

Chapter Two

Literature Review

2 Literature Review

2.1 Introduction

A heterogeneous network here means a combination of several networking technologies and access to these technologies when needed, taking into account different kind of communication requirements at specific situations and user needs. By using these kinds of networks, users are more flexible where several technologies are available to be used within the same coverage, or area of presence. It is well known that different technologies provide different characteristics such as cost of service, bandwidth offered, security levels and coverage. Having this information about different networks the users can save money on services, energy consumption, be connected as long as possible by choosing the right network to operate in. In heterogeneous networks, to satisfy the user by providing always best connected and served concept, the network selection needs to be a continuous process until the decision is made.

Heterogeneous networks play a key role in information dissemination, evolution of communities, and the decisions individuals make [2].

To access multiple wireless networks in heterogeneous wireless network, the mobile station or mobile devices will be equipped with different network interfaces. These mobile devices provide the flexible network access and connectivity to the users but to support different networks it create the stimulating problems. The process through which user maintain his call without any interruption, when he moves across one network to another network is referred to as handoff or handover process [4].

Mobility is the most important feature of today's wireless networking system. Mobility can be attained by handoff mechanisms in wireless networks. Handoff is the process of changing the channel (frequency, time slot, spreading code, or combination of them) associated with the current connection while a call is in progress [4].

For a satisfactory user experience, mobile terminals must be able to seamlessly transfer to the “best” access link among all available candidates with no perceivable interruption to an ongoing conversation (which could be a voice or video session). Such ability to handover between heterogeneous networks is referred to as seamless vertical handovers [5].

2.2 Related Work

Several research works recently have discussed the vertical handover decision making and network selection process which used to elect the best network candidate. Throughout these research works, some mathematical theories have been developed and utilized for addressing these issues.

In [5], a comprehensive survey of the VHD algorithms designed to provide the required Quality of Service (QoS) to a wide range of applications while allowing seamless roaming among a multitude of access network technologies was presented.

In [6], a vertical handoff decision algorithm which uses the received signal to interference and noise ratio (SINR) from various access networks as the handoff criterion is proposed. It has the ability to make handoff decision with multimedia QoS consideration, such as to offer the user maximum downlink throughput from the integrated network, or to guarantee the minimum user required data rate during vertical handoff.

In [7], an RSS based handoff decision scheme is implemented. By applying the auto-regressive integrated moving average model, the future RSS values were predicted. The handoff decision was then made according to these RSS predictions.

Paper [8], discusses the most important mathematical theories used for network selection process in heterogeneous networks. Moreover, they compared the schemes of various mathematical theories and discussed how to come out with combining form of these mathematical theories all together.

In [9], a signal threshold adaptation algorithm for vertical handoff in heterogeneous networks was proposed. They investigated the effect of an application-based signal strength threshold on adaptive preferred-network lifetime-based handoff strategy in terms of the signaling load, available bandwidth, and packet delay for a roaming mobile in a 3G-WLAN inter-network.

2.3 Wireless Heterogeneous Networks

It is expected that the next generation of mobile communication will fulfill the increasing requirements of user and real-time multimedia service. It is, therefore necessary to make such criteria which fulfill the requirements of mobile node and application which is running on mobile node while moving across different heterogeneous networks, such as the requirements can be high bandwidth, minimum packet loss and low handover latency etc. Every network provides different bandwidth, coverage area and quality of services (QoS) to the end users [10].

The advent of heterogeneous networking has increased the complexity of network components. In order to achieve seamless interoperability, components of the 4G protocol stack will exhibit more complex functionality than components of the normal OSI protocol stack due to the additional tasks they will need to support.

2.4 Heterogeneous Networking Framework

The development of 4G heterogeneous networks introduced the attractive paradigm of “seamless QoS provisioning”. However, it also brought along with it a plethora of new challenges at the network, device and application levels. What is needed is a new framework to encapsulate mechanisms that address these challenges in heterogeneous environments. Some of the key requirements of this framework include reconfigurability of network components, QoS management, and policy management for vertical handovers [10].

