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A Survey of Mobility Management in Wireless Networks

Mrs. Radha B K
Asst. Prof. Dept., of CSE
PDA College of Engineering, Gulbarga – India
radhabk_5@yahoo.co.in

Dr. Bharati Harsoor
H.O.D, ISE Dept.,
PDA College of Engineering, Gulbarga – India
bharati_a@rediffmail.com

Abstract: **Mobility management plays an important role in wireless communication networks in effectively providing services to mobile users. Wireless systems have an ability of having the same contact number even when the user moves from one location to another. The wireless telephones are more convenient, flexible and versatile; there have been a growing number of wireless phone subscribers as well as service providers and the number is still increasing. A combination of wireless communication and computer technologies has revolutionized the world of telecommunication. Mobility management facilitates telecommunication networks to find roaming terminals intended for call delivery and to sustain associations as the terminal is moving into a unique service neighborhood. This paper provides study of mobility management components such as location management and handoff management and it also introduces the schemes in which the mobility management tasks and its models. The processing stages of the two operations are introduced respectively. The paper also describes the mobility management issues at the network layer.**

Keywords: **Mobile node, Micro mobility, Macro mobility, Intra-system, Inter-system, Base Station.**

1. INTRODUCTION

The notion of anytime and anywhere communication is the target at which future generation wireless communication systems aim. Mobility management is a technique in which uninterrupted signal connectivity is maintained, when mobile device changes location from one cell to another cell or one network to another network. It is the essential technology that supports roaming users with mobile terminals to enjoy their services in progress through wireless networks.

Over the past few years, the complexity 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 communication 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 is necessary hence the data is accessed from anywhere at any time. Regardless of the services and networks, one of the most important and challenging problems for the seamless access of wireless networks and mobile services is mobility management, used to automatically support mobile terminals enjoying their services while simultaneously roaming freely without the disruption of communications.

2. MOBILITY MANAGEMENT REQUIREMENTS AND SOLUTIONS

There are many other requirements on performance and scalability that should be carefully taken into account when trying to design or select a mobility management scheme, including:

- Fast handoff: the handoff operations should be quick enough in order to ensure that the mobile node can receive IP packets at its new location within a reasonable time interval and so reduce the packet delay as much as possible.
- Seamless handoff: the handoff algorithm should minimize the packet loss rate into zero or near zero which, together with fast handoff, is sometimes referred to as smooth handoff.
- Signaling traffic overhead: the control data load, e.g. the number of signaling packets or the number of accesses to the related databases, should be lowered to within an acceptable range.
- Routing efficiency: the routing paths between the communication nodes to the mobile nodes should be

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optimized to exclude redundant transfer or bypass path as e.g. triangle routing.

- Quality of Service (QoS): the mobility management scheme should support the establishment of new QoS reservation in order to deliver a variety of traffic, while minimizing the disruptive effect during the establishment.
- Fast security: the mobility scheme should support different levels of security requirements such as data encryption and user authentication, while limiting the traffic and time of security process e.g. key exchange.
- Special support required: it is better for a new mobility mechanism to require minimal special changes on the components, e.g. mobile node, router, communication media, networks, other communication nodes, etc.

There are many distinct but complementary techniques especially for mobility management to achieve its performance and scalability requirements listed above, including:

- Buffering and forwarding, to cache packets by the old attachment point during the MN in handoff procedure, and then forward to the new attachment point after the processing of MN's handoff.

- Movement detection and prediction, to detect and predict the movement of mobile host between different access points so that the future visited network is able to prepare in advance and packets can be delivered there during handoff.

Handoff control, to adopt different mechanisms for the handoff control, e.g. layer two or layer three triggered handoff, hard or soft handoff, mobile-controlled or network-controlled handoff.

Paging area, to support continuously reachable with low overhead on location update registration through location registration limited to the paging area.

Domain-based mobility management, to divide the mobility into micro mobility and macro mobility according to whether the mobile host's movement is intra-domain or inter-domain.

