A study on Handovers in Mobile Technology for Next Generation Wireless Networks

Dr. Danish Ather[1], Abdullah Saud[2]

[1]*Associate Professor, CCSIT, TMU, Moradabad*

[2]*Student, BSc (Hons.) CS, CCSIT, TMU, Moradabad*

[1]danishather@gmail.com

[2]abdullahsaudd@gmail.com

Abstract— **With the advancement in technology, the importance of wireless technology is increasing at a rapid rate throughout the world due to cellular and broadband technologies. These rapid advances in wireless network have been driving the evolution of communication technologies towards Next Generation Computing environment where the transmission of data is at higher speed. Today users are connected to different radio access technologies like LTE, UMTS, WiMax, WLAN, etc. It has become more challenging to provide a seamless mobility for Next Generation Wireless Networks (NGWN) in such a heterogeneous environment. The process of changing the point of connection while communicating is known as Handover (Handoff). The process of handover between the access points supporting different technologies is known as Vertical Handover (VHO). This paper presents an overview of Handover in mobile technology with main focus on Handover in Heterogeneous Network. It also provides a basic literature of Handover, its need, classification, desirable features and requirements for Handover Mechanism.**

Keywords— **Handover, Vertical Handover (VHO), Base Station (BS), Mobile Node (MN), Next Generation Wireless Networks (NGWN), Wireless Network (WN)**

I. INTRODUCTION

The development of internet and mobile phones made the entire world just a click away. With the passage of time, when the need to be 'Always Best Connected' arises, since then there has been a huge development in wireless technologies. Now, there are numerous technologies, networks, systems, applications, and devices available with different capabilities as per their purpose.

These advances in wireless technology has started the 4G revolution where technologies like LTE, UMTS, WiMax, WLAN, etc were developed with different standards. These NGWN offer higher speed, diverse area of coverage and variety of services; but these also brings out a very well known issue to the field of WN: **Mobility and Seamless Handover**. Toprovide an efficient and effective end-to-end communication between heterogeneous networks data loss and service interruption must be low, we need to perform Handover (Handoff)[1]. When the BS and TS during Handoff are of different wireless technologies then such handoff is known as Vertical Handover (VHO). A handover decision is a significant problem in any NGWN.

Terminologies and key concepts associated with Handover are shown in Fig 1.

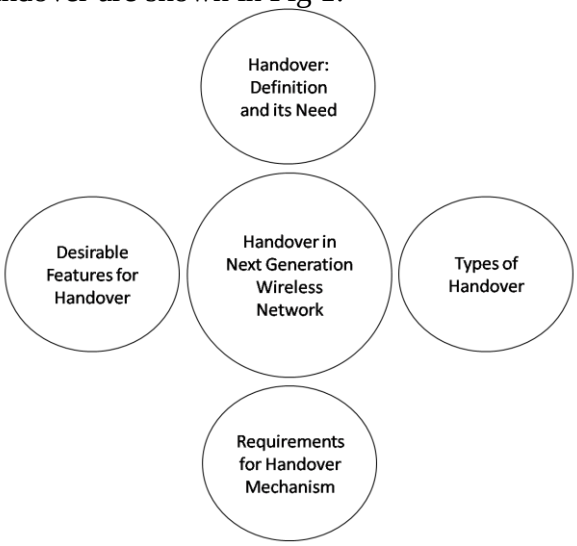

Fig 1. Classification of Handover Concepts

The structure for paper is: Section-II gives the background, definition and need of Handover; Section-III gives the classification of Handover on certain factors; Section-IV lists the requirements for Handover mechanism including both dynamic and non-dynamic; Section-V illustrates Handover in Heterogeneous Network (Vertical Handover); Section-VI lists important desirable features which any Vertical Handover Decision (VHD) algorithm should offer; Section-VII concludes the paper.

II. HANDOVER: DEFINITION AND ITS NEED

Handover in reference to cellular telecommunications is used to refer to the process of transferring an ongoing call or data session from one channel connected to one Base Station (BS) to another BS without any loss of data or interruption of service. In satellite communication, it is the process of transferring satellite control from one earth station to another station without any interruption of service.

In other words, when a mobile user travels from one cell location to another while a call or data session is ongoing then the session should be transferred from the old cell location (BS) to the new BS in order to maintain the session from being terminated. This process of changing the point of connection while communicating is called as Handover.

Fig 2 depicts the pictorial presentation of Handover when a user moves from Old BS to New BS.

