv1 on REF-Router1.
28. TAR-Host1 joins multicast group M1.
29. Observe the packets on all networks.
30. REF-Router1 is disconnected from the network.
31. Enable MLDv2 on TAR-Router1.
32. Observe the packets on all networks.
33. TAR-Host1 leaves the multicast group M1.
34. Observe the packets on all networks.

Part F: Switch version Router

35. Disable MLD on all Devices.
36. Configure REF-Router to MLDv1 mode.
37. Enable MLDv1 on REF-Router1.
38. TAR-Host1 joins multicast group M1.
39. Observe the packets on all networks.
40. REF-Router1 is disconnected from the network.
41. Enable MLDv2 on TAR-Router1.
42. Observe the packets on all networks.
43. Wait for TAR-Router1 to transmit a General Query after [OVQPT].
44. Observe the packets on all networks.

Observable Results:

- *Part A*

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Step 3: REF-Host1 must transmit 2 MLDv1 Reports with a multicast group of M1. TAR-Router1 must continue to transmit MLDv2 General Queries.

Step 5: TAR-Host1 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 with a source address of S1.

Step 7: TAR-Host1 transmits 2 Reports with a Multicast Address Records with a Record type of BLOCK and a multicast group of M1 with a source address of S1. TAR-Router1 must not transmit a Multicast Address Specific Query.

- *Part B*

Step 10: REF-Host1 must transmit 2 MLDv1 Reports with a multicast group of M1. TAR-Router1 must continue to transmit MLDv2 General Queries.

Step 12: TAR-Host1 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 with a source address of S1.

Step 14: REF-Host1 must transmit 2 MLDv1 Done with a multicast group of M1. TAR-Router1 transmits 2 Multicast Address Specific Queries with a Multicast Address of M1. In response to TAR-Router1 Multicast Address Specific Query transmits a Report with a Multicast Address Records with a Record type of IS_IN and a multicast group of M1 with a source address of S1.

- *Part C*

Step 16: TAR-Router1 must transmit MLDv1 General Query.

Step 18: TAR-Host1 must transmit 2 MLDv1 Reports with a multicast group of M1.

- *Part D*

Step 20: TAR-Router1 must transmit MLDv1 General Query.

Step 22: TAR-Host1 must transmit 2 MLDv1 Reports with a multicast group of M1.

Step 24: TAR-Host1 must transmit 2 MLDv1 Done with a multicast group of M1.

- *Part E*

Step 29: TAR-Host1 must transmit 2 MLDv1 Reports with a multicast group of M1.

Step 32: TAR-Router1 must transmit 2 MLDv2 Startup General Queries. In response to TAR-Router1 General Query, TAR-Host1 must transmit an MLDv1 Report with a multicast group of M1.

Step 34: TAR-Host1 must transmit 2 MLDv1 Done message with a multicast group of M1. TAR-Router1 transmits 2 Multicast Address Specific Queries with a Multicast Address of M1.

- *Part F*

Step 39: TAR-Host1 must transmit 2 MLDv1 Reports with a multicast group of M1.

Step 42: TAR-Router1 must transmit 2 MLDv2 Startup General Queries. In response to TAR-Router1 General Query, TAR-Host1 must transmit an MLDv1 Report with a multicast group of M1.

Step 44: TAR-Host1 transmits a Report with a Multicast Address Record with a Record type of IS_EX and a multicast group of M1.

Possible Problems:

- None

Test MLDv2_INTEROP.1.4: Source Specific Mode

Purpose: To verify that a router and listener properly interoperate in SSM.

References:

- [SSM] – 2

This section defines the notion of an "SSM-aware" host and then goes on to describe the API requirements and the SFGMP protocol requirements of an SSM-aware host. It is important to note that SSM can be used by any host that supports source filtering APIs and whose operating system supports the appropriate SFGMP. The SFGMP modifications described in this section make SSM work better on an SSM-aware host, but they are not strict prerequisites for the use of SSM.

