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A Review: Handover in 3G/UMTS Network

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Abstract
Mobile communication with new technology is the fastest growing area with regularly increased data rates and coverage areas. Therefore the upcoming challenge is to make the best possible use of the available different types of networks. For connecting mobile heterogeneous networks handover is necessary. In this paper UMTS technology is used to describe the handover from one mobile circle to another. The third generation mobile communication system UMTS is the successor of GSM technology. It supports the seamless handover between cells of one operator and efficient handover between UMTS and 2nd generation. This paper covers the basic architecture of the UMTS network, the different parts and connections between them are also described. This paper focuses on the different handover types in the third generation mobile system Universal Mobile Telecommunication System (UMTS) .At the end of the paper the comparison between the different types of handover is also discussed.

Keywords: UMTS, RNC, soft handover, softer handover, hard handover

1. Introduction

In this era the mobile communications are commonly seen as one of the most advanced form of human communications ever. In the last decade GSM technology is a leading revolution generation wireless system. UMTS is a part of the IMT-2000 family of 3G mobile communication system. The UMTS network is also called as Global System for Mobile communications (3GSM) because it evolved from that system and the air interface (WCDMA) for the UMTS network is based on Wideband Code Division Multiple Access (WCDMA) and includes the High Speed Packet Access (HSPA) specification. This architecture is as according to the third generation project (3GP) requirements. Besides providing changes in the network infrastructure the UMTS specifications point out the evolution path from GSM circuit switched networks towards packet switched technologies offering higher transmission rates [1].

In mobile communication, Handover is a process when a user switches to another channel without any interruption. It enables the users to receive their calls anywhere and at any time. In Handover process the existing link is replaced by another cell. The network controller decides from the measurement reports about the link quality that the hand over process is needed to another cell or not. The main aim of the handover process is to permit the mobile users to roam freely from one mobile network to another either the network are same or different.

Mobile networks are also called as cellular networks, are based on different multiple access schemes in their radio interface (communication between mobile station and base station). Traditional multiple access schemes such as, Frequency Division Multiple Access (FDMA), time division multiple access (TDMA) and code division multiple access (CDMA) are utilized in first generation and second generation systems.

Analog FDMA-based networks, such as Advanced Mobile Phone Service (AMPS), Nordic mobile telephone (NMT), and Personal handy phone system (PHS) are called first-generation systems. The first digital mobile network, such as North American TDMA and CDMA, European Global System for mobile communication (GSM), and Japanese personal digital cellular telecommunication system (PDC) are called second generation systems. Enhancements of 2G systems, such as packet transmission –General packet radio system (GPRS) and Enhanced data calls for GSM evolution (EDGE) are usually referred as 2.5G.

In the 3G they take a standardization work for entire mobile hierarchy GSM, GPRS, EDGE and UMTS. The UMTS network is also called Global System for Mobile communications (3GSM) because it evolved from that system and the air interface (WCDMA) for the UMTS network is based on Wideband Code Division Multiple Access (WCDMA) and includes the High Speed Packet Access (HSPA) specification. The Internet protocol was based on General-Packet Radio Service (GPRS), which evolved into EDGE.

Necessity of Handover process:

• When the movement of the user equipment/cell phone is very fast.
• The movement of the user's equipment from one cell to another during an ongoing session.
• The experience of interference phenomena by the user's equipment from the near cell.

1.1 UMTS Architecture

This architecture is as according to the third generation project (3GP) requirements. Basically the network can be split up into three different parts: the User Equipment domain (UE) , the UMTS Terrestrial Radio Access Network (UTRAN) and the Core network part

