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NETWORK PLANNING AND DIMENSIONING PROCESS IN WCDMA

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NETWORK PLANNING AND DIMENSIONING PROCESS IN WCDMA

By

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ABSTRACT

NETWORK PLANNING AND DIMENSIONING PROCESS IN WCDMA

By

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An overview of the mobile system/network architecture with Wideband Code Division Multiplexing Access (WCDMA) air interface is highlighted. The main network parameters are first introduced. The WCDMA network planning and dimensioning process is then described, with emphasis on the link budget, coverage and capacity calculations for a specific quality of service (QoS). A cooperative graphical and algorithmic technique is developed to efficiently compute the optimal network load factor and cell radius. The optimum solution of coverage and capacity calculations result in the optimal cell size, and thus the minimum number of Base stations (BTs) required for a given geographical region. Then, applying a modified (energy-based) Self Organization Map (SOM) algorithm, an optimization for BTs positions is achieved as a computational solution to the dimensioning process. As a case study of scale, we apply the developed WCDMA network planning and dimensioning process for a specific quality of service to a test regional area, namely, the Janzour region with an area of 17.38 km^2 and 100,000 in population. The introduced process is implemented for three different services using software environment developed in MatLab. The promising results provide an example of the applicability of the developed planning and dimensioning process.

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Finally, I wish to dedicate this dissertation to my parents for getting me started right and continued support throughout my studies, my sisters and my friends.

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Introduction

1.1. Back ground:

The digitization of our private and working lives is one of the most radical changes that have taken place in recent times. Mobile telephony and the internet are lead technologies symbolizing a massive, epoch-making transformation. The mobile communication wave has engulfed us, gaining a level of acceptance and spreading at a pace that has exceeded even the most optimistic predictions. And things are only just beginning. While in some parts of the world mobile phone ownership is already close to saturation point.

It will be possible for mobile phones, handsets, and mobile terminals of the UMTS generation to be kept permanently ready for operation - "always on". It will be easier to form virtual communities ("communities of interest"). Personalized service designing will be possible. Each user's familiar service environment will also become mobile; this means providing a mix of services tailored to individual interests and needs (Virtual Home Environment, Virtual Office Environment). The services will be especially capable of offering hints and tips on a proactive basis in relation to location, time, occasion, event, or activity. Messages can then reach users on a context-related (or action-oriented) basis. The need for high speed data and the quality service demanding completely clear, as your wireless mobile set controls everything in your life and become reliable tool in any application like:

-Your mobile set now can do lock and unlock for the car, check the battery level of your car and the general condition of the car.

- Now you can control a lot of things in your home like alarm alert, electricity, TV and a lot of other things.

Mainly WCDMA network systems are designed for multimedia communication. But, with them personto-person communication can be enhanced with high quality images and video, and access to information and services on public and private networks will be enhanced by the higher data rates and new flexible communication capabilities of third generation systems. This, together with the continuing evolution of the second generation systems, will create new business opportunities not only for manufacturers and operators, but also for the providers of content and applications using these networks.

In the standardization forums, WCDMA technology has emerged as the most widely adopted third generation air interface. Its specification has been created in 3GPP (the 3rd Generation Partnership Project), which is the joint standardization project of the standardization bodies from Europe, Japan, Korea, the USA and China. Within 3GPP, WCDMA is called UTRA (Universal Terrestrial Radio Access) FDD (Frequency Division Duplex) and TDD (Time Division Duplex), the name WCDMA being used to cover both FDD and TDD operation.

Forth generation systems are currently under development and will be implemented somewhere in 2008-2015. They will not only connect people to people, but machines or houses to people.

1.1.1 History:

The rapid growth in traffic volume and increase in new services has begun to change the configuration and structure of wireless networks. Thus, future mobile communications systems will be distinguished by high integration of services, flexibility and higher throughput.

To support such features, the efficient use of spectrum and optimum management of radio resources will be essential.

To meet these challenges standardization bodies like ETSI (now expanded to 3GPP), have selected the Wideband Code Division Multiple Access (WCDMA) and the hybrid Time Division – CDMA as the radio techniques for the Universal Mobile Telecommunication Systems (UMTS). Hence, UMTS conceived at the eve of this new millennium will without doubt have a large impact on future wideband mobile networks and serve as the leading platform for wireless multimedia communications. [11]

Exactly the UMTS project was initiated by ETSI (European Telecommunications Standards Institute) under its RACE (Research & Development in Advanced Communications technologies in Europe) workgroup as a 3G wireless system. The International Telecommunications Union (ITU) proposed UMTS in 1985. This study, called International Mobile Telecommunications-2000 (IMT- 2000), planned ITU's vision beyond the year 2000. In 1992, the World Radio Congress (WARC'92) allocated the frequency bands of 1885-2050 MHz and 2110-2200 MHz for IMT-2000. IMT-2000 was basically the design architecture and authentication of various competing coding and modulation technologies 3G networks would use.

1.1.2 UMTS Definition

UMTS is the term used in Europe for 3rd generation networks, and it is intended to make the transition from 2nd generation networks smoother, but eventually replace them. This means UMTS will, in the long-term, support all applications currently served by 2nd generation cellular systems such as GSM and PDC, cordless systems like DECT, and satellite systems like IRIDIUM. It will converge contents from the telecom industry like video telephony, IT industry like Internet applications, as well as from the broadcasting industry like video on demand. UMTS will have to support this wide array of services with data rates ranging from 8 kbit/s to 2,048 Mbit/s (later even higher) regardless of location, network, or terminal (adaptive terminals). The costs of such terminals could be kept low by being compensated from a mass market generating huge volumes of data traffic.

The SMG decided to make UMTS backward compatible to GSM in the beginning, but also to upgrade GSM beyond its initial capabilities. UMTS development would therefore, not be compromised by too many compatibility issues.

In order to achieve that goal, UMTS is being developed in a modular Way. This also reduces the risk for operators and allows the creation of a consumer basis for mobile data, which will eventually drive the full deployment of the system as its demand for improved services increases.[18]

UMTS/UTRA is providing much greater data-transmission rates than the current 2G networks using GSM. The rates are as follows:

- 2.048 Mbps for low-mobility outdoor applications, particularly in the pico and micro cellular environments.
- 384 kbps for limited-mobility outdoor applications in the micro and small macro cells (in urban/ suburban areas).

- 144 kbps and 64 kbps for full outdoor mobility applications (large macro cell applications).

- 14.4 kbps for continuous low speed data applications in very large cells.

- 12.2 kbps for speech (4.75 kbps - 12.2 kbps).

- 9.6 kbps globally (satellite).

1.2 The importance of Network planning

Network planning is a major task for operators. It is time consuming, labor-intensive, and expensive. Moreover, it is a never-ending process, which forces a new round of work with each step in the network's evolution and growth. Sometimes extra capacity is needed temporarily in a certain place, especially during telecommunications conferences, and network planning is needed to boost the local capacity. Changes in the network are also needed with changes in the environment: A large new building can change the multipath environment, and a new shopping center can demand new cell sites, and a new highway can create new hotspots.

The quality of the network-planning process has a direct influence on the operator's profits. Poor planning results in a configuration in which some places are awash in unused or underused capacity and some areas may suffer from blocked calls because of the lack of adequate capacity. The income flow will be smaller than it could be, some customers will be unhappy, and expensive equipment will possibly be bought unnecessarily.

For the WCDMA radio access network the problems of dimensioning/planning and algorithm- evaluation/-optimization is a challenging task, which requires methods and tools, that are essentially different from the ones applied for 2G systems. In order to generate reliable results for the highly flexible and dynamic WCDMA network, sophisticated simulation tools have to be applied.

WCDMA cellular networks are being rapidly deployed and expanding with the changes happen on the structure. But, the change of WCDMA network happen without proper planning, a WCDMA radio network can be neither successfully deployed, nor be successfully expanded. Changing the structure of the region and/or type of users on it, demands new planning for the WCDMA network. So, while WCDMA radio network is under operation it will go through optimization and development operation to contain the demands and new business models, this is similar to the new planning except we are saying there are some Base Stations BTs fixed.

As well planned and optimized WCDMA radio network can provide some 30% extra capacities under the same infrastructure cost. The most noticeable thing is network planning and optimization plays vital role for the deployment and maintenance of WCDMA radio networks. From the other sided the planning process will stay challenging issue for long time, because the WCDMA system have self-interference, " breathing effect" and many other effects. The coverage capacity of the BTs restrains each other. So the planning process will be needed frequently as the structure of the region change with time to make sure the trade relation between the coverage, capacity and distribution of the users.

Technically in WCDMA network planning the coverage, capacity and quality of signal are inter-related, multi rate and mixed signal feed to the same carrier at the same time, that shows the complexity of the technology and how the planning process could handle it easily.

For capacity calculations of WCDMA radio interface, due to the possibility of resource allocation for different classes of traffic and sharing the same frequency band, is much more complex. That means all users are going to be served by the same frequency band and the only thing to distinguish them is the orthogonal codes. Things are going to be more complicated when you apply the multipath in to the calculations.

1.3 Objectives of This Project

The main objectives of this project are:

- Develop an understanding of common propagation model used in WCDMA systems.
- To Develop suitable ways capacity and coverage of UMTS are interrelated and their influencing parameters.
- To have an idea about the information required to start and implement a system design (customer requirements: QoS, coverage; traffic for casts, etc.).
- To understand how to calculate the coverage and capacity of a WCDMA network.
- To study UMTS network planning, different parameters and to investigate their effect on the performance of the system.
- To understand the main operations on the network like power control, soft handover.
- Toward implementing an optimization algorithm for planning position of the base station by using Self Organizing Map technique with applying some modification on it, a deep understanding for SOM from side of view related to Artificial Neural Network.

- To develop complete program doing the dimensioning and planning process to any type of region as one package.
- To see the possibility of using some signal process technique for planning, like use different vision of convex sum technique for positioning the base station BTs.
- To implement WCDMA dimensioning and planning methodology in a specific case study.

1.4 Organization of the project:

This project is organized in 7 chapters, with chapter 1 as introduction.

Chapter 2 Gives an overview for hall mobile systems, it describes Their network architecture especially for UMTS network, Network parameters for WCDMA like " types of handover, power control, traffic capacity " and type of service.

Chapter 3 introduces the principles of WCDMA. Like factors that Influence WCDMA network planning & dimensioning process which explain each parameter in link budgets for WCDMA network & its capacity calculation and the idea of dealing with both of them at the same time.

Chapter 4 Talking about Self Organization technique, and what's make it very Powerful technique for optimizing the planning process for optimization. Gives brief talk about SOM modified algorithm with applying the convex sum to the SOM and apply it to the result of dimensioning process.

Chapter 5 presents real case study as an implementation for planning process & dimensioning for WCDMA network where we take Janzour town with area 17.38 km^2, with 100 000 population as a suburban area as a case study.

Chapter 6 Gives the results obtained and a comparison between parameters obtained from different cases of the implementation.

Finally chapter 7 gives conclusions and recommendations of the project.

Chapter II

Overview

2.1. Growth of WCDMA Systems:

In the 2002 as GSM was commercially launched, ETSI had already started the standardization work for the next-generation mobile telecommunications network. This new system was called the *Universal Mobile Telecommunications System* (UMTS). The work was done in ETSI's technical committee *Special Mobile Group* (SMG). SMG was further divided into subgroups SMG1–SMG12 with each subgroup specializing in certain aspects of the system. [3]

Practically and based on the map of frequency bands of different wireless networks. But There have been (and still are) several competing proposals for a global standard which may show more advantages than WCDMA like advanced TDMA, hybrid CDMA/TDMA, and *orthogonal frequency division multiplexing* (OFDM).

But we will speak with some explanations for WCDMA:

The bandwidth of a WCDMA system is 5 MHz or more, and this 5 MHz is also the nominal bandwidth of all WCDMA proposals. This band width is enough to provide data rates of 144 and 384 Kbps (these were 3G targets), and even 2 Mbps in good conditions.

The WCDMA radio interface proposals can be divided into two groups: network synchronous and network asynchronous. In synchronous network all base stations are time synchronized to each other. These results toward more efficient radio interface but require more expensive hardware in base stations. For example, it could be possible to achieve synchronization with the use of *Global Positioning System* (GPS) receivers in all base stations, although this is not as simple as it sounds. GPS receivers are not very useful in high-block city centers (many blind spots) or indoors.

2.1.1 The Architecture of UMTS network with WCDMA air-Interface:

UMTS networks support both types of switching, in each case with special nodes in the Core Network CN. Here the nodes necessary for circuit-switched transmission are shown in the top-right corner of Figure 2.1. This part of the network is heavily based on the existing GSM networks. The nodes used for packet-switched transmission appear underneath. These nodes have already been introduced with GPRS into the GSM architecture, even if some of the protocols are different. Both parts of the core network CN use the same radio access network. The interface between core network CN and Radio Area Network RAN (lu-interface) is divided into the interface for the circuit switched part of the CN (lu-CS-interface) and the interface for the packet switched part (lu-PS-interface).

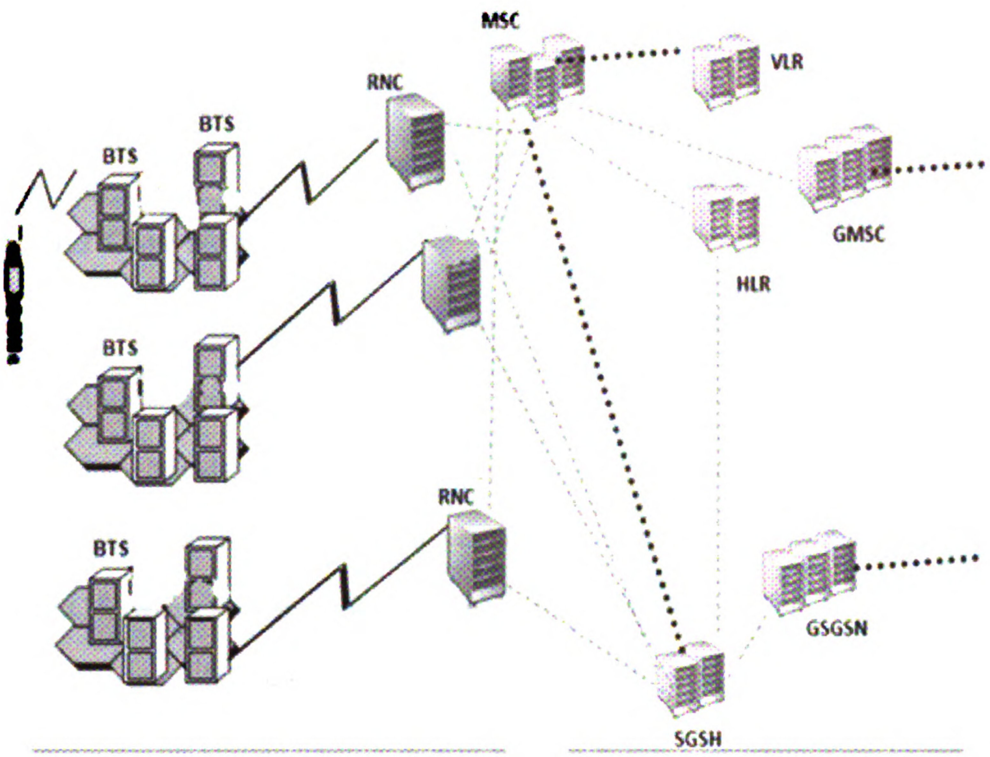

Figure2.1 Architecture of the access plan

The RAN contains two types of nodes: the *Radio Network Controller* (RNC), which controls resource management in one or more base stations (Node B). Node B in turn supplies one or more radio cells. The interface between RNC and Node B is called the lut-interface. A new feature, and not available in this form with GSM, is the direct connection of RNCs over the Iur-interface. The UE is connected with Node B over the Uu-interface. [11]

Compared with the previous generation the major changes are in the radio access network (RAN) with the introduction of code division multiple access (CDMA) technology for the air interface, referred to as wideband CDMA (WCDMA), and asynchronous transfer mode (ATM) as a transport in the transmission part. These changes have been introduced principally to support the transport of voice, video and data services on the same network.

2.1.2 Core Network:

2.1.2.1 Mobile Services Switching Centre (MSC)

The *Mobile Services Switching Centre* (MSC) is a switching node that supports circuit-switched connections. In addition to its switching tasks, an MSC must also support user mobility. If a user moves area while maintaining a connection, the MSC forwards the connection over the appropriate RNCs and Node Bs to the location area of the user (Handover). In addition, the MSC stores (in attached databases) the current location area of the user so that a connection can be set up in the right cell in the event of an incoming call (location management). The MSC also participates in the mechanisms for user authentication as well as in the encryption of user data.

The *Gateway Mobile Services Switching Centre* (GMSC), which also offers interfaces to various external networks, e.g., the *Integrated Services Digital Network* (ISDN), is a special variant of an MSC. The MSC is the central element of the circuit-switched part of the CN. [11]

2.1.2.2 Home Location Register (HLR):

The HLR contains the permanent subscriber data register, which sounds like the personal file of the subscriber. The HLR can be implemented in the same equipment as the MSC/VLR, but the usual arrangement is to have the MSC/VLR as one unit, and the HLR/AuC/EIR combination as another unit. [11]

2.1.2.3 Visitor Location Register (VLR):

The *Visitor Location Register* (VLR) is a database similar to the HLR and stores a local copy of the data from the HLR. However, you can name the data at VLR as temporary data, the data in a VLR is dynamic. As soon as a user changes *location area,* the information in the VLR is updated. [11]

The VLR contains such data that the normal call setup procedures can be handled without consulting the HLR. This is important especially if the user is roaming abroad, and the signaling connection to the home network is expensive.

2.1.2.4 Serving GPRS Support Node (SGSN):

The *Serving GPRS Support Node* (SGSN) carries out tasks for packet-switched transmission similar to those of the MSC and VLR nodes in the circuit switched part. The current position of a user is stored in the SGSN so that an incoming data packet can be routed to the user. In addition to routing functions, the SGSN also handles authentication and stores a local copy of the user information.

2.1.2.5 Gateway GPRS Support Node (GGSN)

The gateways to other packet data networks, such as the Internet, are connected to the *Gateway GPRS Support Node* (GGSN). Consequently,

The GGSN usually incorporates a firewall. Incoming data packets are packed in a special container by the GGSN and forwarded over the *GRPS Tunnel Protocol* (GTP) protocol to the SGSN.

2.1.2.6 GPRS Register (GR):

The information required for the operation of a packet-switched transmission is stored in the GR, a database that is part of the HLR. It includes, for example, a user's authorizations for access to the Internet.

2.1.3 UMTS Terrestrial Radio Access Network:

The UTRAN is the new radio access network designed especially for UMTS. Its boundaries are the Iu interface to the core network and the Uu interface (radio interface) to user equipment (UE).

The UTRAN consists of radio network controllers (RNCs) and Node Bs (base stations). Together, these entities form a radio network subsystem (RNS).

2.1.3.1 Radio Network Controller (RNC)

The *Radio Network Controller* (RNC) is the central node in a radio access network . It takes the place of the *Base Station Controller* (BSC) familiar from GSM and assumes the management of the resources in all attached cells (channel allocation, handover, and power control).

The RNC essentially is responsible for the following:

1. Call admission control
2. Radio resource management
3. Radio bearer set-up and release
4. Code allocation
5. Power control

6. Packet scheduling

7. Handover

8. SRNS relocation

9. Encryption

10. Protocol conversion

11. ATM switching

12. O&M operation and maintenance . [11]

2.1.3.2 Node B:

The name *Node* B is an unfortunate choice: During standardization this name was planned as a temporary solution until the introduction of a more appropriate term. However, the name stuck nevertheless during the course of the standardization activities and therefore the base station in UMTS is called Node B. This node corresponds to the *Base Transceiver Station* (BTS) familiar from GSM. The tasks directly connected to the radio interface are handled in the BTS. The inputs comes from the RNC. A Node B can manage one or several cells and is connected with the RNC over the Iu-interface.

Node B is the counterpart of BTS in GSM. It supplies one or several cells.

Along with the antenna system, Node B includes a CDMA receiver that converts the signals of the radio interface into a data stream and then

forwards it to the RNC over the lub-interface. In the opposite direction the CDMA transmitter prepares incoming data for transport over the radio interface and routes it to the power amplifier. There are three types of Node B corresponding to the two UTRA modes: UTRA-FDD Node B, UTRA-TDD Node B and Dual-mode Node B. which can use both UTRA modes simultaneously.

Currently, the Node B is linked over an ATM link to the RNC. Due to the possible large distance between Node B and RNC and the length of the processing times, certain particularly time-critical tasks cannot be stored in the RNC:

this includes *Inner Loop Power Control* that in a CDMA network ensures that all users receive at the same signal strength.

The RNC has to have as exact a picture as possible of the current situation in a cell so that it can make sensible decisions on handover, power control and call admission control. Consequently, mobile stations and Node B periodically carry out measurements of the connection quality and interference levels and transmit the results to the RNC.

In the special case of softer handover, the splitting and combining of data streams of the various sectors are also already handled in Node B.[11]

2.1.3.3 User Equipment (UE):

The last important network node is the user terminal (UE). This equipment can support one or more radio standards and contains the USIM. It is simultaneously the counterpart to Node B, RNC and the CN

Like Node B, the UE is responsible for processing the radio signal. This compute-intensive task comprises error correction, spreading and signal modulation as well as radio processing up to the power amplifier. On command of the RAN the mobile station must adapt to the transmitter power. [12]

As a counterpart to the RNC, the mobile station participates in the signaling for connection set-up and release as well as in the execution of handovers. For this purpose it measures the received field strength of neighboring cells and transmits the measured values to the RNC. The encryption and decryption of communication also take place with the RNC in the UE.

This long list of tasks handled in a UE is accompanied by the users' request for larger displays that also support the decoding of video data. It is also planned that a camera with an accompanying MPEG codec will be integrated into the equipment. Since a terminal should also enable the playing of games, an efficient processor with substantial memory is to be used. The most important thing, however, is that the equipment should remain small and easy to handle.