The 232/8 IPv4 address range is currently allocated for SSM by IANA [IANA-ALLOCATION]. In IPv6, the FF3x::/32 range (where 'x' is a valid IPv6 multicast scope value) is reserved for SSM semantics [RFC3306], although today SSM allocations are restricted to FF3x::/96. ([SSM] has a more thorough discussion of this topic.) A host that knows the SSM address range and is capable of applying SSM semantics to it is described as an "SSM-aware" host.

A host or router may be configured to apply SSM semantics to addresses other than those in the IANA-allocated range. The GMP module on a host or router **SHOULD** have a configuration option to set the SSM address range(s). If this configuration option exists, it **MUST** default to the IANA-allocated SSM range. The mechanism for setting this configuration option **MUST** at least allow for manual configuration. Protocol mechanisms to set this option may be defined in the future.

- [SSM] – 3

Routers must be aware of the SSM address range in order to provide the SSM service model. A router that knows the SSM address range and is capable of applying SSM semantics to it as described in this section is described as an "SSM-aware" router. An SSM-aware router **MAY** have a configuration option to apply SSM semantics to addresses other than the IANA-allocated range, but if such an option exists, it **MUST** default to the IANA-allocated range.

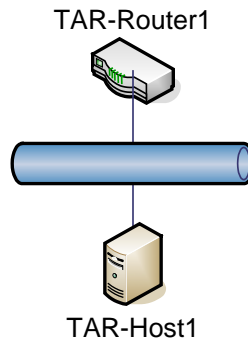
This section documents the behavior of routers with respect to the following types of SFGMP messages for source-specific destination addresses:

- IGMPv3 and MLDv2 Reports (3.1)
- IGMPv3 and MLDv2 General Query (3.2)
- IGMPv3 and MLDv2 Group-Specific Query (3.3)

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- IGMPv3 and MLDv2 Group-and-Source Specific Query (3.4)
- IGMPv1/v2 and MLDv1 Reports (3.5)
- IGMPv1/v2 and MLDv1 Queries (3.6)
- IGMPv2 Leave and MLDv1 Done (3.7)

Test Setup: For each Part, connect hosts and routers as per the figures below.



Procedure:

Part A: Join SSM group

1. TAR-Host1 joins a SSM multicast group SSM.
2. Observe the packets on all networks.

Part B: Leave SSM group

3. TAR-Host1 joins multicast group SSM with a source address of S1.
4. Observe the packets on all networks.
5. TAR-Host1 leaves multicast group SSM with a source address of S1.
6. Observe the packets on all networks.

Observable Results:

- *Part A*
Step 2: TAR-Host1 does not transmit a Report with a Multicast Address Record with a Record type of TO_EX and a multicast group of SSM.
- *Part B*
Step 4: TAR-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of ALLOW and a multicast group of SSM with a source address of S1.
Step 6: TAR-Host1 transmits a Report with a Multicast Address Record with a Record type of BLOCK and a multicast group of SSM with a source address of S1. TAR-Router1 transmits 2 Multicast Address Specific Queries with a Multicast Address of SSM with a source address of S1.

Possible Problems:

- None

GROUP 2: Router Interoperability

Scope:

The following tests are designed to verify a router interoperates with other routers on a network.

Overview:

These tests verify that MLDv2 routers behave correctly when interacting.

Test MLDv2_INTEROP.2.1: Query Election

Purpose: To verify that an MLD router properly handles Querier Election.

References:

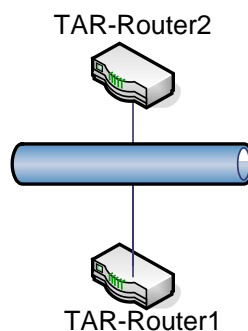
- [MLD] – 7.6.2

MLDv2 elects a single router per subnet to be in Querier state; all the other routers on the subnet should be in Non-Querier state. MLDv2 uses the same querier election mechanism as MLDv1, namely the IPv6 address. When a router starts operating on a subnet, by default it considers itself as being the Querier. Thus, it sends several General Queries separated by a small time interval (see sections 9.6 and 9.7 for details).

