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# Enhancements in Mobility Management for Future Wireless Networks

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ABSTRACT: **The tremendous demands from social market are pushing the booming development of mobile communications faster than ever before, leading to emergence of new advanced techniques. The paper describes about the need for enhancements in mobility management for current and future communication networks and the integration of these heterogeneous networks for a smooth handoff and better Quality of Service (QoS) in the context of next evolutionary step for wireless communication networks. The macro and micro mobility solutions for Mobile IP are analysed and a comparative study is done among HMIP, Cellular IP and HAWAII protocols. The latest changes for Handoff management and location registration are investigated and an outline of the problems regarding the handoffs and QoS to be addressed by the next generation of wireless networks is discussed.**

**Keywords: Mobility management, Handoff management, Quality of Service, Macro mobility, Micro mobility, HMIP, HAWAII, Cellular IP.**

## I. INTRODUCTION

Over the past few years, the sophistication of the access technologies as well as the number of mobile devices increased exponentially. Compared to the traditional cellular interfaces, nowadays the mobile devices are equipped with additional features such as Bluetooth, GPRS, etc. With the increasing demands for new data and real-time services, wireless networks should support calls with different traffic characteristics and guaranteed Quality of Service (QoS). With the converging of mobile and wireless communications with Internet services, the boundary between mobile personal telecommunications and wireless computer networks is disappearing. Wireless networks of the next generation need the support of all the advances on new architectures, standards, and protocols.

Although different networks exist currently to satisfy the needs of their users, they act as complementary to each other in terms of their capabilities and suitability for different applications. Thus, integration of these networks will enable the mobile users to be always connected to the best available access network depending on their requirements. This integration of heterogeneous networks will, however, lead to heterogeneities in access technologies and network protocols. To meet the requirements of mobile users under this heterogeneous environment, a common infrastructure to inter connect multiple access networks will be needed so that the data can be accessed from anywhere at any time. For efficient delivery of services to the mobile users, the next-generation wireless networks require new mechanisms of *mobility management* where the location of every user is proactively determined before the service is delivered. Moreover, for designing an adaptive communication protocol, various existing mobility management schemes are to be seamlessly integrated. Efficient handoff mechanisms are necessary for ensuring seamless connectivity and uninterrupted service delivery [1].Various handover management schemes in heterogeneous networking environment are presented in this paper. Each of these schemes utilizes IP-based technologies to enable efficient roaming in heterogeneous network (Chiussi et al., 2002).

Several vendors and researchers are expressing a growing interest in wireless networks that support universal roaming across multiple wireless and mobile networks—for example, from a cellular network to a satellite-based network to a high-bandwidth wireless LAN. We need a system where roaming is seamless and users are always connected to the best network.

The paper is organized as follows. Section 2 introduces the concepts of mobility management. Section 3presents the Macro mobility solution for Mobile IP. Section 4 discusses the Micro mobility and the three proposed protocols. Section 5 presents the Handover issues. Section 6 discusses the QoS issues and Section 7 concludes the paper.

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## II. CONCEPTS OF MOBILITY MANAGEMENT

Mobility management deals with location of the subscriber for data delivery, maintenance of the subscriber's connection during change of location from one base station to another [1].The main functionalities of mobility management include: Location management and handoff management. Mobility management enables communication network to locate roaming terminals in order to deliver data packets, i.e. function for static scenario and maintain connections with terminals moving into new areas, i.e. function for dynamic scenario.

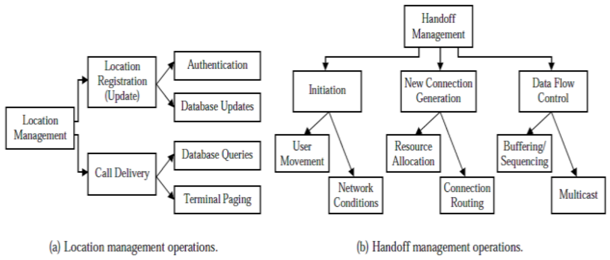


Figure 1: Mobility management operations.

