EAST WEST UNIVERSITY

Breakdown of coverage estimation parameters for WCDMA base on UMTS

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In partial fulfillment of the requirements for the degree of
Bachelor of Science in Electrical and Electronic Engineering
(B.Sc. in EEE)

Fall, 2012

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Approved By

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Approval

The thesis titled 'Breakdown of coverage estimation parameters for WCDMA base on UMTS' submitted by Fahmida Khan Repa(2008-1-86-003) and Fahima Afroz (2009-1-80-032) in the semester of Fall 2012 is approved as satisfactory in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering.

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Declaration

We, hereby declare our thesis work solely to be our own scholarly work. To the best of our knowledge, it has not been shared from any source without due acknowledgement and permission. It is being submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. It has not been submitted before for any degree or examination in any other university.

Fahmida Khan Repa

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Fall semester, 2012

Abstract

The UMTS (Universal mobile telecom system) represents 3rd generation (3G) standard for cellular system. It is based on the existing Global system for mobile (GSM) communication core network (CN) but opted for a totally new radio access technology in the form of a wideband version of code Division Multiple Access (WCDMA). Fast internet, video streaming, multimedia messages, mobile e-commerce mobile entertainment has made it extremely popular. In this research paper, for the coverage estimation in a WCDMA based UMTS network, the link budget of UMTS has been analyzed. Actually link budget is the accounting of all the gains and losses from the transmitter through the medium to the receiver in a telecom system to obtain cell range. Path loss as well cell range obtained from link budget varies for different types of conditions. Increases bit rates; noise rise & loading are many of the factors for these variations. Different types of path loss model can be used for calculating cell range but in our project we have applied the Okamura-Hata curve is an approximation of radio wave propagation characteristics based on aggregated data obtained in actual tests of propagation characteristics between a base station and mobile stations in various areas.

Keywords: WCDMA, UMTS, GSM, Noise Rise, Link Budget

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Authorization page

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CHAPTER 1

Wideband Code Division Multiple Access (WCDMA) and Universal Mobile Telecommunication Service (UMTS)

1.1Fundamentals of WCDMA & UMTS:

1.1.1. What is WCDMA and working principle of WCDMA

- **What is WCDMA?**

W-CDMA (Wideband Code Division Multiple Access) 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 Universal Mobile Telecommunications System (UMTS) family and sometimes used as a synonym for UMTS. It uses 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) and time division duplex (TDD) schemes used today. [1]

- **How does WCDMA work**

Understanding the working of WCDMA involves the knowledge of Direct Sequence Spread Spectrum transmission method. In such transmission method, the spectrum multiplies the original data being transmitted by a pseudo random code consisting of 1 and -1, and transmits at a much higher frequency than the original data, thereby, spreading the energy of the transmitted signal into a much wider band. At the receiving end, the receiver can obtain the original data by multiplying the received signal by the same pseudo random code. Though this feature is similar in design to the CDMA transmission techniques, WCDMA provides a difference in tradeoffs between cost, capacity, density and performance. [2]

1.1.2. Parameters of WCDMA:

Standard Parameters of WCDMA [3]

1. Channel bandwidth: 5 MHz
2. Duplex mode: FDD and TDD
3. Downlink RF channel structure: Direct spread
4. Chip rate: 3.84 Mbps
5. Frame length:10 ms
6. Spreading modulation: a. Balanced QPSK (downlink)
   b. Dual-channel QPSK (uplink)
   c. Complex spreading circuit
7. Data modulation : a. QPSK (downlink)
   b. BPSK (uplink)
8. Channel coding :Convolution and turbo codes
9. Coherent detection :User dedicated time multiplexed pilot (downlink and uplink), common pilot in the downlink
10. Channel multiplexing in downlink: Data and control channels time multiplexed
11. Channel multiplexing in uplink :Control and pilot channel time multiplexed I&Q multiplexing for data and control channel
12. Multi rate :Variable spreading and multi code
13. Spreading factors :4–256 (uplink), 4–512 (uplink)
14. Power control :Open and fast closed loop (1.6 kHz)
15. Spreading (downlink) :OVSF sequences for channel separation Gold sequences 218-1 for cell and user separation (truncated cycle 10 ms)
16. Spreading (uplink):OVSF sequences, Gold sequence 241 for user Separation .Different time shifts in I and Q channel, truncated cycle:10 ms
17. Handover :Soft handover Inter frequency handover
18. Cell search
19. Broadcast channel
20. Paging channel

Now brief discussion about the WCDMA parameters:

→Channel bandwidth:

The signal bandwidth for the W-CDMA system is set at 5 MHz .This high bandwidth allows the received signal to be split into distinct multipath with high resolution. The higher the bandwidth the more resolution is possible. So, for example, if you have 5 MHz Bandwidth and if the sample rate is 10Msps then, you can resolve multipath in a very short time. So we can take the benefits of a great number of multipaths than a system with minor bandwidth.

→Chip rate

The chip rate of WCDMA is Rc=3.84 Mcps. Resolution depends on the chip rate. The chip rate of a code is the number of pulses per second (chips per second) at which the code is transmitted (or received). The chip rate is larger than the symbol rate, meaning that one symbol is represented by multiple chips. The ratio is known as the spreading factor (SF) or processing gain.

→Duplex mode: FDD and TDD:

There are a few characteristics that are typical of TDD systems and different from the characteristics of FDD systems. If we use duplex mode then we can utilized the unpaired band. The TDD system can be implemented on an unpaired band, while the FDD system always requires a pair of bands. It is Possible in interference between uplink and downlink, Flexible capacity allocation between uplink and downlink, Discontinuous transmission.

→Hand over:

The handover algorithm to make the handover decision needs different types of measurement information. The actual handover algorithm implementation is left to equipment manufacturers. Inter frequency handovers are needed for utilization of hierarchical cell structures such as Macro, micro and indoor cells. Several carriers and inter frequency handovers may also be used for taking care of high capacity needs in hot spots.

Two methods are considered for inter frequency measurements in WCDMA:

a) Dual receiver

The dual receiver approach is considered suitable, especially if the mobile terminal employs antenna diversity. During the inter frequency measurements, one receiver branch is switched to another frequency for measurements, while the other keeps receiving from the current frequency.

b) The compressed mode

The compressed mode approach (also referred as slotted mode) is required for the mobile station without dual receiver. The information normally transmitted during a 10-ms frame is compressed either by code puncturing.

→Frame length

Frame length for WCDMA is 10 ms.

→DATA modulation [4]

- **Downlink modulation**

The UMTS modulation format for the downlink is more straightforward than that used in the uplink. The downlink uses Quad-rature Phase Shift Keying (QPSK). The QPSK modulation used in the downlink is used with time-multiplexed control and data streams. While time multiplexing would be a problem in the uplink, where the transmission in this format would give rise to interference in local audio systems, this is not relevant for the downlink where the Node B is sufficiently remote from any local audio related equipment to ensure that interference is not a problem.

- **Uplink modulation**

However the uplink uses two separate channels so that the cycling of the transmitter on and off does not cause interference on the audio lines, a problem that was experienced on GSM. The dual channels (dual channel phase shift keying) are achieved by applying the coded user data to the In-phase input to the DQPSK modulator, and control data which has been encoded using a different code to the Q or quadrature input to the modulator.

→Spreading modulation

- **Uplink**

DPCCH (Dedicated Physical Control Channel) use fixed SF (Spreading Factor); DPDCH (Dedicated Physical Data Channel), which may vary SF (Spreading Factor) on a frame by frame basis.

- **Downlink**

Typically, one cell or sector use a scrambling code (used to separate cells) one code tree is shared by common and dedicated channels. Downlink Dedicated Channels have fixed SF (Spreading Factor). When multimode transmission for a single user, the parallel code channels has different channelization codes and SF are the same.

→Power Control

The purpose of power control is to ensure that each user receives and transmits just enough energy to properly convey information while interfering with other users no more than necessary.

Purpose of power control in WCDMA

- Remove near far effect.
- Mitigate fading.
- Compensâtes change in propagation condition.

In the system level-

- Decrease interference from others.
- Increase capacity of the system.

Uplink: Power control in uplink must make signal from different users nearly equal in order to maximize the total capacity in the cell.

Downlink: In downlink the power control must keep the signal at minimal required level in order to decrease the interference to users in other cells.

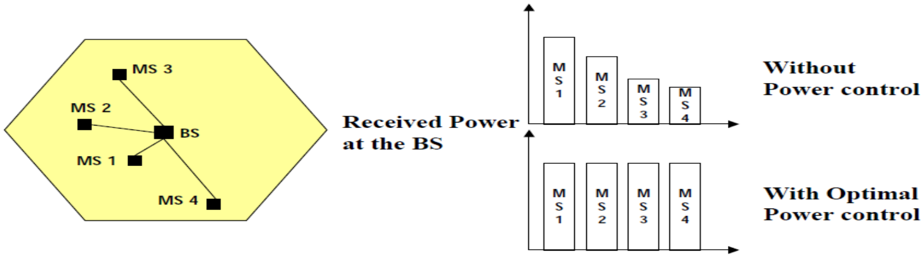


Figure 1: With and without Power control [1]

Power control types in WCDMA:

There are two types of power control available in WCDMA:

1. **Open loop power control:** For initial power setting of MS.
2. **Fast closed loop power control:**
    - Mitigates fast fading rate 1.5 Kbps
    - On uplink and downlink
    - Uses a fixed quality target set in MS/BS

Channel Coding

Provides better error correction at receiver, but brings increment of the delay. Two types of channel coding-

- **Convolution Coding (1/2, 1/3):** Convolution codes are typically used when the timing constraints are tight. The coded data must contain enough redundant information to make it possible to correct some of the detected errors without asking for repeats.
- **Turbo Coding (1/3):** Turbo codes are found to be very efficient because they can perform close to the theoretical limit set by the Shannon's Law. Their efficiency is best with high data rate services, but poor on low rate services. At higher bit rates, turbo coding is more efficient than convolution coding.

Cell Search

During the cell search the mobile station searches for a cell and common channel frame synchronization of that cell. The cell search is typically carried out in three steps:

1. Slot synchronization
2. Frame synchronization and code-group identification
3. Scrambling-code identification

Broadcast Channel

- Broadcast the system and cell specific information.
- Terminal must decode the broadcast channel to register to the cell.
- Uses high power in order to reach all users within the cell.

1.2 . Universal Mobile Telecommunication Service (UMTS)

1.2.1. Introduction of UMTS

UMTS (Universal Mobile Telecommunications Service) is a third-generation (3G) broadband, packet-based transmission of text, digitized voice, video, and multimedia at data rates up to 2 megabits per second (Mbps). UMTS offers a consistent set of services to mobile computer and phone users, no matter where they are located in the world. UMTS is based on the Global System for Mobile (GSM) communication standard. It is also certified by major standards bodies and manufacturers as the planned standard for mobile users around the world. . UMTS networks increase data rates in the radio interface, improve subscriber security, and clarify the functional split between the access and core networks. The achievable data rates with the new WCDMA interface can be as high as 2 Mbps in the hotspots (at pedestrian speeds) and up to 10 Mbps with High-Speed Downlink Packet Access (HSDPA). Once UMTS is fully available, computer and phone users can be constantly attached to the Internet wherever they travel and, as they roam, will have the same set of capabilities. Users will have access through a combination of terrestrial wireless and satellite transmissions.

1.2.2. UMTS Features

- **Access to information and content on the Internet**

As the Internet has grown, so has the dependence of its users for information, entertainment, and business. The Internet has become an integral aspect of many people's lives. Since packet data access in 2G wireless networks is limited by slow speeds and inefficient spectral use, 3G networks are expected to alleviate this problem by addressing the shortcomings and thereby enabling the creation of the wireless Internet. [5]

- **Global roaming**

With the wide disparity in types of networks deployed globally, roaming across networks has become an issue. UMTS requires that a common core network be able to support different types of access networks. With this, roaming across heterogeneous access types becomes easier since the core and the protocols to access the network and services remain the same.

- **Convergence of data com and telecom**

With wired networks moving in the direction of convergence, wireless networks are set to follow suit, and hence a network that is essentially moving in the direction of being a packet based network is another trend.

- **New services**

UMTS networks are also intended to provide new types of services in addition to traditional voice. Multimedia services such as audio and video streaming, video telephony, and integration of voice and data to provide a rich user experience are expected to be possible with these networks.

1.2.3. UMTS Wireless Network Infrastructure

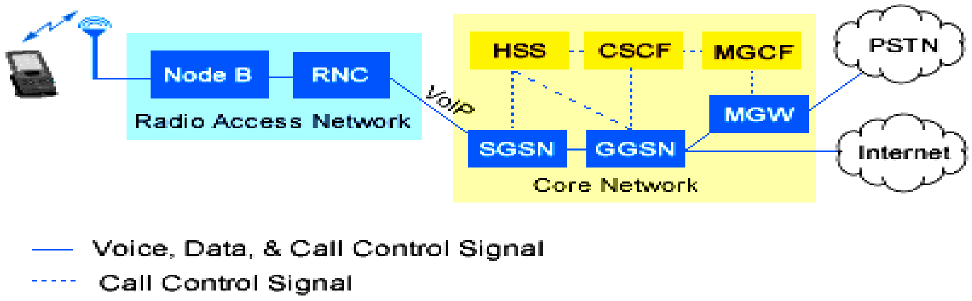


Figure 2: UMTS Wireless Network Infrastructure. [2]

Voice and data transport is performed by the transport layer nodes

- Node B = base transceiver station
- RNC = radio network controller or base station controller (BSC)
- SGSN = serving GPRS support node
- GGSN = gateway GPRS support node
- MGW = media gateway
- HSS=Home Subscriber Sarver
- CSCF= Call State Control Function

1.2.4. Difference Between UMTS And WCDMA

The following sub-section describes the differences between UMTS &WCDMA:

1. UMTS is a 3G telecommunications technology that makes use of the W-CDMA as well as other permutations there, WCDMA is an air interface standard found in 3G mobile telecommunications networks and is a member of the UMTS family.