When a router receives a query with a lower IPv6 address than its own, it sets the Other Querier Present timer to Other Querier Present Timeout; if it was previously in Querier state, it switches to Non-Querier state and ceases to send queries on the link. After the Other Querier Present timer expires, it should re-enter the Querier state and begin sending General Queries.

All MLDv2 queries MUST be sent with the FE80::/64 link-local source address prefix. Therefore, for the purpose of MLDv2 querier election, an IPv6 address A is considered to be lower than an IPv6 address B if the interface ID represented by the last 64 bits of address A, in big-endian bit order, is lower than the interface ID represented by the last 64 bits of address B.

Test Setup: For each Part, connect hosts and routers as per the figures below.



Procedure:

Part A: First Router Elected Querier

1. Configure TAR-Router1 to have a lower IPv6 address than TAR-Router2.
2. Enable MLDv2 on TAR-Router1.
3. Observe the packets on all networks.

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4. Enable MLDv2 on TAR-Router2.
5. Observe the packets on all networks.

Part B: Second Router Elected Querier

6. Configure TAR-Router1 to have a lower IPv6 address than TAR-Router2.
7. Enable MLDv2 on TAR-Router2.
8. Observe the packets on all networks.
9. Enable MLDv2 on TAR-Router1.
10. Observe the packets on all networks.

Part C: Querier, Other-Querier Present Timer Expires

11. Configure TAR-Router1 to have a lower IPv6 address than TAR-Router2.
12. Enable MLDv2 on TAR-Router1 and TAR-Router2.
13. Observe the packets on all networks.
14. Disconnect TAR-Router1 from the network.
15. Observe the packet on all networks.

Part D: First Router, Elected Non-Querier

16. Configure TAR-Router2 to have a lower IPv6 address than TAR-Router1.
17. Enable MLDv2 on TAR-Router1.
18. Observe the packets on all networks.
19. Enable MLDv2 on TAR-Router2.
20. Observe the packets on all networks.

Part E: Second Router, Elected Non-Querier

21. Configure TAR-Router2 to have a lower IPv6 address than TAR-Router1.
22. Enable MLDv2 on TAR-Router2.
23. Observe the packets on all networks.
24. Enable MLDv2 on TAR-Router1.
25. Observe the packets on all networks.

Part F: Non-Querier, Other-Querier Present Timer Expires

26. Configure TAR-Router2 to have a lower IPv6 address than TAR-Router1.
27. Enable MLDv2 on TAR-Router1 and TAR-Router2.
28. Observe the packets on all networks.
29. Disconnect TAR-Router2 from the network.
30. Observe the packet on all networks.

Part G: Three Routers, Querier

31. Configure TAR-Router2 to have a lower IPv6 address than TAR-Router1 and REF-Router1.
Configure TAR-Router1 to have a lower IPv6 address than REF-Router1.
32. Enable MLDv2 on all devices.
33. Observe the packets on all networks.

Part H: Three Routers. Non-Querier

34. Configure TAR-Router1 to have a lower IPv6 address than TAR-Router1 and REF-Router1.
Configure TAR-Router2 to have a lower IPv6 address than REF-Router1.
35. Enable MLDv2 on all devices.
36. Observe the packets on all networks.

Observable Results:

- *Part A*
 - Step 3:** TAR-Router1 must transmit MLDv2 General Queries.
 - Step 5:** TAR-Router1 must continue to transmit MLDv2 General Queries.
- *Part B*

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Step 7: TAR-Router2 must transmit MLDv2 General Queries.