The complexity of UE is very high and it will take a big attention on the part of the developers involved to accommodate all the requirements and still develop attractive terminals.[11]

2.2 Network parameters:

2.2.1 Traffic capacity in cellular CDMA networks:

Since the size of a cell depends on the traffic in the network, the location planning for a WCDMA network is always only optimal for a certain volume of traffic. When traffic volumes are low, large areas of overlapping occur; with very low traffic volumes the cells can shrink to such an extent that gaps occur in the radio coverage. Furthermore, the cells *breathe* differently for services that require different *C/I* ratios. The planning of a CDMA network must therefore not only take into account a certain traffic volume but also a certain service or service mix and the respective quality of service (see Figure 2.2).

So the gross transmission rate is reverse proportional to the spreading factor. The required carrier-to-interference ratio at the receiver therefore increases the higher the transmission rate of the respective service. A higher required *C/I* ratio also means a smaller maximum range of radio coverage. Radio coverage for services with a high spreading factor is therefore higher than for services with a low spreading factor. Depending on the network planning, such high-rate services can only be used in the proximity of the base station, whereas services with a lower transmission rate, such as voice services, are available in the entire cell.

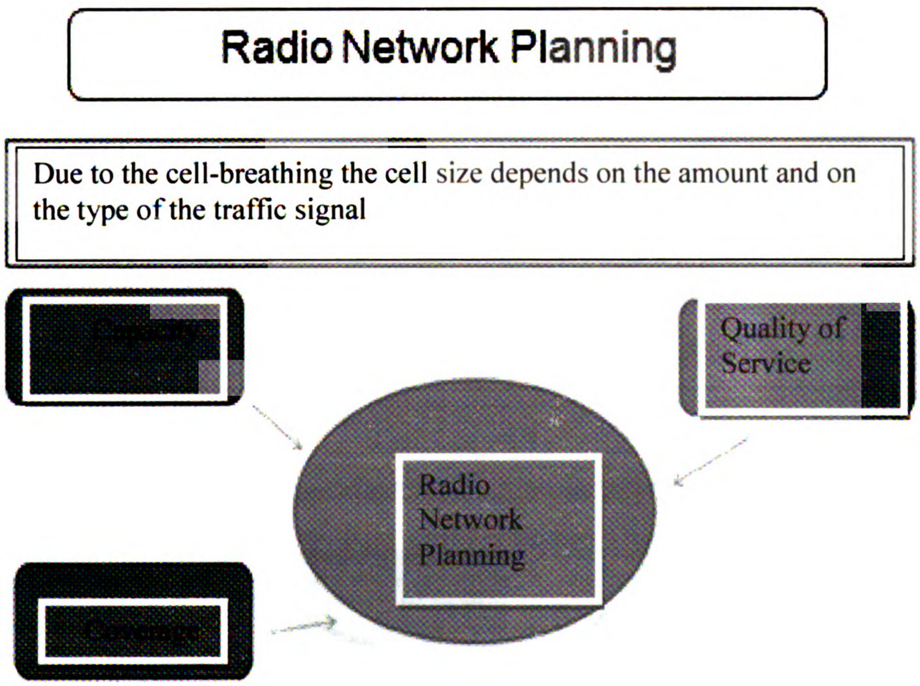

Figure2.2 Interference in radio network planning

The capacity of a cell in a CDMA network essentially depends on the orthogonality and number of spreading codes used. Perfectly orthogonal codes guarantee that the different physical channels do not cause mutual interference. In this case, the traffic capacity of a CDMA cell is only determined by the number of mutually orthogonal codes.

In normal cases where only a scrambling code is used on the downlink in UMTS FDD mode, the theoretical capacity is determined by the number of available Orthogonal Vectors spreading codes.

If the spreading codes are only quasi-orthogonal, as is the case on the uplink of UMTS FDD mode, then cell capacity is determined by the interference this creates.

The transmitters of the mobile stations are controlled by the power control in such a way that in ideal circumstances the signals received at the base station all have the same power, thus preventing near-far effects. Of n transmitters in a cell, one of them thus always supplies the wanted signal; the remaining $n - 1$ contributes to the interference power. As Figure 2.3 shows, the maximum user capacity per cell therefore now only depends on the minimum required C/I ratio.

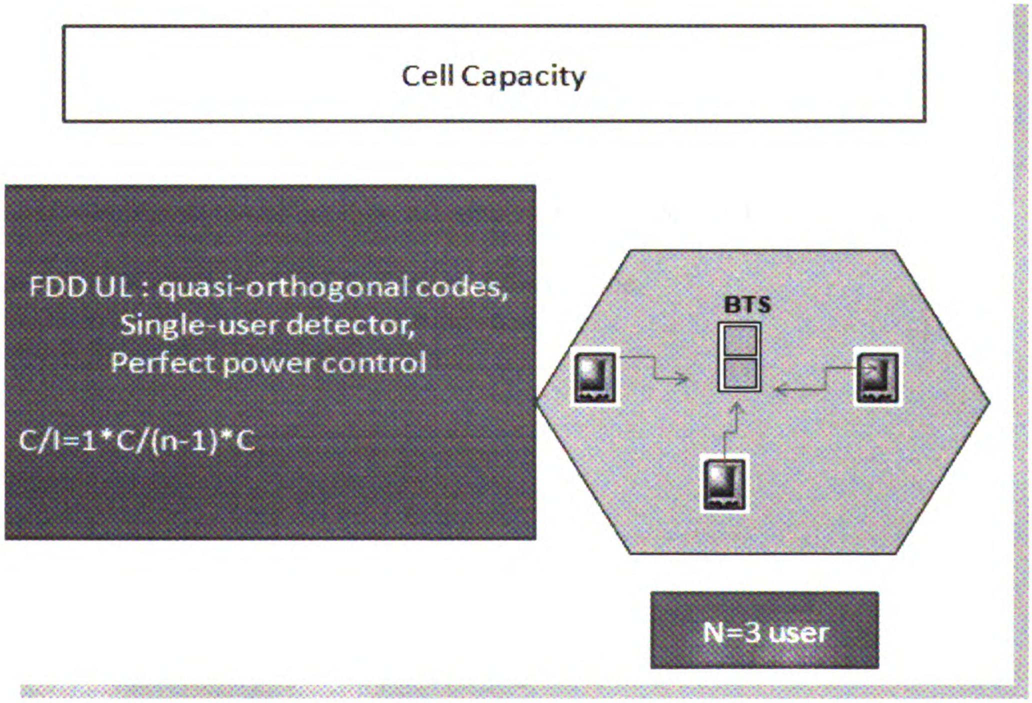

Figure2.3 Simplified calculation of traffic capacity without inter-cell interference

In CDMA networks the interference power is a factor that determines the network capacity. CDMA networks are therefore also referred to as being *interference-limited.*

The connection between user numbers and *C/I* is illustrated in Figure 2.5 the *C/I* at the receiver is spread over the number *n* of active senders in a cell. The more senders that are active in a cell, the higher is the interference power at the receiver and the smaller the *C/I* ratio. The *C/I* ratio required depends on various factors. What is particularly important for determining the required *C/I* ratio are the spreading factor, the channel coding and modulation as well as the tolerable residual bit error ratio. It is obvious from Figure 2.4 that with a required *C/I* of -20dB around 100 users can be active in an individual cell or that with 100 users only a *C/I* ratio of a maximum of -20 dB can be achieved.

The calculation of cell capacity in a multicell mobile radio network has to take into account the intracell interference as well as the intercell interference and thermal noise (see Figure 2.5). In UMTS the spreading codes of different cells are only quasi-orthogonal to one another. All senders in co-channel cells thus produce intercell interference. The interference shown on the

uplink in Figure 2.5 originates in the

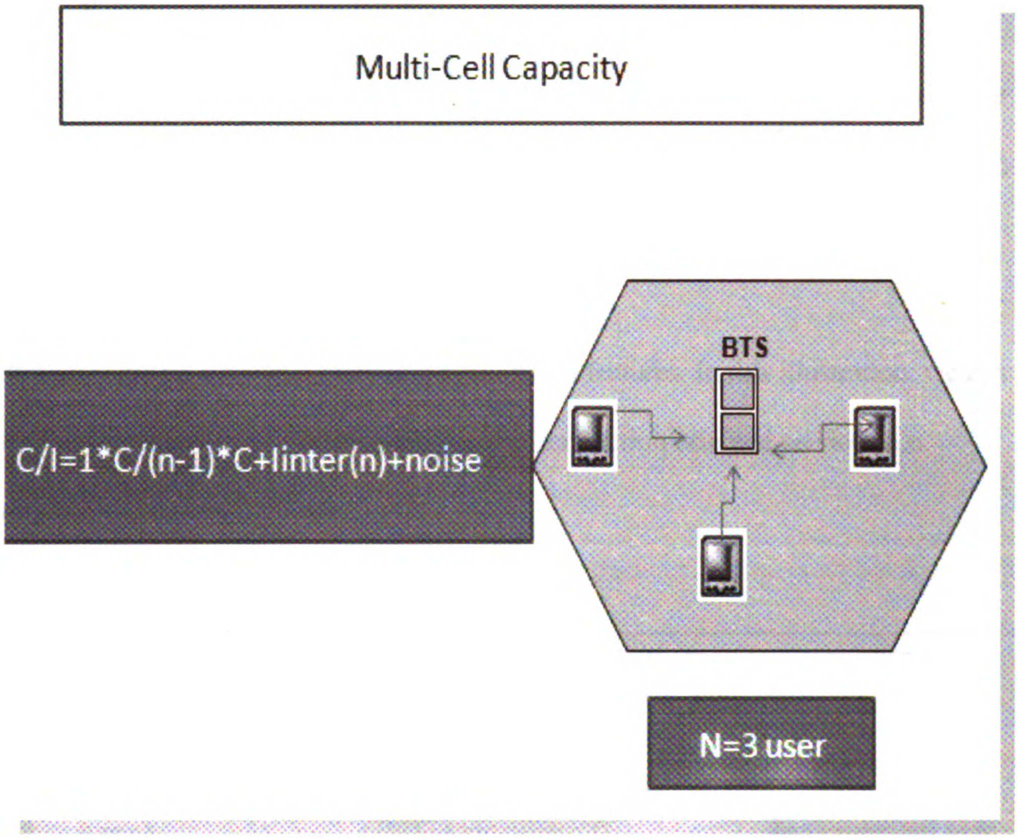

Figure2.4 Calculation of traffic capacity in a multicell CDMA network

transmitters of the mobile stations. In a multicell situation the equation given can no longer simply be resolved based on the number *n* of active participants, because the inter-cell interference also depends on the number of participants in the co-channel cells. However, the cell capacity can also be calculated for a multicell situation. It is easy to see that the cell capacity for a single-cell network is always larger than the cell capacity for a multicell one. Due to thermal noise and intercell interference, the cell capacity in multicell networks is only about half that of single-cell networks that having no intercell interference or thermal noise. [11]

2.2.2 Types of services:

The strength of UMTS services will not reside in one or two applications, but in the conjunction and complementation of a series of application and technologies, which will generate different sets of services. Figure 2.3 illustrates a generic set of application targets.

Primarily for PS networks including multimedia features. In this illustration, we can see the characteristics of connectionless and connection oriented services, i.e. variable and constant bit rate.

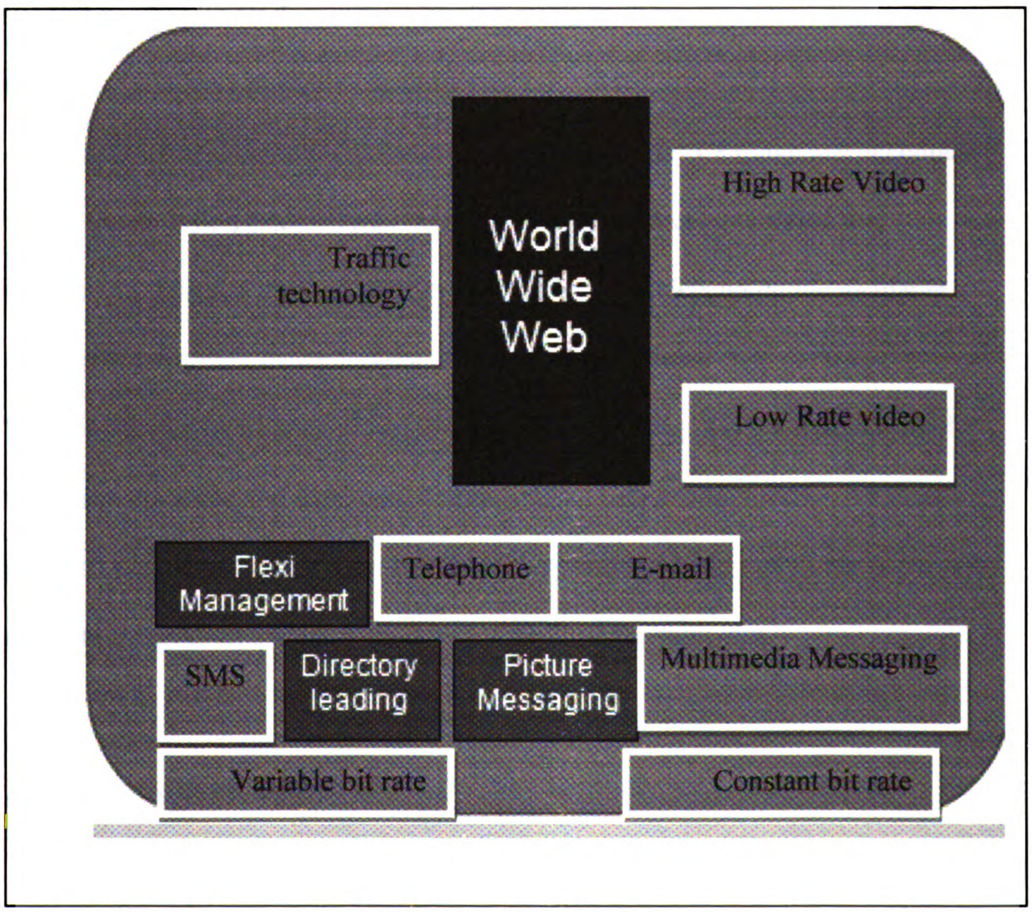

Figure 2.5 Generic range non-voice applications.

We not only need to know to what groups we can address these services (e.g. enterprises, communication firms, telematic centers, content and location based providers, commerce organizations, and typical wireless operators aiming to minimize operational costs and charge). We also need to know where the end user is and how does he/she applies technology.

To meet the needs implies making available the correct tools and environment. Now, if we assume that the infrastructure arrangements will take care of the environment, it remains a big task to find a tool or user equipment device to satisfy users.

A terminal not only needs to be a smart device capable of accessing a PS network, support bandwidth on demand, audio streaming, multimedia, it will also need versatility and have multiple capabilities.

A multi-functional device will make the difference in future usage and acceptance of higher transmission rates offered through UMTS. Market penetration and widespread usage of these of multimedia services will depend on the available and affordable terminals, as well as the pragmatic applications.

Wireless device interconnections, intelligent voice recognition, wireless e-mail, simultaneous voice and data, user defined closed user group, location services personal profile portal, location based delivery and marketing will only occur with efficient integration and inter-working of multiple technologies.

2.2.3. Handover in UMTS:

The term handover always relates to services that are operated on a circuit-switched basis. Packet-switched services use a different technique, which will be explained later.

In UMTS there are mainly three different types of handover. The simple understanding of hand over procedure is shown at Figure

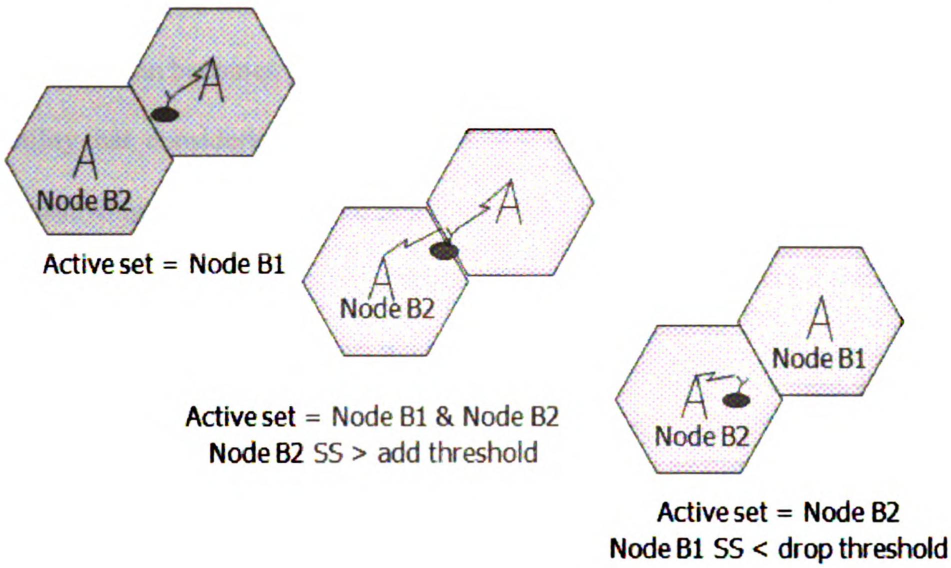

Figure2.6 Hand Over process

The main types of handover are:

1. With *hard handover* already familiar from GSM, a connection is switched hard at a particular time. This method is also used in UTRATDD- mode, because sufficient time is available between the individual transmitters and receivers phases in a mobile station to switch to a new cell. The changeover to the new cell thus occurs from one frame to the next one.

2. A *soft handover* is when a mobile station communicates simultaneously with up to three sectors from different Node-Bs. The data is split up in the RNC (splitting), broadcast over the Node Bs and combined again in the mobile station. Data from all

participating Node Bs is received on the uplink and forwarded to the RNC. The RNC combines the two data streams again and transfers the data to the CN.

This technique is also called macro-diversity and offers several advantages:

a) The connection becomes more resistant to shadowing due to the reduced probability that, considering all supplying base stations, the mobile station will end up in shadowing. If an interference object cuts off a connection to a base station in a soft handover, there is the possibility the connection will function over the second station and the communication will not be cut off.

b) When the minimum received power is calculated, a small reserve against fast fading through multipath propagation can be incorporated. Since the drop in received power through multipath propagation is almost static in the case of static transmitters and can amount to up to 30 dB, it is possible that a static mobile station will not be supplied adequately. Soft handover offers the option of transmitting data over the second Node B and thus maintaining the communication.

c) Furthermore, a soft handover offers the possibility of reducing the near-far effect.

3. *Softer handover* is a special version of soft handover in that transmission can also run in parallel over different sectors of the same Node B. The advantages mentioned in conjunction with soft handover also apply to softer handover, although the Node B can already be entrusted with the task of combining the two data streams and only transferring one data stream to the RNC.

2.2.3.1 Handover types in UMTS:

A distinction is made between various handover types depending on which network elements participate in the handover:

1. Within a Node B a connection can be switched hard or soft from one sector to the next (Intra-Node B, Intra-RNC Handover).
2. Between different Node Bs of the same RNC a connection can be hard switched (Inter-Node B, Intra-RNC-Handover).
3. A connection can be soft switched between the different Node Bs of the same RNC (Inter-Node B, Intra-RNC-Soft-Handover). In this case, the RNC is responsible for the combining/splitting.
4. A connection can also be forwarded between RNCs within the RAN over the Iur-interface. This is the case in which SRNS and DRNS are involved (internal Inter-RNC handover). The term *internal* handover relates to the fact that the handover is carried out totally within the RAN.
5. Switching with relocation of the lu-reference point is called *SRNS relocation.* This is an external Inter-RNC-Handover.

2.2.4 Power control

Power control in a WCDMA system is crucial to its successful operation. This is because each handset transmits on the same frequency and at the same time as other handsets. Each of the handsets therefore generates interference, raising the overall noise level in the cell, and the base station has to be able to distinguish a particular user out of this interference. If a single mobile device is transmitting with too much power, or is physically closer to the BTS, this may drown out the other UEs. Conversely, if a UE is transmitting with too little power, or is physically further away, the base station will never hear it. This is commonly referred to as the *near–far problem.* There are two main concerns regarding power control:

Distance from the base station and fast fading. Within the WCDMA system three types of power regulation are used, open loop, inner loop and outer loop power control. Each of these mechanisms will be dealt with in turn in the following subsections.

The key goals of power control are to:

• provide each UE with sufficient quality regardless of the link condition or distance from the BTS;

• compensate for channel degradation such as fast fading and attenuation;

• optimize power consumption and hence battery life in the UE.

2.2.4.1 Open loop:

This is used when a handset first enters the cell. The handset will monitor the CPICH of the cell and will take received power level measurements of this channel. This information will be used when setting its own power level. The power radiated by the base station will reduce as the distance from the tower increases. Simply having a received power level is not enough information for the mobile device to set its own transmit power. This is because it does not know at this stage at what power level the CPICH was transmitted.

The base station sends out power control information on the broadcast channel, which includes an indication of the power level at which the CPICH is being transmitted. The UE can now determine how much power has been lost over the air interface and thus has an indication of its own distance from the base station. The handset can now calculate what power to transmit at; if it has received a weak signal it will transmit a strong signal since it assumes that it must be a long distance from the base station. Conversely, if it receives a strong signal it assumes that it is near to the base station and can thus send a weaker signal.

The actual mechanism is that the UE will listen to the broadcast channel. From this, it will find out the following parameters:

• CPICH downlink transmit power

• Uplink interference

The UE will then measure the received power of the pilot (CPICH RSCP). The initial power used is then:

Initial power = CPICH downlink transmit power − CPICH RSCP

+ UL interference + Constant value

The constant value really provides a correction figure for better approximation of an appropriate start power. It should be noted that this is a rather approximate mechanism since the base station will be transmitting in a different frequency band to what the handset will use and the power loss over the air interface may be significantly different for each band.

We can summaries the work of power control as the two different mobile devices, depending on their distances from the base station, will send an access request on the RACH at different power levels. This will reduce interference to other mobile devices. The diagram shows separate BCCH and CPICH for the two different mobile devices; in reality only one of each of these is broadcast and all the mobile devices receive it.

2.2.4.2 Inner loop

Inner loop power control feedback is a form of closed loop power control. Information is sent in every slot, i.e. 1500 times per second. This can be compared with IS-95, which has feedback 800 times a second, and GSM, where it is only carried out approximately twice per second. This type of power control is required because the open loop system can only give a rough estimate and is not accurate enough to deal with problems such as fast fading.

To control the power level on the uplink, the base station performs frequent signal to interference ratio (SIR) measurements on the received signals from each of the mobiles. This value is compared to a target SIR value and if the power from the mobile station is deemed to be too high or low it will be told to decrease or increase the power accordingly. Since this task is executed 1500 times per second, it is much faster than power control problems, such as fast fading, that may occur, and hence can compensate for these.

