FIELD MEASUREMENT OF 3G BASE STATION

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ABSTRACT

FIELD MEASURMENT OF 3G BASE STATION

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3G mobile communication systems launched after some hardware and software changes on existing systems. After these changes operators have new services for subscribers. In this thesis, our target is to find problems, which faced by subscribers, with field measurements. Along these field measurements there were drop, congestion, and low data rate problems. After analyzing these problems we did some hardware and software changes. In this thesis you will find information about these hardware and software changes and the result graphs, which contains comparison for before and after these changes. These results verified by verification tests, if needed the problems re-analyzed and tried to optimize the system.

Keywords: 3G, Signal Level, Quality, Coverage, Field Measurements

ÖZ

3G BAZ İSTASYONLARI SAHA ÖLÇÜMLERİ

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Yüksek lisans, Elektronik ve Haberleşme Mühendisliği Anabilim Dalı
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3. Nesil haberleşme sistemlerinin hayata geçmesi, mobil iletişimin omurgasını oluşturan ekipmanlarda yapılan bazı donanımsal ve yazılımsal değişiklikler sonrasında mümkün olmuştur. Abonelerin bu değişimler sonrasında hizmet almaya başladıkları servisler değişim göstermiş, yeni gereksinimler bu servislerle beraber ortaya çıkmaya başlamıştır. Bu tez çalışmasında aboneler tarafından yaşanılabilecek sorunlar, gerçek saha ölçümleri yapılarak ele alınmıştır. Yapılan testler neticesinde abonelerin konuşmalarının kesilmesi, arama yapmak istedikleri zamanlarda şebekeye ulaşamamaları, data bağlantısının beklenilen hızlara ulaşamaması gibi problemlerle karşılaşılmıştır. Alınan gerçek saha olçümleri çerçevesinde belirtilen sorunlar analiz edilerek sistem üzerinde donanımsal ve yazılımsal değişiklikler yapılmıştır. Bu tez çalışması, yapılan değişikliklerden örnekler ve bu çalışmalar sonunda ulaşılan sonuçları içermektedir. Yapılan değişiklilklerin sistem üzerindeki etkileri yeniden gerçek saha ölçümleri alınarak doğrulanmış ve gerektiği yerlerde tekrar analiz edilmek suretiyle sistemin iyileştirilmesi hedeflenmiştir.

Anahtar Kelimeler: 3.Nesil Haberleşme Sistemleri, Sinyal Seviyesi, Ses Kalitesi, Kapsama, Saha Ölçümleri,

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HISTORY AND EVOLUTION OF 3G

The first pre-commercial 3G network was launched by NTT DoCoMo in Japan branded FOMA, in May 2001 on a pre-release of W-CDMA technology. The first commercial launch of 3G was also by NTT DoCoMo in Japan on 1 October 2001, although it was initially somewhat limited in scope; broader availability was delayed by apparent concerns over reliability. The second network to go commercially live was by SK Telecom in South Korea. On the 1xEV-DO technology in January 2002. By May 2002 the second South Korean 3G network was by KT on EV-DO and thus the Koreans were the first to see competition among 3G operators.

The first European pre-commercial network was at the Isle of Man by Manx Telecom, the operator then owned by British Telecom, and the first commercial network in Europe was opened for business by Telenor in December 2001 with no commercial handsets and thus no paying customers. These were both on the W-CDMA technology.

The first commercial United States 3G network was by Monet Mobile Networks, on CDMA2000 1x EV-DO technology, but this network provider later shut down operations. The second 3G network operator in the USA was Verizon Wireless in October 2003 also on CDMA2000 1x EV-DO. AT&T Mobility is also a true 3G network, having completed its upgrade of the 3G network to HSUPA.

The first pre-commercial demonstration network in the Southern Hemisphere was built in Adelaide, South Australia by m.Net Corporation in February 2002 using UMTS on 2100 MHz. This was a demonstration network for the 2002 IT World Congress. The first commercial 3G network was launched by Hutchison Telecommunications branded as three in March 2003.

In December 2007, 190 3G networks were operating in 40 countries and 154 HSDPA networks were operating in 71 countries, according to the Global Mobile Suppliers Association (GSA). In Asia, Europe, Canada and the USA, telecommunication companies use W-CDMA technology with the support of around 100 terminal designs to operate 3G mobile networks.

In Europe, mass market commercial 3G services were introduced starting in March 2003 by 3 (Part of Hutchison Whampoa) in the UK and Italy. The European Union Council suggested that the 3G operators should cover 80% of the European national populations by the end of 2005.

Roll-out of 3G networks was delayed in some countries by the enormous costs of additional spectrum licensing fees. In many countries, 3G networks do not use the same radio frequencies as 2G, so mobile operators must build entirely new networks and license entirely new frequencies; an exception is the United States where carriers operate 3G service in the same frequencies as other services. The license fees in some European countries were particularly high, bolstered by government auctions of a limited number of licenses and sealed bid auctions, and initial excitement over 3G's potential. Other delays were due to the expenses of upgrading equipment for the new systems.

By June 2007 the 200 millionth 3G subscriber had been connected. Out of 3 billion mobile phone subscriptions worldwide this is only 6.7%. In the countries where 3G was launched first - Japan and South Korea - 3G penetration is over 70%.[11] In Europe the leading country is Italy with a third of its subscribers migrated to 3G. Other leading countries by 3G migrations include UK, Austria, Australia and Singapore at the 20% migration level. A confusing statistic is counting CDMA 2000 1x RTT customers as if they were 3G customers. If using this definition, then the total 3G subscriber base would be 475 million at June 2007 and 15,8% of all subscribers worldwide.

In Canada, Rogers Wireless was the first to implement 3G technology, with HSDPA services in eastern Canada in early 2007. Their subsidiary Fido Solutions offers 3G as well. Because they were the only incumbent carrier (out of 3) with UMTS/HSDPA capability, for 2 years Rogers was the sole provider of the popular Apple iPhone. Realizing they would miss out on roaming revenue from the 2010 Winter Olympics, Bell and Telus formed a joint venture and rolled out a shared HSDPA network using Nokia Siemens technology. Bell launched their 3G wireless lineup on 4 November 2009, and Telus followed suit a day later on 5 November 2009. With these launches, the popular iPhone is now available on all 3 incumbent national carriers.

Mobitel Iraq is the first mobile 3G operator in Iraq. It was launched commercially on February 2007.

China announced in May 2008, that the telecoms sector was re-organized and three 3G networks would be allocated so that the largest mobile operator, China Mobile, would retain its GSM customer base. China Unicom would retain its GSM customer base but relinquish its CDMA2000 customer base, and launch 3G on the globally leading WCDMA (UMTS) standard. The CDMA2000 customers of China Unicom would go to China Telecom, which would then launch 3G on the CDMA 1x EV-DO standard. This meant that China would have all three main cellular technology 3G standards in commercial use. Finally in January 2009, Ministry of industry and Information Technology of China has awarded licenses of all three standards, TD-SCDMA to China Mobile, WCDMA to China Unicom and CDMA2000 to China Telecom. The launch of 3G occurred on 1 October 2009, to coincide with the 60th Anniversary of the Founding of the People's Republic of China.

In November 2008, Turkey has auctioned four IMT 2000/UMTS standard 3G licenses with 45, 40, 35 and 25 MHz top frequencies. Turkcell has won the 45 MHz band with its €358 million offer followed by Vodafone and Avea leasing the 40 and 35 MHz frequencies respectively for 20 years. The 25 MHz top frequency license remains to be auctioned. The launch of 3G is at 30 July 2009.

The first African use of 3G technology was a 3G video call made in Johannesburg on the Vodacom network in November 2004. The first commercial launch of 3G in Africa was by EMTEL in Mauritius on the W-CDMA standard. In north African Morocco in late March 2006, a 3G service was provided by the new company Wana.

T-Mobile, a major Telecommunication services provider has recently rolled out a list of over 120 U.S. cities which will be provided with 3G Network coverage in the year 2009.

In 2008, India entered into 3G Mobile arena with the launch of 3G enabled Mobile services by Mahanagar Telephone Nigam Limited (MTNL). MTNL is the first Mobile operator in India to launch 3G services [21].

Mobile broadband industry association the UMTS forum has confirmed today that 3G subscriptions to UMTS networks based on WCDMA technology have exceeded nearby 300 million. UMTS/WCDMA now represents almost a tenth of global GSM/UMTS family (comprising GSM, EDGE, WCDMA and HSPA) that now surpasses 4.2 billion connections.

Aggregated with 100+ million connections to CDMA2000 1xEV-DO networks, the total of all 3G cellular customers worldwide has passed 400 million.

Global demand for mobile broadband is accelerating. HSPA subscriptions are currently growing by 4 million per month, while commercial HSPA network operations already exceed 300. This represents roughly 96% of all UMTS deployments that currently number around 315 commercial networks in 132 countries. Furthermore, HSPA traffic now constitutes over 80% of the total traffic in all 3G/UMTS networks worldwide.

The UMTS Forum anticipates that 3G/UMTS subscriptions will reach 409 million by the end of 2009, representing around 8% of the world's population [21].

Refers to the current total number of operators that have launched commercial WCDMA services per each world region.

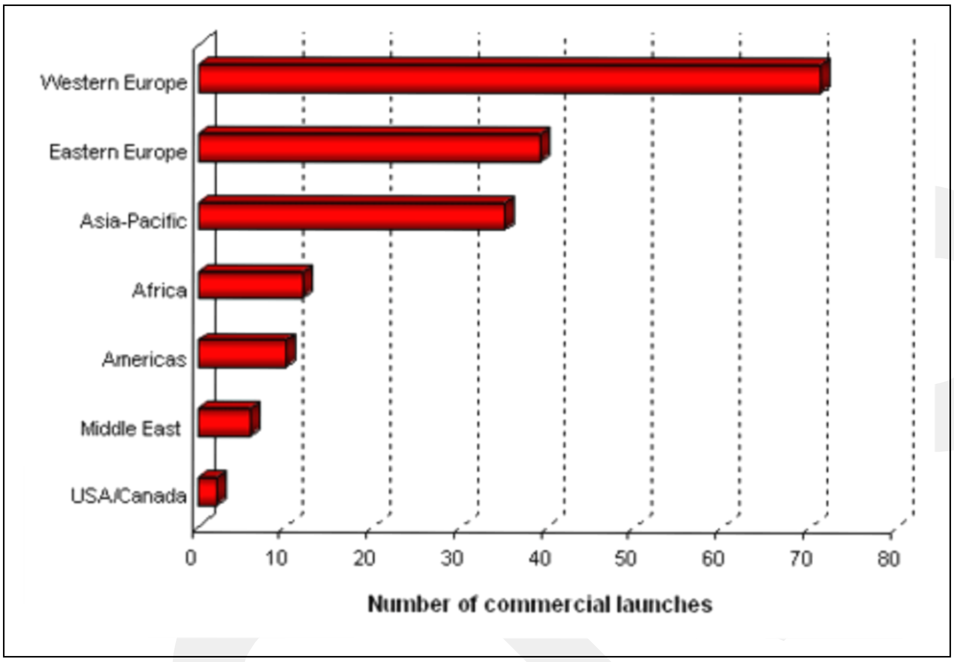


Figure 1.1 Total numbers of operators have launched WCDMA services.

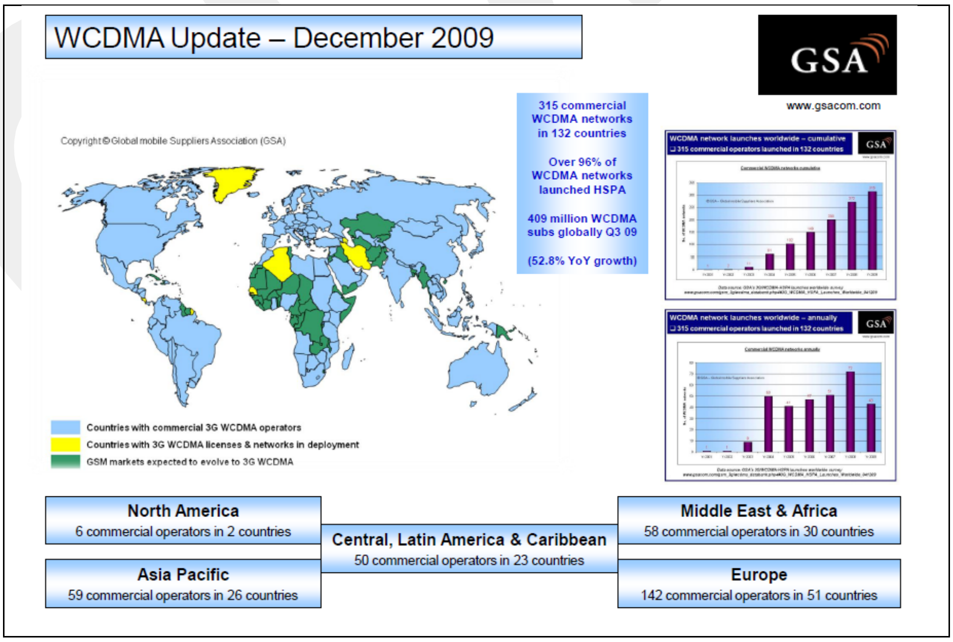


Figure 1.2 WCDMA update number of subscribers all around world.

1.1. Evolution of Mobile Communications

Early Stages 1G-3G:

Electromagnetic waves were first discovered as a communications medium at the end of the 19th century. The first systems offering mobile telephone service (car phone) were introduced in the late 1940s in the United States and in the early 1950s in Europe. Those early single cell systems were severely constrained by restricted mobility, low capacity, limited service, and poor speech quality. The equipment was heavy, bulky, expensive, and susceptible to interference. Because of those limitations, less than one million subscribers were registered worldwide by the early 1980s [22].

1.1.1. First Generation (1G): Analog Cellular

The introduction of cellular systems in the late 1970s and early 1980s represented a quantum leap in mobile communication (especially in capacity and mobility). Semiconductor technology and microprocessors made smaller, lighter weight and more sophisticated mobile systems a practical reality for many more users. These 1G cellular systems still transmit only analog voice information. The most prominent 1G systems are Advanced Mobile Phone System (AMPS), Nordic Mobile Telephone (NMT), and Total Access Communication System (TACS). With the 1G introduction, the mobile market showed annual growth rates of 30 to 50 percent, rising to nearly 20 million subscribers by 1990 [22].

1.1.2. Second Generation (2G): Multiple Digital Systems

The development of 2G cellular systems was driven by the need to improve transmission quality, system capacity, and coverage. Further advances in semiconductor technology and microwave devices brought digital transmission to mobile communications.

Speech transmission still dominates the airways, but the demands for fax, short message, and data transmissions are growing rapidly. Supplementary services such as fraud prevention and encrypting of user data have become standard features that are comparable to those in fixed networks. 2G cellular systems include GSM, Digital AMPS (D-AMPS), code division multiple access (CDMA), and Personal Digital Communication (PDC). Today, multiple 1G and 2G standards are used in worldwide mobile communications. Different standards serve different applications with different levels of mobility, capability, and service area (paging systems, cordless telephone, wireless local loop, private mobile radio, cellular systems, and mobile satellite systems).

Many standards are used only in one country or region, and most are incompatible. GSM is the most successful family of cellular standards (GSM900, GSM–railway [GSM–R], GSM1800, GSM1900, and GSM400), supporting some 250 million of the world’s 450 million cellular subscribers with international roaming in approximately 140 countries and 400 networks [22].

1.1.3. 2G to 3G: GSM Evolution

Phase 1 of the standardization of GSM900 was completed by the European Telecommunications Standards Institute (ETSI) in 1990 and included all necessary definitions for the GSM network operations. Several tele-services and bearer services have been defined (including data transmission up to 9.6 kbps), but only some very basic supplementary services were offered. As a result, GSM standards were enhanced in Phase 2 (1995) to incorporate a large variety of supplementary services that were comparable to digital fixed network integrated services digital network (ISDN) standards. In 1996, ETSI decided to further enhance GSM in annual Phase 2+ releases that incorporate 3G capabilities.

GSM Phase 2+ releases have introduced important 3G features such as intelligent network (IN) services with customized application for mobile enhanced logic (CAMEL), enhanced speech compression/decompression (CODEC), enhanced full rate (EFR), and adaptive multi rate (AMR), high–data rate services and new transmission principles with high-speed circuit-switched data (HSCSD), general packet radio service (GPRS), and enhanced data rates for GSM evolution (EDGE). UMTS is a 3G GSM successor standard that is downward-compatible with GSM, using the GSM Phase 2+ enhanced core network [22].

1.1.4. IMT-2000

IMT–2000 is a set of requirements defined by the International Telecommunications Union (ITU). As previously mentioned, IMT stands for International Mobile Telecommunications, and “2000” represents both the scheduled year for initial trial systems and the frequency range of 2000 MHz (WARC’92: 1885–2025 MHz and 2110–2200 MHz).

All 3G standards have been developed by regional standards developing organizations (SDOs). In total, proposals for 17 different IMT–2000 standards were submitted by regional SDOs to ITU in 1998—11 proposals for terrestrial systems and 6 for mobile satellite systems (MSSs).

Evaluation of the proposals was completed at the end of 1998, and negotiations to build a consensus among differing views were completed in mid 1999. All 17 proposals have been accepted by ITU as IMT–2000 standards. The specification for the Radio Transmission Technology (RTT) was released at the end of 1999.

