Dynamic Hierarchical Mobility Management Approach for IP-Based Mobile Networks

[1]A. Lakshman Rao, [2]P. Jagadeesh Kumar
[1]Dept. of CSE, PRAGATI Engineering College, Surampalem, AP, India
[2]Dept. of Computer Science, PRAGATI Engineering College, Surampalem, AP, India

Abstract
One of the major challenges for the wireless network design is the efficient mobility management, which can be addressed globally (macromobility) and locally (micromobility). Mobile Internet Protocol (IP) is a commonly accepted standard to address global mobility of Mobile Hosts (MHs). It requires the MHs to register with the Home Agents (HAs) whenever their care-of addresses change. Several mobility management strategies have been proposed which aim reducing the signaling traffic related to the Mobile Terminals (MTs) registration with the Home Agents (HAs) whenever their Care-of-Addresses (CoAs) change. They use different Foreign Agents (FAs) and Gateway FAs (GFAs) hierarchies to concentrate the registration processes. However, such registrations may cause excessive signaling traffic and long service delay. To solve this problem, the Hierarchical Mobile IP (HMIP) Protocol was proposed to employ the hierarchy of Foreign Agents (FAs) and the Gateway FAs (GFAs) to localize registration operations. However, the system performance is critically affected by the selection of GFAs and their reliability. In this paper, we introduce a novel dynamic hierarchical mobility management strategy for mobile IP networks, in which different hierarchies are dynamically set up for different users and the signaling burden is evenly distributed among the network. To justify the effectiveness of our proposed scheme, we develop an analytical model to evaluate the signaling cost. The proposed dynamic hierarchical mobility management strategy can significantly reduce the system signaling cost under various scenarios and the system robustness is greatly enhanced.

Keywords
Mobile Networks, IP, Mobility, MT, HA, MIP

I. Introduction
Recently, an efficient and robust mobility management is needed for internet access as wireless mobile communications grow and the use of laptops and handheld devices is widespread. The Current fast increasing demand for wireless access to Internet applications is fueled by the remarkable success of wireless communication networks and the explosive growth of the Internet. However, many telecommunication systems such as first and second generation wireless cellular systems were designed mainly for voice services, and the integration with data networks becomes the major push for third and future generation wireless systems. Mobile IP (MIP) is the mobility-enabling protocol developed by the Internet Engineering Task Force (IETF) to support global mobility in IP networks. This standard has become the solution to solve the user mobility in almost all packet-based wireless mobile systems.
The IP protocol has been designed for wired networks. There are two major functions for the terminal IP addresses in the Internet. An IP address is used to identify a particular end system in the whole network and is also used to find a route between the endpoints. The MIP protocol extends IP by allowing a mobile node to effectively utilize two IP addresses, one for identification and the other for routing. MIP enables mobile terminals to maintain ongoing communications with the Internet while moving from one subnet to another. In the MIP protocol, mobile terminals that can change their points of attachment in different subnets are called Mobile Hosts (MHs). An MH has a permanent address (home address) registered in its home network and this IP address remains unchanged when the user moves from subnet to subnet. This address is used for identification and routing purpose, which is stored in a Home Agent (HA).
An HA is a router in a mobile node's home network, which can intercept and tunnel the packets for the mobile node and also maintains the current location information for the mobile node. In the current MIP protocol, the MH can obtain a new IP address from a router [foreign agent(FA)] in the visited network or through some external means. An MH needs to register with the FA or some one-hop router for the routing purpose. The care-of-address (CoA) for the MH will change from subnet to subnet. In order to maintain continuous services while the user is on the move, MIP requires the MH to update its location to its HA whenever it moves to a new subnet so that the HA can intercept the packets delivered to it and tunnel the packets to the user's current point of attachment.
In this paper, we propose a dynamic hierarchical mobility management scheme for MIP networks (DHMIP). In our scheme, the location update messages to the HAs can be reduced by setting up a hierarchy of FAs, where the level number of the hierarchy is dynamically adjusted based on each mobile user's up-to-date mobility and traffic load information. Analytical model is developed for the performance evaluation. The results show that our new scheme outperforms the MIP and IETF Hierarchical Mobile IP (HMIP) schemes under various conditions. The more important contribution is the new analytical approach we develop in this paper.