2. UMTS requires new base station and frequency allocations to spread, W-CDMA makes use of the DS-CDMA channel access method as well as the FDD Duplexing method to achieve higher speeds and support more users.

3. UMTS has a theoretical transfer speed of 21 Mbit/s; W-DCMA includes radio channels that are 5MHz wide and a chip rate of Mcps.

CHAPTER 2

Literature Survey

Different research papers, books and journals were read during the literature survey relating to this thesis work. Some of the topics that we have gone through during this period are in the following subchapters.

2.1.1. QoS Based Capacity Enhancement For WCDMA Network With Coding Scheme [6]

The wide-band code division multiple access (WCDMA) based 3G and beyond cellular mobile wireless networks are expected to provide a diverse range of multimedia services to mobile users with guaranteed quality of service (QoS). To serve diverse quality of service requirements of these networks it necessitates new radio resource management strategies for effective utilization of network resources with coding schemes. Call admission control (CAC) is a significant component in wireless networks to guarantee quality of service requirements and also to enhance the network resilience. In this paper capacity enhancement for WCDMA network with convolution coding scheme is discussed and compared with block code and without coding scheme to achieve a better balance between resource utilization and quality of service provisioning. The model of this network is valid for the real-time (RT) and non-real-time (NRT) services having different data rate. Simulation results demonstrate the effectiveness of the network using convolution code in terms of capacity enhancement and QoS of the voice and video services.

CALL ADMISSION CONTROL SCHEME

The universal mobile telecommunication system (UMTS), a WCDMA based network, is required to support a wide range of applications each with its own specific QoS requirements. There are four distinct QoS classes of service namely, conversational, streaming, interactive and background. Each class has its own QoS specifications such as delay and bit error rate (BER). One of the main challenges in 3G and beyond wireless networks is to guarantee QoS requirements while taking into account radio resource limitations. Call admission control is a technique to manage radio resources for optimizing the overall network performance. CAC is one of the radio resource management (RRM) process of making a decision for a new call admission taking into account the amount of available resource and users QoS requirements. In call admission control strategies, a user originates a call to the network requesting a desired QoS; the network must check two things before accepting the call request. First, network must make sure that it has sufficient bandwidth to allocate to the user. Second, it must determine if, after admitting the user, it can continue to provide the same QoS for all existing connections. Thus, before the network admits the new user, it should determine whether it can meet the QoS for all connections, old as well as new. The capacity of WCDMA cell is defined in terms of cell load where the load factor, is the instantaneous resource utilization bounded by the maximum cell capacity. Instantaneous values for the cell load range from 0 to 1.

2.1.2. Evolving 3G Mobile Systems: Broadband and Broadcast Services in WCDMA [7]

The third-generation WCDMA standard has been enhanced to offer significantly increased performance for packet data and broadcast services through the introduction of high-speed downlink packet access (HSDPA), enhanced uplink, and multimedia broadcast multicast services (MBMS). This article provides an overview of the key technologies used, the reasons behind their selection, and their integration into WCDMA.

This article discusses how WCDMA has been evolving to meet the increasing demands for high-speed data access and broadcast services. These two types of services have different characteristics, which influence the design of the enhancements. For high-speed data access, data typically arrives in bursts, posing rapidly varying requirements on the amount of radio resources required. The transmission is typically bidirectional and low delays are required for a good end-user experience. As the data is intended for a single user, feedback can be used to optimize the transmission parameters. We have discussed the basic principles employed for high-speed packet data access, for both the downlink and uplink, and exemplify the performance achievable. Broadcast/multicast services carry data intended for multiple users. Consequently, user specific adaptation of the transmission parameters is cumbersome and diversity not requiring feedback is crucial. Due to the unidirectional nature of broadcasted data, a low delay for transmission is not as important as for high-speed data access. The techniques applied to broadcast services are discussed below.

HIGH-SPEED DATA ACCESS AND ENHANCED UPLINK

In WCDMA, the shared downlink resource consists of transmission power and channelization codes in node B (the base station), while in the uplink the shared radio resource is the interference at the base station. Fast scheduling is used to control allocation of the shared resource among users on a rapid basis. Additionally, fast hybrid ARQ (Automatic Repeat request) with soft combining enables fast retransmission of erroneous data packets. A short transmission time interval (TTI) is also employed to reduce the delays and allow the other features to adapt rapidly. Similar principles are used for both HSDPA and enhanced uplink. To meet the requirement on low delays and rapid resource (re)allocation, the corresponding functionality must be located close to the air interface. In WCDMA this has been solved by locating the enhancements in the base station as part of additions to the MAC layer. An illustration of this is found in fig-3, where the overall UTRAN (Universal Terrestrial Radio Access Network) architecture with high-speed downlink packet access (HSDPA) and enhanced uplink is illustrated. A number of radio network controllers (RNCs) are connected to the core network. Each RNC controls one or several node Bs, which in turn communicate with the user equipment (UE). The radio link control (RLC) entity in the RNC is unchanged compared to previous versions of WCDMA; it provides ciphering and also guarantees lossless data delivery if the hybrid ARQ protocol fails, for example, at an HSDPA cell change, where the node B buffers are flushed. Some functionality has also been added to the existing MAC functionality in the RNC to support flow control between the RNC and node B for HSDPA, and reordering and selection combining for enhanced uplink. Furthermore, the RNC handles mobility.

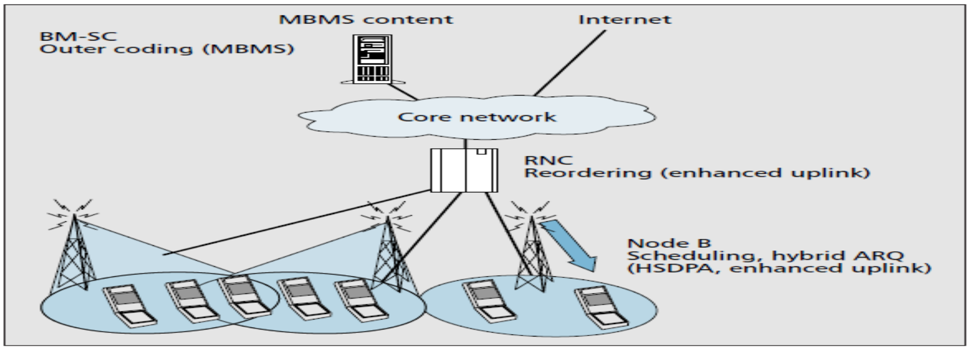


Figure 3: The UTRAN architecture with HSDPA and enhanced uplink additions [3]

HIGH-SPEED DOWNLINK PACKET ACCESS

A key characteristic of HSDPA is the use of shared-channel transmission. This implies that a certain fraction of the total downlink radio resources available within a cell, channelization codes and transmission power is seen as a common resource that is dynamically shared between users, primarily in the time domain. The use of shared-channel transmission, in WCDMA implemented through the high-speed downlink shared channel (HS-DSCH), enables the possibility to rapidly allocate a large amount of the downlink resources to a user when needed. Allocation of the HS-DSCH code resource is done on a 2 ms TTI (Transmission Time Interval) basis. The use of a short TTI reduces the overall delay and improves the tracking of fast channel variations exploited by the link adaptation and the channel-dependent scheduling as discussed below. Although the common code resource is shared primarily in the time domain, sharing in the code domain is also possible, as illustrated in fig-4. The reasons are twofold: support of terminals not able to dispread the full set of codes, and efficient support of small payloads the HSDSCH is not power controlled but rate controlled. This allows the remaining power (after serving other, power the HSDSCH is not power controlled but rate controlled.

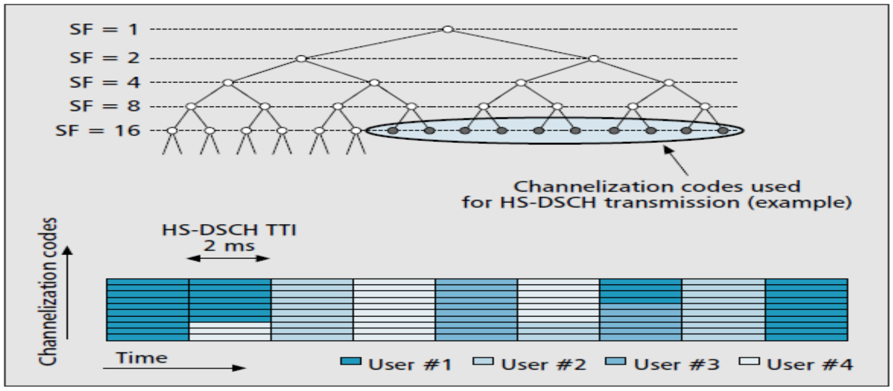


Figure 4: Code and time domain structure for HS-DSCH [4]

2.1.3. Uplink and Downlink traffic capacity performance in WCDMA systems [8]

In this article, simulation results are shown for the uplink and downlink of a typical microcellular WCDMA system. Comparisons are made regarding traffic capacity of both links, taking into account traffic asymmetry of foreseen Third-Generation services. The relationship between coverage and capacity in cellular CDMA systems complicates the tasks of capacity estimation and network planning, and requires the use of simulation. The capacity estimation procedure is based on static, Monte-Carlo type simulation. This article describes a simulation model for WCDMA systems including closed-loop effects, and presents some results comparing uplink and downlink capacity in asymmetric traffic conditions .Because of some problems with user like quality degradation in order to comply with power restrictions this simulation helps the user to connect properly. In the simulations described in this paper, base station assignment is carried out on a minimum attenuation basis. Hand-off is controlled by a relative attenuation threshold (hand-off window), which is fixed to 6 dB. In this article the individual transmit powers in uplink and downlink, the power transmitted by the base-station, system capacity of WCDMA, Maximum outage probability of WCDMA was observe.

2.1.4. Practical Verifications for Coverage and Capacity Predictions and Simulations in Real-World Cellular UMTS Networks [9]

Coverage estimation of UMTS and capacity in a live network using planning and performance tools applied to a real-world operational UMTS network. In this paper Empirical and theoretical (stochastic) models describe the characteristics of radio channels by means of statistical parameters. Here different types of simulation are used for the estimation of the coverage area two types of simulations are commonly used in cellular networks planning tools, Monte Carlo (MC) and discrete event. MC simulation has been shown to be appropriate for determining the coverage of Base Stations (BSs), the radiation patterns of antennas and other related problems. Telecommunications systems are typically capacity dimensioned at the busy hour, where the peak load (user traffic) is served with a required service quality and given resource availability, and it is quantified by its blocking probability.

Here radio propagation prediction model was described in third generation (3G) planning, to describe the propagation characteristics of the local environment more precisely, the Empirical Propagation Model (EPM) is often used.

The EPM model used in this paper can

$$L_{model}=K_1+K_2\log(d)+K_3\log(H_{txeff})+K_{4.Difractionlosss}+K_5\log(d)\log(H_{txeff})+K3\log(H_{Rxeff})+K_{clutter}F(clutter) \quad \ldots\ldots\ldots.(1)$$

Where,

K1: constant offset (dB).

K2: multiplying factor for log (d).

d: distance between the receiver and the transmitter (m).

K3: multiplying factor for log (HTxeff).

HT_{xeff}: effective height of the transmitter antenna (m).

K4: multiplying factor for diffraction calculation.

Diffraction loss: loss due to diffraction over an obstructed path (dB).

K5: multiplying factor for log (HTxeff) log (d).

K6: multiplying factor for HRxeff.

HR_{xeff}: effective mobile antenna height (m).

$K_{clutter}$: multiplying factor for f (clutter).

$f_{(clutter)}$: weighted average of losses due to clutter.

In this survey Continuous Wave (CW) Test for EPM Calibration was also done.

The theoretical and mathematical simulation was done. Theoretical coverage and capacity analyses with mixed UMTS. UMTS mixed service has different types of mix like service mix

Measurement and prediction setup:

Here for measurement and prediction one flow chart is given below in fig-1.5.

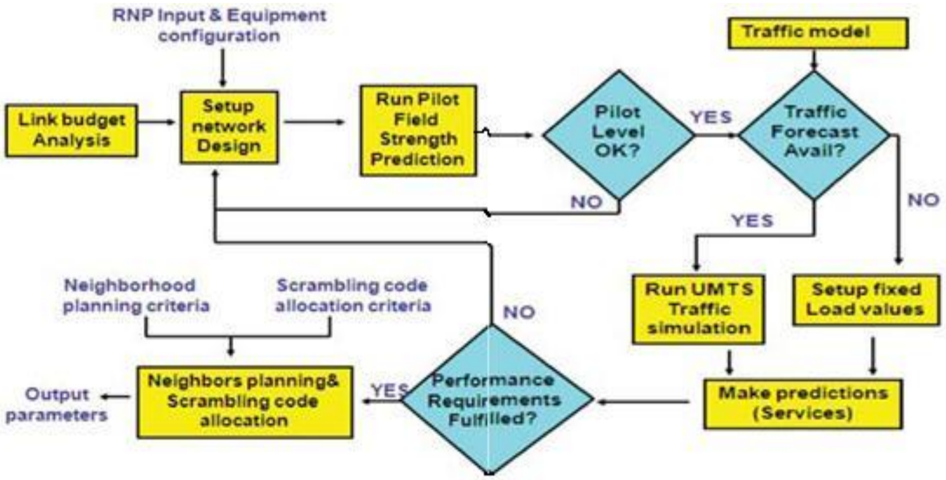


Figure 5: Prediction and simulation tool general flow chart [5]

Coverage predictions and measurements results:

For coverage prediction there are Coverage (RSCP) and Quality (Ec/Io) Predictions, Coverage Level (RSCP) & Quality (Ec/Io) Results Comparison.

Capacity Simulations and System Statistical Results

Monte Carlo (MC) Simulation Output Plots in this study, MC simulations were ran 1000 times, for each MC simulation, a shadowing margin has been derived for each mobile-to-cell link, which is obtained by taking a random value from the probability density distribution for the appropriate clutter class that describes the shadowing effect.

