PERFORMANCE ANALYSIS OF UMTS CELLULAR NETWORK USING SECTORIZATION BASED ON CAPACITY AND COVERAGE

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A project report presented in partial fulfillment of the requirements for the degree of Bachelor of Science in Electronics and Telecommunication Engineering

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APPROVAL

This project titled "Performance analysis of UMTS cellular network using sectorization based on capacity and coverage" submitted by Mir Mohammad Abu Kyum, Md. Baitul Al Sadi, Mrinal Kar to the Department of Electronics and Telecommunication Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Electronics and Telecommunication Engineering and approved as to its style and contents. The presentation was held on February 27, 2011.

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DECLARATION

We hereby declare that the work presented in this project report titled "Performance analysis of UMTS cellular network using sectorization based on capacity and coverage" is done by us under the supervision of Mr. A.K.M Fazlul Haque, Assistant Professor, Department of Electronics and Telecommunication Engineering Daffodil International University, partial fulfillment of the requirements for the degree of Bachelor of Science in Electronics and Telecommunication Engineering. We also declare that this project is our original work. As far as our knowledge goes, neither this report nor any part there has been submitted elsewhere the award of any degree or diploma.

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Abstract

UMTS is one of the standards in 3rd generation partnership project (3GPP).Different data rates are offered by UMTS for voice, video conference and other services. This project presents the performance analysis of UMTS cellular network using sectorization based on capacity and coverage. The major contribution is to see the impact of sectorization on capacity and cell coverage in 3G UMTS cellular network. Coverage and capacity are very much important issue in UMTS cellular Network. Capacity depends on different parameters such as Sectorization, Energy per bit noise spectral density ratio, Voice activity, Inter-cell interference and Intra-cell interference, Soft handoff gain, etc and coverage depends on Frequency, Chip rate, Bit Rate, Mobile Maximum Power, MS Antenna Gain, EIRP, Interference Margin, Soft Handover Gain, Noise figure etc. Different parameters that influence the capacity and coverage of UMTS cellular network are simulated using MATLAB 6.5.0.180913a with increasing sectors. In this project, the outputs of simulation for increasing amount of sectorization showed that the number of users was gradually increased. Also for increasing amount of sectorization showed that the coverage area was gradually increased.

Chapter-1

Introduction

1.1 General Introduction

WCDMA is one of the standards of UMTS cellular network. One of the main issues of UMTS cellular network is capacity.WCDMA capacity is one of the key attributes in UMTS network. There are various definitions of WCDMA capacity but the most of them are referred on maximum number of users per cell or of the whole observed system. In another word the capacity of a WCDMA network is the maximum number of simultaneous users for all services which satisfy certain conditions.

The uplink and downlink capacities do not have just the different values, but they are not comparable because the uplink capacity is mostly related to number of users, and the downlink capacity is related to transmitted power of node-B. Also the WCDMA capacity should be parted from the WCDMA throughput and link-budget, even they are related. This work paper will try to comprise different parameters and relations which affect on WCDMA capacity.

The WCDMA capacity is basically determined by processing gain and required signal-to-noise ratio. The interference is already included in noise power density and it comprises the Multiple Access Interference (MAI), (interference of other users from observed, home cell and interference of users from the adjacent cell), self interference and co-channel interference.

Another main issue of UMTS cellular network is capacity. The area covered by RF signal from Node B or BTS is called UMTS coverage area. To calculate coverage area: We have to calculate the propagation loss or path loss for different environment for urban, dense urban then the allowable path loss by Node B.

The propagation predictions for WCDMA require the same planning phases as in GSM. First, the base station configuration and the link budget have to be defined. Also, the coverage threshold has to be well defined to exceed the required quality criteria but avoid unnecessary additional investments for the radio network elements. Moreover, the capacity targets and forecasts have to be well known at this phase because they have a strong effect on the base station coverage area.

1.2 Previous Work

In mobile communications systems (MCS), signals are transmitted through multipath mixed-phase time variant channels. Mobile multipath channels have non-desirable impact on the transmitted signal, including inter-symbol interference (ISI) and channel variations. a GSM cellular phone moving at 3 Km/h (for a frequency carrier of 1800 MHz) result in doppler shift of 500 Hz which leads to coherence time of nearly 0.8 ms (corresponding to more than 200 symbols in GSM).Taking into account that a typical GSM half-burst contains approximately 60 symbols, this implies non-negligible channel variation during the equalization process. Blind non-cooperative equalization methods have been applied to burst MCS in order to obtain satisfactory performance without using any training symbols [1] but they lack robustness to channel overestimation, among others [2]. HOS approaches were first used for blind equalization but they usually need a large number of samples compared to SOS-based methods, so their applicability in fast fading environments is limited because statistics cannot be assumed stable, even along the (short) burst L. Tong et al introduce in the SOS in [3] blind equalization/estimation through to the extraction of spatial or temporal diversity, leading to the SIMO models. Different SOS methods have been studied in literature, like subspace methods [3] [4] or maximum likelihood methods [5] [6].In general, maximum likelihood (ML) method are attractive to their good near asymptotic performance and relative simplicity. Among these, Statistical ML (SML) approaches achieve the best performance though at the cost of local minima in the minimization problem. Conversely, the deterministic ML (DML) approaches [5] [1] leads to poor performances at low SNR since the method does not make use of any knowledge of the source. This lack of performance prevents the use of these methods in typical mobile scenarios. Conditional ML(CML)methods have also been proposed [5] [2] these method are a tradeoff between SML and DML approaches, since they use approaches can be viewed as special cases of this CML approach which leads to a good tradeoff between the asymptotic performances when the process is initialized close to the global minimum, and the number of local minima. The 3rd generation Partnership Project (3GPP) specifies the speed (depending on the carrier frequency) between the transmitter and receiver under which the system should be guarantee a certain level of performance. Bo Hagerman, Davide Imbeni and Jozsef Barta considered WCDMA 6-sector Deployment Case Study of a Real Installed UMTS-FDD Network [7]. Romeo Giuliano, Franco Mazzenga, Francesco Vatalaro described Adaptive Cell Sectorization for UMTS Third Generation CDMA Systems. Achim Wacker, Jaana Laiho-Steffens, Kari Sipila, Kari Heiska considered the impact of the base station sectorisation on WCDMA radio network performance. S. Sharma, A.G. Spilling and A.R. Nix considered Adaptive Coverage for UMTS Macro cells based on Situation Awareness [8].

1.3 Objective of the Present Work

i) To analysis how sectorization affects the capacity of UMTS cellular network which depends on energy per bit noise spectral density ratio, outer cell interference factor, soft handover factor, voice activity factor and also processing gain.
ii) To analysis how sectorization affects the coverage of UMTS cellular network which depends on data rates for propagation environment such as dense urban and urban case.

1.4 Organization of the Project

Chapter 1 reviews on the Introduction of this project, definition of capacity and coverage of UMTS cellular network and how channel parameters are impacts capacity and coverage of UMTS cellular network.
Chapter 2 reviews on the multiple access techniques, this chapter also highlights early cellular system and their capacity.
Chapter 3 reviews on the basic architecture of UMTS cellular network with overlay GSM network, architecture.

Chapter 4 reviews on the intra-cell interference and outer-cell interference of UMTS cellular network

Chapter 5 reviews on the capacity calculation of UMTS cellular network, this chapter also shows how various parameters related in capacity calculation.

Chapter 6 reviews on the various propagation environment which are related on coverage prediction

Chapter 7 reviews on the coverage of UMTS cellular network, this chapter shows a relationship on coverage and data rates

Chapter 8 reviews on the simulation of capacity and coverage under various parameters from related equation, these chapters' shows, how sectorization has major impacts on coverage and capacity of UMTS cellular network

Chapter 9 brings out on the significant conclusion of the entire work

Chapter-2

Early Cellular Systems and their Capacity

2.1 Early Cellular Systems

Early cellular systems were all analog systems and need FDMA with Frequency Division Duplexing (FDD). The systems were designed to handle voice and the voice signal was frequency modulated. Part of UHF spectrum was utilized to cover sizable areas in today's terms could be categorized as macro cells. The capacity was not a main issue in these systems as demand was not great.

2.1.1 First Generation Systems

The first successful cellular mobile communication system was the Advanced Mobile Phone Service (AMPS) developed in USA in 1970s. It used FDMA technology with FDD and employed 20 MHz bandwidth in the 800 MHz region. AMPS at present operates with a 25 MHz bandwidth in each direction over the frequency allocations of 824-849 MHz for the Uplink (UL) (from mobile to base station), and 869-894 MHz for the Downlink (DL) (from base station to mobile) [9]. This spectrum is divided into 832 frequency channels leaving 416 channels in the uplink and another 416 channels in the downlink. Some of these channels are used to carry system information and control signal while the rest carries voice and data in analog form. In AMPS, each channel occupies 30 kHz of bandwidth using analog Frequency Modulation (FM) [9]. TACS, NMT and AMPS are among the first generation cellular systems.

2.1.2 Second Generation Systems

In the second generation cellular systems, digital technology enabled the use of signal processing techniques to increase the robustness against interference. It also reduced the spectral bandwidth required for each user and hence provided a higher capacity. The second generation systems provide about 3 to 4 times the capacity of the first generation system for the same spectral resource without adding new base stations. Since digital systems are more immune to noise, an Interference-to-Signal (ISR) ratio of about 15 dB is acceptable in digital systems (whereas 18 dB is required for the analog systems under same circumstances [10]). This allowed the use of smaller reuse clusters, thereby increasing the capacity of the system.

The second generation cellular mobile systems were based on Time Division Multiple Access (TDMA) technology, or a combination of TDMA and FDMA.

In 1990, Qualcomm, Inc., proposed a digital cellular telephone system based on Code Division Multiple access (CDMA) technology. In July 1993, the second U.S digital cellular standard (IS-95) was adopted. Using spread spectrum techniques, the IS-95 system provides a very high capacity [9].

2.1.3 Third Generation Systems

2.1.3.1 The CDMA2000 (USA)

Within the standardization committee of Telecommunications Industry Association (TIA), the subcommittee TR45.5.4 was responsible for the specifications of the basic cdma2000 scheme [11]. That is at least 144 Kbps in a vehicular environment, 384 Kbps in a pedestrian environment, and 2048 Kbps for indoor office environment. The main focus of standardization has been to provide 144 Kbps and 384 Kbps bit rates with approximately 5 MHz bandwidth.

For the direct spread option, transmission on the downlink is achieved by using normal chip rate of 3.6864 Mcps [11].

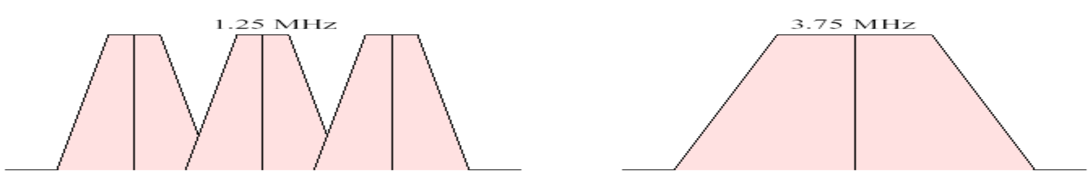


Figure 2.1: Illustration of (a) multicarrier and (b) direct spread downlink for cdma2000

The starting point for bandwidth design for cdma2000 has been the PCS spectrum allocation in the United State. The PCS spectrum is allocated in 5 MHz blocks and 15 MHz blocks. One 3.6864 Mcps carrier can be deployed within 5 MHz spectrum allocation including guard bands. For a 15 MHz block, three 3.6864 Mcps carriers and one 1.2288 Mcps carrier can be deployed [11] [12].

2.1.3.2 IMT 2000 (Europe)

The Europe Telecommunications Standards Institute (ETSI) has been working on the Universal Mobile Telecommunication Services (UMTS), which is to be the European standard for the third generation mobile systems. UMTS will appear as one of the family members within the IMT2000 family. UMTS will utilize the GSM network interfaces as the basis for its network interfaces and proposals. The current GSM network capabilities, which include General Packet Radio Service (GPRS), High Speed Circuit Switched Data (HSCSD), and Customized Application for Mobile Enhanced service Logic (CAMEL), will be enhanced to support UMTS capabilities in terms of services like virtual home environment and multimedia, as well as higher bit rates [12].

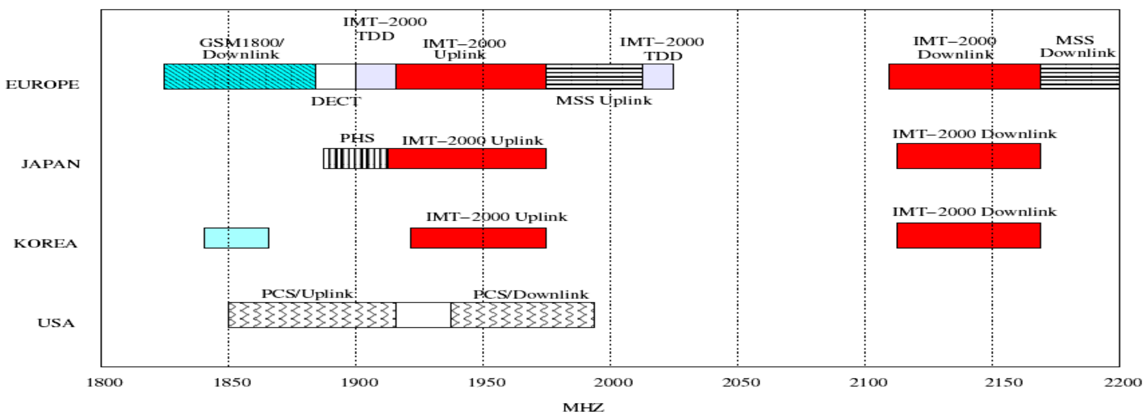


Figure 2.2: Spectrum allocation for WCDMA in Europe, Japan, Korea, and USA [13].

The spectrum allocation for WCDMA in Europe, Japan, Korea, and USA is shown in Fig. 2.5[13]

In Europe and in most of Asia, the International Mobile Telecommunication (IMT)-2000 band consists of 2×60 MHz (1920 -1980 MHz plus 2110-2170 MHz). In Japan and Korea, the IMT-2000 FDD band is the same as that of the rest of Asia and Europe.

Table 2.2 summarizes the main features related to the WCDMA air interface [13].

Multiple access method	Direct sequence Code Division Multiple Access
Duplexing method	Frequency Division Duplex/Time Division Duplex
BS synchronization	Asynchronous
Chip rate	3.84 Mcps
Frame length	10 ms
Multirate Concept	Variable spreading factor and multicode

.