2. MOBILITY MANANGEMENT COMPONENTS

The mobility management provides packet delivery without delay to their destinations and the routing protocol is the basic requirement of this scheme. There are two main aspects in mobility management i .e. location management (addressing, location tracking and update, locating and paging, etc.) and handoff management (handoff initiation, connection routing, smoothing, etc.). Handoff management focuses on rerouting concept while location management routing protocol use location of node for enhancing the performance of routing protocol. **[8]**

3.1 Location Management

Location management enables the system to track the locations of Mobile Terminals (MT) between consecutive communications and is concerned with how to locate a mobile node, track its movement, and update the location information. It includes two major tasks.

- Location registration or location update
- Call delivery

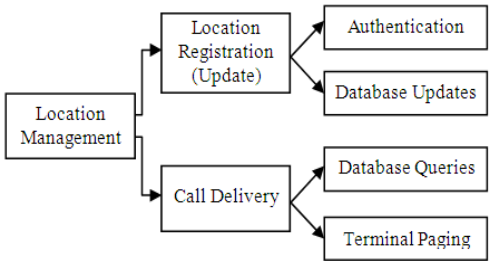

Fig. 1: Location management operations.

In location update the mobile device periodically informs the system to update relevant location databases with its up to 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 i.e., determining the serving database of the called mobile terminal and locating the visiting cell/subnet of the called mobile terminal. This is also called as paging, where polling messages are sent to all the cell/subnets within the residing registration area of the called mobile terminal. [6]

For Intra-system roaming, the design of **Location management** techniques has the following challenges:

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

3.2 Handoff Management

Handoff management is a process by which MT keeps its connection active when it moves from one access point to another and is concerned with control of the change of a mobile node's access point during active data transmission.

The handoff process can be intra or inter system.

Intra-system handoff (horizontal handoff) is the handoff in homogeneous networks. Intra-system (intra domain) roaming refers to moving between different cell of the same system.

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- **Inter-system** handoff (vertical handoff) between heterogeneous networks. Inter-system roaming refers to moving between different backbones, protocols, technologies, or service providers.

The design of Handoff management techniques in wireless systems has the following challenges:

- Reduction of both signaling and power overheads.
- QoS guarantees during the handoff process:
  - Extreme low intra and inter system handoff latency, which includes signaling message processing time, resources and routers setup delay, format transformation time, and so on
  - Limited disruption to user traffic
  - Near – zero handoff failure and packet loss rate
- Efficient use of network resources
- Enhanced scalability, reliability, and robustness. [2]

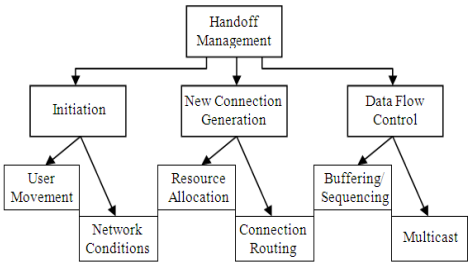

Fig. 2: Handoff management operations

4. HANDOFF CLASSIFICATIONS

Handoff of a mobile node from one subnet/network to another, supported in different access technologies can be classified as shown in Fig.3 Handoff classification depends on many factors like, network types involved, frequencies engaged, number of connections involved, administrative domains involved, necessity of handoff and user control allowed in the handover process.

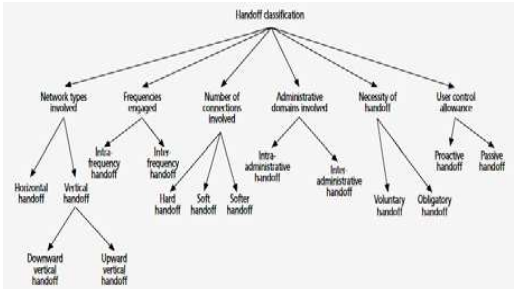

Fig. 3: Handoff Classification

4.1 Network Types Involved

Depending on whether a handoff takes place between a single type of network interface or a variety of different network interfaces type handoffs can be classified as either horizontal or vertical.