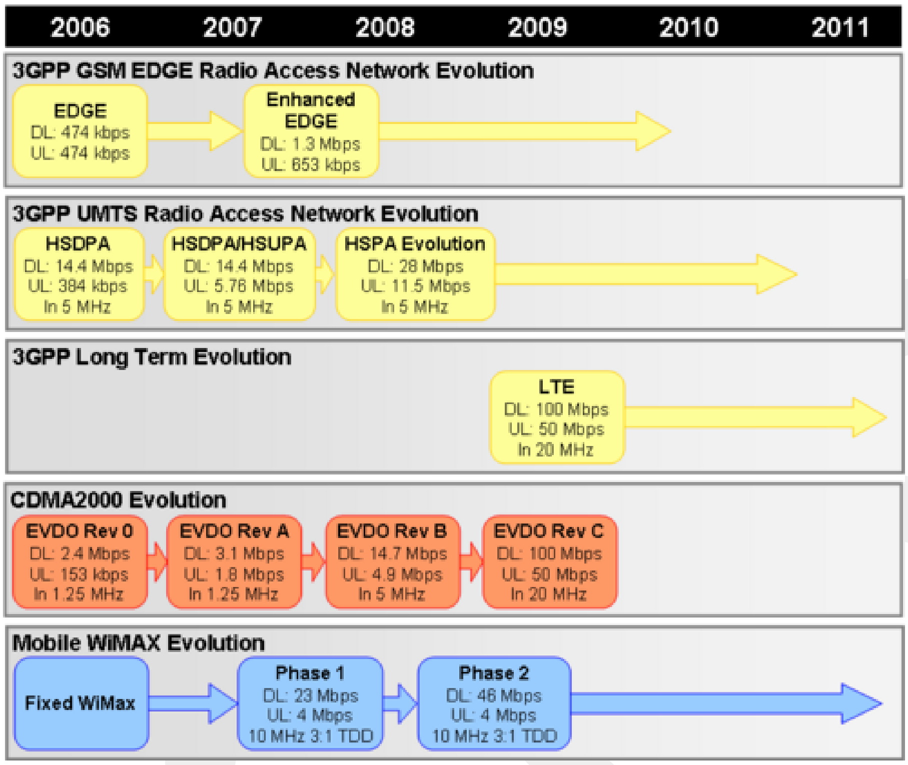
The most important IMT–2000 proposals are the UMTS (WCDMA) as the successor to GSM, CDMA2000 as the interim standard ’95 (IS–95) successor, and time division–synchronous CDMA (TD–SCDMA) (universal wireless communication–136 [UWC–136]/EDGE) as TDMA–based enhancements to D–AMPS/GSM—all of which are leading previous standards toward the ultimate goal of IMT–2000 [3].

UMTS allows many more applications to be introduced to a worldwide base of users and provides a vital link between today’s multiple GSM systems and IMT–2000. The new network also addresses the growing demand of mobile and Internet applications for new capacity in the overcrowded mobile communications sky. UMTS increases transmission speed to 2 Mbps per mobile user and establishes a global roaming standard [22].

UMTS is being developed by Third-Generation Partnership Project (3GPP), a joint venture of several SDOs—ETSI (Europe), Association of Radio Industries and Business/Telecommunication Technology Committee (ARIB/TTC) (Japan), American National Standards Institute (ANSI) T-1 (USA), telecommunications technology association (TTA) (South Korea), and Chinese Wireless Telecommunication Standard (CWTS) (China). To reach global acceptance, 3GPP is introducing UMTS in phases and annual releases. The first release (UMTS Rel. '99), introduced in December of 1999, and defines enhancements and transitions for existing GSM networks. For the second phase (UMTS Rel. '00), similar transitions are being proposed as enhancements for IS–95 (with CDMA2000) and TDMA (with TD–CDMA and EDGE).

The most significant change in Rel. '99 is the new UMTS terrestrial radio access (UTRA), a W–CDMA radio interface for land-based communications. UTRA supports time division duplex (TDD) and frequency division duplex (FDD). The TDD mode is optimized for public micro and pico cells and unlicensed cordless applications. The FDD mode is optimized for wide-area coverage, i.e., public macro and micro cells. Both modes offer flexible and dynamic data rates up to 2 Mbps. Another newly defined UTRA mode, multicarrier (MC), is expected to establish compatibility between UMTS and CDMA2000 [22].

Table 1.1 Expected Evolution of Mobile Communications



1.2. UMTS (Universal Mobile Telecommunication Systems)

Universal Mobile Telecommunications System (UMTS) is one of the third-generation (3G) mobile telecommunications technologies, which is also being developed into a 4G technology. The first deployment of the UMTS is the release99 (R99) architecture. It is specified by 3GPP and is part of the global ITU IMT-2000 standard. The most common form of UMTS uses WCDMA as the underlying air interface but the system also covers TD-CDMA and TD-SCDMA (both IMT CDMA TDD).

Being a complete network system, UMTS also covers the radio access network (UMTS Terrestrial Radio Access Network, or UTRAN), the core network (Mobile Application Part, or MAP), as well as authentication of users via USIM cards (Subscriber Identity Module).

Unlike EDGE and CDMA2000 UMTS requires new base stations and new frequency allocations. However, it is closely related to GSM/EDGE as it borrows and builds upon concepts from GSM. Further, most UMTS handsets also support GSM, allowing seamless dual-mode operation. Therefore, UMTS is sometimes marketed as 3GSM, emphasizing the close relationship with GSM and differentiating it from competing technologies.

The name UMTS, introduced by ETSI, is usually used in Europe. Outside of Europe, the system is also known by other names such as FOMA or WCDMA. In marketing, it is often just referred to as 3G [30].

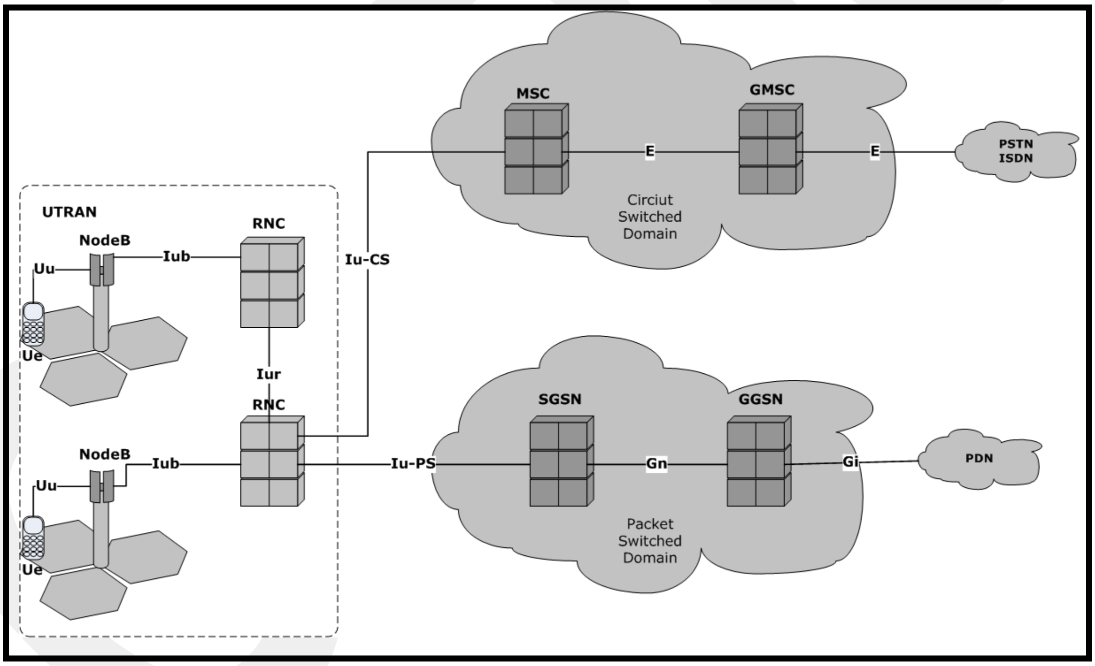


Figure 1.3 UMTS Network Architecture

1.2.1. UMTS Features

UMTS, using WCDMA, supports maximum theoretical data transfer rates of 21 Mbit/s (with HSDPA),although at the moment users in deployed networks can expect a transfer rate of up to 384 Kbit/s for R99 handsets, and 7.2 Mbit/s for HSDPA handsets in the downlink connection. This is still much greater than the 9.6 Kbit/s of a single GSM error-corrected circuit switched data channel.

Precursors to 3G are 2G mobile telephony systems, such as GSM, IS-95, PDC, CDMA PHS and other 2G technologies deployed in different countries. In the case of GSM, there is an evolution path from 2G, to GPRS, also known as 2.5G. GPRS supports a much better data rate (up to a theoretical maximum of 140.8 Kbit/s, though typical rates are closer to 56 Kbit/s) and is packet switched rather than connection oriented (circuit switched).

It is deployed in many places where GSM is used. E-GPRS, or EDGE, is a further evolution of GPRS and is based on more modern coding schemes. With EDGE the actual packet data rates can reach around 180 Kbit/s (effective). EDGE systems are often referred as "2.75G Systems".

Since 2006, UMTS networks in many countries have been or are in the process of being upgraded with High Speed Downlink Packet Access (HSDPA), sometimes known as 3.5G. Currently, HSDPA enables downlink transfer speeds of up to 21 Mbit/s. Work is also progressing on improving the uplink transfer speed with the High-Speed Uplink Packet Access (HSUPA). Longer term, the 3GPP Long Term Evolution project plans to move UMTS to 4G speeds of 100 Mbit/s down and 50 Mbit/s up, using a next generation air interface technology based upon Orthogonal frequency-division multiplexing(OFDM).

The information rate of the channel varies with the symbol rate being derived from the 3.84 Mcps chip rate and the spreading factor. Spreading factors are from 256 to 4 with FDD uplink, from 512 to 4 with FDD downlink, and from 16 to 1 for TDD uplink and downlink. Thus the respective modulation symbol rates vary from 960 k symbols/s to 15 k symbols/s (7.5 k symbols/s) for FDD uplink (downlink), and for TDD the momentary modulation symbol rates shall vary from 3.84 M symbols/s to 240 k symbols/s [30].

1.3. Multiple Access Technologies

To transmit a signal from one user to another, the information must be sent over a channel that is possibly shared with many other users simultaneously transmitting their own channels. A key issue therefore regards ways in which this communications channel is partitioned among the various users such that each receiver is able to accurately recover the signal the sender intended to transmit.

Currently, there are three common types of multiple access systems:

- Time Division Multiple Access (TDMA)
- Frequency Division Multiple Access (FDMA)
- Code Division Multiple Access (CDMA)

1.3.1. WCDMA (Wideband Code Division Multiple Access)

W-CDMA (Wideband Code Division Multiple Access), UMTS-FDD, UTRA-FDD, or IMT-2000 CDMA Direct Spread is an air interface standard found in 3G mobile telecommunications networks. It is the basis of Japan's NTT DoCoMo's FOMA service and the most-commonly used member of the UMTS family and sometimes used as a synonym for UMTS. It utilizes the DS-CDMA channel access method and the FDD duplexing method to achieve higher speeds and support more users compared to most time division multiple access (TDMA) schemes used today.

While not an evolutionary upgrade on the airside, it uses the same core network as the 2G GSM networks deployed worldwide, allowing dual-mode operation along with GSM/EDGE; a feat it shares with other members of the UMTS family.

1.3.1.1. Technical Features about WCDMA

- Radio channels are 5 MHz wide.
- Chip rate of 3.84 Mcps
- Supported mode of duplex: frequency division (FDD)
- Employs coherent detection on both the uplink and downlink based on the use of pilot symbols and channels.
- Supports inter-cell asynchronous operation.
- Variable mission on a 10 ms frame basis.
- Multicode transmission.
- Adaptive power control based on SIR (Signal-to-Interference Ratio).
- Multiuser detection and smart antennas can be used to increase capacity and coverage.
- Multiple types of handoff (or handover) between different cells including soft handoff, softer handoff and hard handoff [29].

1.4. UMTS Air Interface

UMTS provides several different terrestrial air interfaces, called UMTS Terrestrial Radio Access (UTRA). All air interface options are part of ITU's IMT-2000. In the currently most popular variant for cellular mobile telephones, W-CDMA (IMT Direct Spread) is used.

The access scheme is Direct-Sequence Code Division Multiple Access (DS-CDMA) with information spread over approximately 5 MHz bandwidth, thus also often denoted as Wideband CDMA (WCDMA) due that nature.

UTRA has two modes, FDD (Frequency Division Duplex) & TDD (Time Division Duplex), for operating with paired and unpaired bands respectively. The possibility to operate in either FDD or TDD mode allows for efficient utilization of the available spectrum according to the frequency allocation in different regions. FDD and TDD modes are defined as follows;

FDD: A duplex method whereby uplink and downlink transmissions use two separated radio frequencies. In the FDD, each uplink and downlink uses the different frequency band. A pair of frequency bands, which have specified separation, shall be assigned for the system.

TDD: A duplex method whereby uplink and downlink transmissions are carried over same radio frequency by using synchronized time intervals. In the TDD, time slots in a physical channel are divided into transmission and reception part. Information on uplink and downlink are transmitted reciprocally.

In UTRA TDD there is TDMA component in the multiple accesses in addition to DS-CDMA. Thus the multiple accesses have been also often denoted as TDMA/CDMA due added TDMA nature.

A 10 ms radio frame is divided into 15 slots (2560 chip/slot at the chip rate 3.84 Mcps). A physical channel is therefore defined as a code (or number of codes) and additionally in TDD mode the sequence of time slots completes the definition of a physical channel [25].

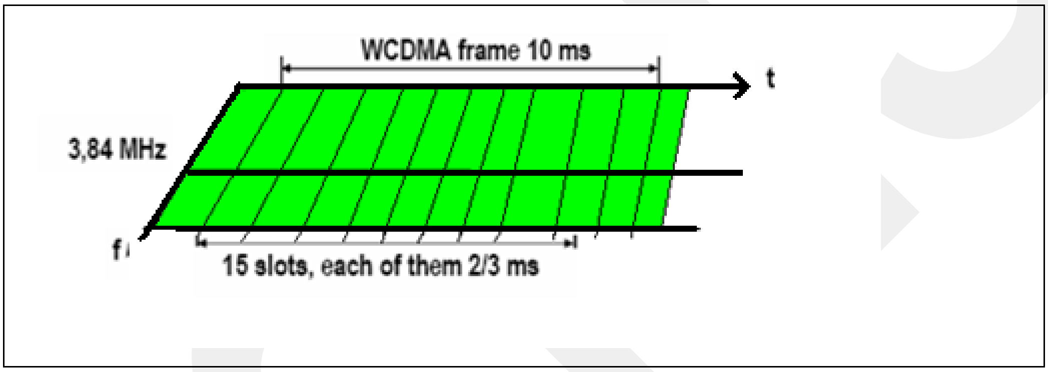


Figure 1.4 WCDMA Frame Structure

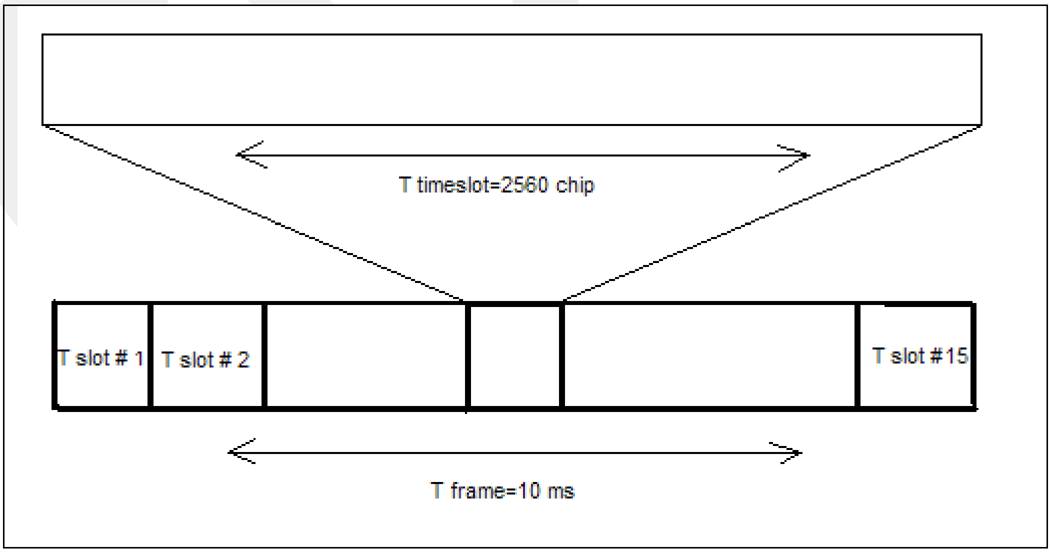


Figure 1.5 WCDMA Frame Structure 2

CHAPTER 2

2.1. Radio Propagation Characteristics

2.1.1. Multipath Characteristics of Radio Channel

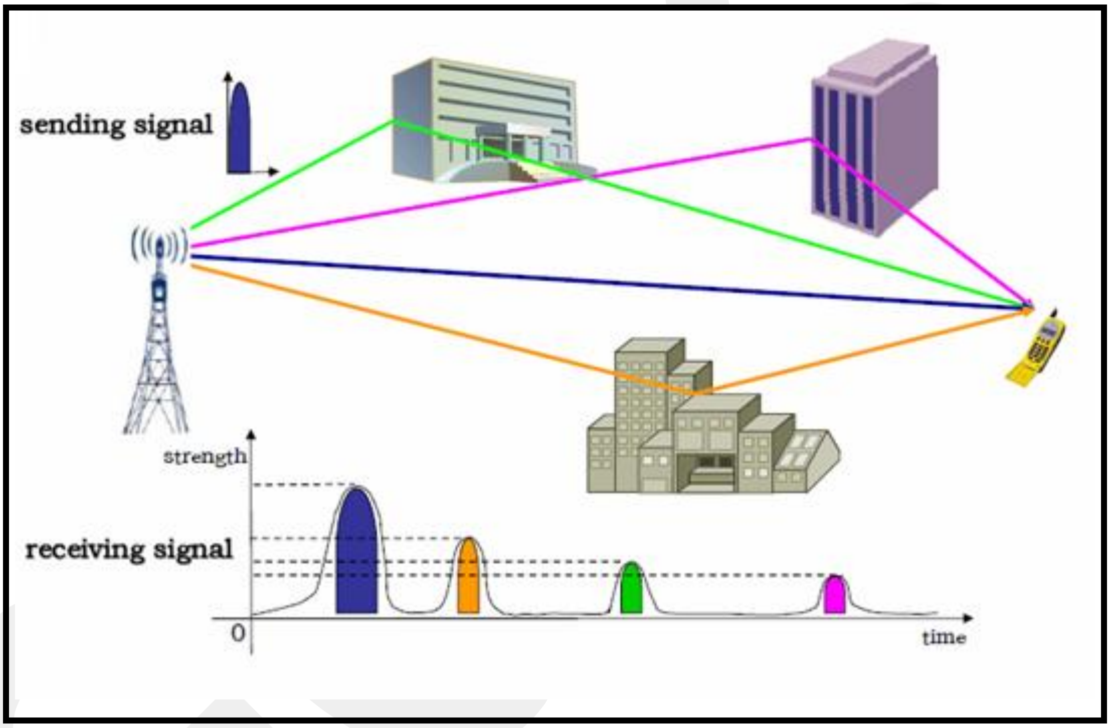


Figure 2.1 Multipath characteristic of radio channel

A mobile communication channel is a multi-path fading channel and any transmitted signal reaches a receive end by means of multiple transmission paths, such as direct transmission, reflection, scatter etc...

