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STUDY OF SOFT HANDOVER IN THIRD GENERATION CELLULAR NETWORK

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Abstract

UMTS (Universal Mobile Telecommunications Network) is considered as 3rd generation networks. WCDMA (wide band code division multiple access) is the most important air interface which is being used in third generation and it works at 2GHz. Soft handover have been applied with WCDMA air interface to get the high quality of services and high data rate and it also provides the flexibility in the network. When we talk in terms of cellular communications systems, handover is a process which is referred to the transfer of a connection from one cell to another. Handover time is generally between 200 and 1,200 milliseconds (ms), which accounts for the delay. In this paper we are going to find the reasons for these factors which affect the Quality of service of handover.

Introduction

Cellular technology has acquired over four generations since 1979, when the first national cellular network was congenital in Japan. Each generation uses spectrum more competently, therefore adding more subscribers who can generate more cash flow for a carrier. The first generation (1G) cellular was only analog and used completely for voice calls. The second generation (2G) is a digital network and also provides some data services. The third generation (3G) cellular network allows high-speed data with voice. One generation doesn't clean off the previous generation; somewhat, a 2G tower operates next to a 1G tower operating at an altered part of the spectrum. But it takes time to install new hardware, cellular devices has been made to fall back to use the old generation network. The service features in almost all networks include air interface standards, and spectrum allocated. However, 3G network features involve packet switched data, transparent roaming services, broadcast quality sound/video.

Cellular Networks

Every network which is wireless comes in this category. The cellular system is essentially designed such that to use the raise of frequency spectrum proficiently. The cellular architecture is designed such that at low power used a more numbers of transmitters, thus it becomes easy to reuse the frequencies [1], this is totally different from old communication system, because in old system of communication only one transmitter was used at very high power at a limited channels. In this system reuse of frequencies was complicated.

In wireless communication GSM technology is playing very important role. GSM use the narrow band TDMA which allows eight calls at the same radio frequency in digital cellular system. To achieve speedy web contact and good quality of videos and images and high data rate services, 3rdGeneration Mobile systems are used.

AMPS (Analog mobile phone system) are the 1st generation technology this technology was found on analog signals. These analog signals travel like a waveform. These waves are generated by mobile device from transmitting ends in mobile networks which means from one base station where it proceeds to decide the next target of the signal. At the last when the signal has reached its final target then base station again restore the signal most likely try to reconstruct in its original shape for further proceeding.

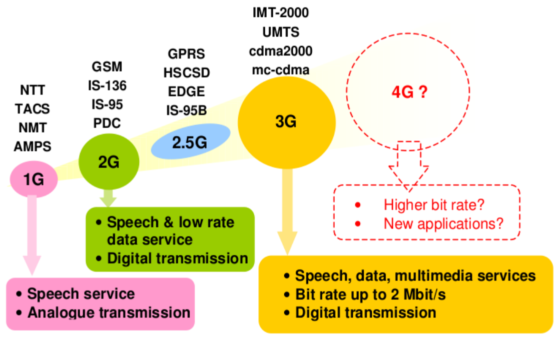

Fig.1 Evolutions of Cellular Networks.

The main Advantages of 2G (2nd Generation) Mobile networks over their previous sections were

Digitally encrypted mobile communications and greater mobile phone penetration levels & signals.

2G systems are limited in terms of maximum data rate. This makes 2G systems practically useless for the increased requirements of future mobile data applications.

In order to provide for efficient support of new services, work on the Third Generation of cellular systems was initiated by the International Telecommunication (ITU) in 1992 [2].The broad objectives of 3G systems are

- Support 2 Mbps for handheld devices, 384 kbps for walking mobile devices, and 144 kbps for car-borne mobile devices.
- The 3G systems should work in all radio environments: urban areas, suburban areas, hilly and mountainous regions, and indoor environments.
- Asymmetric and symmetric services should be supported, i.e., the uplink (from handset to base station) data rates can be lower than the downlink data rate.

The 4G mobile technology has many advantage over 3G networks, 4G networks can give us data rates of about 100 Megabits per seconds(Mbps) and an efficient use of spectrum then the normal 3G networks, low latency and low cost.

