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IGMP and MLD Protocol Extensions for Mobility
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Abstract

This document describes an explicit membership notification operation and IGMP and MLD Hold and Release protocol extensions for hosts and routers. The interoperability with the standard IGMPv3/MLDv2 protocols and these previous versions is also taken into account.

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1. Introduction

The Internet Group Management Protocol (IGMP) [2] for IPv4 and the Multicast Listener Discovery Protocol (MLD) [3] for IPv6 are the standard protocols used by hosts and multicast routers. A mobile host sends a join/leave request for particular multicast session or channel to its upstream router (i.e., an adjacent router or IGMP/MLD proxy [8]), and the router will maintain the multicast reception (or membership) state of the host and serve multicast data to the host.

Conceptually, IGMP and MLD work for mobile communications such with MIPv6 [11] or PMIPv6 [12]. However, wireless access technologies and mobile communications need to preserve the limited resources of mobile hosts and networks [10] and smooth handover. According to a smooth handover scenario, a mobile host wants to accelerate multicast service termination in the previous network before handoff and immediately rejoin the session after the movement. As the router's behavior, when the router remains part of the multicast delivery tree, it keeps the session active without leaving from the session, while the data transmission is paused until the host completes the movement and resumed after the movement.

This document describes a "Notification operation" and "Hold and Release protocol extensions" for the IGMPv3 and MLDv2 protocols for mobile hosts and routers. The IGMP/MLD Hold operation enables to keep the membership state for fast packet forwarding, and the IGMP/MLD Release operation resumes forwarding the multicast data after the host movement. Originally, an idea of MLD Hold was proposed in [13].

Note that discussing the procedure of context transfer (CT) for mobility protocols and the message format for CT will be defined in other documents. Discussing how a mobile host or a router detects the movement and triggers to send an IGMP/MLD Hold message is depend on mobility protocols, and hence out of scope of this document.

The proposed solution interoperates with the IGMPv3 and MLDv2 protocols and preserves compatibility with older versions of IGMP/MLD.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#) [1].

IGMP/MLD Hold:

IGMP/MLD Hold is an operation in which a neighboring mobile host or IGMP/MLD proxy requests a multicast router to suspend data forwarding for temporal period (during mobile host movement).

IGMP/MLD Release:

IGMP/MLD Release is an operation in which a neighboring mobile host or IGMP/MLD proxy requests a multicast router to resume data forwarding that was suspended by the router.

Hold-Req Records:

Hold-Req Records are IGMP/MLD Multicast Address Records (group and source address records with filter-mode) a mobile hosts requests to suspend. Hold-Req Records are specified in an IGMP/MLD Hold message and MAY correspond to the set of Current-State Records the mobile host has joined.

Release-Req Records:

Release-Req Records are IGMP/MLD Multicast Address Records a mobile hosts requests to resume. Release-Req Records are specified in an IGMP/MLD Release message and MAY correspond to the Hold-Req Records the mobile host has sent.

Hold Records:

Hold Records are the IGMP/MLD records for which a multicast router decides to suspend data forwarding.

3. Explicit Membership Notification

This document proposes an IGMP/MLD Notification operation, in which a mobile host *periodically* sends Current-State Record messages expressing which multicast sessions the host is joining, even the host is not requested to report the membership information by its upstream router (i.e., no reception of General Query message).

The IGMP/MLD Notification operation enables the longer [Query Interval] value for IGMP/MLD General Query than the default [Query Interval]. If mobile hosts support the IGMP/MLD Notification operation, a multicast router can obtain downstream membership information without periodic and spontaneous membership solicitation by IGMP/MLD General Query.

The IGMP/MLD Notification operation reduces the number of IGMP/MLD General Query messages. Since a router only needs to refresh downstream membership information by solicited IGMP/MLD General Query to the hosts that do not support the IGMP/MLD Notification operation or leave from network without sending any message to the router, both [Query Interval] and [Unicast Query Interval] (described in [Section 6.1](#)) can be set to longer values. This mechanism may conserve battery power of sleeping hosts, as these hosts do not pay attention to the General Query messages at short intervals.