Figure 2.1 shows the architectural framework for heterogeneous networking. It acts as a reference model similar to the OSI model and clearly defines the functions of all layers and provides a framework for exchanging data between network applications. The seven layers of the framework are as follows:

- **Hardware Platform Layer:** This layer defines the hardware components and technologies required to support a wireless network. It defines characteristics like modulation schemes and Media Access Control (MAC) algorithms.



Figure 2.1 The Heterogeneous Framework

- **Network Abstraction Layer:** This layer provides a common interface for supporting the different network technologies. It is responsible for controlling and maintaining networks on the MN.
- **Vertical Handover Layer:** The layer supports both network-controlled and client-controlled handovers. It is mainly responsible for the specification of mechanisms including state engines and triggers for vertical handovers.
- **Policy Management Layer:** The function of this layer is to evaluate the circumstances when a handover should occur. It is implemented through the definition of a set of rules with regard to all the relevant

parameters and their values which are evaluated with respect to handover.

- **Network Transport Layer:** This layer observes the routing, addressing and transport problems in secondary networks.
- **Quality-of-Service (QoS) Layer:** This layer supports both upward and downward QoS. Its task is to ensure that the QoS offered to applications can be maintained at an acceptable level during the lifetime of a connection.
- **Application Environments Layer:** This layer specifies mechanisms and routines that assist in building applications which can use all the layers of the framework.

2.5 Mobility Management in Heterogeneous Network

One of the most important challenges in 4G is mobility management. Mobility management is critical in maintaining the roaming of users from one system to another [11][12]. The hierarchy of mobility management in heterogeneous network environment is depicted in Figure 2.2.

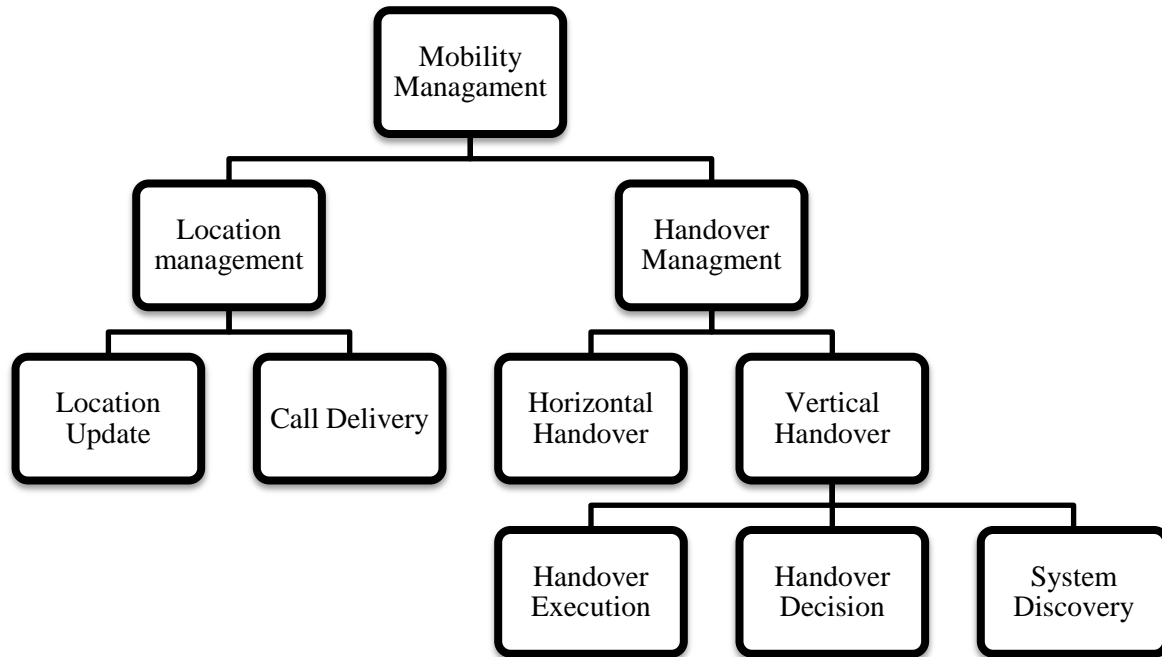


Figure 2.2: Mobility Management in a Heterogeneous Network Environment

There are two main areas for mobility management:

2.5.1 Location Management

Location management allows the network to discover the current Point of Attachment(PoA) of the mobile for call delivery. It involves two stages, location update and call delivery. Location update or registration enables the network to authenticate the user and update the location of the mobile. In this stage, the MT periodically notifies the network of its new access point, allowing the network to authenticate the user and revise the user's location profile. This allows the network to keep track of the MT. Call delivery is responsible for database queries and terminal paging. In this stage, the network is queried for the user location profile and the current position of the MT is found. Current techniques for location management involve database architecture design and the transmission of signaling messages between various components of a signaling network.

