

# HANDOVER in GSM and WiMAX

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**Abstract-**Handover mechanism is extremely important in cellular network because mobility is the distinct feature of wireless mobile cellular system. When a mobile subscriber moves between different radio networks while using network, a handover process is needed. The continuation of an active call is one of the most important qualitative feature in cellular systems. In this paper we aim to present an overview of handover, type of handover, Handover Detection, purpose of handover, handover in GSM and WiMAX. Handover is a process in telecommunication and mobile communications in which a connected cellular call or a data session is transferred from one cell site (base station) to another without disconnecting the data session or call. There are two type of handover: Hard handover and soft handover. The handover in which the connection to the source is broken before the connection to the target is made is called hard handover. This is called break-before-make.

**Index terms:** Handover, 5G, GSM, WiMAX.

## I. INTRODUCTION

Mobility is the unique feature of wireless mobile cellular system. As a mobile subscriber move between different radio networks [1-3] while using the network, a handover process is needed to change its point of attachment i.e. Base Station. The continuation of an active call is the most important feature in cellular systems. In a cellular system a base station has only a limited area of coverage. Hence it is possible for a moving subscriber to get out of reach of the base station while making a call or during transmission. The process by which a data session or call is transferred from one base station to another, as the subscriber crosses the boundary of a cell is called a handover [4]. It is the process in Tele and Mobile communication where a data session or connected call is transferred from one base station to another base station without the loss of the transmission. In

other words, handover is the process of giving control (responsibility) of the one network to another network without any interruption or loss of the service. In satellite, handover is the process where the control ability is transferred from one base station to another base station without causing any interruption. Cellular services are based on mobility and handover, allowing the user to be moved from one cell site range to another [5-7] or to be switched to the nearest cell site for better performance.

## II. Overview of Handover

In this section we will discuss different types of handover.

### 1. Types of Handover:

Handoff is the mechanism which transfers an ongoing call or data session from one cell to another cell as the users move during a call or data transmission. If handoff does not occur quickly, the connection will be lost due to the degradation of Quality of Service (QoS). Handoffs are divided into two categories – *hard and soft handoffs*, which are further classified.

#### a. Hard Handover:

The handover is one in which the channel in the source cell is released, then the channel in the target cell is engaged. Thus the connection to the source is broken before the connection to the target is established. Such handovers are also known as *break-before-make*. Hard handovers are intended to be immediate in order to minimize the interruption to the call. It requires the less processing by the network service providing. When the mobile is between two base stations, then the mobile can switch with any of the two base stations [8-13], then the base stations bounce the link with the mobile back and forth. This is called ping pong. Hard handoff can be further divided as intra and inter-cell handoffs.

- i. **Intra-cell handoff:** In intra-cell handoff the source and target are one and the same cell and only the used channel is changed during the handoff. The purpose of intra-cell handoff is to change a channel, which may be interfered, or fading with a new clearer or less fading channel.
- ii. **inter-cell handoff:** In inter-cell handoff the source and the target are different cells (even if they are on the same cell site). The purpose of the inter-cell handoff is to maintain the call as the subscriber is moving out of the area of the source cell and entering the area of the target cell. Finally, hard handoff is permitted between members of different soft zones, but not between members of the same soft zone. This is primarily used in FDMA and TDMA.

**b. Soft Handover:**

A Soft Handover is one in which the channel in the source cell is retained and used for a while in parallel with the channel in the target cell. In this case the connection to the target is established before the connection is broken to the source, so this handover is called *make-before-break*. The time interval, during in which the two connections are used in parallel [14]. Using connections to more than two cells include in Soft Handover. At the same time more than one connections to three, four or more cells can be maintained by one phone [15]. When a call is in a state of soft handover, the signal of the best of all used channels can be used for the call at a given moment or all the signals can be combined to produce a clearer copy of the signal. The latter is more effective, and when such combining is performed both in the downlinked or uplinked the handover is termed as *softer*. Softer handovers is possible when the cells in the handovers involved a single cell site. Soft handoffs can be classified as Multi-ways and softer handoffs. In soft handoffs the chance that the call will be terminated abnormally are lower [16-18]. Call could only fail if all the channels are interfered or fade at the same time. But this involves the use of several channels in the network to support just a single call. This reduces the number of remaining free channels and thereby reducing the capacity of the network [19]. Soft handoff is permitted between members of a particular soft zone, but not between members of different soft zones.