UMTS

The third generation mobile communication system UMTS (Universal Mobile telecommunications System) is successor of GSM (Global System for Mobile Communications). UMTS networks can be divided in two parts. One part that is responsible for the circuit switched services (CS-domain) and one part that manages packet switched services. The CS-domain manages voice calls and on the other hand the PS-domain is responsible for data connections like connections from a mobile device (called user equipment (UE) in UMTS) to the internet.

UMTS is designed to provide global access and world-wide roaming. To support this the URAN (UMTS Radio Access Network) will be build in different hierarchical levels.

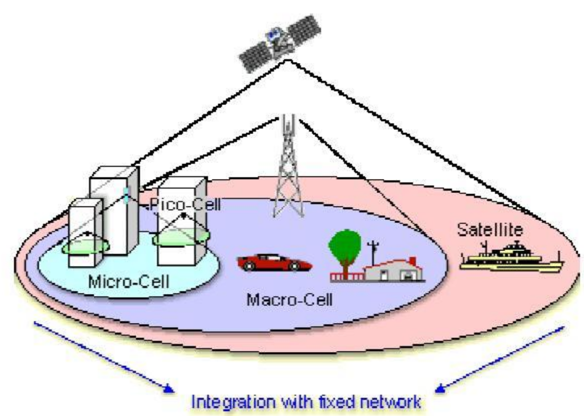

Fig.2 UMTS Cell Structure.

Higher levels cover larger geographical areas. Lower levels cover only little areas but they can handle a higher density of devices that want to access the network in this little areas. They also provide faster wireless links to the network than larger levels. The whole system is connected and integrated with PTSN (Public Telephone Switched Network) and PDN (Public Data Network) like internet etc [3]. The following levels are planned:

Satellite system: This covers the whole planet. Even on seas and in uninhabited regions access to the network is possible via satellites.

UTRAN (UMTS Terrestrial Radio Access Network):

The UTRAN infrastructure is terrestrial and consists also of different levels and cells:

Macro layer:
These cells cover large areas with regions where only few devices access the network.

Micro layer:
In regions with a high density of devices that want access to the network, like bigger cities, micro cells are used. They cover only quite little areas to provide enough capacity for all devices in this area.

Pico layer:

A picocell is normally located in bigger buildings to provide fast and good access to the network. For example hot spots are made out of pico cells in buildings.

UMTS Architecture

The UMTS network can be divided into three parts:

User Equipment (UE):
The UE connects to the UTRAN via wireless radio link to one or more cells. Unlike in GSM it is possible to have a link to many cells at the same time.

UMTS Terrestrial Radio Access Network (UTRAN):

The UTRAN consists of Node Bs (BTS in GSM) that is connected to Radio Network Controllers (RNCs – BSC in GSM). The RNCs are connected to each other and to the core networks via ATM.

Core Network (CN):

The core network is connected to other networks like PTSN (Public Telephone Switched Network), Internet, other mobile networks etc. It is responsible for routing, authentication, location tracking, etc. The core networks is divided into two domains, the circuit switched (CS) and the packet switched (PS) domain. This work will further focus on the PS- domain.

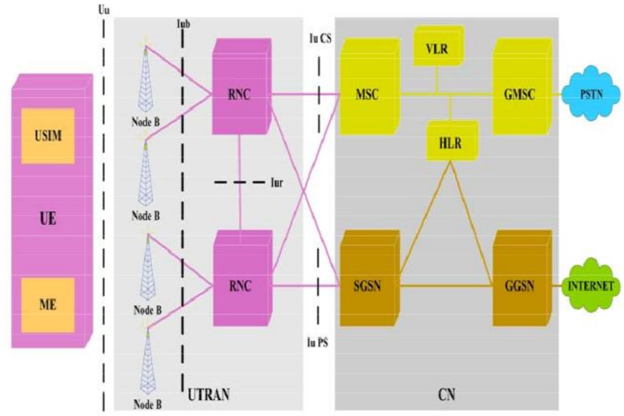

Fig. 3 UMTS architecture

Handover in Mobile Networks

Mobile networks allow users to access services while on the move so giving end users “freedom” in terms of mobility. However, this freedom does bring uncertainties to mobile systems. The mobility of the end users causes dynamic variations both in the link quality and the interference level, sometimes requiring that a particular user change its serving