Step 9: TAR-Router1 must transmit MLDv2 General Queries. TAR-Router2 must not transmit MLDv2 General Queries.

- *Part C*

Step 13: TAR-Router1 must transmit MLDv2 General Queries.

Step 15: After [OQPT] seconds TAR-Router2 must transmit 2 MLDv2 General Queries.

- *Part D*

Step 18: TAR-Router2 must transmit MLDv2 General Queries.

Step 20: TAR-Router2 must continue to transmit MLDv2 General Queries.

- *Part E*

Step 23: TAR-Router1 must transmit MLDv2 General Queries.

Step 25: TAR-Router2 must transmit MLDv2 General Queries. TAR-Router1 must not transmit MLDv2 General Queries.

- *Part F*

Step 28: TAR-Router2 must transmit MLDv2 General Queries.

Step 30: After [OQPT] seconds TAR-Router1 must transmit 2 MLDv2 General Queries.

- *Part G*

Step 33: TAR-Router2 must transmit MLDv2 General Queries.

- *Part H*

Step 36: TAR-Router1 must transmit MLDv2 General Queries.

Possible Problems:

- None

Test MLDv2_INTEROP.2.2: Group Specific Query

Purpose: To verify that an MLD router properly handles Group Specific Query Reception.

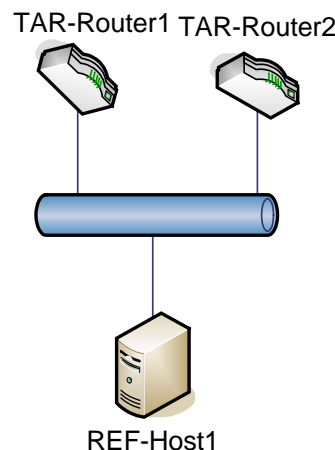
References:

- [MLD] – 7.6.3.1

When a table action "Send Q(MA)" is encountered, the Filter Timer must be lowered to LLQT. The Querier must then immediately send a Multicast Address Specific query as well as schedule [Last Listener Query Count - 1] query retransmissions to be sent every [Last Listener Query Interval], over [Last Listener Query Time].

When transmitting a Multicast Address Specific Query, if the Filter Timer is larger than LLQT, the "Suppress Router-Side Processing" bit is set in the query message..

Test Setup: For each Part, connect hosts and routers as per the figures below.



Procedure:

Part A: Querier

1. Configure TAR-Router1 to have a lower IPv6 address than TAR-Router2.
2. Enable MLDv2 on all devices.
3. REF-Host1 joins multicast group M1.
4. Observe the packets on all networks.
5. REF-Host1 leaves multicast group M1.
6. Observe the packets on all networks.

Part B: Non-Querier

7. Configure TAR-Router2 to have a lower IPv6 address than TAR-Router1.
8. Enable MLDv2 on all devices.
9. REF-Host1 joins multicast group M1.
10. Observe the packets on all networks.

11. REF-Host1 leaves multicast group M1.
12. Observe the packets on all networks.

Observable Results:

- *Part A*
 - Step 4:** REF-Host1 transmits 2 Reports with a Multicast Address Record a Record type of TO_EX and a multicast group of M1.
 - Step 6:** REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router1 transmits 2 Multicast Address Specific Queries with a Multicast Address of M1.
- *Part B*
 - Step 10:** REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.
 - Step 12:** REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router2 transmits 2 Multicast Address Specific Queries with a Multicast Address of M1.

Possible Problems:

- None

Test MLDv2_INTEROP.2.3: Group and Source Specific Query

Purpose: To verify that an MLD router properly handles Group and Source Specific Query.

