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Evaluation of further issues on Multicast Mobility: Potential future work for WG MultiMob
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Abstract

The WG MultiMob aims at defining a basic mobile multicast solution leveraging on network localized mobility management, i.e. Proxy Mobile IPv6 protocol. The solution would be basically based on multicast group management, i.e. IGMP/MLD, proxying at the access gateway. If such a basic solution is essential from an operational point of view, challenges with efficient resource utilization and user perceived service quality still persist. These issues may prevent large scale deployments of mobile multicast applications.

This document attempts to identify topics for near future extension of work such as modifying multimob base solution, PMIPv6 and MLD/IGMP for optimal multicast support, and adaptation of Handover optimization. Far future items such as extending to and modifying of MIPv4/v6 and DSMIP, sender (source) mobility, consideration of multiple flows and multihoming will be dealt with in a future version.

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1. Introduction

Chartered work of WG MultiMob focuses on documentation of proper configuration and usage of existing (specified standard) protocols within both mobility and multicast related areas to enable and support mobility for multicast services and vice versa. The current WG document [I-D.ietf-multimob-pmipv6-base-solution] does not address specific optimizations and efficiency improvements of multicast routing for network-based mobility and thus the operation may be not resource efficient nor grant the service quality expected by the end user.

The described solution resolves the problem to ensure multicast reception in PMIPv6-enabled [RFC5213] networks without appropriate multicast support. However it neither automatically minimizes multicast forwarding delay to provide seamless and fast handovers for real-time services nor minimizes packet loss and reordering that result from multicast handover management as stated in [RFC5757]. Also Route Optimization is out of scope of the basic solution - an issue for reducing amount of transport resource usage and transmission delay. Thus possible enhancements and issues for solutions beyond a basic solution need to be described to enable current PMIPv6 protocols to fully support efficient mobile multicast services. Such extensions may include protocol modifications for both mobility and multicast related protocols to achieve optimizations for resource efficient and performance increasing multimob approaches. The document includes the case of mobile multicast senders using Any Source Multicast (ASM) and Source Specific Multicast (SSM) [RFC4607].

This document focuses on discussion work on multicast protocols such as IGMP/MLD operational tuning (e.g. as proposed in [I-D.asaeda-igmp-mld-optimization]) and enhancements of IGMP/MLD protocol behaviors and messages for optimal multicast support (proposed in [I-D.asaeda-igmp-mld-mobility-extension]).

An alternative approach proposes the addition of acknowledgement messages on group management ([I-D.liu-multimob-reliable-igmp-mld]) and changes the unreliable protocol concept.

Furthermore a modification of PMIPv6 by introducing a dedicated multicast tunnel and support of local routing is discussed in [I-D.asaeda-multimob-pmip6-extension]. Other performance improvements have been outlined in [I-D.schmidt-multimob-fmipv6-pfmipv6-multicast] where extensions to Mobile IPv6 Fast Handovers (FMIPv6) [RFC5568], and the corresponding extension for Proxy MIPv6 operation [I-D.ietf-mipshop-pfmipv6].

Another type of multimob work aims directly at enhancements of the current multimob base solution [I-D.ietf-multimob-pmipv6-base-solution] towards introduction of multicast traffic replication mechanisms and a reduction of the protocol complexity in terms of time consuming tunnel set-up by definition of pre- or post-configured tunnels (as provided by e.g. [I-D.zuniga-multimob-smspmip]). Further work within this topic deals with direct routing (e.g. [I-D.sijeon-multimob-mms-pmip6]) and with dynamic or automatic tunnel configuration (see e.g. [I-D.ietf-mboned-auto-multicast]).

A large field of additional investigations which are partly described in detail in [RFC5757] will be mentioned for completeness and may be subject of a later WG re-chartering.

```
       +------+           +------+
       |  MN  |  =====>   |  MN  |
       +------+           +------+
          |                  .
          |                  .
       +--------+          +--------+
       | MAG 1  |          | MAG 2  |
       |IGMP/MLD|          |IGMP/MLD|
       |Proxy   |          |Proxy   |
       +--------+          +--------+
           |                 |
          ***  ***  ***  ***
         *   **   **   **   *
        *                    *
         *  Internet Subnet *
        *                    *
         *   **   **   **   *
          ***  ***  ***  ***
            |               |
       +-------+          +-------+
       | LMA 1 |          | LMA 2 |
       +-------+          +-------+
           |                 |
          ***  ***  ***  ***
         *   **   **   **   *
        *                    *
         *  Fixed Internet  *
        *                    *
         *   **   **   **   *
          ***  ***  ***  ***
                 |
                +------+
                |  CN  |
                +------+
```