2.1.2. Spreading

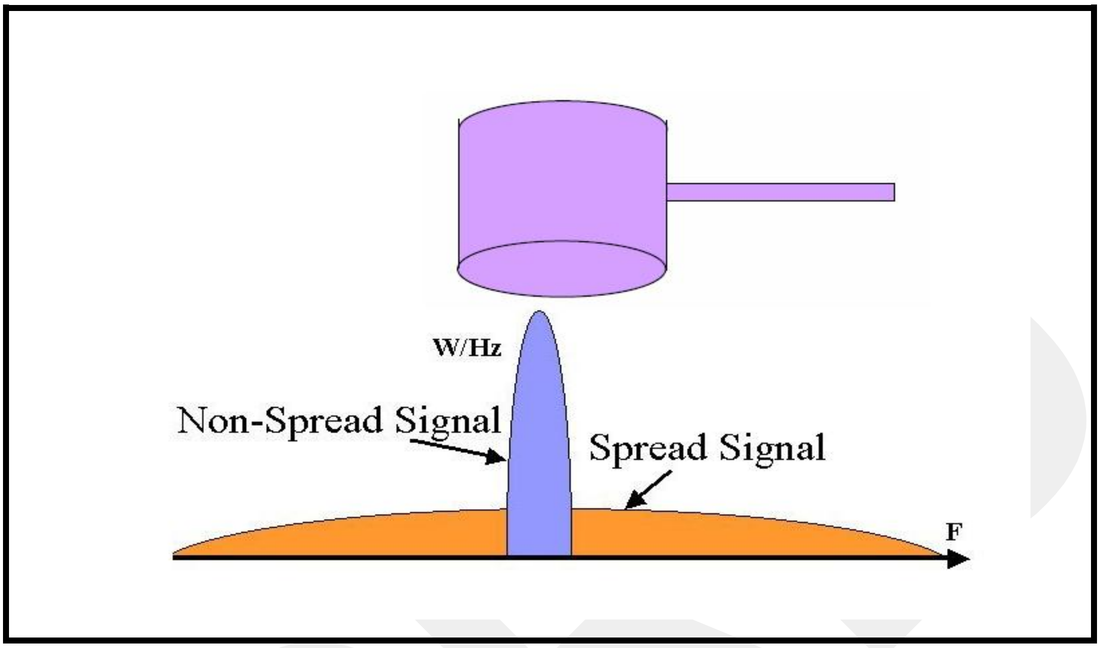


Figure 2.2 Spreading

The basic characteristic of spread spectrum communication is that uses a bandwidth for information transmission much wider than that of the information itself. This means that, the data for transmission with certain signal bandwidth is modulated by high-speed pseudo random codes having a bandwidth wider than the signal bandwidth. The bandwidth of the original data signal is spread, before the signals are transmitted following carrier modulation.

The receiving end uses exactly the same pseudo random codes to process the received bandwidth signals, converting the broadband signals in to the original narrowband signals, that is, dispreading, thus achieving information communication.

Spread Spectrum communication also has the following characteristics;

- It's a digital transmission mode.
- Bandwidth spreading is implemented by modulating the transmitted information with a function irrelevant to the transmitted information.
- At the receiving and the same spread spectrum function is used to demodulate the spread spectrum signals restoring the transmitted information [29].

C.E Shannon found the channel capacity formula in his research in information theory.

$$C=B* \log_2 (1+S/N)$$

- C = capacity of channel
- B = signal bandwidth
- S = average power for signal
- N = average power for noise

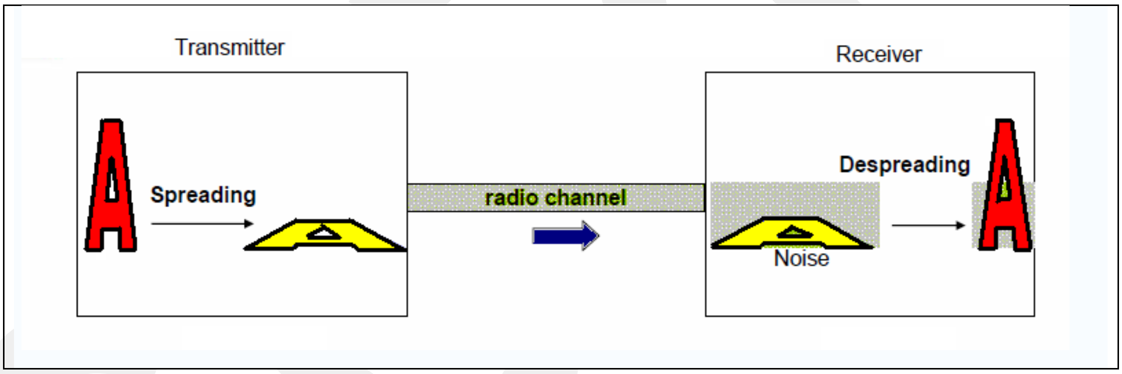


Figure 2.3 Spreading & Dispreading

User information bits are spread over a wide bandwidth by multiplying high speed spread code (chip). Spread signal bandwidth W wider than original signal bandwidth Rb. For WCDMA, W=3.84Mchip/s Rb (voice) =12kbit/s

2.1.2.1. Spreading Modes

2.1.2.1.1. Direct Sequence Spread Spectrum (DS-SS)

Direct-sequence spread spectrum (DS-SS) is a modulation technique. As with other spread spectrum technologies, the transmitted signal takes up more bandwidth than the information signal that is being modulated. The name 'spread spectrum' comes from the fact that the carrier signals occur over the full bandwidth (spectrum) of a device's transmitting frequency [26].

Bandwidth spreading by direct modulation of signals by a wideband spread signal (also called code) is called direct sequence spread spectrum (DS-SS). The DS-SS signal is then modulated by a carrier before final transmission. In DS-SS, the base band signals are usually called bits, and the code bits are called chips. Typically, the baseband signal bandwidth is multiplies several times by the spreading signals. In other words, the chip rate is much higher than the bit rate. The spreading signal sequence is unique for a transmitter, and the same chip sequence is used at the receiver to re-construct the signals (data bits). A mechanism, by name correlation is used to synchronize the received spread signals (that contain data) with the locally generated code. At maximum received signal strength, correlation said to have occurred. The receiver then enters the tracking mode, such that the spread signal modulated signals are received without interruption [26].

2.1.2.1.2. Frequency Hopping Spread Spectrum（FH-SS）

Frequency-hopping spread spectrum (FH-SS) is a method of transmitting radio signals by rapidly switching a carrier among many frequency channels, using a pseudorandom sequence known to both transmitter and receiver. It is utilized as a multiple access method in the frequency-hopping code division multiple access (FH-CDMA) scheme.

The overall bandwidth required for frequency hopping is much wider than that required to transmitting the same information using only one carrier frequency. However, because transmission occurs only on a small portion of this bandwidth at any given time, the effective interference bandwidth is really the same. Whilst providing no extra protection against wideband thermal noise, the frequency-hopping approach does reduce the degradation caused by narrowband interferers.

One of the challenges of frequency-hopping systems is to synchronize the transmitter and receiver. One approach is to have a guarantee that the transmitter will use all the channels in a fixed period of time. The receiver can then find the transmitter by picking a random channel and listening for valid data on that channel. The transmitter's data is identified by a special sequence of data that is unlikely to occur over the segment of data for this channel and the segment can have a checksum for integrity and further identification. The transmitter and receiver can use fixed tables of channel sequences so that once synchronized they can maintain communication by following the table. On each channel segment, the transmitter can send its current location in the table [28].

2.1.3. Orthogonal Code Usage

Table 2.1 Orthogonal Code Usage

Code1	+1 -1 +1 +1 -1 +1 -1 -1
Code2	-1 +1 +1 -1 -1 +1 +1 -1
Mul	-1 -1 +1 -1 +1 +1 -1 +1
Sum	0
Orthogonal	

Code1	+1 -1 +1 -1 -1 +1 -1 -1
Code2	+1 +1 -1 +1 -1 -1 +1 -1
Mul	+1 -1 -1 -1 +1 -1 -1 +1
Sum	-2
Non-orthogonal	

If the sum of multiplication of two codes is zero this means these two codes are orthogonal. If the sum of this multiplication is not equal to zero codes are not orthogonal to each other.

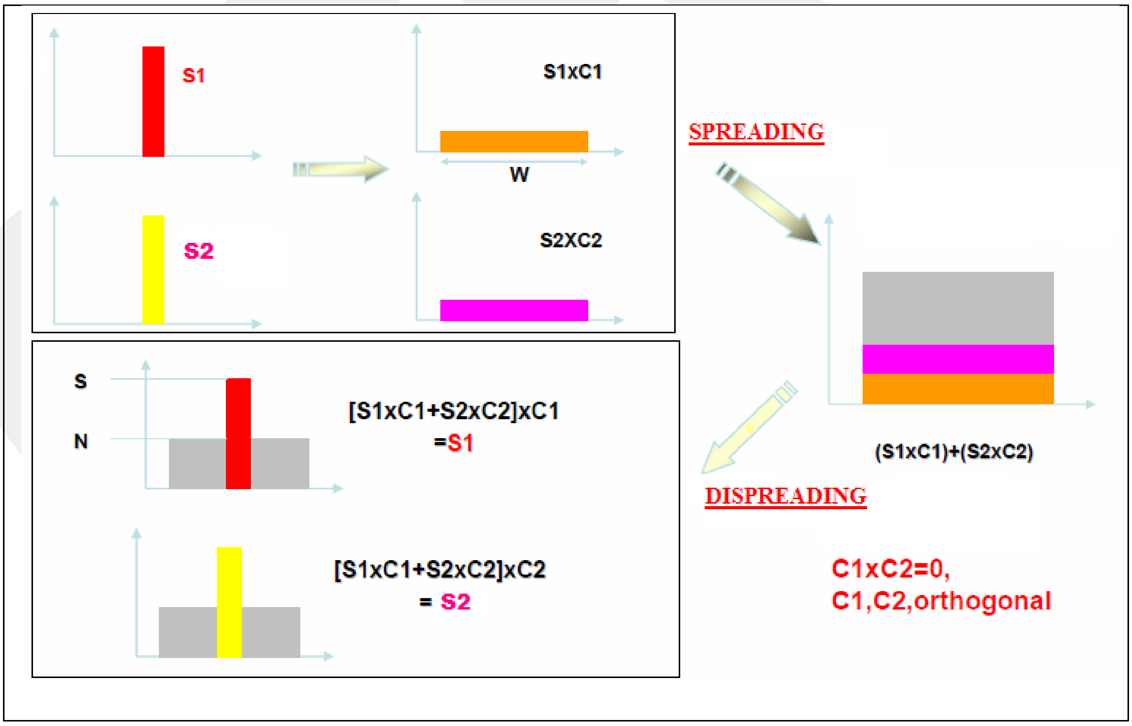


Figure 2.4 Spreading & Dispreading & Orthogonal Code Usage

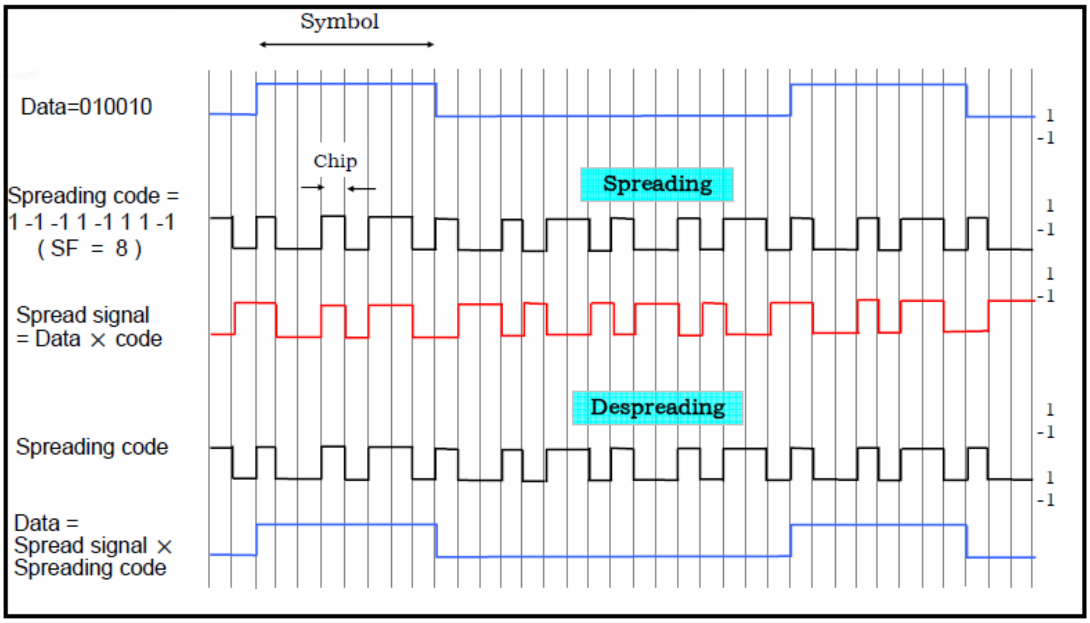


Figure 2.5 Example for Spreading & Dispreading

2.1.4. Channel Coding

In digital communications, a channel code is a broadly used term mostly referring to the forward error correction code and bit interleaving in communication and storage where the communication media or storage media is viewed as a channel. The channel code is used to protect data sent over it for storage or retrieval even in the presence of noise (errors) [28].

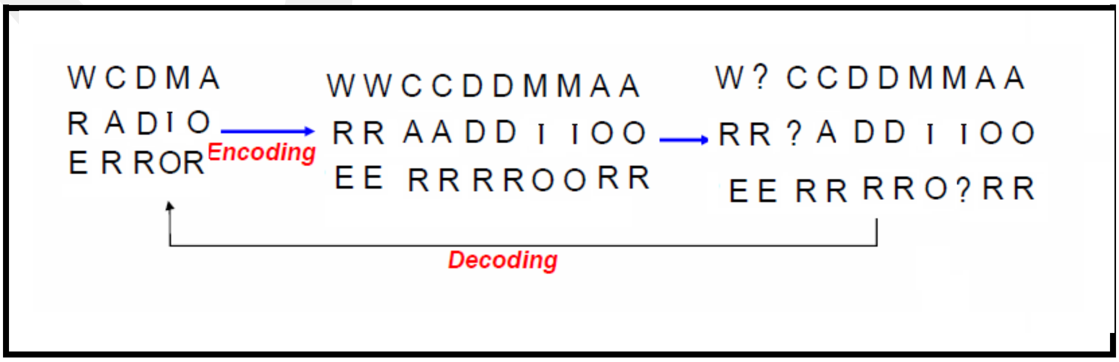


Figure 2.6 Channel Coding

2.1.5. Modulation

Modulation is the process where the amplitude, frequency, or phase of an electronic or optical signal carrier is changed in order to transmit information. Two types of modulation one is digital one is analog modulation.

