Reducing Binding update in NEMO Supported PMIPV6

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ABSTRACT : *Proxy Mobile IPV6 (PMIPV6) is a network-based mobility management protocol, designed to keep track of individual mobile node's mobility. Numerous research works are in progress to enhance functionality of PMIPV6 to support NEtwork MObility (NEMO) as well. NEMO-BSP (NEMO Basic Support Protocol) is the protocol designed for NEMO and it is the extension of MIPV6. But NEMO-BSP cannot be directly used in PMIPV6 due to differences in the underlying protocols. IETF standard has given many design criterions for the protocol which supports NEMO in PMIPV6. This research work concentrates on two among the design considerations called "Resource-efficient handoff management" and "Minimal packet loss during handoff". While mobile network changes its point of attachment in PMIPV6 network, lot of Binding updates (BU) and Binding acknowledgements (BA) are sent over-the-air to handoff, to register new location of nodes in mobile network and acquire network prefix for them. By using the fact that all nodes in the mobile network move together, this research work combines individual BU and BA of all nodes in mobile network and sends them together. By grouping the BUs and BAs, handover time and number of signaling messages to be exchanged during mobile network movement are reduced drastically.*

Keywords *- PMIPV6, NEMO, Binding update, Binding acknowledgement, Mobile Router*

I. INTRODUCTION

PMIPV6 [1] is a network-based mobility management protocol, takes care of individual mobile node's movement inside PMIPV6 network with the help of network elements Local Mobility Anchor(LMA) and Mobile Access Gateway(MAG), and ensures IP session continuity as long as the node is moving inside PMIPV6 network. When a mobile node enters into PMIPV6 network and attached to MAG, MAG sends BU to LMA with mobile node id. LMA makes entry in the routing table with the Home Network Prefix (HNP) allocated to the mobile node and the MAG with which the mobile node is attached. LMA sends BA to MAG with HNP allocated to the mobile node. MAG gives Router Advertisement with allocated HNP to the mobile node. When the mobile node changes its location and attaches to new MAG, same procedure repeats. BU is sent from the new MAG to LMA. LMA searches in the routing table, allocates the same HNP, updates the MAG field with the new MAG information and sends BA with the allocates HNP . As the same network prefix is allocated to the mobile node, mobility is made transparent to the mobile nodes.

NEMO-BSP [2] is designed for mobile network. The nodes in the mobile network treat Mobile Router (MR) as a fixed Access Point and configure their addresses based on the Mobile Network Prefix (MNP) advertised by the MR. The Mobile Router takes care of entire network mobility and the mobility is transparent to the nodes in mobile network. Whenever the mobile network moves to foreign network, MR obtains Care-of-Address (COA) from the foreign network and sends BU to its Home Agent (HA) to inform COA. Nodes in mobile network continue to use the same address which was assigned when the mobile network was in Home network. HA forwards packets destined to the MNP to the COA of the MR. MR forwards it to the respective mobile node in the mobile network. Thus mobile nodes are not aware of their mobility.

PMIPV6 tracks the movement of only individual mobile nodes, not the mobile network movement. Bernardos and et. Al [3, 4] describes the necessity of bringing network mobility support in PMIPV6. Let's consider an airport where access points are available both at fixed locations such as coffee shops, waiting hall and at the mobile platforms such as busses that moves between one terminal to another terminal. The voyagers want their ongoing communications to be uninterrupted while they move around even between fixed and mobile access points (ex. While the user moves from waiting hall and get into the bus). PMIPV6 doesn't handle such scenarios.

Many research works are in progress to bring NEMO functionality in PMIPV6 to enable tracking of mobile network movement along with tracking of individual mobile node movement in PMIPV6. There is no standard protocol announced for this purpose hitherto. Seil Jeon and Younghan Kim [5] have given the requirements to be satisfied by the protocol which supports NEMO in PMIPV6. They are (i) Prefix delegation support for an MNN, (ii) Resource-efficient handoff management, (iii) Minimal packet overhead, (iv) Minimal packet loss during handoff and (v) Minimal end-to-end delay. This research work concentrates on two requirements namely "Resource-efficient handoff management" and "Minimal packet loss during handoff".

