Network Mobility Support Scheme on PMIPv6 Networks

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ABSTRACT

NEMO (Network Mobility) is proposed to support node mobility collectively. NEMO BSP is the most popular protocols to support NEMO based on MIPv6. However it does not satisfy requirements of real-time and interactive application due to problems, such as long signaling delay and movement detection time. Also MN should have mobility function for its handover. Proxy MIPv6 (PMIPv6) is proposed to overcome defects of MIPv6 based protocols. In this paper, we propose a Network Mobility supporting scheme, which supports MNs' mobility between PMIPv6 network and mobile network as well as the basic network mobility.

KEYWORDS

PMIPv6, NEMO, node mobility

1. INTRODUCTION

A mobile network is a set of mobile nodes (MN) that move collectively as a unit. Trains, airplanes or ships with wireless devices are examples of mobile networks. It is inefficient for every MN to participate in handover procedures at the same time whenever the mobile network moves. Moreover, not all MNs in the mobile network may be sophisticated enough to run mobility support protocols such as MIPv6[1], mSCTP[4]. The IETF Network Mobility working group has standardized the network mobility basic support protocol (NEMO BSP) based on MIPv6.

NEMO BSP introduces dedicated device, Mobile Router (MR) that attaches appropriate Access Router (AR) on behalf of MNs involved in mobile network. It allows all MNs in the mobile network not to lose ongoing sessions irrespective of their capabilities during handover. Each MN configures its address based on the Mobile Network Prefix (MNP), which the MR broadcasts periodically with Router Advertisement (RA). Even though the MR changes its point of attachment, the MNP is not changed, and MNs would not aware handover. However since NEMO BSP is based on MIPv6, it inherits the drawbacks of MIPv6 such as long signaling delay and movement detection time. Moreover the delay caused by the movement of the MR affects all MNs in the mobile network. Another problem is that NEMO BSP does not cover MN's movement which moves in or out mobile network. It means that MN should have mobility protocol for own mobility.

Local mobility management (LMM) protocols are proposed to reduce a signaling delay in confined areas. Proxy Mobile IPv6 (PMIPv6)[7] is the most promising LMM protocol proposed by IETF. The prominent characteristic of PMIPv6 is that it is a network-based protocol, which

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excludes the involvement of MNs from handover procedure. PMIPv6 prevent nodes from changing their address after handover and movement detection time is removed. MNs, which do not have mobility function, change its point of attachment without losing connection. Several PMIPv6-based NEMO supporting protocols are proposed [2][5][6].

The NEMO support protocols have studied solutions about managing location and reducing handover latency of the mobile network. But they lack supports for MN's movement into the mobile network or vice versa; MN needs mobility protocol even in case of PMIPv6-based NEMO protocols. We propose a Node Mobility supporting scheme with a mobile network in PMIPv6 network (nmNEMO). The proposed scheme supports node mobility between mobile network and PMIPv6 network without MNs' mobility support capabilities. The MR in a mobile network acts as a MAG as well as gateway. Upon attachment of the node, MR exchanges messages with node's LMA and emulates its home network.

The remainder of this paper is organized as follows: Section 2 shows related works for NEMO protocols. Section 3 describes the proposed a Node Mobility supporting scheme in NEMO (nmNEMO), and implementation result are presented in Section 4. Finally, Section 5 offers some concluding remarks.

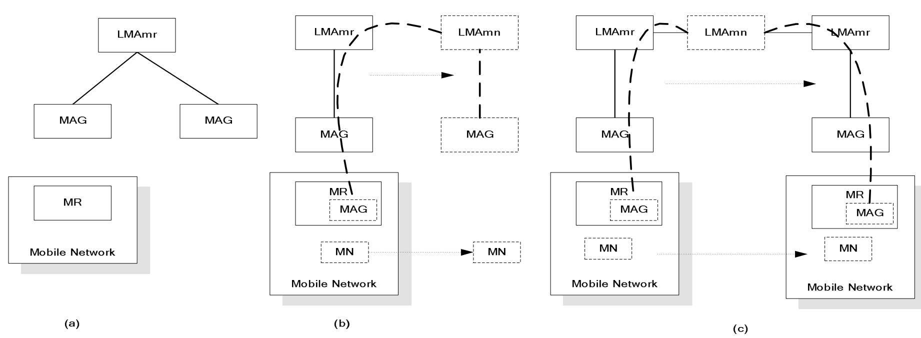

Figure 1. NEMO PMIPv6: (a) network mobility (b) node mobility between mobile network and PMIPv6 network (c) node mobility between mobile networks