### A. Location Management

Location management tracks the mobile node during the communication between two devices. It includes two important tasks, namely, (i) Location update, and (ii) Call delivery. In location update (also called as location registration), the mobile device periodically informs the system to update relevant location databases with its upto date location information. In call delivery, the system determines the current location of the mobile terminal based on the information available at the system databases when a communication for the mobile terminal is initiated. Two major steps are involved in call delivery: determining the serving database of the called mobile terminal and locating the visiting cell/subnet of the called mobile terminal [2].The latter, also called paging, where polling messages are sent to all the cells/subnets within the residing registration area of the called mobile terminal. For intersystem roaming, the design of location management techniques has the following challenges:

- Reduction of signalling overheads and latency of service delivery
- Quality of service (QoS) guarantees in different systems
- When the service areas of heterogeneous wireless networks are fully overlapped:
- Through which networks an mobile node should perform location registrations
- In which networks and how the up-to-date user location information should be stored
- How the exact location of an mobile node would be determined within a specific time constraint

### B. Handoff Management

The handoff management is the process in which the mobile device keeps its connection active when it moves from one access point to another. There are three stages in a handoff process. First, the initiation of handoff is triggered by either the mobile device, or a network agent, or the changing network conditions. The second stage is for a new connection generation, where the network must find new resources for the handoff connection and perform any additional routing operations [2]. Finally, data-flow control needs to maintain the delivery of the data from the old connection path to the new connection path according to the agreed upon QoS guarantees. Depending on the movement of the mobile device, it may undergo various types of handoff. In a broad sense, handoffs may be of two types: (i) intra-system handoff (horizontal handoff) and (ii) inter-system handoff (vertical handoff) [1]. Unreliable and inefficient handoff procedures will reduce the quality and reliability of the system. Handoffs inhomogeneous networks are referred to as intra-system handoffs. This type of handoff occurs when the signal strength of the serving BS goes below a certain threshold value. An inter-system handoff between heterogeneous networks may arise in the following scenarios (Mohanty, 2006) - (i) when a user moves out of the serving network and enters an overlying network, (ii) when a user connected to a network chooses to handoff to an underlying or over laid network for his/her service requirements, (iii) when the overall load on the network is required to be distributed among different systems.

## III. MACRO MOBILITY SOLUTION: MOBILE IP

As the macro mobility solution, we introduce Mobile IP proposal in this section, together with some optimisations on it. An emphasis is also given to Mobile IPv6 that presents new advanced features and represents the future trend.

### A. Basic Principles Of Mobile IP

The basic Mobile IP components include, aside from the Mobile Node (MN), the Home Agent (HA) in the home network, the Foreign Agent (FA) in the foreign

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network, the Correspondent Node (CN) and the Access Router (AR). The MN has a Home Address (H@), typically registered in a Domain Name Server (DNS). The upper 8 bytes of the H@ match the home subnet prefix of the MN's home link [3]. The home link has at least one AR that can offer HA services to the MN. When the MN moves out of the home network into any other foreign network, it can be reached through obtaining a Care-of Address (CoA).

### B. Mobile IP Optimizations

There are some problems in the basic Mobile IP specification that are to be improved by optimal schemes. Two main problems and corresponding optimal protocols are discussed below.

1. Triangle Routing problem. According to the basic Mobile IP protocol, while the MN can send out packets (may be through the FA) along an optimal path that directly route to the CN, the incoming packets from the CN to the MN have to firstly arrive at the HA in order to use IP tunnelling. This is called the Triangle Routing problem. When the current location of the MN is quite close to the CN but the HA is very far away, datagrams need to take a long way.

2. Smooth Handoff. During the MN's handoff, many operations should be implemented together with messages to be sent, e.g. movement detection and FA discovery, registration and BUs. Before the HA (and the CNs) is informed of the MN's new CoA by BU, the packets within the handoff interval will be lost. The process of smooth handoff tries to overcome this disadvantage by optimising the basic Mobile IP standard.

### C. Advances in Mobile IPV6

IPv6 is defined in the IETF working group of IP Next Generation (ipngwg), by providing enhancements over the capabilities of existing IPv4 service [6]. Basic improvements to IPv4 include optimal header format, reasonable addressing architecture, neighbour discovery mechanism, stateless auto-configuration, and security and QoS support. Mobile IPv6 protocol is the same as in IPv4 [7]. Besides, there are some main changes in Mobile IPv6 standard.

## IV. MICRO MOBILITY SOLUTIONS: THREE PROPOSED PROTOCOLS

Micro mobility solutions are presented for the intra-domain mobility management to implement a fast and seamless handoff and minimized control traffic overhead. The movement within a foreign network domain need not inform the MN's HA of the new attachment. The micro mobility protocols ensure that the packets arriving at the mobility server (gateway) can be correctly forwarded to the appropriate access point that the MN currently attaches.