Nodes in mobile network configure the address from MNP advertised by MR and the address doesn't change even if the mobile network changes its point of attachment. Nodes in PMIPV6 network configure their address based on HNP given by LMA. When a mobile node moves between PMIPV6 network and mobile network which is inside the same PMIPV6 network or vice-versa, it gets a different address which contradicts important assumption of PMIPV6 protocol, where mobile nodes in PMIPV6 network will use the same address as long as the node is inside PMIPV6 network. This limits the mobile node movement between mobile network and PMIPV6 network.

To avoid this problem, existing architectures [6, 7, 8] which support in NEMO in PMIPV6 registers mobile nodes in mobile network with LMA and configures their address based on HNP obtained from LMA. While mobile network comes inside PMIPV6 network and during mobile network movement, all mobile nodes in mobile network are registered with the LMA and they are assigned Home network prefix from LMA.

Fig.1 shows the example PMIPV6 network with 1 LMA, 2MAGs and 1 mobile network. Mobile Network is attached to MAG1. If the mobile network changes its point of attachment from MAG1 to MAG2, all the nodes in mobile network will be registered with MAG2 and LMA using BU and BA.

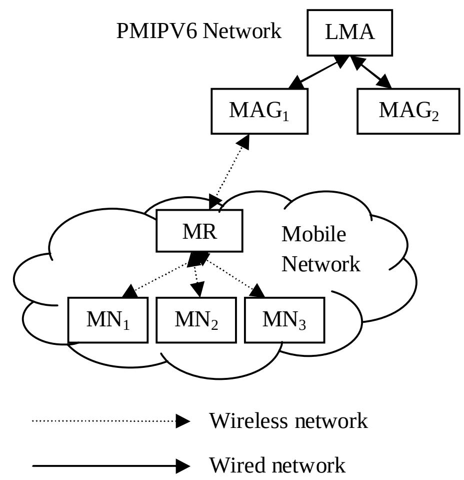

Figure. 1 PMIPV6 network

Fig.2 shows the message flow during mobile network movement from MAG1 to MAG2. MR registers with the MAG2 and the tunnel is established between LMA and MAG2 for forwarding Mobile router's communicating packets. Then same procedure is repeated all nodes in the mobile network. As shown in figure 2, lot of BUs and BAs for Mobile Router and nodes in mobile network are exchanged over the air during Network Mobility.

So during mobile network movement, lot of BUs and BAs are sent in air, as BU and BA for all mobile nodes in the mobile network should be exchanged between MAG and LMA individually. This increases handoff time of mobile network and produces over burst of signaling to carry BUs and BAs. This is due to the restricted capability of PMIPV6 which handles only single node registration and movement. BU and BA messages in PMIPV6 are designed to carry only single node information. So BU and BA needs be sent individually for all nodes in the mobile network. This research work addresses this problem and reduces BUs and BAs drastically by sending them together.