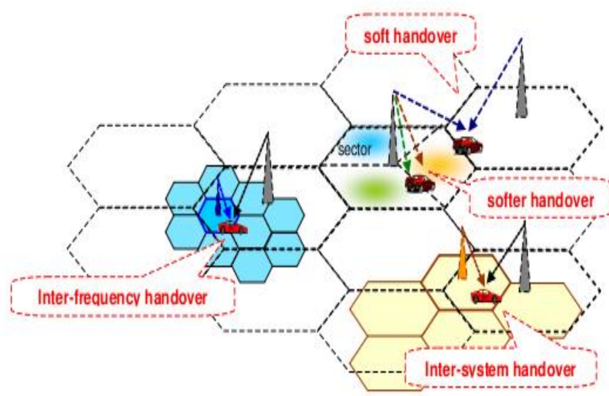

Fig.4 UMTS Cell Architecture

base station. This process is known as handover (HO). Handover is the essential component for dealing with the mobility of end users.

There are four different types of handovers in WCDMA mobile networks. They are:

Intra-system Handover

Intra-system handover occurs within one system. It can be further divided into Intra-frequency handover and Inter-frequency handover. First occurs between cells belonging to the same WCDMA carrier, while second occurs between cells operate on different WCDMA carriers.

Inter-system Handover

Inter-system handover takes places between cells belonging to two different Radio Access Technologies (RAT) or different Radio Access Modes (RAM). The most frequent case for the first type is expected between WCDMA and GSM systems. Handover between two different CDMA systems also belongs to this type.

Hard Handover

Hard handover is a category of handover procedures in which all the old radio links of a mobile are released before the new radio links are established. For real-time bearers it means a short disconnection of the bearer; for non-real-time bearers hard handover is lossless. Hard handover can take place as intra or inter-frequency handover.

Soft Handover and Softer handover

During soft handover, a mobile simultaneously communicates with two (2-way soft handover) or more cells belonging to different BSs of the same RNC (intra-RNC) or different RNCs (inter-RNC). In the downlink (DL), the mobile receives both signals for maximal ratio combining: in the uplink (UL), the mobile code channel is detected by both BSs (2-way soft handover), and is routed to the RNC for selection combining.

Two active power control loops participate in soft handover: one for each BS. In the softer handover situation, a mobile is controlled by at least two sectors under one BS, the RNC is not involved and there is only one active power control loop. Soft handover and softer handover are only possible within one carrier frequency and therefore, they are intra-frequency handover processes.

SIMULATION

We conducted a series of simulations. We can categorize the simulations into two parts. The first part deals with the comparison between the soft handover and the hard handover. And the second part deals with the threshold value for handover.

Comparison between Hard and Soft Handover

The comparison is based on the basis of the following parameters

1. Uplink Transmission
2. End to End delay

The scenario for this simulation is shown in fig. 5.

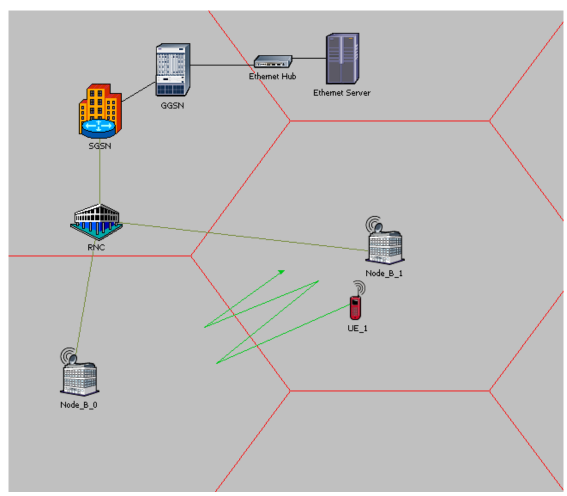

Fig.5 Simulation Scenario

First the uplink transmission power for soft handover and hard handover is considered separately and then both are compared on the same graph to get the clear picture.