2. RELATED WORKS

NEMO BSP [1] is the standard method to support network mobility. It makes a tunnel between a MR and the home agent (HA) of the MR and it forwards all packets to nodes in the mobile network. The MR represents all nodes belong to the MR sub-domain. As the IP addresses of all nodes in the MR has the same prefix, and all packets having the prefix will be captured by the home agent of the MR and they are forwarded to the MR via the tunnel.

Lee et al. [2] discusses several informative scenarios when the mobile network is used in PMIPv6 network. One of these scenarios discussed the same architecture that we assume and give simple message flow. But most cases assume that the MR has MIPv6 protocol and they do not consider the MN's mobility between PMIPv6 and mobile network.

NEMO protocol based on SCTP [3] is proposed. It assumes that the MR and CN have SCTP protocol [4], which is a transport-layer protocol and supports multi-homing. When the MR moves, the MR adds new care of address to CN. As SCTP supports multiple connections between two peers, adding new address and changing the primary connection between the MR and CN have the same effect of handover.

Li et al. [5] proposes a multi-homing based NEMO protocol in PMIPv6. With the information sharing, it uses benefits of multi-homing. The multi-homing is used to supports vertical handover or load balancing.

Relay-based NEMO [6] uses the MR as relay node. All nodes in the mobile network have to re-bind individually when the mobile network changes it point of attachment. These re-bind is done locally, it may cause local binding storm between the relay node and new MAG.

3. PMIPv6-BASED NEMO PROTOCOL WITH NODE MOBILITY

There are three mobility scenarios for mobile network and MN. Fig. 1 (a) shows movement scenario of the mobile network, which NEMO support protocols have generally studied. Since MR is considered as a node, one of LMAs, LMAmr, manages location and assigns a network prefix for the MR. While the MR does not leave the PMIPv6 domain, handover will be supported by the network. In addition, the mobile network may move between several PMIPv6 domains without any modifications, if the domains through which it passes supports inter-domain roaming mechanism [8].

. 1 (b), (c) shows node mobility scenarios between the mobile network and PMIPv6 network, and between mobile networks, respectively. To support the node mobility with the mobile network and exclude involvement of the node, the mobile network needs MAG functions at the MR. When MN moves into the mobile network, MR get the network prefix from the LMA, which was chosen for serving the MN, and emulates the home network for the MN. Therefore the NEMO architecture has another PMIPv6 network over the underlying PMIPv6 network. Another PMIPv6 network is composed of LMA and MN while underlying PMIPv6 network is composed of LMAmr and MR.

3.1. Network mobility

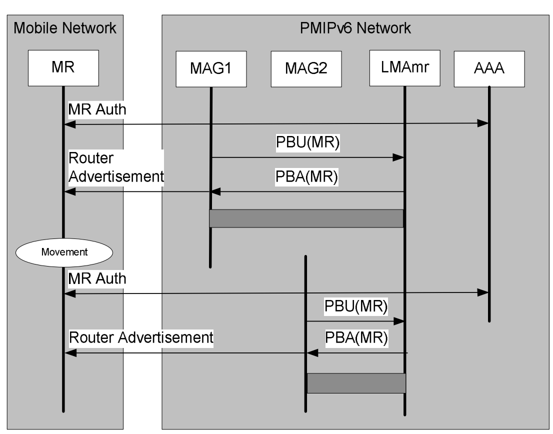

Figure 2. Network Mobility Flow

Fig. 2 shows the messages flow of the network mobility. The procedure is the same as that of PMIPv6 standard operation. After MR successfully is authenticated on access network connected to MAG1, MAG1 obtains MR's profile, which contains MN-Identifier, LMAmr address. Then MAG1 sends Proxy Binding Update (PBU) to LMAmr. LMAmr allocates a binding cache entry for the MR and it responds to MAG1 using Proxy Binding Acknowledgement (PBA), which includes a Home Network Prefix (HNP). The MAG1 sends a RA with the HNP to the MR. When the MR moves to MAG2, MAG2 repeats the authentication procedure, and it sends a RA having the same HNP to the MR.

