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Requirements for the extension of the IGMP/MLD proxy functionality to support multiple upstream interfaces
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Abstract

   The purpose of this document is to define the requirements for a MLD
   (for IPv6) or IGMP (for IPv4) proxy with multiple interfaces covering
   a variety of applicability scenarios. The referred scenarios, while
   describing not sophisticated service situations, present cases that
   existing technology does not allow to solve in a simplistic manner.
   This document is then intended to serve as input for future documents
   defining the support of multiple upstream interfaces by IGMP/MLD
   proxies being compliant with the aforementioned requirements.

Status of This Memo

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1. Introduction

The aim of this document is to define the functionality that an IGMP/
MLD proxy with multiple upstream interfaces should have in order to
support different scenarios of applicability in both fixed and mobile
networks. IGMP/MLD proxis are a generic solution very much deployed
in existing carrier networks. An extension to them in the sense of
supporting multiple upstream interfaces can provide a more flexible
and lightweight solution than other potential alternatives that could
face more complexities (like multi-domain routing in the case of PIM,

or the need of some external elements -e.g., controllers- if the
coordination of actions required lays outside the proxy).

The functional behavior of an IGMP/MLD proxy with multiple upstream
interfaces here described is needed in order to simplify node
functionality and to ensure an easier deployment of multicast
capabilities in all the use cases described in this document.

For doing that, a number of scenarios are described, representing
current deployments and needs from operator's networks. From that
scenarios, certain requirements are identified as needed to simplify
operational situations, enable optimized service delivery, etc.
Those represent functional requirements to be satisfied by IGMP/MLD
proxies with multiple upstream interfaces. These functional
requirements reflect the need of coordinating actions from a single
element in the network (i.e., the IGMP/MLD proxy), optimizing the
delivery of the content within the network at any time.

Any Source Multicast (ASM) [RFC1112] and Source-Specific Multicast
(SSM) [RFC4607] represent different service models at the time of
subscribing to multicast groups by means of IGMPv3 [RFC3376],
[RFC5790] and MLDv2 [RFC3810]. When using ASM a receiver joins a
group indicating only the desired group address to be received. In
the case of SSM, a receiver indicates the specific source address as
well as a group address from where the multicast content is received.
Both service models are taken into account along this document, and
the specific requirements are derived from them.

2. Terminology

This document uses the terminology defined in [RFC4605].
Specifically, the definition of Upstream and Downstream interfaces,
which are repeated here for completeness.

Upstream interface: A proxy device's interface in the direction of
   the root of the tree. Also called the "Host interface".

Downstream interface: Each of a proxy device's interfaces that is
   not in the direction of the root of the tree. Also called the
   "Router interfaces".

