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Location Update Cost Analysis of Mobile IPv6 Protocols

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***Abstract*—**Mobile IP has been developed to provide the continuous information network access to mobile users. In IP-based mobile networks, location management is an important component of mobility management. This management enables the system to track the location of mobile node between consecutive communications. It includes two important tasks- location update and call delivery. Location update is associated with signaling load. Frequent updates lead to degradation in the overall performance of the network and the underutilization of the resources. It is, therefore, required to devise the mechanism to minimize the update rate. Mobile IPv6 (MIPv6) and Hierarchical MIPv6 (HMIPv6) have been the potential candidates for deployments in mobile IP networks for mobility management. HMIPv6 through studies has been shown with better performance as compared to MIPv6. It reduces the signaling overhead traffic by making registration process local. In this paper, we present performance analysis of MIPv6 and HMIPv6 using an analytical model. Location update cost function is formulated based on fluid flow mobility model. The impact of cell residence time, cell residence probability and user's mobility is investigated. Numerical results are obtained and presented in graphical form. It is shown that HMIPv6 outperforms MIPv6 for high mobility users only and for low mobility users; performance of both the schemes is almost equivalent to each other.

***Keywords*—**Wireless networks, Mobile IP networks, Mobility management, performance analysis, Handover.

I. Introduction

WIRELESS communication technology has become the major tool for accessing Internet. However, in wireless mobile communication, ensuring the continuity of on going session during the movement of a mobile user across the boundaries of different networks and/or sub networks is a challenging task.

To enable the mobile users access the IP based networks, Internet Engineering Task Force (IETF) developed a mobility management protocol namely Mobile IPv4 in 1996.

However, MIPv4 has a number of shortcomings including limited number of IP addresses and exhaustive communication process. To overcome its shortcomings, IETF has designed MIPv6 with advanced capabilities [1-2]. Looking at the fast growth of mobile devices, it is expected that this version of Mobile IP can generate enough addresses to successfully handle large number of mobile devices. MIPv6 maintains the transparent connection while Mobile Node (MN) moves from one subnet to another. Each MN is assigned a home address on its home network. This address remains the same irrespective of the actual location of the MN. When a MN leaves its home network and enters a foreign network, it sends its location information to its home agent, which is a router on the home network. This agent keeps the track of the MN's current location through temporary Care of Address (CoA). This CoA is assigned to the MN by the foreign network.

MIPv6 eliminates the requirement of foreign agents. MN can generate its own IP address by combining the prefix of the network with a device identifier such as MAC address. This protocol keeps the ongoing session between MN and its Corresponding Node (CN) by creating a binding scheme between MN's home address and its CoA during handover process [3-4]. However, MN is required to send binding updates to home agents for each handover when it moves from one Access Router (AR) to another. Under micro-mobility case, when a MN moves from one subnet to another in a small coverage area, it may induce frequent handovers. It yields significant amount of signaling traffic in the core network and, therefore, renders it unsuitable for such scenario. It shows poor performance under the scenario if MN performs frequent handovers in a local domain due to high signaling cost, large handover latency and packet loss. MIPv6 does not differentiate global mobility from local mobility. It updates both the external hosts and nodes irrespective of whether it is global mobility or local mobility. This mechanism leads to unnecessary and inefficient use of resources.

Later on, IETF developed HMIPv6, which separates the global mobility from local mobility. In HMIPv6, global mobility is handled by MIPV6 protocols but a new entity called Mobility Anchor Point (MAP) handles the local movements of the MN [5-7].

It eliminates the need to update external system elements leading to fast updates and reduced handover latency. MAP acts like a local home agent. It receives all packets for MNs in its coverage area, encapsulates and forwards those to the current address of the MN. It minimizes location updates signaling with external networks. MN locally registers itself in a domain without informing MN's home agent. MAP acts a proxy home agent for MNs within local domain and makes local handovers transparent to MIPv6 entities.

In spite of these evolutions in context of mobility management protocols, provisioning of seamless handover of MN across networks' boundaries is still a challenging problem. That is why efficient and seamless transfer of ongoing session across networks, with minimum degradation

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in the quality of service has been the subject of many research activities. The present research work focuses on maintaining the ongoing communication with prompt location updates.

Next-generation mobile wireless networks are expected to support multimedia applications wherein user behavior will be the dominating factor for selecting the network. The mobility management scheme has to deal with various mobility patterns of user and different traffic loads at different points of time. Under such scenario, it is further required to investigate if HMIPv6 performs better consistently for all types of mobility patterns and traffic loads. This is still an open issue in mobile IP networks. In this paper, we conduct analytical performance evaluation of both schemes in different mobility environments. Numerical results are obtained for location update costs. We further show that the relative performance of MIPv6 and HMIPv6 depends on the mobility pattern.