II. Related Work
User mobility in wireless networks that support IP mobility can be broadly classified into macromobility and micromobility. The macromobility is for the case when an MH roams across different administrative domains of geographical regions. The macromobility occurs less frequent and usually involves longer timescales. The MIP can ensure the mobile users reestablish communication connections after a movement. The micromobility means the MH movement across multiple subnets within a single network of domain. For micromobility, which occurs quite often, the MIP paradigm needs to be enhanced. Most of the related works attempt to improve the MIP micromobility handling capability.
A scalable mobility management scheme which uses hierarchical FAs to handle the user mobility within one subnetwork for wireless Internet, and FA hierarchy in this scheme is preconfigured. In this architecture, the base stations are assumed to be network routers. The higher levels of the hierarchy rely on MIP to handle the macromobility. The Handoff-Aware Wireless Access Internet Infrastructure (HAWAII) is a separate routing protocol to handle micromobility. The scheme hinges on the assumption that most user mobility is local to an administrative domain of the networks.

ISSN : 0976-8491 (Online) | ISSN : 2229-4333 (Print)

An MH entering a new foreign network is assigned a new CoA and retains its CoA unchanged while moving within the foreign domain. In this scheme, the HA and any corresponding host are unaware of the host's mobility within that domain. The route to the MH is established by specialized path setup scheme that updates the forwarding tables with host-based entries in selected routes in that domain. For macromobility, the HAWAII uses the traditional MIP. By this means, the scheme can be considered as an enhanced MIP.

In this paper, we propose another dynamic hierarchical mobility management scheme for the MIP networks. In our scheme, when an MH changes its subnet and obtains a new CoA from the new FA (one-hop router), the new FA (one-hop router) updates the new address to the MHs previous FA (one-hop router) so that the new FA (one-hop router) forms a new location management hierarchical level for that user. The FA hierarchical architecture is specific for every user, which makes the user avoid frequently updating his/her home network. The packets delivered to the MH can be tunneled via the multiple levels of FAs to the user. In order to avoid long packet delivery delay, there is an optimal level number (or threshold) for the hierarchy for each user according to his/her Call-to-Mobility Ratio (CMR). The threshold can be dynamically adjusted based on the up-to-date mobility and traffic load for each terminal. When the threshold is reached, the MH performs home registration and sets up a new hierarchy for its further movements. The optimal threshold for each user can be derived by an iterative algorithm. Since our scheme significantly reduces the registration traffic to the HAs, it can also greatly reduce the in-flight packet loss.

III. Dynamic Hierarchical Location Management Scheme

In our new dynamic hierarchical system architecture, there is no fixed hierarchical architecture for users or any restriction on the shape and the geographic location for subnets. In the MIP protocol, an MH can determine if it enters a new subnet by detecting the agent advertisement messages sent by the mobility agents (HAs or FAs). The MH then obtains a new CoA and sends a location update message to its HA. Upon receiving the message, the HA sets up a binding between the MH permanent address and current CoA so that the HA can intercept the packets to this MH and tunnel them to the user's current access point. The MHs in the MIP networks are required to update their new CoA whenever they are changing their locations (subnets) even though the MHs do not communicate with others. As shown in fig. 1, this could result in significant signaling traffic to the networks.