3. Problem statement

The concept of IGMP/MLD proxy with several upstream interfaces has
emerged as a way of optimizing (and in some cases enabling) service
delivery scenarios where separate multicast service providers are
reachable through the same access network infrastructure. Figure 1
presents the conceptual model under consideration.

```
                        downstream          upstream
                        interface         interface A
                            |                 |
                            |                 |       _____
                            |    +-------+    v     /               \
                            |    |       |        O-------( Multicast Set 1 )
          +----------+   v  |    | IGMP/ |         _____/
          | Listener |------|    |  MLD  |          _____
          +----------+      |    | Proxy |         /               \
                            |    |       |        O-------( Multicast Set 2 )
                            +-------+    ^     _____/
                                         |
                                         |
                                     upstream
                                    interface B
```
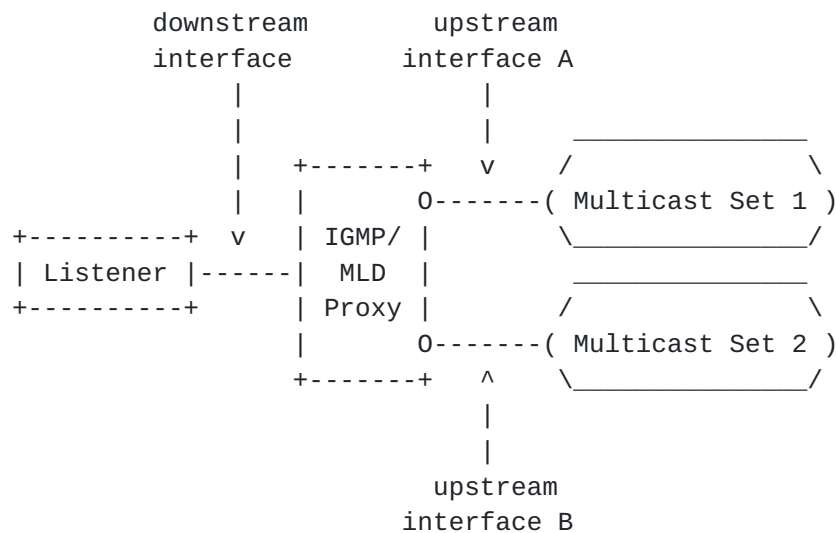
Figure 1: Concept of IGMP/MLD proxy with multiple upstream interfaces

This document is focused on both fixed and mobile network scenarios.
Applicability of IGMP/MLD proxies with multiple upstream interfaces
in mobile environments has been previously identified as beneficial
in scenarios as the ones described in [RFC6224] and [RFC7287].

In the case of fixed networks, multicast wholesale services in a
competitive residential market require an efficient distribution of
multicast traffic from different operators or content providers, i.e.
the incumbent operator and a number of alternative providers, on the
network infrastructure of the former. Existing proposals are based
on the use of PIM routing from the metro/core network, and multicast
traffic aggregation on the same tree. A different approach could be
achieved with the use of an IGMP/MLD proxy with multiple upstream
interfaces, each of them pointing to a distinct multicast router in
the metro/core border which is part of separated multicast trees deep
in the network. Figure 2 graphically describes this scenario.

```
                  downstream          upstream
                   interface        interface A
                      |                  |
                      |                  |     _____
                      |    +--------+    v    /                \
                      |    | Aggr.  O-------( Multicast Set 1 )
                      |    | Switch |         _____/
                 +----+    v   |         |      (e.g. from the Incumbent
                 | AN |-------| (IGMP   |            Operator)
                 +----+       |  /MLD   |         _____
                 (e.g.        | Proxy)  |        /                \
                 DSLAM        |         O-------( Multicast Set 2 )
                 /OLT)        +--------+   ^    _____/
                                           | (e.g. from an Alternative
                                           |         Provider)
                                           |
                                       upstream
                                     interface B
```
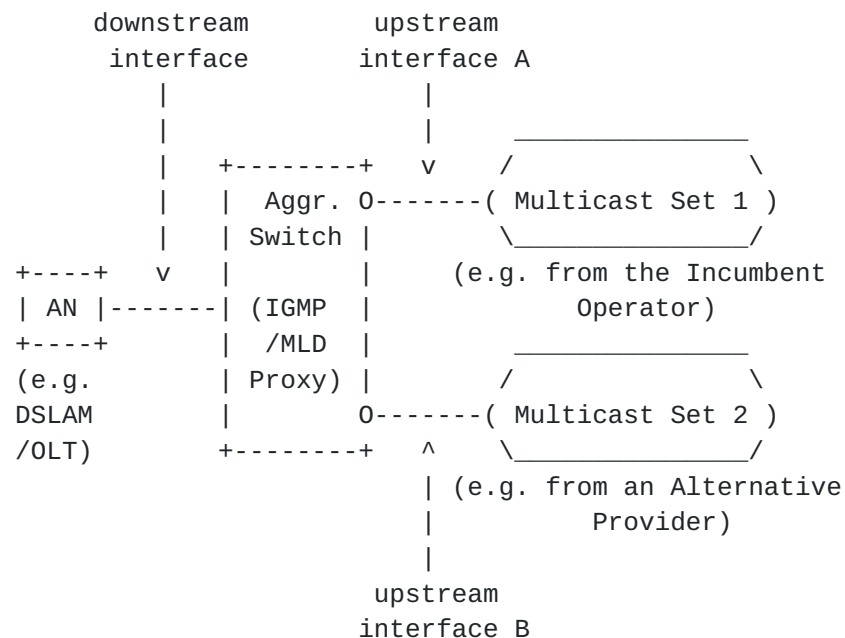
        Figure 2: Example of usage of an IGMP/MLD proxy with multiple
               upstream interfaces in a fixed network scenario

