Signaling Cost Evaluation of SIGMA

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I. INTRODUCTION

Mobile IP (MIP) [1] is the standard proposed by IETF to handle mobility of Internet hosts for mobile data communication. Several drawbacks exist when using MIP in a mobile computing environment, the most important issues of MIP identified to date are high handover latency, and high packet loss rate. Even with various recent proposed enhancements such as HMIPv6, FMIPv6, Mobile IP still can not completely remove the latency associated handover, and the resulting packet loss rate is still high [2].

A number of transport layer mobility protocols have been proposed in the context of TCP, for example, MSOCKS and connection migration solution. These protocols tried to implement mobility as an end-to-end service without the requirement on the network layer infrastructures; they are not aimed at reducing the high latency and packet loss resulted from handovers. The handover latency for these schemes is in the scale of seconds.

We designed a new scheme for supporting low latency, low packet loss mobility called Seamless IP diversity based Generalized Mobility Architecture (SIGMA) [3]. SIGMA relies on the signaling message exchange between the MH, correspondent node (CN), and location manager (LM). For every handover, MH need to send binding update and location update to CN and LM, respectively. For SIGMA to be useful in real world wireless system, all these signaling messages should not cost too much network bandwidth to leave no space for payload data transmission.

The signaling cost analysis for MIP protocols are presented earlier in [4], [5], but there is no work done in extensively analyzing the signaling cost of transport layer mobility solutions. The objective of this paper is to look into the signaling cost required by SIGMA.

The contributions of our paper can be outlined as follows:

- Developed an analytical model for SIGMA signaling cost using detailed mobility model and arrival traffic model.
- Evaluated the signaling cost of SIGMA under various input parameters such as mobile host moving speed, number of mobile host, number of correspondent node, and per-hop transmission cost.
- Compared the signaling cost of SIGMA and HMIPv6. We choose HMIPv6 as the benchmark protocol for signaling cost comparison because it has the lowest signaling cost in all versions of MIP6 enhancements.

The rest of this abstract is structured as follows: The network structure, mobility model, and arrival traffic model for SIGMA signaling cost evaluation is presented in Sec. II. The full analytical model is not presented in this abstract due to space limitations. We evaluate and compare the signaling cost of SIGMA and HMIPv6 by the proposed model in Sec. III. Finally, concluding remarks are presented in Sec. IV.

II. MODELLING ASSUMPTIONS

Network structure: The network structure that is used in our analytical model is shown in Fig. 1(a). In the figure, a two dimensional subnet arrangement is assumed for modeling MH movement. AR1,1, · · · ARm,n stand for the access routers. There are one location manager and a number of CNs connected into the topology by Internet. The MHs are roaming around in the subnets covered by AR1,1, · · · ARm,n, and each of them are communicating with one or more of the CNs. Between each pair of MH and CN, intermittent file transfers occur caused by mobile user request information from CNs using protocols like HTTP. We call each active transferring period during the whole MH-CN interactivity as one session.

Mobility model and Arrival traffic model: Mobile hosts movement is assumed to be captured by Random Waypoint model [6], which is the most frequently used model in recent mobile networking research. We also assume both session time and session interval time are of Pareto distribution to better model HTTP traffic [7].
III. NUMERICAL RESULTS FOR SIGNALLING COST COMPARISON OF SIGMA AND HMIPv6

In this section, we present results showing the signaling cost comparison of SIGMA and HMIPv6 using our proposed analytical model.

A. Impact of number of MHs under different maximum MH moving speeds

The impact of number of MHs on total signaling cost of SIGMA and HMIPv6 for different MH moving speed is shown in Fig. 2(a). When the moving speed is higher, the subnet residence time $T_r$ decreases, resulting in an increase of the location update and binding update costs per second. We can also observe that the total signaling cost of SIGMA is less than that of HMIPv6 in this scenario; this is because when per-hop location update and binding update cost are small, the overall location update and binding update costs are not high, and the high packet tunneling cost will make the signaling cost of HMIPv6 much higher than that of SIGMA.

B. Impact of average number of communicating CN and location update transmission cost

The impact of the number of average CNs with which an MH communicates with for different per-hop transmission cost for location update cost ($\delta_U$) is shown in Fig. 2(b). It can be observed from this figure that when the average number of communicating CNs increases, the total signaling cost increases. We can also see that the impact of $\delta_U$ is much smaller in HMIPv6; this is because HMIPv6’s signaling cost is less sensitive to location update cost due to its hierarchical structure. In this scenario, signaling cost of HMIPv6 is higher than that of SIGMA when $\delta_U = 0.4$ or 1.0. However, when $\delta_U = 6.4$, SIGMA requires a higher signaling cost due to frequent location update for each subnet crossing (compared to HMIPv6’s hierarchical mobility management policy).

C. Session to Mobility Ratio

Session to Mobility Ratio (SMR) is a mobile packet network’s counterpart of Call to Mobility Ratio (CMR) in PCS networks. The impact of SMR on total signaling cost for different $N_{mh}$ is shown in Fig. 2(c). We can observe that a higher SMR results in lower signaling cost in both SIGMA and HMIPv6. This is mainly because high SMR means lower mobility, and thus lower signaling cost due to less location update and binding update. Also, we can see that the decrease of HMIPv6’s signaling cost as a function of SMR is not as fast as that of SIGMA. This again is because HMIPv6’s hierarchical structure already reduces the impact of mobility on the signaling cost. The signaling cost, therefore, decreases slower than that of SIGMA when MH’s mobility decreases.

D. Relative signaling cost of SIGMA to HMIPv6

Fig. 2(d) shows the impact of (location update transmission cost) / (packet tunnelling cost) ratio ($\delta_U/\tau$) on the relative signaling cost between SIGMA and HMIPv6. A higher $\delta_U/\tau$ ratio means that the location update requires more cost while packet encapsulation/decapsulation costs less. This ratio depends on the implementation of the intermediate routers. We can see that as long as $\delta_U/\tau < 12$, the signaling cost of SIGMA is less than that of HMIPv6 due to the advantage of no tunnelling required. After that equilibrium point, the cost of location update will take dominance, and the signaling cost of SIGMA will become higher than that of HMIPv6.

IV. CONCLUSIONS

This paper evaluates the signaling cost of SIGMA by using an analytical model. We also compared the signaling cost of SIGMA with that of HMIPv6. Numerical results show that, in most scenarios, the signaling cost of SIGMA is lower than HMIPv6. However, there is a tradeoff between location update transmission cost ($\delta_U$) and packet tunnelling cost ($\tau$); very high $\delta_U/\tau$ ratio results in the signaling cost of SIGMA being higher than that of HMIPv6.

REFERENCES