2.5.2 Handover Management

Handover management is classified into; Horizontal and Vertical Handover

1. Horizontal Handover

Horizontal handover or intra-system handover is a handover that occurs between the APs or the BSs of the same network technology. In other words, a horizontal handover occurs between the homogeneous cells of a wireless access system. For example, the changeover of signal transmission of an MT from BS to a geographically neighboring BS is a horizontal handover process. The network automatically exchanges the coverage responsibility from one point of attachment to another every time an MT crosses from one cell into a neighboring cell supporting the same network technology. Horizontal handoffs are mandatory since the MT cannot continue its communication without performing it.

2. Vertical Handover

Vertical handover or inter-system handover is a handover that occurs between the different points of attachment belonging to different network technologies. For example, the changeover of signal transmission from access point to the BS of cellular network is a vertical handover process. Thus, vertical handovers are implemented across heterogeneous cells of wireless access systems, which differ in several aspects such as received signal strength (RSS), bandwidth, data rate, coverage area, and frequency of operation. The implementation of vertical handovers is more challenging as compared to horizontal handovers because of the different characteristics of the multiple access networks involved.

Figure 2.3 shows horizontal and vertical handovers [9]. In this case, cell B and cell C are using the same network technology while cell A is using a different network technology.

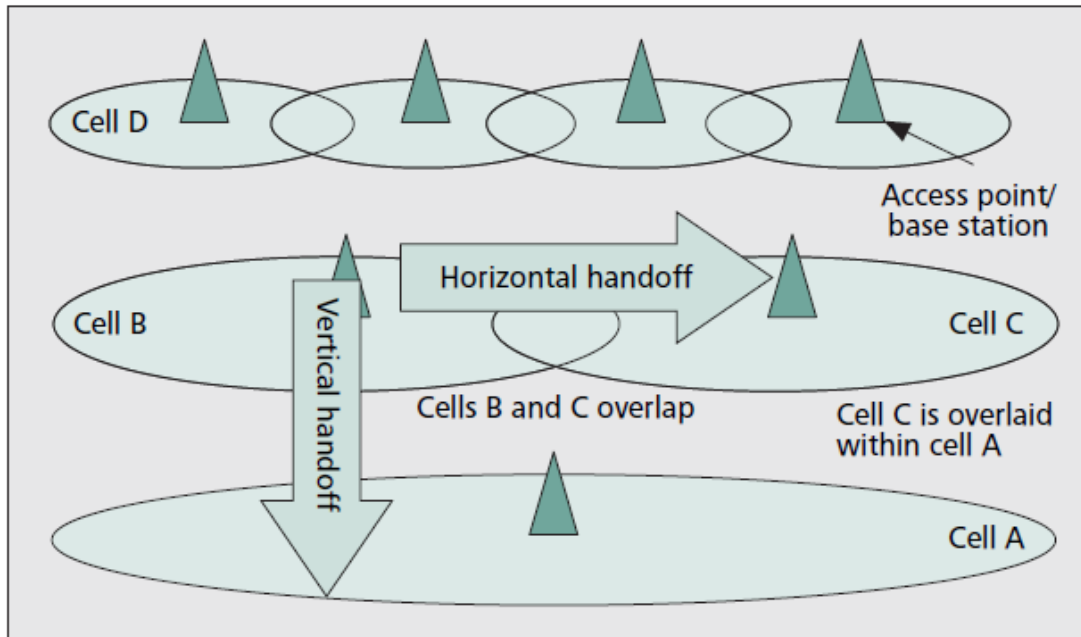


Figure 2.3: Horizontal and Vertical Handovers

2.6 Vertical Handover Process

Vertical handover processes is divided into three sequential phases; network discovery, handover decision, and handover execution [13] as shown in Figure 2.2.

