ProxyMIP Extension for Inter-MAG Route Optimization
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Abstract

This draft describes a light weight route optimization technique that helps to optimize the media path between two communicating nodes when Proxy MIP is used as the mobility protocol. This routing optimization technique is most useful when the two communicating hosts are away from home and need to communicate with each other using an optimized path. It takes advantage of the data packet between LMA and MAG to set up the optimized data path between the communicating hosts. This route optimization technique is applicable to both the intra-LMA and inter-LMA scenarios.

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1. Introduction

Wireless Service Providers (WISPs) strive to provide secured and seamless connectivity to the roaming users. When a mobile is subjected to repeated handoff, quality of existing communication gets degraded due to delay and packet loss. There are several transition events during the handoff, such as discovery, configuration, authentication, security association, binding update and media redirection that contribute to the handoff delay and the associated packet loss. This specific route optimization technique reduces the delay due to media delivery by reducing the media traversal path between the communicating hosts.

In order to reduce the delay due to binding update and associated one-way-delay of the media, when a mobile’s movement is confined to a specific domain, various local mobility management protocols have been designed. These include Cellular IP, HAWAII, IDMP, HMIPv6 etc. NETLMM working group within IETF has recommended a set of goals and host requirements to support localized mobility [RFC4830], [RFC4831], [RFC4832]. Based on these goals, IETF has currently designed Proxy MIPv6 protocol [I-D.ietf-netlmm-proxymip6] that helps to reduce the delay due to long binding update. It takes much of the burden away from the mobile and puts it on the wired access routers within the network that are called Media Access Gateway (MAG). MAG is equipped with proxy mobility agent (PMA) that sends the binding update to the home agents on behalf of the mobiles. Each mobile is anchored with a certain MAG until it hands off to a new MAG. The PMIPv6-based mobility protocol is preferred when mobility is confined within a domain and wireless service providers do not want to overload the mobile nodes stack by setting up a tunnel between the mobile and the LMA. A tunnel is not desirable on the mobile node because it adds extra processing and bandwidth constraints to the wireless hop.

Although Proxy Mobile IP provides optimization compared to other global mobility protocols, it still needs improvement in certain areas such as route optimization. Route optimization reduces the delay due to media delivery between the two communicating mobiles by reducing the traversal distance of the media packets between the communicating hosts. Some of the requirements for route optimization are mentioned in [I-D.jeong-netlmm-pmipv6-roreq]. There are also few proposals that have discussed route optimization for Proxy MIPv6, [I-D.abeille-netlmm-proxymip6ro] and [I-D.qin-netlmm-pmipro]. These mechanisms either depend on the MIPv6 route optimization procedures or introduce a heavy weight route setup procedure to obtain the desired optimization. In this draft we describe a lightweight route optimization technique for PMIP that will further improve the effectiveness of PMIP for both intra-domain and inter-domain movement. This technique takes advantage of the data packet and sets
up the route optimization between the mobile hosts.
2. Terminology

Binding Cache Entry: A binding cache in the network entity that provides the route information about a communicating node. BCE can exist either within an LMA or in the MAG.

Route Optimization: Route optimization is a mechanism by which the data path is from CN to MN is optimized.

Proxy Binding Update: A procedure to update the identifier of the mobile by a third party. In the context of PMIPv6, MAG sends the binding update to LMA on behalf of the mobile.

Local Mobility Agent (LMA): Local mobility agent is the local home agent that is responsible to maintain the binding cache of the mobile when the mobile’s movement is confined to a domain. LMA actually does the job of a Home Agent, and thus can be used interchangeably in the document.

Media Access Gateway: MAG is the first hop access router that is equipped with the Proxy Mobility Agent (PMA). MAG sends the proxy binding update on behalf of the mobile. MAG stores the binding cache entry created by Correspondent Binding Update (CBU) message, so that it can forward the traffic to the neighboring MAG without sending it to HA (LMA). MAG has been used interchangeably with AGW in the document.

Access Gateway (AGW): AGW is the first hop access router that is equipped with the Proxy Mobility Agent (PMA). AGW sends the proxy binding update on behalf of the mobile. AGW been used interchangeably with MAG in this draft.

Proxy Mobility Agent (PMA): PMA is the proxy mobility agent that resides in each of the access routers that are within a mobility domain. PMA helps to send proxy binding update to LMA on behalf of the mobile.
Correspondent Binding Update:

Binding update message that updates the route in the neighboring MAGs for route optimization. This CBU update can be between the LMA and MAG or between the MAGs. This helps to update the route cache on the AGWs, so that they can route the packet based on mobile’s destination.