- i. **Multi-ways handover:** A soft handoff which involves using connections to more than two cells is a multi-ways handoff.
- ii. **Softer handover:** When a call is in a state of soft handoff the signal of the best of all used channels can be utilized for the call at a given moment or all the signals can be combined to produce a clear signal, this type is called softer handoff.

**c. Handover Purpose:**

All the area is covered with the cell which is also called 7cells when a person with a phone is moving from one cell to another cell then the call need to transferred to second cell in order to avoid the termination of the call when the call is outside the range of the first cell when the capacity of new calls is full and a new user is come in the existing cell then the call is transferred to The neighbored cell in order to connect that call.

- i. When the capacity for connecting new calls of a given cell is used up and an existing or new call from a phone, which is located in an area overlapped by another cell, is transferred to that cell in order to free-up some capacity in the first cell for other users, who can only be connected to that cell.
- ii. In non-CDMA networks when the user behavior changes, e.g. when a fast-travelling user, connected to a large, umbrella-type of cell, stops then the call may be transferred to a smaller macro cell or even to a micro cell in order to free capacity on the umbrella cell for other fast-traveling users and to reduce the potential interference to other cells or users (this works in reverse too, when a user is detected to be moving faster than a certain threshold, the call can be transferred to a larger umbrella-type of cell in order to minimize the frequency of the handovers due to this movement).
- iii. In non CDMA networks when the channel used by the phone becomes interrupted by another phone using the same channel in a different cell, then the call is transferred to a different channel in the same cell or to a different channel in another cell in order to avoid the interruption;
- iv. In CDMA networks a handover may be induced in order to reduce the interference

to a smaller neighboring cell due to the "near-far" effect even when the phone still has an excellent connection to its current cell.

- v. The most basic form of handover is when a phonecall in progress is redirected from its current cell (called source) to a new cell (called target). In terrestrial networks the source and the target cells may be served from two different cell sites or from one and the same cell site (in the latter case the two cells are usually referred to as two sectors on that cell site) [20].
- vi. Such a handover, in which the source and the target are different cells (even if they are on the same cell site) is called inter-cell handover. The purpose of inter-cell handover is to maintain the call as the subscriber is moving out of the area covered by the source cell and entering the area of the target cell.

#### **d. Reasons of handover failure:**

Handover failure can occur for a number of reasons. Some of them are listed below:

- i. The network takes too long to set the handover after the handover has been initiated.
- ii. There is no available channel on the target base stations.
- iii. The target link fails in some way during the execution of handoff.
- iv. Handoff is denied by the network, either for lack of resources or because the portable has exceeded some limit on the number of handoffs which may be attempted in some period of time.
- v. In some other systems, handoffs can fail due to resource blocking.

#### **e. Handover in different types of cellular networks:**

First, we discuss handover in GSM followed by WiMAX.

#### **1. Handover in GSM**

The purpose of the handover procedure is to preserve ongoing calls when the mobile station moving from one cell to another. In GSM, measurements reports to perform the handover, which is made by the serving BSC has no direct knowledge of the radio quality [21-24]. These measurements reports contain the radio signal quality of the downlink from the BTS to MSC of the call and up to five neighboring cells. The serving BTS measures the uplink from the MSC to BTS radio signal quality of the call and forward in the measurements reports. The information in the measurements reports the BSC is able to decide whether a handover to another cell is needed [25]. These measurements reports are periodically transmitted from the MSC to BSC on the SACCH channel assigned to each communication for every connection.

