Palestine Polytechnic University

PPU College Of Engineering and Technology
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College of Engineering and Technology
Electrical and computer Engineering Department

Graduation Project

Network Planning Of The Fourth Generation Using Wimax in Yatta Region.

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بسم الله الرحمن الرحيم

جامعة بوليتكنك فلسطين
كليه الهندسة والتكنولوجيا
دائرة الهندسة الكهربائية والحاسوب

اسم المشروع:

Network Planning Of The Fourth Generation Using Wimax in Yatta Region.

أسماء الطلبة:

أحمد جديع　　　　جهاد المقوسي

عيسى الشواهين　　　　طارق مخامرة

بناءً على نظام كليه الهندسة والتكنولوجيا وإشراف ومتابعة المشرف المباشر على المشروع وموافقة أعضاء اللجنة الممتحنة و تم تقديم هذا المشروع إلى دائرة الهندسة الكهربائية والحاسوب وذلك استكمالاً لمتطلبات درجة البكالوريوس في تخصص هندسة الاتصالات .

توقيع المشرف　　　　..........................

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توقيع رئيس الدائرة　　　　..........................

DEDICATION

To all who helped in the success of this project

To our Supervisor:

Dr. Ghandi Manasra.

To AL Wataniya Mobile Team:

Eng. Naim J. Nazzal

Eng. Ahmed Assaf

Eng. Louai Alawneh

To Our families and Friends.

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ABSTRACT

This project comes in response to the revolution of the broadband wireless communication systems. These system are characterized by their ability to introduce high data rate with low bit error rate (BER) at high signal to noise ratio (SNR). Wimax system is one of those systems that is used for high data rate based on application such as internal browsing. For these reasons, we select Wimax as graduation project .In this project , Wimax planning in Yatta region , we make a full network design using network planning tools in order to improve capacity and enhancement the network.

WiMAX is a standards-based on IEEE 802.16 technology enabling the delivery of last mile .

Wireless broadband access as an alternative to wired broadband like cable and DSL. WiMAX provides fixed , nomadic, portable and, soon, mobile wireless broadband connectivity without the need for direct line-of-sight with a base station. In a typical cell radius deployment of three to ten kilometers, WiMAX Forum Certified™ systems can be expected to deliver capacity of up to 75 Mbps per channel, for fixed and portable access applications.

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LIST OF ABBREVIATIONS

WiMAX	Worldwide Interoperability for Microwave Access
IEEE	Institute of electrical and electronics engineers
PDAs	personal digital assistants
WWANs	wireless wide area networks
WPANs	wireless personal area networks
ETSI	European Telecommunications Standards Institute
3GPP	3rd Generation Partnership Project
WWAN	Wireless Wide Area Networks
2G	second-generation system.
GSM	Global System for Mobile Communications
CDPD	Cellular Digital Packet Data
CDMA	Code Division Multiple Access
3G	third –generation
ITU	International Telecommunication Union
WMAN	Wireless Metropolitan Area Networks
MMDS	Multi-Channel Multi-Point Distribution Service
LMDS	Local Multi-Point Distribution Services
WLAN	Wireless Local Area Networks
Mbps	megabit per second
GHz	gigahertz
WPAN	Wireless Personal Area Networks
POS	personal operating space
SIG	Special Interest Group
WiFi	Wireless Fidelity
ADSL	Asymmetric digital subscriber line
LTE	Long Term Evolution
OFDMA	Orthogonal Frequency Division Multiple Access
SC-FDMA	Single Carrier Frequency Division Multiple Access
DSL	digital subscriber line
BWA	Broadband wireless access
BS	base station
SS	subscriber station
CDMA	division multiple access
VoIP	voice over IP
HSDPA	high speed downlink access
IP	Internet Access

	Wireless Broadband
	Universal Mobile Telecommunications System
	wideband code division multiple access
	evolution data only
	Multi input Multi output
	Asynchronous Transfer Mode
	Internet Protocol version 4
	Internet Protocol version 6
	virtual local area network
	Quality of service
	Third Generation Partnership Project 2
	line-of-sight
	single-channel
	Quadrature Phase Shift Keying
	Quadrature Amplitude Modulation
	fast Fourier transform
	forward error control
WiMAX BSs	WiMax Base stations
MAC	medium access control
P-P	point-to-point
P-MP	point-to-multi-point
CPE	customer premise equipment
NLOS	non-line-of-sight
AP	access point
MCS	modulation and coding scheme
DL	downlink
UL	uplink
FDD	frequency division duplexing
TDD	time division duplexing
RBS	radio base station
PUSC	partially used sub-carrier
FUSC	full used sub-carrier

WiBro	Wireless Broadband
UMTS	Universal Mobile Telecommunications System
W-CDMA	wideband code division multiple access
EVDO	evolution data only
MIMO	Multi input Multi output
ATM	Asynchronous Transfer Mode
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
VLAN	virtual local area network
QOS	Quality of service
3GPP2	Third Generation Partnership Project 2
LOS	line-of-sight
SC	single-channel
QPSK	Quadrature Phase Shift Keying
QAM	Quadrature Amplitude Modulation
FFT	fast Fourier transform
FEC	forward error control
WiMAX BSs	WiMax Base stations
MAC	medium access control
P-P	point-to-point
P-MP	point-to-multi-point
CPE	customer premise equipment
NLOS	non-line-of-sight
AP	access point
MCS	modulation and coding scheme
DL	downlink
UL	uplink
FDD	frequency division duplexing
TDD	time division duplexing
RBS	radio base station
PUSC	partially used sub-carrier
FUSC	full used sub-carrier

Chapter One

Introduction

1.1 WiMax Technology

1.2 History of network planning

1.3 Characteristics of 4G/WiMAX Network

1.4 WiMax as a Solution to 4G

1.5 Evolution of 4G

1.6 Project Importance

1.7 Project object

1.8 Activity description and time plan

Chapter One

1.1 WiMax Technology

1.1.2 Definition of WiMax

WiMax (Worldwide Interoperability for Microwave Access) is a communication technology for wirelessly delivering high-speed Internet service to large geographical areas. WiMax offers data-transfer rates of up to 75 Mbit/s.

1.1.3 Overview of WiMax

The demand for broadband services is growing sharply today. The traditional solutions to provide high-speed broadband access is to use wired access technologies, such as cable modem, digital subscriber line (DSL), Ethernet, and fiber optic. However, it is too difficult and expensive for carriers to build and maintain wired networks, especially in rural and remote areas. Broadband wireless access (BWA) technology is a flexible, efficient, and cost-effective solution to overcome the problems. The global deregulation of radio spectrum also encourages the development of BWA technologies. WiMAX is one of the most popular BWA technologies today, which aims to provide high speed broadband wireless access for wireless metropolitan area networks (WMANs). The air interface standard, IEEE 802.16, commonly referred to as WiMax is a specification for broadband wireless communication standards developed for WMANs, which supports fixed, nomadic, portable, and mobile broadband accesses and enables interoperability and coexistence of BWA systems from different manufacturers in a cost-effective way. Compared to the complicated wired network, WiMax system only consists of two parts: the WiMax base station (BS) and WiMax subscriber station (SS), also referred to as customer premise equipments. Therefore it can be built quickly at a low cost.

Ultimately, WiMax is also considered as the next step in the mobile technology evolution path. The potential combination of WiMax and code division multiple access (CDMA) standards is referred to as 4G.

1.2 History of network planning

The communications landscape is changing dramatically under the increasing pressure of rapid technological development and intensifying competition. The most significant development in the communications industry in the past ten years has been the dramatic increase in network capabilities and the subsequent fall in communications pricing. The effects of this revolution have been felt in almost every sector including banking, investment, healthcare, real estate, education, trading, manufacturing, governance, and law. The empowering capabilities of advanced communication technologies will certainly be the pivotal force shaping economies and societies over the next few years.

In less than one generation, the distinctions among telephone, broadcast, cable, satellite, wireless, and information services have all but disappeared as broadband, and wireless Internet technologies subsume all modes of news, entertainment, data, and voice transmissions.

Although the 1970s and 1980s will be remembered as the information age and the 1990s will undoubtedly be singled out in history as the beginning of the Internet age, the first decades of the twenty-first century may become the broadband age, or even better, the age of convergence. The advent of the networked computer was truly revolutionary in terms of information processing, data sharing, and data storage. In the 1990s, the Internet's influence was even more revolutionary in terms of communications and furthering the progress of data sharing from the personal level to the global enterprise level.

Today, broadband elements such as fiber optics, wireless access, and cable modems provide very-high-speed access to information and media of all types via corporate networks and the Internet, creating an "always-on" environment. The result will eventually be a widespread convergence of entertainment, telephony, and computerized information: data, voice and video, delivered to a rapidly evolving array of Internet appliances, personal digital assistants (PDAs), wireless devices (including cellular telephones), and desktop computers.

The broadband market continues to be a dynamic sector as the competitive landscape and consumer demand for new communication services continue to evolve. Driven by the need to find new sources of revenue, service providers are looking for ways to unleash the potential of broadband networks.

1.3 Characteristics of 4G/WiMAX Network

4G wireless networks can be realized with an IP-based core network for global routing along with more customized local area radio access networks that support features such as dynamic hand-off and ad hoc routing as well as newer requirements such as self-organization, Quality of service (QoS), multicasting, content caching, etc. For a successful deployment of the 4G technology, it is imperative that we define the vision for the 4G services and applications that effectively meet the users need. The vision that is driving us is the users' vision as listed below:

1. Broadband: You want to be able to send and receive all kinds of information—images, video, big data files, and the same can be done at any location. 100MHz per operator is required for 4G voice, video, and data services. As applications require more data rates that is where technologies such as mobile WiMax are valuable and the goal is to build bridges to traditional 3GPP and 3GPP2 standards.

2. Mobility: With 4G, a wireless customer might be able to take a car or train ride coast to coast and surf the Web uninterrupted. With WiMAX network service providers will now enjoy the flexibility to market mobile, nomadic, and fixed services at true broadband speeds to customers with extremely efficient control over the access and use of their radio spectrum and network resources.

3. Roaming between various networks: If you are moving around and you go from a high-speed wireless LAN to a cell or satellite system, you want the hand-off to be smooth. Your applications should adapt gracefully, not choke or drop out. The key here will be enabling the "hand-off'' procedures that allow a mobile device to switch the connection from one BS to another, from one 802 network type to another. For example, a notebook could connect via Ethernet or 802.11 when docked, and stay connected with 802.16 when roaming the city or suburbs. The goal is to standardize the hand-off so that devices are interoperable as they move from one network type to another. The aim is to build a network interface to these networks connecting to all networks including DSL and cable infrastructure because we want WiMax technology to be adapted by both the mobile operators and fixed operators.

4. Convergence: You want to be able to access the network from lots of different platforms, such as cell phones, laptops, PDAs. WiMax is a powerful system that delivers connectivity intelligent and flexible enough to support streaming video, VoIP telephony, still or moving images, email, Web browsing, e-commerce, and location-based services through a wide variety of devices. That means freedom for consumers.