   Since those scenarios can motivate distinct needs in terms of IGMP/
   MLD proxy functionality, it is necessary to consider a comprehensive
   approach, looking at the possible scenarios, and establishing a
   minimum set of requirements which can allow the operation of a
   versatile IGMP/MLD proxy with multiple upstream interfaces as a
   common entity to all of them (i.e., no different kinds of proxies
   depending on the scenario, but a common proxy applicable to all the
   potential scenarios).

[4]. Scenarios of applicability

   Having multiple upstream interfaces creates a new decision space for
   delivering the proper multicast content to the subscriber. Basically
   it is now possible to implement channel-based (i.e., leveraging on
   multicast group IP address) or subscriber-based (i.e., referenced to
   the subscriber IP address) upstream selection, according to
   mechanisms or policies that could be defined for the multicast
   service provisioning.

   This section describes in detail a number of scenarios of
   applicability of an IGMP/MLD proxy with multiple upstream interfaces
   in place. A number of requirements for the IGMP/MLD proxy
   functionality are identified from those scenarios.

All the exemplary scenarios here described are based on the support
of two upstream interfaces. However, all of them are applicable also
to the support of more than two upstream interfaces.

4.1. Fixed network scenarios

Residential broadband users get access to multiple IP services
through fixed network infrastructures. End user's equipment is
connected to an access node, and the traffic of a number of access
nodes is collected in aggregation switches.

For the multicast service, the use of an IGMP/MLD proxy with multiple
upstream interfaces in those switches appears as a simple and
straightforward solution.

4.1.1. Multicast wholesale offer for residential services

This scenario has been already introduced in the previous section,
and can be seen in Figure 2. There are two different operators, the
one operating the fixed network where the end user is connected
(e.g., typically an incumbent operator), and the one providing the
Internet service to the end user (e.g., an alternative Internet
service provider). Both can offer multicast streams that can be
subscribed by the end user, independently of which provider
contributes with the content.

Note that it is assumed that both providers offer distinct multicast
groups. However, more than one subscription to multicast channels of
different providers could take place simultaneously.

4.1.1.1. Requirements

o The IGMP/MLD proxy should be able to deliver multicast control
   messages sent by the end user to the corresponding provider's
   multicast router.

o The IGMP/MLD proxy should be able to deliver multicast control
   messages sent by each of the providers to the corresponding end
   user.

o The IGMP/MLD proxy should be able to support ASM and SSM at the
   time of requesting the content. Since the use case assumes that
   each provider offers distinct multicast groups, the IGMP/MLD proxy
   should be able to identify inconsistencies in the SSM requests,
   that is, the case in which for an (S, G) request the source S does
   not deliver a the group G.

4.1.2. Multicast resiliency

In current PIM-based solutions [RFC7063], the resiliency of the
multicast distribution relays on the routing capabilities provided by
protocols like PIM [RFC7761] and VRRP [RFC5798]. A simpler scheme
could be achieved by implementing different upstream interfaces on
IGMP/MLD proxies, providing path diversity through the connection to
distinct leaves of a given multicast tree.