This fast power control is very effective for slow to moderate movement speeds of the mobile device. However, benefits decrease as the speed of the mobile increases. This also deals with the near–far problem, where signals from mobile devices which are far from the base station will suffer greater attenuation.

The object of the fast power control is that the signal from each mobile should arrive at the BTS at its target SIR value. The same type of power control is used on the downlink. When communicating with mobile devices that are on the edge of the cell the base station may *marginally* increase the power it sends. This is required since these particular mobiles may suffer from increased other-cell interference.

2.2.4.2 Outer loop :

As noted, inner loop power control measures the power from the mobile device and compares it to a set SIR target. This target value is set and adjusted by the outer loop power control within the RNC. This value will change over time but does not need to be adjusted at the same high frequency. The target value is actually derived from a target BER or BLER that the service is expected to meet.

Some errors with the data received from the mobile device are expected. If there are no errors, then the UE is assumed to be transmitting at too high a power, with the consequences of causing interference and reducing the battery life of the device. To implement this method of power control the mobile device will compute a checksum before sending any data. Once received, a new checksum is computed on the data and this is compared to the one sent by the mobile device. The BTS will also measure the quality of the received data in terms of BER. If too many frames are being received with errors, or frames have too high a BER, then the power can be increased. The target set-point is not static: it does change over time. This is required so that the cell can be more efficiently utilized. [18]

Chapter III

Network Dimensioning Process

3.1. Introduction:

The Planning and dimensioning process is the initial step on the radio network planning for WCDMA or any other 3G Network. In general we can see three main phases on the network design process: starting with (a) the preparation phase which responsible on setting the principles and collecting the all needed data for the network planning process, followed by (b) the high level network planning phase " Network Dimensioning", and (c) the detailed radio –network planning phase.

This chapter talking mainly on the Dimensioning Process for WCDMA network which the initial step on the whole radio network planning process and we use its outcome as an input for the final stage of the planning process. The dimensioning process uses the all available parameters of the network to get all amounts of instruments we need on installing the network.

The dimensioning must satisfy all the operator's requirements on capacity, coverage and quality of service, where in this chapter we introduce the knowledge of: both coverage and capacity which are related to each other .So, we have to optimize defining them simultaneously; this will be one of our challenging targets during this chapter and its case study.

As the network become under testing mode, we observe its performance by measurements. So, it will be easy to use these measurements to optimize the network performance. But, with intelligent tools, network elements and observation of the changes of all network parameters we can get the optimum values for the network.

In a WCDMA network cell, the available data rate depends on the interference level—the closer the UE is to the base station, the higher the data rates that can be provided. Thus, an operator that is aiming to provide 384-Kbps coverage must use more base stations than an operator that is aiming for 144-Kbps coverage and so on. All this is related to the cell shrinking phenomena but not the main explanation of this phenomena that will be explained in details later on next chapters.

There are other planning parameters must be mentioned like: the allowed blocking

probability, migration aspects (if the operator already has an existing cellular network), the quality of service (QoS), and so on. If call blocking is allowed with a non-negligible probability, then less capacity needs to be allocated as result, and the network will be cheaper and easier to implement.

Now it is clear the WCDMA network is interference limited, where the use of one carrier frequency within all users on all the cells of the network gives the network soft capacity limit (Soft Limit Capacity). The interference limit is mainly effected by the load factor which the main parameter on the dimensioning process and the planning optimization process as well.

This load factor parameter is clearly affected the coverage calculation and the capacity calculation as we will see in this chapter. all these make this parameter playing the main role and make all the process of planning depends on it.

It is clear now after getting through the introductory chapters there are some preliminary steps that an operator must apply like: acquiring the population and vehicle traffic information from the planned coverage area (the project position).

How many people live in an area? How many people work there? What is the vehicle traffic density on main roads during rush hours? Are there any special places that may require lots of capacity at certain times? These could include sports arenas, conference centers, and sites of public festivals. Then the operator must estimate the mobile-phone penetration and the amount of traffic generated by each user. Note that an average business user probably generates more traffic than an average residential user. The business calls will probably be longer, and many of those calls may include data traffic.

3.1.1. Network Planning Terminology

So here are some concepts and terms used in network planning. It mainly gives general idea about Erlangs or blocking probability where its purpose is to clarify the required QoS :

• *Traffic intensity:* is measured in Erlangs. One Erlang is equivalent to one call continued one hour. Thus, the traffic intensity can be calculated from

• [Number of calls (per hour) × average call duration (in seconds)]/3,600

• If the result is smaller than 1 Erlang, then quite often the appropriate unit is the mErlang (= 0.001 Erlang).

• *Traffic density* measures the number of calls per square kilometer (Erlang/km^2).

Traffic density value is only usable for circuit-switched voice calls. For data services, the traffic density usually measured using Mbps/km^2.

• *Spectral efficiency* is defined as the traffic that can be handled within a certain bandwidth and area:

Traffic intensity (Erlang)/(Bandwidth × Area) = bps/(MHz × km^2)

• *Outage* is the probability of a radio network not fulfilling a specified QoS target.

• *Cell loading* indicates the relative occupancy of the cell. This is given as a percentage of the maximum theoretical capacity.

• *Loading factor* defines the amount of interference loaded into the cell by surrounding cells (outer cell interference). This is given as a ratio of the power received by a base station from other cells to the power it receives from mobiles in its own cell. Notice that all power received from outside the home cell is interference. [9]

3.1.2.Dimensioning:

WCDMA radio network dimensioning is a process through which possible configurations and the amount of network equipment needed to install the network are estimated, based on the operator's requirements and through the following calculation. [13]

Coverage:

_ coverage area;

_ area type information ;

_ propagation conditions.

Capacity:

_ spectrum available;

_ subscriber growth forecast;

_ traffic density information.

Quality of Service:

_ area location probability (coverage probability);

_ blocking probability;

_ end user throughput.

Dimensioning calculation including radio link budget and coverage analysis, capacity estimation and, finally, estimations on the amount of sites and base station hardware, radio network controllers (RNC), equipment at different interfaces, and core network elements (i.e. Circuit Switched Domain and Packet Switched Domain Core Networks).[13]

3.2 WCDMA Parameters in link Budgets:

Transmissions in different cells of a CDMA cellular system are not divided into groups of different frequency channels as in an FDMA cellular system, but are wideband and share a common spectral band for all the users. Rather than having the repeating frequency reuse plan of sets 1 to 7 of narrowband frequency channels and take care about the frequency reuse distance, a CDMA cellular system is designed to use the same set of frequencies in each cell or one carrier frequency at time.

The effective size of a CDMA cell, expressed as the radius of a circle or hexagonal, is the maximal distance at which the forward or reverse link can operate reliably, so in the calculation we are working on the less radios which mean the worst case. This distance for a given radio link is the pointer or the indicator for maximal propagation loss that can be tolerated while receiving the signal with sufficient power strength to overcome noise and interference so it can be gotten, as determined by the link's "power budget." It is clear now the effective CDMA cell radius can be completely different on the forward link than it is on the reverse link, where all the parameters of link budget calculation will change completely depending on if the calculation is for up-link or down link. In general, there is more effecting of interference on the upper link (reverse link), that's make the power of signal sent by mobile user is less than the strength of power can be sent by the base-station and that difference of power level are noticeable as we will see later.

Therefore, as will be explained below, an effort is made to "balance" the forward and reverse links by adjusting power and other parameters to make their maximum tolerable propagation losses approximately equal, all this is done under Power control, where in Planning Process we are working with worst case scenario.[9]

First there are some WCDMA-specific parameters in the link budget calculation are not included on 2^{nd} G planning process where here we need to main keys for our calculation because in WCDMA the network are based on interference limit not on frequency reuse factor.

The most important new parameters effected the link budget calculation on WCDMA networks are as following:

* **Interference margin:** The interference margin is needed in the link budget because the loading of the cell, the main indicator for interference margin is the load factor which affects the coverage. The more loading is allowed in the system, the larger is the interference margin so larger load factor which lead to smaller coverage area. So we have two output cases of Link budget calculation: coverage limited or capacity limited.

For coverage-limited cases a smaller interference margin is suggested to get as large as we could, while in capacity-limited cases a larger interference margin should be used to get the maximum capacity. In the coverage-limited cases, the cell size is limited by the maximum allowed path loss in the link budget, and the maximum air interface capacity of the base station site is not used.

* **Fast fading margin (= power control headroom):** It is headroom is needed in the mobile station transmission power for maintaining adequate closed loop fast power control, as we need to apply fast power control to compensate the fast fading. This applies especially to slow-moving pedestrian mobiles where fast power control is able to effectively compensate the fast fading.

Typical values for the fast fading margin are 2.0–5.0 dB for slow-moving mobiles. [13]

* **Soft handover gain:** The soft and the hard handover are gives gain works against the slow fading, where the slow fading is meaning no correlation between the base station and the coming signal. So we apply the gain of hand over as reduction on the required log-normal fading margin and by making a handover the mobile can select a better base station.

The clear constructed way on WCDMA is the soft handover gives extra gain which we can benefit of it because we can decrease required E_b/N_0 relative to a single radio link, due to the effect of macro diversity combining. Typically the total soft handover gain is assumed to be between 2.0 and 3.0 dB in the examples below, including the gain against slow and fast fading.

Other parameters to be specified at this stage include the data rates, mobile speeds, coverage requirements, terrain types, and asymmetry factors. These values can be based on empirical tests or assumptions. [9]

Practically, using of fully dynamic simulator that implements the all effecting radio resources in the link budget calculation like Radio Resource Management simulators (RRM) use input data indicate the Power Control, Soft Handover, Packet Scheduling, etc.

3.2.1 Coverage Calculation steps:

The main calculation step in any wireless network is the link budget calculation or as they named coverage calculation, it is based on the all parameters effecting the signal during its trip from the source to the destination where any obstacles will effect on the negative direction and the gains will effect on positive direction. So, in link budget calculation all the physical distribution of the area should be mentioned in the estimation.

Now we know the load factor and the other WCDMA parameters is effecting the link budget calculation.

✓ So from the first phase we have to calculate the maximum path loss from this equation:

$$L_{max} = \text{EIRP} - \text{receiver sensitivity} + G_{BS\ R} - L_{cabel\ BS} - \text{fast fading gain} \quad (3.1)$$

Where:

Fast fading gain: it's gain depending on the power control which depends on speed of the user.

- $L_{cabel\ BS}$ = Loss per Km * the height of the tower of Base Station (3.2)

- $G_{BS\ R}$: the gain of receiver antenna at the Node B (Base Station).

- Receiver sensitivity = E_b/N_o – 10 log (chip rate / data rate) + Receiver power noise + interference margin. (3.3)

Where

❖ chip rate = 3.84 Mbps is stander for WCDMA

❖ receiver power noise = KTB_TF (3.4)

Where

K: poltizman constant = 1.381×10^{-23} J/K

T : Temperature in Kelvin

B_T: transmitted BW

F: Noise figure

❖ interference margin= 10 log (1- load factor for type of link) (3.5)

EIRP : Effective Isotropic Radiated Power = maximum radiated power from UE transmitter + UE antenna gain + Body loss (3.6)

✓ For the second phase and from the link budgets above, the cell range R can be readily calculated for a known propagation model, for example the Okumura–Hata model or the Walfish–Ikegami model.

The propagation model describes the average signal propagation in that environment, and it converts the maximum allowed propagation loss in dB to the maximum cell range in kilometers. So, instead of having the limited power we will have limited distance or maximum distance between the mobile user and the base station. There are different propagation models already established and done for different types of area based and now we have its own constants and ready to use.

As an example we can take the Okumura–Hata propagation model for an urban macro cell with base station antenna height of 30 m, mobile antenna height of 1.5 m and carrier frequency of 1950 MHz

$$L = 137.4 + 35.2 \log_{10}(R) \qquad (3.7)$$

Where L is the path loss in dB and R is the range in km. For suburban areas we assume an additional area correction factor of 8 dB and obtain the path loss as:

$$L = 129.4 + 35.2 \log_{10}(R) \qquad (3.8)$$

[13]

✓ Now after we know R max, we have a scenario that is doable:

(1) we can see the area of cell and from all area we got the number of Base Stations (node B) and with the distribution of people we can estimate the number of users in the cell. After that, we use the load factor equation; by trial and error solution we can get the actual R for the cell by changing the estimate value of load factor. Repeat all the steps above to get the suitable load factor as shown in figure (3.1).

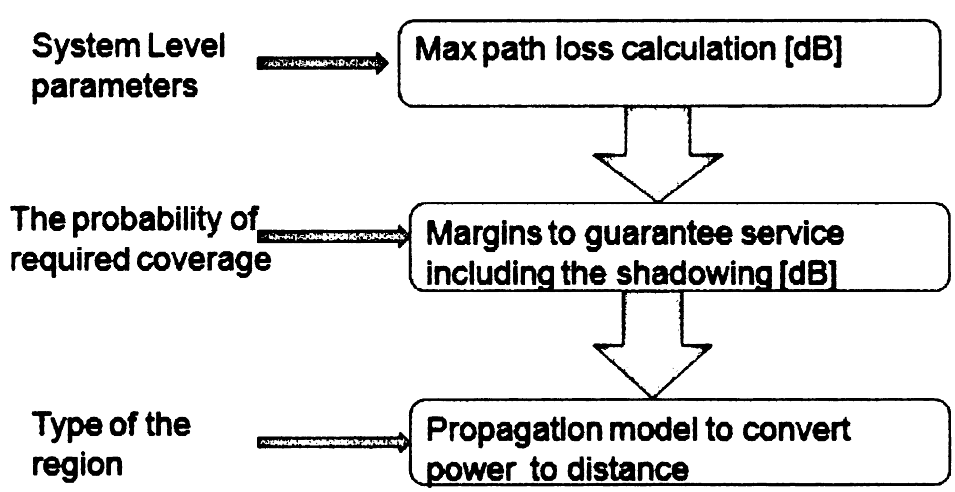

Figure 3.1 Cell range calculation [13]

Using all the previous steps we can decide that, the perfect way of design is to design where a transmitting bit rate is the highest, one but this will create large cost, so we can customize it.

(2) Clearly, the first way depends on trial and error which may not converge and bring us a suitable value. The other clear way for us now, is to change the meaning of our limit from maximum radios to maximum number of subscribers, With this way, we will be clearer with the meaning of the limit. To get the maximum number of subscribers allowable for certain radios we fellow these steps:

1- Get the **density of subscribers** of the whole area we want to install the network on it by: subtracting the population of the region over the area of the region.

2- Using the maximum distance between the subscriber and the base station, which we got for the link budget calculation as radios of hexagonal cell and find the **hexagonal cell area**.

3- Take the output of the (density of subscriber x hexagonal cell area) as the maximum number of subscribers the base station can cover based on the link budget calculation.

Now we have the maximum limit of coverage on terms of number of the subscribers which is going to help us on the optimization stage after we get the output of the capacity calculation.

3.2.2. Load factors:

As clear the importance of the load factor is playing on the WCDMA calculation, where it has the biggest effect is on the link budget calculation, as well as in noise rise and fading margin. So it is very important to see what it means exactly, how can we calculate it or get the optimum value of it, what are the most important parameters effecting it, and how is it effecting the planning process.

It is estimating the amount of supported traffic per base station site. To see the meaning of its values: if the frequency reuse of a WCDMA system is 1, the system is typically interference-limited and the amount of interference and delivered cell capacity must thus be estimated.

It is clear now that the load factor is the indicator for the interference in front of the receiver and it is different in uplink to the downlink.

3.2.1.1. Uplink Load Factor:

Moving toward a full understanding of load factor, we will start to understand the main parameters effecting the load factor, even theoretically. Additionally, spectral efficiency of a WCDMA cell can be calculated from the load equation, whose derivation is shown below. We first define the E_b/N_O, energy per bit to noise spectral density ratio:

$$\left(\frac{\text{Eb}}{\text{No}}\right)_j = \text{G}_j \cdot \frac{\text{Signal power of user j}}{\text{Total receiver power}} \tag{3.9}$$

where G_j is the processing gain of user j

This can be written:

$$\left(\frac{\text{Eb}}{\text{No}}\right)j = \frac{W}{\alpha.Rj} \cdot \frac{Pj}{Itotal-Pj} \tag{3.10}$$

P_j is the received signal power from user j,

W is the chip rate (= 3840 kbps) for WCDMA network,

α_j is the activity factor of user j where services are not in use 100 % of the time,

R_j is the bit rate of user j and

I_{total} is the total received wideband power including thermal noise power in the

Base Station. Solving for P_j gives:

$$P_j = \frac{1}{1+[\frac{W}{\left(\frac{E_b}{N_o}\right)_j . R_j . \alpha_j}]} . I_{total} \qquad (3.11)$$

By defining $P_j = L_j \times I_{\text{total}}$, we obtain the UL load factor L_j of one connection:

$$Lj = \frac{1}{1+[W/\left(\frac{Eb}{No}\right)_j . Rj . \propto j]} \qquad (3.12)$$

Where L_j is the fraction of the total power received at the BS that constitutes the

"wanted signal".

For practical meaning of the load factor, we insert would typical values like:

$(E_b/N_o)_j = 5$ dB

$W = 3840$ kcps

$R_j = 12.2$ kbps

$\alpha_j = 0.67$ for voice & 1 for data

$\rightarrow L_j = 1/150$

Thus the j^{th} user must be responsible for 1/150 of the total power received by the BS.

The total received interference, excluding the thermal noise P_N, can be written as the sum of the received powers from all *N* users in the same cell.

Now the load factor of single user has been established. So, the total load factor is:

$$\eta UL = \sum_{j=1}^{m} Nj.Lj \tag{3.13}$$

and it is clear that *m* is the number of traffic classes or services you have.

Nj is the number of users of j service.

Equation (3.13) is for a single cell system. But, in reality usually the system consists of multi cells so the other cells subscriber will have an effect on its own cell interference, which will change the equation (3.13) with another equation, including the interference factor on it as:

$$\eta_{UL} = (1+i).\sum_{j=1}^{m} N_j L_j \tag{3.13}$$

The bigger load factor, the higher level of the noise generated in the system. The noise rise is defined as the ratio of the total received wideband power to the noise power:

$$Noise\ rise = \frac{I_{total}}{P_N} = \frac{1}{1-\sum_{j=1}^{N} Lj} = \frac{1}{1-\eta_{ul}} \tag{3.14}$$

Where we have defined the overall UL load factor as:

$$\eta_{ul} = \sum_{j=1}^{N} L_j \tag{3.15}$$

As η_{ul} moves closer to one , the corresponding noise rise approaches to infinity and the system will have pole capacity.

As the whole network works with the same frequencies, the other cell will have its effectiveness in the load factor. So, the interference from the other cells must be included by the ratio of the other cell to own cell interference, "i":

$$Interferance\ ratio\ (i) = \frac{other\ cell\ interference}{own\ cell\ interference} \tag{3.16}$$

The UL load factor can then be written as

$$\eta UL = (1+i).\sum_{j=1}^{N} Lj = (1+i).\sum_{j=1}^{N} \frac{1}{1+[\frac{W}{(\frac{Eb}{No})j\ .\ Rj\ .\ \alpha j}]} \tag{3.17}$$

The up load equation is the best prediction or indicator for the noise rise over thermal noise due to interference. The noise rise is equal to $-10\log_{10}(1-\eta_{\text{ul}})$. The interference margin in the link budget must be equal to the maximum planned noise rise. The parameters are further explained in this chapter.

The load equation is giving us a semi-analytical prediction of the average capacity of a WCDMA cell, without going into system-level capacity simulations. This is the second place we find the effect of the load factor after we know its effect on the link budget calculation. This load equation can be used for the purpose of predicting cell capacity and planning noise rise which is very important in the dimensioning process.

If there are N identical users each using a data rate of R, the above UL load equation can be approximated and simplified to:

$$\eta_{ul} = \frac{N(1+i)}{1+\frac{W}{\left(\frac{E_b}{N_o}\right)R.\alpha}} \tag{3.18}$$

$$\text{Throughput} = N \times R \tag{3.19}$$

Examining the noise rise (Equations 3.14, 3.18 and 3.19) reveals that the noise rise will approach infinity as:

$$\text{Throughput} \rightarrow \frac{R\,.\alpha+\left(\frac{W}{\frac{E_b}{N_o}}\right)}{\alpha\,.(1+i)} \tag{3.20}$$

This value of throughput is the "pole capacity". The actual throughput of the cell is planned to be a fraction of this in accordance with the allowed noise rise. A throughput of 50 % of this value would be appropriate for a noise rise of 3 dB.

$$\text{UL Throughput} = \eta_{ul} \times \text{Pole Capacity} \tag{3.21}$$

For a large number of users, we can note that:

$$\frac{W}{\left(\frac{Eb}{No}\right).R.\alpha} \gg 1 \tag{3.22}$$

If there are N identical users each using a data rate of R, the above UL load equation can be approximated and simplified to:

$$\eta_{ul} = \frac{E_b/N_o}{W/R}\,.N.\alpha\,.(1+i) \tag{3.23}$$

Notice that, in the approximation and assumption above, the loading factor is directly proportional to throughput. Examining the noise rise (Equations 3.14, 3.19 and 3.24) reveals that the noise rise will approach infinity as

$$\text{Throughput} \rightarrow \frac{W}{\left(\frac{E_b}{N_o}\right)\alpha(1+i)} \qquad (3.24)$$

This value of throughput is known as the "pole capacity".[13]

The load factor equation's parameters have its own definitions and recommended values like:

N: Number of users per cell, most wanted value in dimensioning process.

α_j: Activity factor of user j at physical layer. Based on [13] it is 0.67 for, assumed 50% voice activity and 1.0 for data transmission.

E_b/N_0: Signal Energy per bit divided by noise spectral density that is required to meet a specific Blocking error rate. Its value is dependent on the service, bit rate, multipath fading channel, mobile speed, etc.

W: WCDMA chip rate which usually is 3.84 Mcps

R_j : Bit rate of user j or the speed of the service the user j using.

i: Other cell to own cell interference, we can get its value based on equation (3.16)

3.2.1.2 Down Link load Factor:

As we have to connection during the call one is uplink connection the other is downlink connection. It is clear the most effected link on dimensioning and planning process is the uplink. This is based on the knowledge of the interference ratio that is higher in the uplink than on the down link, more discussion about this information will be mentioned later. But, deep understanding is needed on the downlink calculation because it is effecting the type of sending channels by base station. We can see the best technique we use for the handover through the downlink load factor and it has extra factors effecting it like orthognality factor, etc.