Network Operating System Statistics (OSS) KPIs

As a verification to the MC capacity simulated results, network radio OSS KPIs were extracted from the UTRAN Radio Network Controller (RNC) over a period of seven days. It was shown that the DL power congestions occurred at the highlighted cell 110 out of 114 times for the whole network under study, i.e., around 97 percent. The importance of calibrated propagation models and traffic maps to build and maintain cellular UMTS networks and reflects how such calibrated models embedded in today’s planning tools can accurately capture and forecast the conditions in a live cellular network and therefore guide the engineers to plan and optimize the scare and expensive radio resources. The network under study is chosen to be large enough in order to obtain representative results not biased due to insufficient number of samples or dominance of a particular radio environment. The terrain varies from hilly areas with foliage and water surfaces, to suburban housing neighborhoods and downtown commercial buildings.

In this case study the coverage of particular area was estimated and how it works it was observed in different way.

Chapter 3

WCDMA (UMTS) Link Budget

3.1. Link Budget:

A link budget is the accounting of all of the gains and losses from the transmitter, through the medium (free space, cable, waveguide, fiber, etc.) to the receiver in a telecommunication system. It accounts for the attenuation of the transmitted signal due to propagation, as well as the antenna gains, feed line and miscellaneous losses. Randomly varying channel gains such as fading are taken into account by adding some margin depending on the anticipated severity of its effects. The amount of margin required can be reduced by the use of mitigating techniques such as antenna diversity or frequency hopping.

A simple link budget equation looks like this:

Received Power (dBm) = Transmitted Power (dBm) + Gains (dB) − Losses (dB)

3.1.1. Equation [10]

A link budget equation including all these effects, expressed logarithmically, might look like this:

$$P_{RX}=P_{TX}+G_{TX}-L_{TX}-L_{FS}-L_{M}+G_{RX}-L_{RX}\ldots\ldots\ldots\ldots\ldots(3.1)$$

Where:

P_{RX}= received power (dBm)

P_{TX}= transmitter output power (dBm)

G_{TX}= transmitter antenna gain (dBi)

L_{TX}= transmitter losses (coax, connectors...) (dB)

L_{FS}= free space loss or path loss (dB)

L_M= miscellaneous losses (fading margin, body loss, polarization mismatch, other losses...) (dB)

G_{RX}= receiver antenna gain (dBi)

L_{RX}= receiver losses (coax, connectors...) (dB)

3.1.2. WCDMA (UMTS) Link Budget:

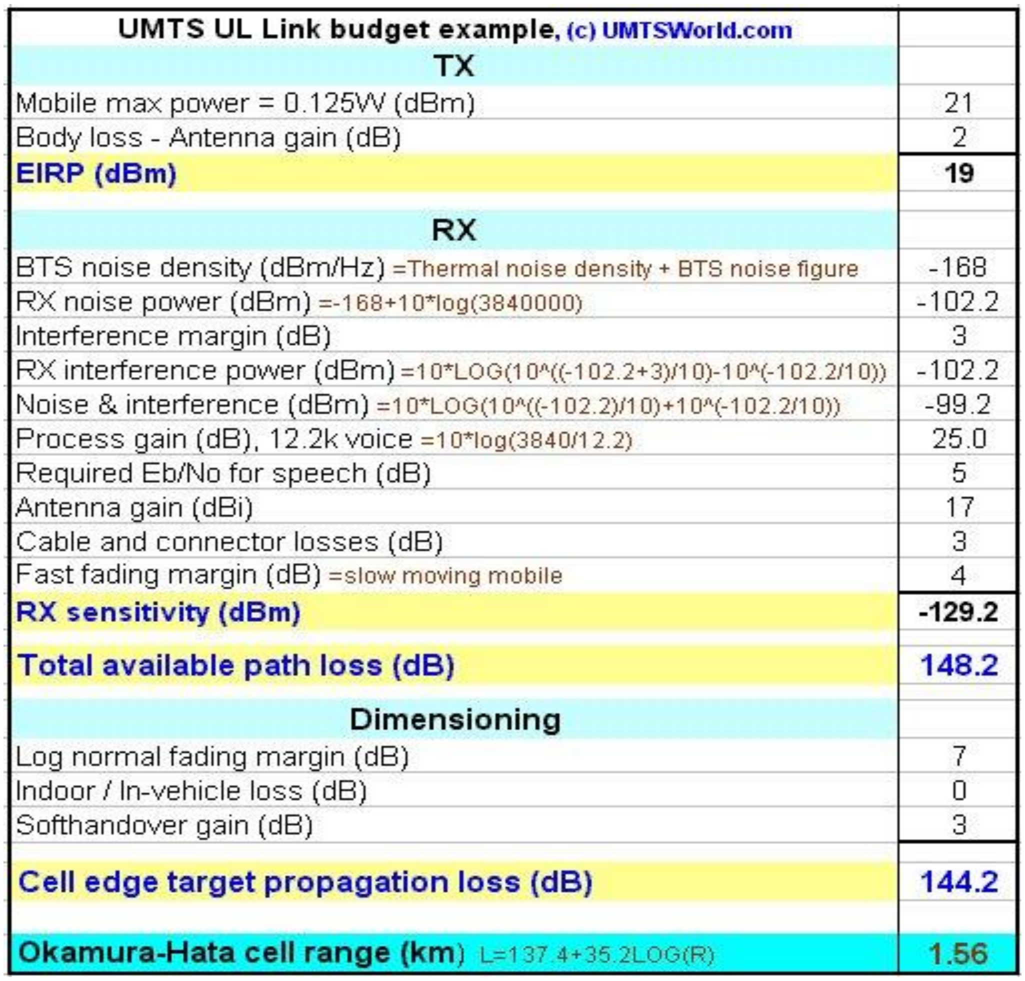
Link budget planning is part of the network planning process, which helps to dimension the required coverage, capacity and quality of service requirement in the network. UMTS WCDMA macro cell coverage is uplink limited, because mobiles power level is limited to (voice terminal 125mW). Downlink direction limits the available capacity of the cell, as BTS transmission power (typically 20-40W) has to be divided to all users. In a network environment both coverage and capacity are interlinked by interference. So by improving one side of the equation would decrease the other side. System is loosely balanced by design. The object of the link budget design is to calculate maximum cell size under given criteria. [11]

- Type of service (data type and speed)
- Type of environment (terrain, building penetration)
- Behavior and type of mobile (speed, max power level)
- System configuration (BTS antennas, BTS power, cable losses, handover gain)
- Required coverage probability
- Financial and economical factors (use of more expensive and better quality equipment or not the cheapest installation method) and to match all of those to the required system coverage, capacity and quality needs with each area and service.

In an urban area, capacity will be the limiting factor, so inner city cells will be dimensioned by required Erlangs/km² for voice and data. Even using 25dB as in building penetration loss into the building core area, link budget would typically allow about 300m cell range, which is a way too much for a capacity purposes. In a rural area uplink power budget will determine the maximum cell range, when typically cells are less congested. A typical cell range in rural areas will be several kilometers depending on a terrain (area).

Below is an example of how WCDMA voice call link budget can be done. Some of the values can be debated, including the propagation model, but it gives an idea of the calculation method.

Here a UMTS UL link budget example for OKAMURA HATA model:



UMTS UL Link budget example, (c) UMTSWorld.com	
TX	
Mobile max power = 0.125W (dBm)	21
Body loss - Antenna gain (dB)	2
EIRP (dBm)	**19**
RX	
BTS noise density (dBm/Hz) =Thermal noise density + BTS noise figure	-168
RX noise power (dBm) =-168+10*log(3840000)	-102.2
Interference margin (dB)	3
RX interference power (dBm) =10*LOG(10^((-102.2+3)/10)-10^(-102.2/10))	-102.2
Noise & interference (dBm) =10*LOG(10^((-102.2)/10)+10^(-102.2/10))	-99.2
Process gain (dB), 12.2k voice =10*log(3840/12.2)	25.0
Required Eb/No for speech (dB)	5
Antenna gain (dBi)	17
Cable and connector losses (dB)	3
Fast fading margin (dB) =slow moving mobile	4
RX sensitivity (dBm)	**-129.2**
Total available path loss (dB)	**148.2**
Dimensioning	
Log normal fading margin (dB)	7
Indoor / In-vehicle loss (dB)	0
Softhandover gain (dB)	3
Cell edge target propagation loss (dB)	**144.2**
Okamura-Hata cell range (km) L=137.4+35.2LOG(R)	**1.56**

Table 2: UMTS link budget [1]

3.2. Some Other Important Parameters and their Effect on the Radio Link Budget

3.2.1. Base Station Noise Figure

Desensitization(caused by a nearby transmitter with a strong signal on a close frequency) of the BS receiver in pico-cells has been proposed as one way of counteracting the possibly severe interference problems that may arise from time to time in TDD (and partly also in FDD). The idea, roughly described as 'increasing the BS receiver noise figure', is to make the receiver less sensitive to interfering signals coming from TDD and FDD MSs and other TDD BSs located close to the BS. However, this approach does not completely solve the problems and it also has the negative effect of increasing the overall interference level in the own system since, then, the wanted MSs must increase their respective output powers to compensate for the poorer uplink receiver performance. [12]

3.2.2. Fast Fading Margin

This parameter is similar to transmit power control headroom in FDD. It ensures that the Transmit Power Control (TPC) scheme has enough room to vary the power to compensate for fading effects. If TPC is not used, this parameter will be set to zero. [13]

Chapter 4

Comparative study of Different Types of Outdoor Propagation model

4.1. Different types of propagation model

- Hata Model
- PCS extension to hata model
- Walfisch and Bertonl model
- Wideband PCS microcell model
- COST 231 model

4.1.1. Okamura Model [14]

Okamura's model is one of the most widely used models for signal prediction in urban areas. This model is applicable for:

- frequency f: 150 MHz → 1920 MHz
- distance d: 1 km → 100 km
- transmit antenna height h_{te}: 30 m → 1000m

Advantage

Okamura's model is considered to be among the simplest and best in terms of accuracy in path loss prediction for mature cellular and land mobile radio systems in cluttered environments. It is very practical and has become a standard for system planning in modern land mobile radio systems in Japan as well as although the world.

Drawback

Okamura's model is wholly based on measured data and does not provide any analytical explanation. For many situations extrapolations of the derived curves can be made to obtain values outside the measurement range, although the validity of such extrapolations depends on the circumstances and the smoothness of the curve in question. The major disadvantage with the model is its slow response to rapid changes in terrain therefore the model is fairly good in urban and suburban areas but not as good in rural areas. Common standard deviations between predicted and measured path loss values are around 10dB to 14dB.

4.1.2. Hata model: [14]

- Empirical formulation of Okumura loss data
- Applicable for:

f: 150 MHz $\rightarrow$ 1500 MHz,

h_{te}: 30 m $\rightarrow$ 200 m,

h_{re}: 1 m $\rightarrow$ 10 m

- Standard formula for urban areas is

$$L_{50}\ (dB) = 69.55 + 26.16 \log f_c + 13.82 \log ht_e - a\ (h_{te}) + (44.9 - 6.55 \log h_{te}) \log d)$$

- Standard formula for suburban areas is

$$L_{50}\ (dB) = L_{50}\ (urban) - 2[\log (f_c/28)^2] - 5.4$$

- Standard formula for rural areas is

$$L_{50}\ (dB) = L_{50}\ (urban) - 4.78[\log (f_c)^2 + 18.33 \log f_c - 40.94$$

Where a (h_{re}) is a correction factor for effective mobile antenna height, and depends on coverage area

  - Valid for large-cell systems, but not PCS(personal communication system) systems
  - Has been extended to 2 GHz by European Co-operative for Scientific and Technical research (EURO-COST-231 Model)

4.2. Table for comparative study of propagation model

4.3 Summary from the table:

The main purpose of this table is to analyze the comparative study of various propagation models. There are different types of propagation model such as Hata Model, Okamura model, Longley Rice model, PCS extension to Hata model, Walfish and Bertoni model, Wideband PCS microcell model, Cost-231 model. In wireless communication, the Hata Model for Urban Areas, also known as the Okumura-Hata model for being a developed version of the Okumura Model, is the most widely used radio frequency propagation model for predicting the behavior of cellular transmissions in built up areas. We are working with the Okamura and Hata model these are the model witch cover 1-150 km area and it is a huge area for this reason there application area are urban areas, suburban areas, rural areas .But in the other models their application area is very small and sometimes they cover only urban or only rural or sometimes they cover only personal communication but when we combined the both Okamura and Hata model, it solves the problem created by the others model. The average frequency of Okamura and Hata model is 150 MHz - 1800MHz which is a very high frequency. So it helps the signal to connect station to station. For this type of criteria, these two models are valid for large-cell systems. Also these models have good practical value, simplest in terms of path loss accuracy in cluttered mobile environment. But it has some weak point too like not. In PCS (personal communication system) systems, it gives the slow response to rapid terrain changes and also gives median attenuation relative to free space .This model is developed from extensive measurements using vertical Omni-directional antennas at base and mobile. As a hole, we can say that the combination of Okamura and Hata model is the best model of all the propagation models as it will be proved in the following sections.

Why OKUMURA HATA Model

- Only four parameters are required, so the computation time is very short. [15]
- As the height of the transmitter and the receiver is measured relative to the ground, an effective antenna height is additionally used and added to the antenna height of the transmitter (see figure 6). This also improves the accuracy of the prediction. [15]

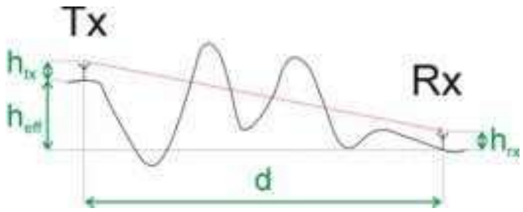


Figure 6: Height of transmitter and receiver [6]

- This model is suitable where buildings exist. [16]
- The Hata model is an empirical formulation of the graphical path loss data provided by Okumura and is valid over roughly the same range of frequencies.
- This model is well recognized and widely used for urban and suburban environments. It is valid for distance range from 1km to 100 km. Also, it can be used for frequencies of 150MHz extended to 3000 MHz Good results can be obtained for base station antenna heights from 30m to1000 m. The modified Hata models were produced to improve on the range limitation that the original Hata model had. [17]

CHAPTER 5

Comparative Study of Path Loss and Cell Range

5.1. Path loss:

5.1.1. Path loss (or **path attenuation**) is the reduction in power density (attenuation) of an electromagnetic wave as it propagates through space. Path loss is a major component in the analysis and design of the link budget of a telecommunication system.