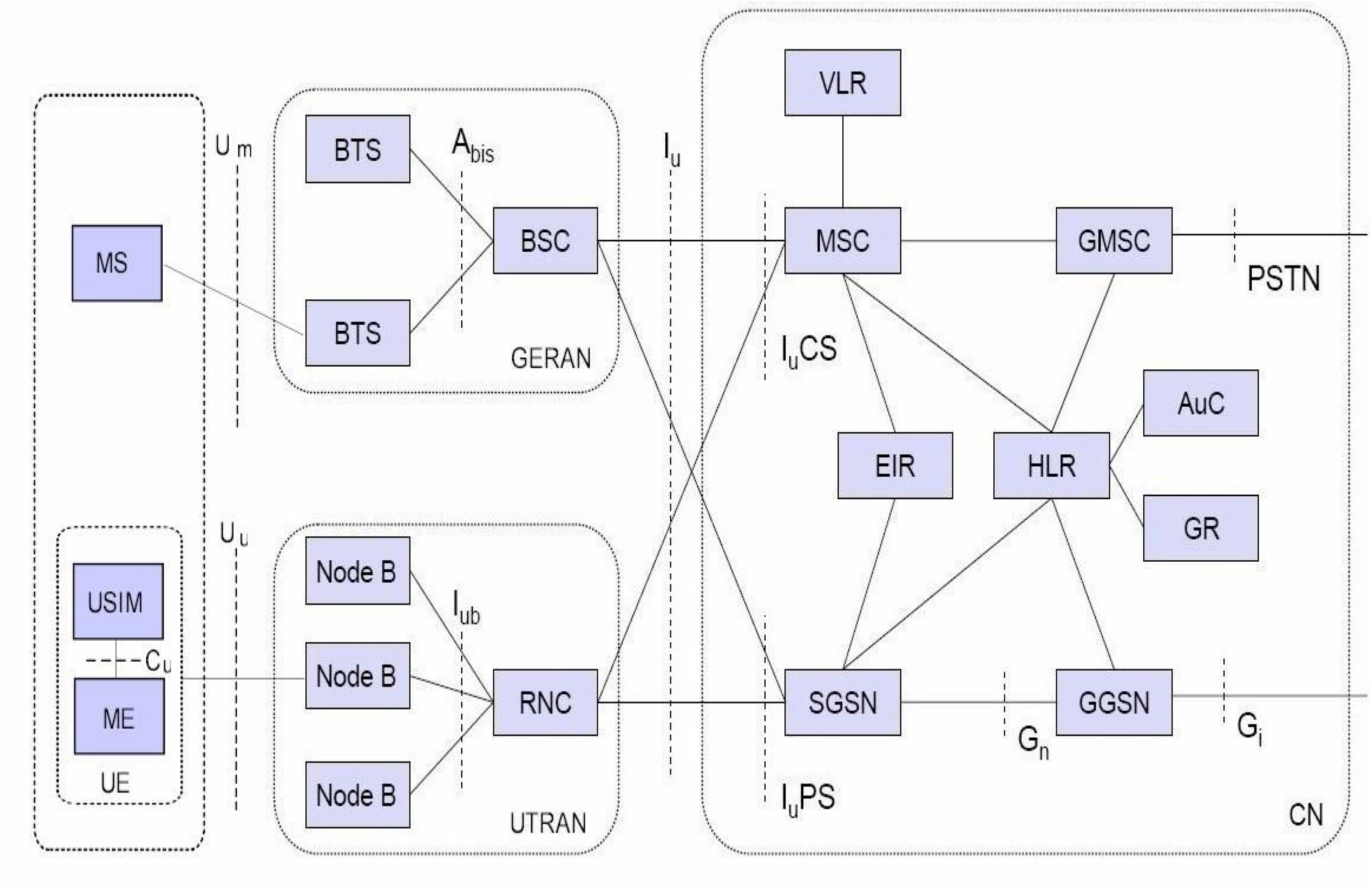

Fig.1 UMTS Architecture

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1.1.1User Equipment domain

The user equipment domain contains the 3 parts.

- **The mobile station**

Fancy handheld devices have been one of the main factors for the phenomenal success of wireless communications. This part of system architecture commonly known as 'mobile' and called as user equipment domain. It describes the equipment used by the user to establish a radio connection to the UMTS network and access the services offered. The User Equipment can be seen as the counterpart of other network elements as its functionality and procedures implemented are also present in the RNC, Node B and the Core Network.

- **The Node B**

The node B provides the same functionality as the Base transceiver station (BTS) in GSM .the main function of Node B is providing the physical radio link between the UE and the network .Concerning handovers, the node B controls softer handover, i.e. the situation where a mobile station is in the overlapping coverage area of two adjacent sectors of the same base station. The Node B is responsible for combining the different uplink signals received from both sectors, sent by one mobile station.

- **The RNC**

The RNCs are responsible for most of the resource control in the UTRAN access network. The load/overload situation of the network is measured by the RNC and controlled by making different handover decisions. This makes the RNC the key element in the handover processes. More specifically for the soft handover process, the RNC fulfils the important task of combining the multiple data signals received from different mobile station.