Downlink load factor ($\eta_{\_DL}$) mainly has the same factors that we are using in calculating the $\eta_{\_up}$ and it is based on a similar principle as the uplink. Equation (3.25) has the form:

$$\eta DL = \sum_{j=1}^{N} Vj \cdot \frac{\left(\frac{Eb}{No}\right)j}{W/Rj} \cdot [(1 - \alpha') + i'] \tag{3.25}$$

Similarly, the noise rise over thermal noise due to multiple access interference can be expressed as in the uplink by: [$-10\log_{10}(1-\eta_{DL})$]. In equation (3.25) there are new parameters like α which is a very important parameter on η_{DL} where it is named as Orthogonality Factor. WCDMA employs orthogonal codes in the downlink to separate users, and without any multipath propagation the orthogonality remains when the base station signal is received by the mobile.

However, if there is sufficient delay spread in the radio channel, the mobile will see part of the base station signal as multiple access interference. The orthogonality of 1 corresponds to perfectly orthogonal users, and zero means no orthognality. Typically, the orthogonality is between 0.4 and 0.9 in multipath channels.[13]

The other parameters used on the down load factor calculation and not included in the uplink equation, which are somehow related to the othogonality factor like:

α' : is the average orthognality factor on the cell, which usually has value between 50% - 90%

i' : is the average ratio of the other cell to own cell base station power received by user. Usually, has values between 55% - up to the 65 % for three sectors case.

In the downlink, the ratio of the other cell to own cell interference, i, depends on the user location and is therefore different for each user j. The load factor can be approximated by its average value across the cell, that is:

$$\eta_{DL} = \sum_{j=1}^{N} V_j . \frac{\left(\frac{E_b}{N_o}\right)_j}{\frac{W}{R}} . [(1-\alpha) + i] \qquad (3.26)$$

The downlink interference modeling can be done in two ways, based on [13] the two ways are:

1. Increase the number of connections by soft handover overhead, and of course, reducing the E_b/N_0 requirement per link with soft handover gain.

2. Keep the number of connections fixed, i.e. equal to the number of users, and use the combined E_b/N_0 requirement.

3.2.1.2 .1 Down Link Common Channels:

In WCDMA the base station sending the traffic channel to the mobile user and the base station sends other type of channels to the mobile user as well, which are sent independently as part of downlink power. The amount of power of the common channels affects the synchronization time, channel estimation accuracy, and the reception quality of the broadcast channel.

The other downlink channels are effecting part of the capacity on the downlink. But it is very good to know these channels and their participation on the downlink. Table 3.1[13] has good descriptions of the specification of these channels.

Table 3.1 Typical powers for the downlink common channels [13]

Downlink common channel	**Relative to CPICH**	**Activity**	**Average power Allocation with 20 W Maximum power**
Common pilot channel CPICH	**0dB**	**100%**	**2.0W**
Primary synchronization channel SCH	**-3dB**	**10%**	**0.1W**
Secondary synchronization channel SCH	**-3dB**	**10%**	**0.1W**
Primary common control physical Channel P-CCPCh	**-5dB**	**90%**	**0.6W**
Paging indicator channel PICH	**-8dB**	**100%**	**0.3W**
Acquisition indicator channel AICH	**-8dB**	**100%**	**0.3W**
Secondary common control physical Channel S-CCPCH	**0dB**	**10%**	**0.2W**
Total common channel powers			**3.6 W**

3.3 Cell capacity Calculation :

The main goal of the WCDMA technology is to fulfil the user requirements which become an innovative services such as enhanced and multimedia messaging through high-speed data channels, which mean very high capacity transmission.

Due to the high costs and the scarcity of radio resources like lack or limit of the spectrum, an accurate and efficient mobile network planning procedure is required. Again the purpose of network planning is to maximize the (usually conflicting goals of) coverage, capacity and the quality of service which lead to the trade of between these requirements.

We are dealing with single cell or even single sector alone then we get to the system level calculation, there are several parameters effects the capacity of the cell which leads to different scenarios, where some scenarios are difficult to solve or deal with. we are dealing with basic scenarios we named as initial senior. So, we can understand and deal with it, then we try to touch the reality by make calculation for complicated ones which will be the final thing.

As it is clear now the load factor is very important parameter on capacity calculation, where it should be included in any capacity calculation, even if it is not included as parameter it will be in other parameter like noise or interference or any other parameter depends on it. Here we have in our final capacity equation the load factor as clear effecting parameter, the load factor is pushing to word the optimization between the coverage and capacity and keep tradeoff on the value of the load factor. In other techniques they just make change on the load factor only up they get very close results on capacity and coverage. But, here as we will see at the end of this chapter we have more than on transient variable.

The output of the capacity calculation or the capacity equation is the number of subscriber that connected to the Base Station at the busy hour, this number is in reality the maximum number of channels that connected to Base Station which mean:

In case of we want to see how many subscriber can one base station afford the connection to, we have to use the Erlang calculation and the Erlang tables, then base on the type of the Erlang we used to work with we could get the amount of users that one base station can cover. But, here after we reach to the final equation we start use it to get the number of channels, then we use Erlang tables which based on equation mentioned on (3.1.1) to get to maximum number of subscriber can each Base station cover to offer its service.

Initial Model for Capacity Calculation :

We first attempt to calculate the maximum number of users in a particular cell. This is based on a static capacity calculation and the following assumptions are made:

1. Each cell is completely isolated. That is, there is no inter-cell interference should be mentioned in the calculation, where we can add the effect of inter-cell interference later when we get the other capacity equation parameters .
2. Signals from mobile stations cause no interference within the cell. That is mean there is no intra-cell interference. We put this just for the beginning.

3. There is perfect power control from the base station. That is mean, all signals arrive at the base station with equal power. It seems like something ideally but somehow doable.

4. There is no limit to the number of spreading codes available. Which mean ideally orthogonal coding.

The actual capacity of a CDMA cell depends on many different factors, such as power control accuracy, interference power, soft and softer handover, etc. We begin by calculating the signal- to-interference ratio which number of subscriber at busy hour is main parameter on it . If there are N users in a cell and the signal is denoted by S then the interference can be calculated as { (N - 1) S +Noise}, where (Noise) is the thermal noise. Hence the SIR is given by

$$SIR = \frac{S}{(N-1)S+Noise} = \frac{1}{(N-1)+Noise/S} \quad (3.27)$$

The value of the Signal to interference ratio is function of number of subscriber on the cell, where all other users cause the interference to certain UE with each by the signal strength. So, the interference is based upon the four assumptions above and is not realistic. For this work we only use this value since other factors are small in our situation. Other interference factors are known as inter- cell and intra-cell interference. The inter-cell interference is attributed to mobile stations and base stations in one cell affecting the operations in another. This brings unwanted noise. Intra-cell interference can be attributed to the effect one mobile station has on the transmitted signal of another within the same cell. It is a simple step to change the interference value to consider the other two factors (inter cell interference and intra-cell interference) which will make equation (3.27) more complicated and closer to the reality.

Suppose the digital demodulator for each users can operate against the noise at an energy per bit-to noise power density level is given by E_b/I_o , where $E_b=S/R$ *and* $I_o= I/W$.

$$\frac{E_b}{I_o} = \frac{S/R}{I/W} = SIR\ \frac{W}{R} \qquad (3.28)$$

Here W is the chip rate and R is rate of data communication.

Hence using (3-27) and (3-28) we can obtain

$$(N-1) = \frac{W/R}{\frac{E_b}{I_o}} - \text{Noise/S} \qquad (3.29)$$

In particular, in the case the user is not speaking during part of the conversation, the output of the coder should be lowered to prevent the power from being transmitted unnecessarily. This reduces the average signal power of all users and consequently the interference received by each user. Then the capacity is increased proportional to this overall rate reduction provided. Speech statistics shows that a user in a conversation typically speaks close to 38% of the time. the effects of voice activity and Sectorization should be considered. This results in an increase in the E_b/I_o by a voice activity gain factor, G_V. Similarly, the sectionsation gain factor G_S.

Also increases the E_b/I_O and the equation for the effective number of users now , N_ε becomes:

$$(N_\varepsilon - 1) = G_v G_s \left(\frac{W/R}{\frac{E_b}{I_o}} - \frac{Noise}{S} \right) \qquad (3.30)$$

Using speech statistics we can set G_V = 2.63 and based upon the usual three sectors for a cell, G_S =2.63.

$\frac{W/R}{\frac{E_b}{Io}}$ is typically valued between 20 to 1000.

Finally, for a cellular system in which all users in all cells employ the common spectral allocation of W in Hertz, we must evaluate the interference. Normally the total interference equal the amount of interference from other cells and interference from given cells.

We define:

f=(interference from other cells)/(interference from given cell)

Due to the interference, the actual numbers of user will decrease from $(N_{\varepsilon} - 1)$ to $(N_{\Phi} - 1)$, the equation (3.30) will be modified into (3.31) :

$$N_{\emptyset} - 1 = G_v G_S \left(\frac{W/R}{\frac{E_b}{I_o}} - \frac{Noise}{S} \right) . \frac{1}{1+f} \tag{3.31}$$

Normally, the total interference from users in all other cells equals approximately three-fifths of that caused by all users in the given cell. That is to say, 1+f=1.6.[10] Based on very recent research papers, based in the equations mentioned on [13],[2] and [3] and based on the equation (3.18) after we apply equation(3.14) on it we can get to better shape with same effect of capacity equation (3.31) as:

$$N = \eta_{UL} . \left(1 + \frac{W/R}{\frac{E_b}{I_o}} \right) . G_v G_S . \frac{1}{1+f} \tag{3.32}$$

We used equation (3.32) as final shape of capacity calculation which brings out the number of subscribers that single base station can serve at the busy hour, where we use all effecting parameters of capacity calculation in this sequence in our simulation program instead of the load factor equation as all the references use like equation (3.18). Equation (3.32) gives more flexibility and more accurate for optimization.

3.4. Simulation Procedure:

After we got the main equations we need to calculate the main important criteria on the dimensioning and planning process, now we could start the optimization process based in these equations.

3.4.1. Simulation Procedure by Controlling the number of users on the cell:

This type of simulation procedure is done by applying certain value of the load factor to both the capacity calculation and the coverage calculation that satisfy the required QoS, then the iteration is started and keep continue decreasing the number of the subscriber on the cell up to the condition of the output of coverage calculation equal or less the output of the capacity calculation.\(Here we mean by output of capacity calculation is number of subscriber based on capacity equation N_C and we mean by output of coverage calculation is the number of subscriber based on coverage equations N_R . After we reach to the optimum value we could get the coverage area with the cell and the capacity within the cell.

3.4.2. Simulation Procedure by controlling both radios & load factor of the cell:

We will see in more details an implementation of simulation procedure by controlling both radios and load factor, where now we just explaining the main methodology of optimization process.

Before we start for the examples we can see the steps for coverage calculation as in fig 3.3:

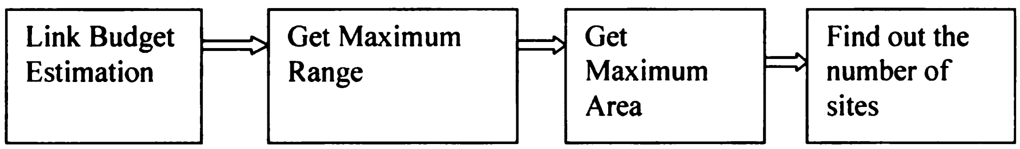

Figure 3.2 Main steps Coverage-based dimensioning

Our main contribution is in optimizing the best solution between the coverage and the capacity results. Where we made the result of both calculation (Coverage and Capacity) on the same unite, this unite is the number of subscriber where we got number of subscribers that can be covered by single base station based in all coverage parameters and we called N_R. The same thing is going to be done for the capacity calculation where we could find out the number of subscribers that each base station can serve based on the capacity parameters for each scenario. So, our main goal to make these two values to be equal with certain accuracy, where the accuracy will help a lot on budget where it helps a lot to save number of base stations. The issue is as mentioned early in this chapter is both calculations depends on the load factor η_{ul} of the uplink (reverse link).

To solve this optimization problem we make Matlab code see graphically how the performance of both values, where this will lead us to the best procedure we could follow in our optimized solution.

3.4.2.1. Simulation procedure simplifying the relation between coverage and capacity calculation:

As mentioned earlier in this chapter our both outputs (coverage output and capacity output) are depends on the Load Factor of the uplink η_{ul} and the all other parameters which explained above, which has big effect on the result of both calculations.

By establishing a fixed scenario with specific values of these parameters, changing the common parameter η_{ul} within its rang to get different results on the both calculations. This shows the performance and the effect that the load factor η_{ul} have for both calculations, and show the function between the both results (N_R, N_c) and the load factor η_{ul}.

The main condition in WCDMA planning calculation is the result should satisfy the capacity and coverage calculation. where in some situation this condition can't be satisfied accurately, always there are approximations because there is a difficulty of applying the accurate values on the calculations. That's happen in most simulation programs. But, watching the true relation between the results of the two calculation helps on choosing optimal approximation, especially that is going to help a lot on understanding the relation between the main factors on the calculation.

- The capacity calculation we count the number of subscribers that can each BTs offer them the service by equation (3.32):

$$N_c - 1 = \frac{\eta_{ul} \, {}^{W}/_{R}}{v_j \, (1+in)^{E_b}/_{N_o}} \, G_s \qquad (3.33)$$

This part we are trying to be qualitative while trying to describe the several Function and their relations to each other. A good presentation for equation (3.33) is:

$$N_c - 1 = C_1 \, \eta_{ul} \qquad (3.34)$$

Where C_1 is certain constant can be calculated for specific value of each parameter on equation (3.33) as the situation of the area will sign these values.

For the coverage calculation which has several equations, we have to go through those equation with applying the value of the load factor, and as we are looking for qualitative description we will explain the coverage equations (3.1), (3.2), ... (3.7) qualitatively :

$$\mathrm{P_{rev}} = \mathrm{P_{tra}} - \mathrm{L_{T1}} + \mathrm{G} \qquad (3.35)$$

Or $$L_{T1} = P_{tra} - P_{rev} + G$$

Practically, we apply most of the effective parameters on the Air Interference to equation (3.35) and the path losses can be calculated as:

$$L_{T1} = P_{tra} - (-10\log_{10}(1-\eta_{ul}) + KTB + NF + EbNo - PG + Lf - Gm + Lm + Hm + Vm + Bm - Gb + Lb + Tm + Fm + Sm) \quad (3.36)$$

All the Air Interface parameters on equation (3.36) has been introduced in earlier equations, and for qualitative analysis we could explain it as:

$$L_{T1} = C_2 + 10\log_{10}(1-\eta_{ul}) \quad (3.37)$$

The other effecting equation is L_{T2} equation which explaining the path losses for the signal while it is traveling in certain region within specific distance R_{Km}, this equation is modeled by different presentations and by different ways. Where in each way there are several presentations based on the type of the area, the carrier frequency and other different parameters. As we are making our work based on Hata model, we chose to present equation (3.38) and it's presentation for suburban area with carrier frequency greater than 400 MHz for example to see the qualitative flavor of the scenario:

$$L_{T2} = [69.55 + 26.16\, log_{10}\, (f_{MHz} - 13.82\, log_{10}\, (h_1) - a(h_2) + (44.9 - 6.55 log_{10}\, (h_1)) log_{10}\, (R_{km}) - K \quad (3.38)$$

It is clear that f_{MHz} is the carrier frequency in MHz, h_1 and h_2 are the base station antenna height and mobile antenna height in sequence. R_{Km} is the distance of the light sight between the two antennas. K is a correction factor on Hata model equation and it has its own equation for each situation or each presentation of Hata model equation.

Where as in equation (3.38) which is sample case of Hata model equation which change with changing the region type, carrier frequency and the other parameters. We can fix most of parameters based on certain situation we have in purpose of qualitative presentation of the equation. So, we can present equation (3.38) as:

$$L_{T2} = C_5 + C_3 \log(R_{Km}) \tag{3.39}$$

For summaries most of the constants we got on our previous analysis are:

C_5=69.55+26.16$\log_{10} f_{MHz}$ – 13.82 $\log_{10}$(h1) – a(h_2) – K.

$C_2 = P_{tra} - KTB - NF - E_b/N_o - PG + L_f + G_m - L_m - H_m - V_m - B_m + G_b - L_b - T_m - F_m - S_m$.

C_3= 44.9 – 6.55$\log_{10}(h_1)$.

As both path losses calculation should be equal. We always can say:

$$L_{T2} = L_{T1} \tag{3.40}$$

We are applying the relation on equation (3.40) to get the value of R_{Km} as function of η_{ul} as we will see at the end of this derivation. And the qualitative shape for the relation are:

$$C_5 + C_3 \log_{10}(R_{Km}) = C_2 + 10\log(1 - \eta_{ul}) \tag{3.41}$$

And based on all Hata equations, equation (3.38) and the steps we need to take them toward getting the maximum distance that our signal can reach, this distance is the radius of each cell, and qualitatively this radius is:

$$R_{Km} = 10^{\left(\frac{C_2 - C_5}{C_3}\right)} (1 - \eta_{ul})^{\frac{10}{C_3}} \tag{3.42}$$

That's leads to:

$$N_R = \rho \frac{3}{2} * R^2{}_{Km} \tag{3.43}$$

Where ρ is the people density on the region and is easily calculated by:

$$\rho = \frac{Total\ number\ of\ the\ subscriber\ in\ the\ region}{Total\ area\ of\ the\ whole\ region} \tag{3.44}$$

So, the equation (3.43) can be written as :

$$N_R = \rho \frac{3}{2} * \left(10^{\left(\frac{C_2 - C_5}{C_3}\right)} (1 - \eta_{ul})^{\frac{10}{C_3}}\right)^2 \tag{3.45}$$

Now it is clear that the relation between η_{ul} and N_R is not linear as equation

(3.43) can tell, which mean our calculation is touching the reality situation in some since.

As we run both calculations which already summarized briefly on equations (3.34) and (3.45), we can see the relation between the two calculations and it is clear there are always an intersection between the two relations in all different situation or in any circumstances. This part of simulation is dealing with all conditions and circumstances and plot the intersection curves to give an indication about the suitable value of η_{ul} to start with which is close to the intersection point in figure (3.3).

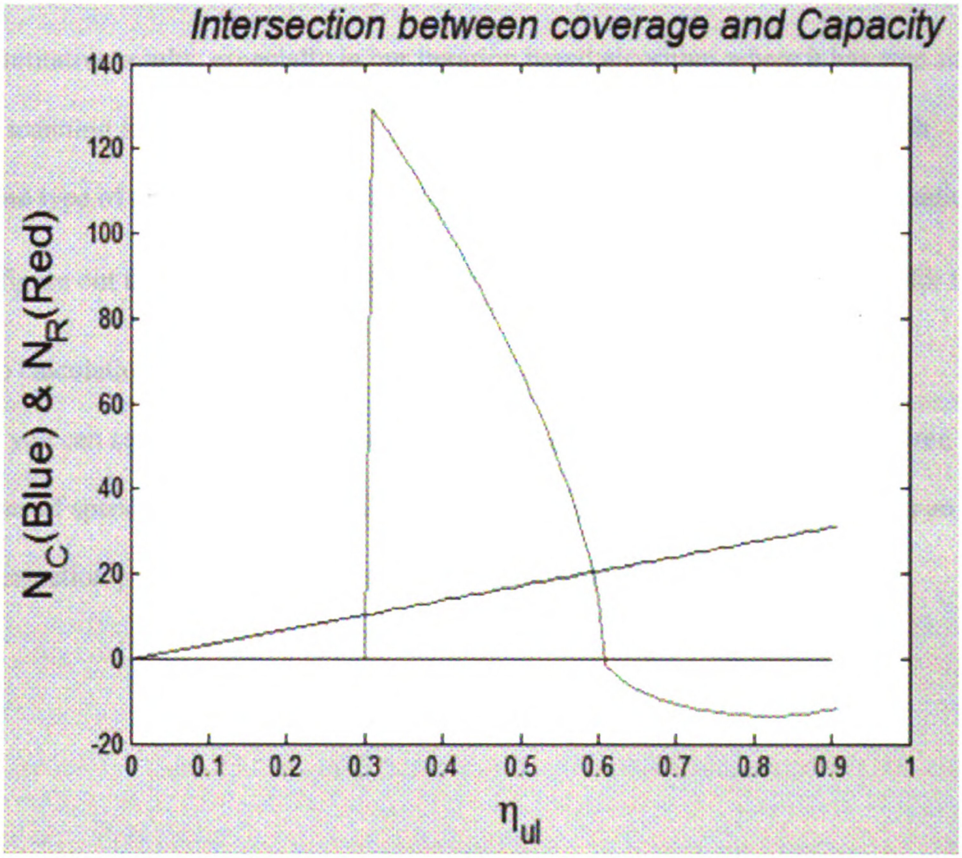

Figure3.3 Relation of coverage, capacity and load factor η_{ul}

In figure(3.3) is plot for the output of both calculations coverage and capacity for all values of η_{ul} in the range, where based on [4] the suitable values of η_{ul} is within the range of (0.3 – 0.7) and figure(3.3) shows that the suitable value of η_{ul} is between (0.3 – 0.64) which reasonable.

The solution we are looking for is the intersection between the curves. But, as we can't assign this very accurate value of η_{ul} for both N_c and N_R and both will be integers, where the value of η_{ul} will not give integers most of the time. So, Iteration technique has been adopted with gradient decent optimization technique for quantitative results, especially in our iteration based algorithm where it has step size on scanning for this intersection. So, we could be very accurate in our scan with some type of optimization technique, this leads to apply certain type of optimization to figure out the values of η_{ul} that going to give real number as solution work for the two calculations.