This term is commonly used in wireless communications and signal propagation. Path loss may be due to many effects, such as free-space loss, refraction, diffraction, reflection, aperture-medium coupling loss, and absorption. Path loss is also influenced by terrain contours, environment (urban or rural, vegetation and foliage), propagation medium (dry or moist air), the distance between the transmitter and the receiver, and the height and location of antennas.

5.1.2. Causes of path loss in WCDMA (UMTS) [18]

Path loss normally includes propagation losses caused by the natural expansion of the radio wave front in free space

- absorption losses (sometimes called penetration losses), when the signal passes through media not transparent to electromagnetic waves,
- Diffraction losses when part of the radio wave front is obstructed by an opaque obstacle, and losses caused by other phenomena.
- The signal radiated by a transmitter may also travel along many and different paths to a receiver simultaneously; this effect is called multipath. Multipath waves combine at the receiver antenna, resulting in a received signal that may vary widely, depending on the distribution of the intensity and relative propagation time of the waves and bandwidth of the transmitted signal.
- The total power of interfering waves in a Rayleigh fading scenario vary quickly as a function of space (which is known as small scale fading). Small-scale fading refers to the rapid changes in radio signal amplitude in a short period of time or travel distance.

Path loss models describe the signal attenuation between a transmitting and a receiving antenna as a function of the propagation distance and other parameters. Some models include many details of the terrain profile to estimate the signal attenuation, whereas others just consider carrier frequency and distance. Antenna heights are other critical parameters.

5.1.3. Propagation prediction of path loss in WCDMA (UMTS)

- In free space the path loss increases with 20 dB per decade (one decade is when the distance between the transmitter and the receiver increases ten times) or 6 dB per octave (one octave is when the distance between the transmitter and the receiver doubles). This can be used as a very rough first-order approximation for SHF (microwave) communication links.
- For signals in the UHF/VHF band propagating over the surface of the Earth the path loss increases with roughly 35 - 40 dB per decade (10 - 12 dB per octave). This can be used in cellular networks as a first guess.

5.2. Comparative study of cell range and Path loss

5.2.1. WCDMA cell range:

- Estimation of the maximum allowed propagation loss in a cell.
- After choosing the cell range, the coverage area can be calculated using propagation models such as Okumura-Hata, Walfisch-Ikegami
- The coverage area for one cell is a hexagonal configuration estimated from: S = K. r2

  S= coverage area.

  r= maximum cell range, accounting the fact that sectored cells are not hexagonal.

  K= Constant accounting for the sectors

5.2.2. Cell coverage range:

Once the maximum allowed propagation loss in the cell is known, then applying Propagation model for cell range assessment. The propagation model is chosen so that it is optionally describes the propagation condition in the area. The restrictions on the model are the carrier frequency used, BS to MS distance, BS and MS antenna heights. For urban and suburban macro-cellular system Okumura-Hata propagation model is used

L_{PUA}=A+Blog$_{10}$f-13.82Log$_{10}$hb-a (hm) +(C-6.55Log$_{10}$hb) Log10R (dB)……. (5.1)

Where:

LPUA: the path loss in urban area (dB).

f: the carrier frequency (MHz).

hb: the base station antenna height (m).

hm: the mobile station antenna height (m).

A = 46.3 dB.

B = 33.9 dB.

C = 44.9 dB.

R = the cell range radius (km).

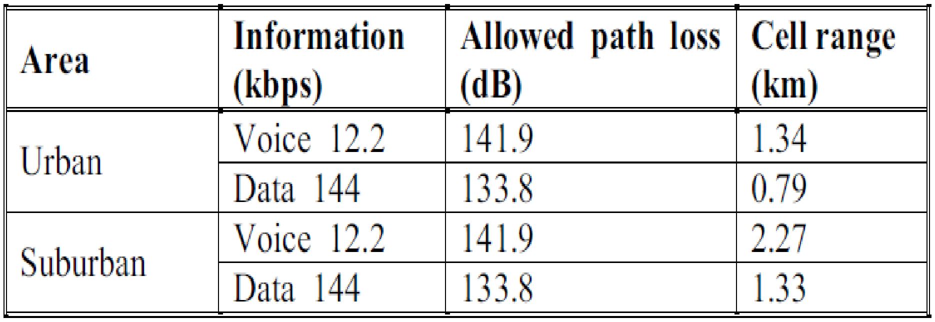
a (hm) is a correction factor for the mobile antenna height=0.

For urban macro cell, f = 1950 MHz, hb = 30 m, hm = 1.5 m, noise rise = 3 dB (corresponds to 50% loading, interference margin of 3 dB for the uplink.

So, L_{PUA}=1.37.4+35.2Log$_{10}$R……………….. (5.2)

The path loss for suburban area is by adding a correction factor of 8dB to the $L_{PUA.}$

For the allowed path loss in the case of voice and data the cell coverage range is calculated and the results are shown in table 03



Area	Information (kbps)	Allowed path loss (dB)	Cell range (km)
Urban	Voice 12.2	141.9	1.34
	Data 144	133.8	0.79
Suburban	Voice 12.2	141.9	2.27
	Data 144	133.8	1.33

Table 03: Allowed propagation loss and calculated cell range in urban and suburban macro cell for voice and data [2]

5.3. Cell range increases with increasing path loss:

Design of a cellular network should be done in such a way to provide services up to a subscriber station (SS) at the boundary edge of a cell. This will ensure the sufficient services to the other SSs within the cell. So our concern will be to find the maximum distance between BS antenna and SS. As path loss increases as a signal travels further i.e. with increase in d, we introduce a parameter M (distance factor) in order to understand the nature of path loss change by a single parameter conveniently.

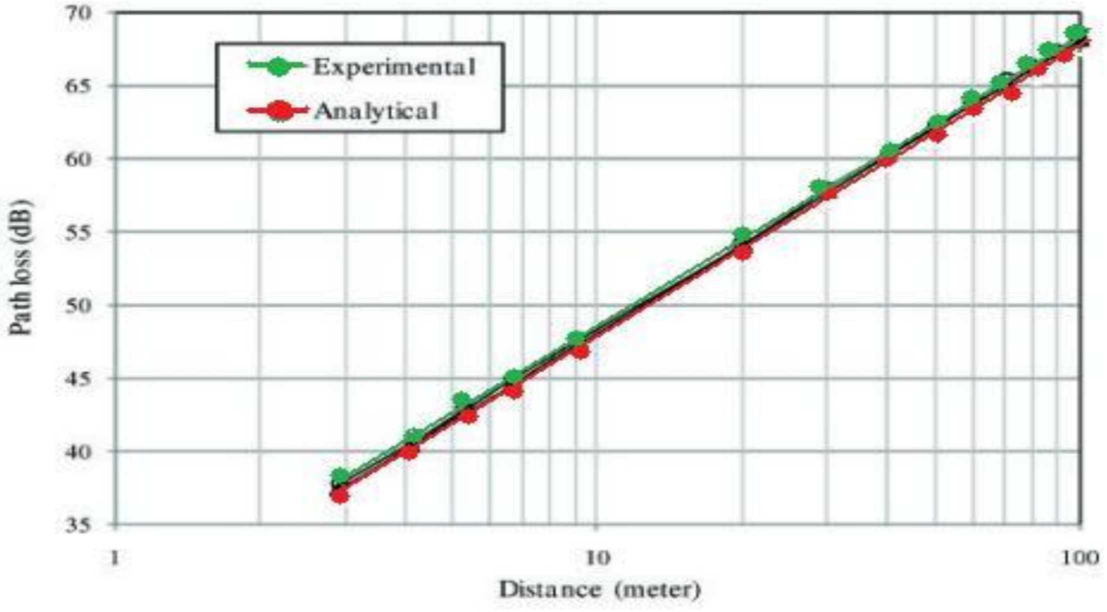


Figure 7: path loss vs. cell distance [7]

In this figure-07 we can see that with the increasing level of cell distance of the path loss is also increasing. Because when we get the higher level of cell range then the loss is also higher. The relation of network load and cell range is shown for various values of cell edge throughput.

5.4 Downlink cell range is very low compare to uplink

In this paper, the results of the single cell capacity tests are undertaken and show how it is possible to be able to support very high number of users in a single cell and how this single cell capacity could be used to estimate the capacity of a loaded WCDMA network.

For the allowed path loss in the case of voice and data, the cell coverage range is calculated and the results are shown in table 4

5.4.1. Theoretical result for Okumura Hata model [14]:

Okamura Hata model Theoretical result:

The Path loss equation of Okumura Hata model for different areas:

Urban

$L_{50}(dB)=69.55+26.16\log f_c+13.82\log ht_e-a(h_{re})+(44.9-6.55\log h_{te})\log d$

Suburban

$L_{50}(dB)=L_{50}(urban)-2[\log(f_c/28)^2]-5.4$

Rural

$L_{50}(dB)=L_{50}(urban)-4.78[\log(f_c)^2+18.33\log f_c-40.94$

Now theoretical result for this model in Uplink when transmission speed is 12.2 Kbps

h_{te}=30 m -200 m,
h_{re}= 1 m -10 m
d=1 to 100 km
f=150 MHz -1500 MHz

Here for calculation we have selected some standard values for every parameter such as-

h_{te}=180m = 22.5 dB
h_{re}= 8.5 m =9.3 dB
d=80 km
f=900 MHz=49.03 dB
$a(hm) =8.29(\log(1.54hm)2 - 1.1$ for $f \leq 200$ MHz

$a(hm) =3.2(\log(11.75hm)^2 - 4.97$ for $f \geq 400$ MHz

Here, frequency is 900 MHz. So we use the second one

a(hm) =3.2(log(11.75hm)2 − 4.97

=$3.2(\log(11.75*3.02)^2)$-4.97

=8.33-4.97

=3.367m

=5.53dB

Theoretical result for urban area

L_{50}(dB)=69.55+26.16log f_c+13.82log ht_e-a(h_{re})+(44.9-6.55logh_{te})log d

=69.55+26.19log89.54+13.89log22.5-5.53*9.3+(44.9-6.55 log 22.55) log 49.03

=69.55+51.06+18.79-5.53*9.3+60.91

=200.31-51.429

=148.881

Theoretical result for Suburban area

L_{50}(dB)=L_{50}(urban)-2[log(f_c/28)^2]-5.4

=148.881-2log(89.54/28)^2-5.4

=148.881-2.019-5.4

=141.462 dB

Theoretical result for rural area

L_{50}(dB)=L_{50}(urban)-4.78[log(f_c)^2+18.33logf_c-40.94

=148.881-4.78(log(89.54)^2)+18.33log(89.54)-40.94 dB

=148.881-18.661+35.78-40.94 dB

=125.606 dB

Theoretical result for urban area (Downlink)

Here for calculation we have selected standard value of that parameter like

h_{te}=180m = 22.5 dB
h_{re}= 8.5 m =9.3 dB
d=80 km
f=200 MHz=23.01 dB
a(hm) =5.53dB

L_{50}(dB)=69.55+26.16log f_c+13.82log ht_e-a(h_{re})+(44.9-6.55logh_{te})log d

=69.55+26.19log23.01+13.89log22.5-5.53*9.3+(44.9-6.55 log 22.55) log 49.03

=69.55+35.67+18.79-5.53*9.3+60.91

=133.01 dB

Theoretical result for Suburban area

L_{50}(dB)=L_{50}(urban)-2[log$(f_c/28)^2$]-5.4

=133.01-2log $(23.01/28)^2$-5.4

=127.96 dB

Theoretical result for rural area

L_{50}(dB)=L_{50}(urban)-4.78[log$(f_c)^2$+18.33logf_c-40.94

=133.01-4.78(log$(23.01)^2$)+18.33log(23.01)-40.94 dB

=104.03 dB

5.4.1a.Comparison of Okumura Hata model and Cost-231 model in terms of Cell range and Path Loss [24]

Okumura Hata model parameters:

Transmitter height=590ft

Receiver Height=27 ft

Local antenna=9 dBi

Remote antenna=9 dBi

Cable Length=3ft

Local receiver threshold=-76 dBm

Remote receiver Threshold=-76 dBm

Local output power=24 dBm

Remote output power=24 dBm

Frequency =900 GHz

Climate=0.3(Moderate)

Cost 231 Model parameters:

Transmitter height=13ft

Receiver Height=3ft

Local antenna=8 dBi

Remote antenna=8 dBi

Cable Length=1ft

Local receiver threshold=-76 dBm

Remote receiver Threshold=-76 dBm

Local output power=20 dBm

Remote output power=20 dBm

Frequency =1200GHz

Climate=0.3(Moderate)

Model →	**Okumura Hata Urban**		**Okumura Hata sub-Urban**		**Okumura Hata Rural**		**Cost -231 Model**	
Miles↓	Cell Range (Km)	Path Loss(dB)	Kilometers	Path Loss (dB)	Cell range (Km)	Path Loss(dB)	Cell Range Km	Path Loss(dB)
0.5	0.805	151.66	0.805	105.63	0.805	50.40	0.805	146.12
1	1.609	160.72	1.609	114.69	1.609	59.46	1.609	152.14
1.5	2.414	166.03	2.414	120.00	2.414	64.77	2.414	155.66
2	3.218	169.79	3.218	123.77	3.218	68.53	3.218	158.16
2.5	4.023	172.71	4.023	126.69	4.023	71.45	4.023	160.10
3	4.827	175.10	4.827	129.07	4.827	73.83	4.827	161.68
3.5	5.632	177.12	5.632	131.09	5.632	75.85	5.632	163.02
4	6.436	178.86	6.436	132.84	6.436	77.60	6.436	164.18
4.5	7.241	180.41	7.241	134.38	7.241	79.14	7.241	165.20
5	8.045	181.78	8.045	135.76	8.045	80.52	8.045	166.12
5.5	8.849	183.03	8.849	137.00	8.849	81.77	8.849	166.94
6	9.654	184.17	9.654	138.14	9.654	82.90	9.654	167.70
6.5	10.459	185.22	10.459	139.19	10.459	83.95	10.459	168.39
7	11.263	186.19	11.263	140.16	11.263	84.92	11.263	169.04
7.5	12.067	187.09	12.067	141.06	12.067	85.82	12.067	169.64
8	12.872	187.93	12.872	141.91	12.872	86.67	12.872	170.20
8.5	13.677	188.73	13.677	142.70	13.677	87.46	13.677	170.72
9	14.481	189.47	14.481	143.45	14.481	88.21	14.481	171.22
9.5	15.285	190.18	15.285	144.15	15.285	88.92	15.285	171.69

