

Heterogeneous Mobility Management and Vision for Wireless Networks

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Abstract: The amazing demands from social market are pushing the development of mobile communications faster than before, leading to emergence of new advanced techniques. This paper describes 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 service in the context of next evolutionary step for wireless communication networks. IP based service technologies are becoming increasingly important in wireless communications. Cellular networks will be used as an access method to the Internet and other IP-based networks. The macro and micro mobility solutions for Mobile IP are analyzed and a comparative study is done among HMIP, Cellular IP and HAWAII protocols.

Keywords: Mobility management, Handoff management, location management, QoS, Macro mobility, HMIP, HAWAII, Cellular IP.

I. Introduction

From past few years, the development of the technologies as well as the number of mobile devices increased steadily. In comparison to the traditional cellular interfaces, now a days 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 convergence 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, amalgamation of these networks will facilitate the mobile users to be always connected to the best available access network depending on their requirements. This integration of heterogeneous networks will 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 elsewhere 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

rightly determined before the service is delivered. Moreover, for designing an adaptive communication protocol, various existing mobility management schemes are to be correctly 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. Several vendors and researchers are expressing a growing interest in wireless networks that support universal roaming across multiple wireless and mobile networks. We need a system where roaming is seamless and users are always connected to the best network.

II. 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. There is some difference in standardization models applied for GPRS and Mobile IP. GPRS is an entire mobile network system where architectural descriptions and interfaces between network elements are standardized. Mobile IP, on another hand, is a protocol applied in the IP environment to support a mobility of IP hosts. In IETF, it has been typical to standardize more or less independent protocols. From architectural point of view the IETF model potentially allows more flexibility. Especially in backbone networks, IETF protocols have become more and more dominant. From cellular terminal implementation point of view, a specification of entire network system and thus a complete radio interface might have been beneficial for interoperability purposes[4].

The important functionalities of mobility management :

A. Location management and

B. Handoff management

These two functionalities come under Single-hop and multi-hop networks.

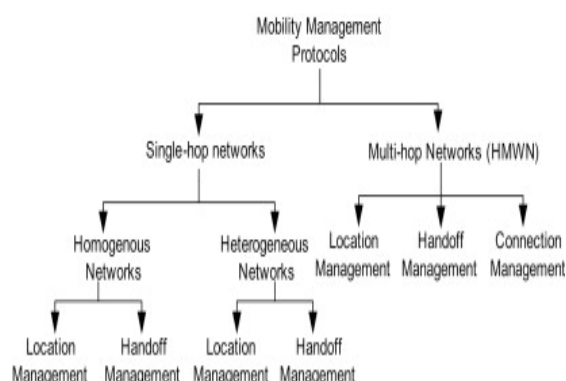


Figure 1. Classification of Mobility Management

Single-hop networks: Every SingleHop Data Center has its own internal network architecture designed to support the clients and servers hosted inside of it.

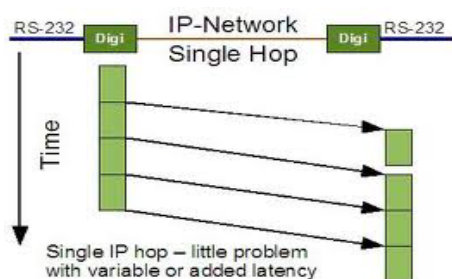


Figure 2: Connection in the network hop based

Multi-hop networks: Multi-hop or ad hoc, wireless networks use two or more wireless hops to convey information from a source to a destination. There are two distinct applications of multi-hop communication, with common features, but different applications.