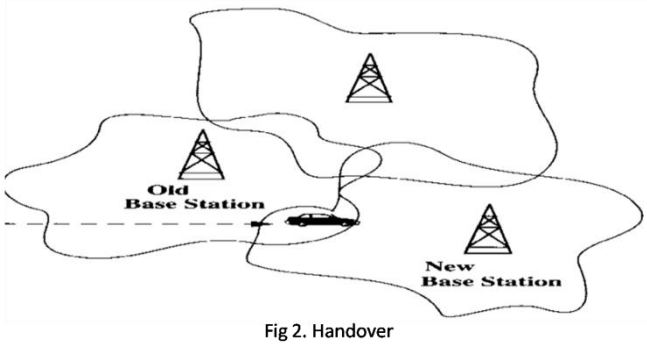

Fig 2. Handover

The term Handoff is also used for handover. It is most commonly used within American organizations and in technologies originated from America like CDMA2000. While Handover is more frequently used within International Organizations and European originated standards like UMTS and GSM.

The primary objective of Handover is to ensure that the ongoing communication between source and destination should be effective. It is also needed to make sure that there should not be nay loss in data or interruption in service.

Following are some of the situations when Handover will occur-

- When received signal level drops below a certain specified threshold value.
- When a user moves away from the area covered by one BS and enters in the area covered by another BS then the call/ data session is transferred to the new BS to avoid service termination when the user gets outside the range of old BS.
- When one BS is nearing its capacity, the network may decide to handover some mobiles over to another BS with enough capacity to accommodate new calls/ data session. In this way, the load on one BS is reduced that is nearly running to its maximum capacity. In this way access is opened to maximum number of users.
- In non-CDMA networks, when a new user interfere to existing user where both are using the same channel but in different cells, then handover is needed to avoid interference.
- In non-CDMA networks, when the user's behaviour changes, handover is needed. For example, a user moving at a fast speed is connected to a large umbrella of cell stops then the session may be transferred to the smaller macro or micro cells to free-up the capacity for other fast-travelling users.

III. CLASSIFICATION OF HANDOVER

The most basic type of handover is the one in which an ongoing call or data session is redirected from a source cell to the target cell. Handover can be classified on the basic of the factors as shown in fig 3.

A. Cell Sites.

i. *Inter-cell Handover.* A type of handover where the source and target are different cells that may or may not be on the same cell site is known as inter-cell handover.Its purpose is to maintain the session as user moves out of the area covered by source cell and enters the area covered by the target cell.

ii. *Intra-cell Handover.* A type of handover where only the channel currently in use is change while the source and target are on

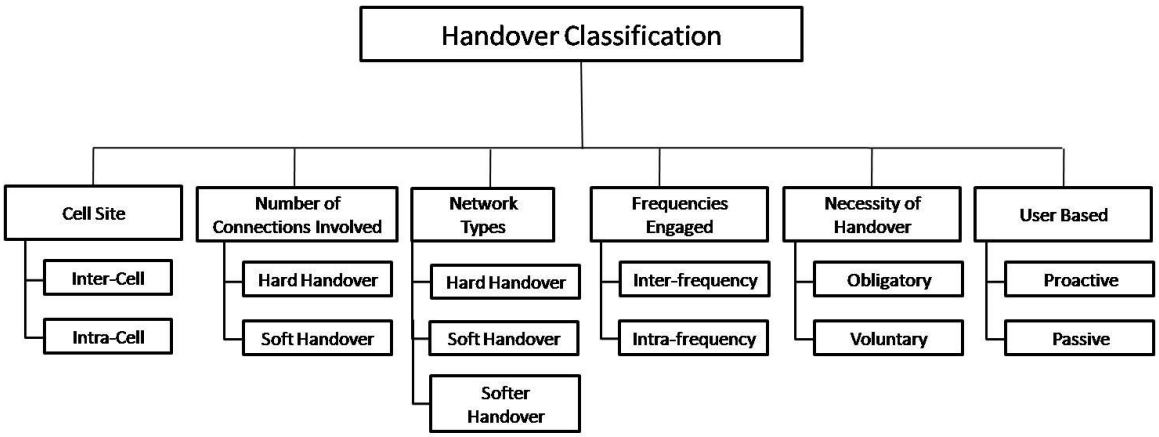

Fig 3. Classification of Handover

the same cell is called as intra-cell handover. The purpose of this handover is to change the channel which may be inferred by a new clearer channel.