1. Network Discovery

Network discovery is the process where a mobile terminal (MT) equipped with multiple interfaces searches for reachable wireless access networks. As the multimode MT moves across the network, it has to discover other available access technologies in its surroundings which might be preferable

to the currently used access network. For example, a multimode MT using a UMTS access network in an NGWN system needs to discover when mobile WiMAX access networks become available and possibly handoff to a mobile WiMAX if this is more preferable to the operator and/or user, or if the radio signal from its serving UMTS cell starts to deteriorate significantly. The network discovery phase collects information about the network, mobile devices, access points, and user preferences to be processed and used for making decisions in the handoff decision phase.

2. Handover Decision

Handover decision is the ability to decide when to perform the vertical handoff and determine the best handoff candidate access network. It includes access network selection and drives the handoff execution. Suppose an MT that is using a UMTS cell has discovered its available neighbor WiMAX cells. The next issue is whether the MT needs to initiate a handoff to a discovered WiMAX cell. Handoff metrics are used to indicate whether or not a handoff is needed. In traditional handoffs which happen in homogeneous networks, only information obtained from the radio-link layer such as the RSS and channel availability are considered for handoff decisions. A handoff is made if the RSS from a neighboring BS exceeds the RSS from the current BS by a predetermined threshold value. A traditional handoff decision time algorithm uses the RSS measurement and optionally the threshold, hysteresis, or dwell timer to make the handoff decision as follows[14]

- Received signal strength: The BS whose signal is being received with the largest strength is selected.

- Received signal strength with threshold: A handoff is made if the RSS of a new BS exceeds that of the current one and the signal strength of the current BS is below a threshold T .
- Received signal strength with hysteresis: A handoff is made if the RSS of a new BS is greater than that of the old BS by a hysteresis margin H .
- Received signal strength with hysteresis and threshold: A handoff is made if the RSS of a new BS exceeds that of the current BS by a hysteresis margin H and the signal strength of the current BS is below a threshold T .
- Algorithm with Dwell timer: Sometimes a dwell timer is used with the above algorithms. A timer is started the instant the condition in the algorithm is true. If the condition continues to be true until the timer expires, a handoff is performed.

3. Handover Execution

This phase executes the vertical handoff procedure to associate the mobile terminal with the new wireless access network. Handoff execution requires the actual transfer of data packets to a new wireless link in order to reroute a mobile user's connection path to the new point of attachment.

2.7 Classification of Vertical Handover

Vertical Handoff can be classified into four types based upon its direction, process, control and decision [1][11]:

1. Upward and Downward Handovers

In vertical handover, if the mobile switches from the network with a small coverage to a network of larger coverage, it is termed as upward handover as shown in Figure 2.4. On the other hand, a downward handover occurs in the reverse direction, i.e. from a network of larger coverage to a network of smaller coverage as shown in Figure 2.4.