2.1.3.3 IMT 2000 Radio Interfaces

Figure shows the radio interface of IMT-2000.The first one and the second one are established from CDMA .The third one is established from a combination of CDMA and TDMA. The fourth one is established from a TDMA, The last one is established with both FDMA and TDMA

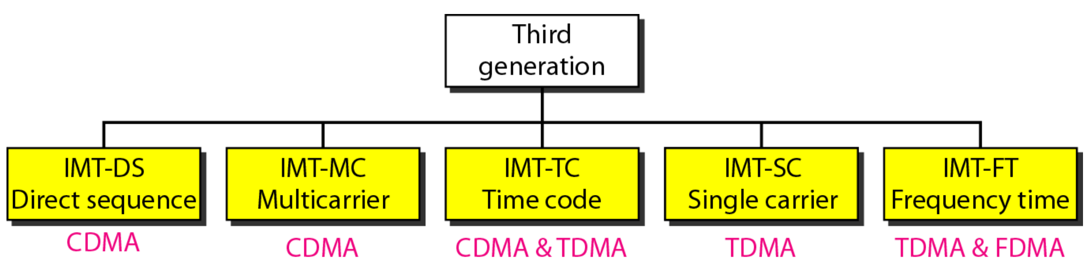


Figure 2.3: IMT-2000 radio interfaces [14]

2.2 Capacity of Early Cellular Systems

The capacity of first and second generation cellular mobile systems was governed by the available number of RF channels within the allocated spectrum. Once the acceptable grade of service (GoS) is specified, the amount of traffic that could be offered in the system with the given number of channels is determined, and this has set a hard limit on the system capacity. The GoS in turn is determined by the signal to interference (or carrier-to-interference) ratio of the system.

2.2.1 Capacity in AMPS System

The AMPS cellular system at 850 MHz is a high capacity system. There are two separate frequency bands, adjacent to each other, each band providing 416 channel pairs, having 30 KHz channel separation [15]. Out of 416 channels, 21 channels are designated as control channels. Control channels are used for call setup and management. The remaining channels (395) are used as voice channels. Channel assignment is based on the following sequence: (K, K + 7, K + 14 ...) where K is the cell number (K = 1, 2... 7 for 7-cell cluster). The channel grouping scheme is shown in Table 1.3 and the corresponding cell cluster is shown in Fig. 2.6, as seen in Fig. 2.6 that the minimal separation (DS) required between two nearby

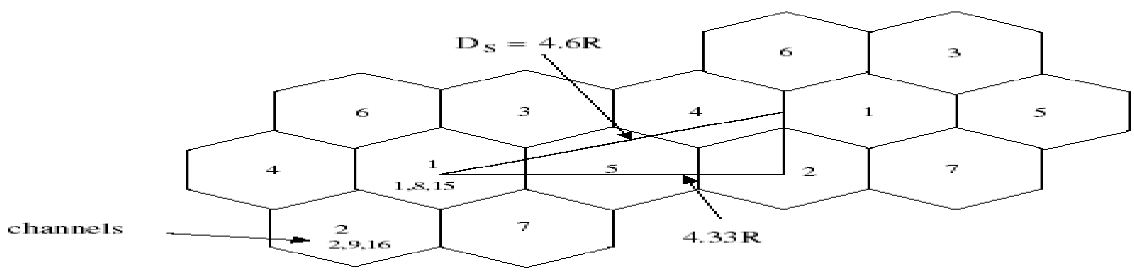


Figure 2.4: Channel allocation in 7-cell cluster system.

Co-channel cells are based on specifying a tolerable co-channel interference, which is measured by the carrier-to-interference ratio (CIR). The CIR is also a function of minimum acceptable voice quality of the system. The CIR of AMPS is defined [16] as,

$$\left(\frac{C}{I}\right)_{AMPS} = 10\log\left[\frac{1}{j}\left(\frac{Ds}{R}\right)^{\gamma}\right]$$

where j is the number of co-channel cells (j = 1, 2,.., 6), γ is the propagation exponent, DS is the frequency reuse distance, and R is the cell radius. The co-channel interference reduction factor, q_s, is defined as,

$$q_s = \frac{Ds}{R}$$

With γ= 4, Ds = 4.6, and j = 6, the CIR becomes

$$\left(\frac{C}{I}\right)_{AMPS} = 18db$$

2.2.2 Capacity in GSM System

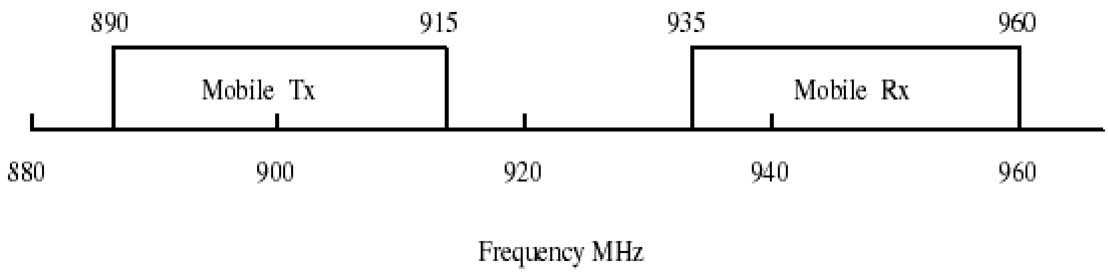


Figure 2.9: GSM spectrum allocation.

GSM uses a Time Division Multiple Access (TDMA) with Frequency Division Duplex (FDD) technique on a total of 125 carrier pairs in the 900 MHz band as shown in Fig. 2.9. Each carrier conveys 8 time divided channels making a total of 125×8=1000 channels. The GSM used Gaussian minimum shift keying (GMSK) modulation with a bandwidth-to-bit-period product (B.T) of 0.3. The spectrum of this signal is tailored to enable it on a radio frequency carrier of 200 KHz bandwidth. The TDMA frame is produced by multiplexing eight channel encoded speech sources in time division. Eight timeslots each of duration 0.577 ms make up one TDMA frame of 4.62 ms and is transmitted on the radio path at a bit rate of 270.833 kbps [17]. The salient features of the air interface of GSM system are shown in Table 2.4.

Table 2.3: Basic air interface parameters of GSM

Feature	Parameter
Channel Spacing	200 KHz
Modulation	GMSK
Modulation depth	B.T=0.3
Data transmission rate	270 Kbps
User data rate (Nominal)	16 kbps or 12.2 Kbps
TDMA frame period	4.62 ms
Time slot duration	0.57 ms

Chapter-3

UMTS Cellular Network Architecture

3.1 UMTS Network Topology

When deploying a WCDMA network, most operators already have an existing 2G network. WCDMA was intended as a technology to evolve GSM network toward 3G services. Paralleling that evolution, this chapter first discusses GSM networks, then highlights the changes that are necessary to migrate to Release 99 of the WCDMA specification. The discussion then moves on to Release 5 of the specification and the network changes needed to support HSDPA.

3.2 GSM Network Architecture

Figure 3.1 illustrates a GSM reference network, showing both the nodes and the interfaces to support operation in the CS and PS domains.

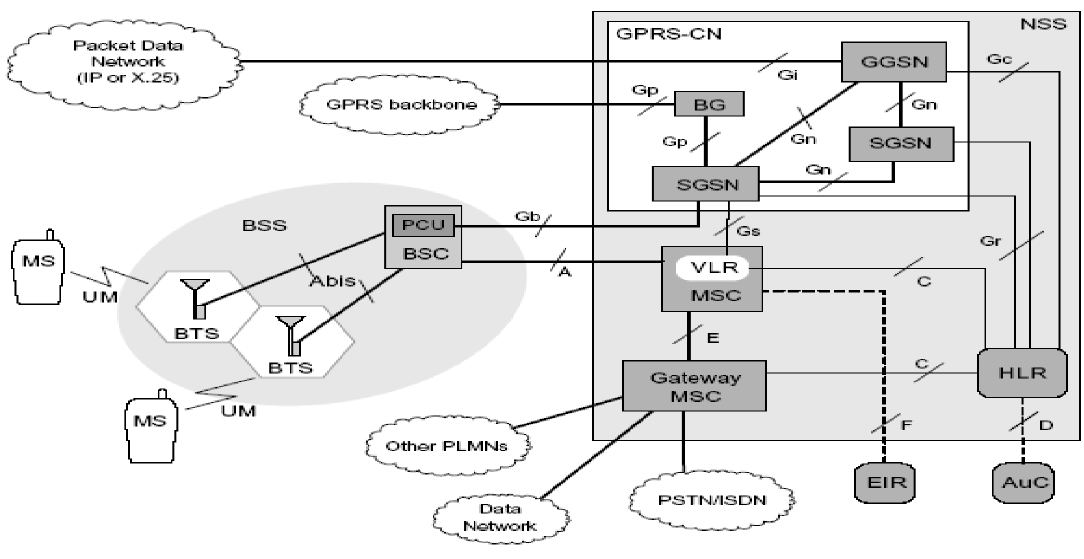


Figure 3.1: GSM reference network [18]

In this reference network, three sub-networks [18] can be defined:

• Base Station Sub-System (BSS) or GSM/Edge Radio Access Network (GERAN).

This sub-system is mainly composed of the Base Transceiver Station (BTS) and Base Station Controller (BSC), which together control the GSM radio interface – either from an individual link point of view for the BTS, or overall links, including the transfers between links (aka handovers), for the BSC.

• Network and Switching Sub-System (NSS).

This sub-system mainly consists of the Mobile Switching Center (MSC) that routes calls to and from the mobile. For management purposes, additional nodes are added to the MSC, either internally or externally. For all practical purposes, the MSC and GMSC are differentiated only by the presence of interfaces to other networks, the Public Switched Telephone Network (PSTN) in the GMSC case. Typically, the MSC and the GMSC are integrated. The interfaces listed (E, F, C, D) are not detailed here but mostly enable the communication between the different nodes as shown.

• **General Packet Radio Service, Core Network (GPRS-CN).**

Within the NSS, two specific nodes are introduced for the GPRS operation: the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN). In the PS domain, the SGSN is comparable to the MSC used in the CS domain. Similarly, in the PS domain, the GGSN is comparable to the GMSC used in the CS domain.Figure 3.1 also shows the Border Gateway (BG) that supports interconnection between different GPRS networks to permit roaming, and the PCU to manage and route GPRS traffic to the BSS.

3.3 UMTS Architecture with Overlay GSM

As mentioned earlier, UMTS is based on the GSM reference network and thus shares most nodes of the NSS and General Packet Radio Service, Core Network (GPRS-CN) sub-systems. The BSS or GERAN is maintained in the UMTS reference network as a complement to the new Universal Terrestrial Radio Access Network (UTRAN), which is composed of multiple Radio Network Systems (RNS) as illustrated in Figure

2.2.Compared to the GSM reference network, the only difference is the introduction of the Radio Network Controller (RNC) and Node Bs within the newly formed RNS. From a practical standpoint, the common nodes between GSM and UMTS would actually be duplicated, with the original nodes supporting the 2G traffic and the added nodes supporting the 3G traffic.

3.4 UMTS Network Architecture

The initial deployments of WCDMA networks comply with Release 99 of the standard [18]. This standard, or family of standards, began to evolve even before being fully implemented, to address the limitations of the initial specifications as well as to include technical advancements. At a higher level, migrating from Release 99 to Releases 4, 5, and then 6 does not change the structure of the network. In addition, the layering changes in Release 5, to support HSDPA and Node B scheduling.

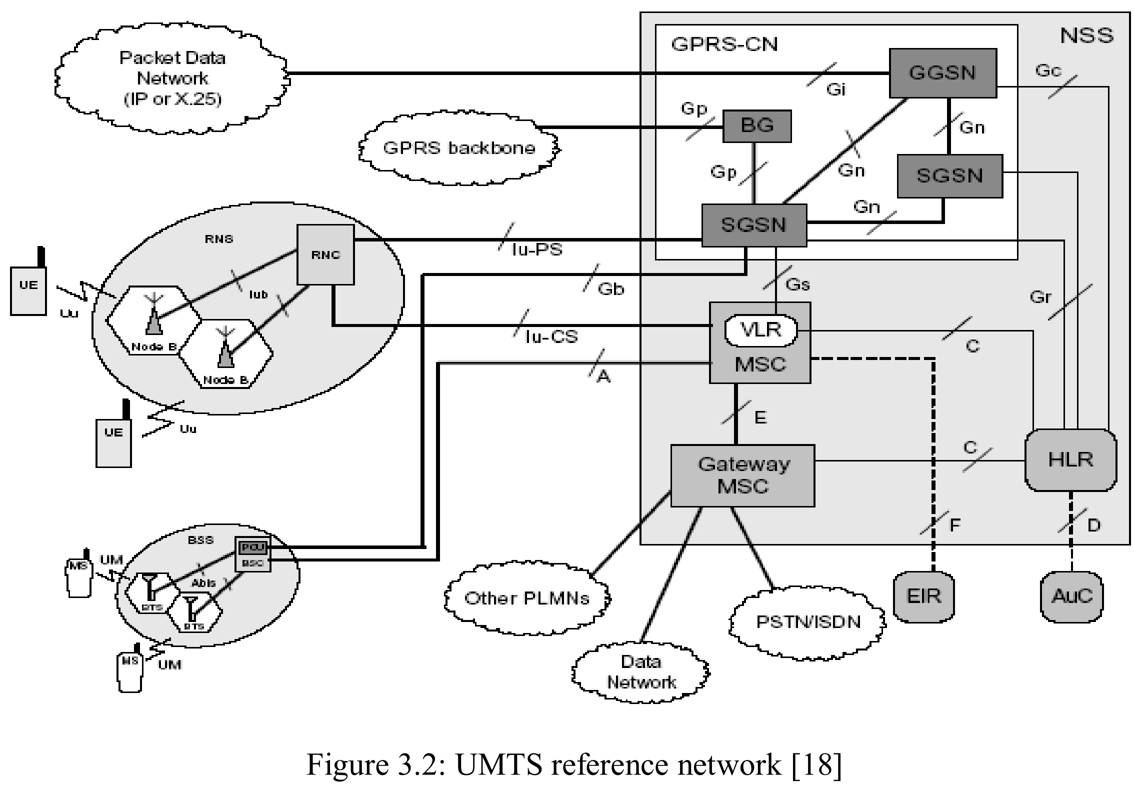


Figure 3.2: UMTS reference network [18]

Chapter-4

Interference analysis in UMTS Cellular Systems

Due to increasing demand in cellular mobile communications, the efficient use of spectrum resource to maximize system capacity remains an important issue in system design. The capacity of a WCDMA cellular network is determined by the amount of co-channel interference it can tolerate.

4.1 Signals-to-Interference Ratio (SNR)

In digital systems, we are primarily interested in the link metric called E_b/N_o or energy per bit to noise power spectral density ratio. This quantity can be related to the conventional Signal-to-noise-Ratio (SNR) by recognizing that energy per bit equates to the average signal power allocated to each bit duration, such that

$$E_b = ST$$

where S is the average signal power and T is the time duration of bit. We can further analyze by substituting the bit rate R_b, which is the inverse of bit duration T

$$E_b = \frac{S}{R_b}$$

The noise-power-spectral-density N_o, is the total interference power I divided by the transmission bandwidth W, i.e,

$$N_o = \frac{I}{W}$$

The total interference power I at the Base Station (BS) receiver could be defined as

$$I = I_{intra} + I_{inter} + \eta$$

=Same cell interference power + other cell interference power + background thermal noise power

Therefore $$\left(\frac{E_b}{No}\right) = \left(\frac{S}{I}\right)\left(\frac{W}{R_b}\right)$$

The ratio W/R_b is known as the processing gain of the system. Therefore, in general, we can write,

$$\left(\frac{S}{I}\right) = \frac{S}{I = I_{intra} + I_{inter} + \eta} = \frac{E_b / N_o}{W / R_b}$$

where S is the received signal power. The power control in the uplink is used to ensure that the power received at the BS from every mobile user is the same. I_{intra} and I_{inter} will be discussed in the next section.