5. Efficient: In addition to being a lot more cost efficient, 4Gis spectrally efficient, so carriers can do more with less. WiMax based on OFDM is spectrally efficient. Also we believe that IP-enabled technology will provide a lower cost and faster time-to-market solution.

6. Access over inaccessible area: With wireless systems, mobile users can be contacted almost anywhere, anytime. The ability to quickly provision service, even in areas that are hard for wired infrastructure to reach; for example, if rivers, free ways, or other obstacles separate buildings you want to connect, a WMAN solution may be much more economical than installing physical cable or leasing communications circuits.

7. Harmonization: As there is no single network blanketing the globe, but rather a vast patchwork of networks, the whole thing has to be heterogeneous and seamless. So, the goal is to build a new high capacity, high-quality interoperable broadband network that can carry any content that any consumer wants to have. That is where WiMax comes in. However, since chipsets are custom-built for each BWA manufacturer, this adds time and cost to the process of bringing a product to market.

1.4 WiMax as a Solution to 4G

Mobile WiMax is a 4G technology that is fairly well accepted and will offer broadband data, voice, and video services. At the moment, WiMax technology will build upon Wi-Fi in a very complementary way, expanding open standard-based wireless networking for metropolitan area outdoor mobility applications including voice over IP (VoIP). Hence WiMax with Wi-Fi can be called as a migration path to 4G [2]. While Wi-Fi is able to provide high-speed, localized, wireless Internet access, the emerging WiMax standard is a wide area technology, supplying wireless coverage over an area of several kilometers. WiMax (IEEE 802.16) with Wi-Fi (IEEE 802.11) will allow operators to deliver high-quality voice, video, and data services on a metropolitan scale and can provide users with connectivity wherever they are. Thus, WiMax will deliver the promise of 4G, expanding open standard-based wireless networking for metropolitan area outdoor mobility applications. This part provides a very strong comparison between WiMax with other BWA 4G-based technologies, deployment of various architectures like (i) WiMax micro-cells formed with Wi-Fi to provide micro mobility, (ii) WiMax macro-cells that provide macro mobility, and (iii) mobile WiMax architecture for full mobility.

1.5 Evolution of 4G

4G is basically a wireless phone standard and has a life of its own. It is a part of the wireless telephone family [3]. The original analog and digital cellular services were invented to cut the wire on landline phone service and provide a regular mobile telephone service. As such, the bandwidth they offer for adding data services is pretty meager, in the low Kbps region. The wireless phone family started competing with the wireless Internet family. Now that a wireless/cell phone is not merely a cell phone, but also a personal digital assistant (PDA), a messaging system, a camera, an Internet browser, and an email reader. This is the place where the whole concept of "G'' thing got started [4]. This new generation of cell phone service has been dubbed 3G for third generation. 3G has been proven to be a tough generation to launch. The demand for greater bandwidth right now has spawned intermediate generations called 2.5G and even 2.75G. While 3G phones and services are just starting to come into their own, the industry is developing triple play models, where voice, data, and video get bundled called 3¼G technologies such as high speed downlink packet access (HSDPA). There is also an emerging cellular standard with true broadband data speeds (20 Mbps) called 4G. These speeds enable high-quality video transmission and rapid download of large music files. While the story of wireless phone family is on one side, the wireless Internet family, which includes WiFi and the emerging WiMax standards, has started offering wireless VoIP telephone services, competing with 3G, and achieving the goals of 4G. These are completely different set of standards based on IP solutions. The first device-level WiMax products, such as laptop cards, will take from 2 to 5 years to come and will enable a user to remain connected within an entire metropolitan area. Recently, a product portfolio known as Wi4, which melds mobile WiMax (802.16e) and 4G technologies, has been introduced by Motorola [4] that can deliver 300 Mbps in a fully mobile environment. Wi4 solutions will use all-IP access technology, peer-to-peer architecture, and "zero footprint'' BS solution that will eliminate the need for a great deal of equipments used in legacy cellular networks. Also Korea's telecom industry has developed its own standard, WiBro, which is derivative of the mobile version of WiMAX [5]. So, a slugfest between cellular phone services and the BWA technologies offering VoIP services is going on. Cellular is trying to carve out its own unique markets next to wireless broadband. However, the question is whether wireless broadband currently like WiMAX be able to deliver 4G goals or will it have to merge with cellular to migrate toward 4G. But there are also possibilities that the two are likely to merge so that they can support both the cellular and VoIP standards.

1.6 Project Importance

Wimax stands for worldwide interoperability for microwave access. As widely know Wimax enables the delivery of last mile wireless broadband access as an alternative to ADSL and cable broadband .

Wimax also has very potential to replace a number of existing world communication infrastructure , in the fixed wireless region, it can replace the telephone copper wire networks, cable TV coaxial cable infrastructure and in cellular zone, Wimax has the capacity to fill in the place of existing cellular networks. The most important thing about it is you get all its services cheaper comparing to the services from another technologies like ADSL, cable, and fiber optics etc...

The working system of Wimax is much different from that of WiFi , which is described as internet hotspots, Wimax is potentially better in terms of coverage, self installation, power consumption, and bandwidth efficiency while comparing to WiFi ,the conception is capable of full mobility support, it has broken away many of WiFi limitations by providing increased bandwidth between the use of wires and cable.

1.6.1 The magnitude of Wimax and its bandwidth make it suitable for possible usages

It is a powerful wireless alternative to ADSL and cable broadband access. It can connect existing WiFi hotspot, with each other and to rest of the internet, It can provide high quality mobile communication services. Wimax wireless broadband and Wimax mobiles service probably work within a local loop.

1.6.2 Broadband internet in Wimax

Many cable and telephone companies are considering installation of Wimax to extend their services where they are not reachable ,thus providing users the complete broadband. So in areas where physical cable or telephone networks are not feasible until now, Wimax will be a viable alternative for broadband access. Wimax working indoor are comparably similar to an ADSL or cable broadband, Wimax out door model allow users to access it form much further away from the Wimax base station.

Another benefit for Wimax, it is highly possible to use Wimax with existing cellular networks, Wimax can share a cell tower without doing any changes in the function of existing cellular arrangement.

1.7 Project object:

- To study and understand the basic concepts in 4G.
- To figure out the main planning concepts in 4G.
- To plan and survey a 4G network in Yatta area, taking into consideration the effective parameters i.e. power, frequency …etc.
- To understand how to use WIMAX in a 4G network.
- To support the preplanned 4G network with WIMAX technology.
- To prepare a WiMAX network plan (Accesqs and Core, quantities and distribution).
- To predict the network coverage.
- To modify and optimize the network to fulfill the network requirements.

1.8 Activity description and time plan

In this part, we will state the project activities ,the time period of each activity the starting and ending time for each of them and the activities dependence .

Table 1.1 Activities description (first semester).

Activity ID	Activity description
A1	Selecting of the project.
A2	Collecting information, abstract And project plan.
A3	Collecting detailed information about project
A4	Collecting information about project region.
A5	Write documentation.

Table 1.2 Time plan (first semester)

Week / Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A1																
A2																
A3																
A4																
A5																

Table 1.3 Activities description (second semester)

Activity ID	Activity description
A6	Drawing the flowchart of the system.
A7	Create project of the systems.
A8	Testing the main program, and beginning of planning.
A9	Analyzing the most important system parameter.
A10	Concluding the result.
A11	Writing the report.

Table 1.4 Time plan (second semester)

Week / Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A6																
A7																
A8																
A9																
A10																
A11																

Chapter Two

WiMAX

2.1 LTE technology

2.2 Understanding The Technology

2.3 Types of WiMax

2.4 Network Topology

2.5 Duplexing scheme TDD or FDD

2.6 FDM, OFDM, OFDMA, SOFDMA

2.7 WiMAX Evolution of the Technology (Standard)

2.8 Advantages of WiMax

2.9 WiMAX Applications

2.10 Impact of Similar Technologies on Wimax

Chapter two

In September 2009, the technology proposals were submitted to the International Telecommunication Union (ITU) as 4G candidates[2] . Basically all proposals are based on two technologies:

- Long Term Evolution (LTE) Advanced standardized by the 3GPP
- 802.16m standardized by the IEEE (i.e. WiMAX)

2.1 LTE Technology

2.1 .1 Definition of LTE

LTE (Long Term Evolution) is a wireless broadband technology designed to support roaming Internet access via cell phones and handheld devices. Because LTE offers significant improvements over older cellular communication standards, some refer to it as a 4G (fourth generation) technology along with WiMax.

2.1.2 Overview of LTE

The multiple access scheme in LTE downlink uses Orthogonal Frequency Division Multiple Access (OFDMA) and uplink uses Single Carrier Frequency Division Multiple Access (SC-FDMA). These multiple access solutions provide orthogonality between the users, reducing the interference and improving the network capacity. The resource allocation in the frequency domain takes place with a resolution of 180 kHz resource blocks both in uplink and in downlink. The frequency dimension in the packet scheduling is one reason for the high LTE capacity. The uplink user specific allocation is continuous to enable single carrier transmission while the downlink can use resource blocks freely from different parts of the spectrum. The uplink single carrier solution is also designed to allow efficient terminal power amplifier design, which is relevant for the terminal battery life.

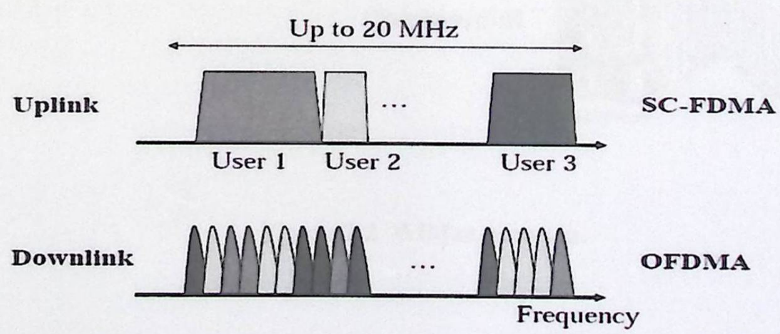

Figure 2.1 LTE multiple access schemes

2.2 Understanding The Technology

2.2.1 How WiMAX Works

Let us take a quick glance at the working of a basic WiMax system. A WiMax base station is connected to public networks using optical fiber, cable, microwave link, or any other high-speed point-to-point (P-P) connectivity, referred as a backhaul . In few cases such as mesh networks, point-to-multi-point (P-MP) connectivity is also used as a backhaul. Ideally, WiMax should use point-to-point antennas as a backhaul to connect aggregate subscriber sites to each other and to base stations across long distances. A base station serves subscriber stations (also called customer premise equipment [CPE] for obvious reasons) using non-line-of-sight (NLOS) or line-of-sight (LOS) point-to-multi-point connectivity, and this connection is referred to as the last mile . Ideally, WiMax should use NLOS point-to-multi-point antennas to connect residential or business subscribers to the base station (Figure 2.2). A subscriber station typically serves a building (business or residence) using wired or wireless LAN.

