Multiple Upstream Interface Support for IGMP/MLD Proxy
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Abstract

   This document describes the way of supporting multiple upstream
   interfaces for an IGMP/MLD proxy device. The proposed extension
   enables an IGMP/MLD proxy device to receive multicast sessions/
   channels through the different upstream interfaces. The upstream
   interface is selected based on the subscriber address prefixes,
   channel/session IDs, and interface priority values. A mechanism for
   upstream interface takeover that enables to switch from an inactive
   upstream interface to an active upstream interface is also described.

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1. Introduction

The Internet Group Management Protocol (IGMP) [2][4] for IPv4 and the
Multicast Listener Discovery Protocol (MLD) [3][4] for IPv6 are the
standard protocols for hosts to initiate joining or leaving of
multicast sessions. A proxy device performing IGMP/MLD-based
forwarding (as known as IGMP/MLD proxy) [5] maintains multicast
membership information by IGMP/MLD protocols on the downstream
interfaces and sends IGMP/MLD membership report messages via the
upstream interface to the upstream multicast routers when the
membership information changes (e.g., by receiving solicited/
unsolicited report messages). The proxy device forwards appropriate
multicast packets received on its upstream interface to each
downstream interface based on the downstream interface's
subscriptions.

According to the specification of [5], an IGMP/MLD proxy has *a single* upstream interface and one or more downstream interfaces. The multicast forwarding tree must be manually configured by designating upstream and downstream interfaces on an IGMP/MLD proxy device, and the root of the tree is expected to be connected to a wider multicast infrastructure. An IGMP/MLD proxy device hence performs the router portion of the IGMP or MLD protocol on its downstream interfaces, and the host portion of IGMP/MLD on its upstream interface. The proxy device must not perform the router portion of IGMP/MLD on its upstream interface.

On the other hand, there is a scenario in which an IGMP/MLD proxy device enables multiple upstream interfaces and receives multicast packets through these interfaces. For example, a proxy device having more than one interface may want to access to different networks, such as a global network like the Internet and local-scope networks. Or, a proxy device having wired link (e.g., ethernet) and high-speed wireless link (e.g., WiMAX or LTE) may want to have the capability to connect to the Internet through both links. These proxy devices shall receive multicast packets from the different upstream interfaces and forward to the downstream interface(s). Several other scenarios and subsequent requirements for the support of multiple upstream interfaces on IGMP/MLD proxy are documented in [7].

This document describes the mechanism that enables an IGMP/MLD proxy device to receive multicast sessions/channels through the different upstream interfaces. The mechanism is configured with either "channel-based upstream selection" or "subscriber-based upstream selection", or both of them. By channel-based upstream selection, an IGMP/MLD proxy device selects one or multiple upstream interface(s) from the candidate upstream interfaces "per channel/session". By subscriber-based upstream selection, an IGMP/MLD proxy device selects one or multiple upstream interface(s) from the candidate upstream interfaces "per subscriber/receiver".

When a proxy device transmits an IGMP/MLD report message, it examines the source and multicast addresses in the IGMP/MLD records of the report message. It then transmits the appropriate IGMP/MLD report message(s) from the selected upstream interface(s). When a proxy device selects "one" upstream interface from the candidate upstream interfaces per session/channel, it enables "load balancing" per session/channel. When a proxy device selects "more than two" upstream interfaces from the candidate upstream interfaces per session/channel, it potentially receives duplicate (redundant) packets for the session/channel from the different upstream interfaces simultaneously and provides "robust data reception".

A mechanism for "upstream interface takeover" is also described in
this document; when the selected upstream interface is going down or
the state of the link attached to the upstream interface is inactive,
one of the other active candidate upstream interfaces takes over the
upstream interface (if configured). The potential timer values to
switch from an inactive upstream interface to an active upstream
interface from a list of candidate upstream interfaces are discussed
in this document as well.

An "automatic upstream configuration" mechanism that selects an
appropriate upstream interface(s) for sessions/channels based on the
network and adjacent routers' conditions is also described in this
document.

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].

In addition, the following terms are used in this document.

Selected upstream interface (or simply, upstream interface):
A proxy device's interface in the direction of the root of the
multicast forwarding tree. A proxy device performs the host portion
of IGMP/MLD on its upstream interfaces. An upstream interface is
selected from a list of candidate upstream interfaces.