Figure 1: MultiMob Scenario for chartered PMIP6 issue

```
    +------+           +------+         +------+
    |  MN  |  =====>   |  MN  | ====>   |  MN  |
    +------+           +------+         +------+
       |                  .               .
       |                  .              .
       |                  .             .
    +--------+         +--------+  +--------+  +--------+
    | MAG 1  |         | MAG 2  |  |  AR 1  |  |  AR 2  |
    |IGMP/MLD|         |IGMP/MLD|  |IGMP/MLD|  |IGMP/MLD|
    | Proxy  |         | Proxy  |  | Proxy  |  | Proxy  |
    +--------+         +--------+  +--------+  +--------+
             \        /           |           |
       ***  ***   ***  ***        ***  ***   ***  ***
      *   **   ***   **   *      *   **   ***   **   *
     *                     *    *                     *
      * Internet Subnet 1 *      * Internet Subnet 2 *
     *                     *    *                     *
      *   **   ***   **   *      *   **   ***   **   *
       ***  ***   ***  ***        ***  ***   ***  ***
       |                 |         |
    +-------+          +-------+   |
    | LMA 1 |          | LMA 2 |  /
    +-------+          +-------+ /
         \                 |    /
          ***  ***  ***  ***   /     ***  ***   ***   ***
         *   **   **   **   * /     *   **   ***   **    *
        *                    *     *                     *
         *  Fixed Internet  *       * Internet Subnet 3 *
        *                    *_____*                     *
         *   **   **   **   *       *   **   ***   **   *
          ***  ***  ***  ***         *** .***   ***  ***
               |                        .
           +-------+          +-------+
           |  CN   |  ====>   |  CN   |
           +-------+          +-------+
```

Figure 2: MultiMob scenario for extended MultiMob issues

Figure 1 illustrates the key components of the foreseen basic Multimob solution. The extended multicast mobility scenario, leading to above issues, is sketched in Figure 2.

In summary additional to a 'Single hop, link, flow' Proxy MIP mobility for listening MNs (scenario shown in Figure 1), future work towards a complete performance-optimized scenario of a 'Multi-hop, -homed, -flow' client mobility (i.e. including MIPv6 [RFC3775] and DSMIPv6 [RFC5555]) would cover a plurality of issues. For the near future we see the following issues as most important:

- o Extension of multimob base solution

- o Modification of base PMIPv6 and MLD/IGMP for optimal multicast support.

- o Consideration of Handover optimization.

All further issues which would include extensions to and modifications of MIPv4/v6 and DSMIP using IGMP/MLD Proxy and the Foreign Agent/Access Router, consideration of sender (source) mobility, support of multiple flows on multihomed mobile nodes, multi-hop transmission, Routing optimization, and so forth will be topics for a potential next stage of future work extension.

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 BCP 14 [RFC2119].

This document uses the terminology defined in [RFC3775], [RFC3376], [RFC3810], [RFC5213], [RFC5757].

3. IGMP/MLD Proxy Architecture

Multimob basic solution is based on IGMPv3/MLDv2 Proxy support at the mobile access gateway (MAG) of Proxy Mobile IPv6 as shown in Figure 1. IGMPv3/MLDv2 proxy keeps multicast state on the subscriptions of the mobile nodes and only an aggregate state is kept at the local mobility anchor (LMA). When LMA receives multicast data it can forward it to the MAG without duplication because MAG takes of the packet duplication. This leads to solving the avalanche problem.

By keeping multicast state locally, IGMPv3/MLDv2 Proxy introduces mobility related problems such as possible packet loss when a mobile node does a handover to another MAG and its multicast state is not modified fast enough at the LMA.

IGMPv3/MLDv2 introduces tunnel convergence problem which occurs when a given MAG serves MNs that belong to different LMAs and MNs subscribe to the same multicast group. In that case MNs receive duplicate multicast data forwarded from more than one LMA.

It can be foreseen that mobile access gateways will serve both mobile and fixed terminals concurrently. The tuning of multicast-related protocol parameters based on the terminal characteristics is needed. Parameters only applicable to mobile users need to be distinguished from the parameters applicable to fixed users. It should be also possible to distinguish between slow and fast movement and handover frequency to form corresponding tunnels for mobile users.

Based on the above observations we will state the problems next and then list the requirements on possible solutions.

4. Problem Description

The general issues of multicast mobility are extensively discussed and described in [RFC5757]. To reduce the complexity of the plethora of requirements listed in [RFC5757] and also in [I-D.deng-multimob-pmip6-requirement] this document summarises some lightweight solutions for multicast mobility which allow for easy deployment within realistic scenarios and architectures. Moreover we focus on approaches building directly on basic MultiMob solution [I-D.ietf-multimob-pmipv6-base-solution] which is based on IGMP/MLD Proxy functionality at the mobile access gateway, and for which already solution proposals have been described.

4.1. Modification of base PMIPv6 for optimal multicast support

Currently discussed aspects of multicast optimization for PMIPv6 include introduction of multicast tunnels and support of local routing such as described in [I-D.asaeda-multimob-pmip6-extension]. For a PMIPv6 domain the establishment of a dedicated multicast tunnel is proposed which may either be dynamically set up and released or be pre-configured in a static manner. Both mobility entities MAG and LMA may be operate as MLD proxy or multicast router.
Since further functional enhancements of PMIPv6 are currently under way in NETEXT WG, both the impact of new features on Mobile Multicast as well as such a Multicast-initiated proposal for PMIPv6 modification have to be considered in a continuous exchange process between MultiMob and NETEXT WGs.