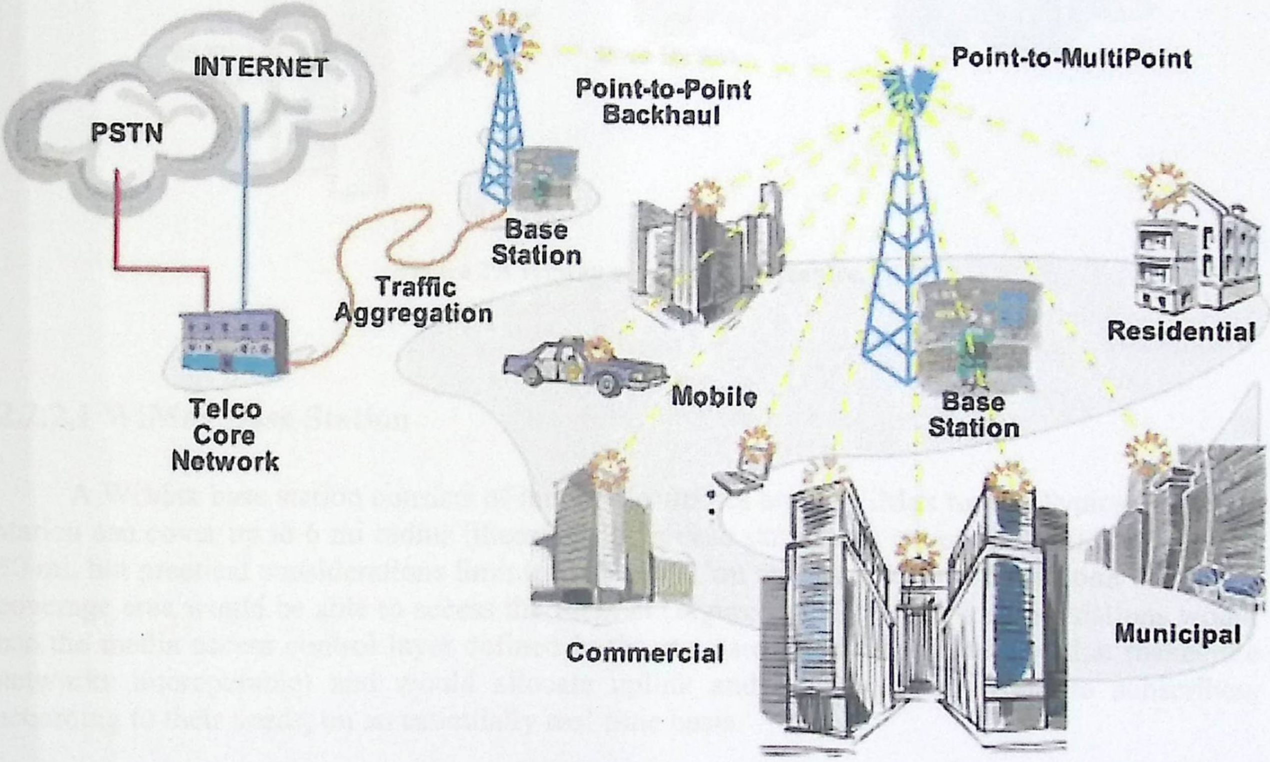

Figure 2.2 WiMax network.

2.2.2 Network Architecture of WiMax

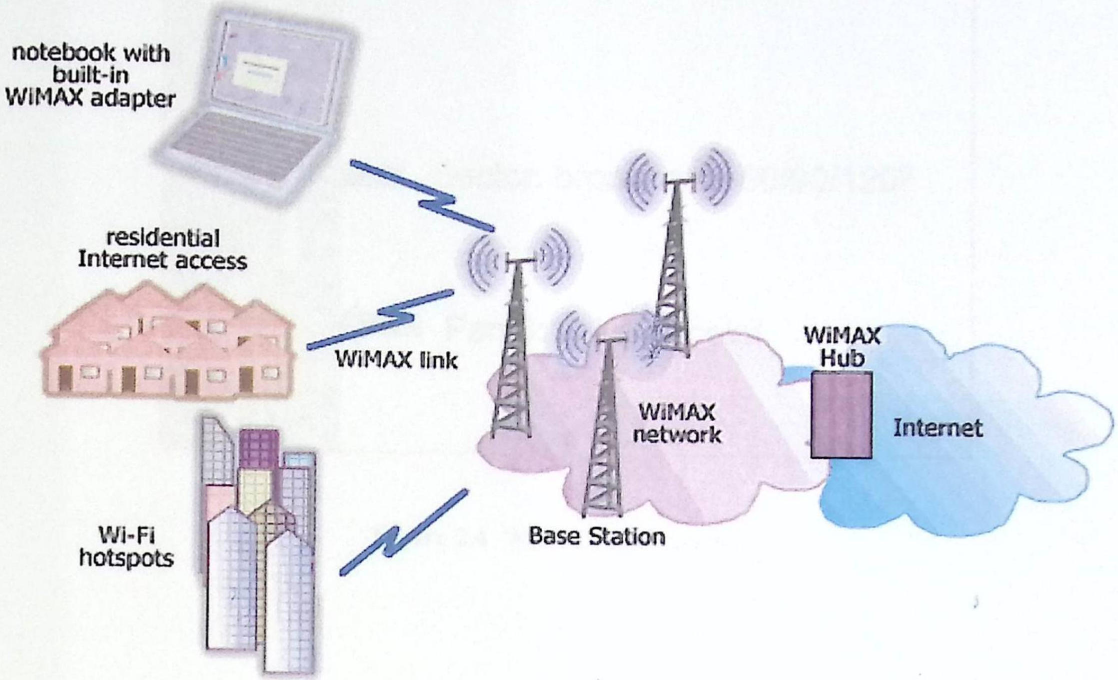

Figure 2.3 WiMax network Architecture.

2.2.2.1 WiMax Base Station

A WiMax base station consists of indoor electronics and a WiMax tower. Typically, a base station can cover up to 6 mi radius (theoretically, a base station can cover up to 50 km radius or 30 mi, but practical considerations limit it to about 10 km or 6 mi). Any wireless node within the coverage area would be able to access the Internet (Figure 2.4). The WiMax base stations would use the media access control layer defined in the standard (a common interface that makes the networks interoperable) and would allocate uplink and downlink bandwidth to subscribers according to their needs, on an essentially real-time basis.

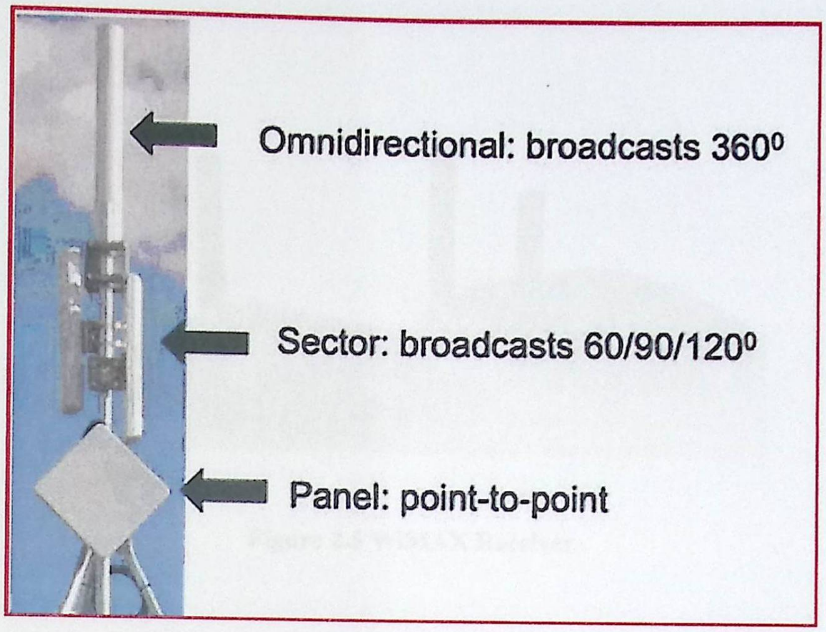

Figure 2.4 WiMAX Base Station.

WiMax base stations can range from units that support only a few subscriber stations to elaborate equipment that supports thousands of subscriber stations and provides many carrier-class features. Whatever number of subscriber stations a base station supports, the latter must manage a variety of functions that are not required in subscriber equipment. Some base stations must support sophisticated antenna capabilities and implement efficient frequency reuse. As a result, WiMax base stations will have many different configurations. They will likely range from simple stand-alone units that support a few users to redundant, rack-mounted systems and server blades that operate alongside wire line networking equipment. On the hardware side, this equipment will typically use off-the-shelf microprocessors and discrete RF components

2.2.2.2 WiMax Receiver

A WiMax receiver, which is also referred as CPE, may have a separate antenna (i.e., receiver electronics and antenna are separate modules) or could be a stand-alone box or a PCMCIA card that sits in a laptop or computer. Access to a WiMax base station is similar to accessing a wireless access point (AP) in a Wi-Fi network, but the coverage is more (Figure 2.5). So far one of the biggest deterrents to the widespread acceptance of broadband wireless access (BWA) has been the cost of CPE. This is not only the cost of the CPE itself, but also that of installation. Historically, proprietary BWA systems have been predominantly LOS, requiring highly skilled labor and a truck role to install and "turn up" a customer. The concept of a self-installed CPE has been the Holy Grail for BWA from the beginning. With the advent of WiMax, this issue seems to be getting resolved.

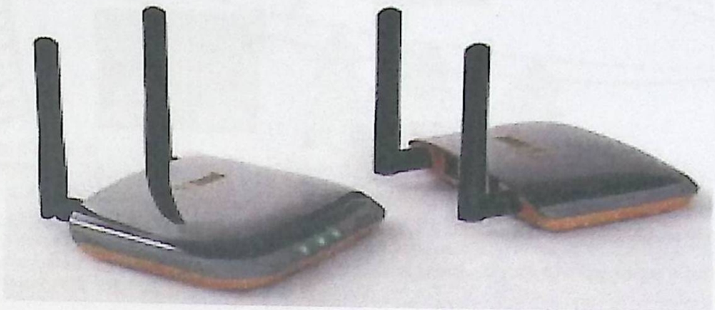

Figure 2.5 WiMAX Receiver

2.2.2.3 Backhaul

Backhaul refers both to the connection from the access point (AP) back to the provider and to the connection from the provider to the core network. A backhaul can deploy any technology and media provided it connects the system to the backbone. In most of the WiMax deployment scenarios, it is also possible to connect several base cc by use of high-speed backhaul microwave links. This would also allow for roaming by a WiMax subscriber from one base station coverage area to another, similar to roaming enabled by cellular phone companies.