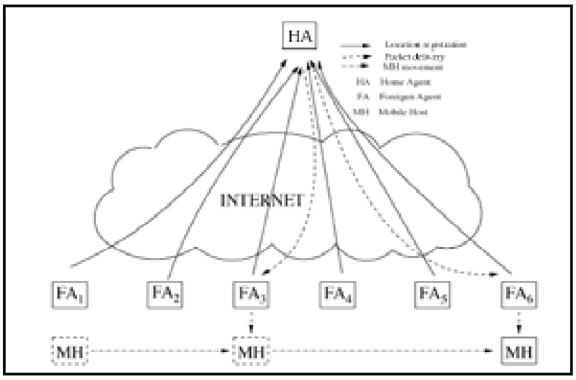


Fig. 1: MIP Location Registration and Packet Routing

In our DHMIP, the location update signaling traffic can be reduced by registering the new CoA to the previous FA, as shown in fig. 2. By this procedure, a dynamic location hierarchy is constructed for a specific mobile user. The packets for this user can be intercepted and retunneled along the FA hierarchy to the mobile terminal. Thus, the location update traffic can be localized. In this scheme, we can use the similar procedures to notify the previous FA the user's new CoA. However, the forwarding through multiple FAs will cause some service delivery delay, which may not be appropriate when there is delay restraint for some Internet applications such as video or voice services. In order to avoid excessive packet transmission delay, we set a threshold on the level number of the hierarchy in the DHMIP scheme. When the threshold is reached, the MH will register to its HA.

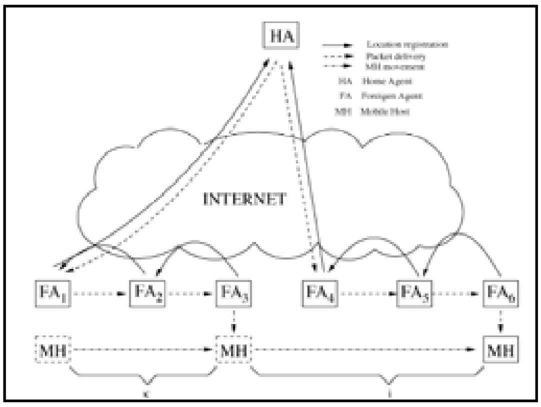


fig. 2: DHMIP Location Registration and Call Delivery

In the DHMIP scheme, the threshold is dynamically adjusted based on every user's traffic load and mobility. The operation of the DHMIP scheme can be seen in fig. 2. In fig. 2, an MHmoves from subnet1 to subnet 6. In the figure, we assume the threshold level of the hierarchy is three. When the user is in subnet 2, subnet 3, subnet 5, or subnet 6, theMH updates the new CoAs to the previous FAs.

Since the previous FAs are usually close to the new ones, the location update cost is usually less than that to the HA. After the user enters subnet 4, the hierarchy level threshold is reached and the MH will set up a new hierarchy. In this case, the MH updates its new CoA to the HA directly. When the user is in subnet 3 and subnet 6, there are packet arrivals for the user. The packets are then intercepted by the HA and tunneled to the user. Since the HA does not have the user's up-to-date location information, the packets are sent to the FA that the user updated last time. In our example, they are and in fig. 2. Then, the packets are retunneled along the hierarchy to the user. The optimal hierarchy level threshold can be computed based on the user's current traffic load and mobility pattern. The can be adjusted in different epochs in the DHMIP scheme. For example, the optimal value can be updated every time the MH enters a new subnet or when the previously calculated threshold is reached or the MH calculates it periodically. There is a tradeoff between the accuracy of and the MHs computational power consumption. The more often the update of , the more accurate the value and the more the signaling traffic saving; however, the more the power consumption. The DHMIP scheme can be described by the pseudocode in fig. 3. In this paper, we assume the optimal value is updated every time the last optimal threshold is reached.

```
% Location registration procedures
K_opt: the optimal hierarchy level threshold;
Initialize i = 0;
IF (MH enters a new subnet)
  i = i + 1;
  IF (i ≤ K_opt)
    New FA registers to the previous FA;
  ELSE
    New FA registers to the HA;
    i = 0;
    Compute the new K_opt;
  ENDIF
ENDIF
% Packet delivery procedures
IF (packets for the MH are intercepted by the HA)
  Tunnel the packets to the first FA;
  IF (The first FA is not the MH current serving FA)
     Retunnel the packets to the current FA;
  ENDIF
  The current FA decapsulates the packets and sends them to the MH;
ENDIF
```

Fig. 3: Dynamic Hierarchical Mip Protocol

IV. Perfromance

The performance of the DHMIP scheme can be improved further by the IP paging and loop removal.