It is assumed that only one of the upstream interfaces is active in
receiving the multicast content, while the other is up and in standby
mode for fast switching. The objective is to avoid video delivery
affection that could imply play out interruption or buffering on the
user side. Service parameters like the ones defined in [Y.1540]
(such as packet loss ratio) or in [RFC4445] (like the delay factor)
can be considered as parameters to be assesed from the service
perspective. For instance, [TECH.3361-1] could be considered as a
SLA framework to be satisfied in this case.

4.1.2.1. Requirements

o The IGMP/MLD proxy should be able to deliver multicast control
   messages received in the active upstream to the end users, while
   ignoring the control messages of the standby upstream interface.

o The IGMP/MLD proxy should be able of rapidly switching from the
   active to the standby upstream interface in case of network
   failure, transparently to the end user.

o The IGMP/MLD proxy should be able to deliver IGMP/MLD messages
   sent by the end user (for both ASM and SSM modes) to the
   corresponding active upstream interface.

4.1.3. Load balancing for multicast traffic in the metro segment

A single upstream interface in existing IGMP/MLD proxy functionality
[RFC4605] typically forces the distribution of all the channels on
the same path in the last segment of the network. The metro and
backhaul network is usually built using ring topologies. The devices
in the ring implement IGMP/MLD functionality to join the content.
Multiple upstream interfaces could naturally help to split the
content demand, alleviating the bandwidth requirements in the overall
metro segment by allowing some of the channels to follow the
protection path, where spare capacity is vacant under normal
conditions. This will allow, for instance, to absorb traffic peaks
when a high number of channels (more than the expected on average) is
requested.

4.1.3.1. Requirements

   o The IGMP/MLD proxy should be able to deliver multicast control
      messages sent by the end user to the corresponding multicast
      router which provides the channel of interest.

   o The IGMP/MLD proxy should be able to deliver multicast control
      messages sent by each of the multicast routers to the
      corresponding end user.

   o The IGMP/MLD proxy should be able to decide which upstream
      interface is selected for any new channel request according to
      defined criteria (e.g., load balancing).

   o In the case of ASM, the IGMP/MLD proxy should be able to balance
      the traffic as a function of the group G requested. In the case
      of SSM, the load balancing mechanism could also consider the
      source S for the decision. In any case, the criteria will follow
      the olicies defined by the network operator. Such policies can be
      influenced by the user requesting the service, for instance
      through the subscription to some channels being offered by a third
      party (which has reached an agreement with the provider for
      delivering that content in its network).

4.1.4. Network merging with different multicast services

   In some network merging situations, the multicast services provided
   before in each of the merged networks are maintained for the
   respective customer base (usually in a temporal fashion until the
   multicast service is redefined in a new single offer, but not
   necessarily, or not in short term, e.g. because of commercial
   agreements for each of the previous service offers).

   In order to assist that network merging situations, IGMP/MLD proxies
   with multiple upstream interfaces can help in the transition
   simplifying the service provisioning and facilitating service
   continuity.

4.1.4.1. Requirements

   o The IGMP/MLD proxy should be able to deliver multicast control
      messages sent by the end user to the corresponding multicast
      router which provides the channel of interest, according to the
      service subscription.

   o The IGMP/MLD proxy should be able to deliver multicast control
      messages sent by each of the multicast routers to the
      corresponding end user, according to the service subscription.

o The IGMP/MLD proxy should be able to decide which upstream
   interface is selected for any new channel request according to
   defined criteria (e.g., service subscription).

o For this use case, the usage of SSM can simplify the decision of
   the IGMP/MLD proxy. For ASM the decision should be assisted by
   further information like the service to which the end user is
   subscribed (e.g., taking into account what is the original network
   from where the end user was part previous to the network merge
   situation).