2.6.2.4 Line-of-Sight

The original 802.16 standard operates in the 10 to 66 GHz frequency band and requires LOS towers. The LOS access service employs a dish antenna that points straight at the WiMax tower from a rooftop or pole. The LOS connection is stronger and more stable, so it is able to send a lot of data with fewer errors. LOS transmissions use higher frequencies, with ranges reaching a possible 66 GHz. At higher frequencies, there is less interference and more bandwidth. Through the stronger LOS antennas, the WiMAX transmitting station would send data to WiMax enabled computers or routers set up within the transmitter's 30 mi radius (3600 sq mi or 9300 sq km of coverage). This is what allows WiMAX to achieve its maximum range.

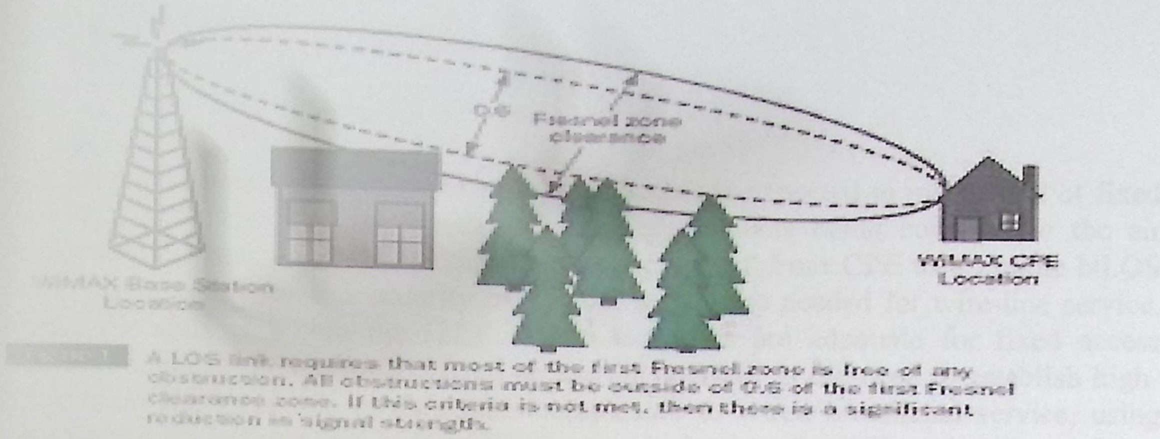

Figure2.6 Wimax LOS

2.6.2.5 Non-Line-of-Sight

The 802.16a extension, ratified in January 2003, uses a lower frequency of 2 to 11 GHz, enabling NLOS connections. This was a major breakthrough in wireless broadband access because LOS between transmission point and the receiving antenna is not necessary. With 802.16a, more customers can be connected to a single tower, substantially reducing service costs. The NLOS access service is very similar to Wi-Fi, in which a small antenna on a computer connects to the tower. Lower-frequency transmissions are not as easily disrupted by physical obstructions as the high-frequency transmissions, and they are better able to diffract, or bend, around obstacles. Based on this principle, WiMax uses a lower frequency range of 2 GHz to 11 GHz (similar to Wi-Fi) in this mode. NLOS-style access will be limited to a radius between 4 to 6 mi (perhaps 25 sq mi or 65 sq km of coverage, which is similar in range to a cell phone zone). The centimeter spectrum contains both tributary and last mile potential. IEEE 802.16-2004 supports fixed-NLOS BWA to supplant or supplement DSL and cable access for last mile service.

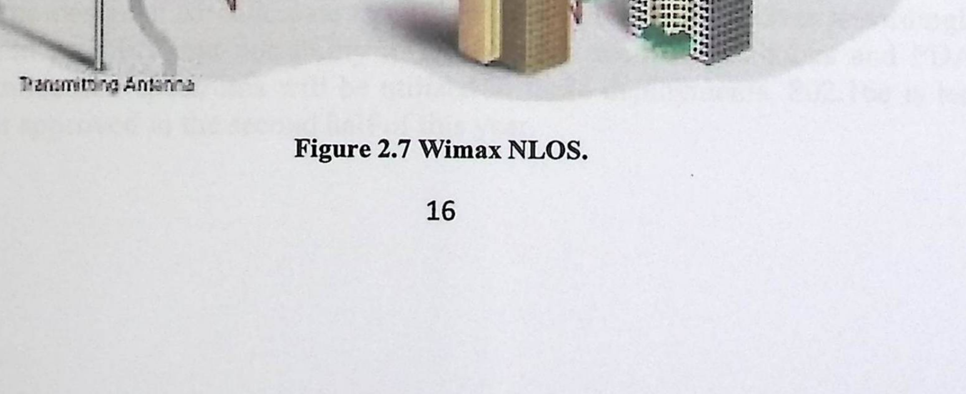

Figure 2.7 Wimax NLOS.

2.3 Types of WiMax

2.3.1 Fixed

Service and consumer usage of 802.16 for fixed access is expected to mirror that of fixed wireline service, with many of the standards-based requirements being confined to the air interface. Because communication takes place via wireless links from CPE to a remote NLOS base station, requirements for link security are greater than those needed for wire-line service. The security mechanisms within the IEEE 802.16 standards are adequate for fixed access service. An additional challenge for the fixed-access air interface is the need to establish high-performance radio links capable of data rates comparable to wired broadband service, using equipment that can be self installed indoors by users, as is the case for DSL and cable modems. IEEE 802.16 standards provide advanced physical (PHY) layer techniques to achieve link margins capable of supporting high throughput in NLOS environments.

2.3.2 Portable or Mobile

The 802.16a extension, ratified in January 2003, uses a lower frequency of 2 to 11 GHz, enabling NLOS connections. The latest 802.16e task group is capitalizing on the new capabilities this provides by working on developing a specification to enable mobile 802.16 clients. These clients will be able to hand off between 802.16 base stations, enabling users to roam between service areas. There can be two cases of portability: full mobility or limited mobility. The simplest case of portable service (referred to as nomad city) involves a user transporting an 802.16 modem to a different location. Provided this visited location is served by wireless broadband service, in this scenario the user re-authenticates and manually reestablishes new IP connections and is afforded broadband service at the visited location. In the fully mobile scenario, user expectations for connectivity are comparable to facilities available in third-generation (3G) voice/data systems.

Users may move around while engaged in a broadband data access or multimedia streaming session. Mobile wireless access systems need to be robust against rapid channel variation to support vehicular speeds. There are significant implications of mobility on the IP layer owing to the need to maintain rout ability of the host IP address to preserve in-flight packets during IP handoff. This may require authentication, and handoffs for uplink and downlink IP packets and MAC frames. The need to support low latency and low-packet-loss handovers of data streams as users transition from one base station to another is clearly a challenging task. For mobile data services, users will not easily adapt their service expectations because of environmental limitations that are technically challenging but not directly relevant to the mode of user (such as being stationary or moving). For these reasons, the network and air interface must be designed to anticipate these user expectations and deliver accordingly. IEEE 802.16e will add mobility and portability to applications such as notebooks and PDAs. Both licensed and unlicensed spectrums will be utilized in these deployments. 802.16e is tentatively scheduled to be approved in the second half of this year.

2.4 Network Topology

Today, there are technologies emerging that take advantage of LOS transmission capabilities long thought out of date. Whereas LOS technology was more often than not point to point, today's advances allow for point to multi-point, providing a much more cost-effective service. Some of these technologies can even support obstructed transmission paths, common in typical communities.

2.4.1 P-P Networks

P-P fixed wireless networks are commonly deployed to offer high speed dedicated links between high-density nodes in a network. Such systems are cost-effective and can be deployed easily. Moreover, as a large part of a wireless network's cost is not incurred until the CPE is installed, the network service operator can time capital expenditures to coincide with the signing up of new customers. P-P systems provide an effective last mile solution for the existing service provider and can be used by competitive providers to deliver services directly to end users. Benefits can be summarized as follows:

- Lower entry and deployment costs.
- Ease and speed of deployment (rapid development with minimal disruption to the community and the environment).
- Fast realization of revenue (as a result of rapid deployment)
- Demand-based build-out (scalable architecture employing open industry standards ensuring services and coverage areas can be easily expanded as customer demand warrants).
- Cost shift from fixed to variable components.
- No stranded capital when customers churn.
- Cost-effective network maintenance, management, and operating costs.

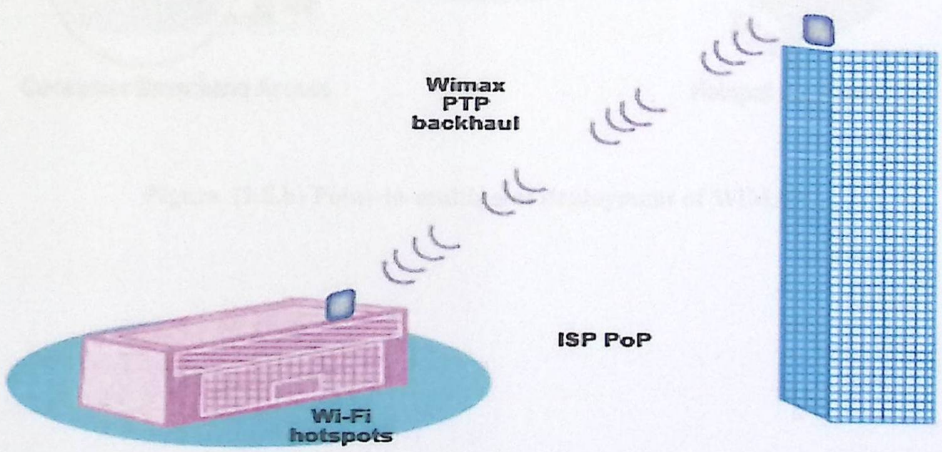

Figure (2.8a) Point-to-point topology.

2.4.2 P-MP Networks

P-MP is a concept in which multiple subscribers can access the same radio platform, utilizing both a multiplexing method and queuing. More recent advances in P-MP technology offer service providers a method of providing high-capacity local access that is less capital intensive and faster to deploy than wire line, and that is able to offer a combination of applications. P-MP implementations are emerging in several bands above 20 GHz, up to about 40 GHz. These consist of a complex TDM hub or base station using sector antennas and TDMA subscriber stations using parabolic antennas. Most P-MP systems use a simple modulation method, e.g., QPSK, but higher-level modulation methods are also used in some systems, e.g., 64QAM. There is a trade-off between modulation method, interference tolerance and link length: more advanced P-MP system capabilities, including even higher level modulation methods.