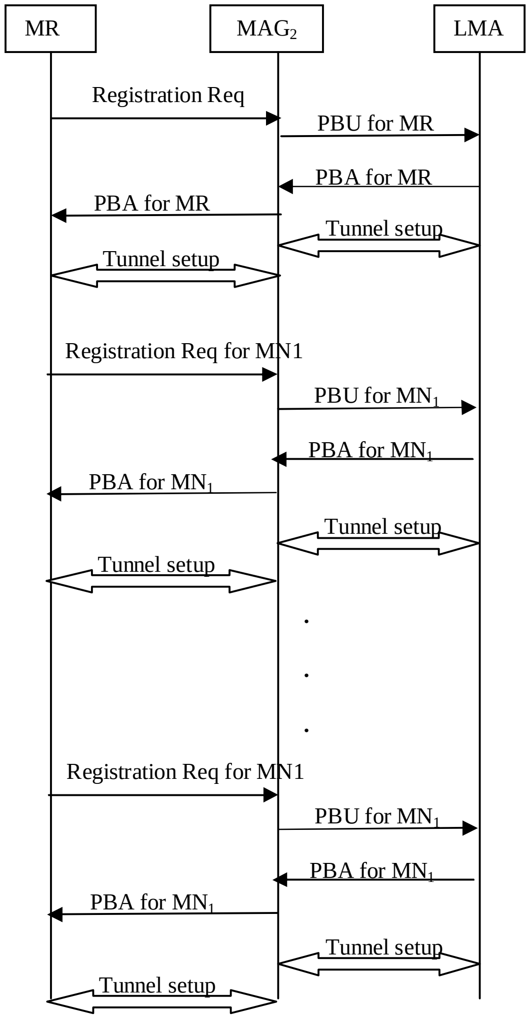

Figure 2 message flow with combination of NEMO-BSP and PMIPV6

Nodes in mobile network move together, so their registration with LMA also can be done together. By doing group registration, Handoff time and number of BUs and BAs to be exchanged are drastically reduced. All existing architectures which support NEMO in PMIPV6 concentrate on preserving unique features of NEMO and PMIPV6; none of them concentrates on reducing BU and BA, while group of nodes move together. This research work has extended the message format of BU and BA to include information for a group of nodes, and the functionalities of LMA and MAG to exchange and process BU and BA for group of nodes.

Section 2 illustrates about existing architecture which supports NEMO in PMIPV6 and whether do they really try to reduce BU and BA. Section 3 describes proposed architecture; section 4 gives performance evaluation for the proposed architecture and section 5 concludes this paper.

II. EXISTING ARCHITECTURE

Few people have come up with architecture which supports NEMO in PMIPV6. But they all lack consideration of group registration and group node movement as described below. Fumio and Tetsuya[9] defines a new architecture called PNEMO to support NEMO in PMIPV6. This architecture mainly concentrates on reducing number of encapsulations needed in case of nested NEMO. It treats nodes in mobile network as individual nodes not as group nodes. Also PNEMO has introduced four signaling messages: the Nested Binding Update (NBU), the Nested Binding Acknowledgment (NBA), the Proxy Nested Binding Update (PNBU), and the Proxy Nested Binding Acknowledgment (PNBA). These additional messages add extra signaling during mobile network movement. So this architecture does not succeed to optimize group node signaling.

Hyo-Beom Lee and Youn-Hee [6] introduce an architecture where MAG is not aware of existence of mobile network. MR registers with MAG as a normal mobile node and obtains HNP from LMA. After the registration MR acts as a MAG for nodes in mobile network and registers them with LMA. During this process lot of BUs and BAs are exchanged between MR and LMA. Thus this architecture also fails to treat mobile network as a group of nodes.

Jong-Hyouk Lee, and Thierry Ernst [7] have a NEMO supported PMIPV6, but they talk about only Locally Fixed Nodes (LFN) in mobile network. MR obtains HNP and MNP from LMA. It uses HNP to configure its own address and broadcasts MNP to LFNs so that LFNs can configure their addresses based on MNP. The problem mentioned in this paper arises only when mobile nodes in mobile network are registered with LMA. This paper does not handle this problem at all.

Soto and et. Al [8] notifies movement of mobile network with the help of single control message informing the movement of MR. But registration of mobile nodes in mobile network with LMA to obtain HNP is done for individual mobile nodes, not as a group activity.

NEMO – BSP [2] is the basic protocol to support Network mobility. This limits the mobile node movement between mobile network and PMIPV6 network as mobile nodes are assigned different addresses during movement and invalidates important property of PMIPV6 where nodes in PMIPV6 use the same IP address as long as they are inside PMIPV6 network.