A. State Activation

Cellular IP supports IP paging. In the IP paging protocol, the HA only keeps approximate location information of MH which is in idle state. The MH will turn to active state when packets are received and update its current location to the HA. We can enhance the performance of the DHMIP scheme by setting up a long threshold for MH in idle state in a similar way.

In this paper, we name the improved DHMIP scheme enhanced DHMIP scheme. We define the idle MH as one that has not received data packet for a system predefined period. In the enhanced DHMIP scheme, the MH can keep a fixed relatively large threshold so that the MH can avoid updating the home network often. An idle MH that receives the first packet turns from idle to active state and updates its current location to the HA immediately and keeps doing it when it enters new subnets if it keeps in active state. In the enhanced DHMIP scheme, the data packets can avoid the extra transmission delay in the DHMIP scheme and the total signaling traffic is reduced at the same time. If the mobile user has not received packet for some predefined period, the MH returns to the idle state again. In this enhanced version, an MH can maintain a fixed threshold without computing and changing it from time to time. This can also reduce the mobile terminal energy consumption. For different mobile users with different call to mobility pattern, they can adopt different predefined thresholds.

Fig. 4, shows the performance of the enhanced DHMIP scheme. We can observe from the figure that there is no optimal threshold for an MH. The larger the threshold, the better the performance. However, a large threshold may generate long packet delivery delay for the first data packet so that the network operator should choose the value by considering the signaling saving and the QoS comprehensively. In fig. 4, we also see that the has little effect on the performance when the CMR is large. The reason is that the MH is always in active state and keeps updating its newly obtained CoA to the HA in this situation and the effective threshold reduces to one no matter what the predefined value is. In the enhanced DHMIP scheme, the total system signaling cost will never exceed that of the MIP scheme under all the conditions.

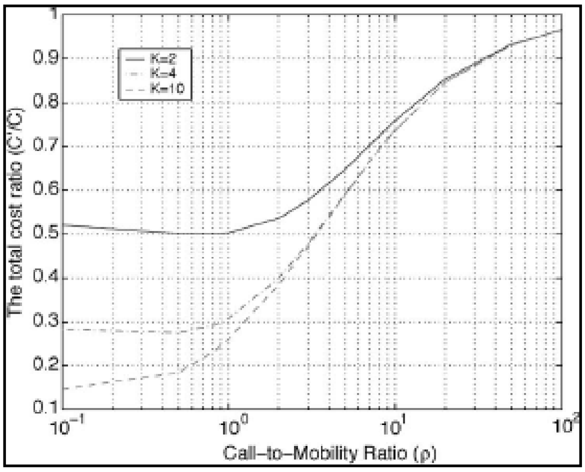


Fig. 4: Total Cost for the Enhanced DHMIP Scheme

B. Loop Removal

The performance of the DHMIP scheme can also be improved by removing the loop formed during the mobile user's movement. In reality, many mobile users roam in a limited region, for example, in an office building. If the mobile users revisit some subnets they have visited before, loop may form in the hierarchical architecture in the DHMIP scheme according to the protocol described before. With the loop removal, the MHs can update their new CoAs less often and the total signaling cost can be mitigated further. When an MH enters a new subnet and tries to set up a new level of hierarchy, the new FA checks its hierarchy list first. If the FA is already in the MH hierarchy, the FA can delete the subsequent FA addresses for that user without updating the old FA so that the loop is removed. In this section, we analyze the loop removal effect on the DHMIP performance.

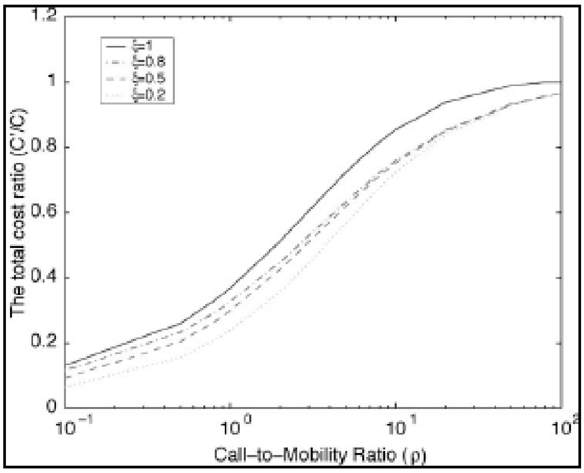


Fig. 5: Total Cost with Loop Removal

For fig. 5, shows the loop removal effect when is 1, 0.8, 0.5, and 0.2, respectively. When , it is the worst case that the mobile user never revisits any subnet he/her visited before. From fig. 5, we can see that the total signaling cost for the DHMIP scheme can be reduced by the loop removal mechanism.