Three main proposals are discussed in this section, i.e. HMIP, Cellular IP, and HAWAII. Table 1 shows a simple comparison of the three proposals. Note that none of these suggestions are trying to replace the Mobile IP [4]. Instead they are enhancements to the basic Mobile IP with the micro mobility management capability.

Table 1: Simple Comparison of Cellular IP, Hawaii and Hierarchical Mobile IP

| | Hierarchical MIP | Cellular IP | HAWAII |
|---|---|---|---|
| OSI Layer | "L3.5" | L3 | L3 |
| Nodes Involved | FAs | all CIP nodes | all routers |
| Mobile Host ID | home addr | home addr | c/o addr |
| Intermediate Nodes | L3 routers | L2 switches | L2 switches |
| Means of Update | signalling msg | data pkt | signalling msg |
| Paging | explicit | implicit | explicit |
| Tunnelling | yes | no | no |
| L2 Triggered Handoff | no | optional | optional |
| MIP Messaging | yes | no | yes |

### A. Hierarchical Mobile IP

The same basic idea of hierarchical structure of visited networks is employed by several proposed protocols. In all these protocol suggestions, the MN's HA needs not to be informed of every movement that the MN performs inside the foreign network domain. In this section, we introduce the proposal from Ericsson and Nokia that employs a hierarchy of FAs to handle the MN's local registrations.

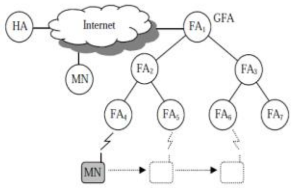


Figure 2: Hierarchical FAs.

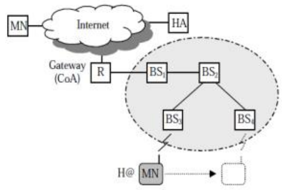


Figure 3: Cellular IP access network.

Consider the illustration in Figure 2, where the FAs in a domain are organized into a hierarchical tree-like structure. The root of the hierarchy (FA1) is a special kind of foreign agent called Gateway Foreign Agent (GFA). An FA's agent advertisement is extended to include in the CoA field the IP addresses of FAs from the FA itself through all the ancestor FAs until the GFA (in the figure FA4, FA3, FA1). The MN's registration is then processed by all the FAs (updating the maintained visitor list entry) on the uplink path ended by the GFA and finally the HA

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stores the GFA's IP address as the current CoA of the MN. Through this mechanism, the location information is managed in a distributed mode.

### *B. Cellular IP*

Columbia University and Ericsson propose the Cellular IP for very frequently moving hosts as well as rarely moving and totally static hosts. The Cellular IP combines the capability of cellular networks in providing smooth fast handoff and efficient location management for active and idle mobile hosts with the inherent flexibility, robustness, and scalability found in IP networks [5]. Location management and handoff support are integrated with routing in Cellular IP access networks. The Cellular IP is intended for use in local or metropolitan area networks. It is an extension to basic Mobile IP protocol instead of a replacement for it.

### *C. Hawaii*

Technologies Bell Labs as a separate routing protocol to take care of the micro mobility inside the visited domain. Still, HAWAII relies on Mobile IP to provide wide-area inter-domain macro mobility management. HAWAII is now transparent to MNs that are compatible with Mobile IP with route optimisation, challenge/response, and Network Access Identifier (NAI) extensions. The main goals of HAWAII include achieving good performance, providing intrinsic support for QoS, and enhancing reliability.

The basic network architecture is illustrated in figure 4. The gateway in each domain is called the Domain Root Router (DRR). No HA is involved when an MN's movement is within the home domain, where the MN is identified by its IP address.

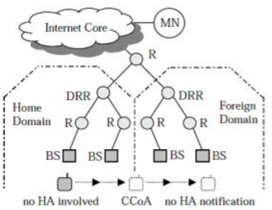


Figure 4: HAWAII network architecture.

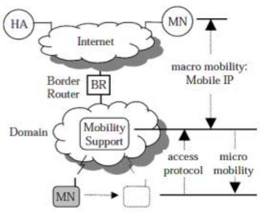


Figure 5: Unified mobility framework.

### *D. Unified Hierarchical Mobility*

It is widely agreed that Mobile IP is suitable to handle the macro mobility between networks, whereas the micro mobility solutions described in the previous sections, together with all the other proposals, define various micro mobility support protocols to be used inside certain sub-networks. It is difficult to find such a micro mobility solution that can be optimal for any kind of network. This situation leads to a need to make it possible that different micro mobility protocols can coexist in the Internet so that the CN and the HA would not need to be aware of the difference.