In many cases these measurements reports takes place to take handover procedure in a way to avoid shortcomings [26-33]. A connection is continuously measured and evaluated by the respective base station and MSC. Handover is based upon that evaluation. As the mobile users leaves the coverage area of the one base station must obtain coverage from the neighboring station in order to keep the connection keep on. Cut off connection or drop call are not acceptable at any level during the call. Handover take places when the traffic level of cell reaches to high level or when neighboring are being underutilized. The figure 8, Summarizes the handover causes showing the percentage of different reasons of handover. Although as far as the mobile is concerned, they are effectively seen as very similar. There are a number of levels involved in understanding a GSM handover from one cell or base station to another cell or base station.

In GSM which uses TDMA protocol techniques the transmitter send for one only slot in eight, and similarly the receiver only receives for only one slot in eight. As a result the RF section of the mobile could be free for 6 slots out of the total eight. This is not the case because during the slots in which it is not communicating with the BTS, it scans the other radio channels looking for beacon frequencies that may be stronger or more suitable. In addition to this, when the mobile communicates with a specific BTS, one of the reaction it makes is to send out a number of the radio channels of the beacon frequencies of the

surrounding BTSs over the Broadcast Channel (BCCH).

The BTS received back the report back the quality of the link when the mobile scan. In that way the mobile assists to make the handover decision and as a result this form of GSM handover is known as Mobile Assisted Hand-Over (MAHO).

The network knows the quality of the link between the mobile and the BTS as well as the strength of local BTSs as reported back by the mobile. It also knows the availability of channels in the nearby cells. As the result it has all the information it needs to be able to make a decision about whether it needs to hand the mobile over from one BTS to another.

If the network decides that it is necessary for the mobile to hand over, it assigns a new channel and time slot to the mobile. It informs the BTS and the mobile of the change. The mobile then retunes during the period it is not transmitting or receiving, i.e. in an idle period.

#### f. Hard handover:

Hard handoff means *break-before-make*, connection to the source is broken before or 'as' the connection to the target is made. In a hard handoff, the link to the prior BS is terminated before or as the user is transferred to the new cell's BS. That is why hard handoff is also known as *break-before-make*. In this case, the MS is linked to no more than one BS at any given time.

Hard handovers are intended to be instantaneous in order to minimize the disruption to the call. A hard handover is perceived by network engineers as an event during the call. It requires the least processing by the network providing service. When the mobile is between base stations, then the mobile can switch with any of the base stations, so the base stations bounce the link with the mobile back and forth. This is called ping-ponging. Hard handoff is primarily used in OFDMA (orthogonal frequency division multiple access) and TDMA (time division multiple access) (i.e. GSM), where different frequency ranges are used in adjacent channels in order to minimize channel interference. So when the MS moves from one BS to another BS, it becomes impossible for it to communicate with both BSs (since different frequencies are used).

If the handoff is performed between two time slot or channel in the same base station, it is called intra cell handoff or intra base station handoff.

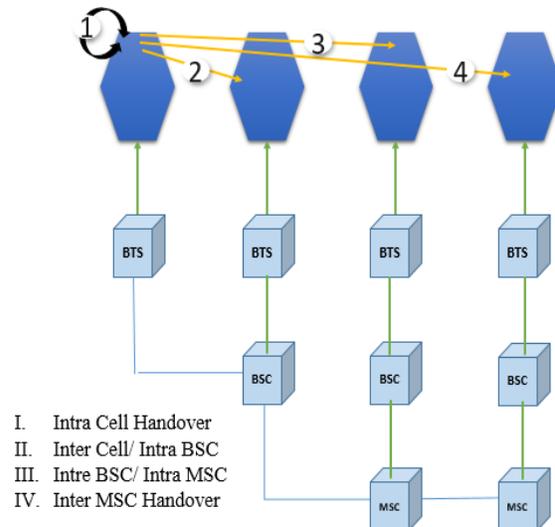


Figure 1: Hard Handover

On the other hand, if the link is transferred between two base stations (BS) connected to the same base station controller (BSC), is called inter cell handoff or inter BS handoff.