4.2 Interference

As mentioned previously the interference consists of intra-cell interference, inter-cell interference, and background noise due to thermal activity.

4.2.1 Intra-cell Interference

The same-cell (I_{intra}) interference on the reverse link consists of the superposition of signals from other mobile stations (MSs) at the base station (BS) receiver. Almost all of the noise received at the BS receiver is due to interference signals. The system capacity is maximized by making each signal power of the same at the BS and as low as possible while achieving satisfactory link performance [19]. Let N denote the number of mobile users per cell (or sector). Assume that S is the signal power received by a cell BS when perfect power control is in place, so that this value is the same for every mobile in the same cell Figure

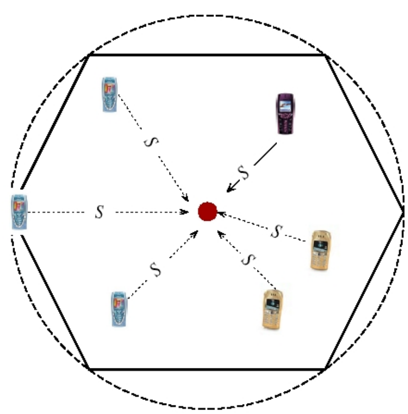


Figure 4.1: Interference from same cell

The interference from the intra-cell mobiles is equal to,

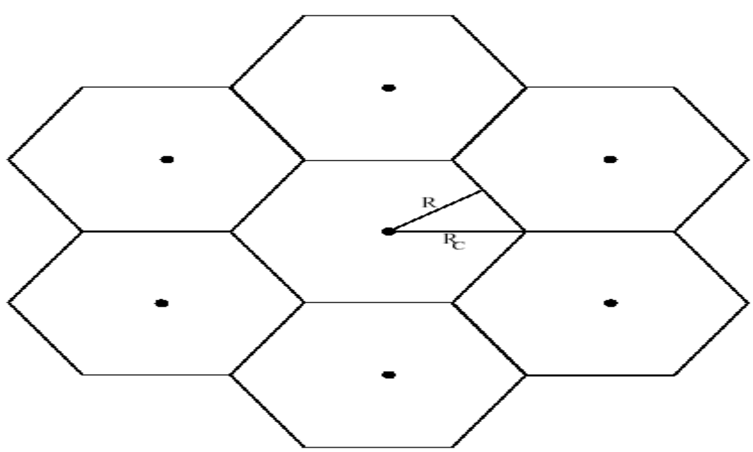
$$I_{intra} = S(N - 1)$$

Thus given N mobile users per cell, the total intra-cell interference is never greater than S(N -1).
But this interference is reduced further with the employment of the voice activity factor [20] [21].

4.2.2 Inter-cell interference

In this investigation, the system model considers only the first tier of interfering cells, which means that there are six interfering (neighboring) cells. Therefore, the geometry of the interference model can be represented as shown in Fig.4.2 (a). The interference from second and third tiers to the home cell is extremely small [19], and thus is ignored. The Fig.4.2 (b) shows the rotational symmetry of the hexagonal grid system that has hexagonal rings of cells round a center [19]. The diagram consists of the center cell and one of six 60^0 sectors around the origin. The coordinates of a cell in the sector are (a, b), where a is the ring number and b = 1, 2 ...a, indexes the cells in the sector that are in ring a. The distance of the bth cell in the ath ring is [19]

$$d(a,b) = 2R\sqrt{a^2 + b^2 - ab} \quad \text{..... (4.2.2.1)}$$



(a)

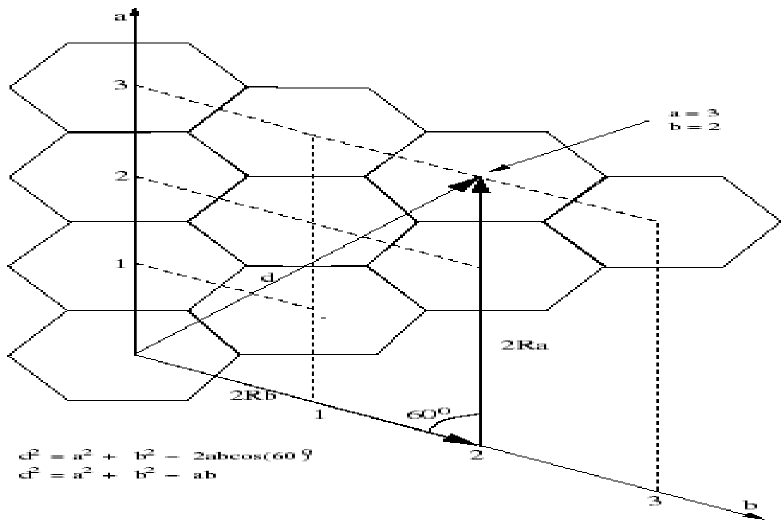


Figure 4.2 (a) Geometry of the system model for interference evaluation (b) Ring cellular coordinate system [19].

From equation (4.2.2.1), the normalized distance of an interfering cell is,

$$r_{a,b} = \frac{d(a,b)}{R} = 2\sqrt{a^2 + b^2 + -ab} \quad .... (4.2.2.2)$$

Table4.1: Reverse link intercell interference calculation [19]

a=Ring	b	d=(a,b)/R	I
1	0	2	0.2844
2	0	4	0.2940
	1	2√3	0.3120
3	0	6	0.3138
	1	2√7	0.3168
	2	2√7	0.3198
.	.	.	.
.	.	.	.
.	.	.	.
100	0	20	.
	.	.	.
	.	.	.
	100	2√9001	0.33

$$I = \sum_{a=1}^{n} \sum_{b=1}^{a} 2\left[2r^2 \ln\left(\frac{r^2}{r^2-1} - \frac{4r^2-6r+1}{2(r^2-1)^2}\right)\right]_{r=r_{a,b}} \quad \text{......} \; (4.2.2.3)$$

Using (4.2.2.3) and (4.2.2.4), it is possible to evaluate n tiers of interfering cells. According to [19], a 100 tier evaluation shows that only the interference from first tier has a significant effect (Table 4.1).

It shows that the first tier interference is approximately 28.4% of intra-cell interference and the total interference from 100 tiers is approximately 33% of the intra-cell interference. Thus the contribution to interference from the second and higher tiers is extremely small compared to that of the first tier.

Chapter-5

Capacity Analysis in UMTS Cellular System

WCDMA capacity is one of the key attributes in UMTS network. There are various definitions of WCDMA capacity but the most of them are referred on maximum number of users per cell of the whole observed system. The uplink and downlink capacities do not have just the different values, but they are not comparable because the uplink capacity is mostly related to number of users, and the downlink capacity is related to transmitted power of node-B. Also, the WCDMA capacity should be parted from the WCDMA throughput and link-budget, even they are related.

5.1 Factors Influence the Capacity of WCDMA Systems

The actual capacity of a WCDMA cell depends on actual interference power introduced by other users in the same cell and in neighboring cells. This in turn depends on many different factors, such as sectorisation, power control accuracy, voice activity, antenna gain, soft handoff gain.

5.1.1 Sectorization

The capacity of a WCDMA system can be increased by cell sectorisation as it reduces the intra-cell interference (I_{intra}). If N_s is t he number of users per sector, the cell capacity (i.e. Number of users per cell), N, is given by

$$N = \Delta \cdot Ns$$

where Δ is the number of sectors per cell. In the case of a three sector cell ($\Delta = 3$), (120^0 sectors) the interference sources seen by an antenna are approximately one-third of those seen by an Omni directional antenna. Therefore, the number of users per sectorized cell is given by,

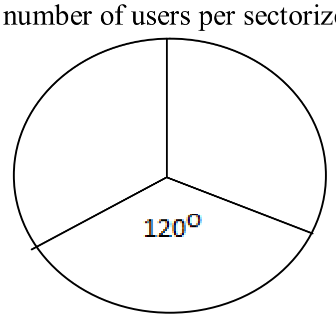


Figure 5.1: Sectorization with a directional antenna with angle 120^0

Sectorization is proposed as a method of increasing the system capacity in WCDMA cellular systems.

5.1.2 Tilted Antenna

Tilted antenna is another technique that can be used to improve the system capacity. The tilted antenna generally reduces the interference (Fig.5.2) by controlling the range of coverage over a sector. This is because the main beam when tilted does not deliver as much power towards other BS as it normally does, and therefore most of the radiated power is directed to an area where it is intended [16]. However, the tilted antenna will shrink the coverage area .It causes the signal strength to be less at the mobile

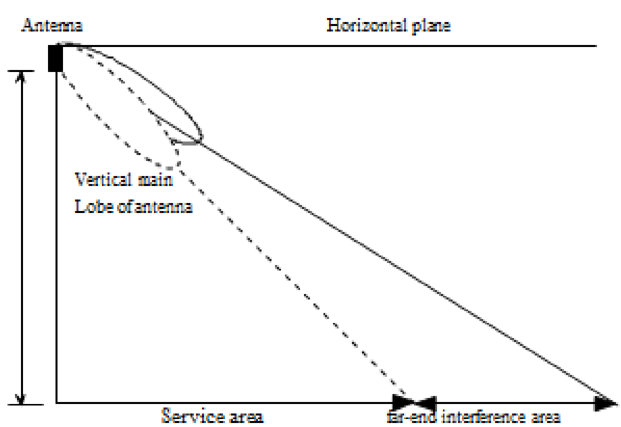


Figure 5.2: Tilted antenna cell coverage.

5.1.3 Channel Activity

Techniques for digital speech concentration such as digital speech interpolation (DSI) take account of the activity factor to reduce the number of mobile channels required to transmit a given number of channels.

As the silences between syllables, words and phrases increase so does the unoccupied time.

In practice, the vocoder (such as the one used in IS-95 (CDMA) system) is a variable rate vocoder, which means that the output bit rate of the vocoder is adjusted according to a user's speech pattern .

Therefore WCDMA system can take advantage in voice transmission in that the interference can be further reduced with the use of voice activation. The studies have shown that a speaker is active only for about 35% to 40% of the time [22]. We assume that the voice activity factor, υ = 37.5% or 3/8, throughout, this investigation.

5.1.4 Outer-cell Interference Factor

In CDMA 100% frequency reuse can be employed therefore in WCDMA,all neighboring cells can use the same spectrum.therefore,for a given level of interference I_x originating within a cell, there is additional interference originating outer side of the cell. For signal propagation loss that follows an $n=4^{th}$ power exponent law, this interference is Estimated at about 55% of the within-cell interfence.the total interference is therefore approximately 1.55 I_x resulting in a user capacity degradation factor H_o of about 1.55(1.9db)[18].

5.1.5 Soft Handover

Because of universal frequency reuse, the connection of a Mobile Station (MS, or generally UE in WCDMA) to the cellular network can include several radio links. When the UE is connected to more than one cell, it is said to be in soft handover [23]. If, in particular, the UE has more than one radio link to multiple cells on the same site, it is in softer handover. Soft handover is a form of diversity, increasing the signal-to-noise ratio when the transmission power is constant. It helps to minimize the transmission power needed in both uplink and downlink. It has two basic characteristics:

- Soft handover gain (ca. 1 to 2 dB applicable in the power budget) due to the proper combination of two or more signal branches

-Soft handover overhead due to the fact that the UEs in the handover area are connected to more than one cell. The overall scenario should be clear from Figure

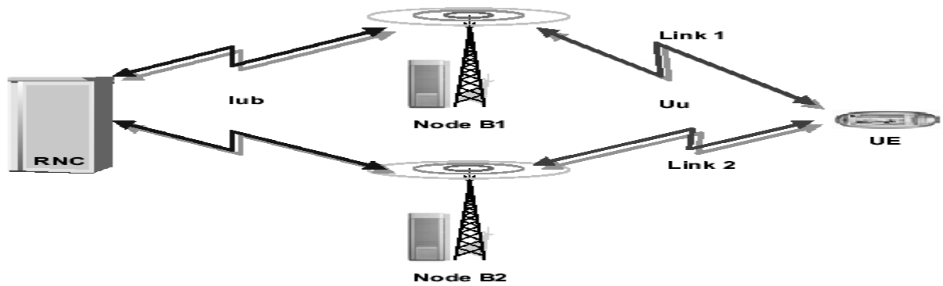


Figure 5.3: UE in Soft handover [24]

This overhead should be kept within reasonable limits to save the downlink traffic capacity of the cell. The usual reasonable or maximum acceptable value in CDMA networks (already applying to IS-95 and expected also for WCDMA) is 20–30% – i.e., 1.2 to 1.5[24] radio links per user connection. We have used 1.5[15]

5.2 Capacity of Cellular WCDMA for UMTS

The capacity of WCDMA system is interference limited, while it is bandwidth limited in FDMA and TDMA.Therefore, any reduction in the interference will cause a linear in the capacity of WCDMA.Put another way in WCDMA system, the link performance for each user increases as the number of users decreases A straightforward way to reduce interference is to use multisectorized antennas, which results in spatial isolation of users. Another way of increasing WCDMA capacity is to operate in a discontinuous transmission mode (DTX) [25].

5.2.1 Uplink Capacity Calculation in WCDMA for UMTS

Let the number of users be N. Then, each demodulator at the cell site receives a composite waveform containing the desired signal of power S and (N - 1) interfering users, each of which has power, S. Thus, the signal-to-noise ratio is [14],

$$SNR = \frac{S}{(N-1)S} = \frac{1}{(N-1)} \quad \text{..........(5.2.1.1)}$$

In addition to SNR, bit energy-to-noise ratio is an important parameter in communication systems. It is obtained by dividing the signal power by the baseband information bit rate, R, and the interference power by the total RF bandwidth, W. The SNR at the base station receiver can be represented in terms of E_b/N_o is given by,

$$\frac{E_b}{N_o} = \frac{S/R}{(N-1)(S/W)} = \frac{W/R}{N-1} \text{........ (5.2.1.2)}$$

Equation (6.2.1.2) does not take into account the background thermal noise, η in the spread bandwidth. To take this noise into consideration, E_b/N_o can be represented as,

$$\frac{E_b}{N_o} = \frac{W/R}{(N-1) + \frac{\eta}{S}} \text{..................... (5.2.1.3)}$$

Thus resolving the number of users, N that can access the system is thus given as,

$$N = 1 + \frac{W/R}{E_b/N_o} - \frac{\eta}{S} \text{............... (5.2.1.4)}$$

where W/R is called the processing gain. The background noise determines the cell radius for a given transmitter power.