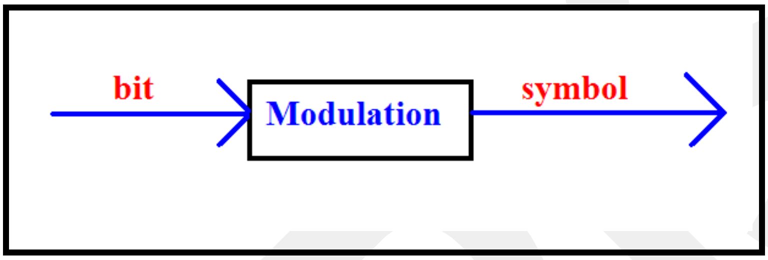


Figure 2.7 Modulation

2.1.5.1. Analog Modulation

The purpose of analog modulation is to impress an information-bearing analog waveform onto a carrier for transmission.

Common analog modulation methods include:

- Amplitude modulation (AM)
- Frequency modulation (FM)
- Phase modulation (PM)

2.1.5.2. Digital Modulation

The purpose of digital modulation is to convert an information-bearing discrete-time symbol sequence into a continuous-time waveform (perhaps impressed on a carrier). Basic analog modulation methods include

- Amplitude shift Keying (ASK)
- Frequency shift Keying (FSK)
- Phase shift Keying (PSK)

2.2. WCDMA Radio Mechanism

2.2.1. WCDMA Data Transmission Procedure

For WCDMA Data transmission procedure is shown on figure;

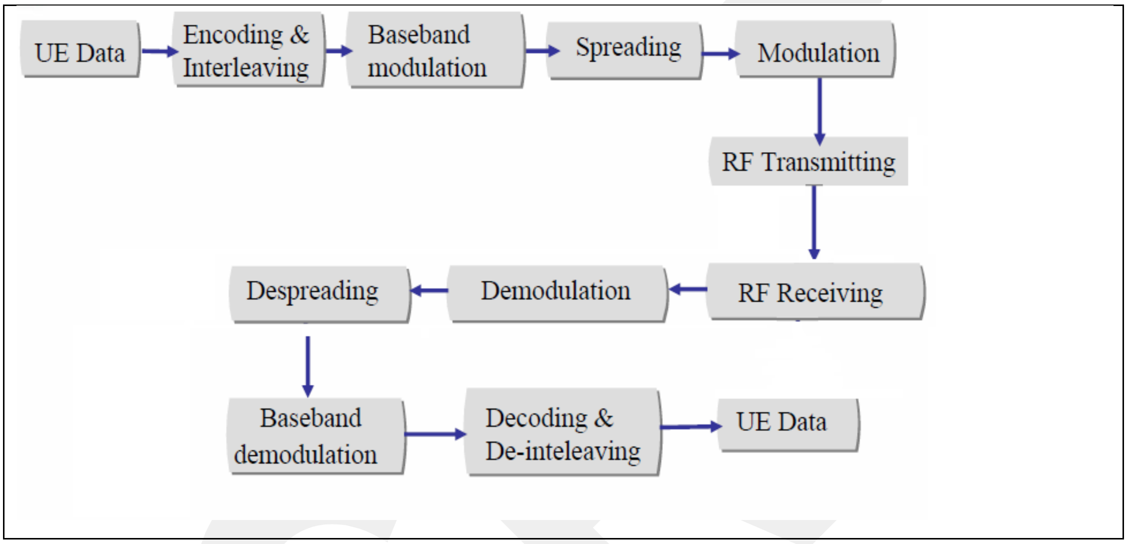


Figure 2.8 WCDMA Data Transmission Procedure

2.2.2. Channel Coding of WCDMA

UTRAN employs two forward error corrections (FEC) schemes: convolutional and turbo codes. The idea is to add redundancy to the transmitted bit stream, so that occasional bit errors can be corrected in the receiving entity.

Convolutional codes are used for anti-interference. Through the technology, many redundant bits will be inserted in original information. When error code is caused by interference, the redundant bits can be used to recover the original information. Convolutional codes are typically used when timing constraints are tight. The coded data must contain enough redundant information to make it possible to correct some of detected errors without asking repeats. Turbo codes are found to be very efficient because they can perform close to the theoretical limit set by Shannon's formula.

Their efficiency is best with high data rate services. At higher bit rates, turbo coding is more efficient than convolutional coding. In WCDMA networks both convolutional code and turbo codes are used. Convolutional code applies to voice service while turbo codes apply to high rate data services.

Block codes and Channel codes are both used in UTRAN. The idea behind this arrangement is that the channel decoder (either convolutional or turbo decoder) tries to correct as many errors as possible, and then the block decoder (CRC Check) offers its judgment on whether the resulting information is good enough to be used in the higher layers [28].

2.2.3. Spreading Technology of WCDMA

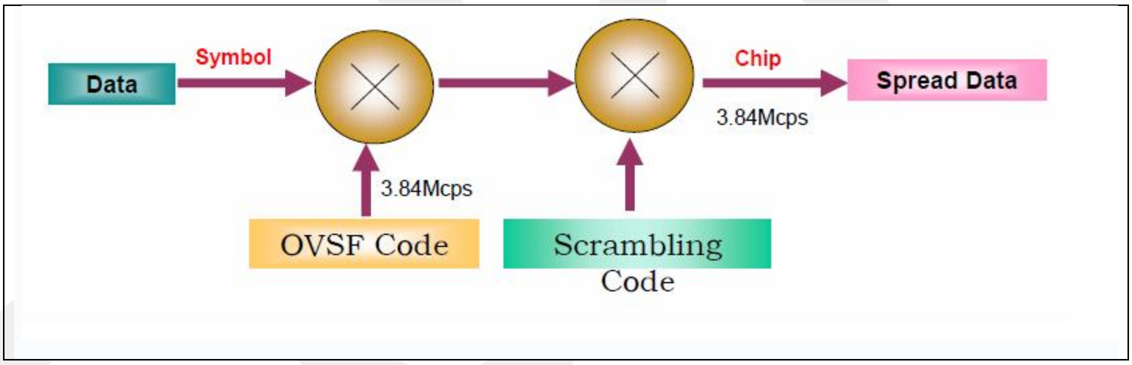


Figure 2.9 Spreading Technology of WCDMA

Spreading means increasing the bandwidth of the signal beyond the bandwidth normally required accommodating the information. The spreading process in UTRAN consists of two separate operations: channelization and scrambling.

The first operation is the channelization operation, which transforms every data symbol in to a number of chips, thus increasing the bandwidth of the signal. The number of chips per data symbol is called Spreading Factor. (SF) Channelization codes are orthogonal codes, meaning that the ideal environment they do not interfere each other.

The second operation is the scrambling operation. Scrambling is used on top of spreading, so it does change the signal bandwidth but only makes the signals from different sources separable from each other .As the chip rate is already achieved in channelization by the channelization codes, the chip rate is not affected by the scrambling [29].

2.2.3.1. Channelization Codes

OVSF (Orthogonal Variable Spreading Factor) is used as channelization codes.

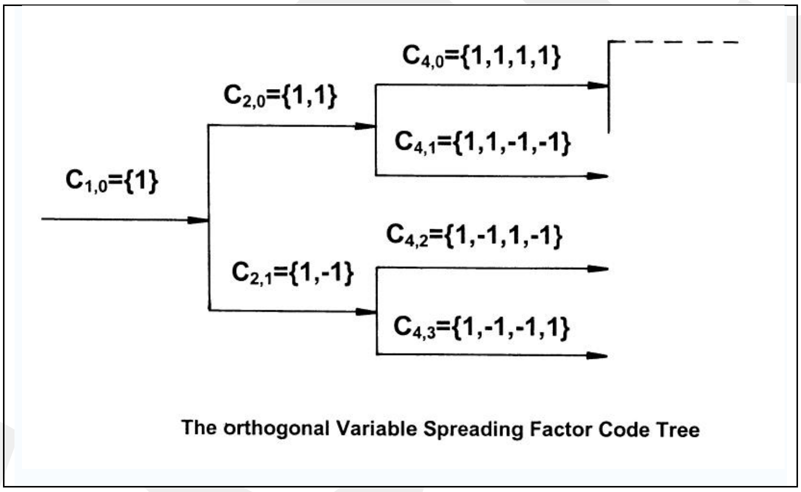


Figure 2.10 OVSF (Orthogonal Variable Spreading Factor)

Orthogonal codes are easily generated by starting with a seed of 1, repeating the 1 horizontally and vertically, and then complementing the -1 diagonally. The process is to be continued with newly generated block until the desired codes with the proper length are generated. Sequences created in this way referred as “Walsh” Code.

Channelization uses OVSF code for keeping the orthogonality of different subscriber physical channels. OVSF can be defined as the code tree can be seen on figure 2.10.

2.2.3.2 Scrambling Code

Table 2.2 Scrambling Code Usages

	Down Link	Up Link
Scrambling Code	-To identify cells. -Code shall be assigned to each cell. -Number of Code ; 512 -Assignment work by System Designer is required.	-To identify Users. -Code shall be assigned to each user. -Number of Code ; 2^{24} -Assignment work by System Designer is not required.

- Primary Scrambling Code is used to identify and distinguish the cells.
- Primary Scrambling Code partly comparable with BCCH and CC combination in 2G.
- All Primary Scrambling Codes are equally orthogonal to each other, there is no ‘adjacent’ code, like in 2G.
- In General Scrambling Code planning is relatively easy due to high amount of codes.
- There are 224 Uplink Scrambling Codes, they are used to distinguish different users in one cell.

- There are 218-1 Downlink Scrambling Codes, used to distinguish different cells
- Scrambling codes usually used are the first 8192 codes, which are code 0 , 1 , …… , 8191. They are divided into 512 aggregations , each aggregation has 1 primary scrambling code (PSC) and 15 secondary scrambling codes (SSC).
- The 512 primary scrambling codes are divided further into 64 primary scrambling code groups, with 8 primary scrambling codes in each group.

CODE GROUPS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	60	61	62	63
PSC 0	0	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144	152	160	168	176	184	192	200	480	488	496	504
PSC 1	1	9	17	25	33	41	49	57	65	73	81	89	97	105	113	121	129	137	145	153	161	169	177	185	193	201	481	489	497	505
PSC 2	2	10	18	26	34	42	50	58	66	74	82	90	98	106	114	122	130	138	146	154	162	170	178	186	194	202	482	490	498	506
PSC 3	3	11	19	27	35	43	51	59	67	75	83	91	99	107	115	123	131	139	147	155	163	171	179	187	195	203	483	491	499	507
PSC 4	4	12	20	28	36	44	52	60	68	76	84	92	100	108	116	124	132	140	148	156	164	172	180	188	196	204	484	492	500	508
PSC 5	5	13	21	29	37	45	53	61	69	77	85	93	101	109	117	125	133	141	149	157	165	173	181	189	197	205	485	493	501	509
PSC 6	6	14	22	30	38	46	54	62	70	78	86	94	102	110	118	126	134	142	150	158	166	174	182	190	198	206	486	494	502	510
PSC 7	7	15	23	31	39	47	55	63	71	79	87	95	103	111	119	127	135	143	151	159	167	175	183	191	199	207	487	495	503	511

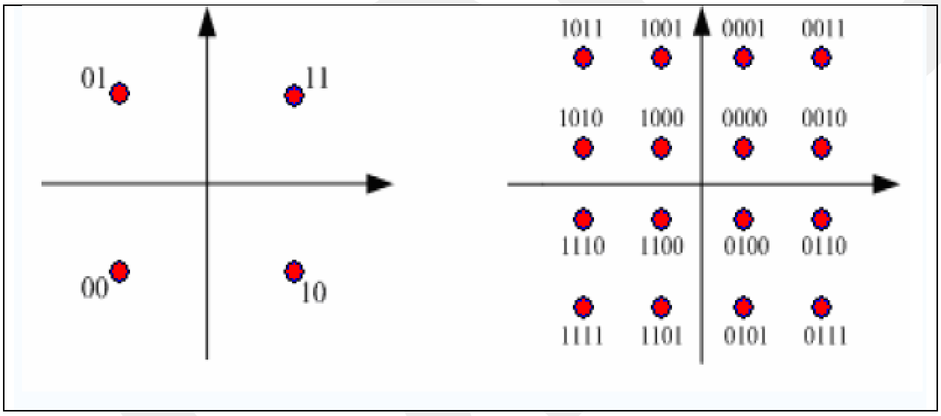
Figure 2.11 Scrambling Code Groups

- Channelization code ---- for separation of physical channels in the uplink and separation of users in the downlink
- Scrambling code ---- for separation of users/terminals in the uplink and cells/sectors in the downlink.

2.2.4. Modulation Methods in WCDMA

Modulation Methods for;

- BPSK (Binary Phase Shift Keying) in Uplink channels
- QPSK (Quadrature Phase Shift Keying) in Downlink channels
- 16QAM (16-state Quadrature Amplitude Modulation) in HSDPA[20].



QPSK-2Bits/Symbol 16 QAM-4Bits/Symbols

Figure 2.12 Modulation Methods

CHAPTER 3

KEY TECHNOLOGIES OF WCDMA

3.1. Power Control

Quality of service (QOS) that radio cell network provides for each subscriber mainly depends on signal-to-interfernce ratio (SIR) of subscriber receiving signals.For CDMA cell system,all subscribers in same cell us same band and timeslot,and subscriber are isolated with each other only by the orthogonalization of spreading code.Correleation characteristic between each subscriber signals are not so gook and signals of other subscribers interfere signals of current subscribers, due to multipath and delay of the radio channels [28].

- All CDMA users occupy the same frequency at the same time. Frequency and time are not used as discriminators.
- CDMA operates by using CODES to discriminate between users.
- CDMA interference comes mainly from nearby users.

Increasing of subscribers or power of other subscribers may enchance interference on current subscriber. Therefore CDMA system is strong power-restricted system and strength of interference influenses system capacity directly.

Power control is regarded as one of the key technology of CDMA system. Power control adjusts transmission power of each subscriber, compensates channel attenuation, recompenses near-far effect and maintains all subscribers at lowest standart of normal communication. It reduces interference on other subscribers at most, increases system capacity and prolongs holding time of mobile phones [28].

Power control is an important part in WCDMA system. If all the MS's in a cell transmit signals at the same power, the signals from near MS to the BTS are stronger and the signal from a far MS to the BTS is weaker. As a result, the strong signals override the weak signals. This is called Near-far effect in communication. WCDMA is a self interference system and all users use same frequency. Therefore the near-far effect is more serious. In addition, for the WCDMA system, the downlink of BTS is power restricted. To achieve acceptable call quality when the TX power is small, both the BTS and the MS are required to adjust the power needed by the transmitter in real time according to the communication distance and link quality. This process is called "Power Control" [28].

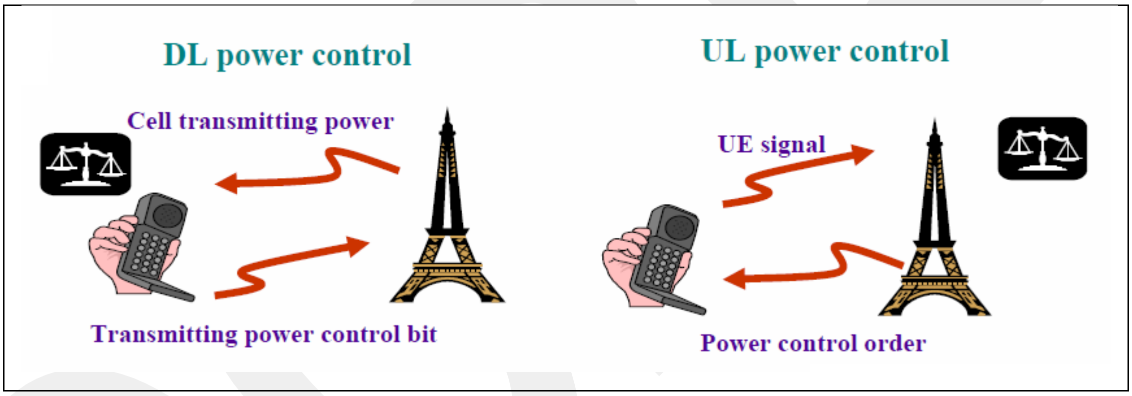


Figure 3.1 Power Control.

Power control of WCDMA includes inner loop and outer loop power control by effect.