References:

- [MLD] – 7.6.3.2

When a table action "Send Q(MA,X)" is encountered by the Querier in the table in section 7.4.2, the following actions must be performed for each of the sources in X that send to multicast address MA, with source timer larger than LLQT:

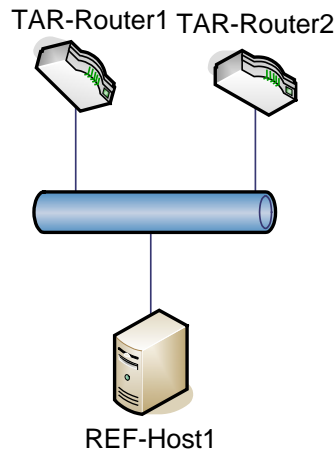
- o Lower source timer to LLQT;
- o Add the sources to the Retransmission List;
- o Set the Source Retransmission Counter for each source to [Last Listener Query Count].

The Querier must then immediately send a Multicast Address and Source Specific Query as well as schedule [Last Listener Query Count - 1] query retransmissions to be sent every [Last Listener Query Interval], over [Last Listener Query Time]. The contents of these queries are calculated as follows.

When building a Multicast Address and Source Specific Query for a multicast address MA, two separate query messages are sent for the multicast address. The first one has the "Suppress Router-Side Processing" bit set and contains all the sources with retransmission state (i.e., sources from the Retransmission List of that multicast address), and timers greater than LLQT. The second has the "Suppress Router-Side Processing" bit clear and contains all the sources with retransmission state and timers lower or equal to LLQT. If either of the two calculated messages does not contain any sources, then its transmission is suppressed.

Note: If a Multicast Address Specific query is scheduled to be transmitted at the same time as a Multicast Address and Source specific query for the same multicast address, then transmission of the Multicast Address and Source Specific message with the "Suppress Router-Side Processing" bit set may be suppressed.

Test Setup: For each Part, connect hosts and routers as per the figures below.



Procedure:

Part A: Querier

1. Configure TAR-Router1 to have a lower IPv6 address than TAR-Router2.
2. Enable MLDv2 on all devices.
3. REF-Host1 joins multicast group M1 with a source address of S1 and S2.
4. Observe the packets on all networks.
5. Disconnect TAR-Router1 from the network.
6. REF-Host1 leaves multicast group M1 with a source address of S1.
7. Observe the packets on all networks.

Part B: Non-Querier

8. Configure TAR-Router2 to have a lower IPv6 address than TAR-Router1.
9. Enable MLDv2 on all devices.
10. REF-Host1 joins multicast group M1 with a source address of S1 and S2.
11. Observe the packets on all networks.
12. Disconnect TAR-Router2 from the network.
13. REF-Host1 leaves multicast group M1 with a source address of S1.
14. Observe the packets on all networks

Observable Results:

- *Part A*

Step 4: REF-Host1 transmits 2 Reports with a Multicast Address Record of type of ALLOW and a multicast group of M1 with a source address of S1 and S2.

Step 7: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 with a source address of S1. TAR-Router2 transmits a Multicast Address and Source Specific Query with a Multicast Address of M1 with a source address of S1.

- *Part B*

Step 4: REF-Host1 transmits 2 Reports with two Multicast Address Records: a Record type of TO_IN and a multicast group of M1 with a source address of S1 and S2 and a Record type of ALLOW and a multicast group of M1 with a source address of S1 and S2.

Step 7: REF-Host1 transmits a Report with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 with a source address of S1. TAR-Router1

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transmits a Multicast Address and Source Specific Query with a Multicast Address of M1 with a source address of S1.

Possible Problems:

- None

Test MLDv2_INTEROP.2.4: Router-Side Processing

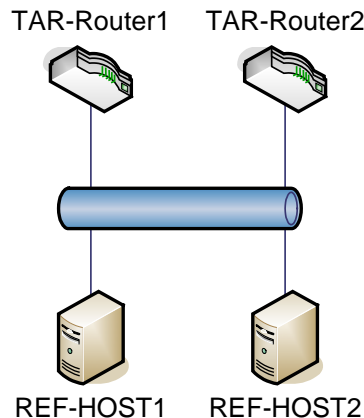
Purpose: To verify that an MLD router properly handles S Flag.