Model →	**Okumura Hata Urban**		**Okumura Hata sub-Urban**		**Okumura Hata Rural**		**Cost -231 Model**	
Miles↓	Cell Range (Km)	Path Loss(dB)	Kilometers	Path Loss (dB)	Cell range (Km)	Path Loss(dB)	Cell Range Km	Path Loss(dB)
10	16.090	190.85	16.090	144.83	16.090	89.59	16.090	172.14
10.5	16.895	191.49	16.895	145.46	16.895	90.23	16.895	172.56
11	17.699	192.10	17.699	146.07	17.699	90.84	17.699	172.96
11.5	18.504	192.68	18.504	146.65	18.504	91.42	18.504	173.35
12	19.308	193.24	19.308	147.21	19.308	91.97	19.308	173.72
12.5	20.113	193.77	20.113	147.75	20.113	92.51	20.113	174.07
13	20.917	194.29	20.917	148.26	20.917	93.02	20.917	174.41
13.5	21.722	194.78	21.722	148.75	21.722	93.52	21.722	174.74
14	22.526	195.26	22.526	149.23	22.526	93.99	22.526	175.06
14.5	23.331	195.72	23.331	149.69	23.331	94.45	23.331	175.36
15	24.135	196.16	24.135	150.13	24.135	94.89	24.135	175.66
15.5	24.940	196.59	24.940	150.56	24.940	95.32	24.940	175.94
16	25.744	197.00	25.744	150.98	25.744	95.74	25.744	176.22
16.5	26.549	197.41	26.549	151.38	26.549	96.14	26.549	176.49
17	27.353	197.80	27.353	151.77	27.353	96.53	27.353	176.74
17.5	28.158	198.18	28.158	152.15	28.158	96.91	28.158	177.00
18	28.962	198.54	28.962	152.52	28.962	97.28	28.962	177.24
18.5	29.767	198.90	29.767	152.88	29.767	97.64	29.767	177.48
19	30.571	199.25	30.571	153.22	30.571	97.99	30.571	177.71
19.5	31.376	199.59	31.376	153.56	31.376	98.33	31.376	177.94
20	32.180	199.92	32.180	153.90	32.180	98.66	32.180	178.16
20.5	32.985	200.25	32.985	154.22	32.985	98.98	32.985	178.37
21	33.789	200.56	33.789	154.53	33.789	99.30	33.789	178.58
21.5	34.594	200.87	34.594	154.84	34.594	99.61	34.594	178.78
22	35.398	201.17	35.398	155.14	35.398	99.91	35.398	178.98
22.5	36.203	201.46	36.203	155.44	36.203	100.20	36.203	179.18
23	37.007	201.75	37.007	155.72	37.007	100.49	37.007	179.37
23.5	37.812	202.03	37.812	156.01	37.812	100.77	37.812	179.56
24	38.616	202.31	38.616	156.28	38.616	101.05	38.616	179.74
24.5	39.421	202.58	39.421	156.55	39.421	101.32	39.421	179.92
25	40.225	202.84	40.225	156.82	40.225	101.58	40.225	180.09

Model →	**Okumura Hata Urban**		**Okumura Hata sub-Urban**		**Okumura Hata Rural**		**Cost -231 Model**	
Miles↓	Cell Range (Km)	Path Loss(dB)	Kilometers	Path Loss (dB)	Cell range (Km)	Path Loss(dB)	Cell Range Km	Path Loss(dB)
25.5	41.030	203.10	41.030	157.08	41.030	101.84	41.030	180.27
26	41.834	203.36	41.834	157.33	41.834	102.09	41.834	180.44
26.5	42.639	203.61	42.639	157.58	42.639	102.34	42.639	180.60
27	43.443	203.85	43.443	157.82	43.443	102.59	43.443	180.76
27.5	44.248	204.09	44.248	158.06	44.248	102.83	44.248	180.92
28	45.052	204.33	45.052	158.30	45.052	103.06	45.052	181.08
28.5	45.857	204.56	45.857	158.53	45.857	103.29	45.857	181.23
29	46.661	204.79	46.661	158.76	46.661	103.52	46.661	181.38
29.5	47.466	205.01	47.466	158.98	47.466	103.75	47.466	181.53
30	48.270	205.23	48.270	159.20	48.270	103.97	48.270	181.68
30.5	49.075	205.45	49.075	159.42	49.075	104.18	49.075	181.82
31	49.879	205.66	49.879	159.63	49.879	104.39	49.879	181.96
31.5	50.684	205.87	50.684	159.84	50.684	104.60	50.684	182.10
32	51.488	206.07	51.488	160.05	51.488	104.81	51.488	182.24
32.5	52.293	206.28	52.293	160.25	52.293	105.01	52.293	182.37
33	53.097	206.48	53.097	160.45	53.097	105.21	53.097	182.51
33.5	53.902	206.67	53.902	160.65	53.902	105.41	53.902	182.64
34	54.706	206.87	54.706	160.84	54.706	105.60	54.706	182.77
34.5	55.511	207.06	55.511	161.03	55.511	105.79	55.511	182.89
35	56.315	207.25	56.315	161.22	56.315	105.98	56.315	183.02
35.5	57.120	207.43	57.120	161.40	57.120	106.17	57.120	183.14
36	57.924	207.61	57.924	161.59	57.924	106.35	57.924	183.26
36.5	58.729	207.80	58.729	161.77	58.729	106.53	58.729	183.49
37	59.533	207.97	59.533	161.95	59.533	106.71	59.533	183.73
37.5	60.338	208.15	60.338	162.12	60.338	106.89	60.338	183.96
38	61.142	208.32	61.142	162.29	61.142	107.06	61.142	184.19
38.5	61.947	208.49	61.947	162.47	61.947	107.23	61.947	184.42
39	62.751	208.66	62.751	162.63	62.751	107.40	62.751	184.65
39.5	63.556	208.83	63.556	162.80	63.556	107.57	63.556	184.87
40	64.360	208.99	64.360	162.97	64.360	107.73	64.360	185.09
40.5	65.165	209.16	65.165	163.13	65.165	107.89	65.165	185.30

Model →	**Okumura Hata Urban**		**Okumura Hata sub-Urban**		**Okumura Hata Rural**		**Cost -231 Model**	
Miles↓	Cell Range (Km)	Path Loss(dB)	Kilometers	Path Loss (dB)	Cell range (Km)	Path Loss(dB)	Cell Range Km	Path Loss(dB)
41	65.969	209.32	65.969	163.29	65.969	108.05	65.969	185.51
41.5	66.774	209.48	66.774	163.45	66.774	108.21	66.774	185.72
42	67.578	209.63	67.578	163.60	67.578	108.37	67.578	185.93
42.5	68.383	209.79	68.383	163.76	68.383	108.52	68.383	186.14
43	69.187	209.94	69.187	163.91	69.187	108.68	69.187	186.34
43.5	69.992	210.09	69.992	164.06	69.992	108.83	69.992	186.54
44	70.796	210.24	70.796	164.21	70.796	108.98	70.796	186.74
44.5	71.601	210.39	71.601	164.36	71.601	109.12	71.601	186.94
45	72.405	210.53	72.405	164.51	72.405	109.27	72.405	187.13
45.5	73.210	210.68	73.210	164.65	73.210	109.42	73.210	187.32
46	74.014	210.82	74.014	164.79	74.014	109.56	74.014	187.51
46.5	74.819	210.96	74.819	164.94	74.819	109.70	74.819	187.70
47	75.623	211.10	75.623	165.08	75.623	109.84	75.623	187.89
47.5	76.428	211.24	76.428	165.21	76.428	109.98	76.428	188.07
48	77.232	211.38	77.232	165.35	77.232	110.12	77.232	188.25
48.5	78.037	211.52	78.037	165.49	78.037	110.25	78.037	188.43
49	78.841	211.65	78.841	165.62	78.841	110.39	78.841	188.61
49.5	79.646	211.78	79.646	165.75	79.646	110.52	79.646	188.79
50	80.450	211.91	80.450	165.89	80.450	110.65	80.450	188.96

Table 04: Path loss & cell range from calculative value [Authors]

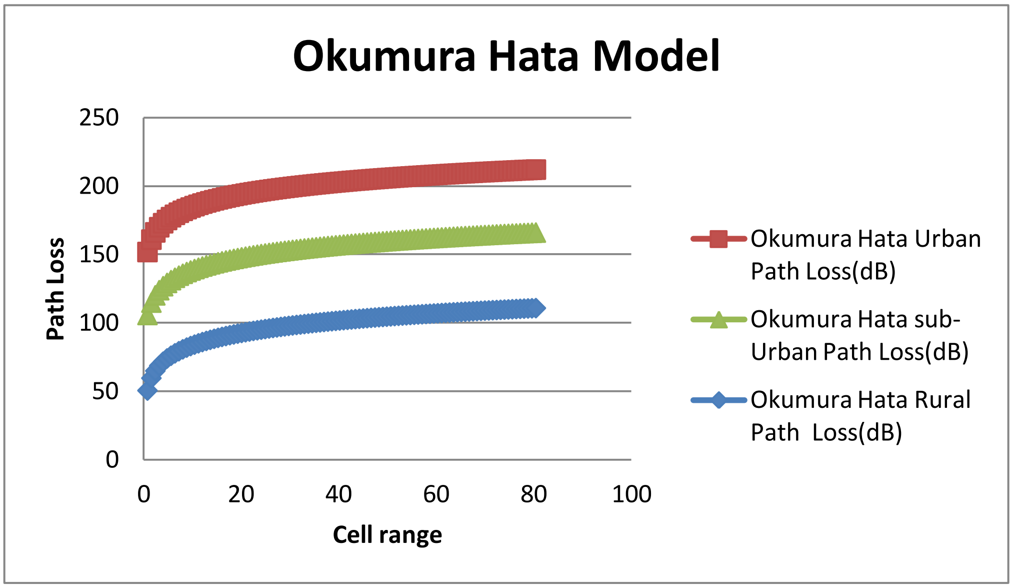


Figure 08:path loss vs. cell range in Okumura Hata model from calculative value [Authors]

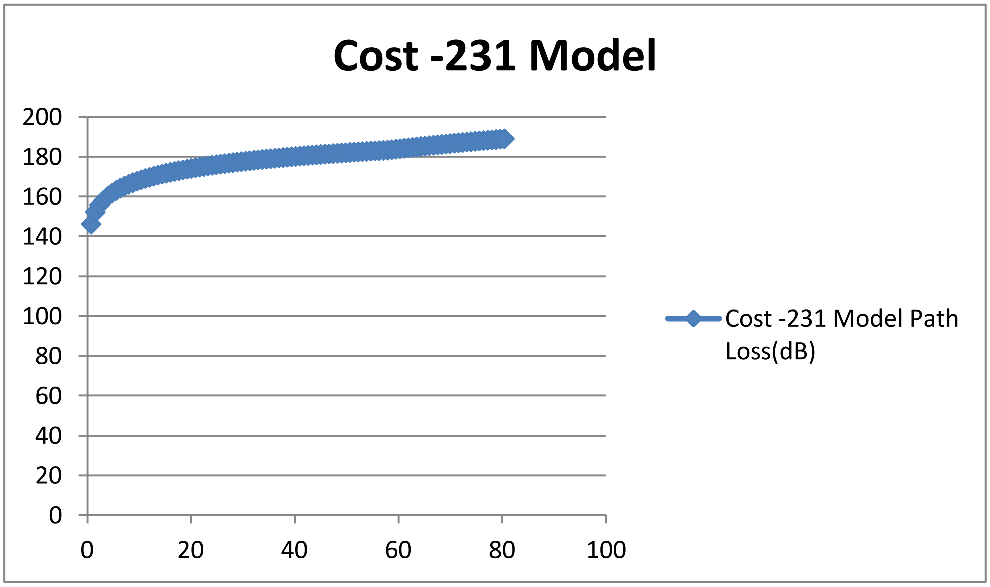


Figure 09:path loss vs. cell range in Cost-231 model from calculative value [Authors]

Discussion:

Accurate estimation of propagation path loss is a key factor for designing of mobile systems. Okumura-Hata model represents in the form of empirical relations for typical wireless environments such as urban, suburban, or rural areas. In this paper, we also observed Cost-231 model & compared with Okumura-Hata model. We choose COST-231 Model because it is a radio propagation model that extends the urban Hata Model (which in turn is based on the Okumura Model) to cover a more elaborated range of frequencies. For this reason path loss value will be close to Okumura-Hata model so that we can see the difference between two models and choose the best propagation model. These models depend on various parameters such as distance, cell coverage range and operating frequency range. Here for Okumura-Hata model operating frequency is 900GHz and for Cost-231 model & operating frequency is 1200GHz. In the table-04 and fig-08 we can see that in Okumura-Hata model (for urban, sub-urban and rural areas) as we increase distance, path loss will increase and cell coverage range will also increase. But in urban area path loss will high rather than sub-urban and rural areas. We can see that in urban, sub-urban and rural area distance and cell coverage range are same but path loss is different. It happens because in urban area number of subscriber is higher than sub-urban and rural areas so that lots of subscriber covers these cell ranges and for that reason path loss is high. In rural area, the subscriber is less than the suburban and urban area. In rural area less subscriber cover a bigger cell range, so the path loss is less in rural area. In Cost-231 model, we can see in fig-09 that with the increase of distance and cell range path loss is also increase. The reason behind it that as we cover more area lots of subscriber can cover these cell ranges so that path loss will increase. Cost-231 model is applicable for urban, sub-urban and rural (flat) areas. Cost-231 does not cover terrain path for rural area but in Okumura-Hata model can cover terrain path and in Okumura-Hata model path loss is less than the Cost-231 model. After observing all these things we choose Okumura-Hata model as a best propagation model.