- Open loop: measure received signal level and adjust transmitting power

- Inner-loop (closed loop): Frequency:1500HZ
  - Measured SIR> Target SIR, lower transmitting power
  - Measured SIR< Target SIR, increase transmitting power
- Outer-loop (closed loop):Measure BLER, adjust target SIR

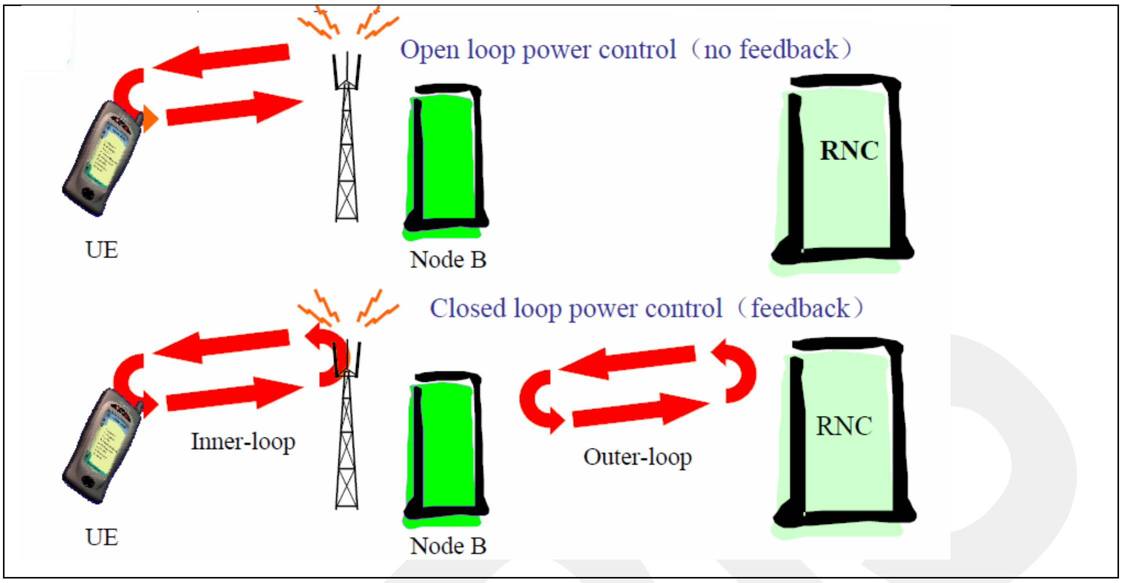


Figure 3.2 Power Control of WCDMA

3.1.1. Open Loop Power Control

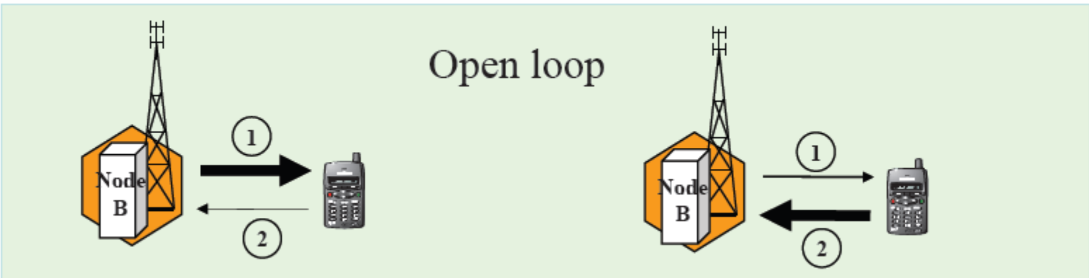


Figure 3.3 Open Loop Power Control

In the WCDMA system every MS is calculating the path loss from the BTS to the MS all the time. When the signal from the BTS to the MS is very strong, it indicates that either the MS is very close to the BTS or the transmission path is excellent.

In this case the MS can lower the TX power, while the BTS can still receive the signal normally. On the other way around when the signal received by the MS is very weak, its TX Power can be increased to counteract the attenuation. Open loop power control occurs only when the MS is power on and only once [29].

3.1.2. Inner Loop & Outer Loop Power Control

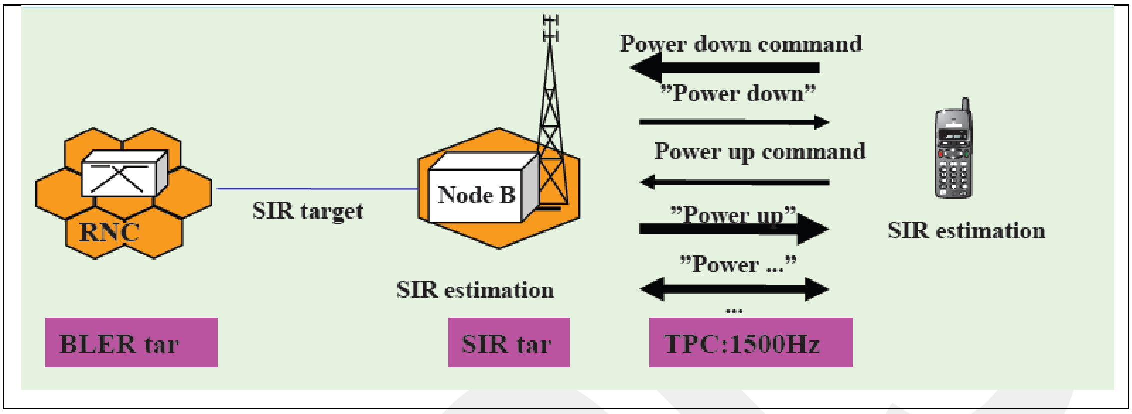


Figure 3.4 Inner Loop& Outer Loop Power Control

- Inner-loop control is very fast
- Inner-loop : according to SIR estimation, Node-B control UE transmission power conducted every 0.66ms (1500Hz)
- Continuously @ rate 1500 times/s,
- Outer-loop : according to BLER(Block error rate) measurement estimation RNC control and adjust SIR target

3.2. Handover

UTRAN distributes radio resources for the UE in the new cell because of UE's moving and system load. Then UE synchronizes with the new cell and transmits data each other. Handover refers to the process in which when a UE moves from one Node B to another during calling. It keeps the service continuity.

In the WCDMA system, handover is divided into soft/softer handover and hard handover;

Soft Handover：

- Intra-RNC, Inter-Node B
- Inter-RNC

Softer Handover:

- Same Node B, Inter-sector

Hard Handover:

- Intra-frequency handover
- Inter-frequency handover
- Inter-system handover (3G&2G)
- Inter-mode (FDD & TDD)

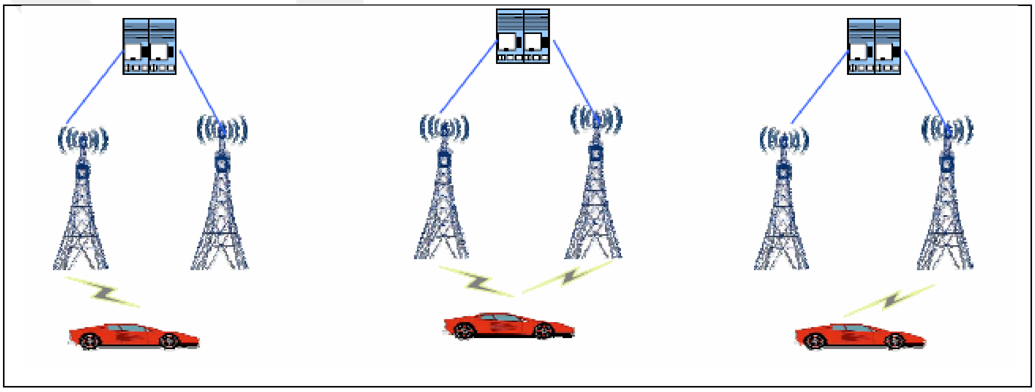


Figure 3.5 Soft Handover

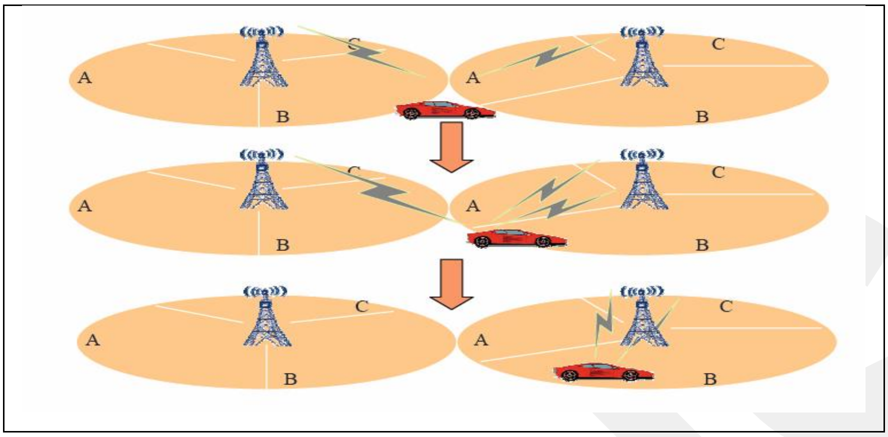


Figure 3.6 Softer Handover

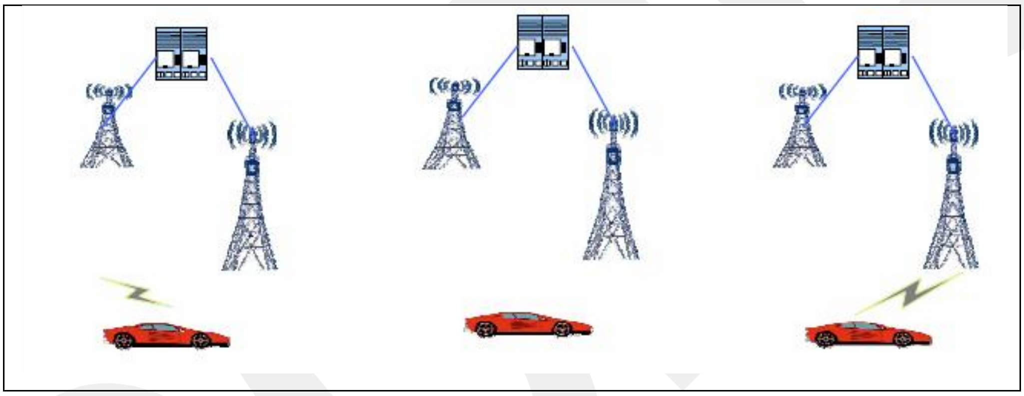


Figure 3.7 Hard Handover

- The soft/softer handover allows swapping from one cell to another without call interruption or without deleting all old radio links (by opposition to hard HO).
- It also allows the UE to be connected to more than one cell simultaneously and take benefit from macro-diversity.
- The hard handover procedure is used in case of service quality degradation or for traffic distribution management.

- During the hard handover procedure, all the old radio links with the UE are abandoned before newones are established.
- Hard handover may occur in the following main cases:
- When the UE is handed over another UTRAN carrier, or another technology mode.
- When soft handover is not permitted (if O&M constraint) [28].

3.2.1. Basic concepts about handover

Basic concepts of handover is using also in measurements.

- Active Set:
  The set of cells connected with UE;
  User information is transmitted from these cells.

- Monitor Set:
  The set of cells not within the active set but being monitored by a UE according to the adjacent node list allocated by UTRAN.

- Detect Set:
  The set of cells in neither the active set nor the monitor set [29].

CHAPTER 4

FIELD MEASUREMENTS OF 3G

The real measurements on 3G systems can do by special investigation tools.

First rule to make these measurements we need a phone in UMTS mode, a computer; which this special tool have to be installed in this computer, a scanner to see the signals on air interface and a GPS to see where we make our measurements. For these measurements we can call a number and measure the signal level, signal quality, pilot pollution and scrambling codes which using by cells with this special investigation tool. Also we will do these tests on idle mode.

The Scanner Measurements obtained during the drive test phase are used to evaluate

• SCH offset problems
• Crossed feeder issues (DL) 10-20 % of sites
• Code plan verification
• Coverage verification, i.e. reasonable CPICH setting and correct antenna direction.
• Interference problems, i.e. cell overlap and pilot pollution.
• Handover areas can be used to detect missing neighbors. The basic measurements of the scanner are:
• CPICH RSCP and CPICH Ec/No

The received signal code power (RSCP) is the received power of the CPICH channel. The serving cell RSCP equals the value of Ec, which is a pure coverage indicator in an unloaded network. The Ec/No distribution is of great interest in the network characterization, as this describes how much load it is possible to have in the network and to indicate excessive interference from common channels. Furthermore Ec/No is used for pilot detection and channel estimation.

4.1. Procedure for Single Site Measurements

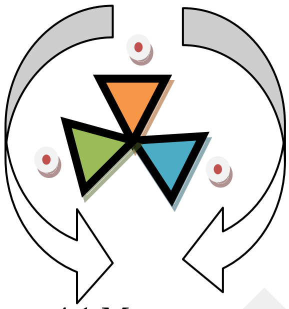


Figure 4.1 Measurement procedure

Figure 4.1 shows the procedure for single site verification. First procedure of these type tests to make a stabile test in front of the sectors. The red points show this procedure. The aim for doing this test is to understand the call setup success and accessability to this cell. After this to measure pilot pollution, signal level and quality we will do a test around the site clockwise and counter clockwise directions. Also Figure 4.2 shows the field measurements of single site verification. On this figure all three sectors coverage area and signal level can be seen. From red color to blue color the signal level becomes good.

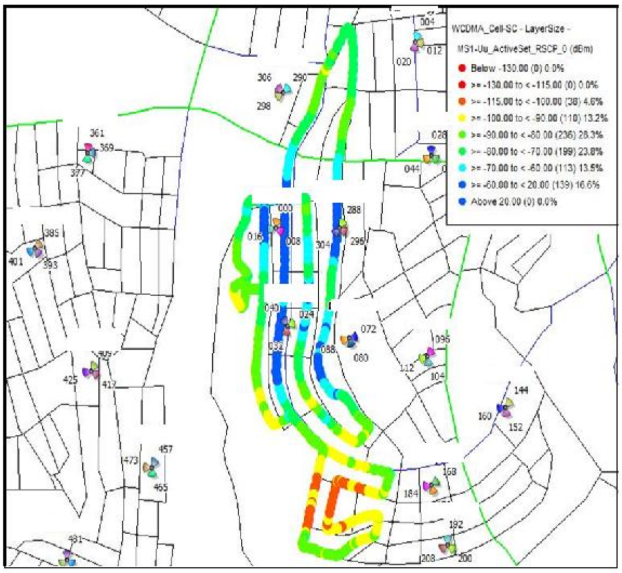


Figure 4.2 Measurement procedure 2

4.2. RSCP (Received Signal Code Power)

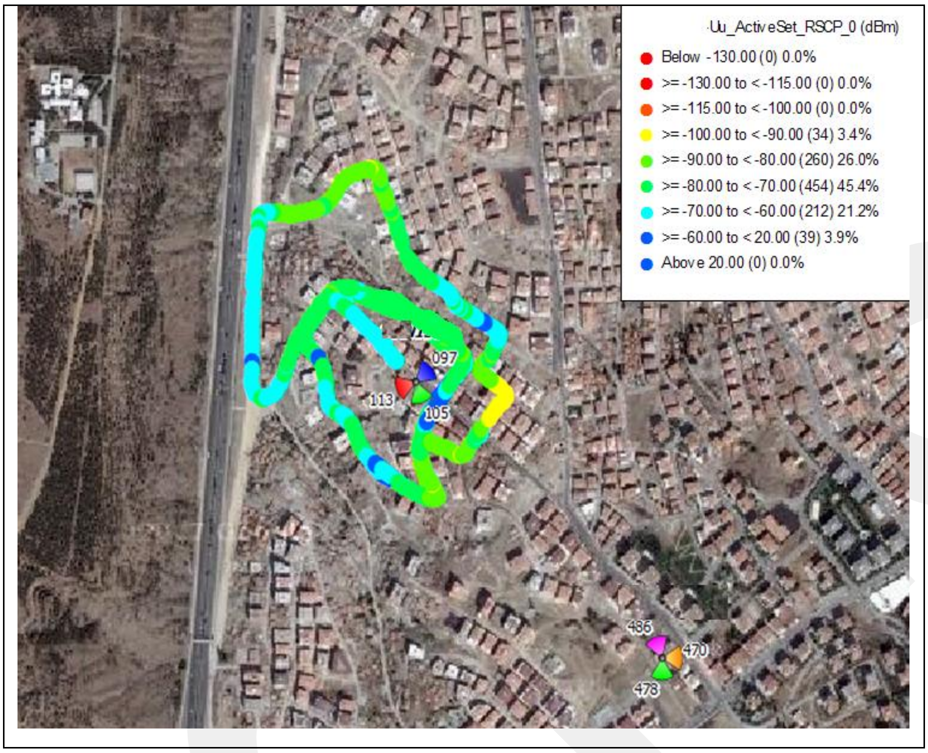


Figure 4.3 Plot for RSCP

In UMTS cellular communication systems, received signal code power (RSCP) denotes the power measured by a receiver on a particular physical communication channel. It is used as an indication of signal strength, as a handover criterion, in downlink power control, and to calculate path loss. In CDMA systems, a physical channel corresponds to a particular spreading code, hence the name. While RSCP can be defined generally for any CDMA system, it is more specifically used in UMTS. Also, while RSCP can be measured in principle on the downlink as well as on the uplink, it is only defined for the downlink and thus presumed to be measured by the UE and reported to the Node B.

As we can see from Figure 4.3 signal levels for these sectors are acceptable for good level. The green color represents signal level below -80 dBm. For the signal level; if the level approaches -110 dBm; this means that level is too bad. This represented by red color. If RSCP level approaches -40 dBm, this means that our level is really good and our call will continue without problem. Good signal level is represented by blue color. By some changes these levels for all three sectors can become more acceptable as good signal level.

4.3. Ec/No (Energy chip /Noise)

Figure 4.4 Plot for Ec/No

Ec/No: Energy of Chip is divided by total noise.This will give us the quality measurement for the cell. As seen on Figure 4.4, Ec/No is very good around this site. Blue color also represents here best quality. If quality approaches 0 we can understand call quality becomes best level. 20 and below is the worst value quality.