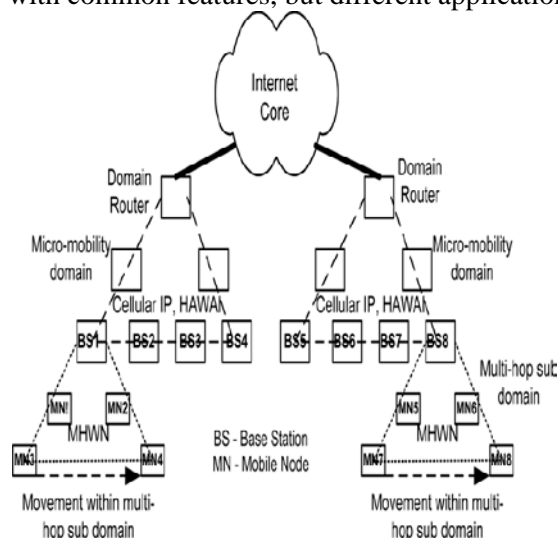


Figure 3. Location Management Scenario

A. Location Management

Location Management in Wireless Cellular Networks, Location Management,

Cellular Networks, LM, Mobility Management, Enhanced 911, E911, Dynamic Location Management, Static Location Management, Paging, Hand-off Velocity Prediction, HVP, Location Update, Location Area, Set-Covering Based Location area Planning, SCLBP. 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. Three issues need to be considered for handoff management:

Handoff detection: To initiate a handoff, two issues must be considered:

- Who initiates the handoff process?
- How is the need for handoff detected?
- When to effect the handoff must be based on measurements of the links made at the MS, at the two BSs, or both.

It is obvious that the measurements can be made at either the MS or the BSs, it is not obvious that the decision to effect the handoff can be made either by the network or by the MS[2].

Channel assignment : Channel assignment schemes attempt to achieve a high degree of spectrum utilization for a given grade of service with the least number of database lookups and the simplest algorithm employed in both the MS and the network[2].

Some trade-offs occur when trying to accomplish the following goals:

- Service quality
- Implementation complexity of the channel assignment algorithm
- Number of database lookups
- Spectrum utilization

Radio link transfer: Hard handoff procedure

- MS connects with only one BS
- Interruption during the link transition
- TDMA, FDMA enabled

Soft handoff procedure

- Soft handoff, Softer handoff
- Receives/transmits from/to multiple BSs simultaneously
- Complicated than hard handoff
- CDMA, TDMA with macro diversity

II . MOBILITY SOLUTION MOBILE IP

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

	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	Signaling msg	Data pkt	Signaling msg
Paging	Explicit	Implicit	Explicit
Tunnelling	yes	No	No
L2 Triggered Handoff	No	Optional	Optional
MIP Messaging	Yes	no	yes

A. Basic of Mobile IP

- A mobile node has two addresses - a permanent home address and a care-of address (CoA), which is associated with the network the mobile node is visiting. Two kinds of entities comprise a Mobile IP implementation:

i. A home agent stores information about mobile nodes whose permanent home address is in the home agent's network.

ii. A foreign agent stores information about mobile nodes visiting its network. Foreign agents also advertise care-of addresses, which are used by Mobile IP. If there is no foreign agent in the host network, the mobile device has to take care of getting an address and advertising that address by its own means.

- A node willing to communicate with the mobile node uses the permanent home address of the mobile node as the destination address to send packets to. Because the home address logically belongs to the network associated with the home agent, normal IP routing mechanisms forward these packets to the home agent[3]. Instead of forwarding these packets to a destination that is physically in the same network as the home agent, the home agent redirects these packets towards the remote address through IP tunnel by encapsulating the datagram with a new IP header using the care of address of the mobile node.

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 tunneling. 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, datagram's 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 time will be lost. The process of smooth handoff tries to overcome this disadvantage by optimizing 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, neighbor discovery mechanism, stateless auto-configuration, and security and QoS support. Mobile IPv6 protocol is the same as in IPv4 [5]. Besides, there are some main changes in Mobile IPv6 standard.

IV. 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.

Table1:Comparison of cellular IP,Hawaii & HMIP

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.

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 each 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.