In Relay-based NEMO [10], individual nodes in mobile network sends BU on its own whenever the mobile network changes its point of attachment which invalidates the concept of NEMO where the mobile nodes are unaware of network mobility.

III. PROPOSED ARCHITECTURE

While the mobile network enters into PMIPV6 network and changes its point of attachment inside PMIPV6 network, Mobile Router and nodes in the mobile network are registered with LMA. This triggers lot of BUs and BAs to be in air. By combining BUs and BAs triggered for nodes in mobile network, signaling and handoff time during handover can be drastically reduced. Existing BU and BA are designed for single node. This architecture extends existing BU and BA message format to carry information for group of nodes instead of only single node.

RFC 5213[1] gives BU message and BA message format used in PMIPV6 and the procedure for constructing them for a single node. Fig.3 gives BU message format designed for PMIPV6. This architecture extends this message format in such a way that it can carry information for group of nodes. Fig.4 gives the extended BU message format. In the new BU message, new field “Number Of mobile nodes (n)” is introduced to give the number of former BUs bundled in this message. This new field is followed by “n” number of BUs of individual mobile nodes. MAG can make use of this new format to consolidate BUs of all mobile nodes in mobile network and send it to the LMA, thus preventing lot of BUs over-the-air.

```
| 0| 1| 2| 3| 4| 5| 6| 7| 0| 1| 2| 3| 4| 5| 6| 7| 0| 1| 2| 3| 4| 5| 6| 7| 0| 1| 2| 3| 4| 5| 6| 7|

|                              |   Sequence No                   |
|A|H| L|K|M|R|P|   Reserved    |        Lifetime                 |
|                     Mobility Options                           |
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Figure 3 Existing Binding update Message Format in PMIPV6

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| 0| 1| 2| 3| 4| 5| 6| 7| 0| 1| 2| 3| 4| 5| 6| 7| 0| 1| 2| 3| 4| 5| 6| 7| 0| 1| 2| 3| 4| 5| 6| 7|

|                    Number of mobile nodes (n)                    |
|                              |  Sequence No                      |   1st node
|A|H| L|K|M|R|P|   Reserved    |        Lifetime                   |