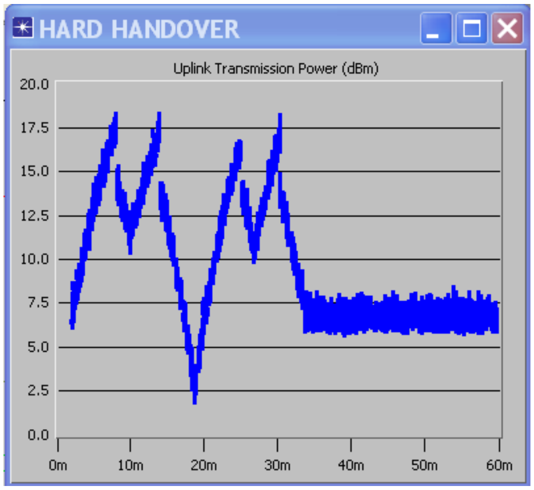

Fig.6 Uplink transmission power for hard handover

In the figure 6 it is clear that in hard handover first the previous connection is disconnected and then the new connection is made, this is more commonly known as "break before make" connection .this disconnection is for a fraction of a second and the user does not notices this. This normally happens after it is clear that the signal coming from one BS is considerably stronger than those come from the others. As we can see the new signal is always stronger than the old signal.

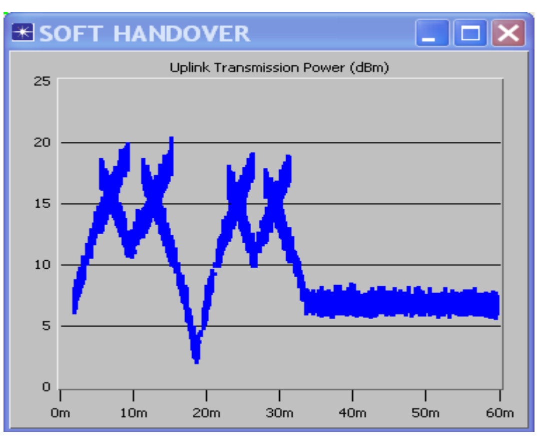

Fig.7 Uplink transmission power for Soft Handover

In the figure 7 it is clear that in soft handover first the new connection is made and then the previous connection is disconnected, this is more commonly known as "make before break" connection. We will focus on this issue in the following simulations.

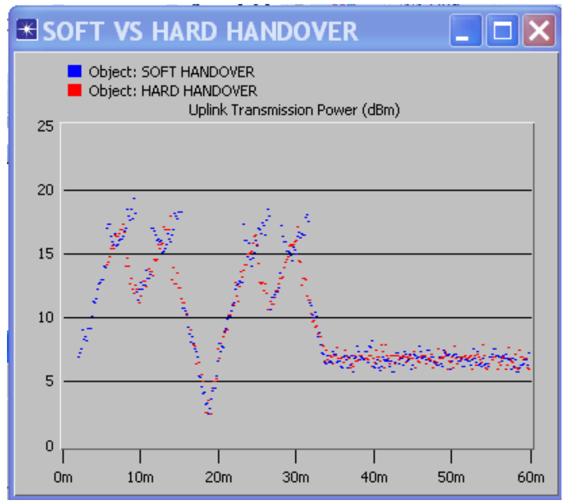

Fig.8 Comparison of uplink transmission power between hard handover and soft handover

It can be observed from figure 8 the variation in uplink transmission power .The maximum value of uplink transmission power is 18.3 dBm for hard handover and 20.3 dBm for soft handover. In case of soft handover less variation in the value of uplink transmission power is observed. The reason for fluctuation in values of uplink transmission power in hard hand over is when the strength of the signal coming from one base station is faded the more uplink transmission power is required in order to maintain the quality of the service. After the execution of hard handover the strength of the signal improves and the lesser transmission power is required. In soft handover the signal strength of the two base stations are monitored simultaneously. When the strength of one base station goes beyond the minimum level then the soft handover is performed thus minimum uplink transmission power is required.