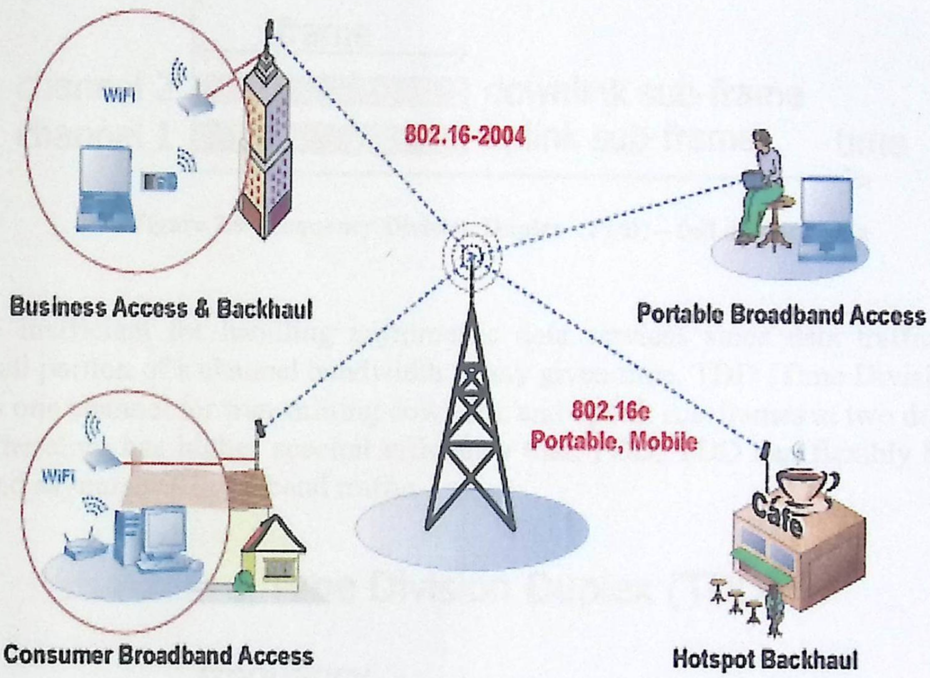

Figure (2.8.b) Point-to-multipoint deployment of WiMAX.

2.5 Duplexing scheme TDD or FDD

Duplexing refers to the way downlink and uplink data is arranged in a two-way wireless transmission.

FDD (Frequency Division Duplex) requires two distinct channels for transmitting downlink sub-frame and uplink sub-frame at the same time slot. FDD is suitable for bi-directional voice since it occupies a symmetric downlink and uplink channel pair. WiMAX supports full-duplex FDD and half-duplex FDD.

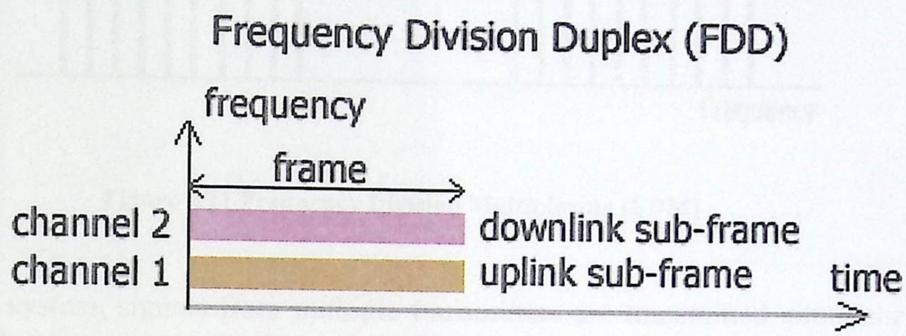

Figure 2.9 Frequency Division Duplex (FDD) – full duplex mode

FDD is inefficient for handling asymmetric data services since data traffic may only occupy a small portion of a channel bandwidth at any given time. TDD (Time Division Duplex) requires only one channel for transmitting downlink and uplink sub-frames at two different time slots. TDD therefore has higher spectral efficiency than FDD. TDD can flexibly handle both symmetric and asymmetric broadband traffic .

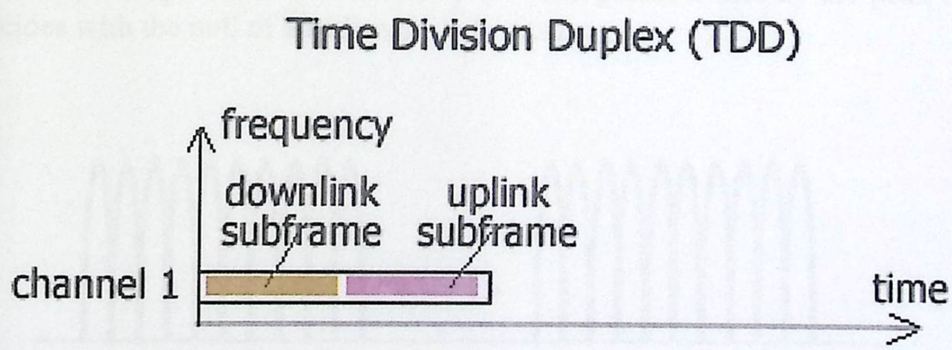

Figure 2.10 Time Division Duplex (TDD)

TDD uses half of FDD spectrum hence saving the bandwidth and the system is less complex.

2.6 FDM, OFDM, OFDMA, SOFDMA

2.6.1 Frequency Division Multiplexing (FDM)

WiMAX air interface is based on OFDM/OFDMA physical layer (PHY). However, OFDM, OFDMA and SOFDMA are based on FDM system.that is described in Figure (2.11).

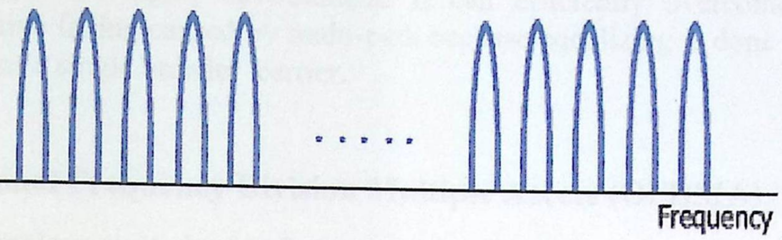

Figure 2.11 Frequency Division Multiplexing (FDM)

In FDM system, signals from multiple transmitters are transmitted simultaneously (at the same time slot) over multiple frequencies.Each frequency range (sub-carrier) is modulated separately by different data stream and spacing (guard band) is placed between sub-carriers to avoid overlap.

2.6.2 Orthogonal Frequency Division Multiplexing (OFDM)

OFDM uses also multiple sub-carriers, though the sub-carriers are closely spaced to each other without causing interference, removing guard bands between adjacent sub-carriers. This is possible due to the frequencies (sub-carriers) are orthogonal, it means, the peak of one sub-carrier coincides with the null of an adjacent sub- carrier.

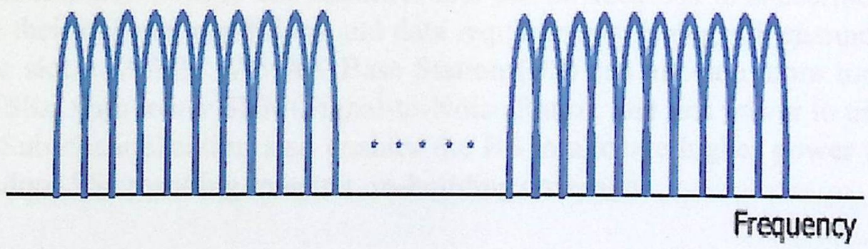

Figure 2.12 Orthogonal Frequency Division Multiplexing (OFDM)

In OFDM system, a high rate data stream is divided into multiple parallel low rate data streams. Each smaller data stream is the mapped to individual data sub-carrier and modulated using some sorts of PSK (Phase Shift Keying) or QAM (Quadrature Amplitude Modulation), i.e. BPSK, QPSK, 16-QAM, 64-QAM.

OFDM requires less bandwidth than FDM to carry the same amount of information. Besides a high spectral efficiency, an OFDM system such as WiMAX is more resilient in NLOS (Non-Line of Sight) environment. It can efficiently overcome interference and frequency-selective fading caused by multi-path because equalizing is done on a subset of sub-carriers instead of a single broader carrier.

2.6.3 Orthogonal Frequency Division Multiple Access (OFDMA)

OFDMA employs multiple closely spaced sub-carriers, but the sub-carriers are divided into groups of sub-carriers. Each group is named a sub-channel. The sub- carriers that form a sub-channel do not need to be adjacent. In the downlink, a sub- channel may be intended for different receivers. In the uplink, a transmitter may be assigned one or more sub-channels.

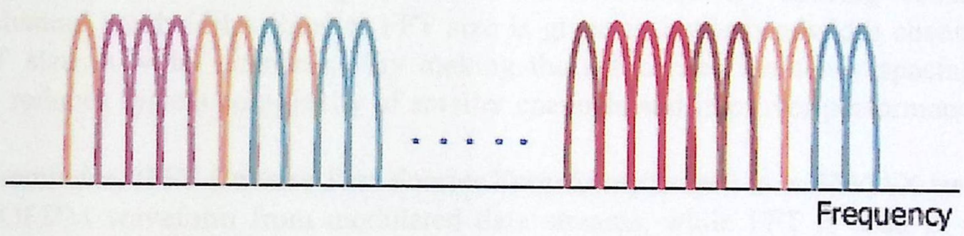

Figure 2.13 Orthogonal Frequency Division Multiple Access (OFDMA)

Sub channelization defines sub-channels that can be allocated to subscriber stations (SSs) depending on their channel conditions and data requirements. Using sub channelization, within the same time slot a Mobile WiMAX Base Station (BS) can allocate more transmit power to user devices (SSs) with lower SNR (Signal-to-Noise Ratio), and less power to user devices with higher SNR. Sub channelization also enables the BS to allocate higher power to sub-channels assigned to indoor SSs resulting in better in-building coverage.

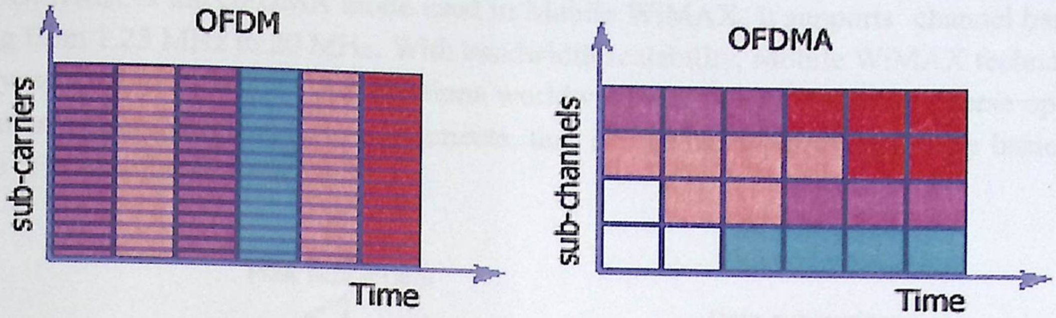

Figure 2.14 Uplink Subchannelization in WiMAX

In OFDM, only one SS transmits in one time slot. In OFDMA, several SSs can transmit at the same time slot over several sub-channels.