B. Number of connections involved.

i. *Hard Handover.* A type of handover where a Mobile Node (MN) can maintain a connection with only one BS at a time. In this, the connection of mobile with source cell is released first, and then the connection with target cell is established. Thus the connection is first broken from source then is made with target- for this reason; it is also known as *break-before-made.*

ii. *Soft Handover.* A type of handover where a MN must be in connection with at least 2 BS and does not release any of these until signal drops below a threshold value. In this, the connection of MN with source is retained and is used in parallel with the target cell. It is also known as *make-before-break* as the connection to the target is created before the connection to the source is broken. It is possible to use in situations where the frequency of the ells in which MN is moving is same.

iii. *Softer Handover*. It is a special case of soft handover where the mobile terminal switches connections over radio links that belong to the same access point.

C. Frequencies engaged.

i. *Inter-frequency Handover.* This type of handover is used for MN across access points which operate on different frequencies. This is the only handover supported in GSM cellular system.

ii. *Intra-frequency Handover.* This type of handover is used for MN across access points which operate on same frequency. It occurs in CDMA networks with Frequency-Division-Duplex (FDD).

D. Necessity of Handover.

i. *Obligatory/ Compulsory Handover.* A type of handover where it is necessary for the MN to perform handover and transfer the connection to another BS in order to avoid disconnection.

ii. *Voluntary/ Optional Handover.* A type of handover where the transfer of connection is optional which may or may not improve the Quality of Service.

E. User Based Handover.

i. *Proactive Handover.* In this type of handover, MN's user is given access to decide when to handoff. The decision for handover is based on the preferences specified by the user. It is considered to be one of the radical features of 4G wireless connection.

ii. *Passive Handover.* In this type of handover, the user has no control over the handoff

decision. It is commonly used in First, Second and Third Generation wireless system.

F. Network Based Handover.

i. Horizontal Handover. A type of handover that takes place when the source cell and target cell belongs to the same network technology is known as Horizontal Handover. It is used in homogenous technologies like First and Second Generation technologies. For example, the changeover of signal between two neighbouring BS of cellular network.

ii. Vertical Handover. A type of handover that takes place between the access points supporting different network technologies is called Vertical Handover. It is used in heterogeneous network like 4G. For example, the changeover of signal between cellular network and WiMax technology. Fig 4 shows horizontal and vertical handover.

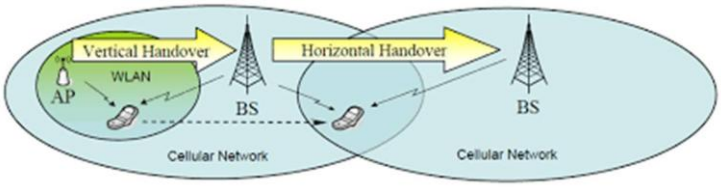

Fig 4. Vertical and Horizontal Handover

IV. Requirements for Handover Mechanism

The requirements for Handover Mechanism can be classified into two categories: Dynamic and Non-Dynamic. Fig 5 shows the classification of requirements for handover mechanism.

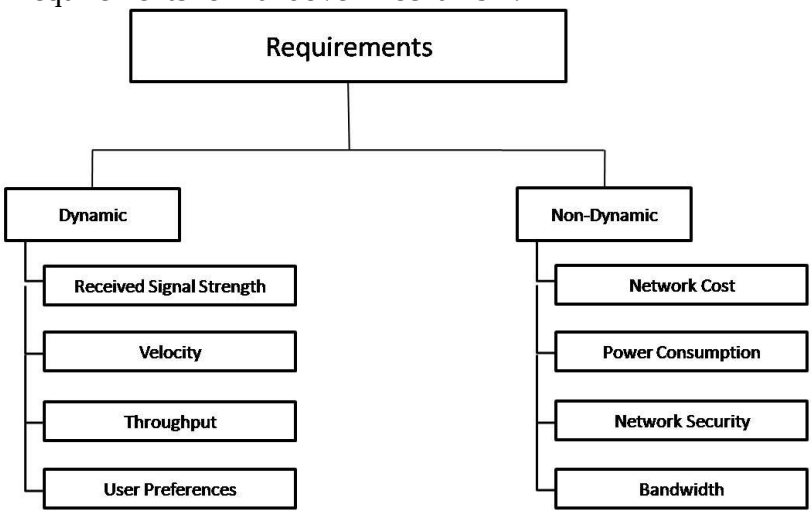

Fig 5. Requirements for Handover Mechanism

The dynamic requirements RSS, velocity, throughput, user preferences; and non-dynamic requirements include network cost, power consumption, network security and bandwidth. A good handover mechanism decision model should have both dynamic and non-dynamic metrics. However, it is important to consider maximum number of static and dynamic requirements during VHO.