As you can see in chapter 5 and with applying the case study we applied the three types of speed of services and it is clear all these kinds of speed of services has an intersection point or solution point as you can see in Figure(3.5):

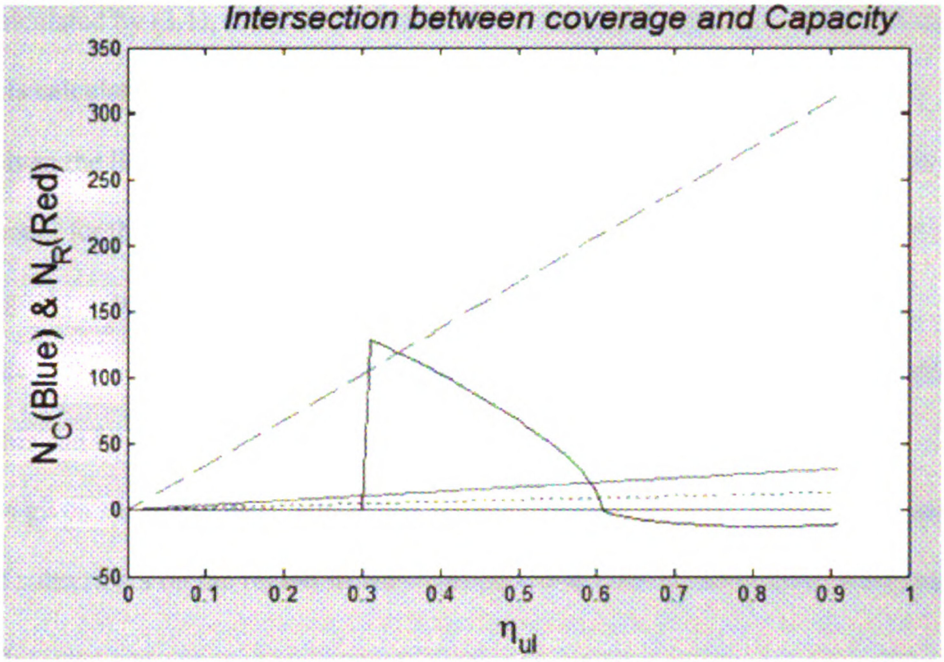

Figure 3.4 Relation of coverage, capacity and load factor η_{ul} for different of services

3.4.2.2 Simulation Process by controlling both radios & load factor of the cell:

The process that the simulation code is going through to visualize the suitable characteristic we have to apply for the area to satisfy the best criteria we need in the area:

Simplified relation between number of active users calculated by different way and load factor

The main procedure are summarized as:

- Given all the parameters for specific area type, we can calculate the radio link budget for a chosen traffic type at the provisional cell edge. All this can be calculated by (3.1), (3.2), ... (3.7) and The maximum system load should be used in this calculation. (phase 1)

- Given the link budget, calculate the maximum cell range given the propagation model for the current terrain type, which mean the maximum distance that can the signal can travel and can be detected by the receiver. (Phase 2)
- Given the new computed cell area, calculate the number of users within the cell. This can be happen in the simulation program by:

  As given specification of region that we want to offer the service to and the number of subscribers on the region so we could get the density of subscriber on the region by:

$$Density\ of\ subscriber = \frac{Number\ of\ subscriber\ in\ the\ whole\ area}{The\ area\ of\ the\ whole\ region} \qquad (3.44)$$

Now, It's clear we could find the number of subscriber in each cell based on coverage calculation:

$$Number\ of\ users =$$

$$Density\ of\ subscriber\ \ X\ \ Area\ of\ the\ cell = N_R \qquad (3.45)$$

(Phase 3)

- By soft capacity equation we calculate the maximum number of subscriber that each BTs can offer them service. This called N_C and we could get it by equation (3.33). (Phase 4)
- In the simulation code with knowledge of both N_R and N_C in each iteration during the run and based on the algorithm each step has been done with size decided by

gradient dissent optimization algorithm and in each step the simulation will face one of this situation:

- If number of subscriber for each cell N_C is greater than the maximum number of users of each BTs N_R, then there are obviously too many users in a cell. Reduce the cell radius in purpose of decreasing the number of subscriber we offer coverage for. After that the simulation will start from phase 3 (calculate the new number of users in the cell again). In this case, the system is said to be capacity limited. (check case A).
- If number of subscriber for each cell N_C is smaller than the maximum number of users of each BTs N_R, and then the system is coverage limited. The cell could have accommodated more traffic. However, it is not possible just to increase the cell radius and calculate the new actual cell loading, as the link budget at the cell edge was calculated for the old cell radius.

  The correct way to solve this problem is to reduce the maximum system load value by changing the load factor η_{ul} by just decreasing it with certain step size, where our program start working from the maximum value, and then return the algorithm starting from phase1. Given the smaller maximum load factor, the cell radius will increase, and furthermore the actual load factor will increase. (Check case B).
- If the actual system loading is equal to the maximum allowed system loading, then the optimum cell size has been found. In other wards. (check case C).

  This algorithm is run until (check case C) becomes true. This gives a cell size for this kind of scenario (terrain, user profiles, etc.). The algorithm must be rerun for all typical scenarios. Given the results, the network planner can then calculate the required number of base stations and also determine their approximate locations.

Generally speaking this algorithm must be run separately for both the uplink and the downlink. But, most of the time you will find the uplink or as they named by (reverse link) in some references gives the suitable solution. The smaller cell size from those runs must be chosen as the optimum cell size, in a cell with symmetric traffic. It will typically be the uplink that determines the size of the cell. This is because WCDMA employs orthogonal spreading codes in the downlink channels, and those cause less interference than the nonorthogonal codes in the uplink which transmitted by the mobile set, the other reason makes the up-link calculation or as they named the reverse link is: the power of the signal that has been transmitted in this link is really weaker than the power that transmitted by the base station on the down link. In this case, the system is said to be uplink limited. However, in a UMTS cell, the traffic can be very asymmetric, and there will possibly be much more downlink than uplink traffic.

If the downlink load increases considerably, it will become the limiting factor for the cell sizes and not the uplink which rarely happen.

There is also an additional factor in WCDMA dimensioning: the orthogonal codes. It is possible that the capacity in the downlink will be limited because of the lack of free codes. If all the orthogonal codes in a cell are already used, it is not possible to add users and traffic to that cell, even if the interference level would still be acceptable. It is, however, possible to start using additional scrambling codes in the downlink, each of them having their own orthogonal channelization code sets. These sets are, however, not fully orthogonal to each other, so interference will be increased.[3]

All the procedure is defined as shown in figure(3.5):

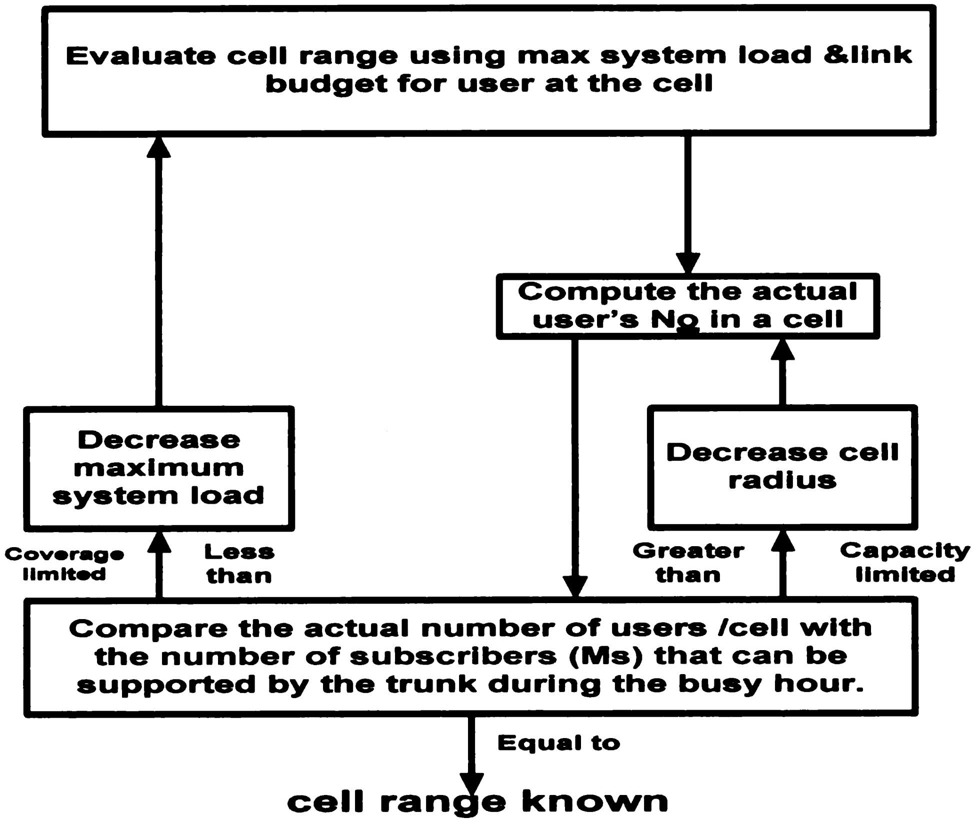

Figure 3.5 Simulation diagram Procedure by controlling both radios & load factor of the cell

It is really clear on telecommunication we always able to convert between the number channels (number of simultaneously active users) to the total number of subscriber even by the erlang B or Erlang C tables. So, by using Erlang B tables and with final active value of channels N and with the standard QoS which operator require we can find the number of the user in the cell which must be compared with previous number of users and then we decide if we have to increase the radius of the cell or decrease it in the comparative stage on our algorithm. Taking into consideration R can't be increased than R_{max} which was obtained at equation (3.8).

In case of mixed service scenario at the same time like " voice and data together" or " voice , data and video call together for several users at the same time". So, through bit techniques can be applied on this kind of calculation.

With the result of the last Matlab program, which gives the number of the base stations we needed to cover the specified area, offered WCDMA network service, and quality of service choose, at this stage of calculation the Dimensioning process is done with the specification about the network in the specified area. The next step in the process is planning the best position for these base stations. As one of the main parts of the planning process is to plan the distribution of the base station of the area. That's going to be introduced and specify good solution for it at chapter4 and the real implementation for the whole process will be applied for specified area on chapter5.

Chapter IV

WCDMA Radio Network Planning Process

4.1. **Introduction:**

The base stations planning process is one of the final steps on the radio network planning for WCDMA or any other 3G Networks. As in general we can see the third phases on the network design process is: the detailed radio –network planning phase.

This chapter talking mainly on the position planning process for WCDMA network base stations which considered as one of the final steps on the whole radio network planning process and its outcome is touching the reality by signing certain position on the specified area. The planning process uses the all available parameters of the network to get certain specification about the position of Base stations in the network.

The position planning must satisfy all the operator's requirements on capacity, coverage and quality of service and it is mainly based on the distribution of the subscribers in the area. In this chapter: one of the best algorithms that touch the probability density function (pdf) of any destitution function, that technique is called Self Organizing Map SOM, and it is optimization algorithm based on Artificial Neural Network back ground. In this chapter we introduce Self

Organization Map and we will talk about how we could use it on optimizing the positions of the base stations.

The general goal for SOM is to give a presentation for the input data has large size with specific criteria like we present it in one or two dimension.

As the network become under testing mode, we observe its performance by measurements. So, it will be easy to use these measurements to optimize the network performance. But, with intelligent tools, network elements and observation of the changes of all network parameters we can get the optimum values for the network. With using the SOM optimization algorithm which depends mainly on the distribution of the population in the ground.

As mentioned earlier there are other planning parameters must be mentioned like: the allowed blocking probability, migration aspects (if the operator already has an existing cellular network), the quality of service (QoS), and so on. If call blocking is allowed with a non-negligible probability, then less capacity needs to be allocated as result, and the network will be cheaper and easier to implement. All these aspects has big effect here.

Now it is clear the WCDMA network is using one carrier frequency in the whole network. The interference limit is mainly affected by the load factor which the main parameter on the dimensioning and the planning optimization process as well. This load factor parameter is clearly explained in the previous chapter and we saw its effect on the whole process, and it is known now that parameter doing great effect on the design of the network.

The main input for this stage on the process is theses questions: How many people live in an area? How many people work there? What is the vehicle traffic density on main roads during rush hours? Are there any special places that may require lots of capacity at certain times? These could include sports arenas, conference centers, and sites of public festivals.

Then the operator must estimate the mobile-phone penetration and the amount of traffic generated by each user. Note that an average business user probably generates more traffic than an average residential user. The business calls will probably be longer, and many of those calls may include data traffic. All this will help on completing the modified Satellite image explaining the subscriber distribution on the area. Starting from the satellite image and based on the distribution of the homes on the image it could give me an initial indication about how the subscriber could be distributed in the region.[6]

4.2. WCDMA Radio Network Planning Problems:

Cellular network planning and optimization is not a new topic, but as new Technologies emerge; the subject remains as fresh as before. It has been proven that WCDMA radio network optimization is a hard problem.

Therefore, Self Organizing Map SOM rather than other exact optimization methods are more suitable to do the job. Historically a lot of solutions come out to solve the Base Stations locations planning issue.

We give a short comparative study on Self Organizing Map SOM optimization of WCDMA networks considering CPICH power and SHO in the model. We have not come across any study consider all these factors together for optimization but the main issues we have are:

- The problem of WCDMA network planning is basically constitutes seeking *p* number of locations each time regardless of how distant the sites are. We implement a particular reductionism that result in a significant shrinking of the search space. All this can be done once the system has been dimensioned and it's basics thoughts about the positioning planning process.

- The other issue for the planning process now is to select specific site from each region to install a BS, such that the traffic capacity and the number of covered Mobile Station MSs are maximized with the lowest installation cost. We assume that a CPICH signal can be detected if and only if the E_C/I_0 ration is not less than a given threshold Value.

If one or more CPICH signals are detected, the best server is chosen to be the BS whose CPICH is received by the Mobile Set MS with the highest level. For simplicity, only CPICH and traffic channels are considered.

Likewise, consider a 2-way SHO, i.e., one MS connects to two BSs (SHO instances With more than 2 connections can be analyzed in a similar way). The following constraints are also taken into account:

1. To be served by a WCDMA network, a MS should receive at least one CPICH signal with an E_C/I_0 that exceeds the threshold value of CPICH signal detection.

2. A MS served by the network must have one and only one best server, whose CPICH signal is received with the highest E_C/I_0 at the MS (without consideration of call admission control—CAC).

3. In downlink, the relative CPICH power is used to determine the SHO server. Therefore, for a MS that is in the SHO state, at least one CPICH signal from a BS rather than its best server should be received by the MS with a power that differs from its best server by no more than a threshold value. This BS will be added into the active set of the MS and selected as one SHO server.

4. Also in downlink, the signals received from the best server and SHO servers are

combined at the MS, and the E_b/N_0 requirements of the downlink traffic should be met with consideration to all possible SHO gains in downlink.

5. In uplink, the signals received at the best server and SHO servers are combined at RNC, and the E_b/N_0 requirements of the uplink traffic should be met with consideration to all possible SHO gains in uplink.

6. A BS should connect to a MS as its best server or SHO server; therefore, all SHO links should be taken into account when calculating BS transmission power and the number of MSs served by the BS.

7. APR and PC headroom should be taken into account in the model with consideration to possible SHO gains.

WCDMA radio network planning, which is a multi-objective optimization problem, can be solved as a single-objective problem by using Self Organizing Map combining all aspects.[7]

4.3.Self organizing Map process:

Practically with implementing the main three steps of SOM with certain specific ways and functions:

4.3.1. How SOM is a competitive process:

From the beginning we should have neurons vectors with same dimension as the input space.

As the input data is

$$X=[x_1,x_2,\ldots\ldots,x_m]^T$$

From the other side the synaptic weight vectors, where the synaptic weight vector of neuron j be denoted by:

$$W_j = [w_{j1}, w_{j2}, \ldots, w_{jm}]^T, \quad j=1,2\ldots\ldots,L$$

L is the total number of the neurons in the networks. We are comparing the output of the multiplication of W^T_j for the wholes neuron in the network and choose the highest value; we will take the indicators of the highest value. Here the only thing we really interested about is the indicator. Lets name i(x) as indicator. So, we can explain our calculation in the competitive process as:

$$i(X) = \arg\min \| X - W_j \|, \quad j=1,2,\ldots,l \tag{4.1}$$

We are looking for the I which indicate the winner neuron X_i. where X_i is the best matching neuron i. [7]

4.3.2. The Cooperative in SOM process:

From the previous process step it is clear that the winning neuron is going to be updated by the input part. To make the other neurons effected by these input component. But, we should update the other neuron with less power than the winning neuron to get positive cooperation from them and this for fast convergence of the neuron network. To achieve these requirements:

The neuron locates to the center of a topological neighborhood of cooperating neuron should have the maximum coefficient and the others should get smaller coefficient where the neurons that excited with amount close to the winning neuron should have coefficient higher than the farther ones. It is clear that we are looking for a function decaying slowly as we are going far from its peak. We end up with function h_{ij} that denote the topological neighborhood centered on winning neuron (i) and excite neuron (j). the d_{ij} denotes the distance between the winning neuron (i) and excited or effected neuron (j). So, the function h_{ij} is unimodal function of the lateral distance d_{ij} which going to satisfy this conditions:

1- The topological neighborhood h_{ij} is symmetric about the maximum point defined by $d_{i,j} = 0$, here we try to say the winning neuron has zero distance of this function

2- The amplitude of topological function is decreases monotonically with increasing the lateral distance $d_{i,j}$, which decaying to zero for $d_{i,j} = \Theta$ this condition for convergence.

The typical function that applies these conditions is Gaussian function:

$$h_{i,j} = \exp(-\frac{d^2{}_{i,j}}{2\sigma^2}) \tag{4.2}$$

the parameter σ in the last equation is independent from the distance $d_{i,j}$, and the parameter σ is called effected width of the topological neighborhood as illustrated in the coming figure; It's measure the degree of effecting of each neuron in the update.

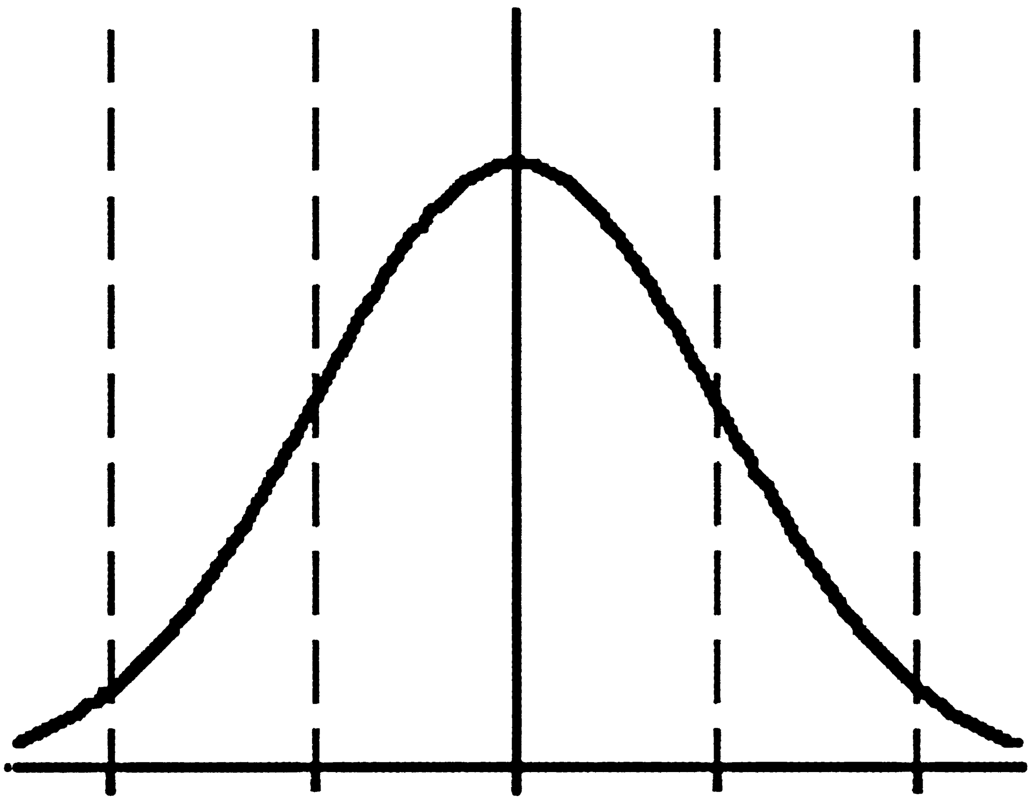

Figure 4.1: Gaussian Neighborhood function

Toward apply best cooperation we apply the distance in the neighborhood function $h_{i,j}$ is centered by the winning neuron and decrease as we get less value than the value of the winning neuron. The distance between winning neuron and the other neurons $d_{i,j}$, $d_{i,j}$ is an integer equal to $|i-j|$, and the case of two dimensional lattice it's going to be defined as:

$$d^2_{i,j} = \|r_j - r_i\|^2 \tag{4.3}$$

The discrete vector r_j defines the position of excited neuron j and r_j defines the discrete position of winning neuron i, both of which are measured in the discrete output space.

SOM has lot of unique features in its algorithm; one of these features is the control it has on the width of the topological neighborhood function especially it is shrinking with time. This feature hlps a lot to keep the network in stable situation after it reach to the convergence period.

This leads to make σ be function of time. So, we can write it as :

$$\sigma(n) = \sigma_o \exp\left(-\frac{d_{j,i}^2}{\tau_1}\right) \qquad n=0,1,2,3\ldots\ldots, \tag{4.4}$$

Where σ_0 is the initial value of σ at initial SOM algorithm, τ_1 is a time constant.

With using the last distribution of σ and the neighborhood equation be come:

$$h_{j,i(x)}(n) = \exp\left(-\frac{d_{j,i}^2}{2\sigma^2(n)}\right), \qquad n=0,1,2\ldots., \tag{4.5}$$

all the component of the previous equation is well known where the time (n) is equal to number of iteration, and it is clear the width is decrease with the time as σ(n) decrease exponentially so, the topological neighborhood function will response with similar way.

With having wide width of neighborhood function at the beginning will help most of the neuron be effected by the update then the decrease of the function will help a lot on the correlation function to stay converged to certain value.