The [Notification Interval] value (described in [Section 6.2](#)) is the interval of Current-State Records periodically sent by a member host that joins one or more multicast sessions. Since a mobile host periodically multicasts Current-State Record to all-router multicast address (224.0.0.2 or FF02::2) in the Notification operation, the [Notification Interval] value can be shorter than the regular [Query Interval] and [Unicast Query Interval]. When mobile hosts receive IGMP/MLD General Query, they reset their [Notification Interval] value and restart it.

When a multicast router works with the Notification operation, it must maintain the following information for each multicast session to recognize receiver host's membership status;

- 1 Receiver address - indicates an address of a receiver host sending the Current-State Report.
- 2 Last membership report - indicates the time that the router receives the last Current-State Report.

- 3 Filter mode - indicates either INCLUDE or EXCLUDE as defined in [\[2\]](#)[3].
- 4 Source addresses and multicast address - indicates the address pair that the receiver joins.

4. IGMP/MLD Hold and Release

4.1. Action for IGMP/MLD Hold Request

When a mobile host moves from a current network (i.e. a mobile host's point of attachment) to a different network, an IGMP/MLD Hold message is sent by either the mobile host itself or a neighboring IGMP/MLD proxy to which the mobile host currently attached. The IGMP/MLD Hold message will be sent by the mobile host or the proxy depending on which mobile protocol is in use. For instance, in MIPv6 [[11](#)], a mobile host detects its own movement and sends the IGMP/MLD Hold message to its upstream router (or Home Agent). On the other hand, in PMIPv6 [[12](#)], while a mobile host initiates multicast join/leave requests by sending regular IGMP/MLD messages [[2](#)][[3](#)], it does not send the IGMP/MLD Hold message. The reason is that a mobile host (or Mobile Node (MN) in [[12](#)]) does not manage its movement but the mobile access gateway (MAG) detects its movement. In this case, MAG sends the corresponding IGMP/MLD Hold messages to its upstream router (in case of local routing) or local mobility anchor (LMA) (in case of bidirectional tunneling) upon the host movement.

An IGMP/MLD Hold message is received by either the adjacent upstream router or an IGMP/MLD proxy that the mobile host attached. An IGMP/MLD proxy performs a host portion of the IGMP/MLD protocol on the upstream interface, and an IGMP/MLD Hold message will be finally proceeded by a multicast router. Therefore if an IGMP/MLD proxy receives an IGMP/MLD Hold message, it forwards the Hold message with the link-local IPv6 source address of its upstream interface. (Note that there is a case that an IGMP/MLD proxy does not forward the Hold message. See [Section 4.3](#).) If the upstream interface of the IGMP/MLD proxy is attached to another (cascaded) IGMP/MLD proxy, then the IGMP/MLD Hold message is forwarded to that cascaded proxy, and the cascaded proxy forwards the Hold message toward its upstream router.

4.2. Action for IGMP/MLD Release Request

When a mobile host completes its movement and attaches a new network, the host or the neighboring IGMP/MLD proxy immediately sends an IGMP/MLD Release message. The Release-Req Records specified in the IGMP/MLD Release message MAY be the same as that of the Hold-Req Records the host sent (since the host does not know the Hold Records, and only knows Hold-Req Records).

As well as an IGMP/MLD Hold message, an IGMP/MLD Release message MUST also be finally proceeded by a multicast router. Hence if an IGMP/MLD proxy receives an IGMP/MLD Release message, it forwards the Release message with the link-local IPv6 source address of its upstream interface. If proxies are cascaded, the IGMP/MLD Release

message is forwarded toward its upstream router.