1) Bandwidth: Bandwidth is the difference between the upper and lower frequencies in a contiguous set of frequencies. It is a measure of the width of a range of frequencies. In order to provide seamless handover for Quality of service (Qos) in wireless environment, Bandwidth requirement of mobile node need to be managed during the movement.It is generally known as the link capacity in a network. Higher offered bandwidth provides higher throughput which ensures lower call dropping and call blocking probabilities [2]. Bandwidth handling should be an integral part of any of the handover technique.

2) Handover Latency: Handover Latency is defined as the delay that occurs during the process of handover of calls between two BS. Handover Latency factor should be considered for developing a good handover decision model, also it should be minimized. The service quality of many applications of mobile users is affected by Handover Latency.

3) Power Consumption: In NGWN, there is a need to find ways to improve energy efficiency. Power is consumed by user terminal during handovers and also attributed to base station equipments. At the user's terminalfrequent interface activation causes battery drainage while in network discovery, the unnecessary interface activation during handover also increases power consumption. Thus it is also

important to incorporate power consumption factor during handover decision.

4) *Network Cost:* The network cost during Handover Mechanism should be kept minimum. Thus an algorithm for handover should also consider the network cost factor. The new call arrival rates and handover call arrival rates can be analysed using cost function. Next Generation Heterogeneous Networks can combine their respective advantages on coverage and data rates, offering a high Quality of Service (QoS) to mobile users. In such environment, multi-interface terminals should seamlessly switch from one network to another in order to obtain improved performance or at least to maintain a continuous wireless connection. Therefore, network selection cost is important in handover decisions.
5) *User Preferences:* When handover happens, the users have more options for heterogeneous networks according to their preferences andnetwork performance parameters. The user preferences could be preferred networks, user application requirements (real time, non-real time), service types (voice, data, video), Quality of service (It is a set of technologies for managing network traffic in a cost effective manner to enhance user experiences for wireless environments) etc. User Preferences can also be considered for VHO in 4G wireless networks.
6) *Network Throughput:* The average data rate of successful data or message delivery over a specific communications link is referred to as Network Throughput. It is measured in bits per second (bps). Maximum network throughput equals the TCP window size divided by the round-trip time of communications data packets. As network throughput is considered in dynamic metrics for making decision of VHO, it is one the important requirement to be considered for the VHO.
7) *Network Load Balancing:* Network load is to be considered during effective handover. It is important to balance the network load to avoiddeterioration in quality of services. Variations in the traffic loads among cells will reduce the traffic-carrying capacity. To provide a high quality communication service for mobile subscribers and to enhance a high traffic-carrying capacity when there are variations in traffic, network load must be paid attention.
8) *Network Security:* Seamless and secure handover has become an important factor in wireless networks with their increasing demand. The network security consists of the provisions and policies adopted by the network to prevent and monitor unauthorized access, misuse, modification, and network-accessible resources. Since in a wireless environment, data is broadcast through the air and there is no physical control over the boundaries of transmissions, so the security features provided in some wireless products may be weaker. In order to attain the highest levels of integrity, authentication, and confidentiality, network security features should be embedded in the handover policies.
9) *Received Signal Strength (RSS):* The performance of a wireless network connection depends upon signal strength. The total amount of network bandwidth available along a connection is determined by wireless signal strength between a mobile node (MN) and access point (AP) in each direction. RSS depicts the power present in a received signal. A signal must be strong enough between BS and MN to maintain signal quality at receiver. The RSS should not be below a certain threshold in a network during handover.

10) *Velocity:* Velocity of the host should also be considered during handover decision. Because of the overlaid architecture ofheterogeneous networks, handing off to an embedded network, having small cell area, when travelling at highspeeds is discouraged since a handover back to the original network would occur very shortly afterwards[2].

V. VERTICAL HANDOVER: HANDOVER IN HETEROGENEOUS NETWORK

Heterogeneous Network is a type of network which connects devices (computers, mobile, etc) with different protocols and standards. For example, a wireless network providing service through WLAN is able to maintain the service when switching to a cellular network composes a heterogeneous network.

Fig 6 shows an example of Heterogeneous Network.