References:

- [MLD] – 2.2

Protocol robustness is also enhanced through the use of the S flag (Suppress Router-Side Processing). As described above, when a Multicast Address Specific or a Multicast Address and Source Specific Query is sent by the Querier, a number of retransmissions of the query are scheduled. In the original (first) query the S flag is clear. When the Querier sends this query, it lowers the timers for the concerned multicast address (or source) to a given value; similarly, any non-querier multicast router that receives the query lowers its timers in the same way. Nevertheless, while waiting for the next scheduled queries to be sent, the Querier may receive a report that updates the timers. The scheduled queries still have to be sent, in order to ensure that a non-querier router keeps its state synchronized with the current Querier (the non-querier router might have missed the first query). Nevertheless, the timers should not be lowered again, as a valid answer was already received. Therefore, in subsequent queries the Querier sets the S flag.

Test Setup: For each Part, connect hosts and routers as per the figures below.



Procedure:

Part A: Querier Multicast Address Specific S flag

1. Configure TAR-Router1 to have a lower IPv6 address than TAR-Router2.
2. Enable MLDv2 on all network devices.
3. Observe the packets on all networks.
4. REF-Host1 joins multicast group M1.
5. Observe the packets on all networks.
6. REF-Host2 joins multicast group M1.

7. Observe the packets on all networks.
8. REF-Host1 leaves multicast group M1.
9. Observe the packets on all networks.

Part B: Non-Querier Multicast Address Specific S Flag

10. Configure TAR-Router2 to have a lower IPv6 address than TAR-Router1.
11. Enable MLDv2 on all network devices.
12. Observe the packets on all networks.
13. REF-Host1 joins multicast group M1.
14. Observe the packets on all networks.
15. REF-Host2 joins multicast group M1.
16. Observe the packets on all networks.
17. REF-Host1 leave multicast group M1.
18. Observe the packets on all networks.

Part C: Querier Multicast Address Specific S flag

19. Configure TAR-Router1 to have a lower IPv6 address than TAR-Router2.
20. Enable MLDv2 on all network devices.
21. REF-Host1 joins multicast group M1 with a source address of S1.
22. Observe the packets on all networks.
23. REF-Host2 joins multicast group M1 with a source address of S1.
24. Observe the packets on all networks.
25. REF-Host1 leaves multicast group M1 with a source address of S1.
26. Observe the packets on all networks.

Part D: Non-Querier Multicast Address Specific S Flag

27. Configure TAR-Router2 to have a lower IPv6 address then TAR-Router1.
28. Enable MLDv2 on all network devices.
29. Observe the packets on all networks.
30. REF-Host1 joins multicast group M1 with a source address of S1.
31. Observe the packets on all networks.
32. REF-Host2 joins multicast group M1 with a source address of S1.
33. Disconnect TAR-Router2 from the network.
34. REF-Host1 leave multicast group M1 with a source address of S1.
35. Observe the packets on all networks.

Observable Results:

- *Part A*

Step 3: TAR-Router1 must transmit MLDv2 General Queries.

Step 5: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 7: REF-Host2 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 9: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router1 transmits a Multicast Address Specific Query with a Multicast Address of M1 with the S Flag clear. In response to the Multicast Address Specific Query, REF-Host2 must transmit a Report with a Multicast Address Record with a Record Type of IS_EX with a multicast group of M1. After REF-Host2 transmits the report TAR-Router1 transmits a Multicast Address Specific Query with a Multicast Address of M1 with the S Flag set.

- *Part B*

Step 12: TAR-Router2 must transmit MLDv2 General Queries.

Step 14: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 16: REF-Host2 transmits 2 Reports with a Multicast Address Record with a Record type of TO_EX and a multicast group of M1.