In order to achieve an increase in capacity, the interference due to other users should be reduced. This can be done by decreasing the denominator of equations (5.2.1.1) or (5.2.1.2). The first technique for reducing interference is antenna sectorization. The second technique involves the monitoring of voice activity such that each transmitter is switched off during periods of no voice activity. Voice activity is denoted by a factor α, and the interference term in equation (5.2.1.2) becomes (N_s — 1) α, where N_s is the number of users per sector. With the use of these two techniques, the new average value of E_b/N_o' within a sector is given as [25]

$$\frac{E_b}{N_o} = \frac{W/R}{(N_s - 1)\alpha + \frac{\eta}{S}} \text{....... (5.2.1.5)}$$

When the number of users is large and the system is interference limited rather than noise limited, the number of users can be shown to be,

$$N_s = 1 + \frac{1}{\alpha}\left[\frac{W/R}{E_b/N_o}\right] \text{.......... (5.2.1.6)}$$

If the voice activity factor is assumed to hate a value of 3/8, and three sectors per cell site are used, Equation (5.2.1.5) demonstrates that the SNR increases by a factor of 8, which leads to an 8 fold increase in the number of users compared to an omni-directional antenna system with no voice activity detection. Now the contribution of sectorization, soft handoff and outer cell interference factor influencing the capacity equation yields,

$$N_s = 1 + \left(\frac{W/R}{E_b/N_o} - \frac{\eta}{S}\right)\frac{1}{(1+\beta)\alpha} \times D \times H \quad ...... (5.2.1.7)$$

Where, N_s=total numbers of users

W=chip rate

R= base band information bit rate

E_b/N_o=Energy per bit to noise power spectral density ratio

H=soft handover factor

D=sectorization

S=signal power

=S1-P(d)-Shadow fading   S1=UE power, P(d)=Propagation loss

η= background thermal noise β = Outer-cell Interference factor and α =voice activity factor

Chapter-6
Radio Propagation Model

A radio propagation model, also known as the Radio Wave Propagation Model or the Radio Frequency Propagation Model, is an empirical mathematical formulation for the characterization of radio wave propagation as a function of frequency, distance and other conditions. Created with the goal of formalizing the way radio waves are propagated from one place to another, such models typically predict the path loss along a link or the effective coverage area of a transmitter

6.1 Characteristics

As the path loss encountered along any radio link serves as the dominant factor for characterization of propagation for the link, radio propagation models typically focus on realization of the path loss with the auxiliary task of predicting the area of coverage for a transmitter or modeling the distribution of signals over different regions.

6.2 Development Methodology

Radio propagation models are empirical in nature, which means, they are developed based on large collections of data collected for the specific scenario. For any model, the collection of data has to be sufficiently large to provide enough likeliness (or enough scope) to all kind of situations that can happen in that specific scenario.

Different models have been developed to meet the needs of realizing the propagation behavior in different conditions. Types of models for radio propagation include

i) Okumura Model

ii) Hata Model for Urban Areas

ii.a) Hata Model for Suburban Areas

ii.b) Hata Model for Open Areas

iii) COST 231 model

6.2.1 Okumura Model

The Okumura model for Urban Areas is a Radio propagation model that was built using the data collected in the city of Tokyo, Japan. The model is ideal for using in cities with many urban structures but not many tall blocking structures. The model served as a base for the Hata Model. Okumura model was built into three modes [26] [27]. The model for urban areas was built first and used as the base for others.

6.2.1.1 Coverage

Frequency = 150 MHz to 1920 MHz [14]
Mobile Station Antenna Height: between 1 m and 10 m
Base station Antenna Height: between 30 m and 1000 m
Link distance: between 1 km and 100 km

6.2.1.2 Mathematical Formulation

$$L = L_{FSL} + A_{MU} - H_{MG} - H_{BG} \sum K_{correction}$$

where,

L = the median path loss. Unit: Decibel (dB)
L_{FSL} = the Free Space Loss. Unit: Decibel (dB)
A_{MU} = Median attenuation. Unit: Decibel (dB)
H_{MG} = Mobile station antenna height gain factor.
H_{BG} = Base station antenna height gain factor.
$K_{correction}$ = Correction factor gain (such as type of environment, water surfaces, isolated obstacle etc.)

6.2.2 COST 231 Model

The COST-Hata-Model is the most often cited of the COST 231 models. Also called the Hata Model PCS Extension, to cover a more elaborated range of frequencies [28] COST (Cooperation européenne dans le domaine de la recherche Scientifique et Technique) is a

European Union Forum for cooperative scientific research which has developed this model accordingly to various experiments and researches.

6.2.2.1 Applicable Conditions

This model is applicable to urban areas. To further evaluate Path Loss in Suburban or Rural Quasi-open/Open Areas, this path loss has to be substituted into Urban to Rural/Urban to Suburban Conversions

6.2.2.2 Coverage

Frequency: 1500 MHz to 2000 MHz [29]

Mobile Station Antenna Height: 1 up to 10m

Base station Antenna Height: 30m to 200m

Link Distance: 1 up to 20 km

6.2.2.3 Mathematical Formulation

The COST-231 Model is formulated as,

$$L = 46.3 + 33.9\log(f_c) - 13.82\log h_b - a(h_r) + (44.9 - 6.55\log h_b)\log d + C_M$$

$$a(h_r) = (1.1\log f_c - .7)h_{re} - (1.56\log f_c - .8) \text{ for urban}$$

$$= 3.2[\log(11.75h_{re})]^2 - 4.97 \text{ for dense urban}$$

C_M = 0 db for median cities and suburban areas

3db for metropolitan areas

Where,

L = Median path loss. Unit: Decibel (dB)

f_c = Frequency of Transmission. Unit: Megahertz (MHz)

h_b = Base Station Antenna effective height. Unit: Meter (m)

d = Link distance. Unit: Kilometer (km)

h_r = Mobile Station Antenna effective height. Unit: Meter (m) $a(h_r)$ = Mobile station Antenna height correction factor as described in the Hata Model for Urban Areas.

6.2.3 Hata Model

This model also has two more varieties for transmission in Suburban Areas and Open Areas[30].Hata Model predicts the total path loss along a link of terrestrial microwave or other type of cellular communications.

6.2.3.1 Coverage

Frequency: 150 MHz to 1500 MHz

Mobile Station Antenna Height: between 1 m and 10 m

Base station Antenna Height: between 30 m and 200 m

Link distance: between 1 km and 20 km.

6.2.3.2 Mathematical Formulation

The Hata Model for urban areas is formulated as,

$$L = 69.55 + 26.16\log(f_c) - 13.82\log h_b - C_H + (44.9 - 6.55\log h_b)\log d$$

For small or medium cities

$$C_H = 0.8 + (1.1\log f_c - .7)h_M - 1.56\log f_c$$

And for large city

$$C_H = 8.29(\log(1.5hm))^2 - 1.1 \text{ if } 150 <= f <= 200$$

$$3.2(\log(11.75hm))^2 - 4.97 \text{ if } 200 <= f <= 1500$$

Where,

L = Median path loss. Unit: Decibel (dB)

f_c = Frequency of Transmission. Unit: Megahertz (MHz)

h_b = Base Station Antenna effective height. Unit: Meter (m)

d = Link distance. Unit: Kilometer (km)

h_M = Mobile Station Antenna effective height. Unit: Meter (m)

C_H= Antenna height correction factor

d= Distance between the base and mobile stations. Unit: kilometer (km).

Chapter-7

Coverage Analysis in UMTS Cellular System

Performance analysis of multi service UMTS networks is major interest for mobile network providers. Because of the W-CDMA technique used in UMTS, which leads to an interference limited system with a dynamic cell capacity and load dependent cell coverage, the service mix has a big influence on the system performance. Now we will provide a detailed description of the performance relevant mechanisms for the uplink of a single UMTS cell and to extract data rates and coverage bounds for single and multi service operation. We propose a simplified calculation model for the multi service case.

7.1 Factors Influence in Coverage

Before going to relationship between coverage and capacity we have to discuss some parameters which influence the coverage:

7.1.1 Frequency

The uplink and downlink range is about 1920MHz to 2100MHz (ITU proposed for a global frequency band for WCDMA in UMTS.)[31] The greater the frequency the greater the path loss.

7.1.2 Chip Rate

ITU proposed 3 standard chip rates [31] as 3.84Mcps, 7.84Mcps, and 15.36Mcps. The greater the chip rate higher processing is needed by Node B.

7.1.3 Bit Rate

UMTS offers high data rate transmission, it is possible to have any type of services between 12.2 Kbps (voice traffic) and 2 Mbps (Data traffic) [31].The higher the bit rate the lower the coverage area.

7.1.4 Mobile Maximum Power

The maximum power of mobile handset is .126W or 21dBM power which defines by manufacture [31].

7.1.5 Ms Antenna Gain

Mobile antenna gain is taken as 0 dBi [31]

7.1.6 Cable Connector Losses

Cable and connector losses influence the noise figure of a low Noise amplifier. The usual case found is that a cable loss in many commercial base station 4 to 6 db [31].

7.1.7 Effective Isotropic Radiated Power

EIRP, Effective Isotropic Radiated Power or equivalent power intercepted by a receiver, but spherically symmetrically by transmitter.

EIRP is known as= $P_{max} + G_a - L$

Where,

P_{max} is maximum power of the transmitter or receiver

G_a antenna gain

L all losses calculated from input and output

7.1.8 Interference Margin

Interference-margin is needed in the link budget because of the loading of the cell, the load factor affects the coverage, the more loading is allowed in the system the large is the interference margin needed in the uplink and the smaller is the coverage area. For coverage limited cases, smaller interference margin is used (1-3 dB) corresponds to 20-50% loading. While in a capacity limited cases a larger interference margin is used.

Interference margin=-10log (1-target load) [31]

7.1.9 Fast Fading Margin or Power Control Headroom

Fast fading margin or power control headroom is needed in the User equipment (UE) transmission power for maintaining closed loop fast power control to effectively compensate the fast fading. Typical values of the fast fading margin are 2-5 dB for slow moving mobiles. [31]

7.1.10 Soft Handover Gain

Handover (soft or hard) gives gain against slow fading (Log normal fading) by reducing the required Log-normal margin. Since slow fading is partly uncorrelated between the Node B, by making a handover, the mobile can select a better Node B.Soft handover gives additional macro diversity against fast fading by reducing the signal power to noise power (E_b/N_o) relative to a single radio link. The total soft handover gain is assumed to be between 2-3 dB in the example below including the gain against slow and fast fading [31].

7.1.11 Noise Figure

Noise figure (NF) is a measure of degradation of the signal-to-noise ratio (SNR), caused by components in a radio frequency (RF) signal chain. The noise figure is defined as the ratio of the output noise power of a device to the portion thereof attributable to thermal noise in the input termination at standard noise temperature T_0 (usually 290 K). The noise figure is thus the ratio of actual output noise to that which would remain if the device itself did not introduce noise. It is a number by which the performance of a radio receiver can be specified.Node b noise figure is taken as 5 db [31].

7.1.12 E_b/N_0

E_b/N_0 (the energy per bit to noise power spectral density ratio) is an important parameter in digital communication or data transmission.

In UMTS typical E_b/N_o are given [31]:

Table 7.1: Typical E_b/N_o

Bit Rate(Kbps)	E_b/N_o(dB)
12.2	6.7
64 Circuit switched	5.7
64 packet switched	4.3
144 packet switched	3.7
384 packet switched	1

7.1.13 Node B Antenna Gain:

The UMTS panel antennas have 65 degrees horizontal and about 4 to 6 degrees vertical beam width and 16 to18 dBi [27][31]

7.1.14 Node B sensitivity:

Also known as required signal power, the sensitivity represents the weakest signal that can be received by the receiving antenna which is calculated as [32],

Node B sensitivity=E_b/N_o-G_p+$N_{\text{Node B interference and noise power}}$

7.1.15 Processing Gain

This defined as [31],

Processing gain=$10\log\left(\frac{Chiprate}{Bitrate}\right)$

7.1.16 Node B Interference Power

Node B Interference Power is calculated as,[32]

Node B Interference Power =$10\log\left(10^{(noisepower + Interfrenc eM \arg in)/10} - 10^{Noisepower/10}\right)$

7.1.17 Node B Noise and Interference

Node B Noise and interference is calculated as [32]

Noise and interference= $10\log\left(10^{(noisepower)/10} - 10^{(Interfrenc\ epower)/10}\right)$

7.1.18 Thermal Noise

Thermal noise is due to thermal agitation of electrons. It is present in all electronic devices and transmission media and is a function of temperature.Themal noise is uniformly distributed across the frequency spectrum and hence is often referred to as white noise [33].

The amount of thermal noise to be found in a and with of 1 Hz in any device or conductor is

$$N=KT\ (W/Hz)$$
$$=10\log\ (KT)\ \text{in dB}$$

7.2 Relationship between Coverage and Data Rates

In UMTS, the scarce resource is the transmission power. Talking about the Frequency Division Duplex mode (FDD) of UMTS, the power budgets for up-link and downlink are independent of each other. While the uplink power budget is limited by the transmission power of each User Equipment (mobile station), the downlink power budget depends only on the capabilities of the Node B

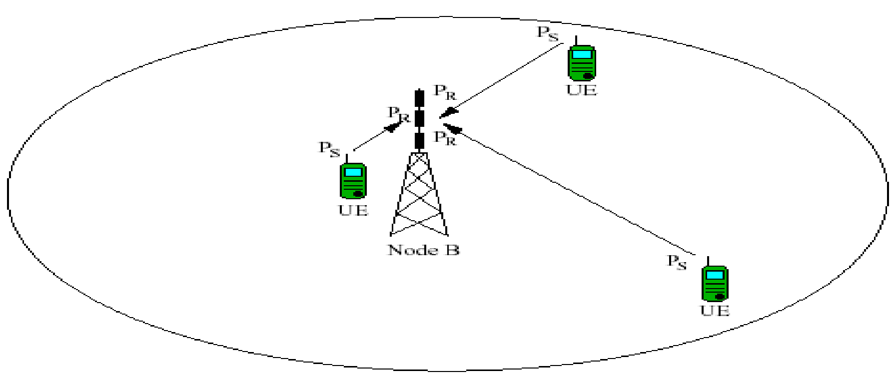


Figure 7.1: UMTS cell[34]

Figure 7.1 shows a UMTS cell where Node B received power P_R from User

Equipment(UE),the Node B sensitivity is the power level of the minimum signal necessary at the input of the BTS receiver to meet requirements in terms of E_b/N_o, G_p and node b interference and noise power given as[32],

Node B sensitivity=$E_b/N_o - G_p + N_{\text{Node B interference and noise power}}$ ……… (7.2.1)

Where G_p, Processing gain=$10\log\left(\frac{Chiprate}{Bitrate}\right) = 10\log\left(\frac{3.84Mcps}{R}\right)$

Node b interference and noise power =$10\log\left(10^{(noisepower)/10} - 10^{(Interfrenc\ epower)/10}\right)$

Now the maximum allowable path loss,

L_p =EIRP-Node b sensitivity + G_{rx} - fast fading margin…… (7.2.2)

Now from radio propagation model, Path loss for dense urban area

$$L = 46.3 + 33.9\log(f_c) - 13.82\log h_b - 3.2[\log(11.75hre)]2 + 4.97 + (44.9 - 6.55\log h_b)\log d + 3$$

from equation (7.2.2) and (7.2.3) we can make relationship between coverage versus data rates for dense urban case,

$$46.3 + 33.9\log(f_c) - 13.82\log h_b - 3.2[\log(11.75hre)]2 + 4.97 + (44.9 - 6.55\log h_b)\log d + 3 = \text{EIRP - Node b sensitivity} + 10\log\left(\frac{\text{Chip rate}}{R}\right) \text{- fast fading Margin} \quad ….. (7.2.4)$$

where d is the coverage radius and R is the data rate

After calculating the cell range, d the coverage area can be calculated. The coverage area for one cell in hexagonal configuration can be estimated with[35]:

Coverage Area=$K.d^2$ …..(7.2.5)

where S is the coverage area; d is the maximum cell range; and K is a constant.