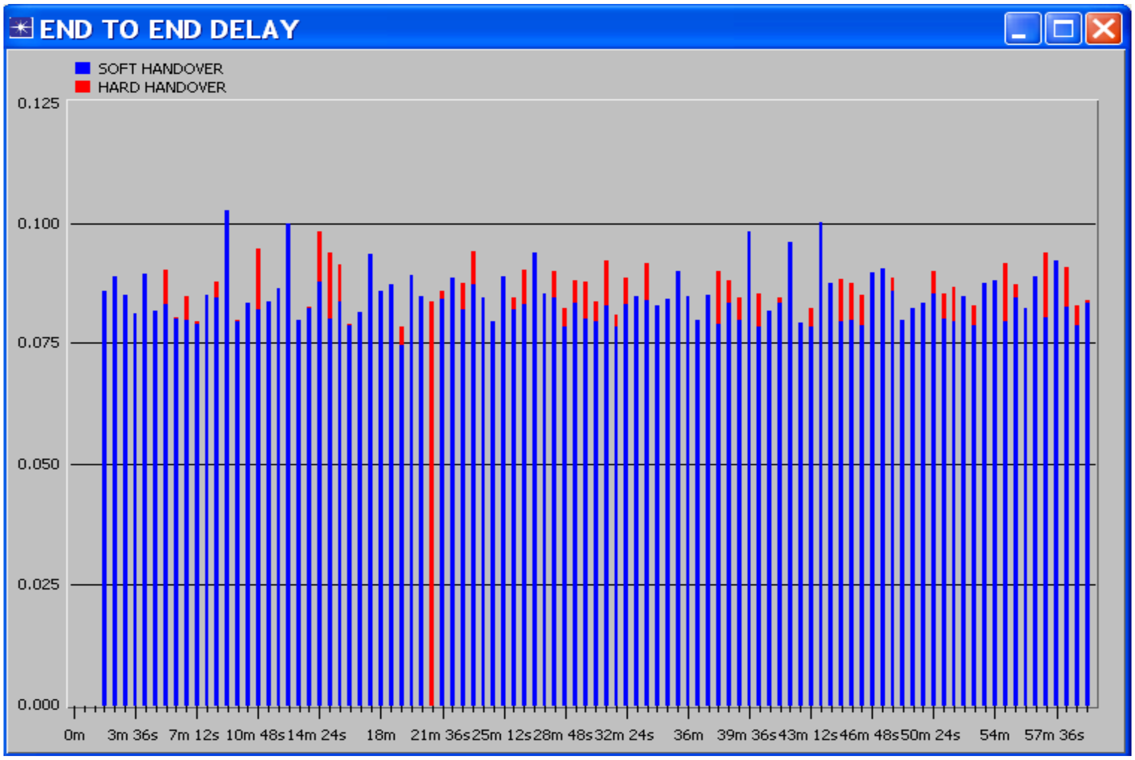

Fig. 9 Comparison of end to end delay between hard handover and soft handover

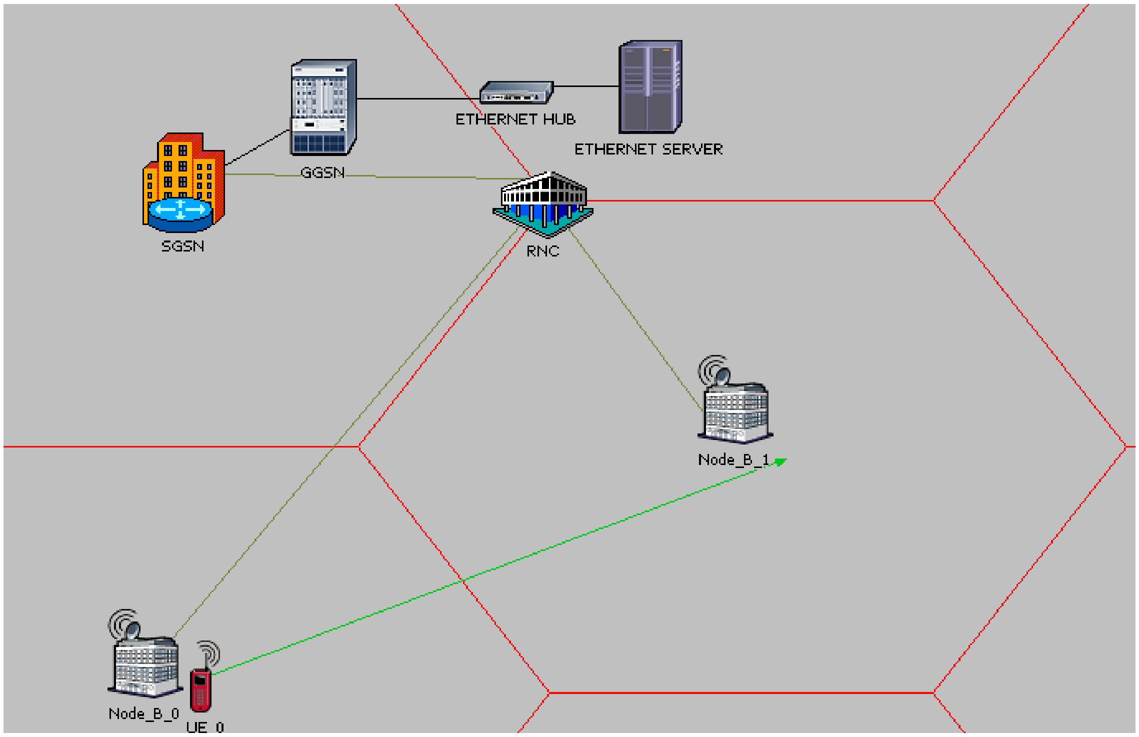

Fig. 10 Simulation scenario for different threshold value

In figure 9 end to end delay is represented. The graph is plotted against time (sec) and end- to- end delay (sec). The blue bar shows the information regarding soft handover and red bar show the data of hard hand over. By observing the graph it can be seen that more delay is recorded in soft handover than in hard handover.

The maximum value of delay recoded in hard handover is 0.0982 second at 14m24s. In soft handover the maximum value