In most of computer programs that using the SOM are using normalizing technique and it's called renormalized SOM from the training. According to which we work with a much smaller number of normalized degree of freedom. This operation is easily performed in discrete form by having a neighborhood function $h_{j,i(x)}(n)$ of constant width, but gradually increasing the total number of neurons. The neurons are interested halfway between the old ones. [7]

4.3.3. Adaptive process:

It is good known that the Self Organizing Map SOM is Artificial Neural Network , so we should think about the process as neural network where neurons and synaptic has been involved in explanations. As in the adaptive process we reach to the last stage of optimization process, the synaptesis w_j which belongs to the neuron (j) should be effected by the input data (x). The goal here is how we could represent the effect that (x) can do in the different synapces. The other thing that can be noticed in the reaction of the synaptic or even in the whole process is SOM is self learned algorithm, where the update of the different can be done automatic from the input data and this update is completely function of the input (x) with certain parameters , In general the update weight can be described as:

$$\Delta w_j = \eta \, y_j \, x + g(y_j) \, w_j \tag{4.6}$$

This is the general presentation for the effect of the data on the synaptic, The main parameters that effect the response that synaptic will response: the most important factor η is the learning rate parameter that the synaptic will be effected by the input data, y_j can be applied as function talks about the response we have for any kind of input data, where both $g(y_j)$ and y_j just correcting factors,

$$y_j = h_{j,i(x)} \tag{4.7}$$

Where we can use the previous equation on the increment function of the weights then we will have the increment as:

$$\Delta w_j = \eta\, h_{j,i(x)}(x-w_j) \tag{4.8}$$

After we understand the increment that effected by the input data which should be added to the previous weight at each instant we can see the big image for the weights reaction as:

$$w_j(n+1) = w_j(n) + \eta(n)\, h_{j,i(x)}(n)(x(n)-w_j(n)) \tag{4.9}$$

This equation going to be applied for all neurons fond in the lattice as neighborhood function . but, it is going to affect each neuron with different value depends on each position, where the winning neuron is going to be updated with complete factor or by value 1 and the others will be effected depending on how far each of them from the complete matching with the input data.

With keeping the process running with using the previous equation for the whole input data we have to get grid of the whole neurons explains the input data with small number of neurons.

The updated weights function is depends in a lot of functions as well, one of these function is $h_{j,i(x)}$ which is heuristic function, it explains the neighborhood behavior for the whole neuron to the all input data. The other heuristic function is $\eta(n)$ where our learning rate is function depends on the history of the input data.

The learning rate function is $\eta(n)$ and it is function with time and initial value η_o and then changing with increasing the time, one of the best expression for $\eta(n)$ is:

$$\eta(n) = \eta_o \exp(-\frac{n}{\tau_2}), \qquad n=1,2,3\ldots.., \qquad (4.10)$$

you can see the learning rate is decaying with time, and it has living time where it's going to stay gives stable response for a while then will start decaying, this men we have complete controle in changble function.

As the learning rate is changing with time it is traveling through two main phases during the whole SOM process:

Modified Self Organizing Map (SOM):

As in the coming equation we will deal on the energy instead of the deference:

$$E_j = ¼ \left[\sum_{L=1}^{N} \left(X_l(n) - W_{j,l}\right)^4 \right]$$

After that in next steps we compute

$$i(x) = \arg\min_j E_j$$

Then, update the "winning" neighborhood as:

$$\Delta W_K(n) = \eta(n)h_{ik}(n)\ \delta/\delta w_K\ (E_j) \text{ for } K \epsilon N(i)$$

$$\Delta W_K(n) = \eta(n)h_{ik}(n)\ (X(n) - W_k)^{\cdot\wedge 3} \text{ for } K \epsilon N(i)$$

4.4. The Self Organizing Map (SOM) algorithm:

The SOM algorithm can be explained in clear steps, with these clear steps we can summaries the Kohonen's SOM algorithm and understand the main functions that SOM algorithm can be applied for, where Kohonen's SOM algorithm is that it substitutes a simple geometric computation for the more detailed properties of

Hebb-Like rule and lateral interactions. The main vision for the algorithm can be summarized as:

A continuous input space of activation patterns that are generated in accordance with a certain probability distribution.

A topology of the network in the form of a lattice of neurons, which gives discreet output. In other words one of main use of the SOM algorithm is to change a continues input data to discrete output data with an other presentation.

The SOM algorithm is using new technique by applying time varying neighborhood function for winning neuron i(x) which will update the neighbors neurons which has close values to the winning neuron to be updated but with smaller values depending how fare it's from the winning neuron.

One of the important parameters in the SOM algorithm is the Learning rate parameter $\eta(n)$ that starts at an initial value η_0 and then decreases gradually with time, n, but never goes to zero.

Those are the main stops we can explain more about one of the main parameters on the algorithm which are the neighborhood function which can be used with applying the next two equations immediately in sequence:

$$H_{j,i(x)}(n) = \exp\left(- \frac{d_{j,i}^{2}}{2\sigma^2(n)}\right), \qquad n = 0,1,2 \tag{4.11}$$

$$\eta(n)= \eta_0 \exp\left(\frac{n}{\tau_2}\right) \tag{4.12}$$

The insist of applying these equations to make sure that $\eta(n)$ will maintain small values like 0.01 during the convergence period which going to be after long time.

The other noticeable way to apply the algorithm is dealing with small neighborhood function even single effected neuron at the earlier first steps and wider at the last ones.

In general we can summaries the SOM algorithm as:

1) Initialize each node's weights: this can be done by choose random values for the initial weight vectors $w_j(0)$. The only restriction here is that the $w_j(0)$ be different for j=1,2,3…,l where l is the number of neurons in the lattice. It may be desired to keep magnitude of the weights small.

The other way to initializing the algorithm is to select the weight vectors $\{w_j(0)\}_{j=1}^{l}$ from the available set of input vectors $\{x_i\}_{i=1}^{l}$ in random manner.

2) Every node is examined to find the Best Matching Unit of the weight vectors.

This step called sampling, draw a sample x from the input space with a certain probability; the vector x represents the activation pattern that is applied to the lattice. The dimension of vector x is equal to m.

3) Similarity matching. find the best " winning" neuron i(x) at time step n by using the minimum distance Euclidean criterion :

$$i(x) = \arg\min_j \|x(n) - w_j\|, \quad j = 1,2,\ldots\ldots l \qquad (4.13)$$

so, here at SOM we are exciting about the rank of the winning neuron to update its value. Then, the radius of the neighborhood around the weight vector is calculated. The size of the neighborhood decreases with each iteration.

4) Each weight and its neighborhood has its weights adjusted to become more like the wanted shape for the SOM weights. Nodes closest to winning neuron are altered more than the nodes furthest away in the neighborhood. Here is the updated low:

$$w_j(n+1) = w_j(n) + \eta(n)\, h_{j,i(x)}(n)(x(n) - w_j(n)) \qquad (4.14)$$

where $\eta(n)$ is the learning–rate parameters, and $h_{j,i(x)}(n)$ is the neighborhood function centerd around the winning neuron i(x); both $\eta(n)$ and $h_{j,i(x)}(n)$ are varied dynamically during learning for best result.

5) Repeat from step 2 for enough iterations for convergence.

6) In terms of modification, we can use equation(4.14) with odd power to the deference, like in our case we can choose power =3. with this way our waits will converge faster and gives better results. So, we rewrite equation (4.14) as:

$$w_j(n+1) = w_j(n) + \eta(n)\, h_{j,i(x)}(n)(x(n) - w_j(n))^3 \qquad (4.15)$$

7) In terms of modification, we can use convex sum technuqe by averaging the effect of each winning neuron. And that going to be implemented as well in chapter 5.

Chapter V

Case study

5.1. **Introduction:**

This case study is implementing the know-how we posted in previous chapters. in this chapter we apply dimensioning and planning Network process for Janzour 15 km west from down town Tripoli (capital of Libya), with 86,956 and area of 17.38 km^2. We use the information about the region Janzour starting from: type of buildings and its height, its trees and natural obstacle, type of the land, and population specifications. We can consider Janzour is a suburban area and this is used in the dimensioning process phase and in the planning process phase. Generally speaking about the structure of this chapter we apply all process phases including the main three phases. It starts with (1) the preparation phase, which sets the principles and collects data, followed by (2) network dimensioning. and (3) the detailed radio-network planning phase.

1- In the preparation phase we set the principles for the planning process. The first thing we announce is that the coverage will be for all Janzour area. We assign 0.01 as quality of service (QoS) for Janzour. So, the preparation phase, which include data gathering and traffic estimation, defines what kind of network will eventually be built in Janzour. The type of area, number of subscribers , the distribution of the subscribers are also needed for the preparation phase. then we have to calculate the capacity that each BTs can handle subscribers. Because of the distribution shown in fig (5.2) we found Janzour area isn't uniformly distributed for residence that's why we didn't apply uniform distribution for Janzour area subscribers. So that leaded us to generate the distribution of subscriber based on data we have about the area.

2- Network dimensioning is a process that aims to estimate the amount of equipment needed in Janzour area network. As the type is WCDMA network, the dimensioning includes both the radio access network and the core network. This process includes calculating radio link budgets, capacity, coverage, and then estimating the amount of infrastructure needed to satisfy these requirements for the Janzour network. The result of the process should be an estimation of the required equipment and a crude placement plan for the base stations. Other parameters to be specified at this stage include the data rates, mobile speeds, coverage requirements, terrain types, and asymmetry factors. These values can be based on empirical tests or assumptions.

3-Detailed Radio-Network Planning includes the exact design of the radio network which includes:

- Detailed characterization of the radio environment;
- Soft handover (SHO) parameter planning;
- Interfrequency (HO) planning;
- Iterative network coverage analysis;
- Radio-network testing.

The task of this project was to define, design, and develop a complete suite of network planning software prototypes for UMTS. We collect all these phases in this chapter and implement our planning process for Janzour area.

To better understand the WCDMA network planning process and the effect of each parameter as they change, we apply a formula to see different relations between certain parameters. This includes the relation between number of BTs & the speed of service, and the relation between the penetration of subscribers & number of BTs for different type of service.

- To finalize the whole process of Janzour Area, we made a calculation of microwave link budget between each BTs & RNC (Radio Network Controller) and between RNC &MSC (Mobile Switch Center) and assign the main position of each one of them.

In the case of WCDMA networks, the detailed planning itself is an optimization process. In the case of the **2nd** generation mobile network the detailed planning concentrated strongly on the coverage optimization. The WCDMA planning is more interference and capacity analysis than only coverage area estimation and frequency reuse planning. During this project, the radio network planning, the base station configurations need to be optimized. The antenna selections, antenna directions and even the site locations need to be tuned as much as possible in order to meet the required Quality of Service ***QoS*** and capacity and service requirements with minimum cost. For this pre-operational optimization process a static prediction method has been proposed.[11]

Today, most mobile solutions offer users a single method by having the capability of interactions at any given point in time.

Although a capability exists to provide multiple interfaces, for example graphical and voice, the user accesses these in singularity, not both at the same time. This has been due in part to mobile network infrastructure that offers the mobile device either a circuit switched service or a packet based service. However, the emergence of the 3GPP Multi-call supplementary service enables mobile service providers to establish both a fixed voice circuit and a packet session with a single device at the same time. [22]

5.1.1 Area under study:

The area under study falls west of Tripoli which covers city of Janzour . It is bounded between latitude $32^{\circ}45'06.98N$ to $32^{\circ}50'12.86''N$ and longitude from $12^{\circ}58'51.62''E$ to $13^{\circ}03'46.18''E$.

Figure (5.1) shows the satellite map of the area. The main features of the area are:

- Geographic area: 6.711 miles^2 = 17.3814 km^2
- Area classification: Suburban and rural area for the design it's assumed suburban area.
- Building configuration: buildings are distributed over the area with maximum 3 floors building height.
- Total number of population: 86956 inhabitants.

Main activity in the area: business, tourist, residential, industrial, agricultural and services.

Mobile service type: voice, real data time " video" and high speed non-real data time

In this case study, a dimensioning and planning of the area is to be performed following the methodology mentioned in the previous chapters. A computer program is developed to help in this aspects.

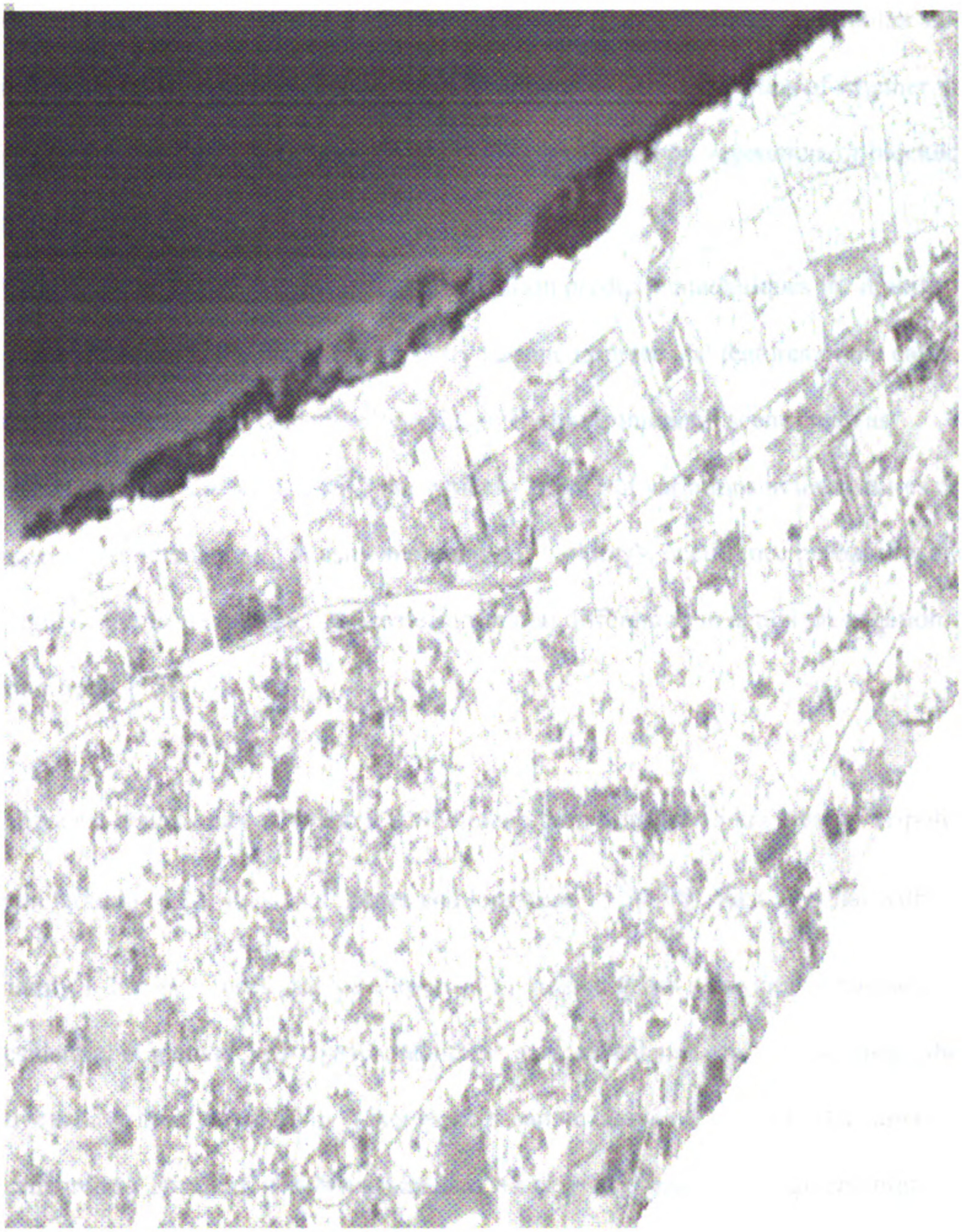

Figure 5.1 Satellite image of Janzour town

5.1.2 Area Classification:

Specifying the class of the area helps in assigning a lot of parameters in the dimensioning and planning process. Land-mobile communication systems suffer from signal fading due to blockage and shadowing by buildings and vegetation. In practical work the analysis of digital hemispherical (fisheye) photographs collected in representative environments has been developed to derive statistics of whether the path to the satellite is open line-of sight (LOS), shadowed by vegetation, or blocked by solid obstacles.

A fundamental deficiency in current propagation prediction techniques for mobile system channels is the inability to specify and incorporate real features of the earth-terminal environment. General categories of the environmental scene, such as "urban," "suburban" and "rural," are typically used, but variations in the features of these environments (e.g., density and height of buildings, occurrence probability and height of trees) are expected to create substantial differences in actual propagation conditions. [15]

Janzour is a small city with about 86956 inhabitants situated 15 km west of Tripoli with latitude of $32^{o}48'42.96''$ North and longitude $13^{o}03'00''$ East. It is flat with mainly 1-3 story houses ,tall trees up to 11 m height. It has a mixture of business residential in general with tourist, industrial, agricultural and services buildings; the streets have mainly two lanes. Thus Janzour can be classified as a suburban area compared to Tripoli downtown urban area which is dominated by large and high buildings, and with narrow crowded streets compared to Janzour .

* Assuming the growth of the population =15%, the best thing for Janzour area is to be considered to have a total population of the area = 86,956 + (0.15*86,956) = 100,000.

So our area Janzour with 100,000 people has area = 17.3814

Thus number of inhabitant per km^2= 5753.27 inhabitant/km^2

5.2 Design and calculation:

This part include the real implementations for the whole process to the specified area Janzour, where the implementation has been applied with different specification for the same area.

5.2.1 Design and calculation for soft blocking Capacity:

The following parameters are assumed.

1- **for 12.2 kbps voice service:**

Table 5.1: Soft capacity parameters for 12.2kbps

Parameter	Value
Spread Spectrum Bandwidth(B) Hz	5,000,000
Voice bit rate (R) b/s	12,200
Voice activity gain factor (G_V)	0.4^{-1}=2.63
Sectionsation gain factor (G_S)	2.63
Chip rate of WCDMA (W) c/s	3,840,000
E_b/I_o	5 dB
KTB	- 106.84 db
The power of the signal S	0.125 W
(interference from other cell)/(interference from given cell)= f	0.6

Now we apply values of table 5.1 which specified exactly for 12.2 kbps as speed of service to equation (3.32) this equation gives us the effective number of users (active number of users) or the number of channels available to use and from this and by using Erlang B tables we got the total number of subscriber that can call at the same time in the busy hour & the total Erlang of the cell, the total Erlang can be calculated after decide the specific Erlang/subscriber that be suitable for the operator and decide the suitable QoS for the operator.

In Janzour area case study we assign the Erlang/subscriber = 21mE and Quality of Service = 0.01 as operator request

So from equation (3.32):

$$N = \eta_{UL}.\left(1 + \frac{W/R}{\frac{E_b}{I_o}}\right).G_v G_S.\frac{1}{1+f} \tag{3.32}$$

The final parameter at equation (3.32) is the load factor η_{ul} where as the Clearfield process of the MatLab program is to start scanning and checking the response from the highest value of the load factor and start decreasing it up to reach to the optimization solution here in this step we applied the highest value of η_{ul} =0.7 as it is clarified at [15].

We got this value for number of active channel =269.71 which supposed to be = 269 channel for safe calculation. So, after using Erlang B able the total Erlang & Number of users that can be supported by single BTs is given in table 5.2

Table 5.2 Obtained capacity results for 12.2kbps

Item	Values
Total Erlang	247.1 E
Number of users at busy hours	11766 user

This result says that from capacity calculation side the number of BTs for Janzour area with 60% population for voice only service = 60,000/11766 = 4.9099 BTs, this is the smallest number of BTs need for 12.2kbps service whatever the link budget calculation the number of BTs will be not this number.

So this previous results are for voice only and this will use for planning process as an input parameters.

2- For 144 kbps real time data service:

Table 5.3 Soft capacity parameters for 144kbps

Item	Value
Spread Spectrum Bandwidth(B) Hz	5,000,000
Data bit rate (R) b/s	144,000
Voice activity gain factor (G_V)	$1^{-1}=1$
Sectionsation gain factor (G_S)	2.63
Chip rate of WCDMA (W) c/s	3,840,000
E_b/I_o	1.5 dB
η = KTB	- 106.84 db
The power of the signal S	0.25 W
(interference from other cell)/(interference from given cell)= i	0.6

Now we apply values of table 5.3which specified exactly for 144 kbps as speed of service to equation (3.32). This equation gave us the effective number of users, or the number of channels available to use =29.43 channel and from this and by using Erlang B tables we got the total number of subscribers that can call in busy hour & the total Erlang of the cell. This happen after decide the specific Erlang/subscriber that be suitable for the operator, and decide the suitable QoS for the operator.
In Janzour area case study we assign the Erlang/subscriber = 21mE and Quality of Service = 0.01 as operator request.

So from equation (3.32) we got this value for number of active channel =29 active channel. So, after using Erlang B tables the total Erlang & number of users that can be supported by BTs is given in table 5.4

Table 5.4 Obtained capacity results for 144 kbps

Results	Values
Total Erlang	29.43 E
Number of users at busy hours	1401.65 user

So this previous results are for real data time, which grantee very good quality for video call. This results mean we need = 60,000 / 1401.65 = 42.8, about 42 BTs. This is the smallest number of BTs need for 144 kbps service with applying the highest load factor.

3- **For non-real time 384kbps data service** :

Table 5.5: Soft capacity parameters for 384kbps

Parameter	Value
Spread Spectrum Bandwidth(B) Hz	5,000,000
Voice bit rate (R) b/s	384,000
Voice activity gain factor (G_V)	$1^{-1}=1$
Sectionsation gain factor (G_S)	2.63
Chip rate WCDMA (W) c/s	3,840,000
E_b/I_o	1 dB
η = KTB	- 106.84 db
The power of the signal S	0.25 W
(interference from other cell)/(interference from given cell)= i	0.6

Now we put these values to equation (3.32) this equation gives us the effective number of users or the number of channels available to use = 16.13 channel and from this and by using Erlang B tables we got the total number of subscriber that can call in busy hour & the total Erlang of the cell this after decide the specific Erlang/subscriber that be suitable for the operator and decide the suitable QoS for the operator.

In Janzour area case study we assign the Erlang/subscriber = 21mE and Quality of Service = 0.01 as operator request for 384 kbps speed of service.

So from equation (3.32) we got this value for number of active channel = 16 , so after using Erlang B tables the total Erlang & number of users that can be supported by single BTs is given in table 5.6

Table 5.6 **Obtained capacity results for 384 kbps**

Results	**Values**
Total Erlang	9 E
Number of users at busy hours	428.571 user

From capacity calculation we find the number of BTs for Janzour with 384 kbps speed of service = 60000/428.571=139.8 ≈ 140 BTs

So this previous results are for 384kbps speed of service y and this will use for planning process as an input parameters.