Default upstream interface:
A default upstream interface is the upstream interface for multicast
sessions/channels for which a proxy device cannot choose other
interfaces as the upstream interface. A default upstream interface
is configured.

Active upstream interface:
An active upstream interface is the upstream interface that has been
receiving packets for specific multicast sessions/channels during the
pre-defined active interval.

Inactive upstream interface:
An inactive upstream interface is the interface that has not received
packets for specific multicast sessions/channels during the pre-
defined active interval.

Downstream interface:
Each of a proxy device's interfaces that is not in the direction of
the root of the multicast forwarding tree. A proxy device performs
the router portion of IGMP/MLD on its downstream interfaces.

Candidate upstream interface:
An interface that potentially becomes an upstream interface of the
proxy device. A list of candidate upstream interfaces is configured
with subscriber address prefixes, channel/session IDs, and priority
values on an IGMP/MLD proxy device.

Channel/session ID:
Channel/session ID consists of source address prefix and multicast
address prefix for which a candidate upstream interface supposes to
be an upstream interface for specified multicast sessions/channels.
Both or either source address prefix and/or multicast address prefix
can be "null".

3. Upstream Selection Mechanism

3.1. Channel-Based Upstream Selection

An IGMP/MLD proxy device selects one or multiple upstream
interface(s) from the candidate upstream interfaces "per channel/
session" based on the "channel/session ID" configuration. This
mechanism is called "channel-based upstream selection" whose
configuration is explained in Section 4.1 and Section 4.2). enables
an IGMP/MLD proxy device to use one or multiple upstream interface(s)
from the candidate upstream interfaces "per channel/session" based on
the "channel/session ID" configuration (as will be in Section 4.1 and
Section 4.2).

3.2. Subscriber-Based Upstream Selection

An IGMP/MLD proxy device selects one or multiple upstream
interface(s) from the candidate upstream interfaces "per subscriber/
receiver". This is called "subscriber-based upstream selection". It
enables a proxy device to use one or multiple upstream interface(s)
per session/channel from the "candidate upstream interfaces" based on
the "subscriber address prefix" configuration (as will be in
Section 4.1).

3.3. Multiple Upstream Interface Selection for Robust Data Reception

When more than one candidate upstream interface is configured with
the same source and multicast addresses for the "channel/session
IDs", and "interface priority values" (as will be in Section 4.3) are
identical, these candidate upstream interfaces act as the upstream
interfaces for the sessions/channels and receive the packets
simultaneously. This multiple upstream interface selection
implements duplicate packet reception from redundant paths. It may
improve data reception quality or robustness for a session/channel,
as the same multicast data packets can come from different upstream

interfaces simultaneously. However, this robust data reception does
not guarantee that the packets come from disjoint paths. It only
configures that the adjacent upstream routers are different.

4. Candidate Upstream Interface Configuration

Candidate upstream interfaces are the interfaces from which an IGMP/
MLD proxy device selects as an upstream interface. The upstream
interface selection works with the configurations of "subscriber
address prefix", "channel/session ID", and "interface priority
value".

4.1. Address Prefix Record

An IGMP/MLD proxy device can configure the "subscriber address
prefix" and "channel/session ID" for each candidate upstream
interface. Channel/session ID consists of "source address prefix"
and "multicast address prefix". Subscriber address prefix and source
address prefix MUST be a valid unicast address prefix, and multicast
address prefix MUST be a valid multicast address prefix. A proxy
selects an upstream interface from its candidate upstream interfaces
based on the configuration of the following address prefix record:

    (subscriber address prefix, (channel/session ID))

where channel/session ID includes:

    (source address prefix, multicast address prefix)

The default values of these address prefixes are "null". Null source
address prefix represents the wildcard source address prefix, which
indicates any host. Null multicast address prefix represents the
wildcard multicast address prefix, which indicates the entire
multicast address range (i.e., '224.0.0.0/4' for IPv4 or 'ff00::/8'
for IPv6).

The candidate upstream interface having the configuration of
subscriber address prefix is prioritized. If network operators want
to assign a specific upstream interface for specific subscribers
without depending on source and multicast address prefixes, both
source and multicast addresses in the address prefix record is
configured "null".