Sub channelization in the uplink can save a user device transmit power because it can concentrate power only on certain sub-channel allocated to it. This power- saving feature is particularly useful for battery-powered user devices, the likely case in Mobile WiMAX.

2.6.4 Scalable OFDMA (SOFDMA)

SOFDMA adds scalability to OFDMA. It scales the FFT (Fast Fourier Transform) size to the channel bandwidth while keeping the sub-carrier frequency spacing constant across different channel bandwidths. Smaller FFT size is given to lower bandwidth channels, while larger FFT size to wider channels. By making the sub-carrier frequency spacing constant, SOFDMA reduces system complexity of smaller channels and improves performance of wider channels.

As a reminder, IFFT (Inverse Fast Fourier Transform) is used in a WiMAX transmitter to create an OFDM waveform from modulated data streams, while FFT is used in a WiMAX receiver to demodulate the data streams. The FFT size equals the number of sub-carriers, e.g. in OFDM/OFDMA system with 256 sub-carriers, the FFT size is 256.

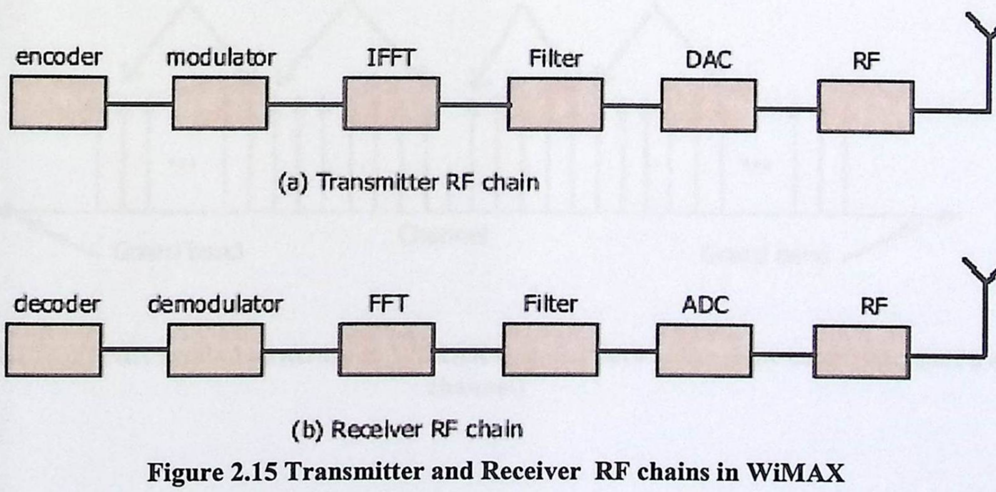

Figure 2.15 Transmitter and Receiver RF chains in WiMAX

SOFDMA is the OFDMA mode used in Mobile WiMAX. It supports channel bandwidths ranging from 1.25 MHz to 20 MHz. With bandwidth scalability, Mobile WiMAX technology can comply with various frequency regulations worldwide and flexibly address diverse operator or ISP (Internet Service Provider) requirements, that is whether for providing only basic Internet service or a broadband service.

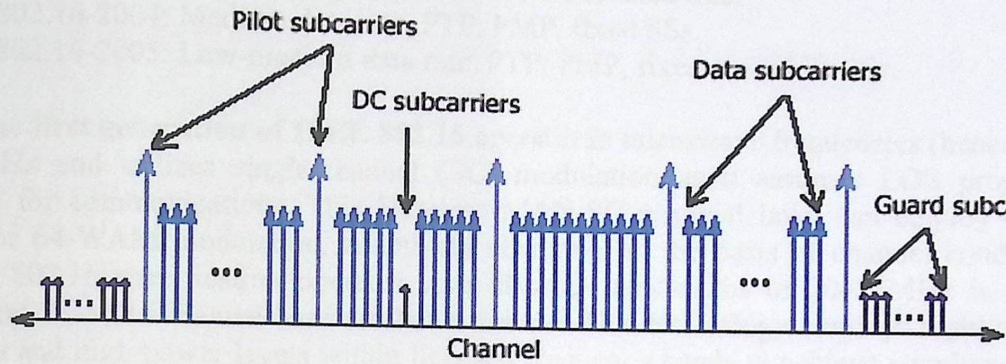

Figure 2.16 OFDM symbol structure in WiMAX

Both OFDM and OFDMA symbols are structured in similar way. Each symbol consists of:

- data sub-carriers (OFDM) or sub-channels (OFDMA) that carry data
- pilot sub-carriers as reference frequencies and for various estimation purposes
- DC sub-carrier as the center frequency
- guard sub-carriers or guard bands for keeping the space between OFDM/ OFDMA signals.

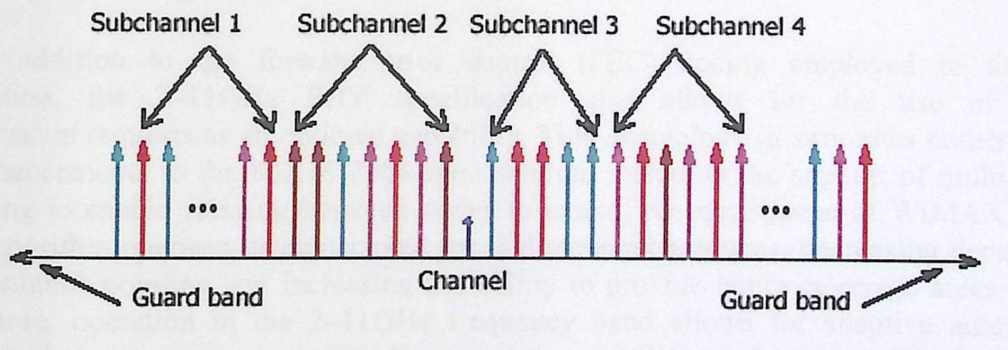

Figure 2.17 OFDMA symbol structure in WiMAX (sub-carriers of the same color represent a sub-channel)

2.7 WiMAX Evolution of the Technology (Standard)

As the envisioned usage scenario has evolved over time, so has evolved the technological basis of WiMax. The IEEE 802.16 technical specification has now evolved through three generations:

• IEEE 802.16: High data rate, high-power, PTP, LOS, fixed SSs.
• IEEE 802.16-2004: Medium data rate, PTP, PMP, fixed SSs.
• IEEE 802.16-2005: Low-medium data rate, PTP, PMP, fixed or mobile SSs.

The first generation of IEEE 802.16 operates in microwave frequencies (hence the name) 10–66GHz and utilizes single-channel (SC) modulation as it assumes LOS propagation is required for communications. This Wireless MAN-SC physical layer can employ QPSK, 16-QAM, or 64-WAM modulation, adaptively changing on the basis of channel conditions. The original 802.16 specification operates with channel bandwidths of 20–25MHz in the United States and 28-MHz channel bandwidths in Europe. This technology employs highly directional antennas and high-power levels within licensed frequency bands to achieve simultaneously high data rates and long ranges. Security mechanisms within the original specification are somewhat rudimentary, with a reliance on antenna directionality to mitigate intrusion. As can be seen, this technology is well suited to a fixed point-to-fixed point backhaul type of application.

The IEEE 802.16-2004 specification the original specification to operate in the 2–11 GHz, both licensed and license-exempt. This frequency band of operations, which was first addressed in the IEEE 802.16a specification, assumes non-LOS communications. This specification provides a total of three air interfaces:
a. WirelessMAN-SC2—single-carrier modulation.
b. Wireless MAN-OFDM—OFDM modulation with a 256-point fast fourier transform (FFT) with TDMA channel access.
c. Wireless MAN-OFDMA—OFDM is employed with a 2048-point FFT. Multiple access is provided by addressing a subset of carriers to individual receivers.

In addition to the forward error control (FEC) coding employed in the original specification, the 2–11GHz PHY specification also allows for the use of automatic retransmission requests as an optional capability. This technology incorporates numerous MAC-layer enhancements to the 802.16-2004 specification, including the support of multi hop mesh networking to enable relaying between nodes to extend coverage areas of WiMAX BSs. This technology often operates using sectored omni directional antennas, decreasing dependence on precise antenna pointing and increasing the ability to provide entire coverage areas of service. Furthermore, operation in the 2–11GHz frequency band allows for adaptive antenna beam-forming techniques to improve interference and scalability performance. Numerous security enhancements, such as two-way authentication, were included in this update to the original specification. It is readily apparent that this technology was certainly designed for the wireless local loop type of application.

The IEEE 802.16-2005 specification was developed with one primary goal: the support for a large number of mobile users. A key enhancement of the IEEE 802.16-2005 specification is the employment of scalable OFDMA(as opposed to the non scalable version employed in the fixed WiMAX specification), which technology proponents argue makes the technology highly robust to network congestion and highly graceful degradation in the presence of interference. Other key enhancements include the introduction of several state-of-the-art technologies, such as hybrid automatic retransmission request, advanced FEC coding schemes such as turbo codes and low-density parity check codes, and multiple-input multiple-output. In general, the technological evolution of WiMAX has traded capacity and range for mobility support and scalability. Figure 2.1 illustrates the basic capabilities of these various forms of WiMAX. From this figure, the trend is clearly toward compromising range and data rate for scalability and mobility support.

An important point to make here is that these various flavors are not compatible with one another. That is, an 802.16-2004 BS cannot interoperate with an 802.16-2005 SS, and vice versa. This could significantly constrain 802.16 deployment in the future. However, major chip manufacturers have already announced dual-mode chipsets that will support both standards. Thus, there will likely emerge products that can interoperate with both 802.16-2004 and 802.16-2005 networks. Unfortunately, there remains numerous regulatory and coexistence issues that complicate if not prohibit heterogeneous Fixed and Mobile WiMAX networks.

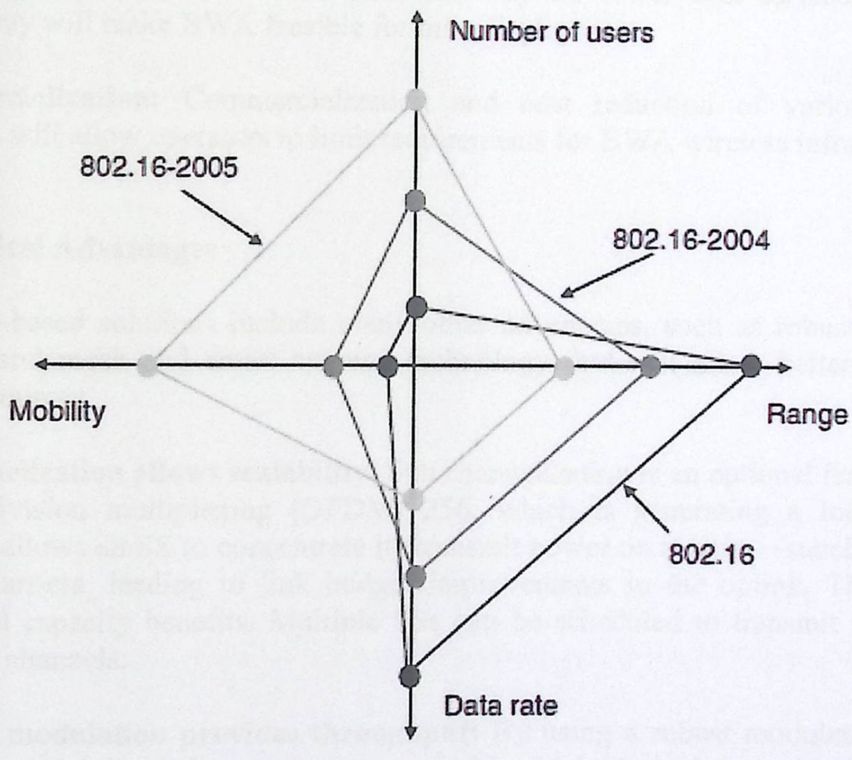

Figure 2.18 Evolution of WiMAX technologies.