5.2.2 Design and calculation for dimensioning process:

The uplink is calculated for several speeds like 12.2 kbps voice and the link budget is shown in Table 5.7. In both uplink and downlink the air interface load affects the coverage but the effect is not exactly the same. In the downlink, the coverage depends more on the load than in the uplink. That's lead us to apply the coverage calculation in the uplink budget. Even practically with knowing the uplink is meaning the signal will travel from the Mobile device set to the BTs is going to be more sensitive than the down link which means the signal will travel from the BTs to the mobile Device. Based on the reference [15] and what it shows in the figures that plot the SNR for the uplink and the downlink you can see the uplink is the pointer.

The reason is that in the downlink the power of 0.125W is shared between the downlink users: the more users, the less power per user. Therefore, even with low load in the downlink, the coverage decreases as a function of the number of users. We note that with the above assumptions the coverage is clearly limited by the uplink " reverse link" as shown in [15] and it's graphical figures about the Signal to noise ratio of the uplink and the down link. So, we made all of our calculation for up link because it's our limit as shown in [15]. The down link maximum path loss is higher than in the up link so we have to take the lowest which will be more safety and here it's uplink " reverse link''.

The WCDMA load equations assume that all users are allocated the same bit rate which corresponds to real time service with a guaranteed bit rate. If we allocate the same power, instead of the same bit rate, to all users, the cell throughput would be increased by 30–40 %.

5.2.2.1 Specification of Maximum System Load:

We apply MatLab program to make the following calculation

1-) Speed 12.2kbps voice service:

The following table provides the parameters used to calculate the reverse link " up link" maximum allowable path loss. These parameters specified for a mobile.

Assuming maximum up link load = 0.8, where this value talked from old job done by [10] so as it's clear in coming figure we are looking for the intersection point of the both calculation. So, in our calculation we keep looking for this intersection with scanning with starting from the highest value of the load factor and apply the both calculations each time with small step size as we could to reach to the Solution Point

Accurately. All these values are taken from several references based on the specifications of our area Janzour and other specifications like the speed of services.

Table 5.7: link budget parameter for 12.2kbps voice service with 120km/h speed

Transmitter (mobile)	Unite	Shortcut	Value
Max mobile transmission power	W	P_m	0.125
Max mobile transmission power	dBm	P_m	21.0
Subscriber Unit Tx Feeder Loss	dB	L_F	0
Subscriber Unit Antenna Gain	dBi	G_m	0
Body Loss	dB	H_m	3
Vehicle Loss	dB	V_m	8
Building Loss	dB	B_m	10
Receiver (base station)			
Base Antenna Gain	dBi	G_b	18
*Line Loss	dB	L_b	2
Noise Figure	dB	N_F	5
E_b/N_o	dB		5
Processing Gain	dB	PG	25
Thermal noise	dBm	KTB	106.84
Base Rx Sensitivity	dBm	RX sensitivity	-121.84
Noise rise due interference	dB	I_m	3.01
Ambient noise rise	dB	T_m	3
Fast fading margin	dB	F_m	7.3
*Shadow Fade Margin	dB	S_m	3
Desired signal strength	dB	dRSS	- 114.83dB

From the equation 5.5 and equation 5.6 we get that:

Maximum allowable loss: L_T =135.85

The Hata propagation model is used and equations of it are:

$$L_{HATA} = 69.55 + 26.16 \times \log f_c - 13.82 \times \log H_b - A(H_m)$$

$$+ (44.9 - 6.5 \log H_b) \times \log R \qquad (5.1)$$

Where:

Suburban area $\quad L_{Hata\ suburban} = L_{HATA} - 2\{\log(f_c/28)\}^2 - 5.4$

(5.2)

With below parameters

Table 5.8 Hata propagation model parameters for 12.2 kbps service.

Parameter	description	value
f_c	Frequency (MHz)	2000
H_b	base station antenna height (m)	30
H_m	mobile antenna height (m)	1.5

So with applying the MatLab code which applying the algorithm we introduced it on Chapter 3 and summarized on figure 3.6 we got:

The initial cell radius is calculated to be 10.38 Km for indoor subscriber antenna with gain = 0 dBi but this is suitable with capacity calculation where cell area = $278.9km^2$ which larger than the total area of our region. So, we need to 1 Base Station in case our calculation based only on coverage calculation only. Which in our case here even on considering the capacity calculation we need 1 Base station, where it must be greater to grantee the capacity and at this type is called coverage limited and the final radius is similar with the initial one R_f=5.71Km

This is for 60% penetration of resident which mean for 60,000 subscriber and this gives area of the cell:

Area of the cell= 2.6 R^2= 84.7 km^2

This gives number of the node B(BTs) = 17.38/84.71 =1 BTs for Janzour area with 12.2kbps speed of service and this case called coverage limited.

2-) 144kbps real time data service:

The following table provides the parameters used to calculate the reverse link " up link" maximum allowable path loss. These parameters specified for a mobile.

Table 5.9 link budget parameter for 144kbps real time data service with 3km/h, indoor user covered by outdoor base station.

Transmitter (mobile)	Unite	Shortcut	Value
Max mobile transmission power	W	P_m	0.25
Max mobile transmission power	dBm	P_m	24.0
Subscriber Unit Tx Feeder Loss	dB	L_F	0
Subscriber Unit Antenna Gain	dBi	G_m	2
Body Loss	dB	H_m	0
Vehicle Loss	dB	V_m	8
Building Loss	dB	B_m	10
Receiver (base station)			
Base Antenna Gain	dBi	G_b	18
*Line Loss	dB	L_b	2
Noise Figure	dB	N_F	1.5
Eb/No	dB		5
Processing Gain	dB	P_G	14.3
Thermal noise	dBm	KTB	106.84
Base Rx Sensitivity	dBm	RX sensitivity	-114.64
Noise rise due interference	dB	I_m	3.01
Ambient noise rise	dB	T_m	3
Fast fading margin	dB	F_m	4
*Shadow Fade Margin	dB	S_m	3
Desired signal strength	dB	dRSS	-104.63dB

From the equation 5.5 and equation 5.6 we get the Maximum allowable loss= 128.63 dB

We applied the previous equations (3.1),(3.2) for Hata model with below parameters

Table 5.10 Hata propagation model parameters for 144kbps service.

Parameter	description	value
f_c	Frequency (MHz)	2000
H_b	base station antenna height (m)	30
H_m	mobile antenna height (m)	1.5

The **initial** cell radius is calculated to be 2.834 Km for indoor subscriber antenna with gain = 2.63dBi so the area of the cell = $2.6*(2.834)^2 = 20.866km^2$

and by this radius each BTs must deal with (20.866/17.3)*60,000 = 1255.5 ≈ 1255 user.

Now with calculating the number of subscribers based on capacity calculation:

N_C = 71.40 ≈ 71 subscribers, which is away smaller than the maximum allowable number of users can each BTs cover. So the program start to decrease the Load Factor of the cell by 0.001 and repeat the calculation up to reach to radius which cover the same number of users that maximum allowable number of user can each BTs cover them, this called final radius. and the final radius = 0.858 km.

This is for 60% penetration of resident which mean for 60,000 subscriber and this gives area of the cell: Area of the cell= $2.6 R^2 = 1.91 km^2$

This gives number of the node B(BTs) = 17.38/1.91 =9.041 ≈ 9 BTs we need for

Janzour area with 144kbps as speed of service.

3-)Non real time 384kbps data service:

The following table provides the parameters used to calculate the reverse link " up link" maximum allowable path loss. These parameters specified for a mobile.

Assuming maximum up link load = 0.5

Table 5.11 Link budget parameter for 384kbps non real data time.

Transmitter (mobile)	Unite	Shortcut	Value
Max mobile transmission power	W	P_m	0.25
Max mobile transmission power	dBm	P_m	24.0
Subscriber Unit Tx Feeder Loss	dB	L_F	0
Subscriber Unit Antenna Gain	dBi	G_m	2
Body Loss	dB	H_m	3
Vehicle Loss	dB	V_m	8
Building Loss	dB	B_m	15
Receiver (base station)			
Base Antenna Gain	dBi	G_b	18
*Line Loss	dB	L_b	2
Noise Figure	dB	N_F	5
Eb/No	dB		1
Processing Gain	dB	P_G	10
Thermal noise	dB	KTB	106.84
Base Rx Sensitivity	dBm	RX sensitivity	-110.84
Noise rise due interference	dB	I_m	-6.98
Ambient noise rise	dB	T_m	3
Fast fading margin	dB	F_m	0
*Shadow Fade Margin	dB	S_m	3
Desired signal strength	dB	dRSS	-116.85

From the equation 5.5 and equation 5.6 we get: Maximum allowable loss LT= 140.85 dB, We apply the previous equations (3.1),(3.2) for Hata model with below parameters

Table 5.12 Hata propagation model parameters for 384kbps service.

parameter	description	value
f_c	Frequency (MHz)	2000
H_b	base station antenna height (m)	30
H_m	mobile antenna height (m)	1.5

The **initial** cell radius is calculated to be 0.683 Km for indoor subscriber antenna with gain = 2.61 dBi this radius depending on coverage parameters only but this radius can't apply for capacity. After the program complete running we got the final radius = 0..592km which very suitable to capacity calculation so is called capacity limited.

This is for 60% penetration of resident which mean for 60,000 subscriber and this gives area of the cell:

Area of the cell= 2.6 R^2 = 0.91 km^2

This gives number of the node B(BTs) = 17.38/0.91 =19.0 BTs for Janzour area with 384kbps as speed of service

Note:

All previous type of calculation is made for choosing the suitable diminution for chosen area so for the best performance of network and in general case we apply choice number 2-) 144kbps real data time to make sure all subscriber has the ability to make video call at any place of the cell and for more safety less cost, but we can deal with less non real time data.

5.2.2.2 Specific Planning for our area:

- for specific look for our area we build these curves:

1- The relation between the number of node B "BTs" and the speed of the service which we made the previous calculation with extra new point it's for 64kbps real data time:

Table 5.13 Relation values of speed of service & number of BTs

speed(kbps)	Number of BTs
12.2	4
64	7
144	9
384	19

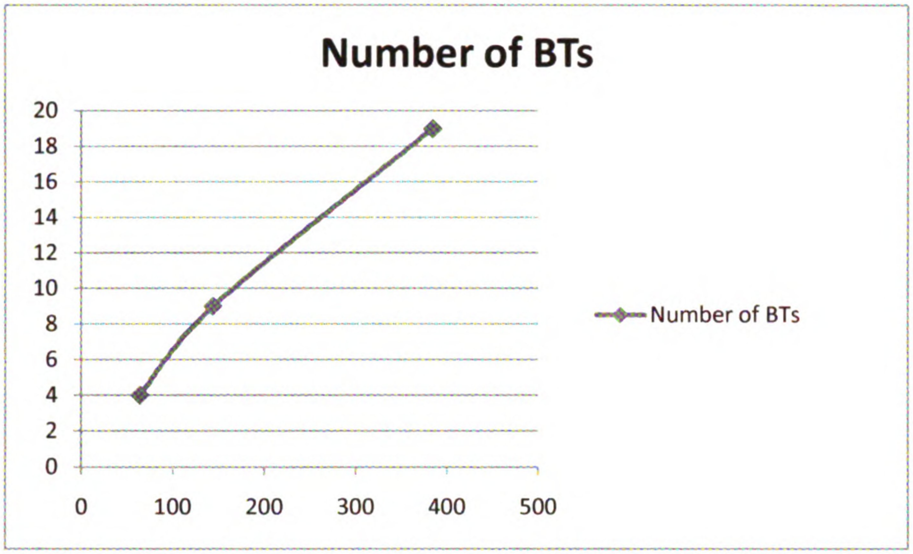

Figure 5.2 Relation of speed of service and number of BTs

2- Relation between number of BTs & number of subscriber [different penetration] for different speed rate:

Table 5.14 Relation between number of subscriber & number of BTs for different service

% of user	Number of BTS		
	speed12.2kbps	speed 144kbps	speed 384kbps
20%	9	20	61
40%	9	39	123
60%	9	59	179
80%	9	81	251
100%	9	100	326

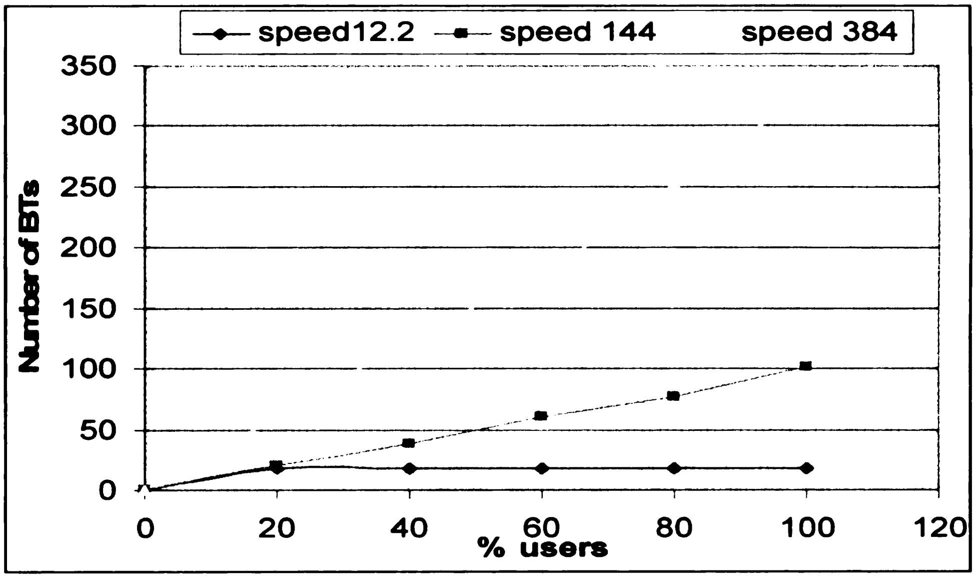

Figure5.3 Relation between number of subscriber & number of BTs for different service

- Now we can deal with different scenarios for our use of our specific area.

We used through bit technique for mixed traffic like voice, data & real time data at the same time for different subscribers.

The total through bit = the speed of service by kbps * activity factor * total Erlang of the service (5.3)

, on the other hand of side we can calculate it with this general equation:

Through bit ⟶ $W/((E_b/N_0)*\alpha*(1+i))$ (5.4)

For our case the general through bit:

Chip rate W= 3.84 Mcps

E_b/N_0= 2.5 dB for mixed traffic

Activity factor α =0.55

Outside interference / inside interference i=0.65

Finally this scenario is applied for planning or dimensioning but for the demo of the implementation of the network to see its way of working and its ability. [16]

For this area and specification of the people live there, we end up the best service can be planned for this area is by applying 144kbps for 60% of the population in the area.

5.2.2.3. Specific Planning for 144kbps with 9BTs implementation at Janzour area:

At Janzour area we found the suitable design is by using 9BTs to grantee best performance of the network mainly for media service.

So for real time data speed 144kbps service with 9 BTs implemented in our area, so in this condition we can fined the bent ration from 60 000 subscriber that can work with 144 kbps speed as following:

By applying the same parameters for link budget calculation that used in 144 kbps real data time so we got:

$R_{initial}$ = 2.83 km

R_{final} = 0.858 km

The maximum distance that user can get this speed of service is = 0.858 km. from the BTs where if the number of real time data 144 kbps users exceed the 1401 user for each cell the speed will decrease, where in our design we grantee that if all subscriber work with the same time each one has 144kbps speed of service which is reasonable at our time.

5.3 Base Stations Positions Planning and Optimization:

The base stations planning process is one of the final steps on the radio network planning for WCDMA or for any other wireless Network. Once the number of base stations (BTs) is determined, one has to consider the optimal assignment / placement of the base stations to match the concentrations of heavy users. It is important to consider approaches that estimate the probability density and concentrations of users. We chose specific area to do our experiment on it, and based on the information we have about this area including the structure of main streets and the place with huge populations we used a satellite picture for this region shown in figure (5.1). we approximate the distribution of the users matches the distribution of the buildings in the satellite image and with using the knowledge we have about the city diagrams and structures. We know the places which occupied daily, the event places and the other special places. You can see in figure (5.4) the distribution that gives an indication about how people distributed in the target area.

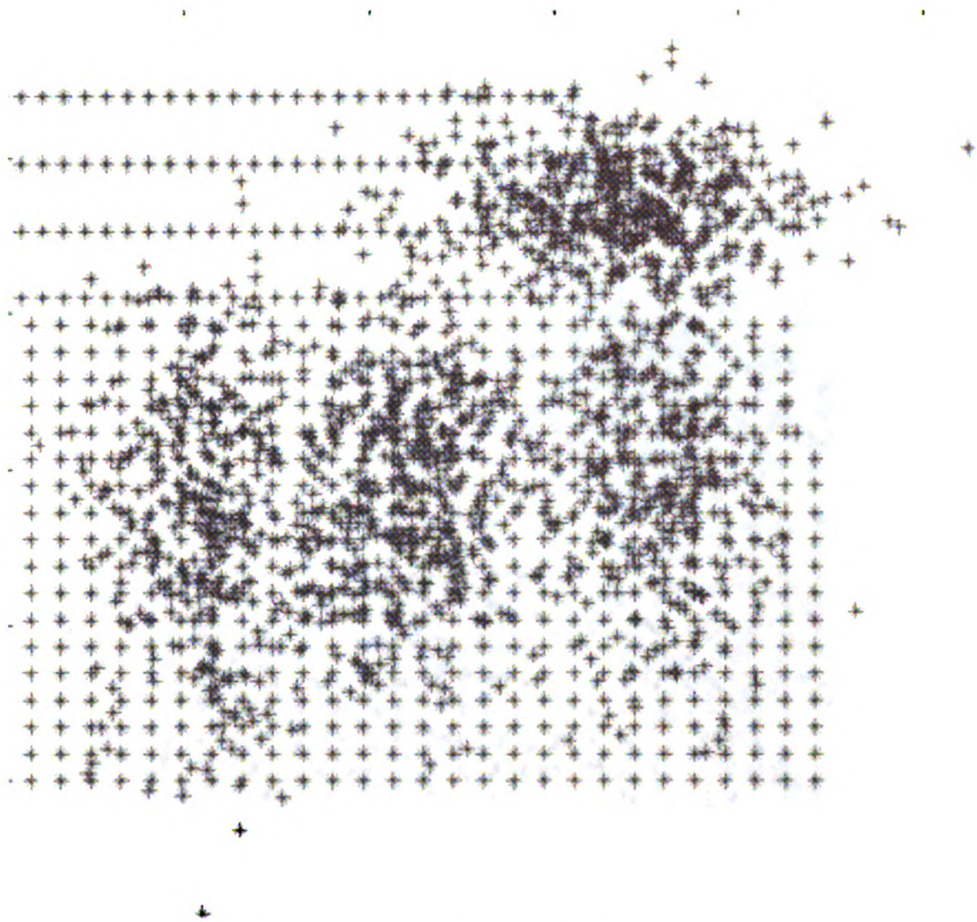

Figure 5.3 Shows suggested population distribution for Janzour area

We applied several modifications to the SOM algorithm to do the optimization:

- The first modified Self Organization Map (SOM) algorithm toward signing the suitable positions of the base stations. With having the distribution density of the subscribers in the area based in distribution of the building and knowledge of structure of the area, we could find the best distribution of the base station numbered by the dimensioning process. That can be done by applying modified Self Organization Map algorithm to the data we have related to the positions of the subscribers. [6]

Our modified SOM algorithm work with the input data, which are a huge number of two dimension vectors, represents the target users in the area. We use this huge number of vectors as training data to another certain number of two dimension vectors which are presenting the base stations. Initially we randomly initiate the position of BTs as you can see the small blue triangles in the next figure:

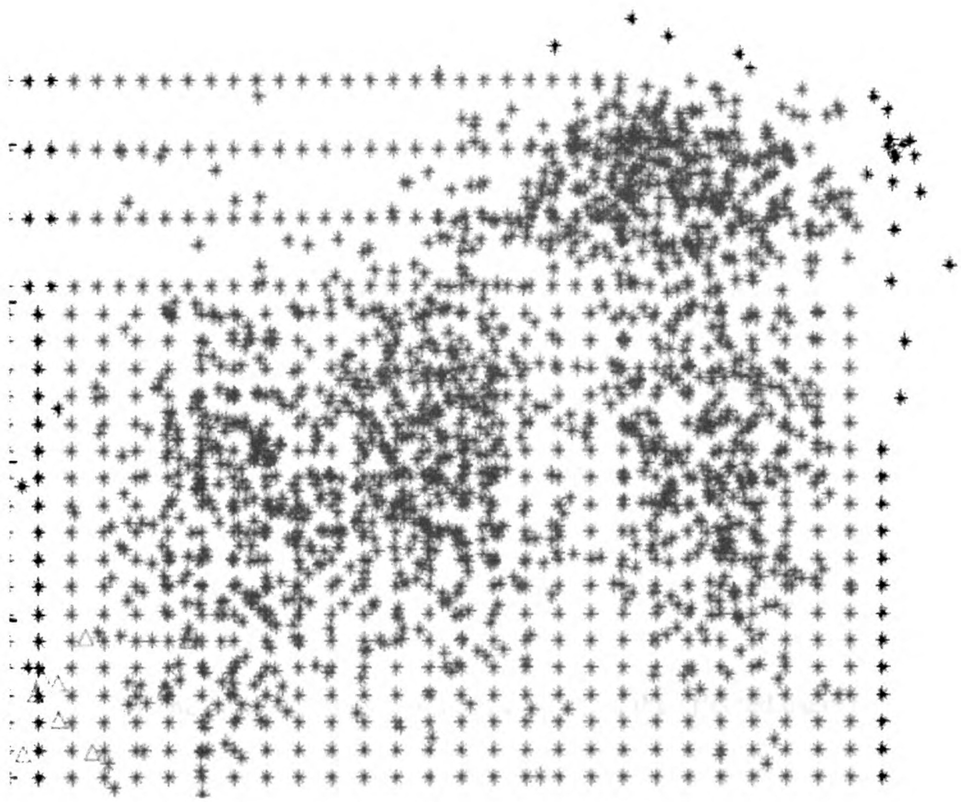

Figure 5.4 Show the random distribution for initial position of BTs in the area

We take these initial positions of BTs as weights in Modified SOM algorithm, so the process keeps running until the weights diverged. Those weights explain the distribution of the subscriber with less number of vectors as you can see in the Next figure.

