Analysis of Proxy Mobile IPv6: A Network-based Mobility Solution

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***Abstract*—Terminal-based mobility protocols require mobile devices to participate in mobility signaling that consumes lots of processing power and memory. Network-based mobility protocol, such as, Proxy Mobile IPv6, solves this problem by excluding low-end mobile devices from signaling requirement. In this paper, we have explained Proxy Mobile IPv6 architecture along with its detailed signaling diagram. We have identified the major advantages and limitations of this protocol. We have also performed the signaling cost analysis of its key mobility entities to obtain the amount of overhead on them. Results show interesting relationships among various network parameters, such as, network size, mobility rate, traffic rate. Our critical analysis can help researchers better understand the strengths and weaknesses of this protocol and our signaling analysis can be used by network engineers to estimate the resource requirements of its entities in actual deployment.**

***Index Terms*—Mobility management, Proxy Mobile IPv6, handover protocol, cost analysis, localized mobility protocol, wireless networks.**

I. Introduction

Proliferation in mobile computing has drawn significant attention of the research community and Mobile IPv6 [1] was standardized to facilitate Internet connectivity to mobile devices. However, as a host-based mobility solution, Mobile IPv6 requires low-end mobile devices to perform all kinds of mobility signaling to maintain connectivity. Therefore, Internet Engineering Task Force (IETF) proposed Proxy Mobile IPv6 [2], a Network-based Localized Mobility Management (NetLMM) solution which provides Internet connectivity to mobile devices without requiring additional software and complex cryptographic configurations in low power devices. NETLMM solutions have received significant attention from the industry, (specially cellular operators), since NETLMM solutions can reduce the cost of network management and facilitate inter-operability and integration among heterogeneous access technologies.

There are a number of advantages of Proxy Mobile IPv6. Mobile devices are free from any mobility signaling, thereby saving its resources. No tunneling in the (wireless) access network and overall reduced signaling. Moreover, Proxy Mobile IPv6 has much less handover latency compared to its base protocol due to the fact that all the mobility signaling are managed by the network components. However, as stated before Proxy Mobile IPv6 only support localized mobility rather than global mobility. Moreover, it does not support route optimization.

To incorporate network-based support, Proxy Mobile IPv6 has redefined the network entities to provide seamless mobility support to the mobile devices. These entities are very crucial for the operation of the protocol. Total overhead on these network entities are influenced by a number of *network parameters* (such as, network size, mobility rate, traffic rate). Proliferation in mobile computing have resulted in more signaling and (multimedia) data traffic on different *mobility management entities*. These entities are very resource restricted; thus, overloading of these entities may result in complete outage for the whole system. Hence, it is crucial to perform entity-wise cost evaluation of Proxy Mobile IPv6 to estimate actual resource requirement of its critical entities.

A few works on Proxy Mobile IPv6 and related protocols can be found in the literature. Kong et al. [3] performed quantitative analysis of Proxy Mobile IPv6 and other terminal-based mobility protocols. Kim et al. [4] performed handover analysis of Proxy MIPv6 and tried to make the handover process seamless. Lee et al. [5] worked on the route optimization of PMIPv6. There have been experimental evaluations [6] for PMIPv6. Lee et al. [7] performed cost analysis of PMIPv6 that lacks entity-wise evaluation of its key entities. Thus, the analyses found in the literature did not explicitly analyze the merits and demerits of this network-based mobility solution, nor these exists any entity-wise cost evaluation for Proxy Mobile IPv6.

Our *objective* of this work is to critically analysis the operation of the Proxy Mobile IPv6 protocol, thereby identifying its strengths and weaknesses. We are also interested to develop an analytical model to obtain signaling overhead of the key entities of Proxy Mobile IPv6.

The *contributions* of this work are: (i) analyzing Proxy Mobile IPv6 along with its detailed signaling diagram (ii) identifying major advantages and limitations of the protocol (iii) signaling cost analysis of its key entities along with numerical results.

Our results show interesting relationships among various network parameters, such as, network size, mobility rate, traffic rate. Our critical analysis can help researchers better understand the strength and weaknesses of Proxy Mobile IPv6 protocol and our signaling analysis can be used by network engineers to estimate the resource requirements of its entities in actual deployment.