Step 18: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of TO_IN and a multicast group of M1. TAR-Router2 transmits a Multicast Address Specific Query with a Multicast Address of M1 with the S Flag clear. In response to the Multicast Address Specific Query, REF-Host2 must transmit a Report with a Multicast Address Record with a Record Type of IS_EX with a multicast group of M1. After REF-Host2 transmits the report TAR-Router2 transmits a Multicast Address Specific Query with a Multicast Address of M1 with the S Flag set.

- *Part C*

Step 22: TAR-Router1 must transmit MLDv2 General Queries.

Step 24: REF-Host1 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 and a source address of S1.

Step 26: REF-Host2 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 and a source address of S1.

Step 28: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 and a source address of S1. TAR-Router1 transmits a Multicast Address and Source Specific Query with a Multicast Address of M1 and a source address of S1 with the S Flag clear. In response to the Multicast Address Specific Query, REF-Host2 must transmit a Report with a Multicast Address Record with a Record Type of IS_IN with a multicast group of M1 and a source address of S1. After REF-Host2 transmits the report TAR-Router1 transmits a Multicast Address and Source Specific Query with a Multicast Address of M1 and a source address of S1 with the S Flag set.

- *Part D*

Step 29: TAR-Router2 must transmit MLDv2 General Queries.

Step 31: REF-Host1 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 and a source address of S1.

Step 33: REF-Host2 transmits 2 Reports with a Multicast Address Records with a Record type of ALLOW and a multicast group of M1 and a source address of S1.

Step 35: REF-Host1 transmits 2 Reports with a Multicast Address Record with a Record type of BLOCK and a multicast group of M1 and a source address of S1. TAR-Router2 transmits a Multicast Address and Source Specific Query with a Multicast Address of M1 and a source address of S1 with the S Flag clear. In response to the Multicast Address Specific Query, REF-Host2 must transmit a Report with a Multicast Address Record with a Record Type of IS_IN with a multicast group of M1 and a source address of S1. After REF-Host2 transmits the report TAR-Router2 transmits a Multicast Address and Source Specific Query with a Multicast Address of M1 and a source address of S1 with the S Flag set.

Possible Problems:

- None

Test MLDv2_INTEROP.2.5: Query Robustness Variable Adoption

Purpose: To verify that an MLD router properly handles robustness variable adoption.

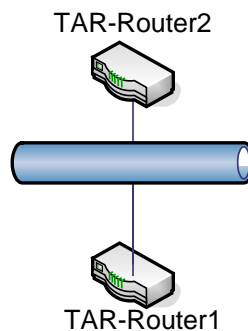
References:

- [MLD] – 5.1.8

If non-zero, the QRV field contains the [Robustness Variable] value used by the Querier. If the Querier's [Robustness Variable] exceeds 7 (the maximum value of the QRV field), the QRV field is set to zero.

Routers adopt the QRV value from the most recently received Query as their own [Robustness Variable] value, unless that most recently received QRV was zero, in which case they use the default [Robustness Variable] value specified in section 9.1, or a statically configured value.

Test Setup: For each Part, connect hosts and routers as per the figures below.



Procedure:

Part A: Querier Adoption

1. Configure TAR-Router1 to have a lower IPv6 address than TAR-Router2.
2. Configure TAR-Router1 to have a Robustness variable of 7.
3. Enable MLDv2 on all network devices
4. Observe the packets on all networks.
5. Disconnect TAR-Router1 from the network.
6. Observe the packets on all networks.

Part B: Non-Querier Adoption

7. Configure TAR-Router2 to have a lower IPv6 address than TAR-Router1.
8. Configure TAR-Router2 to have a Robustness variable of 7.
9. Enable MLDv2 on all network devices.
10. Observe the packets on all networks.
11. Disconnect TAR-Router2 from the network.
12. Observe the packets on all networks.