of delay is observed at time instance 9m and value is 0.102 second. The reason for more end to end delay in soft handover is that the receiving RNC routes the data towards the base station of new RNC from same source for some time period that causes delay until the handover is performed.

Simulation for different Threshold Values

We performed a series of simulations at different threshold values for soft handover. Fig. 10 shows the simulation scenario.

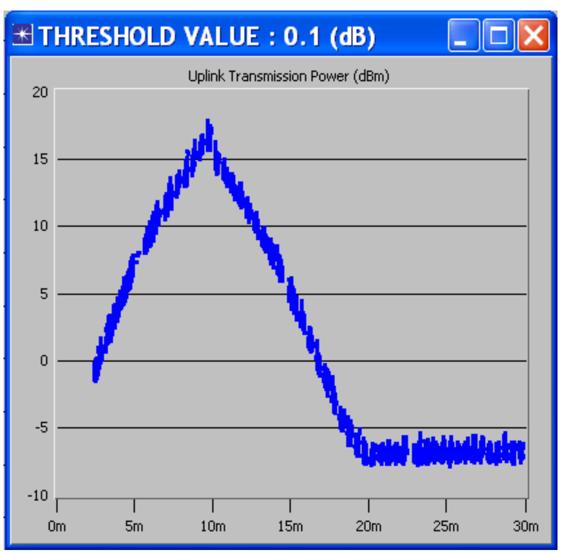

Fig. 11 Uplink transmission power for threshold value 0.1 dB

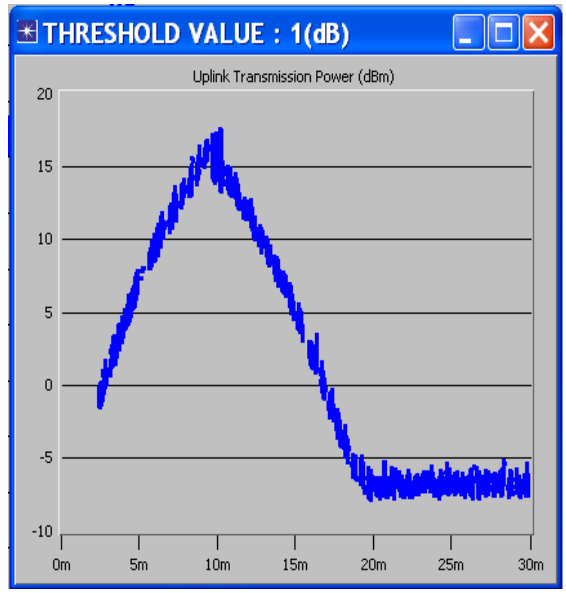

Fig. 12 Uplink transmission power for threshold value 1 db.