1.2 UTRAN

UTRAN stands for **Universal Terrestrial Radio Access Network** is a collective term for Radio Network Controller (RNCs) which make up the UMTS radio access network. This communications network , commonly referred to as 3G for 3rd Generation .Mobile Communication Technology, can carry many traffic types from real-time Circuit Switched to IP based Packet Switched. The UTRAN also allows connectivity between the user and the core network.

The UTRAN consists of one or more radio network subsystems (RNS) each containing a radio network controller (RNC) and a group of node B's. There can be more than one RNS present in a UTRAN. There are four interfaces connecting the UTRAN internally or externally to
other functional entities: Iu, Uu, Iub and Iur.The, external interface is lu that connects the RNC to the Core Network (CN). The Uu is also external, connecting the Node B with the User Equipment (UE).The Iub is an internal interface connecting the RNC with the Node B. the Iur interface is an internal interface most of the time, but can, exceptionally be an external interface too for some network architectures. The Iur interface connects two RNCs with each other.

1.3 The Core Network

The core network of the UMTS can act as a universal cre for connecting different radio access and fixed networks.

- The **'phase 1'** core network consists of circuit switched and a packet switched part.

- **Serving GPRS Support Node (SGSN)**

The Serving GPRS Support Node keeps track of the location of an individual MS(Mobile Station) and performs Security functions and access control. The SGSN also exists in GPRS networks, where it connects to the Base Station controller (BSC). In UMTS networks this node is connected to the above-described Radio Network Controller (RNC) over the IuPS interface.

- **Gateway GPRS Support Node (GGSN)**

The Gateway GPRS Support Node supports the edge routing function of the packet switched GPRS . the GGSN performs the task of an IP router for external packet data networks. to protect the integrity of the GPRS core network, Firewall and filtering functionality are also associated with the GGSN along with a billing function.

- The **MSC** server handles the mobility management,

including the tasks previously performed by the Visitor Location Register (VLR). One MSC server can control multiple Radio Network Subsystems (RNS). Some connection management subtasks are carried out by the Media Gateway (MGW). Implementing the connection management in a MSC server increases the functionality as adding new servers can increase capacity.

2. Types of Handover: Different types of Handover are performed in the network.

1. Hard Handover: Hard handover is also known as "break before make" because this type of handover firstly breaks connection and after breaking makes a new connection with BS.
2. Soft Handover: Soft handover also known as "make before break" because this type of handover firstly build connection and after building a new connection with BS, break connection with old node-b.
3. Softer Handover: Softer handovers is a fact that a UE located in the coverage area of two sectors of one Node B and The UE communicates with one Node B via two radio channels.
3. Vertical Handover (Inter frequency): Vertical handover is normally used where the network service issues between 3G and 2G technology. E.g. UMTS and GSM [1]
4. Horizontal Handover (Inter system): Vertical handover is normally used where the network service issues between 2G and 2G technology. E.g. GSM and GSM [1]

2.1 Soft handover

Soft handover is the one handover in which connection is established before breaking the connection. This handover is known as "make before break". In Soft handover, a mobile at the same time communicates with two or more cells belonging to different BSs of the identical RNC (intra-RNC) or different RNCs (inter-RNC). When a call is in a state of soft handover, the most excellent signal is used or all the signals can be collective to generate a clearer copy of the signal.

Soft handover network consists of user equipment, node B, RNC, GGSN, SGSN and Server. The GGSN include all GPRS functionality that is needed to support GSM and UMTS packet services. The SGSN monitors user location and performs security functions and access control. The GGSN contains routing information for packet-switched (PS) attached users. It provides interworking with external PS networks such as the packet data network (PDN). The model's CN nodes include both SGSN and GGSN functionality. The Circuit Switched Network consists of no. of server. HLR server is used to store the home location of user equipment. VLR server is used to store the random location of user equipment.