The rest of the paper is organized as follows: Section II describes the analytical modeling of the system for performance evaluation. Results are illustrated and discussed in section III. Finally, conclusions are drawn in section IV.

II. System Modeling

We consider an all-IP architecture based wireless network with hexagonal cell structure in picocellular environment. We further assume that each cell is served by one access router as shown in Fig. 1. The number of rings represents the MAP domain size R. Fig. 1 shows a MAP domain with R=3 as it is having three rings. It is assumed that MAP domain is always an integer number and each MAP domain consists of the same number of rings.

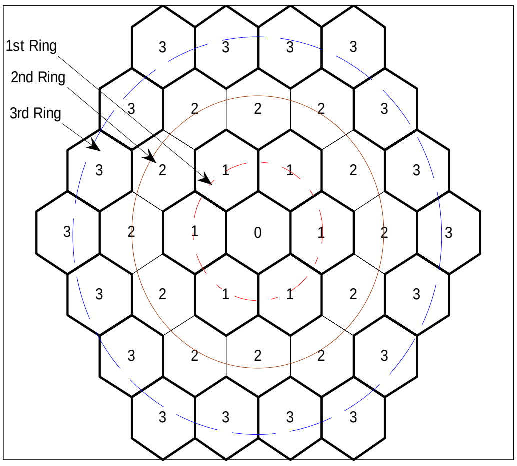

Fig. 1 Network configuration

A. Location Update Cost Function

A MN may exhibit either micro-mobility or macro-mobility in mobile IP networks [9-10]. When MN enters a MAP domain, it will receive router advertisements containing information. The MN can bind its On-Link CoA (LCoA) with an address on the MAP's subnet, which is known as Regional CoA (RCoA). It performs LCoA registration with MAP in micro-mobility scenario and RCoA registration with HA and CN when moves out of the MAP-domain boundary (macro-mobility). RCoA does not change as long as MN moves within the same Map domain. As a result, MN,s mobility becomes transparent to CNs and its HA. The signaling cost in IP networks is proportional to the distance between two network entities and also depends on the processing cost at the nodes. Therefore, the global update cost C_g is given by [5-6]

$$\begin{aligned} C_g &= 2\cdot(\tau_1+\tau_2\cdot(d_{AR-MAP}+d_{MAP-HA})) \\ &\quad +2\cdot N_{CN}\cdot(\tau_1+\tau_2\cdot(d_{AR-MAP}+d_{MAP-CN})) \\ &\quad +P_{HA}+P_{MAP}+N_{CN}\cdot P_{CN} \end{aligned} \tag{1}$$

where,

τ_1 and τ_2 are unit transmission costs in wireless and wired media, respectively,

N_{CN} represents the average number of CNs which are communicating with MN.

d_{AR-MAP}: Average number of hops between AR & MAP

d_{MAP-HA}: Average number of hops between MAP & HA

d_{MAP-CN} : Average number of hops between MAP & CN

d_{HA-CN} : Average number of hops between HA & CN

P_{HA} : Processing cost for binding update at HA

P_{CN} : Processing cost for binding update at CN

P_{MAP} : Processing cost for binding update at MAP

We can formulate the average location update cost for Random-walk and Fluid-flow mobility model. The average location update cost per unit time for Random-walk model is

$$C_{loc}^{RW} = \frac{\Pr\{R\rightarrow R+1\}\cdot C_g + (1-\Pr\{R\rightarrow R+1\})\cdot C_l}{\overline{T}_c} \tag{2}$$

where, $\overline{T}_c$ is average cell residence time of MN.

For Fluid-flow model, with N(R), the number of cells in the network, is given by

$$C_{loc}^{FF} = \frac{X_{domain}\cdot C_g + (N(R)\cdot X_{cell} - X_{domain})\cdot C_l}{\rho\cdot A_{MAP}(R)} \tag{3}$$

In present work, fluid flow mobility model has been considered for location update cost analysis of both MIPv6 and HMIPv6 schemes. The results can be obtained for random walk mobility models also following the same procedure as described here. It is to mention that random walk mobility model is appropriate for pedestrian movement, where mobility is generally confined to a limited geographical area such as residential buildings or business buildings. Fluid flow mobility model on the other hand is more suitable for mobile nodes with high mobility.