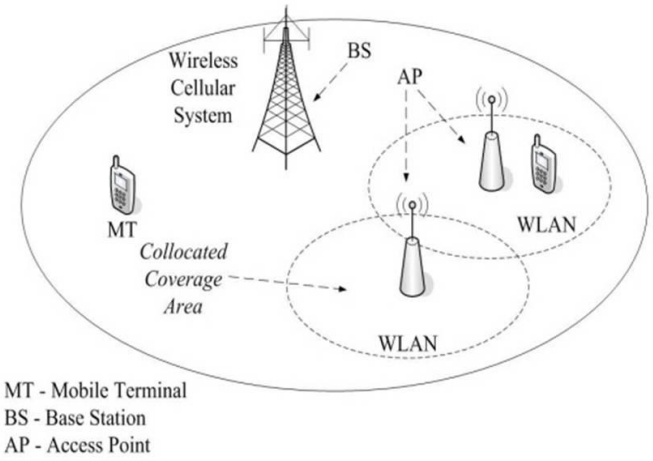

Fig 6. Heterogeneous Network

NGWN is pool of networks which is made up of heterogeneous network managed by different operators like 4G, 3G, 2G mobile communications, WLAN, satellite and WiMax. One of the major issues in 4G is mobility when the user moves from BS of one kind to BS of another kind, the mechanism used to ensure mobility is Handover.

In heterogeneous network, Vertical handover (VHO) is used to provide continuous service. VHO scheme is used to preserve connectivity as devices move about and at the same time certain disturbance may also exist.

A type of handover that takes place between the access points supporting different network technologies is called Vertical Handover. It is used in heterogeneous network like 4G. For example, the changeover of signal between cellular network and WiMax technology.Fig 7 shows Vertical Handover.

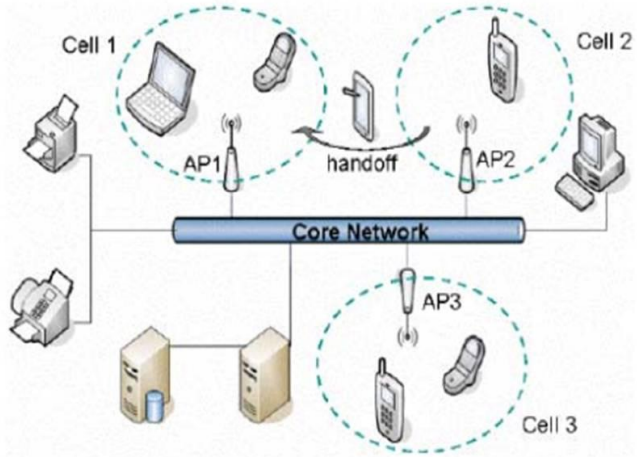

Fig 7. Vertical Handover in Heterogeneous Network

The main capabilities of VHO which makes it quite efficient for providing mobility in 4G are:

i. Multiple network connections are used.
ii. Multiple IP addresses are used.
iii. VHO uses different access technologies.
iv. Multiple network interfaces are used.

A Vertical Handover (VHO) process involves 3 phases- System Discovery Phase, Decision Phase and Execution Phase.

i. *System Discovery Phase.*In this phase, the MN determines the network to be used and the time at which handover will take place. This phase is invoked periodically.

ii. *VHO Decision Phase.*In this phase, the MN determines whether to switch to another network or continue using the existing one. This decision depends upon various parameters including type of application, access cost and delay required by application.

iii. *VHO Execution Phase.*In this phase, the MN is re-routed to the new network selected

in phase-1 from the existing network in a seamless manner. This phase also includes authorization, authentication and transfer of user's information.

VI. Desirable Features for Vertical Handover Decision Algorithm

Any handover must exhibit low latency, high efficiency, minimal amount of data loss, and can be implemented to large scale networks. Following are some of the desirable features which must be provided by a VHO decision algorithm[3]:

- *Reliable.* A handover algorithm should be reliable, i.e. quality of call should be good
- *Seamless.* A handoff algorithm should be fast so that MN does not experience service interruption to the on-going session.
- *Interference Prevention.* Handoff algorithm should provide low interference.
- *Load Balancing.* Handover algorithm should balance network traffic in all cells.
- *Improving Performance.* Number of handoffs should be minimized to reduce the expense. A low number of handoffs will help in preserving the quality of signal for longer period of time.

VII. Conclusion

Keeping in mind the objective of the paper, i.e. to provide overview of handover in mobile technology with main focus of vertical handover, various key points and terminologies related to handover have been discussed. The paper provides the basic knowledge which includes handover, its types and when to perform it. It also discusses various requirements which must be taken into consideration while developing a handovermechanism. We also came to know that VHO is an essential component for NGWN where a mobile user switches between heterogeneous network environments. This paper provides a brief idea on handover to the novice academicians and researchers.

A

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