ISSN : 0976-8491 (Online) | ISSN : 2229-4333 (Print)

V. Conclusion

This paper has provided a new location management scheme for MIP network—the DHMIP strategy. Instead of updating the home networks far away, in the DHMIP scheme, the MHs inform their new CoAs to the previous FAs (or one-hop router). When data packets arrive at the MHs, the packets can be delivered through the FA hierarchy. The transmission distance between the FAs is usually shorter than that between an MH and the HA, so that total signaling cost can be reduced. In this paper, we also proposed an iterative algorithm to compute the optimal threshold values for specific users with different call-to-mobility patterns. The DHMIP can further be improved by considering state activation and loopremoval.

References

[1] I. F. Akyildiz, J. McNair, J. S. M. Ho, H. Uzunalioglu, W. Wang,"Mobility management in next-generation wireless systems", Proc. IEEE, Vol. 87, pp. 1347–1384, Aug. 1999.

[2] F. M. Chiussi, D. A. Khotimsky, S. Krishnan,"Mobility management in third-generation all-IP networks", IEEE Commun. Mag., pp. 124–135, Sept. 2002.

[3] C. E. Perkins,"Mobile IP", IEEE Commun. Mag., Vol. 35, pp. 84–99, May 1997.

[4] C. Perkins,"IIP mobility support for IPv4", in Internet RFC 3344, work in progress, Aug. 2002.

[5] R. Caceres, V. N. Padmanabhan,"Fast and scalable handoffs for wireless internetworks", in Proc. ACMMOBICOM'96, 1996, pp. 56–66.

[6] S. Das, A. Misra, P. Agrawal, S. K. Das,"TeleMIP: telecommunications-enhanced mobile IP architecture for fast intradomain mobility", IEEE Pers. Commun., Vol. 7, pp. 50–58, Aug. 2000.

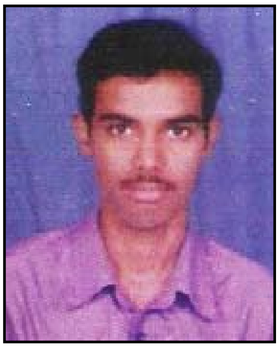
[7] A. T. Campbell, J. Gomez, S. Kim, C.-Y. Wan, Z. R. Turanyi, A. G. Valko,"Comparison of IP micromobility protocols," IEEE Wireless Commun., Vol. 9, pp. 72–82, Feb. 2002.

[8] R. Ramjee, K. Varadhan, L. Salgarelli, S. R. Thuel, S.-Y. Wang, T. La Porta,"HAWAII: a domain-based approach for supporting mobility in wide-area wireless networks", IEEE/ACMTrans. Networking, Vol. 10, pp. 396–410, June 2002.

[9] A. T. Campbell, J. Gomez, A. G. Valko,"An overview of cellular IP", in Proc. IEEE Wireless Communications and Networking Conf. (WCNC'99), New Orleans, LA, Sept. 1999, pp. 606–610.

[10] E. Gustafsson, A. Jonsson, C. Perkins,"Mobile IPv4 Regional Registration", work in progress, Mar. 2002.

A.Laxman Rao received his M.Tech degree in ComputerScience and Engineering from Godavari Institute Of technologies and Engineering From JNTU(Hyderabad) in 2007. He joined the Department of Computer Science and Engineering, Pragati Engineering College as an Associate Professor in 2008.His Research interests include machine learning, Data mining, pattern recognition, Software Engineering. He has published 6 papers in leading international journals or Conference proceedings.



P. Jagadeesh Kumar is a student of PRAGATI college of engineering & Technology, surampalem. Presently he is pursuing his M.TECH from this college.