MR acts as MAG for an MN when the MN is attached to the mobile network. The MR registers it to appropriate LMAs (LMAmn) based on MNs' profile. Because the MN can move out the mobile network, each MN must have its own HNP. This is the difference from the other protocols. In previous proposed schemes, the MR broadcasts its prefix and all nodes uses the prefix to generate their IPv6 address.

3.2. Node mobility and Default Router Invalidation

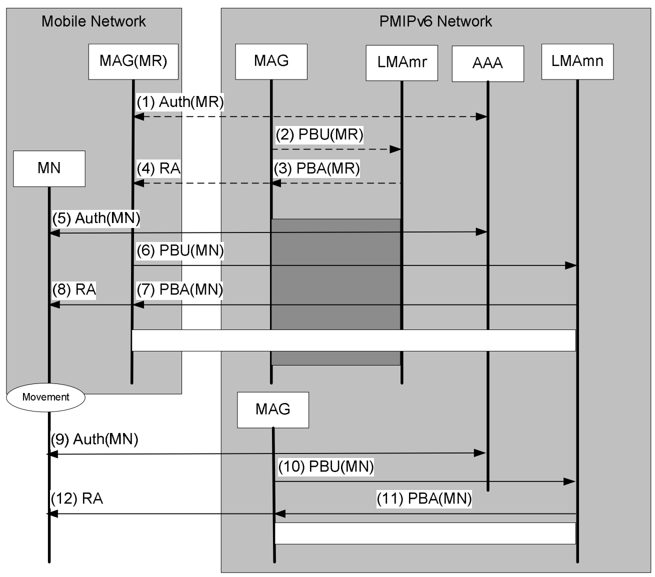

Figure 3. Node Mobility Flow

Fig. 3 shows message flow of overall operation for supporting node mobility. Each step shown in Fig. 3 is described as follows:

Step 1-4: MR is attached to MAG in the PMIPv6 network. Every packet for the MR is passed through MAG/LMAmr tunnel.

Step 5: When an MN moves to the mobile network, it performs authenticate procedure. Through the procedure, MR obtains the MN's profile.

Step 6 and 7: MR sends a PBU to LMAmn, which is obtained from the profile. The MAG treated the PBU as a normal IP packet; the PBU pass through MAG/LMAmr tunnel to LMAmn. After LMAmn receives the PBU, it updates the MN's location and responds PBA with MN's HNP. Then the MR set up a route for MN's HNP and MR/LMAmn tunnel is established.

Step 8: The MR unicasts RA to the MN based on its HNP. After that, every packet for the MN passes through MR/LMAmn tunnel over MAG/LMAmr tunnel.

Step 9-12: When the MN moves out the mobile network, the new MAG updates the MN's location to the LMNmn via the standard PMIPv6 operation.

Whenever MN attaches to different MAG, it may receive different router address from RA. Because the MN considers that previous MAG is still valid as default router, it tries to send traffic through previous MAG; the connection from the MN to CN is disrupted. After invalidation timer for current default router is expired, the MN removes previous MAG and uses new MAG as default router. To avoid the Default Router Invalidation (DRI), all MAGs in a PMIPv6 domain should have the same link-layer address and link-local address.