If network operators want to select specific upstream interface(s)
without depending on subscriber address prefix, subscriber address
prefix in the address prefix record is configured "null".

4.2. Channel/Session ID

   Channel/session ID configuration consists of source and multicast
   address prefixes. Both/either source and/or multicast address may be
   configured "null". A candidate upstream interface having non-null
   source and multicast address configuration is prioritized for the
   upstream interface selection. For example, if a proxy device has two
   candidate upstream interfaces for the same multicast address prefix
   and one of them has non-null source address configuration, then that
   candidate upstream interface is selected for the source and multicast
   address pair. The other candidate upstream interface is selected for
   the configured multicast address prefix except the source address
   configured by the prior interface.

   Source address prefix configuration takes priority over multicast
   address prefix configuration. For example, consider the case that an
   IGMP/MLD proxy device has a configuration with source address prefix
   S_p for the candidate upstream interface A and multicast address
   prefix G_p for the candidate upstream interface B. When it deals
   with an IGMP/MLD record whose source address, let's say S, is in the
   range of S_p, and whose multicast address, let's say G, is in the
   range of G_p, the proxy device selects the candidate upstream
   interface A, which supports the source address prefix, as the
   upstream interface, and transmits the (S,G) record via the interface
   A.

   The same address prefix may be configured on different candidate
   upstream interfaces. When the same address prefix is configured on
   different candidate upstream interfaces, an upstream interface for
   that address prefix is selected based on each interface priority
   value (as will be in Section 4.3).

4.3. Interface Priority

   An IGMP/MLD proxy device can configure the "interface priority" value
   for each candidate upstream interface. It is an integer value and is
   part of the configuration. The default value of the interface
   priority is the lowest value.

   The interface priority value effects only when either of the
   following conditions is satisfied.

   o None of the candidate upstream interfaces configures both the
      subscriber address prefix and the channel/session ID.

   o More than one candidate upstream interface configures the same
      channel/session IDs but does not configure the subscriber address
      prefix.

In these conditions, the candidate upstream interface with the
highest priority is chosen as the upstream interface. And as stated
in Section 3.3, if the priority values for candidate upstream
interfaces are also identical, all of these interfaces act as the
upstream interfaces for the configured channel/session ID and may
receive duplicate packets.

4.4. Default Upstream Interface

An IGMP/MLD proxy device SHOULD configure "a default upstream
interface" for all incoming sessions/channels. A default upstream
interface is selected as the upstream interface, when none of the
candidate upstream interfaces configures subscriber address prefix,
channel/session ID, or interface priority value, or with either of
the following conditions.

o None of the candidate upstream interfaces configures both the
   subscriber address prefix, the channel/session ID, and identical
   interface priority value.

o More than one candidate upstream interface configures the same
   channel/session IDs and identical interface priority value, but
   does not configure the subscriber address prefix.

If a default upstream interface is not configured on an IGMP/MLD
proxy device, the candidate upstream interface whose IPv4/v6 address
is the highest of others is configured as the default upstream
interface for the proxy device.

5. Upstream Interface Takeover

5.1. Proxy Behavior

If a selected upstream interface is going down or inactive, or an
adjacent upstream router is not working, the upstream interface can
be disabled and the other active upstream interface listed in the
candidate upstream interfaces covering the same channel/session ID
can act as a new upstream interface. It recursively examines the
list of the candidate upstream interfaces (except the disabled
interface) and decides a new upstream interface from them. If no
active candidate upstream interfaces exist, the default upstream
interface takes its role.

This function called "upstream interface takeover" is a default
function for a proxy device that enables multiple upstream interface
support. If a proxy device simultaneously uses more than two
upstream interfaces per session/channel, and one or some of these
upstream interface(s) is/are inactive, the proxy device acts either

of the following behaviors based on the configuration; (1) it only
uses the active upstream interface(s) and does not add (i.e., does
not complement) other upstream interfaces, (2) it uses the active
upstream interface(s) and another candidate upstream interface whose
priority is highest among the configured upstream interfaces, or (3)
it uses the active upstream interface(s) and the default upstream
interface.