Correspondent Binding Cache:

Correspondent Binding Cache (CBC) is formed at the MAGs when Correspondent Binding Update (CBU) message is received from the LMA or other MAG. CBC usually has associated timer that helps it to expire after a while.
3. Applicable Scenarios for Route Optimization

In this section, two PMIP-based scenarios are described where the route optimization technique can be applied. This can primarily be divided as Intra-LMA and Inter-LMA. The proposed route optimization technique can be applied to both of these scenarios.

Figure 1 shows a general PMIP architecture with all the PMIPv6 components. In this case the MAGs do not need to be adjacent to each other but can be connected to a core network and thus can be few hops away. Similarly, MAG and LMA also do not need to be adjacent. Route optimization technique offers the best advantage when the LMA is far way from the communicating hosts.
Figure 2 shows a scenario where both the mobiles are in two different PMIP domains. MAG1, MAG2, MAG3 are under LMA1 and MAG4, MAG5 and MAG6 are under LMA2. In this case, route optimization needs to take place when the mobile is in under MAG4 and then it makes a movement to MAG5.
In the next section, the route optimization technique and associated flows are described for the hosts when they operate within a single
and multiple PMIP domains.
4. Route Optimization Techniques

In this section, a lightweight route optimization technique for PMIPv6 is described that can be applied to both Intra-LMA and Inter-LMA scenarios. This route optimization technique takes advantage of the initial data packet to set the route optimization without the need for any additional route setup procedures.

4.1. Intra-LMA route optimization

In this section intra-LMA scenarios are described. Route optimizations for data between MN1 and MN2 in both directions are illustrated.

4.1.1. Initial State

In this section several call flows for intra-LMA route optimization are discussed.

4.1.1.1. Route Optimization from MN1 to MN2

Figure 3 shows the flows associated with the route optimization when a single LMA is used. It shows the route optimization scenario when the mobile is in the initial stage and has not moved. Initially, MN1 is under MAG1 and MN2 is under MAG2, but MN2 moves to MAG3 when the communication session is active.
Path optimization from MN1 to MN2 are described here. Before the handover takes place, MN1 attaches to MAG1 (MAG1) and then the Proxy Mobility Agent within MAG1 sends a binding update to the LMA on behalf of MN1. Similarly, MN2 connects to MAG2 (PMA2), that triggers the proxy-BU to the LMA on behalf of MN2. We then show the optimization procedure. First packet from MN1 to MN2 is tunneled to the LMA. As soon as the LMA gets this packet, it knows how to forward packet to MAG2, but at the same time, it also sends a CB Update (CBU) to MAG1 notifying that MAG2 is the PMA for MN2. On
receiving the CBU, MAG1 keeps a cache that maps MAG2 with MN2. Thus, any subsequent packet from MN1 destined to MN2 gets intercepted by MAG1 and is forwarded to MAG2, instead of being forwarded to the LMA. Trajectory of the optimized packet looks like, MN1->MAG1->MAG2->MN2 instead of MN1->MAG1->LMA->MAG2->MN2, thus optimizing the media route between MN1 and MN2.

4.1.1.2. Optimization from MN2 to MN1

Similarly, Figure 4 shows the path optimization from MN2 to MN1 when the MN2 is in the initial stage and has not handed over yet. This illustrates how this route optimization technique can be applied to optimize media traffic in either direction.
4.1.2. Route Optimization after handoff

In this section, we illustrate how the route optimization takes place after the mobile moves to another AGW (MAG3) under the same LMA (LMA1). We consider the media delivery from both MN1 to MN2 and vice-versa.

4.1.2.1. Route optimization from MN1 to MN2

In this section, we show how the media route is optimized from MN1 to MN2, after MN2 moves from its current location.
Figure 5 shows the flow when MN2 makes a handover from MAG2 to MAG3. It shows the route optimization procedure and optimized route from MN1 to MN2 after MN2 hands over to a new PMA such as MAG3. In this case, MN2 attaches with MAG3 and sends a proxy BU to LMA. At that point, LMA immediately sends a Correspondent Binding Update to MAG2, since the LMA has the knowledge of MAG2. MAG2 in turn sends a proxy BU to MAG1 telling that MN2 is under MAG3. Thus, both MAG1 and MAG2 are made aware of the fact that MN2 is currently connected to MAG3. During this procedure if any data from MN1 destined to MN2 arrives at MAG1, MAG1 forwards it to MAG2 which in turn forwards it to MAG3.
MAG3 finally forwards it to MN2. But once the route optimization procedure is over, any data destined from MN1 to MN2 gets intercepted by MAG1 and then directly gets forwarded to MAG3 which forwards it again to MN2.

### 4.1.2.2. Route Optimization from MN2 to MN1

In this section, we show how data path is optimized between MN2 and MN1 after the MN2 has handed over to MAG3 during communication session.