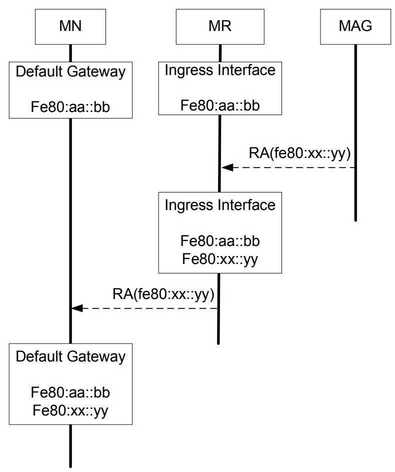

Figure 4. The method to avoid DRI

However, if the mobile network moves across different PMIPv6 domains, by inter-domain roaming mechanism [8], it is hard for all MAGs to have same address. Again, the MN may have wrong default router and send packets to wrong path. This is critical to interactive applications such as messenger, telnet, etc. Fig. 4 shows scheme to avoid DRI. When the MR receives a RA with different default router address from egress interface, it adds the same address to ingress interface and sends RAs with the address to MNs. However the MR maintains old address in the ingress interface and receives packets sent to old address during certain time. After certain time, the MNs change its default router address to new one. Then, the MNs will not experience DRI when they move out or into the mobile network.

4. IMPLEMENTATION RESULTS

Fig. 5 shows the experimental testbed of PMIPv6 NEMO network with one LMA; the LMA is used for LMAmr and LMAmn. The testbed consists of four desktop computers for a MR, a MN and two MAGs with processor speeds 1.8 GHz and memory sizes 512MB, one desktop computer for LMA with processor speed 2.0 GHz and memory size 1GB, and one notebook for CN. MR, MAG and MN have wireless LAN devices, Linksys WMP55AG (802.11a/b/g PCI). All MAGs, MR and LMA use the Debian/Linux Operation system (kernel 2.6.10) and the PMIPv6 daemon, which we implemented based on the MIPL (2.0.2). MN sends ping packets to CN every 10ms. To know effect of DRI, we introduce effective handover latency which means duration from the last received/sent packet to the first packet, which is sent through right path.

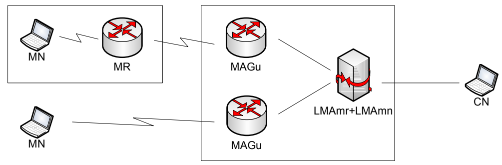

Figure 5. Testbed for PMIPv6 NEMO network

Fig. 6 shows handover delay at the MN when the MR moves between MAGs. The handover delay variation is very high. The variation is caused by the Linksys WMP55AG. The device driver caches the last scanned channel information. The cached information lasts about 2 minutes and then it is removed. If the handover starts when the cache information exists, the handover delay is very small; the average delay is about 78ms. However, if the cache information does not exist, the driver searches all available channels in 2.4 GHz and 5 GHz. The handover delay increases up to approximately 4.5 seconds.

Since scanning delay is too long, we reduce the channel searching range to 4 channels, 5.26, 5.28, 5.29, 5.3 GHz, and perform the scanning procedure every handover. The Fig. 7 shows handover delay at the MN when the MN moves between the mobile network and PMIPv6 network. The total handover is 280ms and the link layer handover delay is 227ms. Even though we use only 4 channels, about 80% of handover delay is consumed by scanning delay.

For node mobility, we measure effective handover latency while MN moves between MAG and MR. Fig. 8 shows effective handover latency without avoiding DRI method. 9 sec is related with the default router lifetime in RA, so it is system dependable. Fig. 9 shows effective handover latency when apply avoiding DRI method. The first handover latency is larger than the other because LMA and MAG need address resolution for each other before they exchange signaling messages. The total handover latency is about 290 ms and link layer handover delay is 267 ms. The result are similar to one of Fig. 7.