The rest of the paper is organized as follows. In Section II,

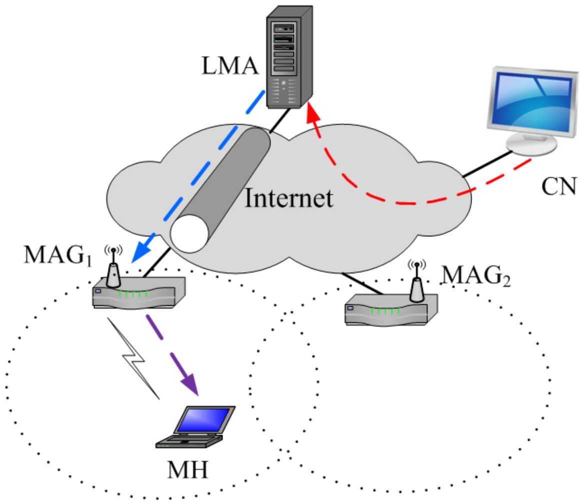

Fig. 1. Proxy Mobile IPv6 architecture.

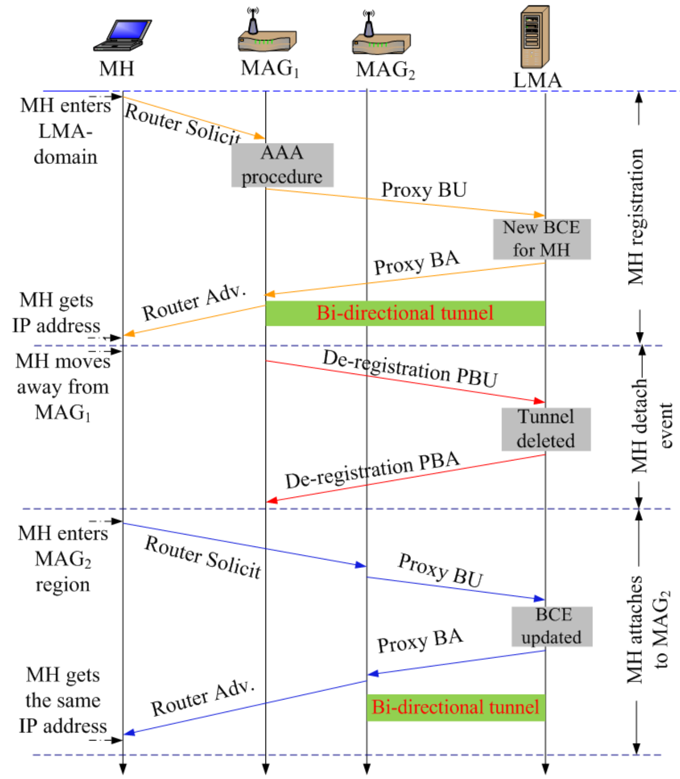

Fig. 2. Timing diagram of Proxy-SEMO6 signaling.

the Proxy Mobile IPv6 architecture is explained along with its signaling diagram. In Section III, we have listed all the advantages of Proxy Mobile IPv6 over its base protocol, followed by the limitations in Section IV. Section V presents the entity-wise signaling cost analysis of the major entities of Proxy Mobile IPv6, followed by the numerical results in Section VI. Finally, we conclude the paper in Section VII.

II. Proxy Mobile IPv6

Proxy Mobile IPv6 [2] is a network-based mobility solution based on Mobile IPv6 [1]. In PMIPv6, all the mobility related signaling responsibilities are shifted from the Mobile Host (MH) to the network. Mobility entities track the MH's movement and initiates mobility signaling on behalf of MH, hence it is named as Proxy Mobile IPv6. The network, where such network-based mobility is supported, is referred to as PMIPv6-domain.

A. PMIPv6 Architecture

Fig. 1 shows the Proxy Mobile IPv6 architecture which has two core mobility management entities: Location Mobility Anchor (LMA) and Mobility Anchor Gateway (MAG).