2.8 Advantages of WiMax

Compared to the previous generation of technologies WiMax offers several advantages.

2.8.1 Economic Advantages

Companies can realize the following economic benefits directly or indirectly by implementing WiMax.

1. Ease of installation in difficult-to-wire areas: The ability to quickly provision service, even in areas that are hard for wired infrastructure to reach; for example, if rivers, free ways, or other obstacles separate buildings you want to connect, a wireless MAN (WMAN) solution may be much more economical than installing physical cable or leasing communications circuits.

2. Mobile data services: 70 Mbps of shared bandwidth to mobile devices, possibly in unlicensed spectrum, allows a user to roam around on their wireless ISP seamlessly from their home Wi-Fi network. So, data connectivity becomes increasingly limited to the individual subscriber like mobile phones are being used and less dependent on a specific location.

3. Economies of scale: At the moment, BWA vendors rely on proprietary, custom-built chipsets, which have kept equipment costs high and customers away. With standardization comes the ability to mass produce products, so research and development costs decline along with manufacturing expenses. This could pave the way for lower cost services, which WiMAX proponents say will make BWA feasible for mass deployment.

4. Commercialization: Commercialization and cost reduction of various smart antenna technologies will allow operators to limit requirements for BWA wireless infrastructure.

2.8.2 Technical Advantages

WiMax-based solutions include many other advantages, such as robust security features, good QoS, and mesh and smart antenna technology that will allow better utilization of the spectrum resources.

1. Subchannelization allows scalability: Sub channelization is an optional feature in orthogonal frequency division multiplexing (OFDM) 256, which is generating a lot of interest from operators. It allows an SS to concentrate its transmit power on a subset (subchannel) of the total OFDM subcarriers, leading to link budget improvements in the uplink. These translate into coverage and capacity benefits. Multiple SSs can be scheduled to transmit simultaneously on different sub channels.

2. Adaptive modulation provides throughput: By using a robust modulation scheme, IEEE 802.16 delivers high throughput at long ranges with a high level of spectral efficiency that is also tolerant of signal reflections. Dynamic adaptive modulation allows the BS to trade off throughput for range [9]. For example, an SS close to the BS can use 64QAM modulation, while the weaker signal from a more remote subscriber might only permit the use of 16QAM or QPSK. The medium access control (MAC) layer can use different modulation methods for each subscriber's downlink and uplink burst.

3. Mesh topology increases coverage: In addition to supporting a robust and dynamic modulation scheme, the mesh topology and smart antenna techniques greatly enhance coverage in extreme environments by using multiple antennas to create "transmit'' and "receive diversity'' [9]. The major benefit of BWA is the ability to provide coverage for a wide variety of uses.

4. Security: Privacy and encryption features are included in WiMAX to support secure transmission and provide authentication and data encryption [9].

5. Increased reliability: A problem inherent in wired networks is the downtime due to cable faults. Moisture erodes metallic conductors. These imperfect cable splices can cause signal reflections that result in unexplainable errors. The accidental cutting of cables can also bring a network down quickly. These problems interfere with the users' ability to utilize network resources causing havoc for network managers. The advantage of WiMAX networking is that it will likely experience fewer problems because less cable is used.

2.9 Wimax Applications

WiMAX attribute opens the technology to a wide variety of applications because of its high transmission rate and large range. It serves as a backbone for Wi-Fi for connectivity to the Internet. It can provide broadband connectivity over large coverage area as compared to 802.11 standard. WiMAX is a broadband wireless communication system, which enables convergence of mobile and fixed broadband networks through a common wide-area and flexible network architecture. The mobile WiMAX air interfaces use OFDMA for improvement in multiple path interference in non-line-of-sight environment. Its ability to support both line-of-sight and nonline-of-sight connections makes it suitable for ubiquitous services offered in rural and urban areas alike. High speed and symmetrical bandwidth satisfy the needs of individual customers, public administration, and enterprises of all sizes [10].

The technology also provides fast and cheap broadband access to markets that lack infrastructure (fiber optics or copper wire), such as rural and unwired countries. Currently, several companies offer proprietary solutions for wireless broadband access, many of which are expensive because they use chipsets from adjacent technologies, such as 802.11. Early field experiments in various countries confirm that expectations in terms of coverage, performance, and usage scenarios are indeed justified. WiMAX has changed the scenario of wireless broadband from proprietary solutions to a standards-based industry. It supports fast Internet access, high-quality audio and video communications, education, entertainment, telemedicine, telemetering, and telesurveillance. WiMAX supports personal broadband services on both fixed and mobile settings because of its high spectral efficiency and wide channelization as well as the advanced antenna technologies. This flexibility in providing both fixed and mobile access within the same infrastructure is unprecedented among wireless technologies, which are typically optimized for either mobile or fixed access [11].

2.9.1 Wimax Military Applications

As WiMAX uses higher frequencies than current military and commercial communications, existing antenna towers share a WiMAX cell tower without compromising the current communication services. WiMAX can be used to support training and war game simulations. An initial deployment of WiMAX has already been constructed by the U.S. Army Fortdix. The U.S. army is testing pre-standard WiMAX gear and Xacta secure wireless system from Tele Corporation in Fort Carson in Colorado for point-to-point and point-to-multipoint communications. The forces at different locations can be connected through WiMAX .They can exchange their information from multiple sources, rapidly and flexibly. This is ideally suited to meet the demands of the tactical defense operations model. The mobile antennas can be attached to a vehicle and the latest data can be provided to the soldiers. A communication from command centers can be made to the different centers, regardless of the distance, and directions can be delivered to the army people. The best part of WiMAX is the handover strategy. It uses "make-before-break'' sequence rather than "break-before-make'' sequence.

2.9.2 Medical Applications

In an emergency situation where patients require immediate medical support, WiMAX can serve as the foundation of a mobile hospital. It can be a platform for e-health. In e-health services a doctor can diagnose his patient at some far l location with the help of e-media. The doctor's computer equipped with the medical instruments can be connected to the patient's computer through WiMAX. A patient at location 2 can send his reports, for example, blood pressure, through his computer to the doctor's computer as shown in Figure 2.10 The doctor can diagnose the patient's disease and give him necessary treatment. The connection between the doctor and the patient is through the Internet. The two computers are connected through WiMAX. Also in some emergency situations, a video consultation with a doctor can be set up and the doctor can instruct the paramedic to mobilize the victim without inflicting further damage. With WiMAX, mobile hospital vans can communicate data and other instructions within a disaster zone. The information through WiMAX can be encrypted and made secure. So in diverse conditions WiMAX can provide to the patient valuable information recommended by doctors over large distances [12].

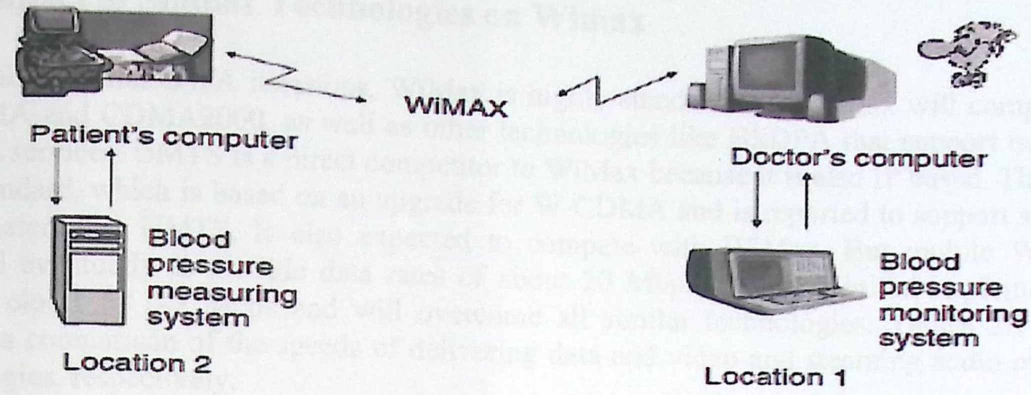

FIGURE 2.19 Medical applications.

2.9.3 Campus Connectivity

Campus system requires high data capacity, a large coverage, and high security. WiMAX can connect various blocks within the campus. Through this connectivity voice, data, and video information can be sent to various interconnecting blocks as shown in Figure 2.11 . It is very difficult to connect various blocks through cables because the lead time to deploy a wired solution is much longer than the lead time to deploy a WiMAX solution. This connectivity not only reduces the paper work circulation but also ensures fast data transfers.

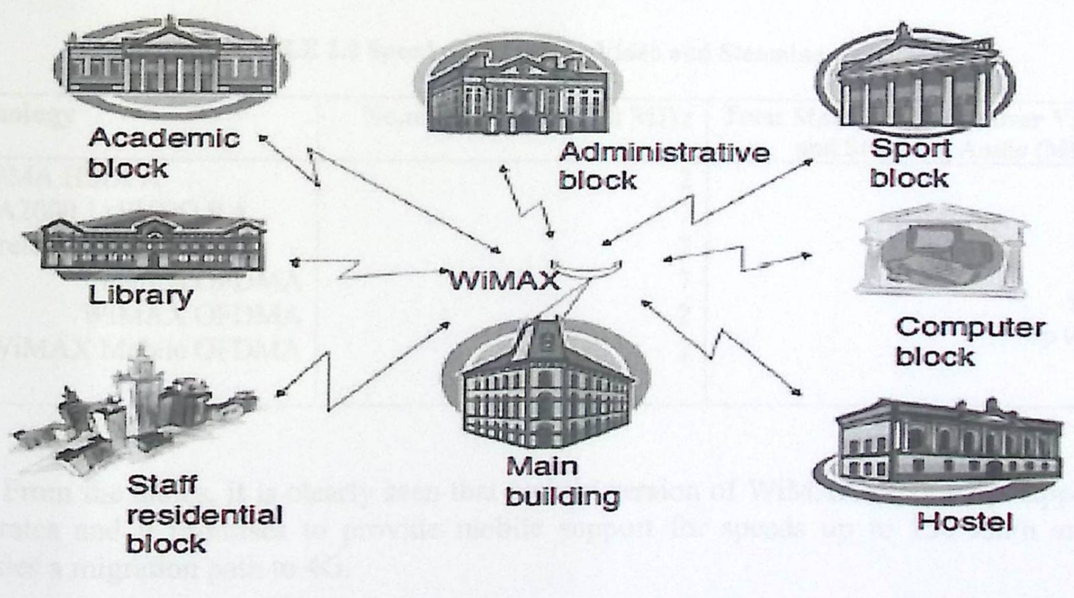

Figure 2.20 WiMAX campus connectivity.