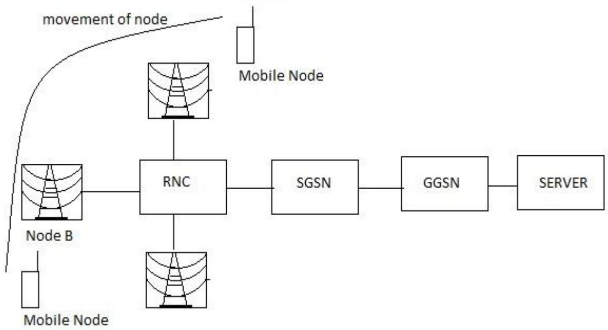

Fig2. Architecture of Soft Handover

Soft Handover is divided into 3 phases [7]: measurement, decision and execution. In measurement Phase: Calculate the ratio of Ec/No based on the RSCP (Received Signal Code Power) AND RSSI (Received Signal Strength Indicator) Using this Ec/No, each pilot [3] to decide on which cell UE is connected to.

$$Ec/No = \frac{RSCP}{RSSI}$$

RSCP is the power of decoded pilot channel. The performed Ec/No is sent by UE to Base Station and further send to RNC for decision of Handoff. In Decision Phase, RNC compares the measurement report with the predefined criteria. After decision phase, execution of soft handover is accomplished.

Advantages and Use of Soft Handover:

- Reduce fading of signal through macro diversity.
- Overcome Node B power which in turn decreases interference and increases capacity.
- Reduced UE power (up 4dB), decreasing interference and increasing battery life.
- does not lose contact with the system during handoff execution

2.2 Hard Handover

Hard handover has been applied when the user's equipment communicates with only just one Node B and the Connection with the old Node B has broken before the new connection is established. Handover is occurred when the signal strength from neighbor's cell exceeding the signal strength from the current cell.

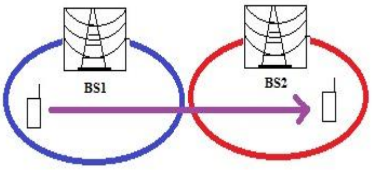

Fig. 3 Hard Handover

- **Comparison of Soft & Hard handover**

Fig 4. Represents that mobile terminal is activated while car is moving from cell 1 to cell 2 and BS1 is the real serving base station. First curve show Ec/Io (pilot signal) of BS1 and second curve show Ec/Io (pilot signal) of second BS2. In (a) the mobile continuously monitors the strength of the signal coming from the serving base station BS1, as the user moves across the boundary of first cell and moves into the second cell. At this time the mobile receives the pilot signal from second base station .The Ec/Io of BS2 is subtracted from Ec/Io of BS 1 and if the value is greater than hysteresis margin than hard handover is perform [4]. If we have a larger value of hysteresis it causes more delay.

In (b) it has been shown that the car moves across the boundary of two cells at that moment mobile receives the pilot signal of both base station i.e. BS1 and BS2. If the pilot signal strength of BS2 is greater than BS1 pilot signal strength and the handover condition has fulfilled and soft handover is performed. The mobile continuously communicates with the BS1 and BS2 before dropping the BS1. [3]

Soft handover causes less delay or no delay.