4.3. Action for IGMP/MLD Hold Reception

When a multicast router receives an IGMP/MLD Hold message from a neighboring mobile host or IGMP/MLD proxy, it records the following information; 1) the source IP address of the IGMP/MLD Hold message, and 2) the Hold-Req Records. After that, the router needs to decide whether it suspends the data forwarding or not. Since the decision has to be made whether to know the message sender is the last member for notified sessions/channels, the router sends the Group-Specific or Group-and-Source Specific Queries for all Hold-Req Records in the Hold messages. If the router receives the inquired IGMP/MLD reports, it eliminates the records from the Hold-Req Records and keeps forwarding the data. If it does not receive the IGMP/MLD reports for some of the Hold-Req Records, it recognizes that the Hold message sender is the last member host joining the sessions or channels on the interface, keeps them as the Hold Records, and suspends the data forwarding.

The multicast router maintains Hold Records until it receives the corresponding IGMP/MLD Release message (described in the next section) or the IGMP/MLD Hold Interval timer (described in [Section 6.3](#)) is expired. When either the Release message reception or the timer expiration occurs, the router resume data forwarding for the Hold Records and discards the Hold Records.

If a multicast router receives an IGMP/MLD Hold message whose Multicast Address Records have already kept in the Hold Records, the router restarts the IGMP/MLD Hold Interval timer for the corresponding Multicast Address Records.

As described in [[10](#)], there is an advantage if a router has been tracking multicast memberships of all downstream hosts, as it can recognize whether the message sender host is the last member joining the sessions/channels without sending the Group-Specific or Group-and-Source Specific Queries.

When an IGMP/MLD proxy receives an IGMP/MLD Hold message from a downstream mobile host, it forwards the message to its upstream router as described in [Section 4.1](#). Since the IGMP/MLD information presented by the proxy to its upstream routers is the aggregation of all its downstream group membership information, prior to forwarding the Hold message, an IGMP/MLD proxy MUST inquire downstream memberships and organize new Hold-Req Records. Then it forwards the appropriate IGMP/MLD Hold message including the newly organized Hold-Req Records to its upstream router.

4.4. Action for IGMP/MLD Release Reception

When a mobile host moves to a new network, the host or the neighboring IGMP/MLD proxy immediately sends an IGMP/MLD Release message to request its upstream router to release the hold request previously sent. The format of the Release message is the same as that of the standard IGMP/MLD Current-State Report message. (See [Section 4.5.](#))

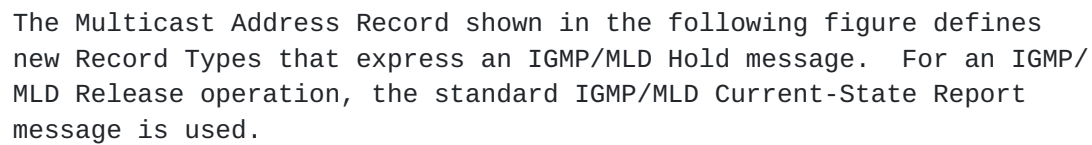
When a multicast router receives an IGMP/MLD Release (i.e. Current-State Report) message, the router examines the message sender and an IGMP/MLD Hold Interval timer. If the router has the Hold Records given from the Release message sender, it compares the Hold Records with the notified Multicast Address Records specified in the IGMP/MLD Current-State Report message. For the matched Multicast Address Records, the router then removes the entries from the Hold Records and resume data forwarding with restarting the group or source timers. For the mismatched Multicast Address Records, the router keeps untouched (then removed by timeout) or explicitly starts the leave (or prune) procedures for the sessions/channels, while it depends on the implementation.