Horizontal handoff (HHO): It is the handoff process of a mobile terminal between access points supporting the same network technology. For example, the changeover of signal transmission (as the mobile terminal moves around) from an IEEE 802.11b base station to a geographically neighboring IEEE 802.11b base station is considered as a horizontal handoff process.

Vertical handoff (VHO): It is the handoff process of a mobile terminal among access points supporting different network technologies. For example, the changeover of signal transmission from an IEEE 802.11b base station to an overlaid cellular network is considered a vertical handoff process.

4.2 Frequencies Engaged

In cellular technology, handoff is the process of switching of signal from one frequency to another.

Intra-frequency handoff: It is the handoff process of a mobile terminal across access points operating on the same frequency. This type of handoff is present in code-division multiple access (CDMA) networks with frequency division duplex (FDD).

Inter-frequency handoff: It is the handoff process of a mobile terminal across access points operating on different frequencies. This type of handoff is present in CDMA networks with time-division duplex (TDD) and is the only handoff type supported in GSM cellular systems.

4.3 Number of Connections Involved

Evolution in the mobile devices to support multiple interfaces, leads to handoff such as hard, soft, or softer depending on the number of connections maintained during the handoff.

Hard handoff (Break Before Make): In a hard handoff the existing connection with the current base station is released when the new connection is established with the new base station. In other words, using hard handoff, a mobile node is allowed to maintain a connection with only one base station at any given time.

Soft handoff (Make Before Break): In a soft handoff a mobile node maintains a radio connection with no less than two base stations in an overlapping handoff region and does not release any of the signals until it drops below a specified threshold value. Soft handoffs are possible in situations where the mobile node is moving between cells operating on the same frequency.

Softer handoff: A softer handoff is very similar to a soft handoff, except the mobile terminal switches connections over radio links that belong to the same access point.

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4.4 Administrative Domains Involved

An administrative domain is a group of systems and networks operated by a single organization of administrative authority. Administrative domains play a significant role in 4G wireless networks as different networks which controlled by different administrative authorities, become available. Consequently, the classification of handoffs in terms of administrative domains is a crucial issue.

Intra-administrative handoff: a handoff process where the mobile terminal transfers between different networks (supporting the same or different types of network interfaces) managed by the same administrative domain.

Inter-administrative handoff: a handoff process where the mobile terminal transfers between different networks (supporting the same or different types of network interfaces) managed by different administrative domains.

4.5 Necessity of Handoff

Handoffs are initiated due to necessity of QoS requirements, cost, bandwidth and delay. Depending on the necessity, handoffs can be classified such as obligatory and voluntary.
Obligatory handoff: In some situations it is necessary for the mobile terminal to transfer the connection to another access point in order to avoid disconnection.

Voluntary handoff: In other situations transfer of connection is optional and may or may not improve the quality of service

4.6 User Control Allowance

Depending on the users control in handoff, it can be classified as proactive or passive.

Proactive handoff: In a proactive handoff the mobile terminal's user is allowed to decide when to handoff. The handoff decision can be based on a set of preferences specified by the user. Proactive handoff is expected to be one of the radical features of 4G wireless systems.
Passive handoff: The user has no control over the handoff process. This type of handoff is the most common in first-, second-, and third-generation wireless systems. Handoff in heterogeneous network is called Vertical handoff because of roaming of mobile devices between different accesses technologies as shown in Fig. 4. In case of multiple interface device, heterogeneous network support soft handoff.

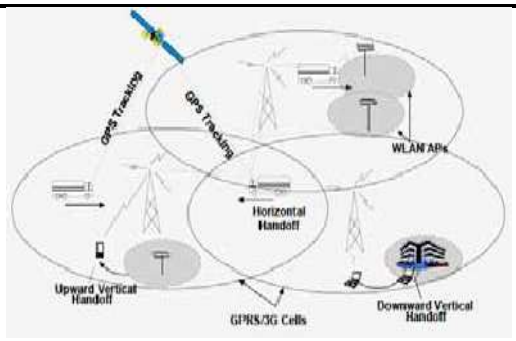

Fig. 4: Heterogeneous Network

5. MOBILITY MANAGEMENT MODELS

5.1 General mobility management model

A general mobility model is presented in Figure 5. Typically, we assume that the public network is the Internet and IP is the network layer protocol. The components in the model are introduced as follows [1]:

- Two mobile network entities. MN is a node that can change its point of attachment to the network from one link to another by freely roaming with its user, while still being reachable. Corresponding Node (CN) is either a mobile or a stationary node that can communicate with the concerned mobile node by sending or receiving packets to or from the mobile node.