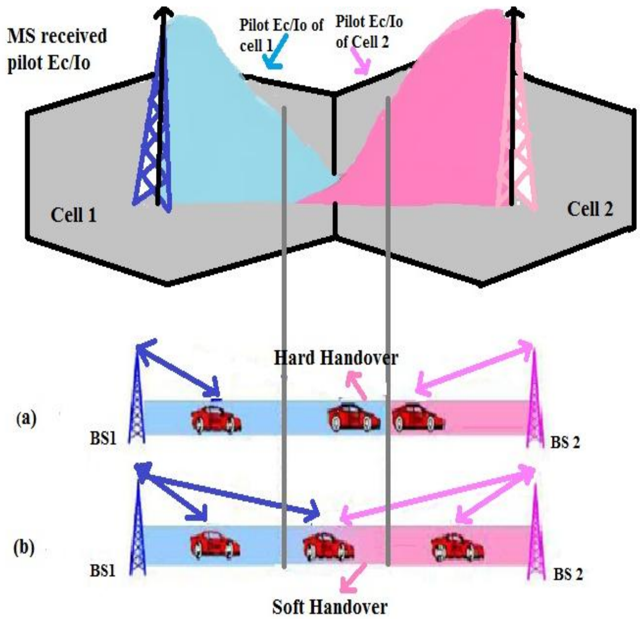

Fig. 4 Comparison of soft & hard handover

2.3 Softer Handover

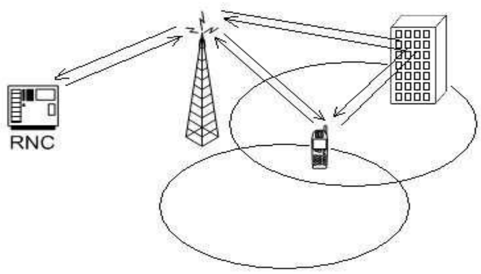

Fig 5 Softer handover

Softer handover is similar to soft handover. The only diff-erence between the soft and softer handovers is a fact that a UE located in the coverage area of two sectors of one Node B and The UE communicates with one Node B via two radio channels. In the downlink direction the situation of combining the signals is same as in the case of soft handover. In the uplink direction, the combination of the signals is realized in this Node B's rake receiver. [1]

2.4 Inter/intra-system handovers

Inter-system handover is realized when the UE moves among cells belonging to two different radio access systems. For example: between the UMTS and GSM systems. Before implementation of Inter System Handoff MTSO compatibility must be checked and in Inter System Handoff local call may become long distance call. Intra-system handover occurs within one communication system. Intra-system handover can be further

divided into inter-frequency and intra frequency handovers.
If during ongoing call user moves from one cellular system to adjacent cellular system which is controlled by same MSC, that handoff procedure which is used to avoid dropping of call is referred as Intra System Handoff.

2.5 Intra/inter-frequency handover

Intra-system handover can be defined as intra-frequency handover and inter-frequency handover. Intra-frequency handover can occurs when the user is moving between two cells, but the operating frequency still remains the same. Inter-frequency handover can occurs while the UE moves among cells but the operating frequency changes. Inter-frequency handover is used in order to balance loading among the carriers and to extend the coverage area [2].

Table 1. Comparison of different types of handover in UMTS

Types	*communication*	*capabilities*
Hard Handover	Only with one node B	Low speed mobility
Soft handover	At least with two node B	Enhance the system capacity and coverage
Softer handover	Cells belongs to the same base station	Sufficient signal quality
Intra frequency	Between two cells, when user is move	Frequency remain same and in small area
Inter frequency	User moves among cells, slotted frequency	Load balancing and extend the coverage area
Inter system handover	Between two different radio system. for e.g. UMTS & GSM	Long distance call and large coverage area.

3. Air Interface

There are different types of air interface measurements are:

- Intra frequency measurement

Measurements on downlink physical channels at the same frequency act as the active set. This measurement object corresponds to one cell.

- Inter-frequency measurements:

Measurements on downlink physical channels at frequencies that are differ from the frequency of the active set. This measurement object corresponds to one cell.

- Inter-RAT measurements:

Measurements on downlink physical channels belongs to the another radio access technology than UTRAN, for e.g. GSM. The measurement object corresponds to one cell.

- Traffic volume measurements:

These measurements are held on the uplink traffic volume. The measurement object corresponds to one cell.

- Quality measurements:

These are measurements of downlink quality parameters, for e.g. downlink transport block error rate. The measurement object corresponds to one timeslot in TDD.

- UE-internal measurements:

These are measurements of UE transmission power and UE received signal level.

- UE positioning measurements:

This is measurements of UE position. The UE supports a number of measurements running in parallel and each measurement is controlled and reported independently of every other measurement.

4. Conclusion

This paper analyzes the current handover situation in the UMTS networks. The UMTS technology was designed naturally as a mobile network. The first type, hard handover, is analogical to hard handover in UMTS. In both cases, the MS (in UMTS called UE) communicates with just one BS (denoted Node B in UMTS). Hard handover allows only low speed mobility (portability or simple mobility). Handovers can also be used to balance the load in a communication network and in the case of soft handovers it enhances the system capacity and the coverage.
Inter-system handovers are necessary for enabling compatibility between UMTS and other system architectures, e.g. GSM. Characteristic for this handover type is that the necessary measurements preceding the handover are done using slotted mode. This is due to the fact that the measurements take place at another frequency. From technical point of view this handover type

belongs to the hard handovers. Softer handovers occur when the mobile station is in the overlapping coverage area of two cells. In softer handover the cells belong to the same base station.

5. Future Work

The future work may consist of trying to discover the reasons of handover. Enhanced density of base stations can be implemented to avoid the handover and performance issues of the UMTS. For future research more attention has to be drawn to quality of service requirements in the system. As the implementation of QoS is essential for offering for example real time services, this is a vital aspect of the UMTS system.

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