Up to six sectors are reasonable for WCDMA, but with six sectors estimation of the cell coverage area becomes problematic, since a six-sectored site does not necessarily resemble a hexagon. A proposal for cell area calculation at this stage is that the equation for the 'omni' case is also used in the case of six sectors and the larger area is due to a higher antenna gain. The more sectors that are used, the more careful soft handover overhead has to be analyzed to provide an accurate estimate. In Table some of the K values are listed.

Table 7.2: K values for the site area calculation [35]:

Site configuration:	Omni	Two-sectored	Three-sectored	Four-sectored
Value of K:	2.6	1.3	1.95	2.6

7.3 Multi Service Case

The multi service case is characterized by the request for different radio link services. Different spreading factors as well as other signal to noise ratios may be requested, resulting in different service parameters. Generally, also for the multi service case the received power levels required at Node B can be calculated for all users, and for an increasing number of users or different class of services causes the cell radius will small results a small coverage area. If we classified the different types as in table then resulting figure will look like figure:

Table 7.3: Different Class of Services

Bit Rate(Kbps)	class
12.2	Class 5
32	Class 4
64	Class 3
144	Class 2
384	Class 1

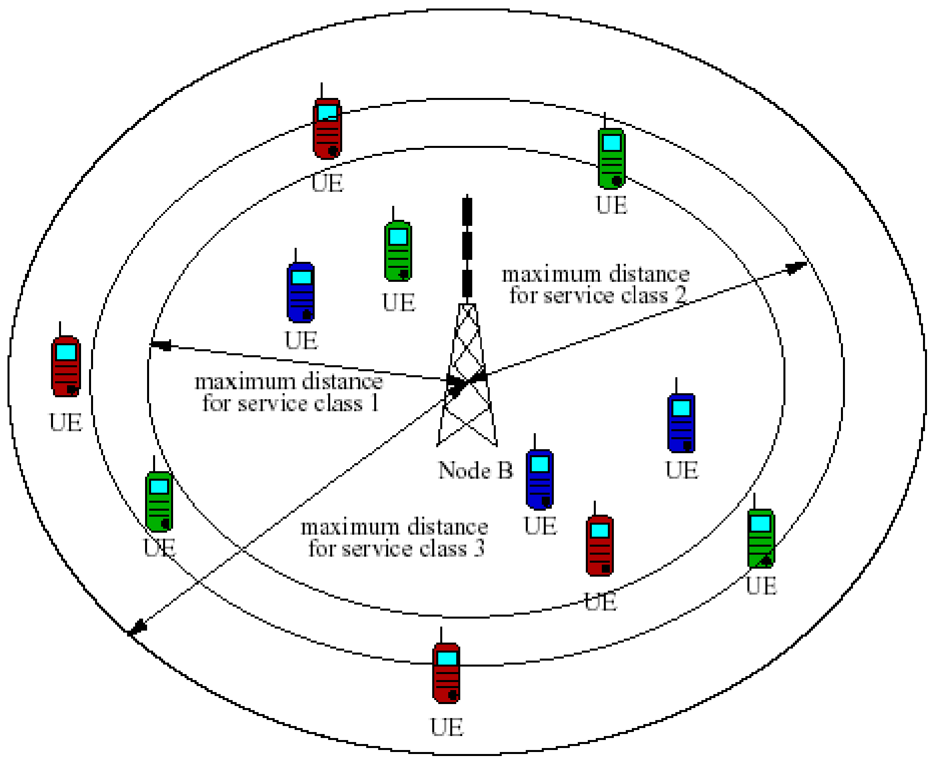


Figure 7.2: Different Class of Services vs. Maximum Distance

Figure 7.2 shows the muliti service case,which shows that for different class of sevices such as sevices class 1, maximum distance is observed by UE(User Equipment) from Node B,similarly for sevices class 2 and sevices class 3 UEs are maintained maximum distance from Node B.The maximum distance determined the coverage area for particular services.We can increase the coverage area for a particular services by increasing sectors,which is also observed target in this project.

Chapter-8

Simulation and Result

We have already told that UMTS has different class of services.Voice, Data, Multimedia is serverd by the UMTS using different data rates.In this chapter we have simulated Numbers of simultaneous users with standard data rates vs. different factors that influence capacity with changing numbers of sectoring cell.

Then we have simulated different data rates vs coverage area for urban and dense urban cell with operating frequency 2000MHz.

8.1 Algorithm for Capacity Analysis Using Sectorization:

Begin

Set energy per bit to noise spectral density ratio (Eb/No) = [1 2 3 4 5 6 7 8 9 10]

Set soft handover gain (H) = [1.5]

Set inter-cell interference (β) = [1.55]

Set channel activity for data (α) = [1]

Set channel activity for voice (α) = [.38]

Set thermal noise (η) = [4.04X10^-21]

Set user signal power (S1) = [.126]

Set shadow fading (sh_fd) = [6.30]

Set cell range in km (R) = [2]

Set chip rate (W) = [3840000]

Set base band information rate in kbps (R) = [12.2 64 144 384 2000]

Set base antenna height in meter (h_b) = [20]

Set user antenna height in meter (h_{re}) = [2]

Set sector (D) = [1 2 3 4 6]

Set frequency range in MHz (f_c) = [2000]

Set data rate in kbps (R) = [12.2 64 144 384 2000]

//Processing

Processing gain (PG) = (W/R)

Propagation loss in dense urban (Pro_loss) =

$46.3+33.9\log(f_c)-13.82\log h_b-3.2[\log(11.75\text{hre})]^2+4.97+(44.9-6.55\log h_b)\log d$
$+3$

Signal Power (S) = S1-Pro_loss-sh_hd

//Output

$$\text{Numbers of users in UMTS cell (ns)} = 1+\left(\frac{W/R}{E_b/N_o}-\frac{\eta}{S}\right)\frac{1}{(1+\beta)\alpha}\times D\times H$$

End

8.2 Algorithm for Coverage and Data rates Analysis Using Sectorization

Begin

Set Transmitter=Mobile Station

Set Receiver=Node B

Set mobile max power in dbm (mo_mx) = [21]

Set mobile gain in db (M_G) = [0]

Set cable and connector losses in db (ca_cn_loss) = [3]

Set thermal noise in dbm (η) = [174]

Set node B noise figure in db (nodeB_NF) = [5]

Set target load (tar_ld) = [.4]

Set chip rate (W) = [3840000]

Set base antenna height in meter (h_b) = [20]

Set user antenna height in meter (h_{re}) = [2]

Set energy per bit to noise spectral density ratio (Eb/No) = [5]

Set Power Control Margin or Fading Margin (MPC) = [4]

Set Value for sectors (Sec) = [1 2 3 4]

Set constant value for sectors (K) = [2.6 1.6 1.95 2.6]

Set data rate in kbps (R) = [100 200 300 400 500 600 2000]

//Processing

Chip rate in db (W_db) = 10log (W)

Processing gain (PG) = (W/R)

Effective isotropic radiated power (EIRP) = mo_mx-ca_cn_loss+M_G

Node B noise density (nodeB_ND) = η+ nodeB_NF

Node B noise power (nodeB_NPW) = nodeB_ND +W_db

Interference margin (IM) =-10log (1-tar_ld)

Node B Interference Power (nodeB_IP) = $10\log\left(10^{(nodeB\_NPW+IM)/10} - 10^{nodeB\_NPW/10}\right)$

Node B Noise and interference (nodeB_NIFPW) = $10\log\left(10^{(nodeB\_NPW)/10} - 10^{(nodeB\_IP)/10}\right)$

Node B antenna gain (nodeB_AG) = [18]

Receiver Sensitivity (Srx) = Eb/No-PG+ nodeB_NIFPW

Total Allowable Path loss=EIRP-Srx+ nodeB_AG-MPC=EIRP-(Eb/No-PG+ nodeB_NIFPW) + nodeB_AG-MPC

Path loss in dense urban (Durban_Ploss) =

$$46.3 + 33.9\log(f_c) - 13.82\log h_b - 3.2[\log(11.75hre)]^2 + 4.97 + (44.9 - 6.55\log h_b)\log d + 3$$

=142.17+36.37logd

//Output

Cell radius (d) = 10^ ((1/36.37)* (EIRP-(Eb/No-PG+ nodeB_NIFPW) + nodeB_AG-MPC-142.17))

Cell Area (A) = K*d2

End

8.3 Performance Analysis in Capacity Using Sectorization for UMTS

i)Varying Eb/No and changing the sectors the Numbers of simueltaneous user can be observed here we consider themal noise -174dbm/Hz,shadow fading 8db,user transmit power 21dbm,inter cell or outer cell interference factor 1.55,soft handover gain 1.5

Table 8.1: Simulated Numbers of Simultaneous 384 kbps Users vs. Eb/No in UMTS cell

Energy per bit to Noise spectral density ratio(E_b/N_o)	Users without sector	Users with 2 sectors	Users with 3 sectors	Users with 4 sectors	Users with 6 sectors
1	10.677	20.355	30.032	39.71	59.065
2	5.8387	10.677	15.516	20.355	30.032
3	4.2258	7.4516	10.677	13.903	20.355
4	3.4194	5.8387	8.2581	10.677	15.516
5	2.9355	4.871	6.8065	8.7419	12.613
6	2.6129	4.2258	5.8387	7.4516	10.677
7	2.3825	3.765	5.1475	6.53	9.2949
8	2.2097	3.4194	4.629	5.8387	8.2581
9	2.0753	3.1505	4.2258	5.3011	7.4516
10	1.9677	2.9355	3.9032	4.871	6.8065
11	1.8798	2.7595	3.6393	4.5191	6.2786
12	1.8065	2.6129	3.4194	4.2258	5.8387
13	1.7444	2.4888	3.2333	3.9777	5.4665
14	1.6912	2.3825	3.0737	3.765	5.1475
15	1.6452	2.2903	2.9355	3.5806	4.871
16	1.6048	2.2097	2.8145	3.4194	4.629
17	1.5693	2.1385	2.7078	3.277	4.4156

Table 8.2: Simulated Numbers of Simultaneous 144 Kbps Users vs. Eb/No in UMTS cell

Energy per bit to Noise spectral density ratio(E_b/N_o)	Users without sector	Users with 2 sectors	Users with 3 sectors	Users with 4 sectors	Users with 6 sectors
1	26.806	52.613	78.419	104.23	155.84
2	13.903	26.806	39.71	52.613	78.419
3	9.6022	18.204	26.806	35.409	52.613
4	7.4516	13.903	20.355	26.806	39.71
5	6.1613	11.323	16.484	21.645	31.968
6	5.3011	9.6022	13.903	18.204	26.806
7	4.6866	8.3733	12.06	15.747	23.12
8	4.2258	7.4516	10.677	13.903	20.355
9	3.8674	6.7348	9.6022	12.47	18.204
10	3.5806	6.1613	8.7419	11.323	16.484
11	3.346	5.6921	8.0381	10.384	15.076
12	3.1505	5.3011	7.4516	9.6022	13.903
13	2.9851	4.9702	6.9553	8.9404	12.911
14	2.8433	4.6866	6.53	8.3733	12.06
15	2.7204	4.4409	6.1613	7.8817	11.323
16	2.6129	4.2258	5.8387	7.4516	10.677
17	2.518	4.0361	5.5541	7.0721	10.108
18	2.4337	3.8674	5.3011	6.7348	9.6022
19	2.3582	3.7165	5.0747	6.4329	9.1494
20	2.2903	3.5806	4.871	6.1613	8.7419

Table 8.3: Simulated Numbers of Simultaneous 64 Kbps Users vs. Eb/No in UMTS cell

Energy per bit to Noise spectral density ratio(E_b/N_o)	Users without sector	Users with 2 sectors	Users with 3 sectors	Users with 4 sectors	Users with 6 sectors
1	59.065	117.13	175.19	233.26	349.39
2	30.032	59.065	88.097	117.13	175.19
3	20.355	39.71	59.065	78.419	117.13
4	15.516	30.032	44.548	59.065	88.097
5	12.613	24.226	35.839	47.452	70.677
6	10.677	20.355	30.032	39.71	59.065
7	9.2949	17.59	25.885	34.18	50.77
8	8.2581	15.516	22.774	30.032	44.548
9	7.4516	13.903	20.355	26.806	39.71
10	6.8065	12.613	18.419	24.226	35.839
11	6.2786	11.557	16.836	22.114	32.672
12	5.8387	10.677	15.516	20.355	30.032
13	5.4665	9.933	14.4	18.866	27.799
14	5.1475	9.2949	13.442	17.59	25.885
15	4.871	8.7419	12.613	16.484	24.226
16	4.629	8.2581	11.887	15.516	22.774
17	4.4156	7.8311	11.247	14.662	21.493
18	4.2258	7.4516	10.677	13.903	20.355
19	4.056	7.1121	10.168	13.224	19.336
20	3.9032	6.8065	9.7097	12.613	18.419

Table 8.4: Simulated Numbers of Simultaneous 12.2 kbps or voice Users vs. E_b/No in UMTS cell

Energy per bit to Noise spectral density ratio(E_b/N_o)	Users without sector	Users with 2 sectors	Users with 3 sectors	Users with 4 sectors	Users with 6 sectors
1	305.6	610.2	914.8	1219.4	1828.6
2	153.3	305.6	457.9	610.2	914.8
3	102.53	204.07	305.6	407.13	610.2
4	77.15	153.3	229.45	305.6	457.9
5	61.92	122.84	183.76	244.68	366.52
6	51.767	102.53	153.3	204.07	305.6
7	44.514	88.029	131.54	175.06	262.09
8	39.075	77.15	115.23	153.3	229.45
9	34.845	68.689	102.53	136.38	204.07
10	31.46	61.92	92.38	122.84	183.76
11	28.691	56.382	84.073	111.76	167.15
12	26.383	51.767	77.15	102.53	153.3
13	24.431	47.862	71.292	94.723	141.58
14	22.757	44.514	66.272	88.029	131.54
15	21.307	41.613	61.92	82.227	122.84
16	20.038	39.075	58.113	77.15	115.23
17	18.918	36.835	54.753	72.671	108.51
18	17.922	34.845	51.767	68.689	102.53
19	17.032	33.063	49.095	65.126	97.19
20	16.23	31.46	46.69	61.92	92.38

ii)Varying intercell interfrence and changing the Sectors the Numbers of simueltaneous 384 kbps users can be observed,here we consider themal noise -174dbm/Hz,shadow fading 8db,user transmit power 21dbm,inter cell or outer cell interference factor varying,soft handover gain 1.5