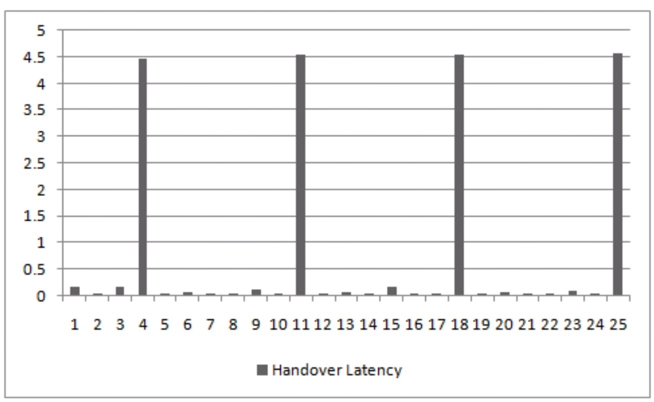

Figure 6. Handover delay at the MN with Linksys WMP55AG

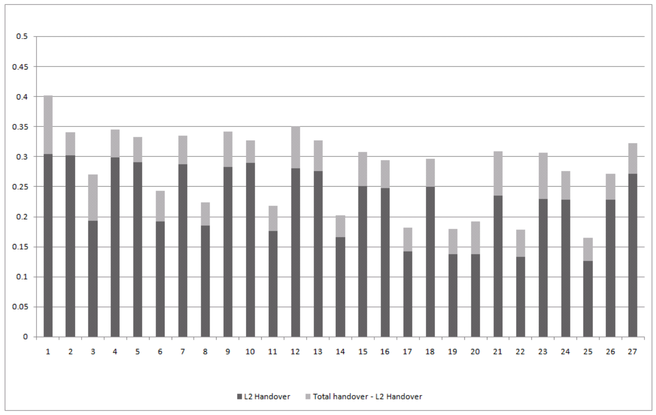

Figure 7. Handover delay at the MN (scan only 4 channel for each handover)

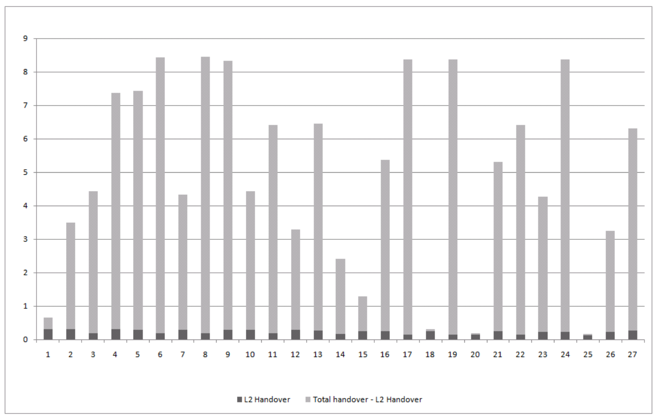

Figure 8. Effective Handover latency at the MN

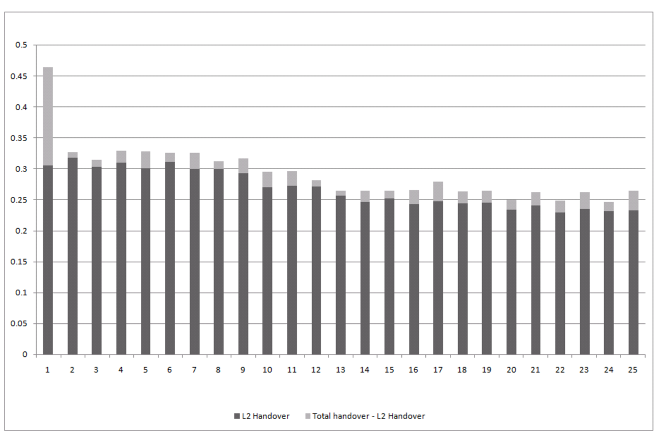

Figure 9. Effective Handover delay at the MN with avoiding DRI method

5. CONCLUSION

We proposed a node mobility supporting scheme with the mobile network. NEMO BSP and other NEMO support protocols do not covers node mobility between a mobile network and a PMIPv6 network or between mobile networks. But in PMIPv6 network, MNs are not assumed to have mobility functions as the network supports their mobility. The proposed scheme introduces MAG functions to the MR and extends PMIPv6 network to a mobile network. Therefore MN handovers between the mobile network and PMIPv6 network with only IPv6 stack.

We implemented PMIPv6 protocol and nmNEMO without any modifications for LMA and MAG. The results shows link layer handover latency is critical to total handover latency. Also, effective handover shows that DRI occur poor quality in interactive application. But it can be solved by DRI avoiding scheme in the MR.

In further works, we are going to add a seamless handover solution to the proposed scheme. As PMIPv6 does not support seamlessness during handover and the wireless link between the MR and MAG carries the aggregate traffic for the mobile network, a mechanism to guarantee the seamlessness during handover may be appropriate.

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