III. PERFORMANCE EVALUATION

In this section, we analyze the effect of various system parameters including cell residence time, cell residence probability, and user's mobility. MATLAB® 7.0.4 and MATHEMATICA® 5.1.software packages are used to obtain the numerical results. Cell residence time and session arrival process follow exponential and Poisson distributions respectively. The velocity of the MN is assumed to be uniform across the cell area.

The important system parameters considered for numerical analysis are given below:

Cell residence probability: 0.2-0.9
Session arrival rate: 10 sessions/sec
Number of CNs: 5
Average cell residence time: 0.1-10 sec
Session size: 10 packets
Cell perimeter: 120 m

The following observations are made:

1. Fig. 2 depicts the location update cost as a function of cell residence time for various settings of cell residence probabilities. It is observed that the location update cost decreases with an increase in average cell residence time for both MIPv6 and HMIPv6 schemes. This is due the fact that the more static user demands less location updates with CNs and HA. It is further illustrated that HMIPv6 yields less signaling overhead than MIPv6.It is due to the presence of MAP domain which makes intra-domain registration, local. Further, the reduction rate is more prominent at higher values of cell residence probability. Larger residence time indicates less mobility. At higher setting of residence time, location update cost functions almost overlap for both schemes. This result indicates that for low mobility users, performance of both schemes is almost equivalent.

Moreover, cell residence probability 'q' is defined as the probability of MN to remain in the current cell at the next time unit. Higher setting of 'q' implies that MN will perform fewer movements and therefore will require less number of updates.

2. As MAP domain size is increased from R = 1 to R= 4, HMIPv6 demands lesser global location updates and hence update cost is further decreased as depicted in Fig. 3. Numerical results show that HMIPv6 reduces location update cost up to 60% for static users and up to 30% for dynamic users. Larger size of MAP domain is more effective in reducing the location update cost.

3. The effect of user mobility in terms of velocity on location update cost is illustrated in fig. 4. As the user's velocity increases, location update cost under both schemes increases linearly. Here also, HMIPv6 performs better with less cost value due the presence of MAP. It shows that the provision of MAP significantly improves the performance of the mobility management protocols. The improvement is more prominent at higher velocity of the user. Consequently, location update cost is significantly reduced. This observation indicates that HMIPv6 is more suitable for high mobility environment.

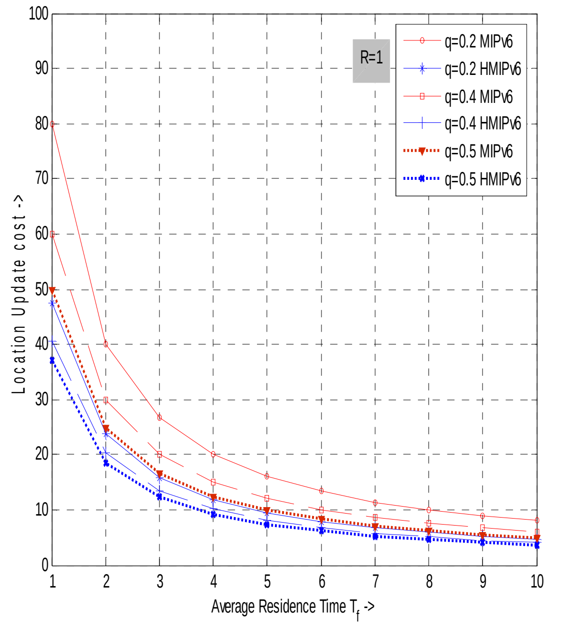

Fig. 2 Location update cost Vs average cell residence time with MAP domain size R=1

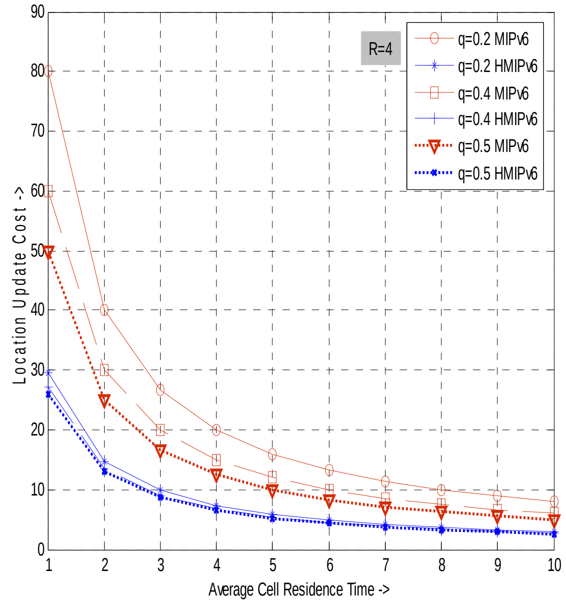

Fig. 3 Location update cost Vs average cell residence time with MAP domain size R= 4