![Figure 6: Call Flow for data path MN2 to MN1](image)

Figure 6 shows the route optimization procedure when the data is destined from MN2 to MN1 after the handover. After the route optimization is over, data from MN2 destined to MN1 gets picked up by MAG3 which finally sends to the MAG1 to be delivered to MN1. During
the route optimization procedure, however the first packet gets routed via LMA and is subjected to little delay. These techniques thus avoid the route from LMA to AGWs (MAGs) and forward the traffic from one AGW (MAG) to another AGW (MAG). However the first packet is not subjected to route optimization.

4.2. Inter-LMA route optimization

4.2.1. Initial state

In this section, we describe the route optimization procedure when the communicating mobiles are under two different LMA domains. Figure 7 shows a typical inter-LMA handoff procedure. Initially, the mobile is anchored at MAG1 (MAG1) that is under LMA1, and MN2 is anchored at MAG4 which is under LMA2. First packet from MN1 to MN2 traverses via LMA1 and LMA2, and gets delivered to MN2. When the first packet is traversed, LMA2 sends Correspondent Binding Update message to LMA1, LMA1 in turn sends it back to MAG1 to update the binding cache entry. At this point MAG1 keeps a cache entry for MN2. Thus any subsequent packet does not travel via LMA1 and LMA2 any more but is forwarded from MAG1 to MAG4 where the mobile resides. Thus, any further data packet during this communication session is optimized until the mobile moves away from MAG4.
Figure 7: Inter-LMA route optimization before handoff
4.2.2. Route optimization after handoff

This section shows the route optimization procedure after the mobile has handed over to MAG5 that is under LMA2. Figure 8 shows the call flow of the route optimization procedure. As soon as the mobile gets connected to MAG5, LMA2 gets notified and it sends a CB update to MAG4 notifying that the mobile is under MAG5. Thus the first packet after the handover still flows from MAG1 to MAG4 that forwards this packet to MAG5, MAG5 in turn delivers the packet to MN2. As it is shown the path is not optimized. At this time, MAG4 notifies MAG1 about the existence of MN2 under its attachment. Thus, any subsequent packet from MN1 and MN2 flows using the route optimized path, MN1->MAG1->MAG5->MN2.
It is to be noted that Inter-LMA CBU needs to carry the IP address of the source and destination hosts in addition to the address of source MAG. This is needed as the LMA1 needs to determine which MAG it needs to send the CBU back. Thus, new mobility option type needs to be added to the CBU message.
5. Message Format

In this section, we describe the message format for the Correspondent Binding Update (CBU) message.

5.1. Correspondent Binding Update Message

In order to make the optimization technique light weight and compatible with the existing Binding Update messages, a slight extension of the existing Proxy Binding Update method is proposed to take care of route optimization. In order to differentiate Correspondent Binding Update (CBU) message from the regular Proxy Binding Update (PBU), a new flag "C" is suggested to be added in the existing BU message. Also, Inter-LMA CBU needs to include additional addresses such as the source address, destination address and destination MAG address. Thus, new mobility option may need to be defined to carry these IP address prefix (MN-Prefix, CN-Prefix) and MAG address. Alternatively, MAG address may be contained in Alternate care-of-Address option. These prefixes may also be sent using HNP option as well. A sample message format is shown in figure 9.

```
+---------+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| A | H | L | K | M | R | P | C | Reserved | Lifetime |
+---------+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 9: CBU Message Format

A new flag (C) is included in the Proxy Binding Update message format to indicate that this is Corresponding Binding Update message.
5.2. Correspondent Binding Acknowledgement

In order to acknowledge the CBU, the Correspondent Binding
Acknowledgement (CBA) message is used. The message format is
identical to the PBA message, but a new flag (C) is included to
distinguish from the PBA. A sample binding update message is shown
in Figure 10.

```
+-----------------+-----------------+-----------------+-----------------+
| Status           | K | R | P | C | Resv'd |
+-----------------+-----------------+-----------------+-----------------+
| Sequence #      |    |    |    |    |        |
+-----------------+-----------------+-----------------+-----------------+
| Mobility options|    |    |    |    |        |
+-----------------+-----------------+-----------------+-----------------+
```

Figure 10: CBA Message Format
6. Security Considerations

The CB update (CBU) messages need to be secured. Since mobile’s movement is constrained within a domain, these route optimization update messages can use the existing security mechanism that is in place as part of ProxyMIP deployment. It is assumed that there is standard security mechanism in place between the MAGs (Media Access Gateway) and between MAG and LMA. Thus, the CB update messages can be protected accordingly.
7. IANA Considerations

TBD
8. Acknowledgments

Authors acknowledge the useful discussion with Dana Chee.
9. References

9.1. Normative References


9.2. Informative References


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