5.4.2a. Comparative study of Path loss & Cell range in uplink:

In this table we see the analysis of path loss and Cell range for Uplink in different areas

Environment Uplink(dual QPSK)	**Rural**		**Suburban**		**Urban**	
parameters	**Path Loss (dB)**	**Cell Range (Km)**	**Path Loss (dB)**	**Cell Range (Km)**	**Path Loss(dB)**	**Cell Range (Km)**
12.2 kbps	152.84	24.8	144.84	1.69	137.84	0.96
144 kbps	151.72	23.05	143.72	1.57	136.7	0.89
384 kbps	144.86	14.72	136.86	1	129.86	0.57

Table 5: Path loss & cell range for uplink [3]

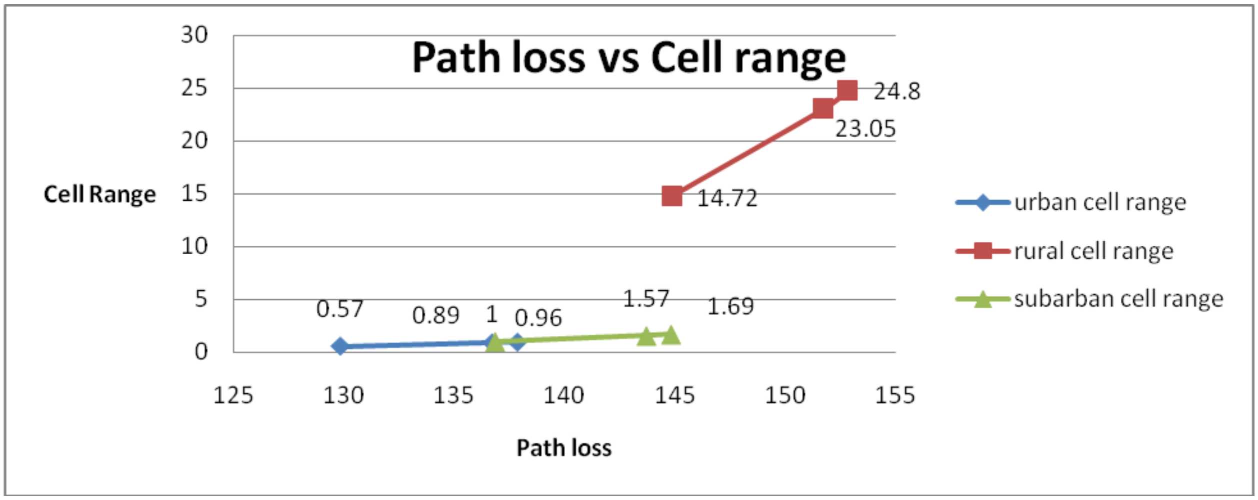


Figure 10: Path loss vs Cell range for Uplink [Authors]

From link budget calculation which we have found from Ericsson Bangladesh for different areas (rural/suburban/urban) different path loss occurs. In table-05 these data are obtained from this link budget for various areas and these values are for uplink. For the values if the data represented graphically then it can be seen in fig-10 that cell range is increasing path loss. This is different for different areas. Like in urban area the changing rate of cell range is very low and in suburban area this rate is also very low. But for rural area the rate of cell range increasing is very high. With the decreasing path loss cell range is also decreasing. After comparing the three areas (rural, suburban, and urban) then it is seen that in rural area for a particular path loss cell range is higher. But if we go to the suburban area for a particular path loss cell range is lower compare to rural area. The Urban area’s cell range is much smaller than the rural and suburban area.

The reason behind this, in rural area the subscriber is less than the suburban and urban area. In rural area less subscriber cover a bigger cell range, so the path loss is less in rural area. One of the concepts in data communication in urban area is the idea of allowing several transmitters to send information simultaneously over a single communication channel. This allows several users to share a band of frequencies. This concept is called multiple accesses . For multiple access interference is high so the path loss is also high in small cell range. Path loss also causes Diffraction losses when part of the radio wave front is obstructed by a solid obstacle, and losses caused by other phenomena.

5.4.2b. Comparative study of Path loss & Cell range in uplink:

The table below shows the analysis of path loss and Cell range for Uplink in different areas.

Uplink(BPSK)	**12.2 kbps**		**144 kbps**		**384 kbps**	
Environment	**Path Loss (dB)**	**Cell Range (Km)**	**Path Loss (dB)**	**Cell Range (Km)**	**Path Loss(dB)**	**Cell Range (Km)**
Rural	152.84	24.8	151.72	23.05	144.86	14.72
Suburban	144.84	1.69	143.72	1.57	136.86	1
Urban	137.84	0.96	136.7	0.89	129.86	0.57

Table 06: Table of Path loss & cell range for uplink [3]

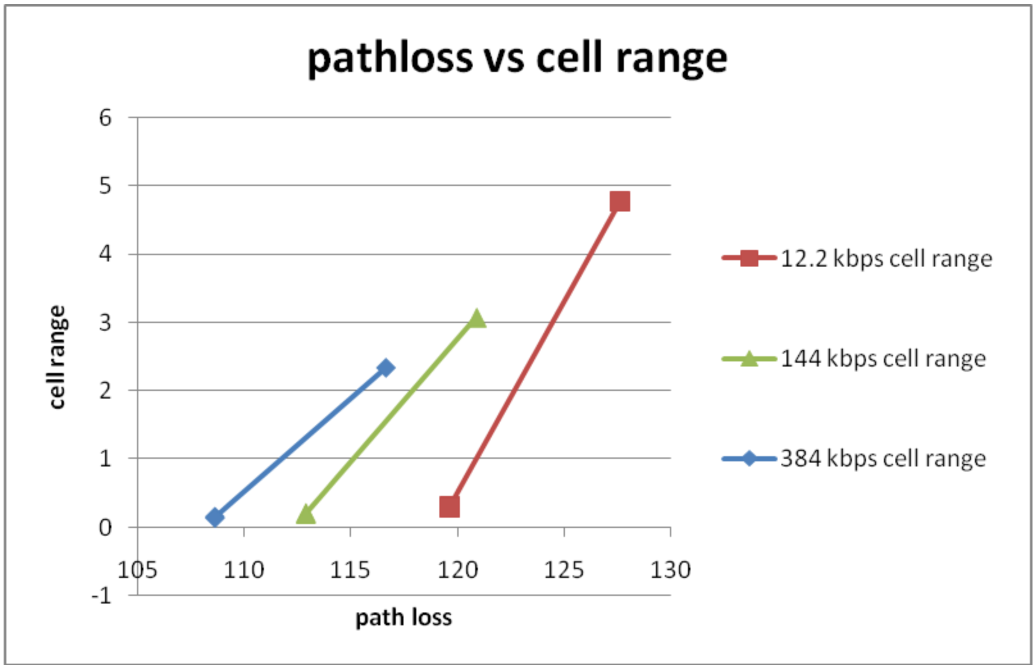


Figure 11: Path loss vs cell range for Uplink [Authors]

For table-06, the data was obtained from the link budget for various range and these values presented here are for uplink. After representing the data graphically based on real values, we can find cell range, which is increasing with increasing rate of path loss.

Also, when cell range is lower, path loss gets high and when the speed increases the cell range decreases as well. Path loss may be due to many effects, such as free-space loss, refraction, diffraction, reflection, aperture-medium coupling loss and absorption. Path loss is also influenced by terrain contours, environment (urban or rural, vegetation and foliage), propagation medium (dry or moist air), the distance between the transmitter and the receiver, and the height and location of antennas. The signal radiated by a transmitter may also travel along many and different paths to a receiver simultaneously; this effect is called Multi-path. In urban area, when the speed is high this problem occurs.

So we can say from the practical value and from fig-11 that, when speed is low cell range is high.

5.4.3a. Comparative study of Path loss & Cell range in downlink:

In table-07, the analysis of path loss and Cell range for downlink in different areas is been mentioned.

Environment Downlink(QPSK)	**Rural**		**Suburban**		**Urban**	
Parameters	**Path Loss (dB)**	**Cell Range (Km)**	**Path Loss (dB)**	**Cell Range (Km)**	**Path Loss(dB)**	**Cell Range (Km)**
12.2kbps	127.63	4.77	119.63	0.32	116.65	2.33
144kbps	120.91	3.08	112.91	0.21	108.65	0.16
384kbps	116.65	2.33	112.91	0.19	108.65	0.14

Table 07: Path loss & cell range for downlink [3]

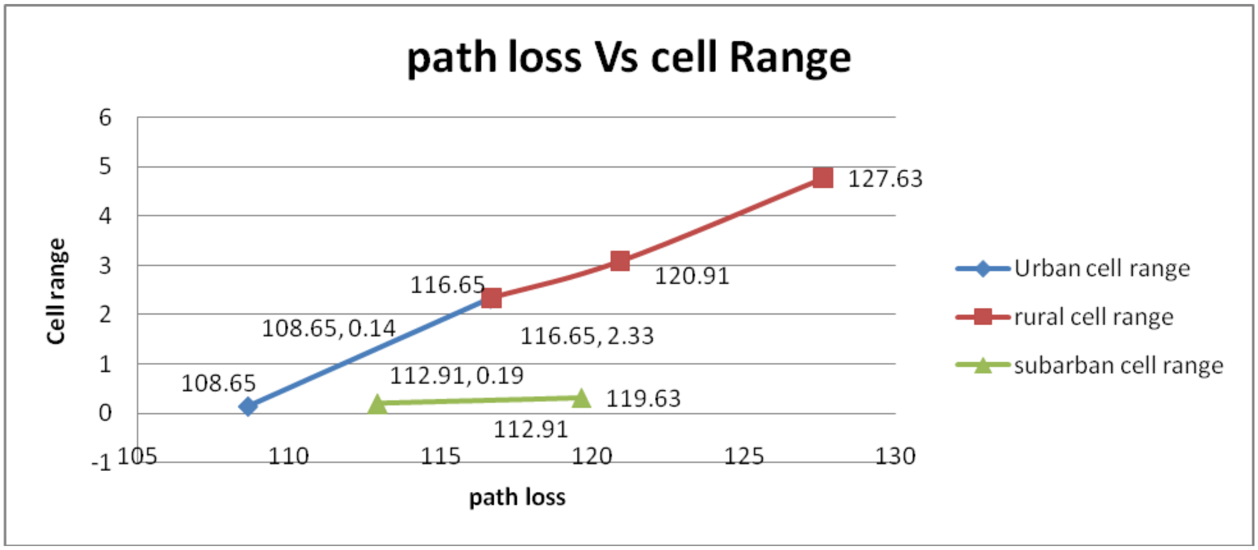


Figure 12: Path loss Vs cell range for downlink [Authors]

From link budget for different areas (rural/suburban/urban) different path loss occurs. In table-07 this data is obtained from the link budget for various areas and these values are for downlink parameter. Here the data represented graphically is based on real values; it can be seen in fig-12 that the cell range is increasing with increasing path loss. This is different for various areas.

Like in suburban area the changing rate of cell range is very low but for rural area cell range increases in a high rate and in suburban area this rate is also very high corresponding to suburban area.

From a general view from figure 10 it can be said that, when the cell range is high the path loss is also high. If it is analyze in terms of different areas, it is seen that in rural area the cell range is higher for a particular path loss. When the cell range is increasing, the path loss is also increasing. In suburban area a cell range is much lower than the rural area although the path loss is almost in a same range like rural area. It also happens in urban area. The cell range and path loss is lower than the rural and suburban area for different cell range. From uplink and downlink discussion it can be said that the downlink cell range and path loss is lower than uplink parameter. The reason for high cell range in uplink is it uses the dual channel modulation.

5.4.3b. Comparative study of Path loss & Cell range in downlink:

In the table below, shows the analysis of path loss and Cell range for downlink in different areas.