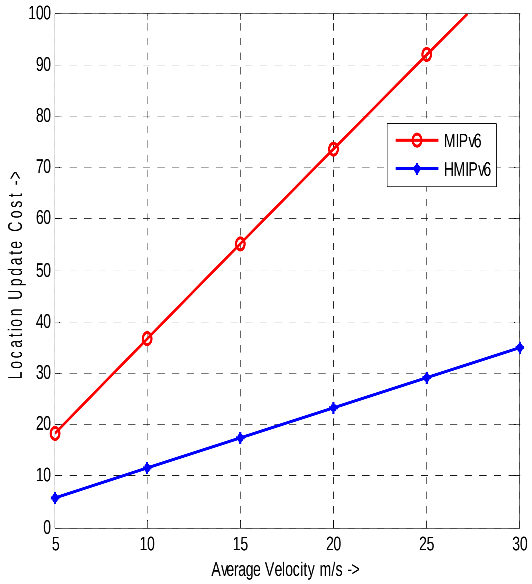

Fig. 4 Location update cost function Vs user's velocity

IV. Conclusion

In this paper, we have conducted the comparative performance analysis of MIPv6 and HMIPv6 in terms of location update cost. Analytical modeling was obtained and through numerical results it was shown that performance of MIPv6 and HMIPv6 is relative to each other and depends on the mobility of the users. For static users, the performance of MIPv6 and HMIPv6 is almost equivalent to each other. However, for high mobility users, HMIPv6 outperforms the MIPv6. It is, therefore, concluded that the mobile network should opt for HMIPv6 scheme in high mobility environment for optimum resource utilization. This option will minimize the overall location management cost. But for static users, one should opt for MIPv6 scheme as its implementation is easier as compared to HMIPv6.

References

[1] Johnson, D. Perkins, C "Mobility Support in IPv6", IETE Draft, draft ietf mobileip-ipv6-15 .txt.

[2] Montavont, N. Noel, T., "Handover Management of Mobile Nodes in IPv6 Networks", IEEE Communication Magazine, Vol. 40. No. 8, 2002,.pp. 38-43.

[3] Choi Y.J., Lee K.B. & Bahk S., "All-IP 4G Network Architecture for Efficient Mobility & Resource Management", IEEE Wireless Communications Magazine, vol.14, no. 2, pp.42-46, April 2007.

[4] Vaughan-Nichols S. J., "Mobile IPv6 and the Future of Wireless Internet Access", IEEE Computer Magazine, vol.36, no.2, pp.18-20, February 2003.

[5] Castellucia C, "HMIPv6: A Hierarchical Mobile IPv6 Proposal", IEEE/ACM SIGMOBILE Mobile Computing and Communications Review (MC2R), vol.4, no.1, pp.48-59, January 2000.

[6] Kong K-S., Roh S-J., & Hwang C-S., "Signaling Load of Hierarchical Mobile IPv6 Protocol in IPv6 Networks", Proc. of PWC 2004, LNCS, vol.3260, pp.440–450, September 2004.

[7] Pack S., Nam M., Kwon T., & Choi Y., "A Performance comparison of mobility anchor point selection schemes in Hierarchical Mobile IPv6 networks", Science Direct, Computer Networks, vol.51, no.6, pp.1630-1642, April 2007.

[8] Jiang Xie, Ian F. Akyildiz, "A Distributed Dynamic Regional Location Management Scheme for Mobile IP", IEEE INFOCOM 2002,pp. 1069-1078.

[9] Pack S. & Choi Y., "A Study on Performance of Hierarchical Mobile IPv6 in IP-Based Cellular Networks", IEICE Transactions on Communications, vol.E87-B, no.3, pp.462-469, March 2004.

[10] Johnson D., Perkins C., & Arkko J., "Mobility Support in IPv6", RFC 3775. June 2004.

[11] Han Y.H. & Jeong D., "A Comprehensive Study on Handover Performance of Hierarchical Mobile IPv6", Proc. of EUC 2006, LNCS, pp.1108-1118, October 2006.

[12] Campbell A.T., Gomez J., Kim S., Wan C-Y., Turanyi Z.R., & Valko A.G., "Comparison of IP Micromobility Protocols" IEEE Wireless Communications Magazines, vol.19, no.1, pp.71-82, February 2002.