Table 8.5: Simulated Numbers of Simultaneous 384 Kbps Users vs. Inter-cell interference in UMTS cell

Intercell interference	Users without sector	Users with 2 sectors	Users with 3 sectors	Users with 4 sectors	Users with 6 sectors
0.1	23.388	70.767	122.62	201	901
0.2	12.194	35.884	61.811	101	451
0.3	8.4627	24.256	41.541	67.667	301
0.4	6.597	18.442	31.405	51	226
0.5	5.4776	14.953	25.324	41	181
0.6	4.7313	12.628	21.27	34.333	151
0.7	4.1983	10.967	18.375	29.571	129.57
0.8	3.7985	9.7209	16.203	26	113.5
0.9	3.4876	8.7519	14.514	23.222	101
1	3.2388	7.9767	13.162	21	91
1.1	3.0353	7.3425	12.057	19.182	82.818
1.2	2.8657	6.814	11.135	17.667	76
1.3	2.7222	6.3667	10.356	16.385	70.231
1.4	2.5991	5.9834	9.6873	15.286	65.286
1.5	2.4925	5.6512	9.1081	14.333	61
1.6	2.3993	5.3605	8.6014	13.5	57.25
1.7	2.3169	5.104	8.1542	12.765	53.941
1.8	2.2438	4.876	7.7568	12.111	51
1.9	2.1783	4.672	7.4011	11.526	48.368
2.0	2.1194	4.4884	7.0811	11	46

iv) Varying voice activity factor and changing the Sectors the Numbers of simueltaneous voice or 12.2 kbps usera can be observed only for voice users not for data users as in data users activity factor is always 1, here we consider themal noise -174dbm/Hz, shadow fading 8db, user transmit power 21dbm, inter cell or outer cell interference factor 1.55,soft handover gain 1.5

Table 8.6: Simulated Numbers of Simultaneous Voice Users vs. Voice activity factor in UMTS cell

Voice activity factor	Users without sector	Users with 2 sectors	Users with 3 sectors	Users with 4 sectors	Users with 6 sectors
0.1	455.63	910.26	1364.9	1819.5	2728.8
0.2	228.31	455.63	682.94	910.26	1364.9
0.3	152.54	304.09	455.63	607.17	910.26
0.4	114.66	228.31	341.97	455.63	682.94
0.5	91.926	182.85	273.78	364.7	546.55
0.6	76.771	152.54	228.31	304.09	455.63
0.7	65.947	130.89	195.84	260.79	390.68
0.8	57.828	114.66	171.49	228.31	341.97
0.9	51.514	102.03	152.54	203.06	304.09
1	46.463	91.926	137.39	182.85	273.78

iii) Varying soft handover gain and changing the Sector the Numbers of simueltaneous 384 kbps users can be observed,here we consider themal noise -174dbm/Hz,shadow fading 8db,user transmit power 21dbm,inter cell or outer cell interference factor 1.55

Table 8.7: Simulated No. of Simultaneous 384 kbps Users vs. soft handover factor in UMTS cell

Soft handover factor	Users without sector	Users with 2 sectors	Users with 3 sectors	Users with 4 sectors	Users with 6 sectors
0.1	1.6452	2.2903	2.9355	3.5806	4.2258
0.2	2.2903	2.2903	4.871	6.1613	7.4516
0.3	2.9355	4.871	6.8065	8.7419	10.677
0.4	3.5806	6.1613	8.7419	11.323	13.903
0.5	4.2258	7.4516	10.677	13.903	17.129
0.6	4.871	8.7419	12.613	16.484	20.355
0.7	5.5161	10.032	14.548	19.065	23.581
0.8	6.1613	11.323	16.484	21.645	26.806
0.9	6.8065	12.613	18.419	24.226	30.032
1	7.4516	13.903	20.355	26.806	33.258
1.1	8.0968	15.194	22.29	29.387	36.484
1.2	8.7419	16.484	24.226	31.968	39.71
1.3	9.3871	17.774	26.161	34.548	42.935
1.4	10.032	19.065	28.097	37.129	46.161
1.5	10.677	20.355	30.032	39.71	49.387
1.6	11.323	21.645	31.968	42.29	52.613
1.7	11.968	22.935	33.903	44.871	55.839
1.8	12.613	24.226	35.839	47.452	59.065
1.9	13.258	25.516	37.774	50.032	62.29
2.0	13.903	26.806	39.71	52.613	65.516
2.1	14.548	28.097	41.645	55.194	68.742
2.2	15.194	29.387	43.581	57.774	71.968
2.3	15.839	30.677	45.516	60.355	75.194
2.4	16.484	31.968	47.452	62.935	78.419
2.5	17.129	33.258	49.387	65.516	81.645

8.4 Performance Analysis in Coverage and Data rates Using Sectorization for UMTS

In this analysis we have simulated Coverage Vs data rates for Dense Urban .As we assume operating frequency 2000 MHz we use COST 231 Model as radio propagation model.We use mobile nax power 21dbm,cable and connector losses-3db, EIRP=18dbm,themal noise -173.82 dbm BTS noise figure 5 db,at 40% load the coverage versus capacity is:

Table 8.8: Simulated Coverage Vs Data rates in Dense Urban Cell using COST 231 Model

Data rate (kbps)	Cell range in meter	Cell Area without Meter^2	Cell Area with 2 Meter^2	Cell Area with 3 Meter^2	Cell Area with 4 Meter^2
100	942	887.36	1153.6	1730.4	2307.1
200	773.67	598.57	778.14	1167.2	1556.3
300	689.52	475.44	618.07	927.11	1236.1
400	635.43	403.77	524.9	78.7.34	1049.8
500	596.41	355.7	462.41	693.62	924.82
600	566.31	320.71	416.92	625.38	833.84
700	542.05	293.82	381.97	572.95	763.94
800	521.88	272.36	354.07	531.1	708.14
900	504.71	254.74	331.16	496.74	662.31
1000	489.83	239.94	311.92	467.88	623.84
1100	476.75	227.29	295.48	443.22	590.97
1200	465.12	216.33	281.23	421.85	562.47
1300	454.66	206.72	268.74	403.1	537.47
1400	445.19	198.2	257.66	386.49	515.31
1500	436.56	190.58	247.76	371.63	495.51
1600	428.63	183.72	238.84	358.26	477.67

Table 8.9: Simulated Coverage Vs Data rates in Urban Cell using COST 231 Model

Data rate (kbps)	Cell range in meter	Cell Area without sector $Meter^2$	Cell Area with 2 sectors $Meter^2$	Cell Area with 3 sectors $Meter^2$	Cell Area with 4 sectors $Meter^2$
100	1172.6	1375	1787.5	2681.2	3575
200	963.07	927.5	1205.8	1808.6	2411.5
300	858.32	736.71	957.72	1436.6	1915.4
400	790.98	625.65	813.34	1220	1626.7
500	742.41	551.17	716.52	1074.8	1433
600	704.95	496.95	646.03	969.05	1292.1
700	674.75	455.29	591.87	887.81	1183.7
800	649.64	422.03	548.64	822.96	1097.3
900	628.27	394.72	513.14	769.71	1026.3
1000	609.75	371.79	483.33	725	966.66

8.5 Graphical Representation:

Performance Analysis in Capacity Using Sectorization for UMTS

i)Varying Eb/No and changing the Sectors the Numbers of simueltaneous voice usera can be observed here we consider themal noise -174dbm/Hz,shadow fading 8db,user transmit power 21dbm,inter cell or outer cell interference factor 1.55,soft handover gain 1.5

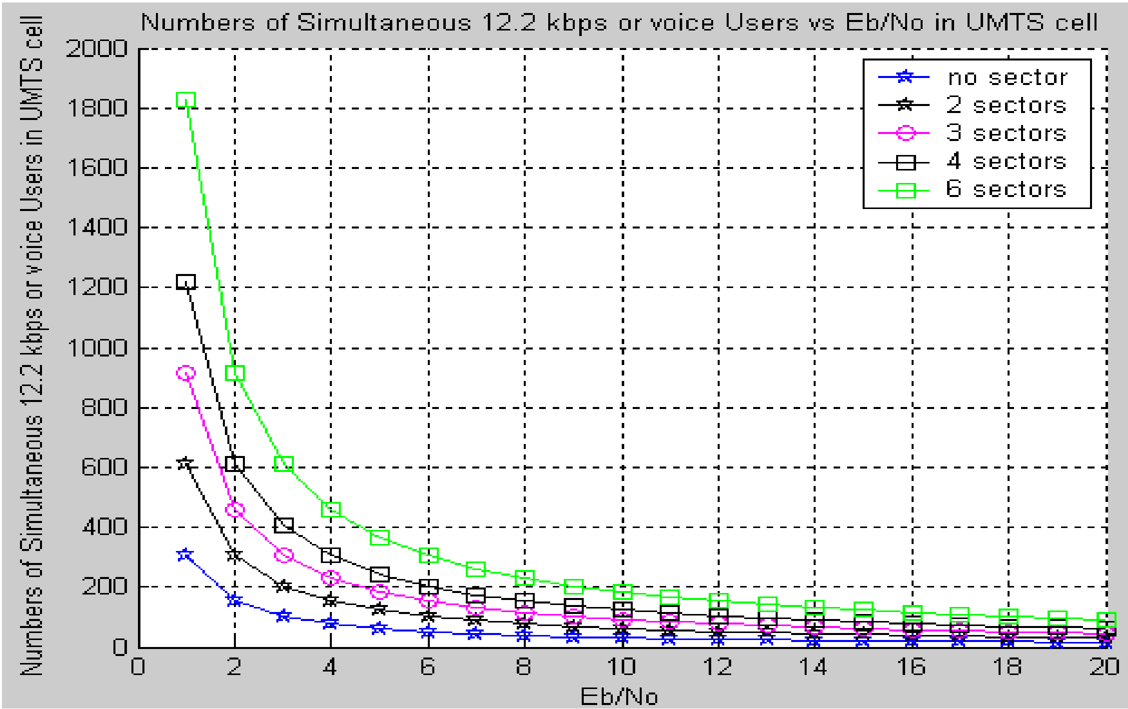


Figure 8.1: Numbers of Simultaneous voice users vs. Eb/No in different sectorized cell

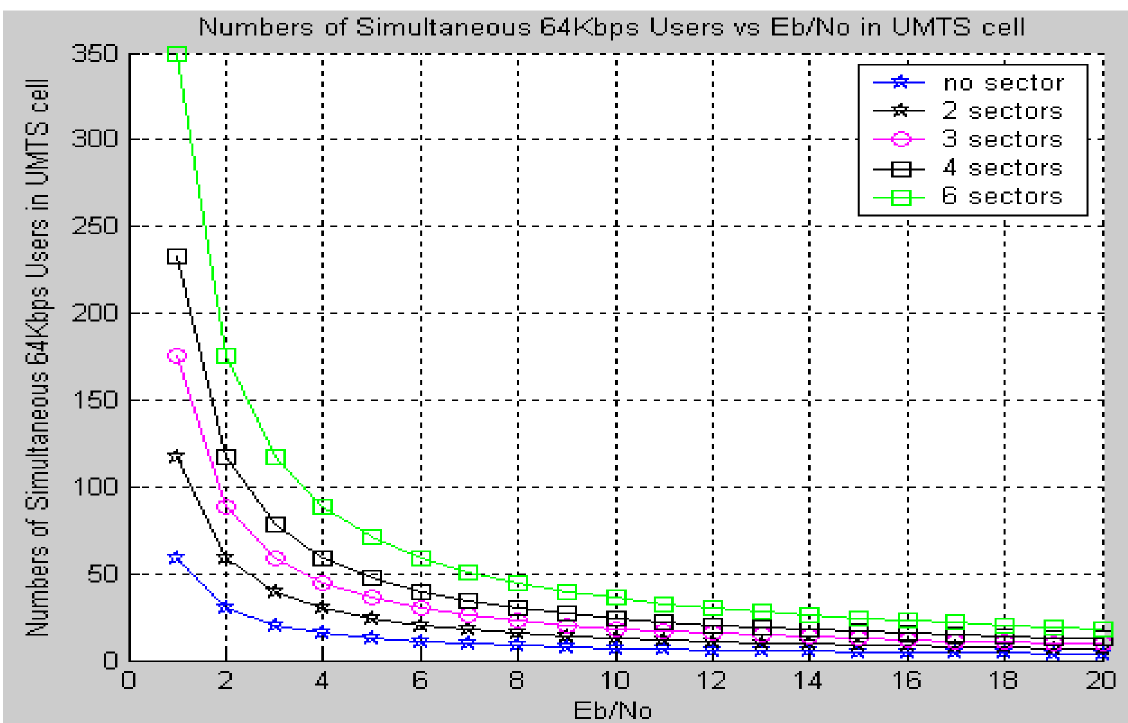


Figure 8.2: Numbers of Simueltaneous 64 kbps users vs. Eb/No in different sectorized cell

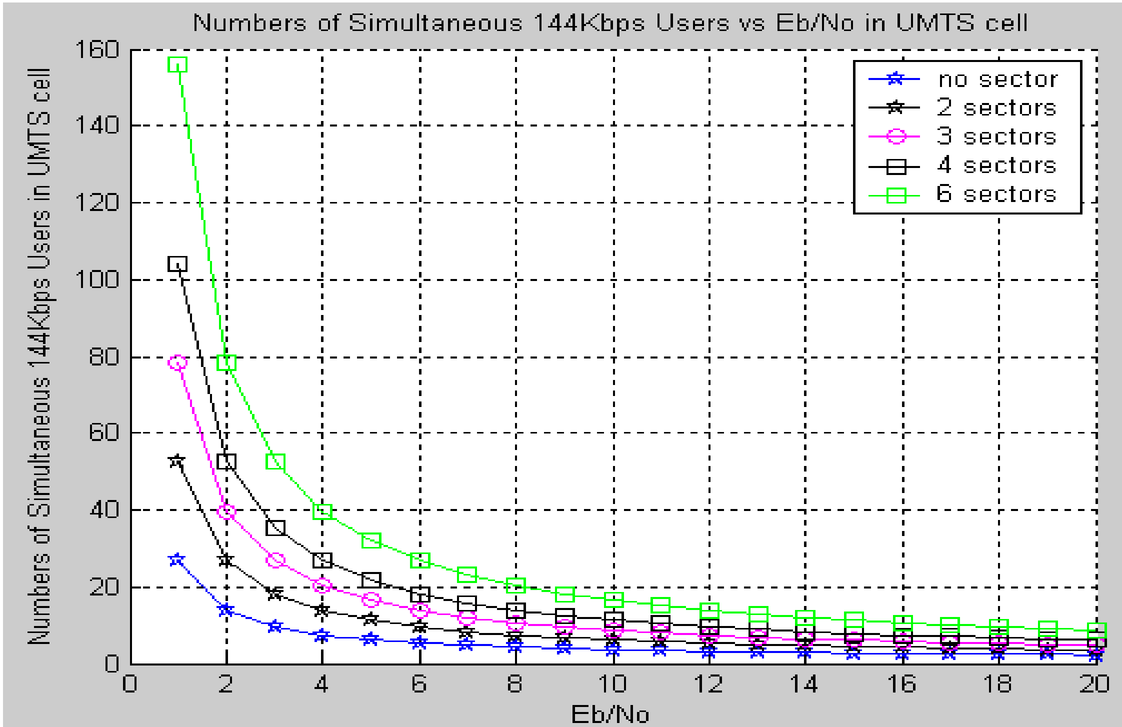


Figure 8.3: Numbers of Simultaneous 144 kbps users vs. Eb/No in different sectorized cell