4.4. Scrambling Code

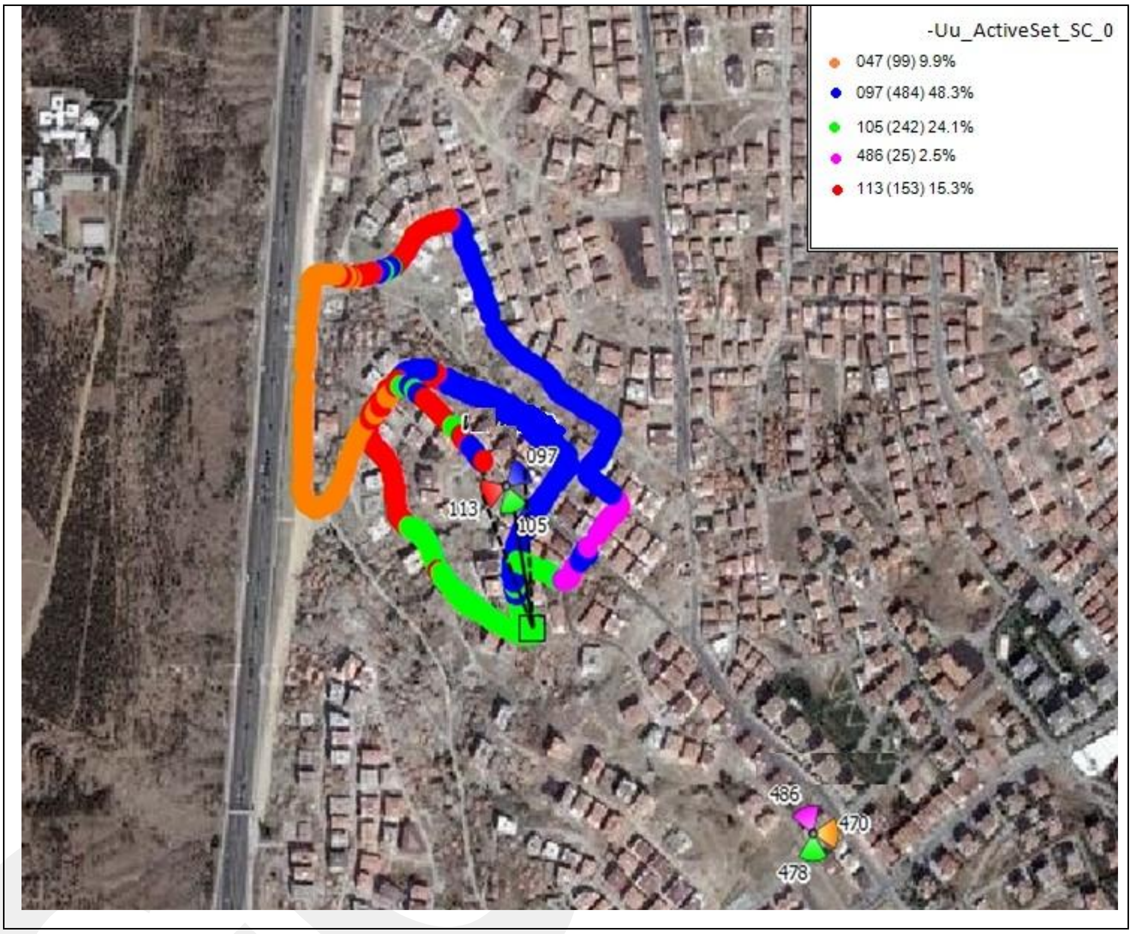


Figure 4.5 Plot for Scrambling Code

From that plot, we can understand which cell use which scrambling code. Also we can understand if it is overshooting or not, by the way we can easily check the cells it has a cross feeder or not. We can see as scrambling code 105 is the scrambling code of sector 3 and scrambling code 097 is used for sector 2. If SC of sector 3 is appears in front of sector 2 and vise versa SC of sector 2 appears front side of sector 3 this means as cross feeders. It should change on site by changing the TRX's on node B.

4.5. Pilot Pollution

Figure 4.6 Plot for Pilot Pollution

Pilot pollution is a type of co-channel interference in CDMA systems caused when the pilot code from a distant cell or base station is powerful enough to create an interference problem. From the plots also we can understand how many cells have a signal on one point.

Pilot pollution can define as; have to be more than three cells in active set. To solve this pilot pollution problem a new site can be set there to be a dominant cell for this region. By the way we will make some tilt change on overshooting cells to solve problem.

4.6. Comparison of Two Tests for Same Region (Before-After Test)

<u>Before:</u>

Regional drive test before some parametric changes, hardware and software changes.

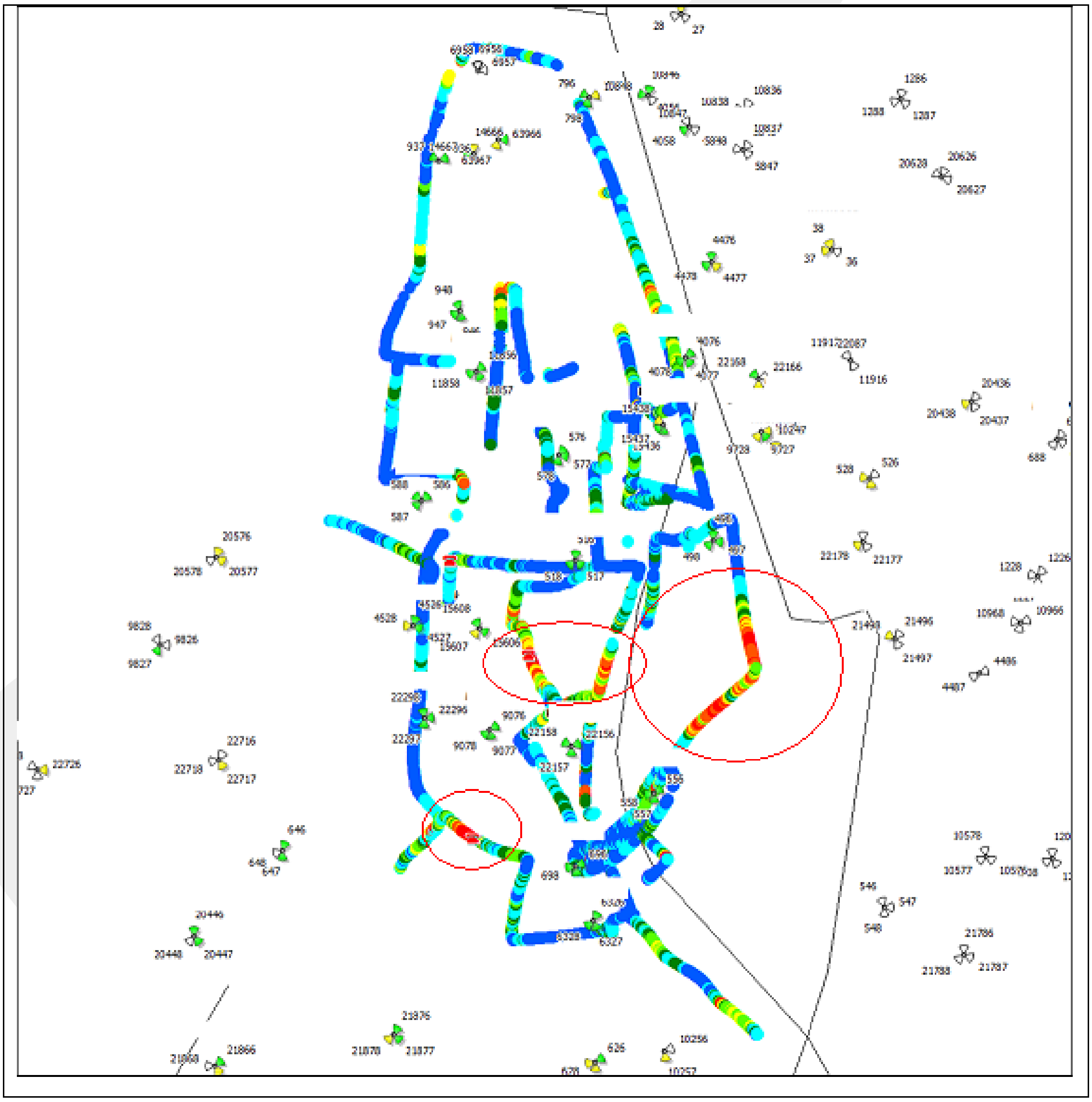


Figure 4.7 Regional Test 1

After:

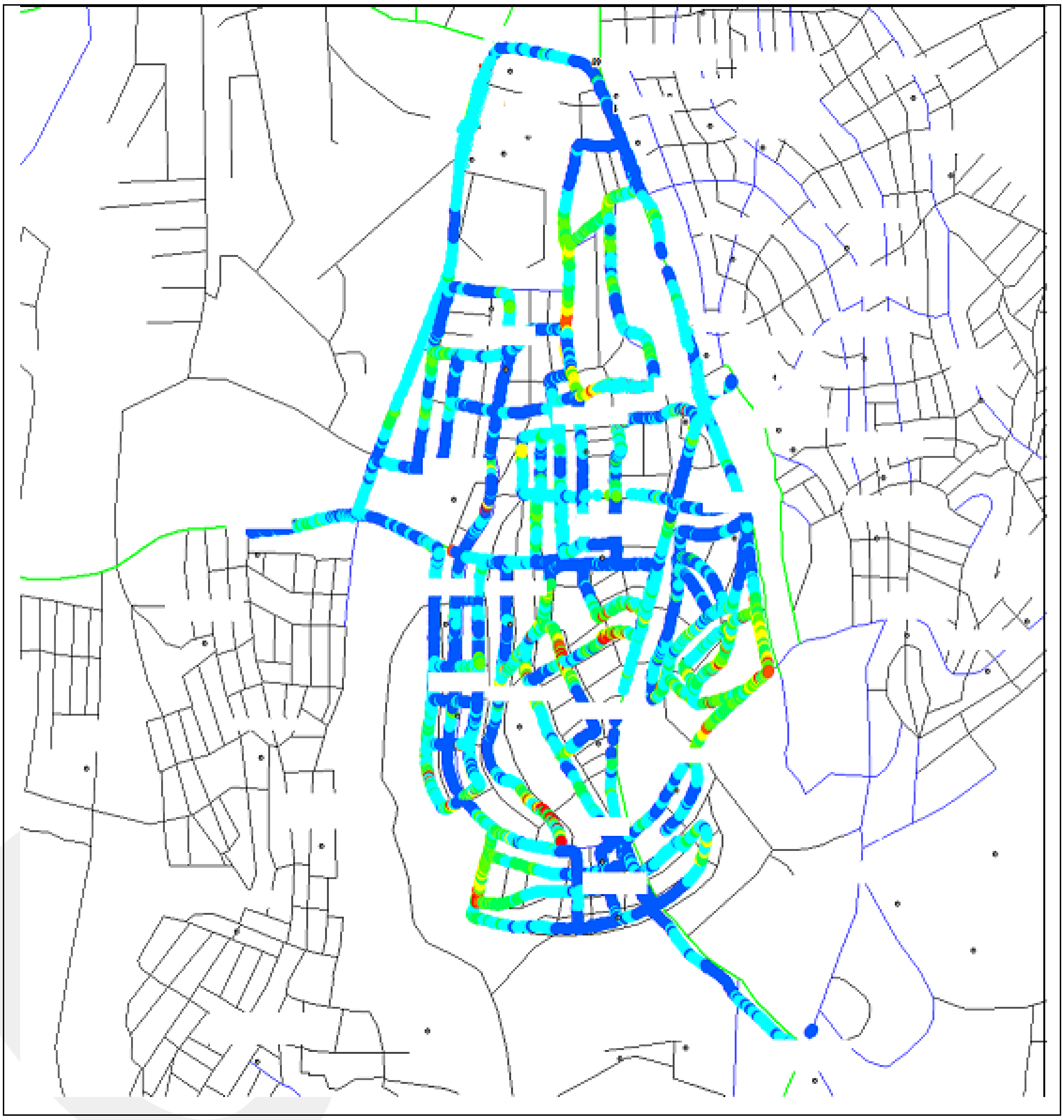


Figure 4.8 Regional Test 2

Before compare these two tests we should look two plots Figure 4.7 and Figure 4.8. As we can see second plot is more detailed drive test. The differences between these two tests are some hardware, software and parametric change. Let's check what these changes were;

Parameter set to solve problems;

Table 4.1 Parameter Set

Description	**Current_Values**	**Rec_Values**
Start Measurements ECNO Threshold, RT	-14	-11
Stop Measurements ECNO Threshold, RT	-12	-10
Start Measurements RSCP Threshold, RT	-97	-100
Stop Measurements RSCP Threshold, RT	-94	-97
Start Measurements ECNO Threshold, HS	-15	-14
Start Measurements ECNO Threshold, NRT	-15	-14
Stop Measurements ECNO Threshold, HS	-13	-12
Stop Measurements ECNO Threshold, NRT	-13	-12
Start Measurements RSCP Threshold, HS	-110	-108
Start Measurements RSCP Threshold, NRT	-110	-108
Stop Measurements RSCP Threshold, HS	-107	-105
Stop Measurements RSCP Threshold, NRT	-107	-105
Hysteresis value for 2D event	4	2
Hysteresis value for 2F event	4	2
GSM Threshold RT	16	13 (-99)
GSM Threshold NRT	12	13 (-99)
GSM Threshold HS	12	13 (-99)
S criterium for intrasearch in idle mode	5	6
S criterium for intrasearch in connected mode	5	6
Maxımum UL Load for new Conversatıonal Radıo Bearers	65	75
Maxımum UL Load for other services	70	80
Maxımum UL Load for handover addmission	75	85

Parameter set informations:

Parameter 1: Start Measurements ECNO Threshold, RT:

For CS domain services, when Ec/No is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to activate compressed mode and start inter-RAT measurement, if the UE reports the event when the measured value is smaller than the value of this parameter. By changing this parameter,measurments start at a lower Ec/No and risks of drop calls and handover fails will decrease.

Parameter 2: Stop Measurements ECNO Threshold, RT:

For CS domain services, when Ec/No is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to deactivate compressed mode and stop inter-RAT measurement, if the UE reports the event 2F (end point of measuring) when the measured value is larger than the value of this parameter. This parameter is related with first one and changed automatically with the first one.

Parameter 3: Start Measurements RSCP Threshold, RT:

For CS domain services, when RSCP is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to activate compressed mode and start inter-RAT measurement, if the UE reports the event 2D(starting point of measurements) when the measured value is smaller than the value of this parameter. By changıng thıs parameter measurments start at a lower receıve level and hence rısks of drop calls and handover fails will decrease.

Parameter 4: Stop Measurements RSCP Threshold, RT:

For CS domain services, when RSCP is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to deactivate compressed mode and stop inter-RAT measurement, if the UE reports the event 2F when the measured value is larger than the value of this parameter. This parameter is related with third one and changed automatically.

Parameter 5: Start Measurements ECNO Threshold, NRT:

For PS domain services, when Ec/No is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to activate compressed mode and start inter-RAT measurement, if the UE reports the event when the measured value is smaller than the value of this parameter. By changıng thıs parameter measurments start at a lower ECNO and hence rısks of drop calls and handover faıls wıll decrease.

Parameter 6: Stop Measurements ECNO Threshold, NRT:

For PS domain services, when Ec/No is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to deactivate compressed mode and stop inter-RAT measurement, if the UE reports the event 2F when the measured value is larger than the value of this parameter. This parameter is related with prevıous one and changed automatically with the previous one.

Parameter 7: Start Measurements RSCP Threshold, NRT:

For PS domain services, when RSCP is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to activate compressed mode and start inter-RAT measurement, if the UE reports the event 2D when the measured value is smaller than the value of this parameter. By changıng thıs parameter measurments start at a lower receıve level and hence rısks of drop calls and handover faıls wıll decrease.

Parameter 8: Stop Measurements RSCP Threshold, NRT:

For PS domain services, when RSCP is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to deactivate compressed mode and stop inter-RAT measurement, if the UE reports the event 2F when the measured value is larger than the value of this parameter. This parameter is related with previous one and changed automatically.

Parameter 9: Start Measurements ECNO Threshold, HIGH SPEED:

For HS domain services, when Ec/No is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to activate compressed mode and start inter-RAT measurement, if the UE reports the event when the measured value is smaller than the value of this parameter. By changıng thıs parameter measurments start at a lower ECNO and hence rısks of drop calls and handover faıls wıll decrease.

Parameter 10: Stop Measurements ECNO Threshold, HIGH SPEED:

For HS domain services, when Ec/No is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to deactivate compressed mode and stop inter-RAT measurement, if the UE reports the event 2F when the measured value is larger than the value of this parameter. This parameter is related with prevıous one and changed automatically with the previous one.

Parameter 11: Start Measurements RSCP Threshold, HIGH SPEED:

For HS domain services, when RSCP is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to activate compressed mode and start inter-RAT measurement, if the UE reports the event 2D when the measured value is smaller than the value of this parameter. By changıng thıs parameter measurments start at a lower receıve level and hence rısks of drop calls and handover faıls wıll decrease.

Parameter 12: Stop Measurements RSCP Threshold, HIGH SPEED:

For HS domain services, when RSCP is used as the measurement quantity for inter-RAT measurement, the RNC sends the signaling to deactivate compressed mode and stop inter-RAT measurement, if the UE reports the event 2F when the measured value is larger than the value of this parameter. This parameter is related with previous one and changed automatically.

Parameter 13-14: Hysteresis for events:

The value of this parameter is relevant to the slow fading characteristic. The larger the value of this parameter, the less the ping-pong effect and the fewer the decision mistakes. In this case, however, the event 2D -2F might not be triggered in time.These two parameters effect to start stop time of measurements.

Parameter 15: GSM Threshold RT: For CS domain services,

If the value of [Inter-RAT report mode] is EVENT_TRIGGER, this parameter is used to set the measurement control on the event 3A. The event 3A is triggered, when the quality of the cell with the target frequency is higher than this threshold and the threshold of the used frequency quality of the corresponding measurement quantity is reached.