Local Mobility Anchor: Local Mobility Anchor is the home agent for the MH in a PMIPv6 domain. It is the topological anchor point for the MH's home network prefix(es) and is the entity that manages the MH's binding state. The LMA has the functional capabilities of a HA [1] with the additional capabilities required for supporting PMIPv6 protocol. all traffic destined to the MH from any Correspondent Node (CN) are routed through the LMA. In a PMIPv6-domain, there can be multiple LMAs– each serving a different group of MHs.

Mobile Access Gateway: Mobile Access Gateway in PMIPv6-domain is basically an access router that is responsible for tracking MH's movement in its access link and subsequently informing the LMA through Proxy Binding Update (PBU). Thus MAG performs all mobility related signaling on behalf of the MH, thereby saving MH's resources.

For PMIPv6 protocol operation, bidirectional tunnel is established between LMA and MAG, and Security Association (SA) is set up for authenticating PBUs to prevent attack. The egress interface of the MAG is known as Proxy Care-of-Address (PCoA) and is the transport endpoint of the tunnel with the LMA.

B. Protocol Operation

For PMIPv6 protocol operation, the mobility entities require a stable identifier (e.g., MH-ID) to identity the MH. MH's MAC address can be an example of MH-ID. The mobility entities also require access to certain configuration parameters (known as policy profile) for providing the mobility service to a given MH. This can be stored in a policy store from where MAG or LMA can obtain this profile.

When a MH enters a PMIPv6-domain, the corresponding MAG consults with the policy store to authorize the PMIPv6 support to the MH. Each MH is assigned a single IP address (e.g., MH-HoA) as its Home Address (HoA) that is used in the entire domain. The network entities ensure that the MH does not detect any change in L3 attachment even after changing its point of attachment. Thus, movement within a PMIPv6-domain is transparent to the MH and it appears to be a single link.

C. Timing diagram

The timing diagram for the PMIPv6 signaling is shown in Fig. 2. When a MH enters the LMA-domain, it attempts to attach to the access network (L2 attachment) through one of its network interface and sends router solicitation to the access router (e.g., MAG_1). Upon receiving the solicitation, the MAG uses MH's identification (e.g., MAC address) to determine whether the MH is authorized to use the localized mobility support. The MAG then registers the MH with the LMA through Proxy Binding Update (PBU) which associates MAG_1's address with MH's network interface. The LMA adds a Binding Cache Entry (BCE) into its table and establishes a bi-directional tunnel with the MAG_1 if one does not already exist. The LMA also sends Proxy Binding Acknowledgement (PBA) to the MAG_1 along with the assigned prefix. Upon receiving the PBA, the MAG_1 sends the MH Router Advertisement (that includes the allocated prefix), allowing MH to configure its IP address through stateless auto-configuration.

When the MH moves away from the MAG_1 link, the (L2 detachment) event is detected by the MAG_1. The MAG_1 then informs the LMA about this event through the deregistration PBU which results in possible tunnel deletion (if not needed for any other MH). The LMA starts a timer and if no PBU is received from another MAG during that time, the binding cache entry of the MH is deleted.

When the MH moves in a new MAG-region, it attempts to acquire IP address from the MAG_2 in a similar way mentioned above (see Fig. 2). Thus, when the LMA receives the PBU from the MAG_2, the LMA update the BCE corresponding the MH and establishes similar bi-directional tunnel with the MAG_2. The LMA replies with the same IP prefix (assigned already) to the MAG_2 and the MH gets the same IP address. Hence, the MH does not detect any change of access link, making the handoff completely transparent.

III. Benefits in Proxy Mobile IPv6

There are a handful of advantages of Proxy Mobile IPv6 over its base protocol, Mobile IPv6. These benefits include battery power savings of the mobile device, no requirement to change the MH's protocol stack, efficient tunneling and faster handover. In this section, we have explained all the major advantages of Proxy Mobile IPv6 compared to Mobile IPv6.

A. Battery power saving

First of all, PMIPv6 eliminates all the signaling requirement of the mobile devices, thereby saving battery power which is very crucial for any mobile device. All the mobility related signaling are managed by the network entities.