4.2. Modification of MLD/IGMP for optimal multicast support

Potential approaches for enhancement of group management as specified e.g. by MLDv2 [RFC3810] include operational improvements such as proper tuning in terms of default timer value modification, specific query message introduction, and standard (query) reaction suppression, beside introducing multicast router attendance control in terms of e.g. specification of a Listener Hold message as proposed in [I-D.asaeda-multimob-igmp-mld-mobility-extensions].

4.3. Consideration of Handover Optimization

Ideally the customer experience while using multicast services should not be affected by transmission issues whether the terminal is operated in a fixed or a mobile environment. This implies not only that the terminal should be unaware of changes at network layer connectivity (seamless communication) as is typically the case in a PMIPv6 domain, but also that any impact of connectivity changes (handover) should be minimized. In the framework of Multimob this relates to reduction of delay, packet loss, and packet reordering effort for mobile multicast by applying fast handover mechanisms, which have originally been developed for unicast traffic to multicast group management. [I-D.schmidt-multimob-fmipv6-pfmipv6-multicast] works on specification of extension of the Mobile IPv6 Fast Handovers (FMIPv6) [RFC5568] and the Fast Handovers for Proxy Mobile IPv6 (PFMIPv6) [I-D.ietf-mipshop-pfmipv6] protocols to include multicast traffic management in fast handover operations. Issues for further work are details of including multicast group messaging in context transfer, for both predictive and reactive handover mode, as well as details of corresponding message exchange protocols and message design.

4.4. Specific PMIP deployment issues

Currently several proposals are under work which describe extensions of the base protocol WG draft [I-D.ietf-multimob-pmipv6-base-solution]. While MAG operation will remain that of an MLD proxy additional LMA functionalities are described in [I-D.zuniga-multimob-smspmip] which allow for replication of multicast traffic and solution of the tunnel convergence problem. The dedicated multicast LMA may either set up dedicated multicast tunnels dynamically or a-priory via pre-configuration or a delayed release.

Another solution on dynamic and/or automatic tunnel configuration is proposed within multicast WG MBONED [I-D.ietf-mboned-auto-multicast].

A direct or local routing approach is described in [I-D.sijeon-multimob-mms-pmip6]. This scenario may hold for short term deployment focusing on an architecture where multicast traffic is provided via the home network. However, depending on the network topology, namely the location of the content delivery network, the LMA may not be on the optimal multicast service delivery path. This enables mobile nodes to access locally available multicast services such as local channels.

Figure 3 illustrates the use-case for local routing.

```
                   +----+
                   |LMA |
                   +----+
                     |
                     |
             ***  ***  ***  ***
            *   **   **   **   *
           *                     *       +-------------+
            *  Local Routing   *   _____ | Content     |
           *                     *       | Delivery    |
                                         | Network     |
            *   **   **   **   *         +-------------+
             ***  ***  ***  ***
               ||           ||
            +----+        +----+
            |MAG1|        |MAG2|
            +----+        +----+
             |  |            |
             |  |            |
            MN1 MN2          MN3
```

Figure 3: local Multicast routing

In such a case, the MAG should act as a multicast router to construct the optimal multicast delivery path. If the MAG also supports MLD proxy function issue raises up on the dual mode behaviour. In such a case, a pragmatic approach could be to leverage only on multicast routing at the MAG in the PMIP domain.

Whatever is the MAG operation mode, the multicast state is locally kept at the access gateway, so unknown from the mobility anchor. In other words, the multicast service is independent from the mobility service that the mobile node is receiving from the network in the form of PMIPv6 or DSMIPv6. However, handover support is still desirable but cannot be provided by the mobility anchor (i.e. HA or LMA). In such a case mobility support for locally available multicast should be provided by extending multicast protocols of IGMP or MLD.

5. Requirements on Solutions

This section tries to identify requirements from the issues discussed in previous section.

- o Seamless handover (low latency and during the handover).
- o Similar packet loss to unicast service.
- o Multiple LMAs architecture.
- o Agnostic mobile host re-subscription. So, MAGs must be able to retrieve multicast contexts of the mobile nodes.
- o Solution address IPv6, IPv4 only and dual stack nodes.
- o Supports sender (source) mobility.
- o Optimal local routing.
- o To be completed...

6. Security Considerations

This draft introduces no additional messages. Compared to [RFC3376], [RFC3810], [RFC3775], and [RFC5213] there have no additional threats been introduced.

7. IANA Considerations

Whereas this document does not explicitly introduce requests to IANA some of the proposals referenced above (such as [I-D.asaeda-multimob-pmip6-extension] and [I-D.schmidt-multimob-fmipv6-pfmipv6-multicast]) specify flags for mobility messages or options. For details please see those documents.

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