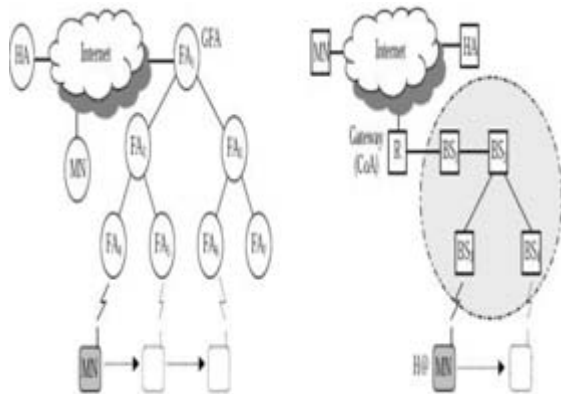


Figure 4. Symbolic Representation of Hierarchical and Cellular Networks

Consider the illustration in Figure 4, 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). All the FAs (updating the maintained visitor list entry) then process the MN's registration

on the uplink path ended by the GFA and finally the H 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 as shown in figure 4. 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. Protocol 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 optimization, 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.

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. Thus, these issues must be dealt in a reliable way.

VI. QUALITY SERVICE

QoS (Quality of Service) bottleneck today often occurs within the wireless segment from the peer-to-peer data path based on our deployment experiences of Third Generation (3G) mobile network and Wireless Local Area Networks (WLANs). This originates from the inherent properties of mobile radio environment. While the total resources 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]. The quality of service QoS refers to several related aspects of telephony and computer networks that allow the transport of traffic with special requirements. In particular, much technology has been developed to allow computer networks to become as useful as telephone networks for audio conversations, as well as supporting new applications with even stricter service demands.

In the field telephony, quality of service was defined by the ITU in 1994. Quality of service comprises requirements on all the aspects of a connection, such as service response time, loss, signal-to-noise ratio, cross-talk, echo, interrupts, frequency response, loudness levels, and so on. A subset of telephony QoS is grade of service (GoS) requirements, which comprises aspects of a connection relating to capacity and coverage of a network, for example guaranteed maximum blocking probability and outage probability. In the field of computer networking and other packet-switched telecommunication networks, the traffic engineering term refers to resource reservation control mechanisms rather than the achieved service quality. Quality of service is the ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow. For example, a required bit rate delay jitter, packet dropping probability and/or bit error rate may be guaranteed. Quality of service guarantees are important if the network capacity is insufficient, especially for real-time streaming multimedia applications such as voice over IP, online games and IP-TV, since these often require fixed bit rate and are delay sensitive, and in networks where the capacity is a limited resource, for example in cellular data communication.

A network or protocol that supports QoS may agree on a traffic contract with the application software and reserve capacity in the network nodes, for example during a session establishment phase. During the session it may monitor the achieved level of performance, for example the data rate and delay, and dynamically control scheduling priorities in the

network nodes. It may release the reserved capacity during a tear down phase.

A best-effort network or service does not support quality of service. An alternative to complex QoS control mechanisms is to provide high quality communication over a best-effort network by over-provisioning the capacity so that it is sufficient for the expected peak traffic load. The resulting absence of network congestion eliminates the need for QoS mechanisms. QoS is sometimes used as a quality measure, with many alternative definitions, rather than referring to the ability to reserve resources. Quality of service sometimes refers to the level of quality of service, i.e. the guaranteed service quality. High QoS is often confused with a high level of performance or achieved service quality, for example high latency and low bit error probability.

An alternative and disputable definition of QoS, used especially in application layer services such as telephony and streaming video, is requirements on a metric that reflects or predicts the subjectively experienced quality. In this context, QoS is the acceptable cumulative effect on subscriber satisfaction of all imperfections affecting the service. Other terms with similar meaning are the quality of experience (QoE) subjective business concept, the required "user perceived performance the required "degree of satisfaction of the user" or the targeted "number of happy customers". Examples of measures and measurement methods Mean Opinion Score (MOS) Perceptual Speech Quality Measure (PSQM) and Perceptual Evaluation of Video Quality (PEVQ). See subjective video quality.

CONCLUSION

The paper discusses the mobility management for the next generation mobile networks. The macro and micro mobility solutions for Mobile IP have been discussed. In the macro mobility solution, basic principle of Mobile IP is introduced, jointly with optimal schemes and the advances in IPv6. Mobile IP on solving the micro mobility problem is analyzed, 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 give out as an effective steer 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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