If the value of [Inter-RAT report mode] is PERIODICAL_REPORTING, this parameter is used to evaluate coverage-based inter-RAT handovers at the RNC.

Parameter 16: GSM Threshold NRT: For PS domain R99 services,

If the value of [Inter-RAT report mode] is EVENT_TRIGGER, this parameter is used to set the measurement control on the event 3A. The event 3A is triggered, when the quality of the cell with the target frequency is higher than this threshold and the threshold of the used frequency quality of the corresponding measurement quantity is reached.

If the value of [Inter-RAT report mode] is PERIODICAL_REPORTING, this parameter is used to evaluate coverage-based inter-RAT handovers at the RNC.

Parameter 17: GSM Threshold HS: For PS domain HSPA services,

If the value of [Inter-RAT report mode] is EVENT_TRIGGER, this parameter is used to set the measurement control on the event 3A. The event 3A is triggered, when the quality of the cell with the target frequency is higher than this threshold and the threshold of the used frequency quality of the corresponding measurement quantity is reached.

If the value of [Inter-RAT report mode] is PERIODICAL_REPORTING, this parameter is used to evaluate coverage-based inter-RAT handovers at the RNC.

Parameter 18: S criterium for intrasearch in idle mode:

A threshold for intra-frequency cell reselection in idle mode. When the quality (CPICH Ec/No measured by UE) of the serving cell is lower than this threshold plus the [Qqualmin] of the cell, the intra-frequency cell reselection procedure will be started.

Parameter 19: S criterium for intrasearch in connected mode:

A threshold for inter-frequency cell reselection in connect mode. When the quality (CPICH Ec/No measured by UE) of the serving cell is lower than this threshold plus the [Qqualmin] of the cell, the inter-frequency cell reselection procedure will be started.

Parameter 20: Maxımum UL Load for new Conversatıonal Radıo Bearers:

Based on the current load factor of the system and the service properties of the call requesting for admission, the uplink admission control algorithm predicts the load factor of the system after the new call is admitted, uses the sum of the predicted load factor value and the common channel uplink load factor as the predicted value of the new load factor, and then compares the predicted value of the load factor with the load factor threshold. If the predicted load factor value is not bigger than the load factor threshold, the call will be admitted; otherwise it is rejected.

The uplink load thresholds include this parameter and uplink threshold for conversation non-AMR service, uplink threshold for other services and uplink handover admission threshold. According to the relations among these four parameters, the proportions of the conversation service and other services in the cell can be limited. These parameters can be also used to ensure the priorities of handover users and the conversation service access.

Parameter 21: Maxımum UL Load for other services:

This parameter is the uplink threshold for services other than the conversation service. It is used for uplink admission of other services.

Parameter 22: Maxımum UL Load for handover admission:

Based on the current load factor of the system and the service properties of the call requesting for admission, the uplink admission control algorithm predicts the system load factor after the new service is admitted, uses the sum of the predicted value of the load factor and the uplink load factor of the common channel as the predicted value of the new load factor, and compares the predicted load factor value with the load factor threshold. If the predicted load factor value is not greater than the load factor threshold, the call is admitted; otherwise it is rejected.

The uplink load thresholds include this parameter, uplink threshold for other services and uplink threshold for conversation services. According to the relations among these three parameters, the proportions of the conversation service and other services in the cell can be limited. These parameters can also be used to guarantee the priority of the handover users and the conversation service access. Uplink handover admission threshold must be smaller than uplink OLC trigger threshold for smart load control.

This parameter is to reserve resources for handover and to ensure the handover performance; the value of this parameter must be greater than uplink threshold for conversation services.

This parameter has effects only on inter-frequency handover; it has no influence on intra-frequency handover.

Also, during the parameter changes we add new carrier to some cells to distrubute the traffic load between HSPA and Release 99 services. And we tilted some cells to reduce the overshooting and pilot pollution. Mostly 2 or 3 degree. And also we add and delete some neighbours.

4.6.1. Results after parametric and hardware changes:

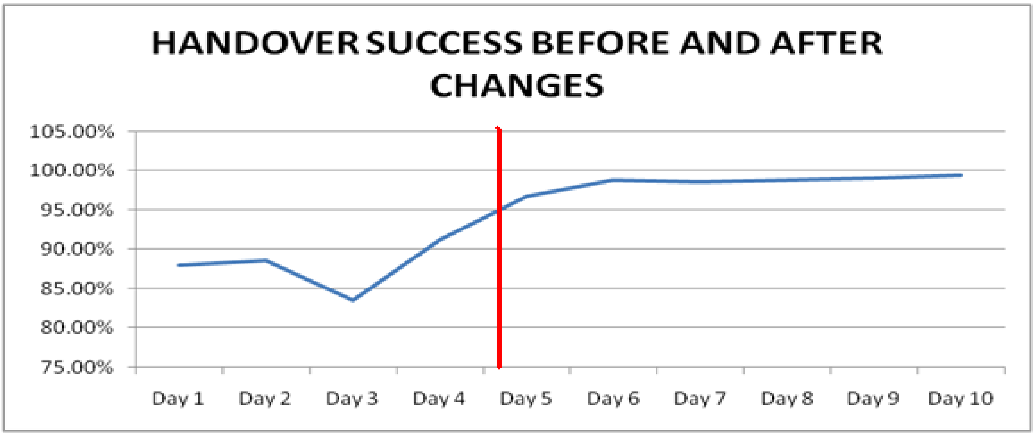


Figure 4.9 Handover Success Before and After Changes

As mentioned in Figure 4.9 after parameter and hardware changes handover success rate is increasing. This means that a call can continue without any drop. Call will continue further the serving cell changes. The implementation date is the fifth date. It is specified by red line. After implementation we can see the exact improvement on handover success rate.

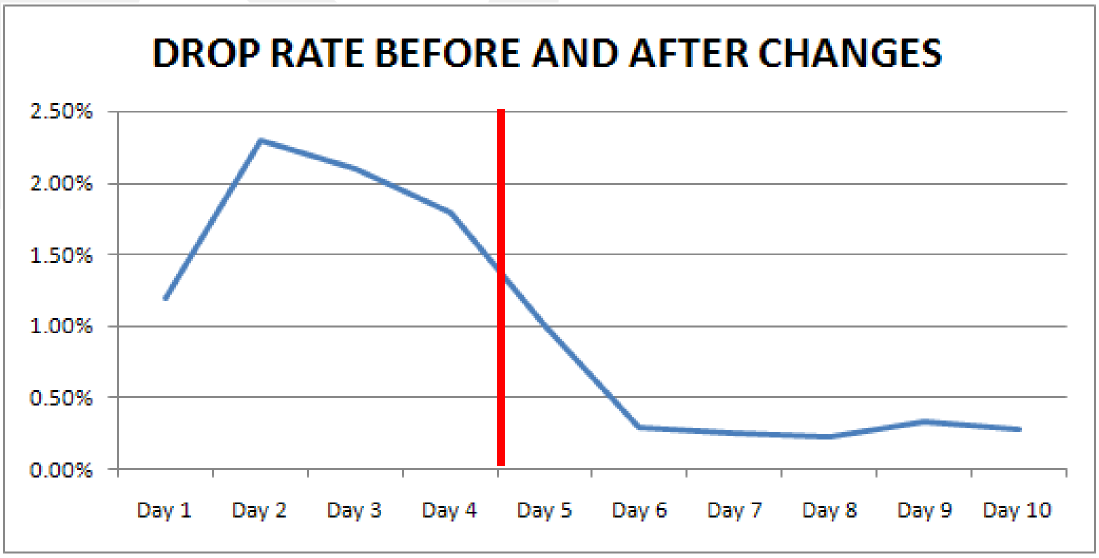


Figure 4.10 Drop Rate Before and After Changes

From drop rate graph Figure 4.10 we can understand how these changes acts the network. From all parametric and hardware changes the drop rate average of these cells reduced. For subscribers; on this region they can make a call easily and the call will continue without any deduction.

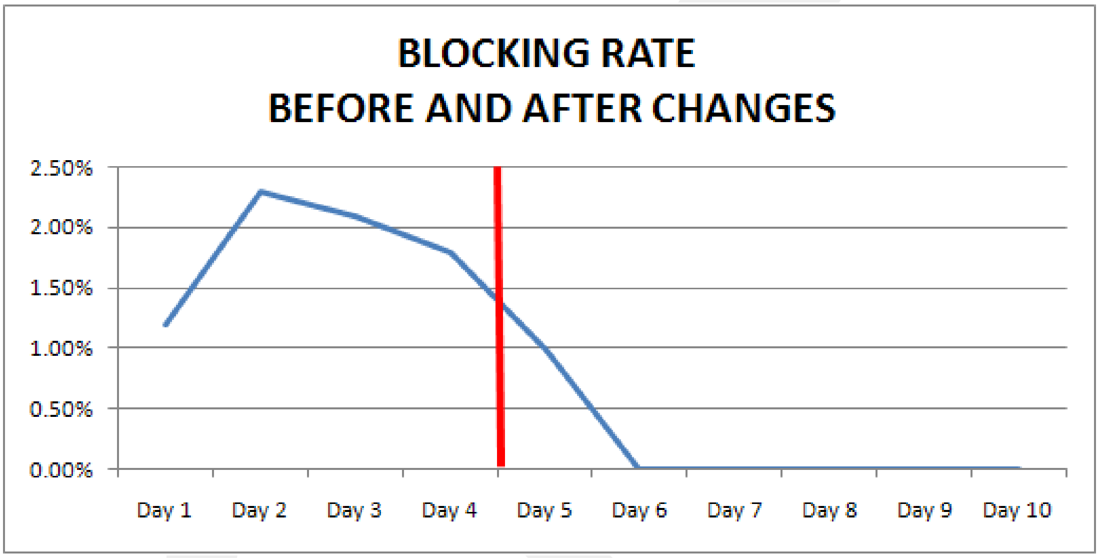


Figure 4.11 Blocking Rate Before and After Changes

Figure 4.11 shows us blocking rate of cell in our test region. Block means as not to make a connection between base station and user equipment. For subscribers block means as try to dial number several times. We will see a warning as “network busy” on tge screen of user equipment.

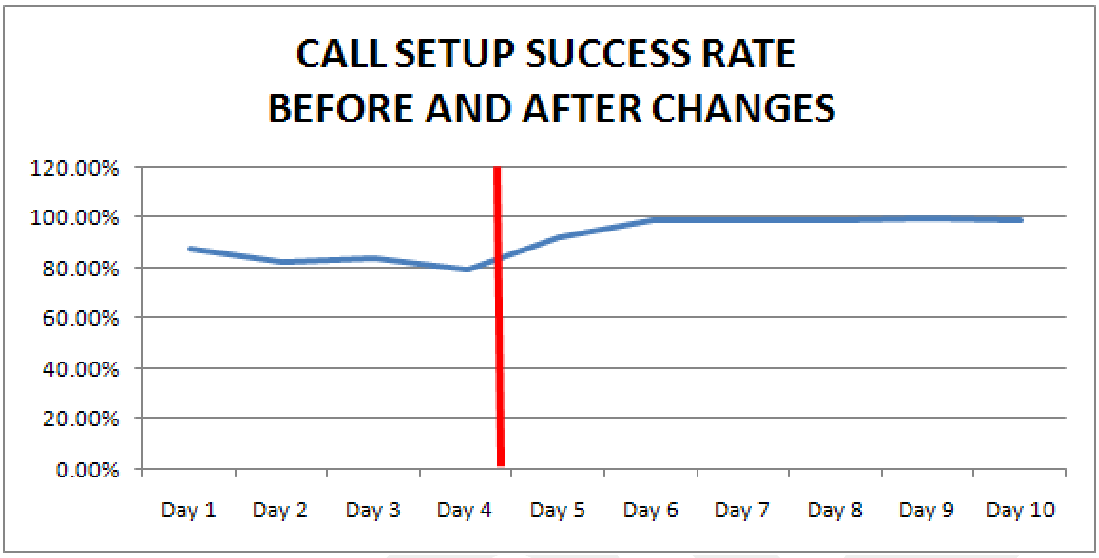


Figure 4.12 Call Setup Success Rate Before and After Changes

Call setup success rate is shown on Figure 4.12 explain us call setup success rate. Meaning as a call can setup succesfully without any block or interference.

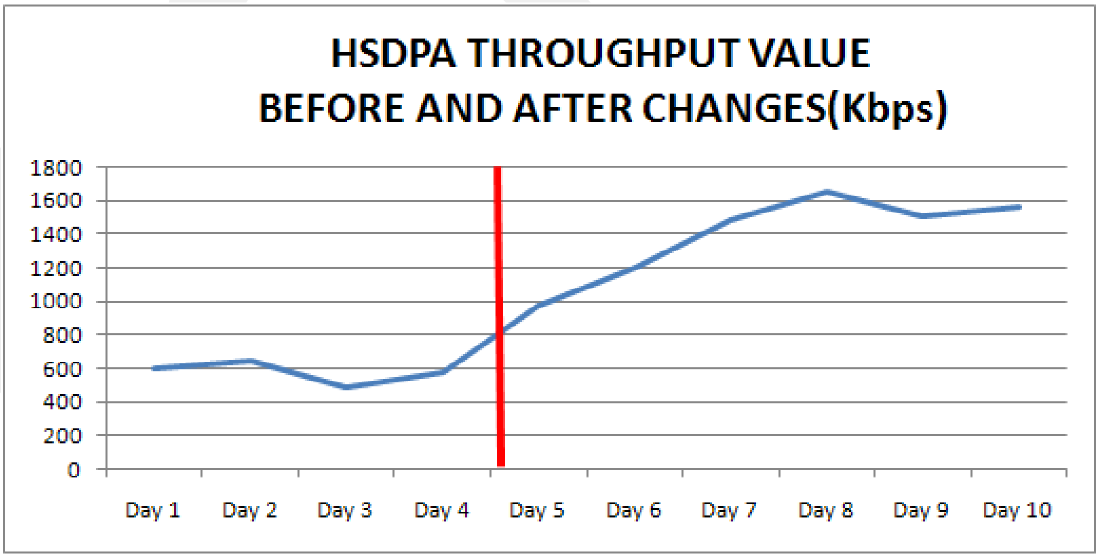


Figure 4.13 HSDPA Throughput Value Before and After Changes

HSDPA Throughput value Figure 4.13 explain us high speed downlink packet access data rate per second.Avearge value for data rate increase up to Mbit/ s levels.

4.6.2. Conclusion for Changes:

We can understand from the plots after parametric, hardware and software changes the signal level (RSCP) and quality (Ec/No) is getting better. On the plots before changes there are some problematic areas. But after these changes signal level and quality are getting better.

The results from changes which implemented like parameter set, add new carriers and change the tilt values of antennas obtain us a certain improvement for the performance of these cells.

4.7. Hardware & Software Tilt Changes

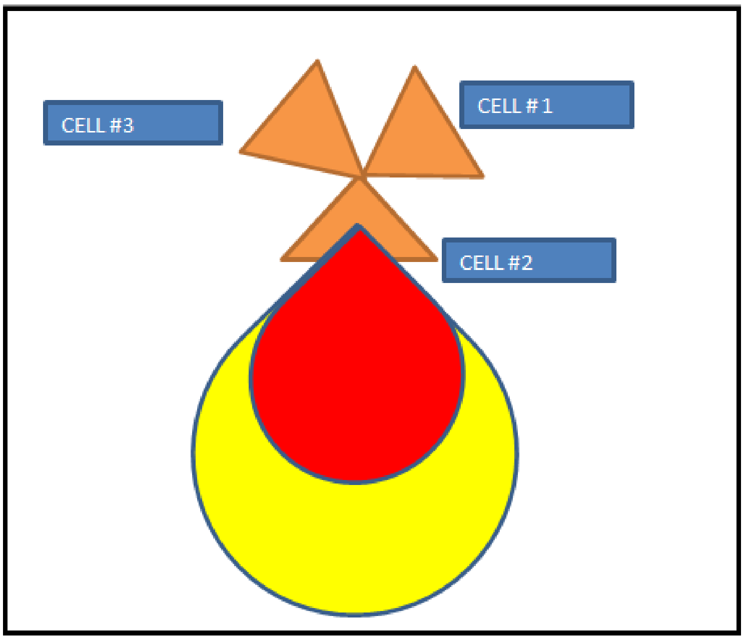


Figure 4.14 Tilt Changes

Most common and useful hardware & software change is decrease or increase the tilt value of antenna. Antenna joins to pole with special equipment. This equipment acts like hinge and has 10 or 15 degree value on it. Downtilt; meaning as increasing the tilt value. Uptilt is decreasing the tilt value of the antenna.

For example one cell has 5 degree tilt value; and our aim 2 degree downtilt; after implementation new value for tilt becomes 7. On the other hand after uptilt this cell 2 degree final value becomes 3 degree. Mechanical and Electrical tilt change is two type of tilt changing. Electrical tilt change is ranked as software change. These changes can do by remote controller unit, which implemented edge of antenna. Mechanical tilt can do manually at the site.

As mentioned in Figure 4.16 changes in tilt values acts on coverage which shown by red and yellow shapes. By downtilt or uptilt it can increase or decrease coverage area of a cell. From drive test or cell statistics we can analyse if a cell is overshooting or not. Depends on coverage area and statistics we decide to give uptilt or downtilt to the antenna.