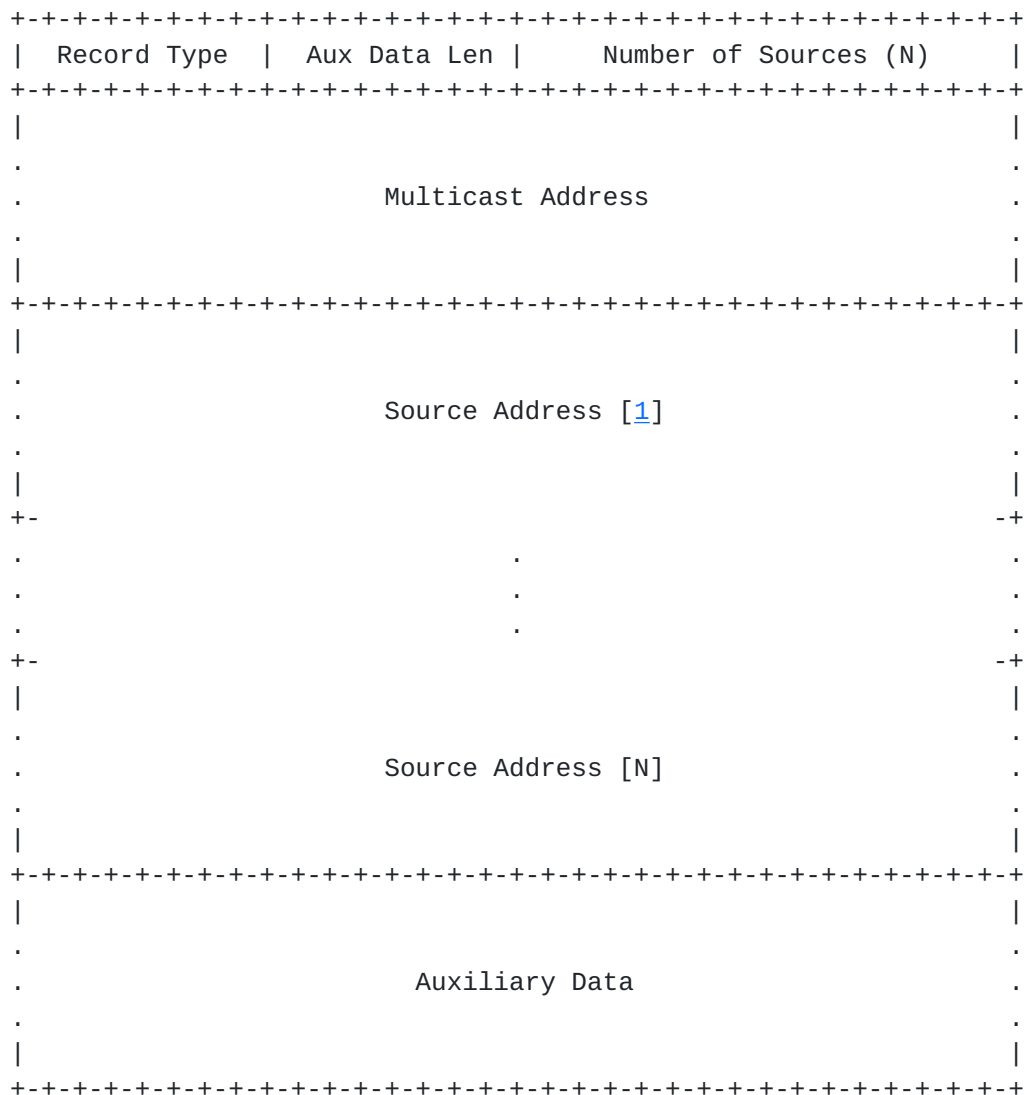
If either the router does not have the corresponding Hold Records or the IGMP/MLD Hold Interval timer has expired, then the router does not take any action.

If a router that did not recognize an IGMP/MLD Hold message (e.g., due to packet loss or some troubles in its transmission) receives an IGMP/MLD Current-State Report message, it will accept the message as a regular Current-State Report IGMP/MLD message as specified in [Section 5.](#)

4.5. IGMP/MLD Hold Message Format

The following figure is the Report message format defined in IGMPv3 [2] and MLDv2 [3]. Type field is either IGMP Version 3 Membership Report (0x22) or Version 2 Multicast Listener Report (decimal 143); it is not necessary to change IGMP/MLD Report message format to support IGMP/MLD Hold messages.