4.1.5. Multicast service migration

This scenario considers the situation where a multicast service needs
to be migrated from one upstream interface to another upstream
interface (e.g. because of changes inside the service provider's
network). The migration should be "smooth" and without any service
interruption. In this case the multicast content is initially
offered in both upstream interfaces and the proxy dynamically
switches from the first to the second upstream interface, according
to certain policies, and enabling to shut down the first upstream
interface once the migration is completed.

4.1.5.1. Requirements

o The IGMP/MLD proxy should be able to deliver multicast control
   messages sent by the end user to the corresponding multicast
   router before and after the service migration.

o The IGMP/MLD proxy should be able to deliver multicast control
   messages sent by each of the multicast routers to the
   corresponding end user, according to the situation of the user
   with respect to the service migration.

o The IGMP/MLD proxy should be able to decide which upstream
   interface corresponds to each user, according to the situation of
   the user with respect to the service migration, i.e., the status
   of the user with respect the platform migration as purely
   operational situation while transitioning from one platform to
   another in a smooth manner.

o The IGMP/MLD proxy should be able to decide which upstream
   interface corresponds to each ASM or SSM request, according to the
   situation of the group and source included in the request with
   respect to the service migration.

4.2. **Mobile network scenarios**

   Mobile networks offer different alternatives for multicast
   distribution.

   One of them is defined by 3GPP [TS23.246] for the Multimedia
   Broadcast Multicast Service (MBMS). In this case, a MBMS gateway
   (MBMS GW) is connected to multiple evolved Node B (eNodeB) -- which
   are the base stations connecting the mobile handsets with the network
   wirelessly [TS36.300] -- for data distribution by means of IP
   multicast. The MBMS GW delivers the IP multicast groups. The eNodeB
   joins the appropriate group multicast address allocated by the MBMS
   GW to receive the content data. At this distribution level, an IGMP/
   MLD proxy could be part of the transport infrastructure providing
   connectivity to several distributed eNodeBs. The potential scenarios
   from this case do not essentially differentiate from the ones
   described for the fixed network scenarios, so the same situations and
   requirements apply.

   Another alternative is given by Proxy Mobile IPv6 (PMIPv6) protocol
   for IP mobility management [RFC5213]. PMIPv6 is one of the
   mechanisms adopted by the 3GPP to support the mobility management of
   non-3GPP terminals in future Evolved Packet System (EPS) networks.
   PMIPv6 allows a Media Access Gateway (MAG) to establish a distinct
   bi-directional tunnel with different Local Mobility Anchors (LMAs),
   being each tunnel shared by the attached Mobile Nodes (MNs). Each
   mobile node is associated with a corresponding LMA, which keeps track
   of its current location, that is, the MAG where the mobile node is
   attached. As the basic solution for the distribution of multicast
   traffic within a PMIPv6 domain, [RFC6224] makes use of the bi-
   directional LMA-MAG tunnels. The use of an MLD proxy supporting
   multiple upstream interfaces can improve the performance and the
   scalability of multicast-capable PMIPv6 domains, for both multicast
   listener and multicast source mobility. Once again, the potential
   scenarios in this case are contained into the ones described for the
   fixed network scenarios, so the same situations and requirements
   apply.

5. **Summary of requirements**

   Following the analysis above, a number of different requirements can
   be identified by the IGMP/MLD proxy to support multiple upstream
   interfaces. The following table summarizes these requirements.

Functio-nality	Multicast Wholesale	Multicast Resiliency	Load Balancing	Network Merging	Network Migration
Upstream Control Delivery	X	X	X	X	X
Downstr. Control Delivery	X	X	X	X	X
Active / Standby Upstream		X			
Upstr i/f selection per group			X	X	
Upstr i/f selection all group		X			X
ASM	X	X	X	X	X
SSM	X	X	X		X

Figure 3: Functionality needed on IGMP/MLD proxy with multiple
upstream interfaces per application scenario

6. Security Considerations

All the security considerations in [RFC4605] are directly applicable
to this proposal.

7. IANA Considerations

There are no IANA considerations.

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