B. No modification in MH

In MIPv6, the end device has to run the mobility software. That is, every mobile device is required to update the protocol stack which is sometimes very difficult task. On the other hand, PMIPv6 requires changes in the protocol stack of the mobile device, thereby making it simple for the service provider. Only the network components are configured to provide localized mobility support.

C. Unique IP address in the whole LMA-domain

In MIPv6, the MH gets multiple care-of-address (CoA) based on its location in the foreign network. When the MH moves to another foreign network, it gets another CoA from the access network. The session continuity is ensured through the use of single Home Address (HoA). On the other hand, a MH does not detect any change of IP address in a PMIPv6-domain. The network entities ensure that the MH is assigned the same home prefix (and IP address) as long as the MH resides within the PMIPv6-domain. This saves a lot of time unlike in case of MIPv6 where change of IP addresses requires several signaling message to be exchanged between the MH and the access networks.

D. Movement detection by the network

After each handover, Mobile IPv6 requires each MH (to inform HA) through binding update which is an overhead for low-power mobile device and consumes its bandwidth. However, in PMIPv6, movement of MH is detected by the MAG and is informed through Proxy Binding Update.

E. Reduced signaling in wireless access link

Since MH exchanges several signaling messages through the wireless access link in MIPv6, the wireless link is heavily used for MIPv6. However, this is not the case for PMIPv6 where the network entity (MAG) automatically detects the movement of the MH and informs the LMA about such movement. This significantly reduces the signaling traffic on the wireless access link.

F. Efficient Tunneling

In MIPv6, the MH is responsible to decapsulate the (encapsulated) packet sent by the HA. There is a bi-directional tunnel for every MH with the HA. On the other hand, for Proxy MIPv6, the bi-directional tunnels are established between the MAG and the LMA, and all the MH's traffic under a MAG shares the same tunnel, thereby reducing number of tunnels compared to MIPv6. In addition, the wireless link in PMIPv6-domain does not receive any tunneled packet (which contains extra IP header), thereby saving wireless bandwidth of the access link.

G. No Return Routability test

To protect against session hijacking in MIPv6, return routability test is mandatory (for MH) and is performed just before sending binding update to the CN. This incurs additional overhead on the MH. However, the return routability is not required in PMIPv6 as the MAG sends PBU on behalf of the MH and the MAG has pre-established security associations with the LMA.

H. No duplicate address detection

Since a MH uses only one IP address in the entire PMIPv6-domain, the Duplicate Address Detection (DAD) is only performed when the MH first enters the localized mobility domain. On the other hand, in Mobile IPv6, the DAD must be performed every time the MH hands off between subnets and acquires a new CoA from the foreign network. The DAD process increases the handover latency of the MIPv6.

I. Low handover latency

In Mobile IPv6, the handover period includes movement detection, Duplicate Address Detection (DAD) time, Authentication, Authorization, and Accounting (AAA) delay and location registration delay. However, Proxy Mobile IPv6 handover period does not include movement detection and DAD period unlike in MIPv6. This is because the movement detection is performed by the MAG automatically on behalf of the MH. Moreover, a MH under a LMA-domain uses the same IP address. Therefore, no question of any duplicate address detection. Thus, PMIPv6 handover is faster than MIPv6 handover.

IV. Drawbacks of Proxy Mobile IPv6

There are a few limitations of Proxy Mobile IPv6. They are explained as follows:

A. No route optimization

MIPv6 supports route optimization which allows the CN to send packets directly to the MH, bypassing the HA. To enable route optimization in Mobile IPv6, the MH has to send binding update to the CN. On the other hand, Proxy MIPv6 does not support route optimization; all the CN traffic must go through the LMA which is the topological anchor point of the MH in the localized mobility domain. Therefore, signaling requirement on the LMA can be higher depending on the number of MHs in the LMA-domain, which may results in performance degradtion.

B. Localized mobility management only

Proxy Mobile IPv6 is not a global management protocol. Rather it is a localized mobility solution. The MH must be registered to get PMIPv6-support in a PMIP-domain. When the MH moves out of the PMIPv6-domain, it must get mobility support from a global mobility solution, such as, Mobile IPv6.