Figure 4.15 and Figure 4.16 show us timing advance values of a cell before and after changes. X axis shows us total attempt to the cell, Y axis shows range in km/2.
That means the value 9 is 4.5 km about 1200 attemps. We can understand from second figure downtilt reduce the coverage for cell and this cell serves narrower area.

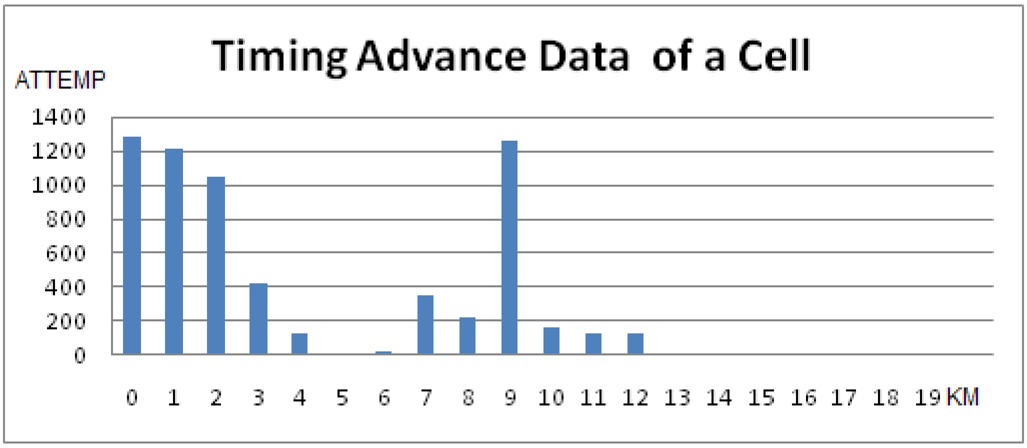


Figure 4.15 Timing Advance Data of Cell before Changes

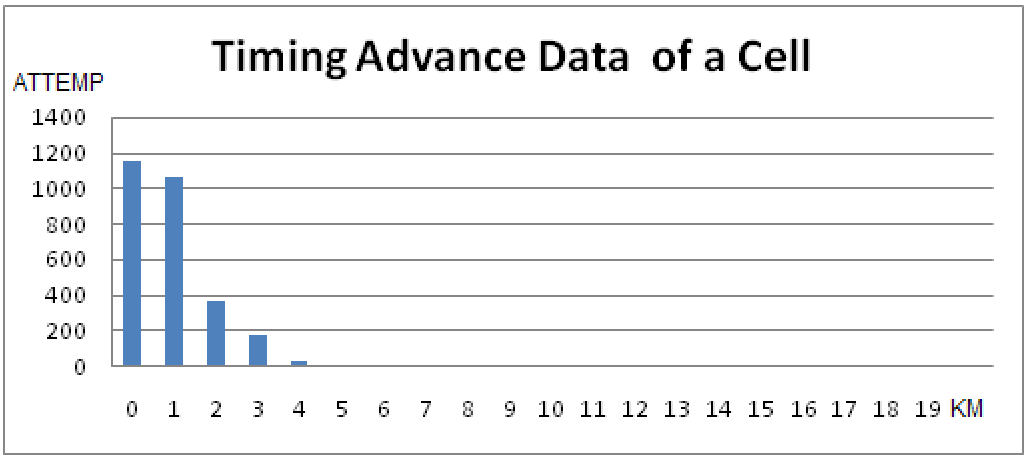


Figure 4.16 Timing Advance Data of Cell after Changes

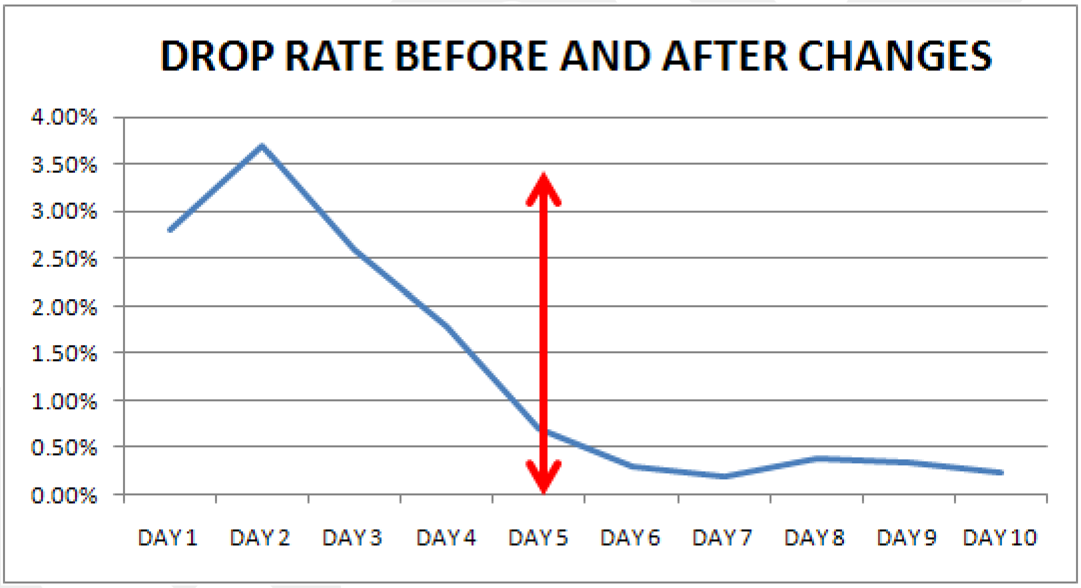


Figure 4.17 Drop Rate before and after Changes

Figure 4.17 mentioned us variation of drop rate of this cell. After implementation of downtilt, cell starts to serve narrover area and not overshoot. So drop rate reduce after implementation.

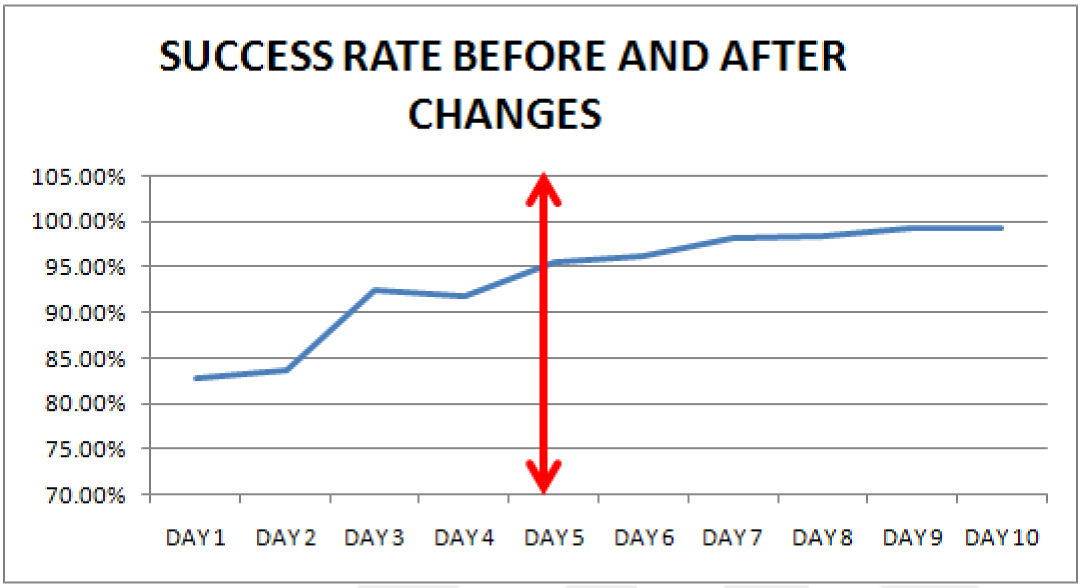


Figure 4.18 Success Rate before and after Changes

Figure 4.18 shows us success rate before and after changes. After implementation we can see call success rate increase and call setup percentage approach to hundered percentage. This means after implementation subscribers can connect to network at their first attempt. So; no need to dial the number several times.

4.7.1. Conclusion for Hardware & Software Tilt Changes

From the outputs which shown at Figure 4.17 and Figure 4.18 we can easily understand hardware and software tilt value changes can be useful in some occasions.

It reduces overshoot of a cell and also decrease drop rate and increase call success rate. So it can be implemented after analyzing the condition of cells.

4.8. Drop Analysis:

Figure 4.19 shows us a plot from drive test tool. As we can see, call drop because of cross feeder on cell 2 and cell 3. On plot blue line shows us the serving cell when the call dropped. Cell 2 should serve for this direction, but on plot it definitely seen as cell 3 serves this direction. So from that test we can understand that cell 2 and cell 3 has cross feeders.

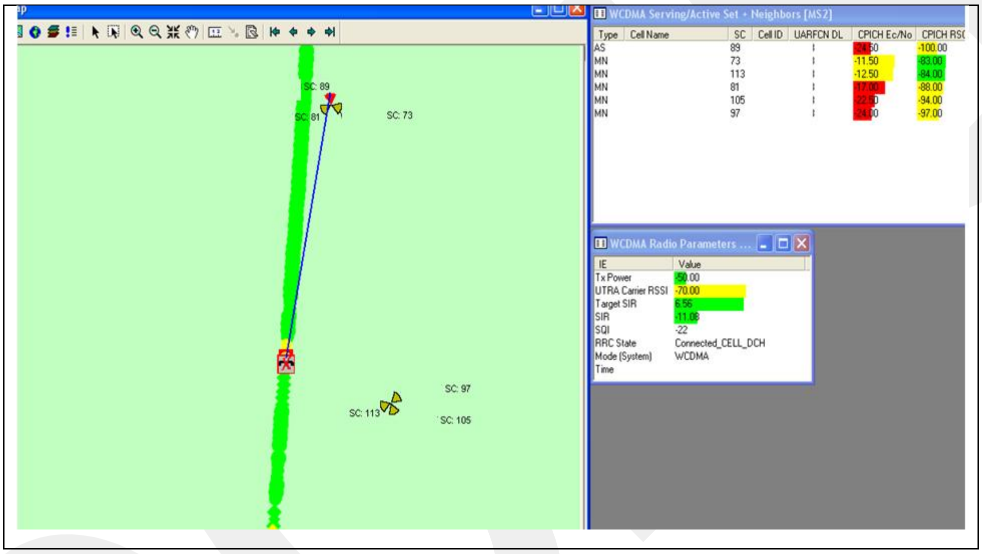


Figure 4.19 Example for drop because of cross feeder

On Figure 4.20 we can see drop rate for cell 2 and cell 3 after cross feeder problem solved. Blue bars represent drop rate for cell 2 and red bars represents drop rate for cell 3.

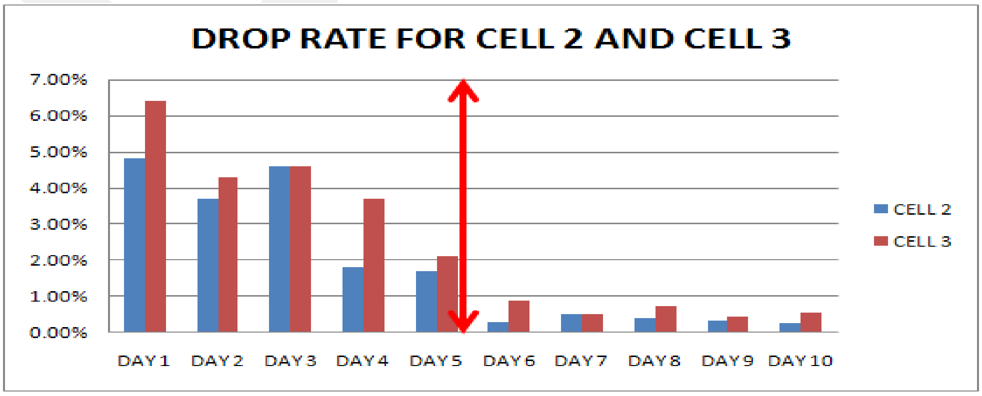


Figure 4.20 Drop rate for cell 2 and cell 3 after changes

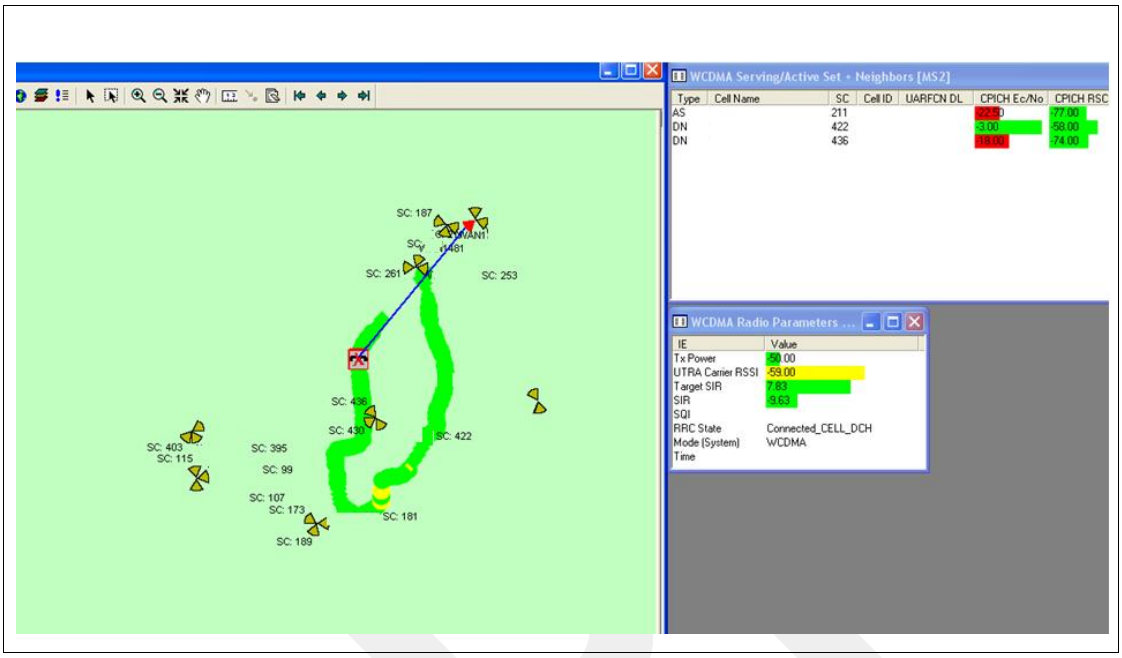


Figure 4.21 Example for drop because of missing neighbor.

Figure 4.21 mentioned as drop problem because of missing neighbour. After defining neighbourhood, between serving cell and detected neighbor cell which is measured on test but not in neighbor list of serving cell, drop problem will be solved. Result for drop problem is shown on Figure 4.22.

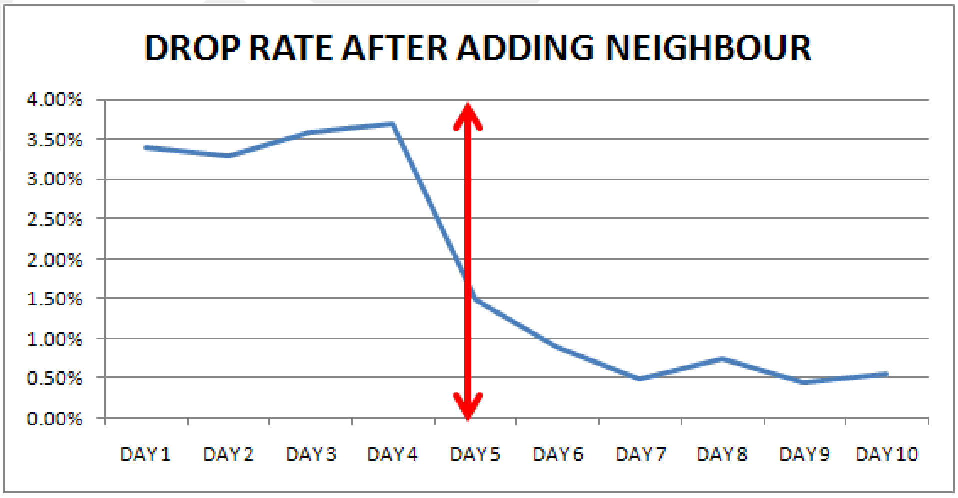


Figure 4.22 Drop rate for cell after adding neighbours

CHAPTER 5

CONCLUSION

Field measurement is the key activities for solving subscriber problems. With field measurements we solved some different problems as mentioned in thesis study. We can understand from analysis part; changing parameters, making hardware and software tilt changes, add or delete neighbor cell to serving cells can be solution for subscriber problems.

Every problem has different occasions. For example as mentioned in “before and after” test every parameter has different behavior. One can be reducing drop number; one can use for increase the call seizure success or reduce the blockings. Making drive tests or getting a report from the systems about one cell is the best way for analyzing problems detaily. By using these datas we can decide easily how we solve a problem.

In thesis, result parts show us usability of our recommendations or our actions. As we can see from the plots after changes drops are reduced, call seizure success is increase, blocking approaches to zero, handover success rate becomes nearby hundred percentages, and HSPA throughput value is increased. Wrong tilt values can cause problems and worst performance. By changing tilt value of an antenna we can increase the performance of a cell, determine coverage area, and prevent overshooting of a cell.

Speciality of this thesis study is using real measurements and analyzing problems by using real measurements datas. As we saw every problem has different behaivour and it has different solution way, cannot fix by some formulas or some cases.

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APPENDIX

CURRICULUM VITAE

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