Value Name and Meaning

- 1 HOLD_INCLUDE - indicates that the interface has a filter mode of INCLUDE for the specified multicast address. The Source Address [i] fields in this Multicast Address Record contain the interface's source list for the specified multicast address. A HOLD_INCLUDE Record is never sent with an empty source list.
- 2 HOLD_EXCLUDE - indicates that the interface has a filter mode of EXCLUDE for the specified multicast address. The Source Address [i] fields in this Multicast Address Record contain the interface's source list for the specified multicast address, if it is non-empty. When a mobile host works with

LW-IGMPv3/LW-MLDv2 ([\[9\]](#)), the Multicast Address Record does not contain the Source Address [i] field with HOLD_EXCLUDE type value.

5. Interoperability with Older Protocols

This document assumes multicast routers that deal with mobile hosts MUST be IGMPv3/MLDv2 capable (regardless whether the protocols are the full version or lightweight version). Therefore this document does not need to consider interoperability with older version protocols.

An IGMP/MLD Notification operation is a simple optimization for mobile hosts to spontaneously send IGMP/MLD Current-State Report to their upstream multicast routers. Since a multicast router solicits downstream membership information by IGMP/MLD General Query, non-upgraded mobile hosts can coexist in the network. However, join and leave latency for non-upgraded mobile hosts may become longer due to the longer [Query Interval] timer configuration for multicast routers. Note that the IGMP/MLD Notification operation does not require any modification to multicast routers.

If a multicast router does not support an IGMP/MLD Hold operation, it will ignore the IGMP/MLD Hold message. In this case, an IGMP/MLD Current-State Report message sent by a mobile host that previously requested an IGMP/MLD Hold operation to stop forwarding data is dealt with as a new join request for the specified multicast sessions (when the corresponding group or source timer is expired) or simply updates the corresponding group and/or source timer (when these timers are not expired and the membership status has been still active).

6. Timers, Counters, and Their Default Values

6.1. Unicast Query Interval

IGMPv3 and MLDv2 specifications [2][3] describe that a host MUST accept and process any Query whose IP Destination Address field contains any of the addresses (unicast or multicast) assigned to the interface on which the Query arrives. According to the scenario, this document defines [Unicast Query Interval] value that is separately managed from [Query Interval] by a router and explicitly used for unicast General Query. If a router keeps track of membership information, it can unicast General Query to tracked member hosts in [Unicast Query Interval]. Unicasting IGMP/MLD General Query would be effective especially when a wireless link is heavily loaded.

[Unicast Query Interval] value has correlation with [Query Interval] value and the number of multicast member hosts. The default value of [Query Interval] is 125 seconds [2][3], and the default value of [Unicast Query Interval] is 90 seconds. [Unicast Query Interval] should be smaller than [Query Interval]. However, if a number of member hosts are active on a wireless link, a router disables unicast General Query (i.e. by setting [Unicast Query Interval] value 0) and multicasts General Query.

6.2. Notification Interval

The default [Notification Interval] value is 60 seconds. The [Notification Interval] value MUST be shorter than both [Query Interval] and [Unicast Query Interval] values.

6.3. IGMP/MLD Hold Interval Timer

After a multicast router receiving an IGMP/MLD Hold message will identify the corresponding multicast sessions/channels, it suspends data forwarding and keeps the Hold Records until the given amount of timer value is expired. This timer is named the "IGMP/MLD Hold Interval timer", which is a configurable value.

The Hold Interval is used to allow a multicast router to resume the multicast session. Therefore, if the multicast router does not receive the corresponding IGMP/MLD Release (or Current-State Record) message for the IGMP/MLD Release operation within the Hold Interval, it leaves the sessions/channels recorded in the Hold Records and discards the Hold Records. Note that the router does not send any IGMP/MLD Query message for the timeout sessions/channels and immediately leave them.

7. Security Considerations

TBD.

For the use of IGMP/MLD Hold message, it may be required to confirm that the IGMP/MLD Hold messages sender is the IGMP/MLD Release sender. This document assumes the use of the simplest way of comparing the sender's IP address of each message, while it may require a more secure mechanism being robust from IP address spoofing.

8. Acknowledgements

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