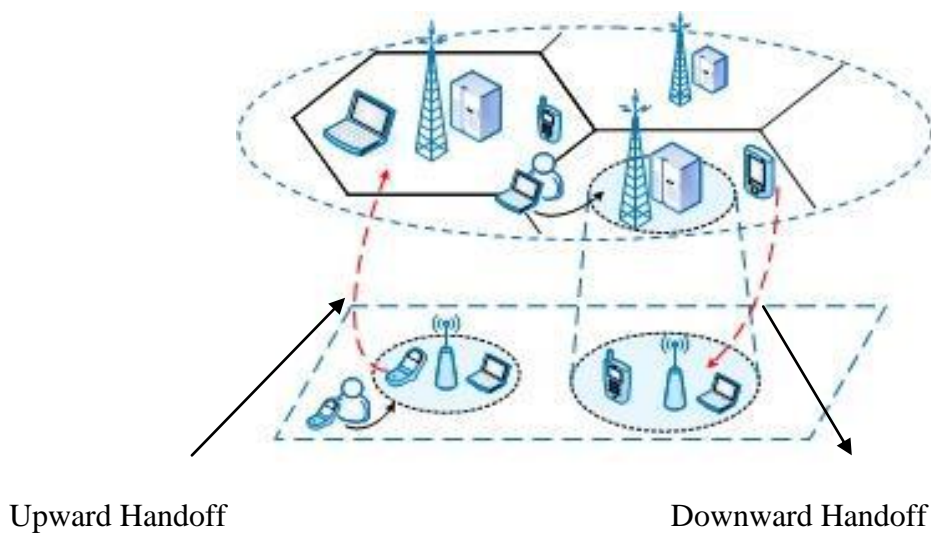


Figure 2.4: Upward and Downward Handovers

2. Hard and Soft Handover

Hard handover occurs when the MT is associated with only one point of attachment at a time. In other words, an MT may set up a new connection at the target point of attachment after the old connection has been torn down as shown in Figure 2.5 or hard handoff an MS is served by only one BS at a time. It makes contact with the new BS only after breaking its connection with the serving BS. This is referred to as 'break before make' connection.

A soft handoff or a make before break handoff occurs if the MT can communicate with more than one point of attachment during handoff as shown in Figure 2.5. In this case, the MT's connection may be created at the target point of attachment before the old point of attachment connection is released. For example, an MT equipped with multiple network interfaces can simultaneously connect to multiple points of attachment in different networks during soft handoff.

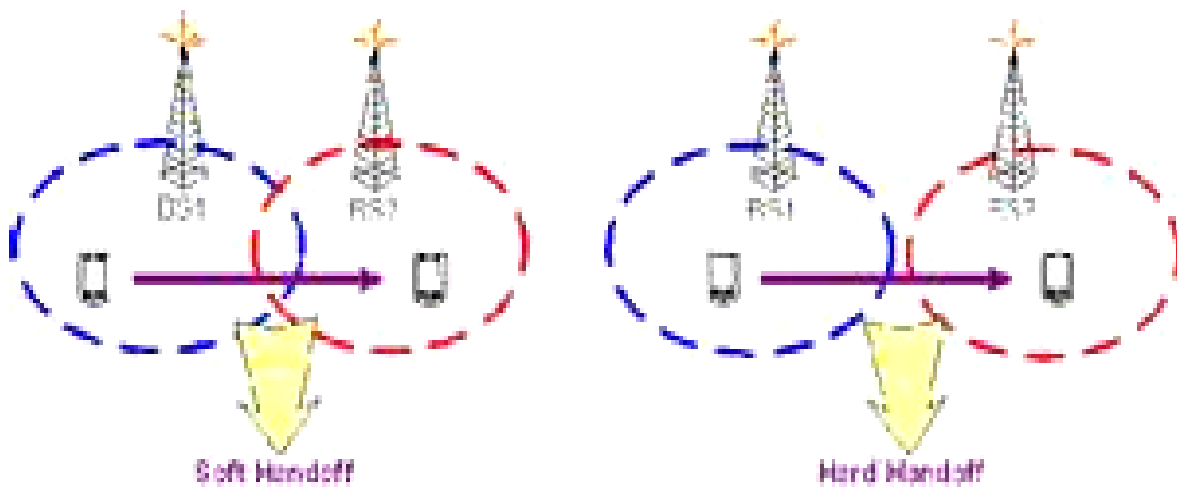


Figure 2.5 Hard and Soft Handovers

3. Imperative and Alternative Handovers

When there is loss of signal strength an imperative handoff occurs. For imperative handoff the RSS is sufficient to be considered. On the other hand, an alternative vertical handoff is initiated to provide the user with better performance. For alternative handoffs several other network parameters such as available bandwidth, supported velocity and cost of the network are to be considered in addition to the device parameters such as quality of service demanded by the application and user preference.

4. Mobile Controlled and Network Controlled Handovers

Vertical handoffs can further be classified based on who controls the handoff decision. If mobile node controls the handoff decision, it is termed as Mobile controlled handoff (MCHO). In Network controlled Handoff (NCHO) networks control the handoff decision. The handoff decision control is shared between the network and mobile in case of Mobile controlled Network Assisted (MCNA) and Network Controlled Mobile Assisted handoffs (NCMA). MCNA handoffs are more suitable because only mobile nodes have the knowledge about the network interfaces they are equipped with and user preferences can be taken into consideration.