Further, if the link is transferred between two base stations (BS) connected to the different BSCs on the same mobile switching center (MSC), is called inter BSC handoff. The inter BSC handoff is also known as intra MSC handoff. And, if the link transfer takes place at two base stations connected to different BSCs, it is known as inter MSC handoff. If during ongoing call mobile unit moves from one cellular system to adjacent cellular system [34-36] which is controlled by same mobile telephone switching office (MTSO), a handoff procedure which is used to avoid dropping of call is referred as Intra System Handoff. When a mobile signal becomes weak in a given cell and MTSO find other cell with in its system to which it can transfer the call then it uses Intra system handover. Finally, if during ongoing call mobile unit moves from one cellular system to a different cellular system which is controlled by different MTSO, a handoff procedure which is used to avoid dropping of call is referred as Inter System Handoff. When a mobile signal becomes weak in a given cell and

MTSO cannot find other cell with in its system to which it can transfer the call then it uses Inter system handoff. On the other hand, Inter system handoff is the handover between different radio systems, e.g. UMTS - GSM.

**g. Soft handover in GSM:**

Soft handoff is a "Make before break" handoff. That is, the mobile station (MS) is up on a call and moves from one base station (BS) to another, but the MS starts communicating with a new BS before terminating communications with the old BS. Soft handoffs can only be used between BSs on the same frequency. The technique improves reception as MSs Move between cells (on cell boundaries). During soft handoff the MS actually communicates with more than one BS at a time, so that when it's time to move from the weaker BS to the stronger one, the MS is already in communication with the stronger one. During a soft handoff, the mobile station receives independent closed loop power control bits from the two BSs and perform "Or of Downs" logic to determine how to adjust its power. That means the mobile station will increase its power level if and only if both power control bits from the two BSs are 0 (indicating up). If the power control bit from any base station equals to '1' (indicating down), the mobile station shall decrease its power. Soft handover or soft handoff refers to a feature used by the CDMA and W-CDMA standards, where a cell phone is simultaneously connected to two or more cells (or cell sectors) during a call. If the sectors are from the same physical cell site, it is referred to as softer handoff. In power controlled CDMA systems soft handoff is preferred over hard handoff strategies. This is more pronounced when the IS-95 standard is considered wherein the transmitter [the base station] power is adjusted dynamically during the operation. Here the power control and soft handoff are used as means of interference-reduction, which is the primary concern of such an advanced communication system. The previous and the new wideband channels occupy the same frequency band in order to make an efficient use of bandwidth, which makes the use of soft handoff very important. The primary aim is to maintain a continuous link with the strongest signal base station otherwise a positive power control feedback would result in system problems. Soft handoff ensures a continuous link to the base station from which the strongest signal is issued. A softer

handoff occurs when the MS is communicating with two sectors of a cell.

**III. Handover in Mobile WiMAX:**

WiMAX stands for Wireless Interoperability for Microwave Access. It is a telecommunication technology that provides wireless data communication over a long distances in several ways, from point-to-point connection to full mobile cellular type access. The main objective of Mobile WiMAX is seamless handover such that there is no loss of data. In WiMAX both Mobile and Base station (MS and BS) scans the nearest base stations to selecting the best one for a potential handover. The Mobile device should be able to change its serving base station if there exists another base station with better signal strength in the reach of mobile station (MS). Handover is a procedure that provides continuous connection when a MS migrates from the air interface of one BS to another air-interface provided by another BS without interfering the existing connections. Handover provides mobility. For the occurrence of handover, at least two base stations are necessary, serving (source) base station (SBS) and target base station (TBS). The handover is considered generally as the change of serving base station but it does not mean that the base station must be changed.

For the implementation of a mobile network, a handoff mechanism must be defined to maintain user communication session during his/her movement from one place to another without interruption. Handoff mechanism handles subscriber station (SS) switching from one Base Station (BS) to another base station. Different handoff techniques have been developed. Generally, they can be divided into two types, soft handoff and hard handoff.