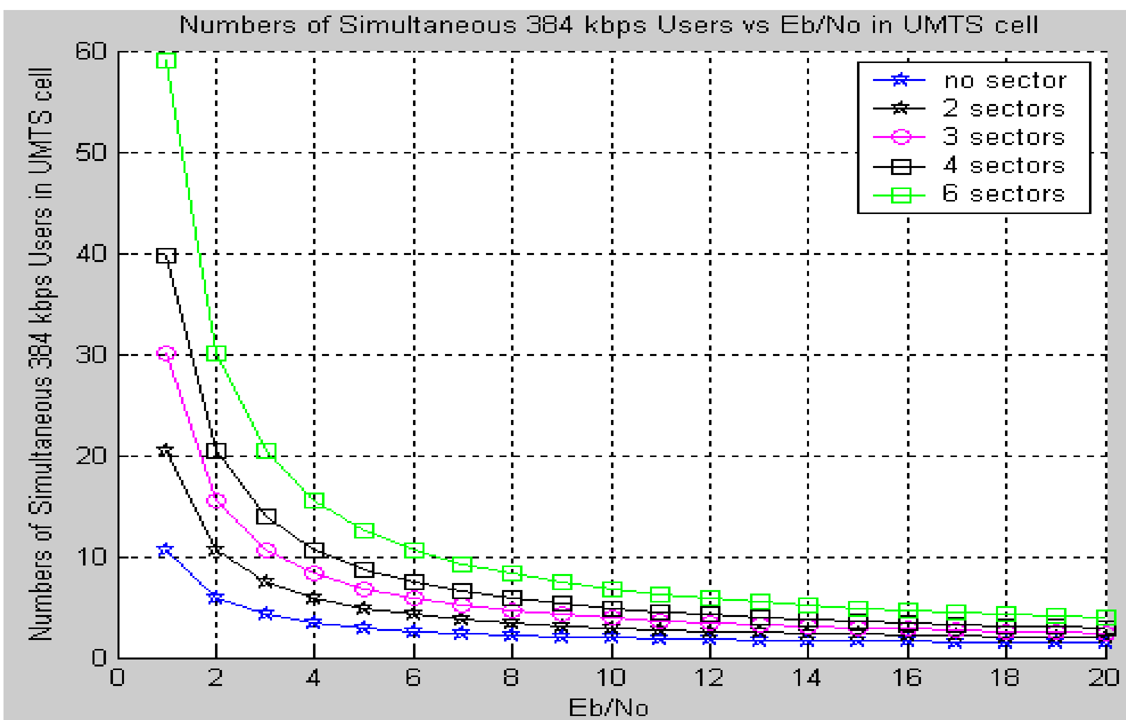


Figure 8.4: Numbers of Simultaneous 384 kbps users Vs Eb/No in different sectorized cell

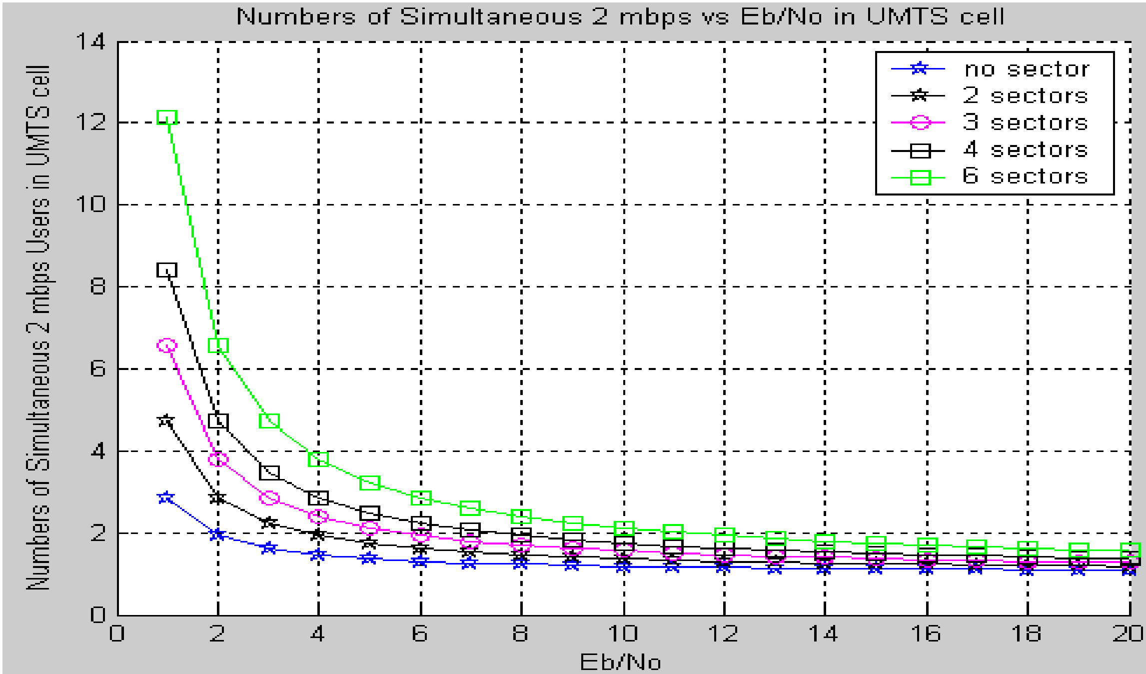


Figure 8.5: Numbers of Simultaneous 2 mbps users vs. Eb/No in different sectorized cell

ii) Varying intercell interfrence and changing the Sectors the Numbers of simueltaneous user can be observed,here we consider themal noise -174dbm/Hz,shadow fading 8db,user transmit power 21dbm,inter cell or outer cell interference factor varying,soft handover gain 1.5

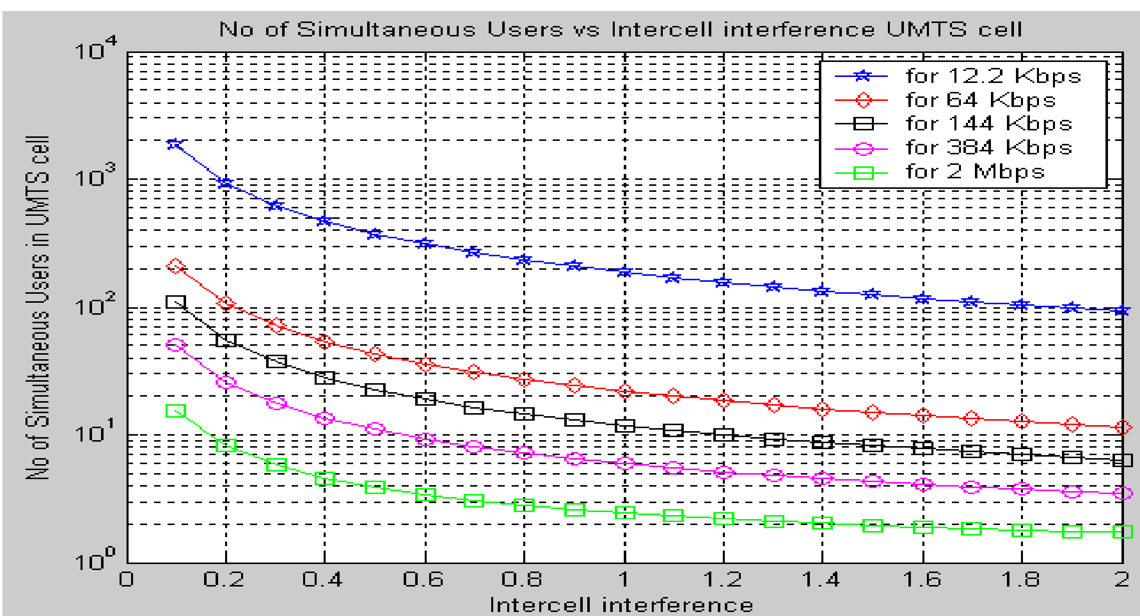


Figure 8.6: Numbers of Simultaneous users vs. Inter-cell interference in non-sectorized cell

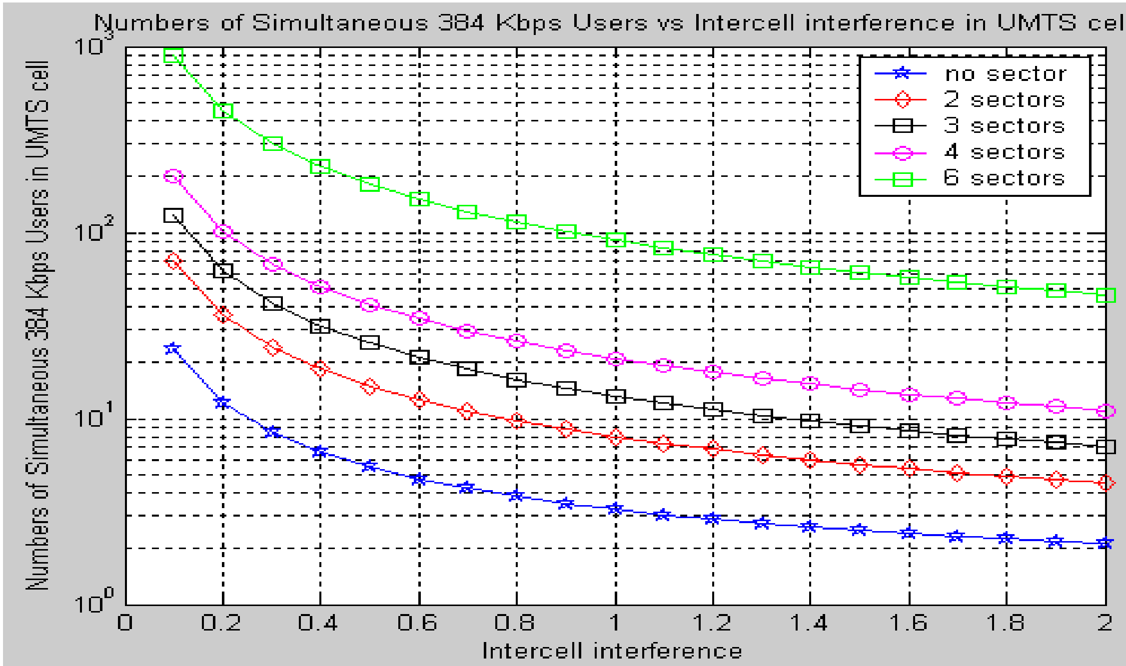


Figure 8.7: Numbers of Simultaneous 384 kbps users vs. Inter-cell interference in sectorized cell

iii) Varying soft handover gain and changing the Sector the Numbers of simueltaneous user can be observed,here we consider themal noise -174dbm/Hz,shadow fading 8db,user transmit power 21dbm,inter cell or outer cell interference factor 1.55,soft handover gain varying

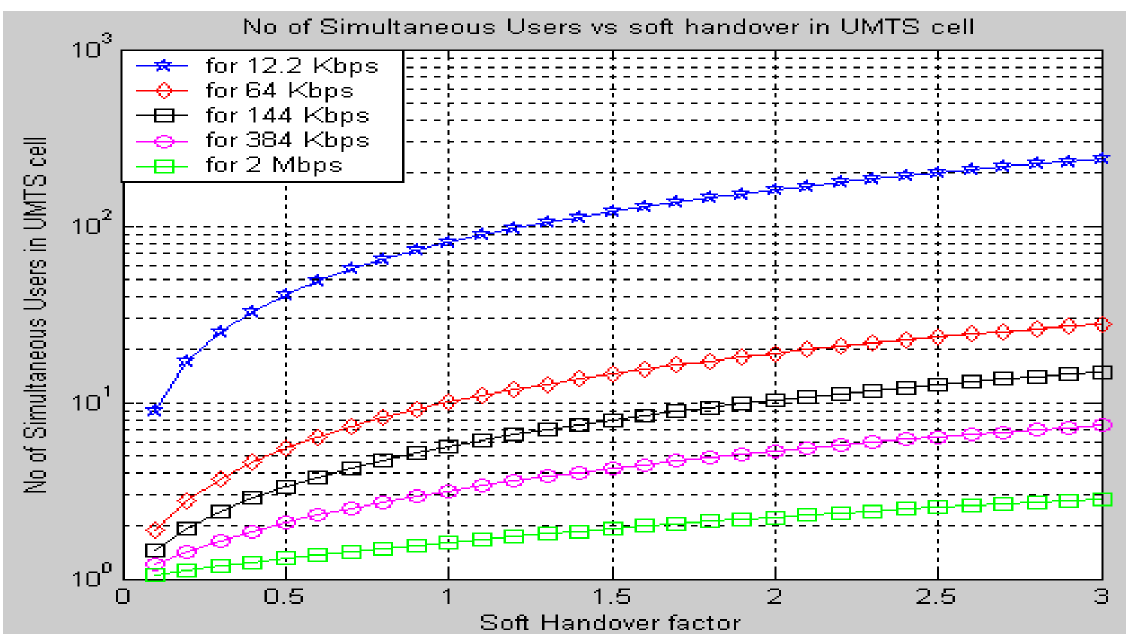


Figure: 8.8: Numbers of Simultaneous users vs. soft handover in non- sectorized cell