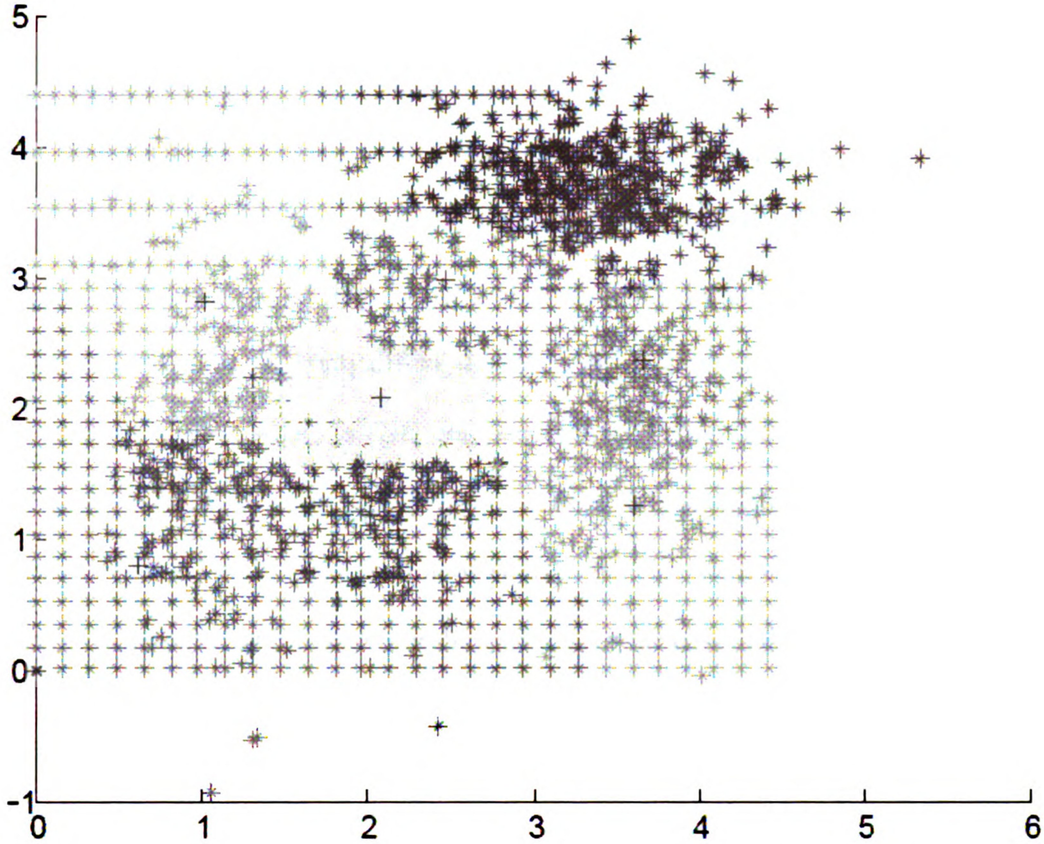

Figure 5.5 The optimized position for the BTs and the effected users by distribution

The modified SOM algorithm we used is based on regular SOM decision maker, which is looking for the minimum distance between each input point and certain weight. So, the closest weight to the input point will be activated and the neighborhood weights will activated with less amount based on the neighborhood function. But, in our case we are using very small width of neighborhood function up to updating only the activated neuron (the closest one). One of the other modifications we applied to the SOM to get what we want is:

The amount of the updating has been done to be the average of the all input points that affected the specified weight.

With this we got weights (BTs position) make very clear clustering and it is positioned based on the distribution of the input data in each cluster as shown in the last figure, the plus shape in the figure represents the position of the BTs.

- The second modification we applied to SOM algorithm is by changing the update rule of the weights on the original SOM algorithm. We just change the power of the difference measure and apply different powers which should be odd. For our case just make it to the power 3 is gives completely better result. So we just need to work on equation (4.14) by applying odd power to the deference in the equation.

With using this kind of modification of SOM to our case we notice it works easier and gives smother optimization for the positions of the base stations. As you can see in figure 5.7.

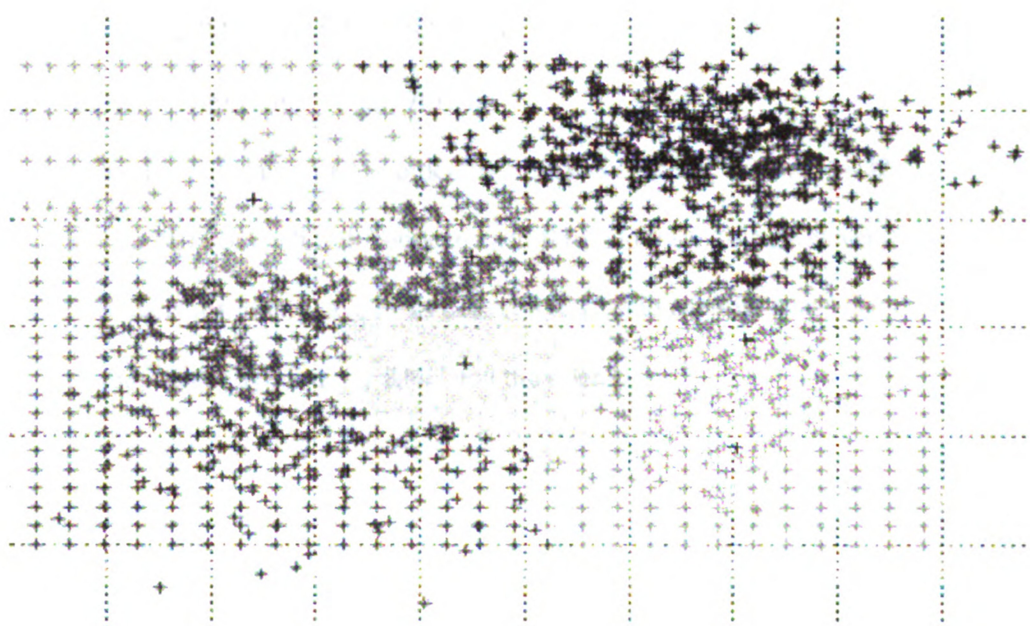

Figure 5.6 The final optimized position for the BTs and the effected users by distribution

5.4 Design and calculation for RNC & microwave link:

As mentioned above the suitable scenario for planning is that one which designed for 144kbps speed of service, that gives the ability to use the multimedia service to grantee for a subscriber that can make a video call from any place of the cell. This is important but the network can deal with less speed of service for non real time 384 kbps data service so for back bone mobile network calculation will be based in 144kbps real data time case as well.

1-) Microwave links are suggested to link BTS with the radio network controller RNC centered in Janzour which is connected by microwave link to the head-quarter operator center in Tripoli, where the Mobile Switch Center (MSC). The capacity of each link is calculated as follows:-

By using data from table 4.4 & table 4.5 we got:

For each of the BTS1, BTS2, BTS3, BTS4, BTS9

1049 users $\times$ 21mErlang = 22.029Erlang

By using table B Erlang for 1% blocking probability 22.029 Erlang $\rightarrow$ 32 channels which need 2E1 for each link between each BTs and NRC this gives very safety spare channels for microwave links between RNC and each BTs.

2-) for the microwave link for RNC and the operator building in Tripoli ' abuseta' is need:

Where E4 has 1920 channel and we have 9 x 32 = 288 channel

Chapter VI

Results and Comparisons

The Universal Mobile Telecommunication System (UMTS) has introduced a completely new high bit rate technology known as Wideband Code Division Multiple Access (WCDMA). So you can say the best thing come out on UMTS is sharing the same frequency band among different users or base stations. In order to preserve quality of existing connections, a new call can be accepted only if the estimated load in the access cell and in the neighboring cells will not exceed particular thresholds set by the radio network planner either in uplink or downlink. [15]

By applying this network system in Janzour area some results have been gotten for different service, where some of these results are general for UMTS network system and an other specifically for Janzour area case study. A comparison between the requirements and parameters have been applied for different service that applied to the network system From the other side we found the results as definitions for the main parameters of the design and the specific values from Janzour area case study.

6.1 Results of planning process of WCDMA network:

6.1.1 General results:

- In WCDMA, the cell sizes are not fixed, but depend on the required capacity. So coverage and capacity parameters are dependent on each other. This means that both parameters have to be planned together online.
- In both Up Link and Down Link the air interface load affects the coverage and as the effect is not exactly the same in the UL and the DL. The calculation of planning will be based on up link because it has less maximum path loss.
- In a WCDMA cell, the available data rate depends on the interference level the closer the MS is to the BS, the higher the data rates that can be provided. Thus, an operator that is aiming to provide 384 kbps coverage must use more BTs than an operator that is aiming for 144 kbps coverage.
- An interference margin is required to prevent pulsating (breathing) cells. In WCDMA, the loading of a cell affects its coverage. The higher the load (higher number of users or higher bit rate), the smaller the cell size.
- The best way to optimize the positions of BTs is to make their positions as brief explanations of the distributions of the subscribers on the area. This comes after deep analysis for defining the distribution of the people in the region.
- Modified SOM in terms of convex sum technique gives the best averaging position for the BTs in terms of effected users. Averaging the effect of data on

neurons based on the size of the window. So, each neuron (BTs) effected by certain data will be centered at the best place.

- Applying the modified SOM and then just repeating the clustering will optimize the results for the region. So, we can find the best position for the neurons (BTs) and then we will look for which data (users) closer to it for clustering.
- The regular SOM algorithm gives fair optimization and clustering where the weights will describe the probability density of subscribers and how frequently each weight has been updated. But, the modified SOM technique gives positions to the weights describe just the density of the users only, which more accurate.
- Free space loss increases as distance increases; also, increasing the frequency will increase the free space path loss.
- Propagation models vary widely in their approach, complexity, and accuracy.

6.1.2. Results related to Janzour area:

* The dimensioning phase, the capacity parameters are dominating than the coverage parameters in Janzour case study. This dependency appear in high speed of service, because of the high density population the area has, even if it is classified as suburban area.

* The uplink has less value for maximum path of losses so it's the limit for design as done in Janzour case study.

* At Janzour area with its population, we found that to get 12.2 kbps speed of service we have to make 5.7km^2 as the maximum distance between the mobile set and the BTs. For 144kbps speed of service the maximum distance is 858 meter

between the subscriber and the Node B. For the maximum distance between BTs & MS is 683 meter. This difference shows the inverse relation between speed of service and distance (figure 5.4) where when the speed of service increase the maximum distance will decrease where the number of BTs increase.

* Janzour area needs 9 BTs to cover 60,000 subscribers by 144kbps as speed of service.

* The best speed of service to grantee Video call is 144kbps where we have ability to make video call by 64kbps but with low quality so the best scenario for Janzour area is to apply 9 BTs for all types of user.

* To obtain the best distribution for the BTs in the region. The distribution of the Base Stations BTs should be mainly depending on the distribution of the users in the area. In Janzour case and based on the all information we have about it, it's not very well designed, there are normal distribution for the users around the main, there are high density populated area in some centers of the city as well and the other parts you can see uniform distribution.

* To distribute the dimensioned number of BTs on the area need an optimization technique. Self Organizing Map SOM is the best technique can be used with some modification on it for the assumed distribution for the Janzour area.

* Self Organizing Map algorithm has been applied with some modification on it. With using the modified version of SOM we reach to the best distribution for the BTs. The way is using the convex sum technique which we applied by averaging the effect that each BTs effected by. Convex sum gives good optimization as well.

6.2. Comparison between different scenarios by definitions of the Radio Frequency Link Budget parameters:

There are two main purposes for establishing the RF link budget for CDMA designs. The first one is to establish system design assumptions for all of the gains and losses in the RF path (such as vehicle loss, building loss, ambient noise margin, maximum subscriber transmit power, etc.). The second purpose of a link budget is to establish an estimate for maximum allowable path loss. This maximum allowable path loss number is used in conjunction with the propagation model to estimate cell site coverage, which ultimately determines the number of cells required for adequate system RF signal coverage and hence the system cost.

The parameters within the RF link budget can be divided into four major categories.

6.2.1 Propagation Related Parameters:

Propagation related parameters are those gains or losses of a link budget that are constant, independent of the multiple access technology chosen or vendor.

6.2.1.1 Building Loss

Building loss is associated with the degradation of the RF signal strength caused by a building structure.

In our calculation done for indoor case which has constant losses for voice 12.2 kbps & video call by 10 dB where we apply it 15dB for 384 kbps because the building loss will have effect.

6.2.1.2 Vehicle Loss

Vehicle loss is the degradation of the RF signal strength caused by a vehicular enclosure.

So in our case we put Vm=8dB as vehicle loss in our calculation, this was only for mobile calculation because it's calculated for the car.

6.2.1.3 Body Loss

Body loss, also referred to as head loss, is the degradation of the RF signal strength due to the close proximity of the subscriber handset antenna to the person's body which is indicated for mobile calculation as 3db manly constant for all types of service.

6.2.1.4 Ambient Noise:

The ambient noise defines the environmental noise that is in excess of KTB for the sector. This noise could be generated from automobiles, factories, machinery, and other man made noise. The ambient noise margin parameter can be added to the link budget to allow for an adjustment to the thermal noise value.

6.2.1.5 RF Feeder Losses:

RF feeder losses include all of the losses that are encountered between the base station cabinet and the base antenna.

6.2.1.6 Antennas:

Antennas can be either omni or directional. Omni antennas provide approximately the same amount of gain throughout the entire 360° horizontal pattern. Directional antennas, sometimes referred to as sector antennas, have a maximum gain in one direction with the backside being 15 to 25 dB below the maximum gain this for BTs antenna where we took it 18 dBi.

the other types of antennas called sectorial antenna which sometimes be 3 sectors or 6 sectors where we use 3 sectors antenna with sectionastion gain factor Gs = 2.63. And for mobile antenna gain we apply 2dBi where we used at data only and it's zero for voice transmission.

6.2.1.7 Interference Noise Rise:

In determining RF coverage in CDMA systems, the effect of interference generated from other users on the serving cell as well as the neighboring cells must be considered.

The interference margin is needed in the link budget because the loading of the cell, the load factor, affect the coverage. The more loading is allowed in the system, the larger is the interference margin needed in the uplink, and the smaller is the coverage area. For coverage-limited cases a smaller interference margin is suggested, while in capacity-limited cases a larger interference margin should be used. In the coverage-limited cases the cell size is limited by the maximum allowed path loss in the link budget, and the maximum air interface capacity of the base station site is not used.

Typically values for the interference margin in the coverage-limited cases are 1.0-3.0 dB, corresponding to 20-50% loading

6.2.1.8. E_b/N_o:

E_b/N_o corresponds to energy per bit over interference plus noise density for a given target Frame Erasure Rate (FER, typical voice FER target is 1%).The E_b/N_o requirement depends on the bit rate, service, multipath profile, mobile speed, receiver algorithms and receiver antenna structure. For mobile systems, The E_b/N_o target varies dynamically as the subscriber moves around.

In our case study we use these different values for these different services:

Table 6.1 Different values for E_b/N_o for different speed of services

Speed of service	E_b/N_o Value (dB)
Voice 12.2 kbps	5 dB
Real data time 144 kbps	1.5 dB
384 kbps non real data time	1 dB
Mixed type of service	2.5 dB

6.2.1.8. Fast fading margins (power control headroom):

Some headroom is needed in the mobile station transmission power for maintaining adequate closed loop fast power control. This applies especially to slow-moving pedestrian mobiles where fast power control is able to effectively compensate the fast fading. Typical values for the fast fading margin are 2.0-5.0 for slow-moving mobiles where it's decreasing with increasing the speed of subscriber.

6.2.1.9. Product Specific Parameters

Product specific parameters are those items in the RF link budget which can vary based on the product (base station and subscriber) chosen.

6.2.1.10. Product Transmit Power:

The transmit power is typically referenced by the power output of the piece of equipment prior to the RF transmission lines and antennas. The maximum transmit power of the base station and the mobile is a product specific parameter. Its value is dependent on hardware components and design.

For the Subscriber Unit using directive antennas for transmission will have a class dependent limit.

We here use for mobile transmitter 0.125 W for voice 12.2 kbps, but for 144kbps real time data is 0.25 W and for non real data 384kbps is 0.25 W, which is important for uplink calculation. [6]

6.3. Comparison between different scenarios by definitions of Quality of Service parameters:

1-) Bad quality calls: Defined as call having an average frame error rate FER exceeding a threshold (usually **5%** for speech). The minimum call duration is set to 7 seconds in order to increase the confidence of the averaging. Statistical data of these calls are recorded such as coordinates, start and end time and the call duration.

2-) Dropped calls: i.e. calls that have consecutive frame errors that exceed a threshold (usually **50** frame errors). Usually dropped calls are considered as severely poor quality calls.

So bad quality and dropped calls can be taken as one measure whose percentage is referred to the number of started calls after the warm-up period.

3-) Power outage: - for speech, this is taken from active terminals. Therefore it is slightly distorted. So the actual outage for terminals that are actively "talking," is higher. Rough value is twice than that of the output. There is no discrepancy for data.

4-) E_b/N_0 targets: is taken from all active terminals including those in SHO. *So* all factors regarding the channel and diversity are taken into account.

In reality the base stations antennas are not installed at equal height and thus the optimization of the base stations should be performed site by site. however the benefit of optimization is rather small when the system is strongly downlink limited and thus the uplink sensitivity improvement is not so beneficial.

We have to note that the ***QoS*** can be improved in the uplink direction in lightly loaded networks. And it's known that How much of the uplink capacity improvement can be utilized in the downlink direction planning & depends naturally on the current downlink loading situation and the admission and load control strategies implemented in the network. The results of this study also clearly show that the higher sectorisation offers more capacity to the network but to achieve this antenna selection is very crucial to effectively control the interference and soft handover overhead. For each sectorisation case an optimum beam width exists.

Chapter VII

Conclusion

7.1. Conclusions

1- Network planning is not just frequency planning, but a much broader process. The network planning process includes things like traffic estimation, figuring the proper number of cells, the placement of BSs, and in terms of frequency planning estimation for code spreading has been done.

2- The propagation model is used in conjunction with the RF link budget to obtain an estimation of the cell radius based on the allowable path loss from the link budget.

3- WCDMA is a multiple access scheme based on spread-spectrum communication techniques. It spread the message signal to a relatively wide bandwidth by using a unique code that reduces interference.

4- Indoor propagation models are based on the characteristics of the interior of the building, building materials, and other factors and are described in terms of various zone models.

5- Multipath and the Doppler Effect contribute to short-term fading, and multiple reflections lead to long-term fading.

6- In CDMA spread spectrum technique, a wideband carrier does not increase the capacity of the allocated BW, but it increases the ability of offering mixed services.

7- In WCDMA system, the capacity is typically not limited by the exact number of channels elements, but by the amount of interference in the air interface (soft capacity).

8- In CDMA systems, it is possible to reuse the same frequency in adjacent cells. This means that the frequency reuse factor is one, while in typical GSM systems the value is between four to seven.

9- Efficient power control is very important for CDMA network performance. It is needed both in the UL and in the DL to minimize the interference in the system.

10- The UTRAN is the new radio access network designed especially for UMTS. The UTRAN consists of radio network controllers (RNCs) and Node Bs (base stations). An RNC is comparable to a Base Station Controller (BSC) in GSM networks.

11- The operator may use hierarchical cell structures in certain places where traffic may need some kind of partitioning among cells with overlapping coverage.

12- The dimensioning developed program makes it easy to calculate initial and final cell radius and it provides easy interface for the users. This can be happening easily with applying the capacity calculation and coverage calculation simultaneously.

13- The link between user data rate, signal to noise ratio and system capacity has been demonstrated. The relationship between the parameters is dynamic in a way that is unique to CDMA systems. Link budgets are affected by fast fading margins and interference margins as well as by the higher noise levels that are due to the increased BW.

14- The main calculations on the WCDMA network planning process is coverage calculation and capacity calculation, both have common factor (load factor η_{ul}) and the best way to make the planning process is by doing both of them at the same time (online). And in terms of wanting both methods to be satisfied, the minimum should be selected.

15- As the main parameter in the planning process is Load Factor η_{ul}. We should be accurate about its initial value to be close to the intersection point between the two calculation to make sure the optimum solution we got is within the active region of the calculation, for this reason graphical calculation needed before running any algorithm.

16- Looking for the convex sum technique from angle as modification of Self Organizing Map apply best optimization for positioning the base station on the area based on the distribution of the subscribers in the land.

17- For optimizing the base station positions, The regular SOM algorithm gives fair optimization and clustering where the weights will describe the probability density of subscribers and how frequently each weight has been updated. But, the modified SOM technique gives positions to the weights describe just the density of the users only, which more accurate.

7.2 Future Trends

Even though 3G telecommunications systems are implemented a lot and people start thinking about the switch to ward next generation. But, WCDMA networks still under development and not yet in widespread operation throughout the world. In today's fast moving information society, continuous improvement is essential. This applies equally to 3G systems themselves, which have already evolved a long way from the first such systems in terms of services and capacities.

And what comes after 3G? Obviously, 4G. Fortunately, also here there seems to be some consensus on the features of such a system. Even higher bit rates will be supported, averaging perhaps around 2 Mbps with some peaks at 20 Mbps and in extreme cases up to 200 Mbps.

As to trends in services, it will become more and more important to deliver the right information at the right time and to the right place. Content and applications become of high importance.

Location-based services are enabling a variety of new applications and are complementing many existing applications with a new dimension. It is thought that many services will exist at the same time in different environments and with different resolutions.

Many location-based services are already possible today provided that the location is input manually. The enhancement of those services with automatic location by the network will add value for all parties. Finally the market will decide on service profitability and on which location methods will succeed. Location-based services, as well as many other applications, are already well developed and implemented.

So right now we have to start with :

1- The need for the information about the area need to be more developed to get more accurate results. Depending only on small number of information resources makes the planning process more attractive but not too much accurate. So, some work related to collecting the data about the target region should be done.

2- More real experiments should be done toward signing suitable values for the link budget parameters and loses power will help on the dimensioning process.

3- The planning program can be improved by using subprograms to estimate the density and positions of traffic from digital maps based just on very important information about the area. For example Satalite image for the region, population of the area and architecture information about buildings.

The way that used by the program to solve the BTS position can be modified to apply to fixed communication field for more ability of com.

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