|                        Mobility Options                          |
|                              |  Sequence No                      |   2nd node
|A|H| L|K|M|R|P|   Reserved    |        Lifetime                   |
|                        Mobility Options                          |
                                .
                                .
|                              |  Sequence No                      |   nth node
|A|H| L|K|M|R|P|   Reserved    |        Lifetime                   |
|                        Mobility Options                          |
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Figure 4 Extended Binding update Message Format

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| 0| 1| 2| 3| 4| 5| 6| 7| 0| 1| 2| 3| 4| 5| 6| 7| 0| 1| 2| 3| 4| 5| 6| 7| 0| 1| 2| 3| 4| 5| 6| 7|

|                              |  Status          |K|R|P|Reserved|
|          Sequence No         |        Lifetime                 |
|                        Mobility Options                        |
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Figure 5 Existing Binding acknowledgement Format

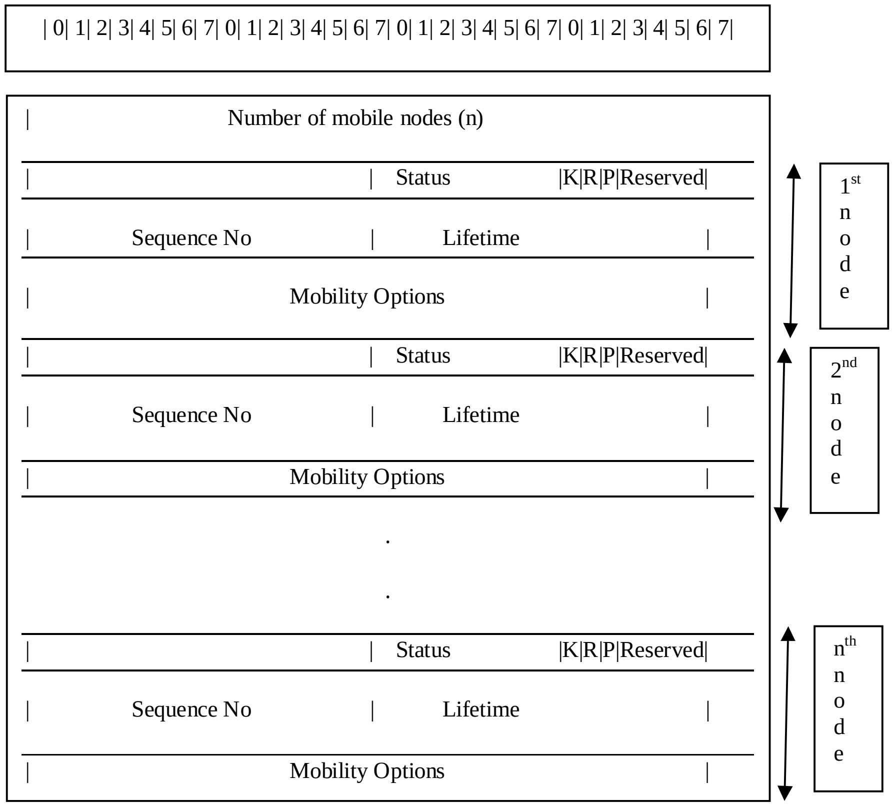

Fig 6: Extended Binding acknowledgement Format

Figure 5 shows the BA message format designed for PMIPV6. This architecture extends this message format in such a way that it can carry information for group of nodes. Figure 6 gives the extended BA message format. Similar to extended format of BU, new field “Number Of mobile nodes (n)” is introduced to give the number of former BAs bundled in this message. This new field is followed by “n” number of BAs of individual mobile nodes. MAG can make use of this new format to consolidate BAs of all mobile nodes in mobile network and send it to the LMA, thus preventing lot of BAs over-the-air.

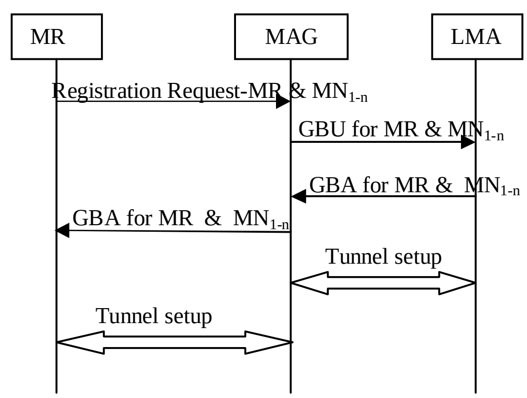

Figure 7 Message flow with the extended format of GBU and GBA

New BU and BA is named as Group BU(GBU) and Group BA(GBA) respectively. With GBU and GBA, the message flow during network mobility is shown in figure 7. Registration of entire mobile network with LMA is completed using only 4 messages consists of 2 BUs and 2 BAs. The number of BUs and BAs has reduced from 2n+2 to 4 where n is the number of mobile nodes in the network. As the number of messages to be exchanged during handover is reduced, packet loss during handover is also reduced.