- Two networks. Home network is the unique network at which the mobile node is continually reachable to the other corresponding nodes, by an originally assigned address – Home Address. Foreign network is the network to which the mobile node is currently attached instead of its original home network, and is reachable by a new generated address – Care-of Address (CoA).

- Two addresses. Home Address is the static unchangeable IP address assigned to the MN that is used to identify the end-to-end connection, also as the IP address when MN is in its home network. Care-of-Address (CoA) is the IP address to identify the MN's current point of attachment to the Internet when it is in a foreign network.

- Two mobility agents. Home Agent (HA) is a router on the home network that makes the mobile node reachable when the mobile node is attached to a foreign network. Foreign Agent (FA) is a router on the foreign network that assists the mobile node to access the Internet by receiving data grams delivered to the Care-of Address. The basic assumption within IP is that an IP address always identifies the node's location in the Internet. So if a node moves to another location in the Internet, a new IP address must be generated and assigned to the node in order to route following IP packets to its new attachment

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point. So the basic function of mobility management in the Internet is just to translate a node's original IP address (Home Address into the new temporary IP address (Care-of Address) as promptly and efficiently as possible.

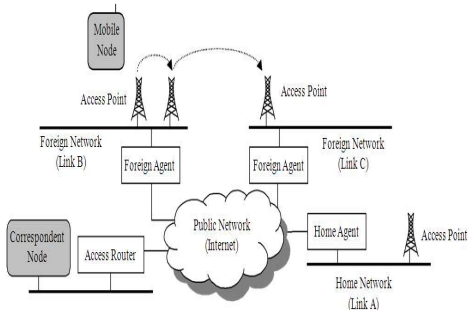

Fig. 5. General Mobility model

5.2 Hierarchical mobility management model

The basic idea behind the domain-based mobility management scheme introduced in the mobility management strategy should be based on a hierarchical mobility management scheme that localizes the management of mobility by introducing the concept of domain, in order to achieve the requirements on performance and flexibility especially for frequently moving hosts. With this in mind, two kinds of mobility can be defined as follows, according to the movement span:

- Micro mobility, i.e. mobile node's movements inside a domain, to which intra-domain mobility management solutions are suitable, focusing mainly on a fast, efficient, seamless mobility support within a restricted coverage.

- Macro mobility, i.e. mobile node's movements between different domains, to which inter-domain mobility management schemes can be employed, acting as a global mobility solution with the advantages of flexibility, robustness, and scalability.

  A domain is defined as a collection of networks sharing a common network administration, which may include one or more foreign (visited) networks. The following figure shows the hierarchical mobility management model. It is worthy to note that the concepts micro and macro mobility based on the definition of domain are possibly recursive: a movement may be micro in one domain whereas macro in another [1].

The mobility management of homogeneous networks depends on network related parameter i.e., Received Signal Strength (RSS). However the mobility management of heterogeneous networks, not only depends on network related parameters, but also on terminal-velocity, battery power, location information, user-user profile & preferences and service-service capabilities & QoS etc. Designing mobility management with all-IP, while, considering issues such as context of networks, terminal, user and services is the main concern of industry and researchers in the current era. **[5]**