Observable Results:

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- *Part A*
Step 4: TAR-Router1 must transmit MLDv2 General Queries.
Step 6: After [OQPT] seconds TAR-Router2 must transmit 2 MLDv2 General Queries.
- *Part B*
Step 10: TAR-Router2 must transmit MLDv2 General Queries.
Step 12: After [OQPT] seconds TAR-Router1 must transmit 2 MLDv2 General Queries.

Possible Problems:

- None

Test MLDv2_INTEROP.2.6: Query Interval Code Adoption

Purpose: To verify that an MLD router properly handles Interval Code adoption.

References:

- [MLD] – 5.1.9

The Querier's Query Interval Code field specifies the [Query Interval] used by the Querier. The actual interval, called the Querier's Query Interval (QQI), is represented in units of seconds, and is derived from the Querier's Query Interval Code as follows:

If $QQIC < 128$, $QQI = QQIC$

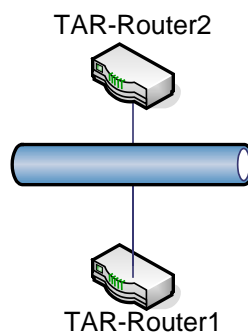
If $QQIC \geq 128$, $QQIC$ represents a floating-point value as follows:

```
0 1 2 3 4 5 6 7
+--+--+--+--+--+--+
|1| exp | mant |
+--+--+--+--+--+--+
```

$QQI = (mant \mid 0x10) \ll (exp + 3)$

Multicast routers that are not the current Querier adopt the QQI value from the most recently received Query as their own [Query Interval] value, unless that most recently received QQI was zero, in which case the receiving routers use the default [Query Interval] value specified in section 9.2.

Test Setup: For each Part, connect hosts and routers as per the figures below.



Procedure:

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Part A: Querier QQIC 30

1. Configure TAR-Router1 to have a lower IPv6 address than TAR-Router2.
2. Configure TAR-Router1 Query Interval to 30.
3. Enable MLDv2 on all devices.
4. Observe the packets on all networks.
5. Disconnect TAR-Router1 from the network.
6. Observe the packets on all networks.

Part B: Querier QQIC 144

7. Configure TAR-Router1 to have a lower IPv6 address than TAR-Router2.
8. Configure TAR-Router1 Query Interval to 144.
9. Enable MLDv2 on all devices.
10. Observe the packets on all networks.
11. Disconnect TAR-Router1 from the network
12. Observe the packets on all networks.

Part C: Non-Querier QQIC 30

13. Configure TAR-Router2 to have a lower IPv6 address than TAR-Router1.
14. Configure TAR-Router2 Query Interval to 30.
15. Enable MLDv2 on all devices.
16. Observe the packets on all networks.
17. Disconnect TAR-Router2 from the network.
18. Observe the packets on all networks.

Part D: Non-Querier QQIC 144

19. Configure TAR-Router2 to have a lower IPv6 address than TAR-Router1.
20. Configure TAR-Router2 Query Interval to 144.
21. Enable MLDv2 on all devices.
22. Observe the packets on all networks.
23. Disconnect TAR-Router2 from the network.
24. Observe the packets on all networks.

Observable Results:

- *Part A*
Step 4: TAR-Router1 must transmit MLDv2 General Queries.
Step 6: After [OQPT] seconds TAR-Router2 must transmit 2 MLDv2 General Queries.
- *Part B*
Step 10: TAR-Router1 must transmit MLDv2 General Queries.
Step 12: After [OQPT] seconds TAR-Router2 must transmit 2 MLDv2 General Queries.
- *Part C*
Step 16: TAR-Router2 must transmit MLDv2 General Queries.
Step 18: After [OQPT] seconds TAR-Router1 must transmit 2 MLDv2 General Queries.
- *Part D*
Step 22: TAR-Router2 must transmit MLDv2 General Queries.
Step 24: After [OQPT] seconds TAR-Router1 must transmit 2 MLDv2 General Queries.

Possible Problems:

- None.