## V. HANDOFF ISSUES

Before we discuss about the issues of the handoffs, we must have a clear idea upon the different criteria involved in Handoffs. They are as follows. If not chosen appropriately, then the call might be handed back and forth several times between two adjacent BSs. If they are too conservative, then the call may be lost before the handoff. For this, three handoff detection schemes are considered. They are (i) Mobile-controlled handoff (MCHO) where MS continuously monitors the signals of the surrounding BSs and initiates handoff process when some criteria are met, (ii) Network-controlled handoff (NCHO) where the surrounding BSs measure the signal from the MS, and the network initiates the handoff process when some criteria are met, and (iii) Mobile-assisted handoff (MAHO) where the network asks the MS to measure the signal from the surrounding BSs. The network makes the handoff decision based on reports from the MS. The advanced mobile systems follow MAHO [8].

Though the management of the handoffs can be done in an efficient way, there are certain issues that need to be considered. Firstly, handoffs are expensive. So it is important that we find a mechanism that is relatively cheaper to implement than the existing mechanisms. The handoffs include the problem of fading which must be focussed upon. Fading can be categorized into three types, namely, (i) Distance-dependant Fading or Path Loss that occurs when the received signal becomes weaker due to increasing distance between MS and BS, (ii) Lognormal Fading or Shadow Fading that occurs when there are physical obstacles (e.g. hills, towers, and buildings) between the BS and MS, which can decrease the received signal strength, and (iii) Rayleigh Fading or Multipath Fading that occurs when two or more transmission paths exist between MS and BS. The multipath fading can be classified as, (i) Rayleigh Fading: when obstacles are close to the receiving antenna, and (ii) Time Dispersion: when the object is far away from the receiving antenna. So these issues must be dealt in a reliable way.

## VI. QOS ISSUES

QoS (Quality of Service) limitations/bottleneck today often occurs within the wireless segment from the end-to-end data path based on our deployment experiences of Third Generation (3G) mobile networks and Wireless Local Area Networks (WLANs). This originates from the inherent properties of mobile radio environment. While the total re-sources available over the air interface are, on average, sufficient to meet the total resource requirements of the user application sessions admitted to the system, the level of QoS desired/expected by users may not be provided. Consequently, services that are tolerant of longer delay and higher rates of data loss is sacrificed [9]. Thus, more explicit QoS control mechanisms are required at the radio access level especially with consideration given to the entire (end-to-end) network QoS. The Qos mechanisms must meet the requirements of certain challenges especially for adhoc devices. They are (i) When the overhead is too high, (ii) Maintaining the precise link state information is very difficult and, (iii) The reserved resource may no longer available because of path breakage (iv) When channel allocation is dynamic, the randomly selected path may or may not give the best service.

## VII. CONCLUSION

The paper discusses the mobility management for the next generation mobile networks. The macro mobility and micro mobility solutions for Mobile IP have been discussed. In the macro mobility solution, basic principle of Mobile IP is introduced, together with optimal schemes and the advances in IPv6.

Mobile IP on solving the micro mobility problem is analysed, based on which three main proposals are discussed as the micro mobility solutions, including HMIP, Cellular IP, and HAWAII. The issues in Handoff management and QoS have been discussed. A unified model is also described in which the different micro mobility solutions can coexist simultaneously in mobile networks. The issues discussed in the paper can serve as an effective guide to the overall solution and systematic research on the problem of mobility management for the next generation wireless communications. Since global roaming will be an increasing trend in future, attention must be paid on mechanisms which are applicable in heterogeneous networks.

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Mr. Pramod Kumar has taught primarily introductory programming courses, database courses, courses in software engineering, and courses that focus on professional communication for over 8 years. His research interests lie in the areas of Data Mining, Multimedia Analysis, Information Retrieval, Mobile Computing, Algorithms and Adhoc Networks.

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Mr. Thirupathi V is working as an Assistant Professor in SR Engineering College , Warangal. He received his M.Tech degree in Software Engineering at JNTU Hyderabad and has six and half years of teaching experience. His research areas are Algorithms, Mobile Computing, Adhoc networks and Embedded Systems.

Monica is a 7th semester graduate at SR Engineering College, Warangal majoring in Information Technology. Monica's intuitive communication skills and a creative intellect have enabled her to participate in various academic activities. Her research interests include areas like Mobile computing, Data mining and Web Technologies.