V. Signaling Cost Analysis

In this section, we perform the signaling cost analysis of mobility management entities of Proxy Mobile IPv6: LMA, MAG and the MH. The LMA and MAG – two key components of PMIP6 – have been chosen for entity-wise evaluation. These entities are very resource restricted; thus, overloading these entities may result in complete outage for the whole system. Hence, it is crucial to perform entity-wise cost evaluation of PMIPv6.

A. Assumptions

To make the model analytically tractable, the following assumptions have been made.

- Session arrival at each MH is equal.
- All session lengths are of equal size.
- Binary seearch is used to search entries in binding cache.
- Our cost analysis ignores standard IP switching costs.

B. Notations

The notations used in the analysis are listed below.

N_m	Number of MHs in the LMA-domain,
N_c	Average number of CNs per MH,
β_M	Unit transmission cost for message type M = {PBU, PBA, DP, DA, ... }
σ	Proportionality constant of wireless link over wired link,
ω	Linear coefficient for lookup cost,
T_r	Subnet residence time,
λ_s	Average session arrival rate,
κ	Maximum transmission unit,
α	Average session size,
δ_X	Processing cost at entity X.

C. Local Mobility Anchor

In Proxy-Mobile IPv6, the major costs for LMA are 1) initial registration cost, 2) binding update cost, and 3) data delivery cost.

1) Initial registration cost: We assume that ϵ fraction of MHs enters into the LMA-domain from outside at a rate of θ_d. Thus, a total of $\epsilon N_m \theta_d$ MHs enters into the LMA-domain per second. When a MH enters the LMA-domain, the MAG tracks it and sends PBU to the LMA. The LMA processes the PBU, allocates prefix for the MH, updates the binding cache and sends back PBA to the MAG. Thus, the cost of initial registration on the LMA is as follows:

$$\Psi_{LMA}^{Reg} = \epsilon N_m \theta_d \big(\beta_{PBU} + \beta_{PBA} + \delta_{LMA}\big) \tag{1}$$

2) Binding update cost: When the MH moves within the LMA-domain and crosses subnets (in every T_r seconds), the concerned (new) MAG detects it and sends the PBU to the LMA. In addition, MAGs send periodic refreshing updates to the LMA for extending the binding lifetime so that the entries are not removed from the cache.

Let the binding lifetime be T_l. Therefore, $\lfloor \frac{T_r}{T_l} \rfloor$ refreshing updates will be sent to LMA within the time T_r. Thus, the frequency of sending periodic refreshing updates are $\eta_r = \lfloor \frac{T_r}{T_l} \rfloor / T_r$, and total frequency of sending LU and refreshing LU is $\eta_t = \Big(1 + \lfloor \frac{T_r}{T_l} \rfloor\Big)/T_r$, This again incurs transmission and lookup cost at the LMA which is given by,

$$\Psi_{LMA}^{PBU} = \eta_t N_m \big(\beta_{PBU} + \beta_{PBA} + \omega \log_2 N_m\big) \tag{2}$$

3) Data delivery cost: In a session between the CN and MH, an average of $\lceil \frac{\alpha}{\kappa} \rceil$ data packets (and corresponding ACK) are transmitted. The total data packet arrival rate to the LMA is $\lambda_p = N_m N_c \lambda_s \lceil \frac{\alpha}{\kappa} \rceil$. Data packets received by the LMA are tunneled through the respective MAG to the destination MH. This incurs transmission cost for data and Ack packet (β_{DP} and β_{DA}) including extra IP-header (β_{IP}), and lookup cost. Therefore, data delivery cost for the LMA is given by,

$$\Psi_{LMA}^{DD} = \lambda_p \big(\beta_{DP} + \beta_{DA} + \beta_{IP} + \omega \log_2 N_m\big) \tag{3}$$

4) Total Cost on LMA: Thus, the total cost on the LMA can be obtained by adding Eqns. (1), (2), and (3):

$$\Psi_{LMA} = \Psi_{LMA}^{Reg} + \Psi_{LMA}^{PBU} + \Psi_{LMA}^{DD} \tag{4}$$

D. Mobility Anchor Gateway

The major costs for MAG are 1) MH authentication cost, 2) binding update cost, and 3) data delivery cost.