IV. PERFORMANCE EVALUATION

Simulation for the proposed architecture has been done on NS-2 with PMIPV6 network consists of 1 LMA, 3 MAGs, and 1 mobile network. Simulation is conducted for different number of mobile nodes in mobile network.

4.1 Scalability Analysis

During mobile network movement from one MAG to another MAG, BUs and BAs are exchanged between LMA and MAG to register all nodes in mobile network with the new MAG. Using existing BU and BA message format, "n" number of BUs and BAs are needed for "n" number of nodes to complete the registration with the new MAG. With GBU and GBA, Only 1 GBU and 1GBA are needed to finish the registration.

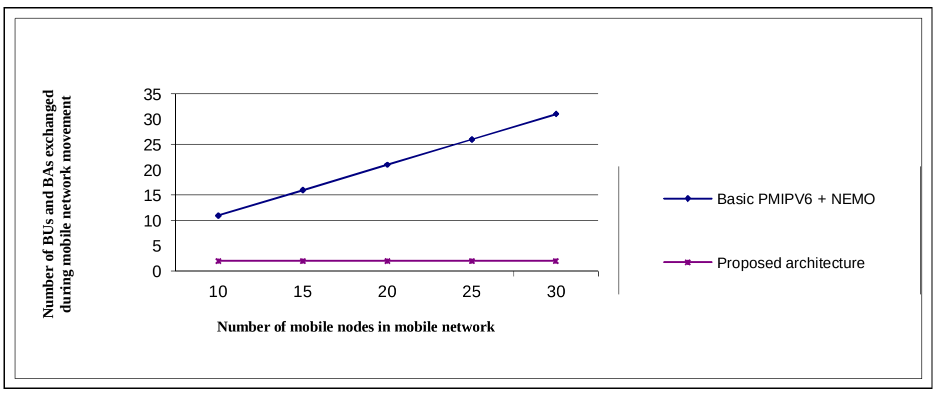

Figure 8 Scalability Analysis

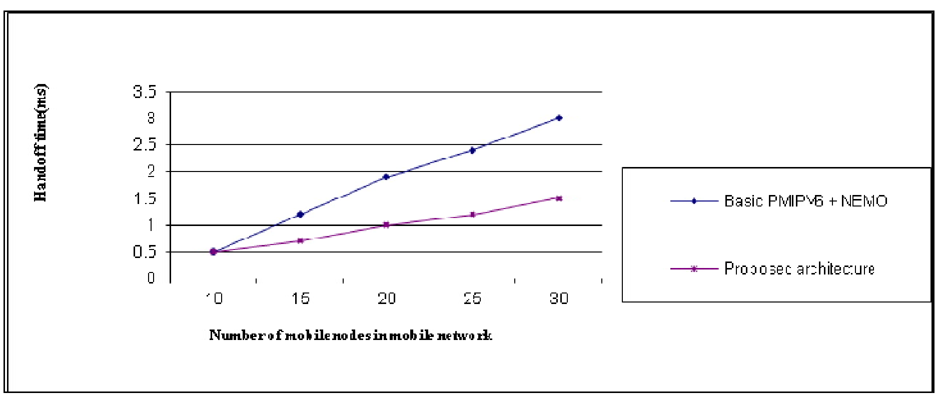

Figure 9 Handoff time Analysis

Fig.8 shows the simulation result. Existing architecture shows increase in number BU signaling messages, while the number of nodes in the mobile network increases. At the same time, the proposed architecture shows very less and constant number of signaling messages, irrespective of increase in number of mobile nodes in the mobile network. The simulation results shows better scalability results for the proposed architecture compared to the architecture which has basic PMIPV6 and NEMO-BSP.

4.2 Handoff time Analysis

With the help of GBU and GBA, Registration time with new MAG is drastically reduced. Hence handoff time is also reduced comparatively as shown in fig.9. Reduction in handoff time leads to reduction in packet loss also.

V. CONCLUSION

PMIPV6 is designed to support individual node movement in PMIPV6 network. With the introduction of NEMO in PMIPV6, PMIPV6 is able to support tracking of mobile network movement along with tracking of individual mobile node movement. The proposed architecture extends message format of BU and BA to support group node registration and movement. With the new message format, the number of messages exchanged is reduced drastically. Also it exhibits reduction in handoff time and packet loss during handover as shown in the simulation results. This paper needs functionality of LMA and MAG also to be extended to create and process new BU and BA message format.

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