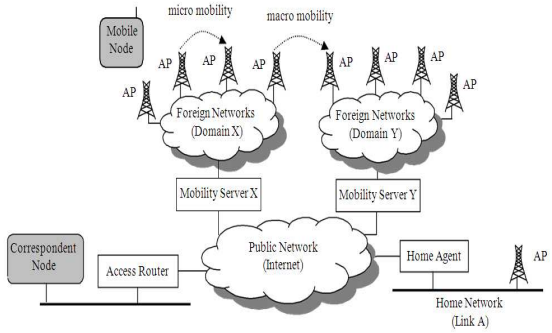

Fig. 6. Hierarchical mobility management

6. RESEARCH ISSUES IN WIRELESS NETWORKS

Wireless networks are among the fastest growing areas in networking research. Wireless communication extends the capabilities of fixed network to include location independent information storage, transport, retrieval and processing, and to support mobility of terminals and users. Future wireless networks allow people on the move to communicate with anyone, anywhere, and at any time using a range of multimedia services and heterogeneous platforms, networks, and devices. Wireless networks play a major role in the application of active networking technology. The dynamic behavior of mobile nodes and the inherently complex and time-varying characteristics of wireless channels provide signification additional motivation for intelligence in network nodes over wireless networks. There are many technical issues that must be overcome in wireless networks for advanced services. These issues transcend all levels of the overall system design, including hardware, communication link, network, and application design [9]. Wireless networks of the next generation need the support of all the advances on new architectures, standards, and protocols. Mobility management is an important issue in the area of mobility communication, which can be best solved at the network layer. The performance of any wireless network is highly influenced by the mobility patterns of nodes in the networks. In fact, mobility behavior is the most important environmental factor that determines performance and influences network design, Thus it is important to develop models that determine the mobility of node. There is a need to define a mobility architecture framework for the wireless network. Some of the challenges in designing the different wireless networks while considering the mobility factor as follows:

- Maintaining data synchronization to the user mobility through periods of connection and disconnection should

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be there in the mobility control scheme of Wireless Body Area Networks (WBANs).

- Personalized feature mobility is an important issue in Wireless Personal Area Networks (WPANs). It is a very important component for the future services so that users are presented with consistent user interface capabilities and services in any networks. The network should be able to move this personalized portal and the associated contents services along with the user mobility.
- To support mobility in Wireless Local Area Networks (WLANs), IP header compression is an important mechanism. The limited bandwidth of the wireless medium puts considerable limits on the bandwidth used for TCP/IP header. So IP header compression is one option in compression importance should be given to the compression efficiency, Robustness of the scheme, and the compression reliability.
- In Wireless Metropolitan Area Networks (WMANs), signaling traffic overhead is a prime concern. The control data load, for example, A number of signaling packets or a number of accesses to the related databases, should be lowered to within an acceptable range.
- In Wireless Wide Area Networks (WWANs), the handoff operations should be quick enough to ensure that the mobile node can receive IP packets at its new location within a reasonable time interval and so as to reduce the packet delay as much as possible. It must support for seamless handoff. The handoff algorithm should minimize the packet loss rate to zero or near zero, together with fast handoff, which is sometimes referred to as smooth handoff. The mobility management scheme should support the establishment of new QoS reservation to deliver a variety of traffic , while minimizing the disruptive effect during that establishment.

The conceptual study forms a clear layout to outline the research area of mobility management for mobile communications and can direct systematic research on mobility management issues for the future mobile system. The performance evaluation of the mobility management schemes of the future mobile communication systems is becoming more and more difficult and complex a task. Future mobile communication systems evolve with the trend of global connectivity through the internetworking and interoperability of heterogeneous wireless networks. Roaming in such a network architectures is very complex a situation and causes many new problems. The future mobile systems should support a huge number of subscriber population with diverse movement modes, hence its necessary to propose the advanced architecture and new protocols which overcomes the above mentioned challenges in future. New models are needed to describe the impacts of mobility leading to different models that are finally used for various evaluation purposes.

7. CONCLUSION

Mobility management has widely been recognized as one of the most important and challenging problems for a seamless access to wireless networks and mobile services. This paper discusses the general concepts of mobility management and its components. The processing stages of these two component operations are introduced respectively, together with the discussions of key research issues and possible solutions. This paper includes the two major mobility management models – General mobility management model and Hierarchical mobility management model. The conceptual framework constructed forms a clear layout to outline the research area of mobility management for mobile communications and can direct systematic research on mobility management issues for the future mobile systems. The processing stages of the two operations are introduced respectively, together with the discussions of key research issues and possible solutions.

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