1) MH authentication cost: When a registration request arrives at MAG for an incoming MH into the domain, the MAG is responsible authenticating the MH. If the credentials of the MH matches corresponding AAA information, the MAG accepts the registration request and proceeds with the PBU request. Otherwise, MAG rejects the request. As a total of $\epsilon N_m \theta_d$ MHs enters into the LMA-domain per second and if there are m MAGs in the LMA-domain, therefore each MAG processes $\epsilon N_m \theta_d / m$ authentication requests. Hence, cost on each MAG regarding the authentication process can be obtained as follows:

$$\Psi_{MAG}^{AAA} = \frac{\epsilon N_m \theta_d}{m} \times \delta_{MAG} \tag{5}$$

2) Binding update cost: Assuming MHs are uniformly distributed in the LMA-domain, each MAG sends PBU and refreshing PBU messages on behalf of N_m/m MHs. Hence, cost incurred at each MAG for binding updates can be obtained as follows:

$$\Psi_{MAG}^{PBU} = \frac{\eta_t N_m}{m} \big(\beta_{PBU} + \beta_{PBA}\big) \tag{6}$$

3) Data delivery cost: Each MAG receives data packets tunneled from the LMA and decapsulate them and sends them to the corresponding MH. So the data delivery cost at each MAG is given by,

$$\Psi_{MAG}^{DD} = \frac{N_m N_c}{m} \Big\lceil \frac{\alpha}{\kappa} \Big\rceil \lambda_s \big(\beta_{DP} + \beta_{DA} + \beta_{IP}\big) \tag{7}$$

4) Total Cost on MAG: Thus, the total cost on the MAG can be obtained by adding Eqns. (5), (6) and (7):

$$\Psi_{MAG} = \Psi_{MAG}^{AAA} + \Psi_{MAG}^{PBU} + \Psi_{MAG}^{DD} \tag{8}$$

E. Mobile Host

As a network-based mobility solution, Proxy Mobile IPv6 incurs no mobility signaling overhead at the MH. As all the encapsulation and decapsulation are performed by the MAG (for the packets to and from the MH), the wireless access network is not affected by the transmission of extra IP headers. The only cost incurred at the MH is the packet delivery cost which can be expressed as follows:

$$\Psi_{MH} = \sigma N_c \Big\lceil \frac{\alpha}{\kappa} \Big\rceil \lambda_s \big(\beta_{DP} + \beta_{DA}\big) \tag{9}$$

F. Efficiency

We define a new metric called *efficiency* to measure the performance of Proxy Mobile IPv6. It is defined as the ratio of net data delivery cost (excluding all overheads along the optimal route) to the total cost (that includes signaling and data delivery costs) required for the mobility protocol. The net data delivery cost of LMA can be expressed as follows:

$$\Psi_{LMA}^{Net-DD} = \lambda_p \big(\beta_{DP} + \beta_{DA}\big) \tag{10}$$

Hence, the efficiency of LMA can be obtained as follows:

$$\xi_{LMA} = \frac{\Psi_{LMA}^{Net-DD}}{\Psi_{LMA}} \tag{11}$$

The net data delivery cost of MAG can be expressed as follows:

$$\Psi_{MAG}^{Net-DD} = \frac{N_m N_c}{m} \Big\lceil \frac{\alpha}{\kappa} \Big\rceil \lambda_s \big(\beta_{DP} + \beta_{DA}\big) \tag{12}$$

Hence, the efficiency of MAG can be obtained as follows:

$$\xi_{MAG} = \frac{\Psi_{MAG}^{Net-DD}}{\Psi_{MAG}} \tag{13}$$

As the MH has no mobility signaling overhead, according to the above definition, the efficiency of the MH is 100%.