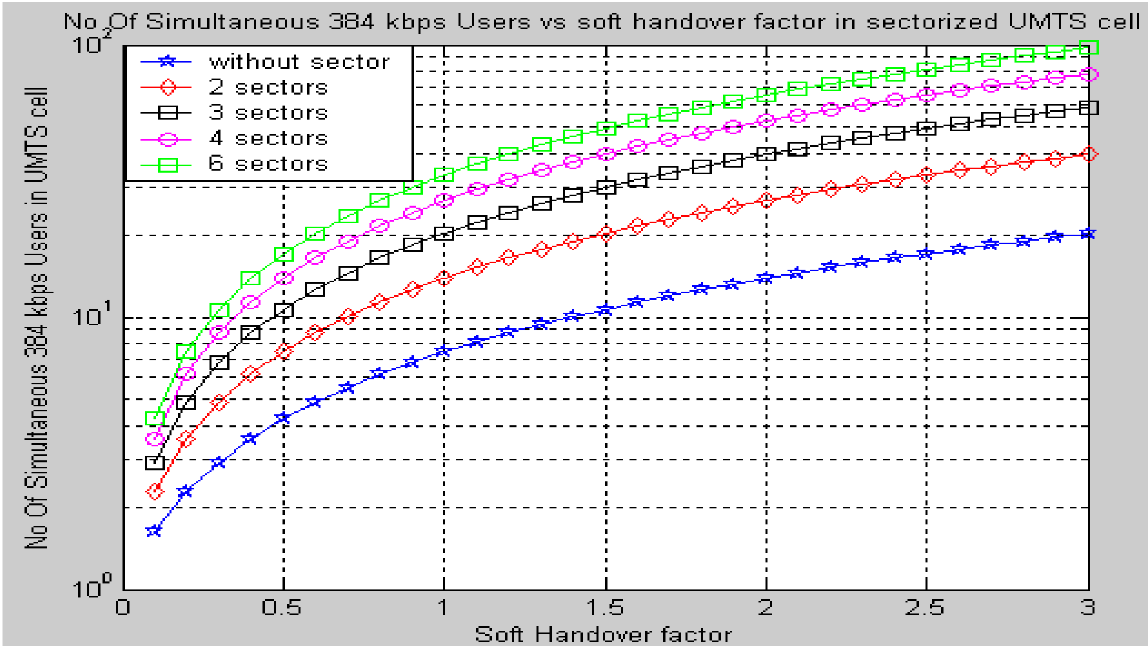


Figure 8.9: Numbers of Simultaneous users vs. soft handover in sectorized cell

iv)Varying voice activity factor and changing the Sectors the Numbers of simueltaneous user can be observed only for voice users not foe data users as in data users activity factor is always 1,here we consider themal noise -174dbm/Hz,shadow fading 8db,user transmit power 21dbm,inter cell or outer cell interference factor 1.55,soft handover gain 1.5 with Node B height 20m and UE height 2m

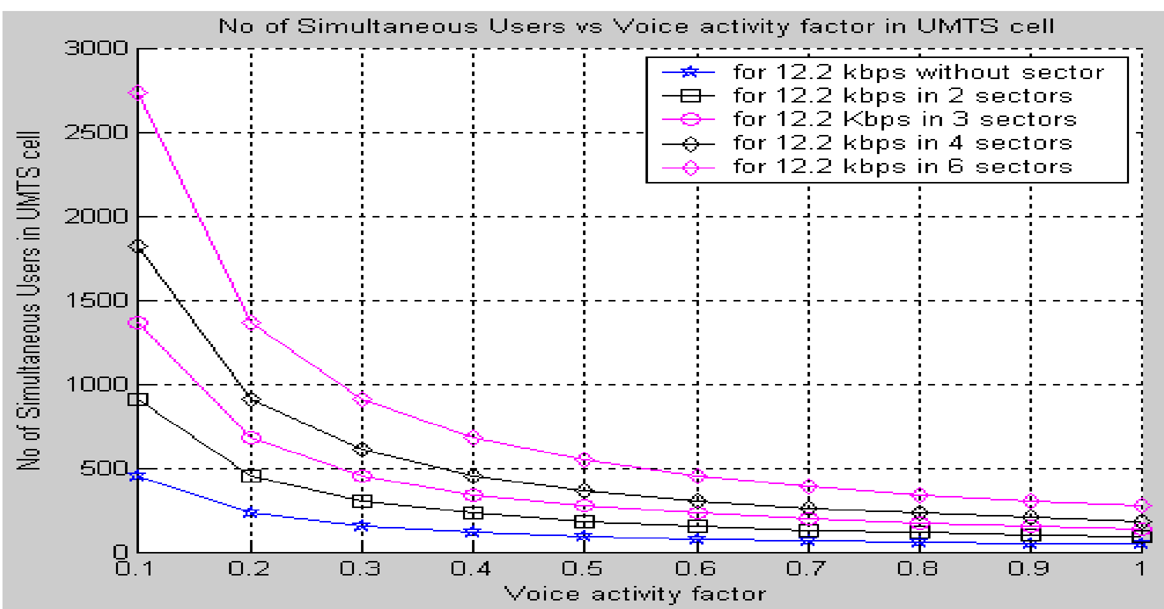


Figure 8.10: No of Simueltaneous Users vs. Voice activity factor in sectorized cell

8.2 Performance Analysis in Coverage and data rates using Sectorization:

In this analysis we have simulated Coverage Vs data rates For Dense Urban .As we assume operating frequency 2000 MHz we use COST 231 Model as radio propagation model.We use mobile nax power 21dbm,cable and connector losses-3db, EIRP=18dbm,thermal noise -173.82 dbm BTS noise figure 5 db,at 40% load with Node B height 20m and UE height 2m the coverage versus data rates is:

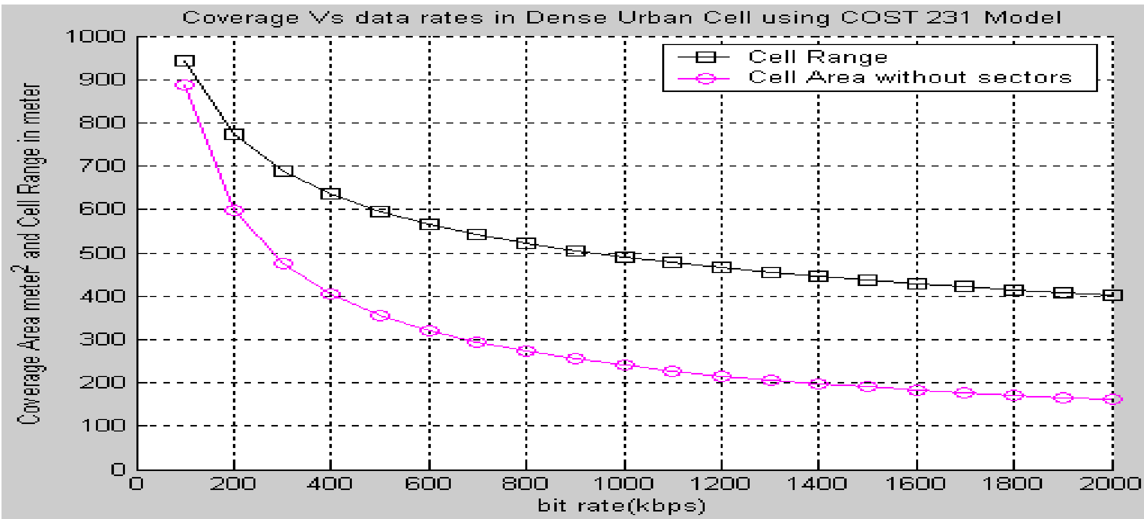


Figure 8.11: Coverage vs. data rates for Dense Urban Using COST 231 Model

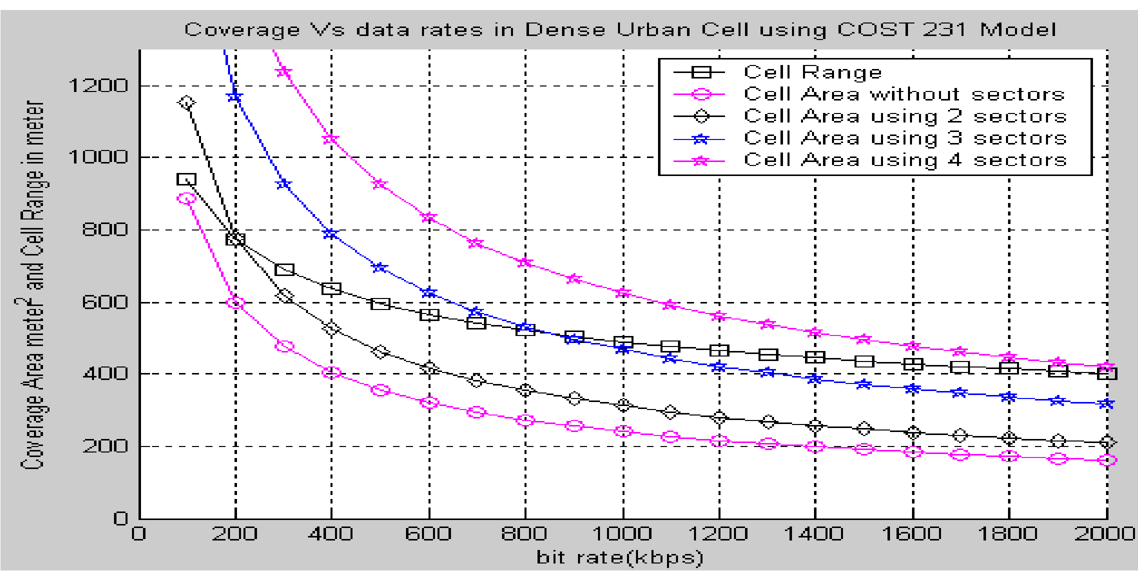


Figure 8.12: Coverage vs. bit rates for Dense Urban Using COST 231 Model in sectorized cell

Now Coverage vs Data rates for urban Using COST 231 Model with mobile nax power 21dbm,cable and connector losses-3db, EIRP=18dbm,themal noise -173.82 dbm BTS noise figure 5 db,at 40% load with Node B height 20m and UE height 2m:

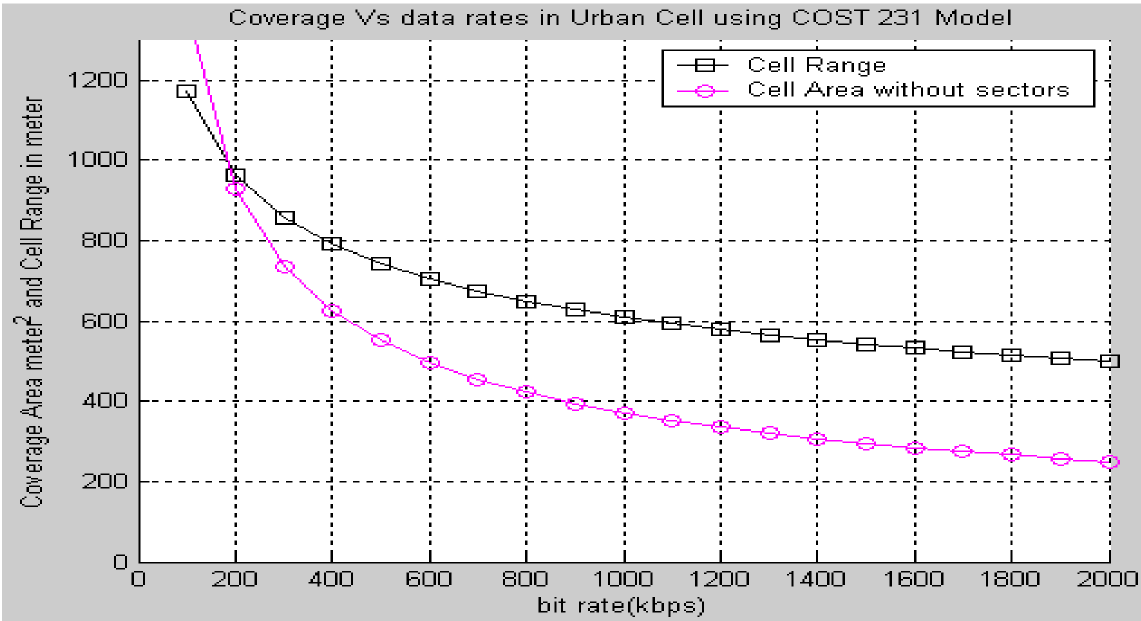


Figure 8.13: Coverage vs. data rates for Urban Using COST 231 Model

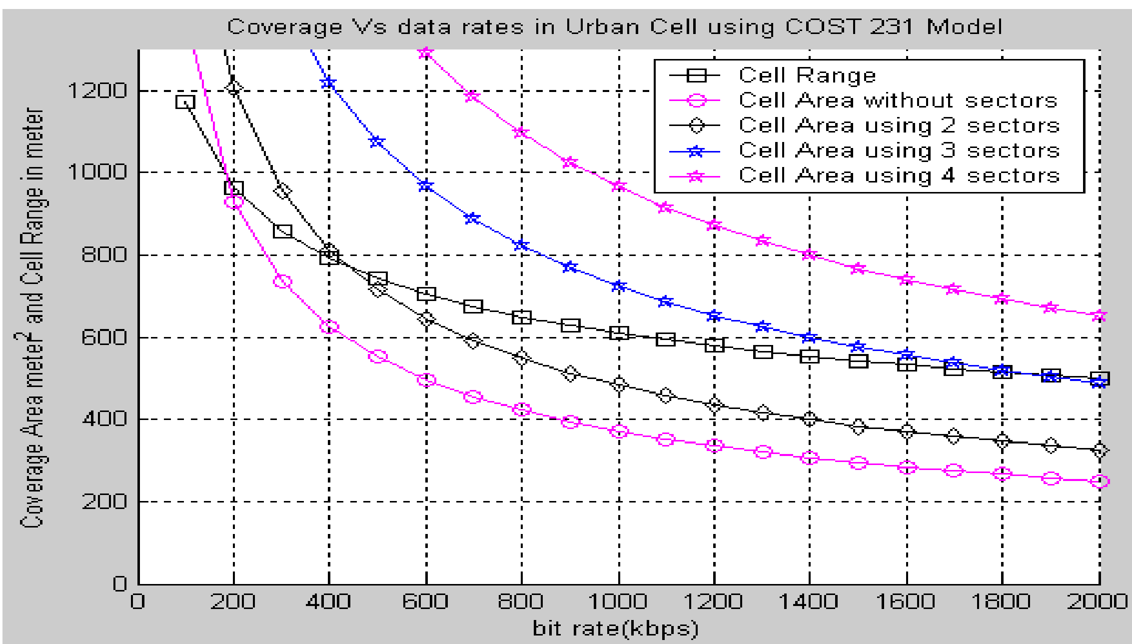


Figure 8.14: Coverage vs. data rates for Urban Using COST 231 Model in sectorized cell

Chapter-9

Conclusion

In this project the performance analysis in coverage and capacity of UMTS cellular network using sectorization have been simulated and evaluated. Simulation shows that the capacity of UMTS cellular network depends on energy per bit noise spectral density ratio Eb/No, as Eb/No increases the capacity is also decreases, simulation also shows that the capacity of UMTS cellular network depends on sectorization ,D ,as sectorization , D, increases the capacity is also increases, simulation also shows that the voice users capacity of UMTS cellular network depends on channel activity α ,as channel activity, α increases the capacity is also decreases, Simulation also shows that the capacity of UMTS cellular network depends on outer-cell or intra-cell or outer cell interference factor β ,as β increases the capacity is also decreases, simulation also shows that the capacity of UMTS cellular network depends soft handover H ,as H increases the capacity is also increases. Simulation also shows that the most effective is sectorization in capacity for increasing UMTS cellular network. Simulation also shows that the capacity of UMTS cellular network depends on coverage, as capacity increases the coverage decreases, for dense urban cell and urban cell we have simulated this phenomena using COST231 Model since our operating frequency is 2000MHz. Here simulation also shows that the most effective is sectorization for increasing coverage of UMTS cellular network.

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