**a. Hard handover:**

Mobile WiMAX has been designed similar as a broadband technology capable of delivering three services (voice, data, Video). However, a typical Mobile WiMAX network is dominated by delay-tolerant data traffic. Voice in Mobile WiMAX is separated into packets (what is called VoIP) and treated as other types of IP packets except it is prioritized. Therefore Hard handoff (HHO) is used in Mobile WiMAX. In hard handoff, a connection with a Base Station (BS) is ended first before a Subscriber station (SS) switches to another Base station (BS).

This is known as *break-before-make* approach. Hard handoff is more efficient than soft handoff, but it causes a bit longer delay. A network-optimized hard handoff mechanism was developed for Mobile WiMAX to keep a handoff delay under 50ms.

The entire process of HHO in IEEE 802.16e is broadly divided into Network Topology Acquisition Phase (NTAP) and the Actual Handover phase (AHOP). Detailed explanation of the entire procedure can be found in Network Topology Acquisition Phase: During the NTAP, the MS and serving BS (SBS), together with the help of the backhaul network, gather information about the underlying network topology before the actual handover decision is made.

This is done to identify lists of potential NBSs, out of which one particular TBS may be chosen for the handover activity. The major tasks involved in this phase are briefly as follows: BS advertises the Network Topology: Using MOB NBRADV (Mobile Neighbor Advertisement) message, the SBS periodically broadcasts information about the state of the NBSs, preparing for potential handover activities. The SBS keeps on gathering these channel information of the NBSs with the help of the backbone network. The MS scans the advertised BSs within specific timeframes, to select suitable candidate BSs for the handover. A list of potential candidate TBSs is thus maintained. This procedure is carried out with the help of Scanning Interval Allocation request and response messages (MOB SCN-REQ and MOB SCN-RSP), respectively, sent by the MS and the SBS. In the end, Scanning Result Report (MOB SCN-REP) summarizes all the scanning activities [33].

Ranging and Optional Association Activities: The scanning is followed by contention/non-contention ranging activities through which the MS gathers further information about the PHY channel related to the selected TBSs. Ranging Request (RNG REQ) and Ranging Response (RNG RSP) messages are used for this purpose. Ranging may be followed by optional association activities through which the MS gets associated with the potential target BS candidates [35]. Association Result Reports (MOB ASC-REP) are used for this purpose.

## **b. Soft Handover:**

Also known as “*make-before-break*”, means that in this type of handover mechanism the connection of MSS with source BS is retained until the establishment of connection with another i.e. target BS. In this manner the MSS is connected with two (or may be more) BS at a given piece of time. The time for which both the connection run in parallel may be very small but also may grow large in some conditions.

The soft handover, in contrast to hard handover, establishes multiple connections with neighboring cells. Soft handover is used by the code division multiple access (CDMA) systems where the cells use same frequency band using different code words. It is suitable to handle voice and other services such as Internet multiplayer game and video conference. When used for delivering data traffic (such as web browsing and e-mail), soft handoff will result in lower spectral efficiency [36-44] because this type of traffic is busy and does not require continuous handover from one BS to another. Each MS maintains an active set where BSs are added when the RSS exceeds a given threshold and removed when RSS drops below another threshold value for a given amount of time specified by a timer. When a presence or absence of a BS to the active set is encountered soft handover occurs. The systems using soft handoff are Interim Standard 95 (IS-95) and Wideband CDMA (WCDMA).

## **IV. Conclusion:**

In this paper we introduce handover, its types, handover detection, purpose of handover, and reasons of handover failure. Furthermore we have discussed handover in two types of cellular networks i.e. handover in GSM and WIMAX. We also discussed the most important procedure of GSM handover, handover types and their measurements reports to ensure mobility in GSM network. For every specific network environment specific handover is suitable. To emphasize the fact that handover in GSM network are very important to maintain the quality of a call. The technology of hard handover is applicable for

low speed mobile WIMAX networks, it is cheaper and simple.

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