VI. Results

In this section, we present numerical results showing impact of various system parameters on Proxy Mobile IPv6 entities. The parameter values used in numerical analysis are derived using similar approaches used in [8], [9]; each cost metric is a relative quantity and is based on the specific packet size (unit cost for 100 bytes [9]). For example, β_{PBU} = 0.76, since the size of PBU packet is 76. Therefore, we have set the parameters as follows: β_{PBA} = 0.76, β_{IP} = 0.40, β_{DP} = 5.72, β_{DA} = 0.60, $\epsilon = 20\%, \theta_d = 0.10$, σ = 10, η = 0.3, T_r = 70 sec, T_l = 120 sec, η = 0.3, λ_s = 0.01, δ_{LMA} = 0.3, δ_{MAG} = 0.3, κ = 512 bit/sec, α = 10240 bits. The default values of other parameters are m = 10, $N_m = 4000$, and N_c = 1. It can be noted that while computing the total overhead of the LMA and MAG, we have considered all the factors considered including tunneling overhead, except payload delivery cost.

A. LMA

Fig. 3 shows the impact of number of MHs on the total overhead of LMA for different subnet residence times. Total overhead of LMA increases with the increase of number of MHs in the LMA-domain due to increase in number of registration messages, binding updates as well as tunneling of packets. For increase in subnet residence times (that means less mobility), the overhead decreases (slightly) due to the fall in binding updates to the LMA.

Fig. 4 shows the impact of number of CNs (per MH) on the total overhead of the LMA for different session arrival rates. Total overhead on the LMA increases for both increase of number of CNs and higher session arrival rates. Higher session arrival affects data tunneling overhead of the LMA since more data packets are required to be tunneled through the LMA.

Fig. 5 shows the impact of Session to Mobility Ratio (SMR) on the total overhead of LMA for different session lengths. SMR is the product of subnet residence time (T_r) and session arrival rate (λ_s). We have kept session arrival rate (λ_s = 0.01) fixed while varying the value of T_r. Again higher session lengths increases the data delivery overhead on the LMA, resulting in higher total overhead on the LMA. However,

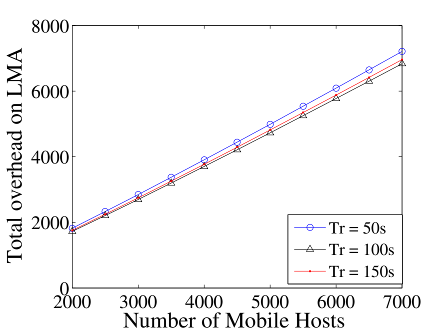

Fig. 3. Impact of number of MHs on total cost of LMA for different subnet arrival rates.

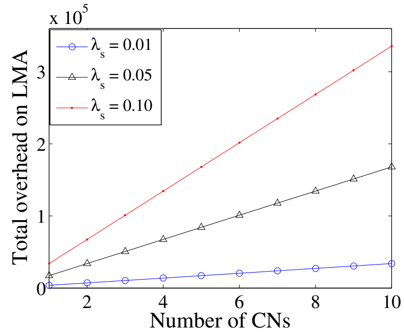

Fig. 4. Impact of number of CNs on total cost of LMA for different session arrival rates.

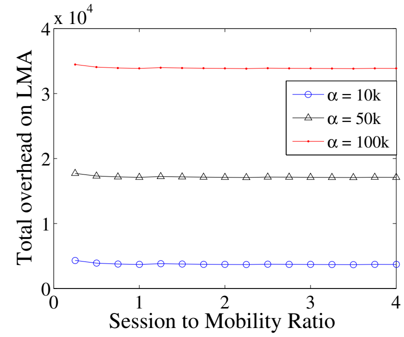

Fig. 5. Impact of SMR on the cost of LMA for different session lengths.

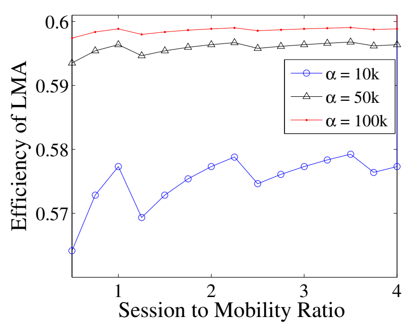

Fig. 6. Impact of SMR on the efficiency of LMA for different session lengths.