Downlink(QPSK)	**12.2 kbps**		**144 kbps**		**384 kbps**	
Environment	**Path loss dB**	**cell range Km**	**Path loss dB**	**cell range km**	**Path loss dB**	**cell range km**
Rural	127.63	4.77	120.91	3.08	116.65	2.33
Suburban	119.63	0.32	112.91	0.21	108.65	0.16
Urban	119.63	0.29	112.91	0.19	108.65	0.14

Table 08: Table of Path loss & cell range for downlink [3]

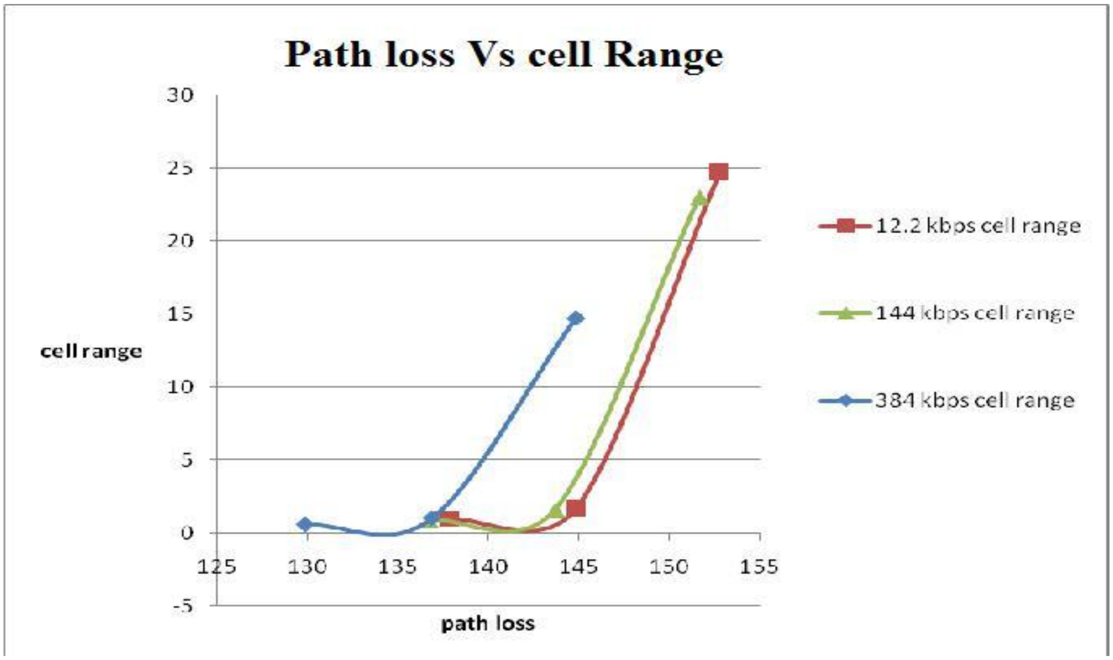


Figure 13: Path loss vs cell range for downlink [Authors]

In fig-13 we can observe that these curves are obtained from the link budget for various range and these values are for downlink parameter. If the values are present graphically, then we can find that the cell range is increasing with increasing path loss where the value is increasing exponentially. Here for smaller speed of 12.2 kbps, the changing rate of path loss and cell range is higher but changing rate is lower in higher speed. Path loss in downlink parameter occurs for Scattering when objects are smaller than the wavelength of the propagating wave like plants, street signs, lamp posts, and the incoming wave is scattered into several weaker outgoing signals. It also happens for Reflection Propagating wave interrupts on the object that is larger as compared to wavelength (e.g. the surface of the earth, tall buildings, large walls, etc.). Diffraction allows propagating waves to propagate around the curved surface of earth and behind obstruction producing Fresnel Zone (shadow region). Scattering and diffraction result in small-scale fading while reflection results in large scale fading.

5.5. UMTS Cell Range

Cell breathing should be taken into account while calculating cell range in UMTS network. The increasing rate of traffic in the cell decreases the sensitivity of the Node-B because of the increased interference and so the UE will require more power to remain connected to the cell. And when there is not much load in the cell, the interference would be low and the UE can use the same power to connect to that particular cell even from a longer distance. This variation in cell ranges is called as cell breathing. Simply put, cell capacity influences cell coverage area. One of the parameter in link budget is Interference margin.

The 900 MHz and 1800 MHz bands are being widely used by GSM systems in Europe. . UMTS will co-exist with GSM in the 900 MHz and 1800 MHz frequency bands in the future. The main interest for some European operators to deploy UMTS in the 900 MHz band is the better coverage compared to UMTS at 2100 MHz, especially to provide coverage for rural areas. UMTS900 offers a considerably more cost efficient solution for operators to offer UMTS services in rural areas with low population density. The total bandwidth of the 1800 MHz frequency band is 2 x 75 MHz. In some countries, the 1800 MHz band is not totally used by GSM systems, especially in rural areas with low population density. Part of the 1800 MHz band can become a complementary band for deploying UMTS, the interest for operators to deploy UMTS in the 1800 MHz band comes also from the fact that it is easy to share the same GSM1800 radio sites by UMTS systems operating in the 1800 MHz band. [19]

5.5.1. UMTS900 deployment scenarios

The deployment of UMTS in the 900 MHz and 1800 MHz bands does not mean the immediate replacement of GSM networks by UMTS. Some operators may plan to deploy only UMTS in 900 MHz band. For some others (and it is believed for most of the existing GSM operators) the most probable transition strategy is to use part of the 900 MHz frequency band for deploying UMTS in order to offer 3G services, while keeping GSM networks in operation. GSM and UMTS will be in co-existence and operated in adjacent channels. Particularly, the deployment of UMTS in the 900 MHz band in rural areas allows providing 3G services at a much lower cost compared to the deployment of UMTS in 2.1 GHz band. A preliminary study comparing the GSM and UMTS link budgets has shown that the cell range of GSM speech service is similar to that of UMTS CS64. This means for a GSM operator, by re-using the existing GSM sites without adding any new sites, UMTS CS64 video-telephony service can be offered by the co-location of GSM and UMTS sites. For offering higher data rate services, such as PS128, CS128, PS384, some additional new sites could be required. Considering these deployment scenarios, the following sharing scenarios should be studied:

1) Coordinated GSM and UMTS sites (co-located GSM and UMTS BS)

2) Uncoordinated GSM and UMTS sites

3) Uncoordinated UMTS networks sites.

In reference to the existing GSM900 networks, it can be reasonably assumed that the representative cell ranges of macro cells are respectively:

i) 577 m in urban area
ii) 2400 m in sub-urban area
iii) 5000 m in rural area.

The actual GSM cell range in low population density rural area is in average at least 5 km; it can go up to 20 km. Therefore sharing study for rural areas with cell range of at least 5 km appears necessary and important. Due to the better propagation conditions in the 900 MHz band compared to the 2 GHz band, deploying UMTS900 in urban areas can improve indoor coverage and offer deeper indoor penetration.

GSM900 has been deployed as macro cells, microcells and indoor pico cells, the study of co-existence between UMTS900 and GSM900 in urban areas should take into account the scenarios of GSM900 microcells and pico cells.

Six deployment scenarios for UMTS900 have been identified and studied:

- Scenario_1: UMTS (macro)-GSM (macro) in urban area with cell range of 577 m in uncoordinated operation
- Scenario_2: UMTS (macro)-GSM (macro) in rural area with cell range of 5000 m in uncoordinated operation
- Scenario_3: UMTS (macro)-GSM (macro) in rural area with cell range of 5000 m in coordinated operation

- Scenario_4: UMTS (macro)-UMTS (macro) in rural area with cell range of 5000 m in uncoordinated operation
- Scenario_5: UMTS (macro)-GSM (micro) in urban area in uncoordinated operation
- Scenario_6: UMTS (macro)-GSM (pico) in urban area in uncoordinated operation

5.5.2. Co-existence between UMTS networks in rural areas:

Scenario_4: UMTS (macro)-UMTS (macro) in rural areas with cell ranges of 5000 m in uncoordinated operation

– 2 x 5 MHz uncoordinated operation between UMTS macro cell and UMTS macro cell.

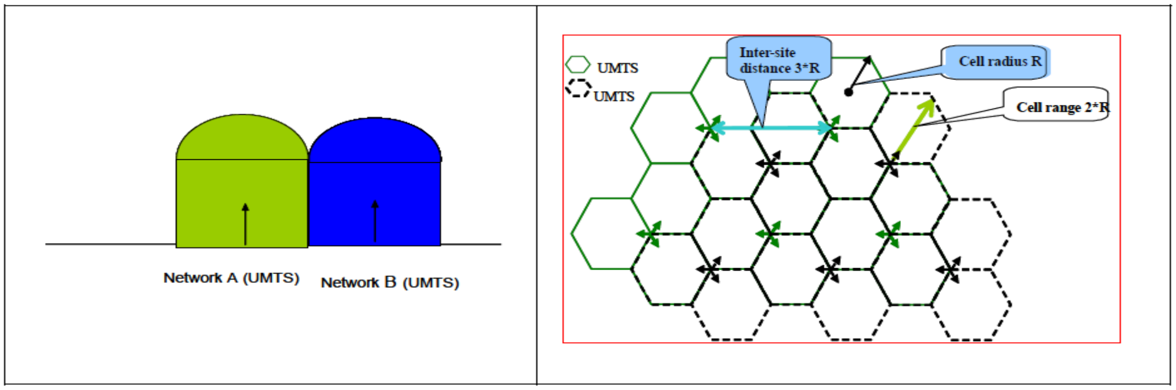


Figure 14: 2 x 5 MHz uncoordinated operation of two UMTS networks [9]

Carrier separation between two UMTS networks is 5 MHz the cell range is 5000 m. As shown in figure-14, the BS of network B is located at the cell edge of network.

Chapter 6

Analysis of Noise Rise Corresponding To the Bit-Rate

6.1. Introduction of Noise Rise

6.1.1. Noise Rise

In theory, the “noise rise” is defined as the ratio of total received wideband power to the noise power. Higher “noise rise” value implies more users are allowed on the network, and each user has to transmit higher power to overcome the higher noise level. This means smaller path loss can be tolerated and the cell radius is reduced. To summarize, a higher noise rise means higher capacity and smaller footprint, a lower noise rise means smaller capacity and bigger footprint. [20]

Wideband Code Division Multiple Access (WCDMA) telecommunication systems have many attractive properties that can be used for future development of telecommunication services. A specific technical challenge in WCDMA and similar systems is the scheduling of enhanced uplink channels to time intervals where the interference conditions are favorable, and where there exist a sufficient capacity in the uplink of the cell in question to support enhanced uplink channels. It is well known that existing users of the cell all contribute to the interference level in the uplink of WCDMA systems. Further, terminals in neighbor cells also contribute to the same interference level. This is because all users and common channels of a cell transmit in the same frequency band when CDMA technology is used. The load of the cell is directly related to the interference level of the same cell. [21]

6.1.2. Uplink Noise Rise

Noise rise can be described as the increase in wideband interference level over the thermal noise in the base station reception.

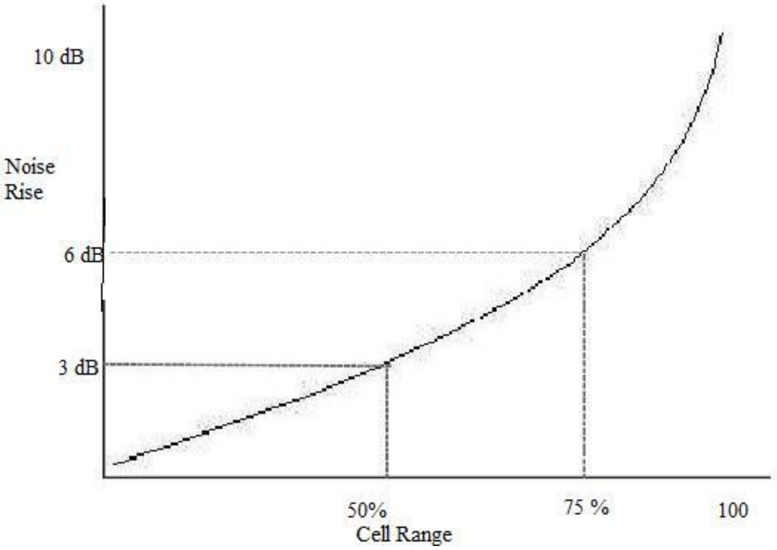


Figure 15: Uplink noise rise [9]

From fig-15 it can be seen that as the noise rise increases to 3dB, this equates to 50 per cent of the data throughput, or could be described as equivalent to a load factor of 50 per cent. However the noise rise curve is not linear, due to interference.Therefore, as the noise rise reaches 6.0dB which corresponds to a load factor of 75 per cent. The total amount of data throughput is the combined throughput of all users simultaneously. In this example, a total data throughput of 1300kbps could be achieved with a noise rise of 6dB. The ultimate results of this noise rise will be a reduction in cell size. Taking the average attenuation between the base station transmitter and the UE receiver (taking into consideration the sensitivity of the UE), the minimum transmission power for each subscriber can be determined. The effect of the noise rise due to interference must be included with this minimum power level and therefore this can be stated as the required transmission power for a user situated an ‘average’ location within a cell. The transmission power should be based on the average transmitted power and not the maximum transmitted power for the periphery of the cell. [22]

6.1.3. Uplink Resources and Limits

Noise rise (RoT – Rise over Thermal) is the relation of received uplink power to thermal noise level. Operator defined noise rise limit prevents Node B to allocate high transmit power i.e. high E_c/N_0 which further converts to high data rate, to a user., the most significant of the limitations, and also the most obscure to wider audiences, is noise rise. In HSPA downlink the shared resource is Node B transmit power, which can be allocated to a single user at a time on per TTI basis. In uplink the same is not possible as users have their own transmitters and the system's uplink transmit power is distributed throughout the network. In uplink users transmit simultaneously and fast power control is applied to ensure that different users' signals are received with equal powers in the Node B. This prevents the so called near-far-problem in non-orthogonal WCDMA uplink. If there are too many users in the cell, the RoT increases too much preventing users at cell edge to use the system. Users in poor radio conditions simply do not have enough transmit power to overcome high RoT and they are out of uplink coverage. This RoT relation to coverage effect is known as cell breathing. To prevent too aggressive cell breathing, live networks are configured to apply load control if RoT increases too much. As higher bitrates require higher Ec/N0 values, and higher E_c/N_0 values produce higher RoT, RoT can be considered the uplink shared resource. [23]

6.2. Bit-Rate:

Bit-Rate, as the name implies, describes the rate at which bits are transferred from one location to another. In other words, it measures how much data is transmitted in a given amount of time. It is commonly measured in bits per second (bps), kilobits per second (Kbps), or megabits per second (Mbps).

Average bit-rate (ABR) refers to the average amount of data transferred per unit of time, usually measured per second, commonly for digital music or video.

Average bitrate can also refer to a form of variable bit rate (VBR) encoding in which the encoder will try to reach a target average bit rate or file size while allowing the bit rate to vary between different parts of the audio or video. As it is a form of variable bit rate, this allows more complex portions of the material to use more bits and less complex areas to use fewer bits. However, bit rate will not vary as much as in variable bit rate encoding. At a given bit rate, VBR is usually higher quality than ABR, which is higher quality than CBR (constant bit rate). ABR encoding is desirable for users who want the general benefits of VBR encoding (an optimum bit rate from frame to frame) but with a relatively predictable file size. Two-pass encoding is usually needed for accurate ABR encoding, as on the first pass the encoder has no way of knowing what parts of the audio or video need the highest bitrates to be encoded.