The condition whether the upstream adjacent router is active or not
can be decided by checking the link/interface condition on the proxy
device or detected by monitoring IGMP/MLD Query or PIM [6] Hello
message reception on the link. There are the cases that PIM is not
running on the link or IGMP/MLD Query messages are not always
transmitted by the upstream router (e.g., because of enabling the
explicit tracking function [8]). Therefore, network operators MUST
configure either; (1) the proxy device disables the upstream
interface takeover, (2) the proxy device triggers upstream interface
takeover by detecting no IGMP/MLD Query message within the active
interval, or (3) the proxy device triggers upstream interface
takeover by detecting no PIM Hello message within the active
interval, for each candidate upstream interface.

Network operators may want to keep out of use for the inactive
upstream interface(s). This causes, for example, when subscriber-
based upstream selection is configured, according to their accounting
policy (because the specific subscribers are planned to use the
specific upstream interface and cannot receive packets from other
upstream interfaces.) In that case, this upstream interface takeover
must be disabled, and the proxy device keeps using that interface as
the upstream interface for them (and waits for working the interface
later again).

5.2. Active Interval

Active interval is a period, after which a proxy device recognizes
that the selected upstream interface is inactive. Active interval
for each candidate upstream interface SHOULD be configured. The
active interval values are different in the situation whether the
network operators want to trigger by either IGMP/MLD or PIM messages.
The default active interval to detect an inactive upstream interface
is around twice of IGMP/MLD General Query interval and PIM Hello
interval. Further discussion [TBD].

6. Automatic Upstream Interface Configuration

6.1. Signaling-based Upstream Interface Configuration

There may be the ways for a proxy device to automatically configure
the upstream interface for specific multicast channels/sessions. It
works for the case in which there are no static configurations for a
candidate upstream interface or operators decide. The algorithms are
achieved by monitoring existing or newly proposed IGMP/MLD messages,
but further discussions are TBD.

6.2. Controller-based Upstream Interface Configuration

A centralized controller can instruct the proxy what upstream
interface is the appropriate one to use based on a certain multicast
channel or on the user herself.

There are options for selecting the most appropriate upstream
interface:

o Association of membership requests from a specific user,
   identified by the source IP of the IGMP/MLD message, to a specific
   upstream interface, meaning that all the multicast traffic for
   that end user is received from a certain upstream interface.

o Association of (S,G) to a specific upstream interface, meaning
   that an end user request for specific content delivered from a
   specific source should be received from a certain upstream
   interface.

o Association of (*,G) to a specific upstream interface, meaning
   that a user request of given content, independently of the source
   of that content, should be received from a certain upstream
   interface.

o Association of (S,*) to a specific upstream interface, meaning
   that all the requests from a certain user, independently of the
   group identifying the content, should be received from a certain
   upstream interface.

The list above does not show any precedence. Thus precedence should
be defined to indicate priority in the selection of the criteria to
apply, as a list of ordered actions.

The controller should also configure a default upstream interface for
those subscription requests that do not match an explicitly
configured behavior. In case of upstream interface failure, the
default upstream interface could take over the failed upstream to
provide redundancy.

To enable this manner of configuration, some control and management interface has to be supported by the proxy in order to receive configuration instructions from the controller.

The controller could interact with a number of proxies in the network. Being a centralized element, it could take coordinated decisions for managing all the multicast traffic in the network in a coordinated manner.

7. IANA Considerations

This document has no actions for IANA.

8. Security Considerations

This document neither provides new functions nor modifies the standard functions defined in [2][3][4]; hence there is no additional security consideration provided for these protocols themselves. On the other hand, it may be possible to encounter DoS attacks to make the function for upstream interface takeover stop if attackers illegally sends IGMP/MLD Query or PIM Hello messages on a LAN within a shorter period (i.e., before expiring the active interval for the upstream interface). To bypass such threats, it is recommended to capture the source addresses of IGMP/MLD Query or PIM Hello message senders and check whether the addresses correspond to the correct adjacent upstream routers. Consideration [TBD].

9. Consideration for Updating YANG Model

About the IGMP/MLD YANG model proposed in [9], there is a description of interfaces for IGMP (similar for MLD). When this document is officially approved, it is necessary to update the proposed YANG model to include all the information related to the upstream interfaces defined in this document, and consider the actions related to the selection of the upstream interfaces as mentioned in Section 6.

10. References

10.1. Normative References

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