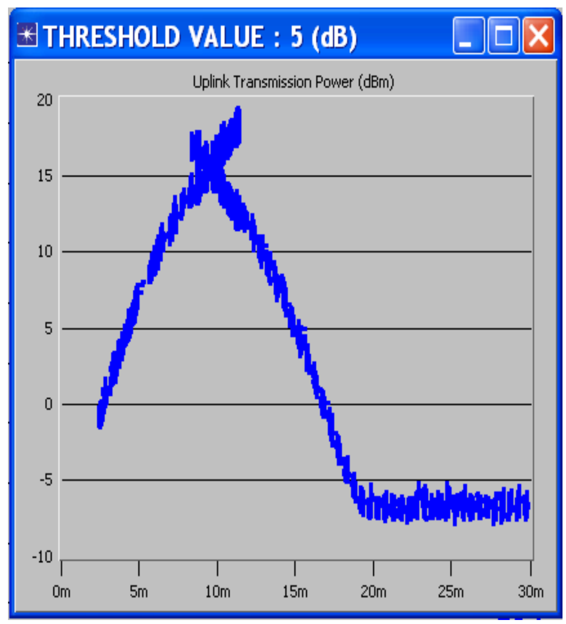

Fig. 13 Uplink transmission power for threshold value 5 dB

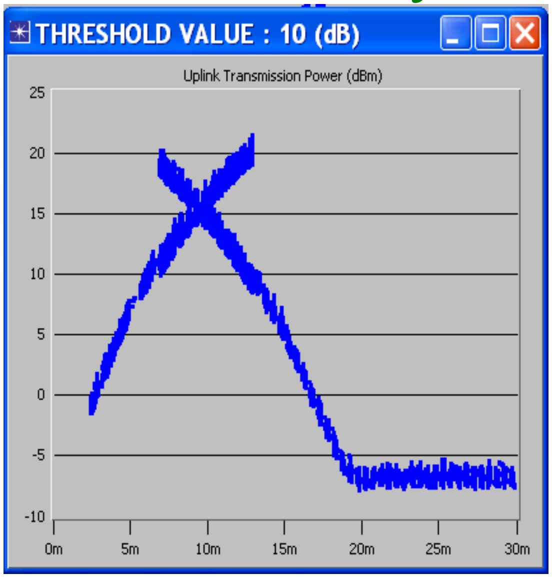

Fig.14 Uplink transmission power for threshold value 10 dB.

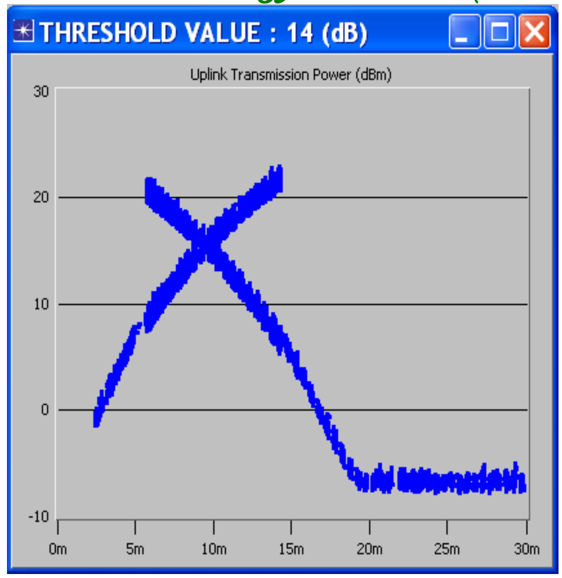

Fig. 15 Uplink transmission power for threshold value 14 dB

CONCLUSION

We conducted a series of simulations for uplink transmission signal at different threshold values .The handoff window is the area over which the received strengths of the pilot signal differ less than the handover threshold. The simulations carried out show that for higher threshold values the handoff window becomes wider.

We also made conclusion about the soft handover probability distribution inside on cell. We see that near the cell centre very few users are in soft handover. In the cell edge area a soft handover probability of 100% is achieved. Concerning the effect of the handover threshold it is shown that the lower the value of this parameter, the slower the transition from 0% to 100% is made.

Soft handovers in the system also influence the capacity by increasing the traffic load due to the overhead in connections made during soft handovers.

Also the total amount of interference present in the system is minimal for networks with soft handovers enabled when considerably low threshold values are used.

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