6.2.1. Information transfer in Bit rate basis in WCDMA (UMTS):

For connection in WCDMA (UMTS) It is required that the bearer service provides one of the following [23]

- Guaranteed/constant bit rate
- Non-guaranteed/dynamically variable bit rate, and
- Real time dynamically variable bit rate with a minimum guaranteed bit rate.

6.2.2. Supported bit rates in WCDMA (UMTS):

It shall be possible for one application to specify its traffic requirements to the network by requesting a bearer service with any of the specified traffic type, traffic characteristics, maximum transfer delay, delay variation, bit error ratios & data rates. It shall be possible for the network to satisfy these requirements without wasting resources on the radio and network interfaces due to granularity limitations in bit rates. It shall be possible for one mobile termination to have several active bearer services simultaneously, each of which could be connection oriented or connectionless. The only limiting factor for satisfying application requirements shall be the cumulative bit rate per mobile termination at a given instant (i.e. when summing the bit rates of one mobile termination's simultaneous connection oriented and connectionless traffic, irrespective of the traffic being real time or non real time) in each radio environment: [16]

- At least 144 Kbits/sec in satellite radio environment.
- At least 144 Kbits/sec in rural outdoor radio environment.
- At least 384 Kbits/sec in urban/suburban outdoor radio environments.
- Greater than 2 Mbits/sec in urban/suburban outdoor radio environments.
- At least 2048 kbits/sec in indoor/low range outdoor radio environment.
- Greater than 2 Mbits/sec in indoor/low range outdoor radio environment.

6.3. Analysis of noise rise corresponding to the bit-rate:

Noise rise is another issue for link budget analysis. Actually noise rise is defined as the ratio of received wideband power to the noise power.

$$\text{Noise Rise} = I_{total} / P_n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, I_{total}=Received power

P_n= Noise power

By placing throughput in X-axis and noise rise in Y-axis the figure is obtained. It is seen here that noise increases in much higher rate for higher bit rates. The obtained values are given in table-09

(Variation of noise rise with bit rate)

Bit rate (kbps)	Noise rise
12.2	1.007
144	1.091
384	1.289

Table 09: Variation of noise rise with Bit rate [3]

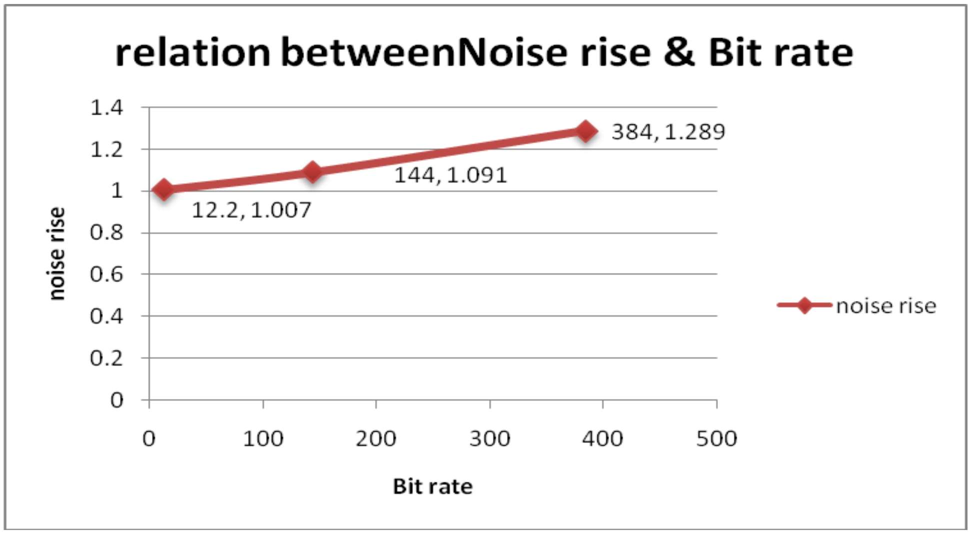


Figure 16: Relation between Noise rise and Bit rate [Authors]

Using the value of Ericsson Bangladesh, if we put the noise rise in Y axis and the Bit rate at the X axis the fig-16 is obtained. From the figure we can see that noise rise is increases in much higher rate for higher bit rates. From practical rate we can see that when the bit rate increases the noise rise is also increasing .This rate of change is changing in a linear way. When the transmitting speed is higher we get higher noise.

When the bit rate is 12.2 kbps then the noise rise 1.007 dB after that when the bit rate is higher than before 144 kbps we get the increases noise 1.091. When the bit rate is also high 384 kbps then we get the increases noise of 1.289 dB.

The reason behind this, as it mentioned before noise rise is the relation of received power and noise power. So when the speed is in a higher range the received power is also high. And for the higher power, interference is also higher. For the higher speed it covers more subscribers in small cell range and more subscribers creates more interference or increasing interference noise is rising

6.4. Relation between bit-rate and path loss:

For certain region, cell range and path loss decreases with increasing bit rate. Actually for higher bit rate processing gain get reduced, thus cell range becomes lower. This is the case for both uplink and downlink. In table 09 and figure 16 this fact is illustrated for suburban area. It is found that for a certain region with bit rate cell range decreases. As higher bit rate is needed only for data transmission, so voice transmission can easily be accomplished by UMTS in a greater cell range. UMTS thus offers flexible cell coverage for different data rates according to priority.

Bit rate	**Cell range uplink**	**Cell range downlink**
12.2	**1.69**	0.32
144	**1.57**	0.21
384	**1**	0.16

Table 10: Change in Cell Range with Bit Rate [3]

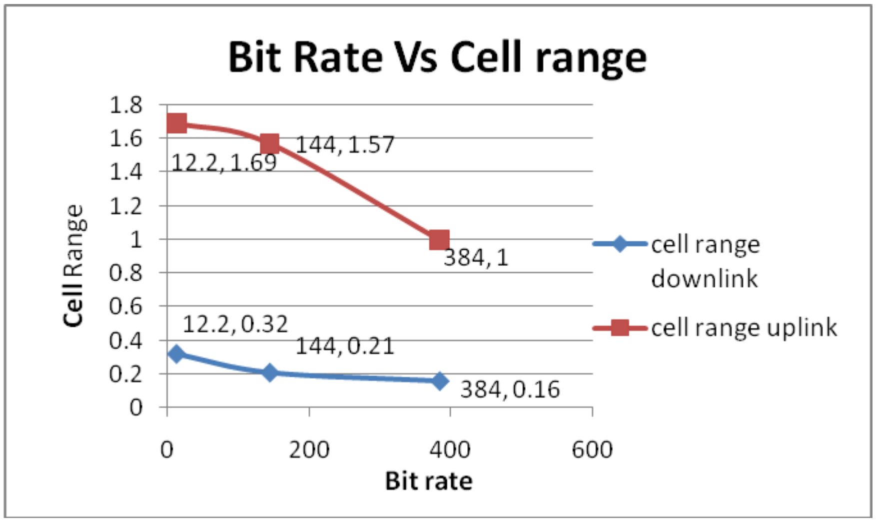


Figure 17: Bit rate Vs cell range [Authors]

This graphical representation of real values (obtained from Ericsson Bangladesh) is illustrated in fig-17 for suburban area. From fig-17 we can see that with corresponding bit rate cell range is decreasing. This happens for both uplink and downlink. We can see that the uplink cell range is decreasing by upward and for downlink cell range is decreasing by downward.

Here we can see that in uplink parameter when bit rate is 12.2 kbps then cell range is 1.69.when bit rate is 12.2 kbps we get the cell range of 1.57 km and when the bit rate is higher 384kbps we get cell range of 1 km. Here we can see that in downlink when bit rate is 12.2 kbps then cell range is 0.32, when bit rate is 12.2 kbps we get the cell range of 0.21 km and when the bit rate is 384kbps we get cell range of 0.16 km.

The reason of decreasing cell range with increasing bit rate both in uplink and downlink is when the speed is low then it transmits data or voice very slowly. For this situation it creates fading. For slow fading comparatively small bit rate like 12.2 kbps cover higher cell range. The fading may vary with time, geographical position or radio frequency, speed and is often modeled as a random process. When the speed is high, fading range varies. For higher speed there is fast fading and it transmits voice or data very fast as it needs smaller cell range.

Uplink cell range is comparatively high then downlink cell range because uplink uses the spreading modulation of Dual-channel QPSK (Quadra phase shift keying) and downlink uses the spreading modulation of Balanced QPSK .For dual channel slight speed can cover more cell that is why uplink cell range is higher than the downlink cell range although both are in the same cell range As higher bit rate is needed only for data transmission. So voice transmission can easily be accomplished by UMTS in a greater cell range. UMTS thus offers flexible cell coverage for data rates according to priority. We can also find the same value if we do it for Urban and Rural area.

Chapter 7

Conclusion

7.1. Discussion:

Form different propagation models it can be said that Okamura-Hata model is the best one because its frequency is in a valid range ,its coverage area is also high and it is appropriate for all of the areas like rural, suburban Urban areas. It is mostly appropriate for urban area where other models are not appropriate for all of the areas.

After that we discussed the Okamura-Hata model with practical value and the practical value is almost same with the theoretical value.

From analysis of the link budget it can be said that

- Cell range was increasing with increasing path loss. Like in suburban area the changing rate of cell range is very low but for rural area cell range increase is very high and in suburban area this rate is also very high corresponding to suburban area.
- Noise was increasing with increasing Bit rate.
- Cell range was decreasing with increasing bit rate both in Uplink and downlink. But Uplink cell range was much higher than the downlink cell range although they have the same Bit rate.
- In urban area the changing rate of cell range was very low and in suburban area this rate is also very low. But for rural area cell range increase rate was very high.

The analysis of link budget for UMTS in various environments has been presented through various graphs. The study brings out the fact that with high bit rate it also offers greater cell range with lower noise rise. Even though cell range in downlink is load dependent and lower compared to uplink transmission transmit diversity is included in WCDMA to improve the downlink capacity to support the asymmetric capacity requirements between downlink and uplink. This could be plausible in rural areas as well. Rural areas without access to the data highway have considerable location disadvantages. As UMTS can be easily applied over GSM network with least change of infrastructure and provide higher bit rate up to 2 Mbps so for poor countries it is highly recommended to be implemented. By providing higher data rate through

UMTS the working conditions at local businesses can be improved and the quality of life of citizens in countries under poverty level can be enhanced.

7.2 Future Development:

Here, we have represented our real values in Microsoft excel 2007. But for future development for presenting better simulation, our real values can be analyzed & simulate using MAT LAB software, which will surely represent & compare the theoretical & practical values will compute in a better & professional way.

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4.2. Table for comparative study of propagation model

Model→ parameters ↓	**Longley-Rice Model**	**PCS extension to hata model**	**Walfish and Bertoni model**	**Wideband PCS microcell model**	**COST -231 Model**
Frequency	f=20MHz -40GHz	f=200-1500MHz	F=90MHz-180MHz	Frequency 1900 MHz	F=500 MHz to 2000 MHz
Coverage	1 to 2000 km	hte =30m to 200 m hre=1m to 10 m d =1 km to 20 km	not done in a standard value	hte=3.7, 8.5, 13.3 meters hre=: 1.7 meters	H_{te} = 4 – 50 m h_{re} = 1 – 3 m d = 0.02 – 50 km
Application area	urban areas	Public communication service	suited for urban areas	LOS and Obstructed (OBS) Environment	Only in Urban area
Formula	not done in a standard value	not done in a standard value	$S(dB)=L_o+L_{rts}+L_{ms}$	not done in a standard value	PL = 46.3 + 33.9 log10 (f) − 13.82 log10 (hb) − ahm + (44.9 − 6.55 log10(hb)) log10 d + Cm

Formula explanation	not done in a standard value	not done in a standard value	L_o=Free space loss L_{rts}=rooftop to street diffraction and scatter loss L_{ms}=multi screen diffractions loss due to the row building.	not done in a standard value	L = Median path loss. Unit: Decibel (dB) f = 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.
Strongest point	Deals with radio propagation in urban areas and this is particularly relevant to mobile radio.	Used for public communication service.	used in finding the impact of rooftop and building height	Two ray ground reflection model is suitable	Only used for 3.5 GHz band
Weak point	Does not provide a way of determining corrections, No consideration of correlation ,No consideration of multipath .	Range is small	Cover small place , tolerate a weaker signal, multiscreen loss	The **weak** contribution from the signals	This model requires that the base station antenna is higher than all adjacent rooftops.

Model→ parameters ↓	**Hata Model**	**Okamura model**
Frequency	f=150 MHz -1500 MHz,	f=150MHz -1920MHz
Coverage	h_{te}=30 m -200 m, h_{re}= 1 m -10 m 1 to 100 km	hte =30m to 1000 m, d =1 km to 100 km
Application area	urban areas, suburban areas, rural areas	Urban and suburban areas
Formula	**Urban** $L_{50}(dB)=69.55+26.16\log f_c+13.82\log ht_e-a(h_{re})+(44.9-6.55\log h_{te})\log d$ **Suburban** $L_{50}(dB)=L_{50}(urban)-2[\log(f_c/28)^2]-5.4$ **Rural** $L_{50}(dB)=L_{50}(urban)-4.78[\log(f_c)^2+18.33\log f_c-40.94$	$L_{50}=L_F+A_{rms}(f,D)-G(h_{tx})-G(h_{re})-G_{AREA}$
Formula explanation	L = Median path loss. f = Frequency of Transmission d = Link distance. Unit: Kilometer hte- transmitting station antenna height (m) hre - mobile unit/transmission antenna height (m)	L_{50} = 50% value of propagation path loss (median) L_F = free space propagation loss $A_{mu}(f,d)$ = median attenuation relative to free space $G(h_{te})$ = base station antenna height gain factor $G(h_{re})$ = mobile antenna height gain factor G_{AREA} = gain due to environment
Strongest point	Valid for large-cell systems, Good practical value, very close to the Okumura's results	Simplest & best in terms of path loss accuracy in cluttered mobile environment
Weak point	Not PCS(personal communication system) systems, does not provide coverage to the whole range of frequencies covered by Okumura Model	Slow response to rapid terrain changes