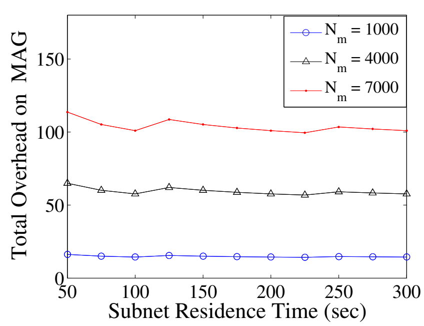

Fig. 7. Impact of subnet residence times on total overhead of each MAG for different number of MHs in the PMIPv6-domain.

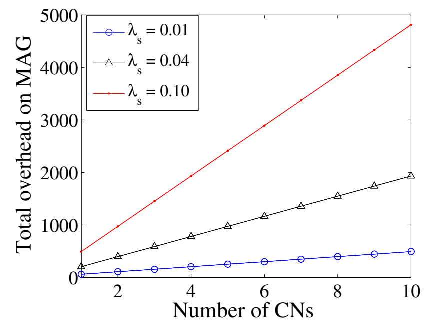

Fig. 8. Impact of number of CNs on the total overhead of each MAG for different session arrival rates.

with respect to SMR, the total overhead on LMA decreases very slowly. This is due to the fact that higher SMR (less mobility rate) causes reduction in PBU cost, which is very small compared to the data tunneling overhead. Hence the graphs are almost flat in nature. This is an interesting finding phenomena obtained from our analysis.

Fig. 6 shows the impact of SMR on the efficiency of LMA. We find that efficiency increases for higher session lengths, having more payload traffic compared to mobility signaling traffic.

B. MAG

Fig. 7 shows the impact of subnet residence times on the total overhead of each MAG, for different number of MHs in the PMIPv6-domain. The total overhead on each MAG decreases for higher values of T_r, producing less PBUs. However, there are some additional refreshing PBU sent to the LMA by the MAG, to keep the binding entry valid and those refreshing PBUs causes the overhead on MAG to rise in 120 sec and then 240 sec, which are multiple of binding entry lifetime (we set T_l = 120 sec).

Fig. 8 shows the impact of number of CNs on the total overhead of each MAG for different session arrival rates. Higher session arrival rates causes more signaling overhead including tunneling between LMA and MAG. Moreover, larger number of CNs per MH causes more traffic towards the LMA-domain, thereby increasing the total overhead on the MAG.

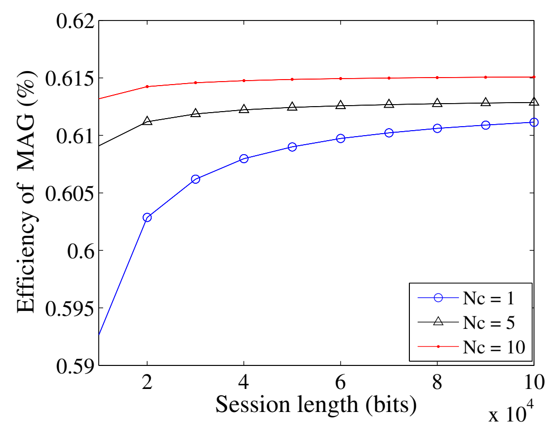

Fig. 9. Impact of session lengths on the efficiency of each MAG for different number of CNs.

Fig. 9 shows the impact of session lengths on the efficiency of each MAG for different number of CNs. Efficiency increases for larger sessions as net data delivery through the MAG increases. In addition, higher number of CNs also results in more data traffic to the CNs, resulting in the increase of the MAG efficiency.

VII. Conclusion

In this paper, we have explained Proxy Mobile IPv6, a network-based mobility solution, along with its detailed signaling diagram. We have identified the major advantages and limitations of this protocol. We have also performed the signaling cost analysis of its key mobility entities to obtain the amount of overhead. Results show interesting relationships among various network parameters, such as, network size, mobility rate, traffic rate. Our critical analysis can help researchers better understand the strengths and weaknesses of Proxy Mobile IPv6 protocol and our signaling analysis can be used by network engineers to estimate the resource requirements of its entities in actual deployment.

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