2.10 Impact of Similar Technologies on Wimax

Unlike earlier BWA iterations, WiMax is highly standardized. WiMax will compete with W-CDMA and CDMA2000, as well as other technologies like HSDPA that support both voice and data services. UMTS is a direct competitor to WiMax because it is also IP based. The "Super 3G'' standard, which is based on an upgrade for W-CDMA and is reported to support speeds 10 times faster than UMTS, is also expected to compete with WiMax. But mobile WiMax is expected eventually to provide data rates of about 20 Mbps, although initial implementations may be closer to 1–2 Mbps and will overcome all similar technologies. Tables 2.1 and 2.2 provide a comparison of the speeds of delivering data and video and steaming audio of various technologies, respectively.

TABLE 2.1 Data speed of Various Technologies

Technology	Bandwidth (MHz)	Max Speed to Deliver Data (Mbps)
W-CDMA HSDPA	5.00	14.4 (fixed and mobile)
CDMA2000 1×EVDO RA	1.25	3.2 (fixed and mobile)
IP Wireless (UMTS TDD)	5.00	7.5 (fixed and mobile)
Flarion	1.25	3.1 (fixed and mobile)
WiMAX	20.00	75 (fixed/nomadic)
	5.00	4-18 (fixed/nomadic)
Mobile WiMAX	5.00	Up to 15 (mobile)

TABLE 2.2 Speed of Delivering Video and Steaming Audio

Technology	No.of Channels in 10 MHz	Total Max Speed to Deliver Video and Steaming Audio (Mbps)
W-CDMA HSDPA	2	28.8
CDMA2000 1×EVDO RA	7	31.1
IP Wireless (UMTS TDD)	2	15.0
Flarion OFDMA	7	22.4
WiMAX OFDMA	2	8-46
WiMAX Mobile OFDMA	2	Up to 30

From the tables, it is clearly seen that mobile version of WiMAX reportedly supports high data rates and it promises to provide mobile support for speeds up to 150 km/h and hence provides a migration path to 4G.

Chapter Three

Network design

3.1 Introduction to radio network planning

3.2 Process of radio network planning

3.3 Planning details

3.4 Propagation model

Chapter three

3.1 Introduction to radio network planning

Deployment of the access network is a very important process for operator as it is the dominant portion of the total investment for providing services and, in addition, it is highly correlated with the service quality. In order to achieve cost-effective network deployment, it is necessary to determine the optimal location and height, the type of the equipment (such as indoor/outdoor, BS, repeaters, sector) and the sector configuration. Good service quality and maximum coverage with optimal investment can be ensured by arranging such an optimal cell planning.

Radio network planning is critical rule in Wimax designing process, must do proper RF plan by keeping the future growth plan in mind, a lot of problems that encounter in the future and also the cost of optimization will reduced.

In designing the radio network, the following two factors should be considered: first, it is important to understand the system and the radio environment. To do this, we need to analyze the propagation characteristics of the 3.5 GHz radio wave and determine the service quality based on the received signal strength indicator (RSSI) and SINR values. Secondly, it is important to do efficient cell planning of the ground. In support of this, we need to choose the potential BS sites by considering the center of high data traffic areas, relatively high buildings to insure the line-of-sight (LOS) site as much as possible, and good locations for indoor services of huge buildings adjacent to the main roads.

3.2 Process of RNP

Figure 3.1 describes the overall procedure of radio network planning. This whole RNP process, in general, is composed of three stages, which are dimensioning, preliminary planning, and final planning[13].

3.2.1 Dimensioning

The dimensioning process is the first stage of the RNP. Its goal is to determine the BS counts and the network configuration based on the analysis of the coverage and capacity. In the dimensioning stage, the first procedure is the coverage planning which is done based on the link budget. It is composed of the following four steps:

1. Analyze the link budget parameters such as slow fading margin, handover gain, interference margin, receiver sensitivity, and noise figure.
2. Calculate the maximum allowable path loss (MAPL).
3. Analyze the prediction model.

4. Determine the BS counts and configuration.

Capacity planning is another key process in the dimensioning stage, which can be done based on the user traffic. It is composed of the following four steps:

1. Generate the user traffic model.
2. Calculate the system capacity.
3. Determine the traffic loading.
4. Determine the BS counts and configuration. The BS counts and configuration process may be terminated by examining the balance of the coverage and capacity planning.

3.2.2 Preliminary planning

Preliminary planning is the second stage of the RNP. It is the preparation process before doing on-site cell planning based on the BS counts and the configuration obtained in the dimensioning stage .after defining the traffic and coverage threshold requirement ,we could finally design and implement the network ,in order to make clear radio planning, coverage, capacity and frequency planning should done and documented. successive planning must take into account the radio propagation properties of the actual environment. such planning done with complex measurement techniques and computer analysis tool for radio propagation studies planning tool is software package designed to simplify the process of planning and optimizing a network[13].

The following five steps are performed in this stage:
1. Field survey
2. The 1st simulation (using the cell planning tools).
3. Fine coverage and capacity planning.
4. Coarse site location and search ring.

3.2.3 Final planning

Final planning is performed based on the results of the preliminary planning. In this stage, site survey is performed and all the system parameters are determined. Specifically, this stage is composed of the following four steps:

1. Site survey: First, site position is determined, and equipment type is determined as well, by considering all the aspects including the coverage, capacity, and interference. Throughout the overall RNP procedures and network optimization process, site location and height are the most important factors that influence on the network performance. Second, antenna position, as well as antenna type and configuration (azimuth and down-tilt) values, are determined to ensure the desired coverage.
2. Setting all the RF engineering parameters.
3. The 2nd simulation (using the detailed RF engineering parameters).
4. Setting system parameters.

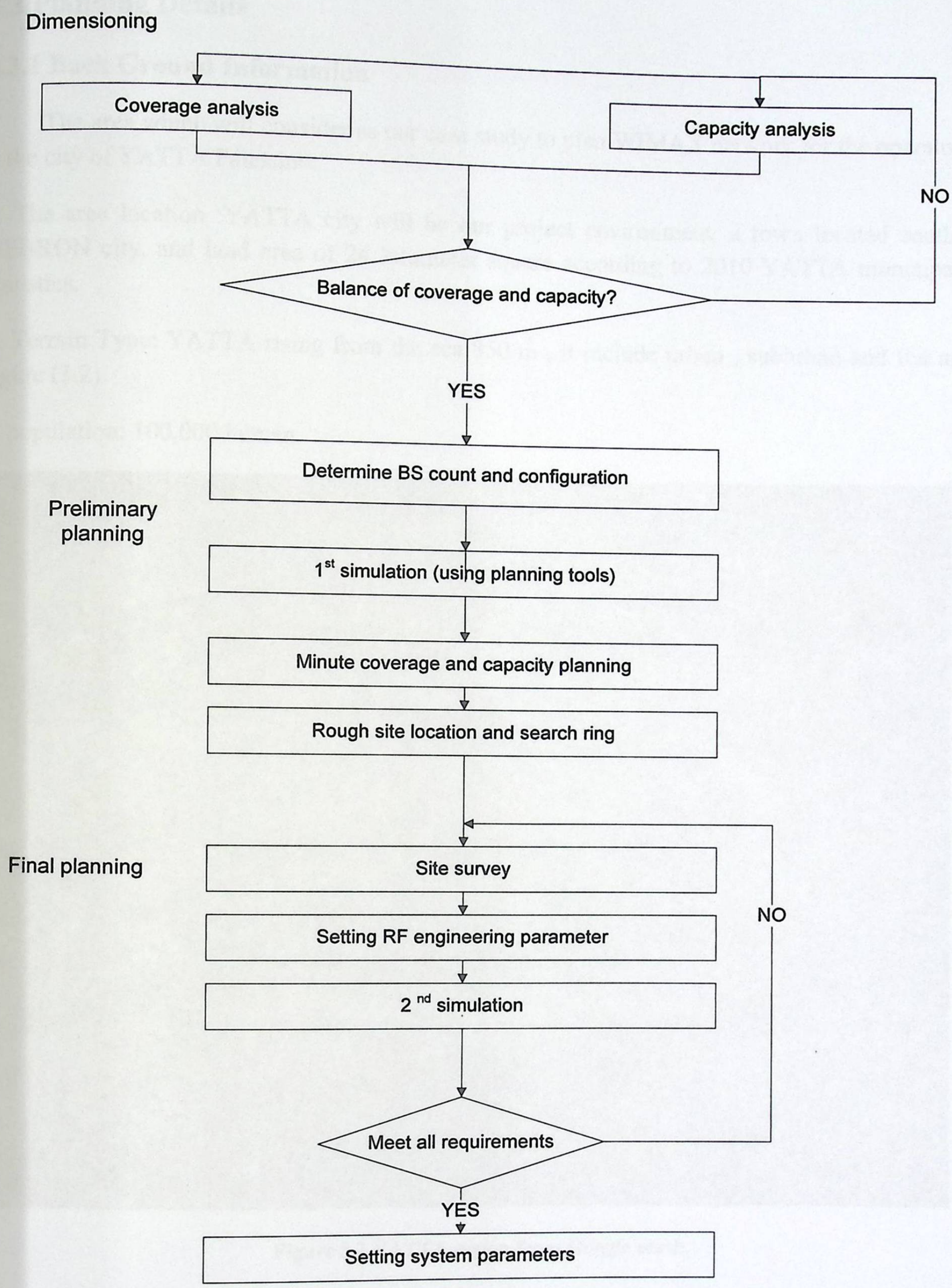

Figure 3.1 Overall procedure of radio network planning.

3.3 Planning Details

3.3.1 Back Ground Information

The area which will consider as our case study to plan WIMAX network for the operator in it the city of YATTA/Palestine:

a. The area location :YATTA city will be our project environment, a town located southern HEBRON city, and land area of 24 kilometer square according to 2010 YATTA municipality statistics.

b. Terrain Type: YATTA rising from the sea 850 m , it include urban , suburban and flat area, figure (3.2).

c. population: 100,000 human.

Figure 3.2 YATTA region from Google earth.

This map shows the nature of the geographic area , Each color represents a different geographical nature of roads, trees and areas of flat water and others from of areas, As shown in the picture.

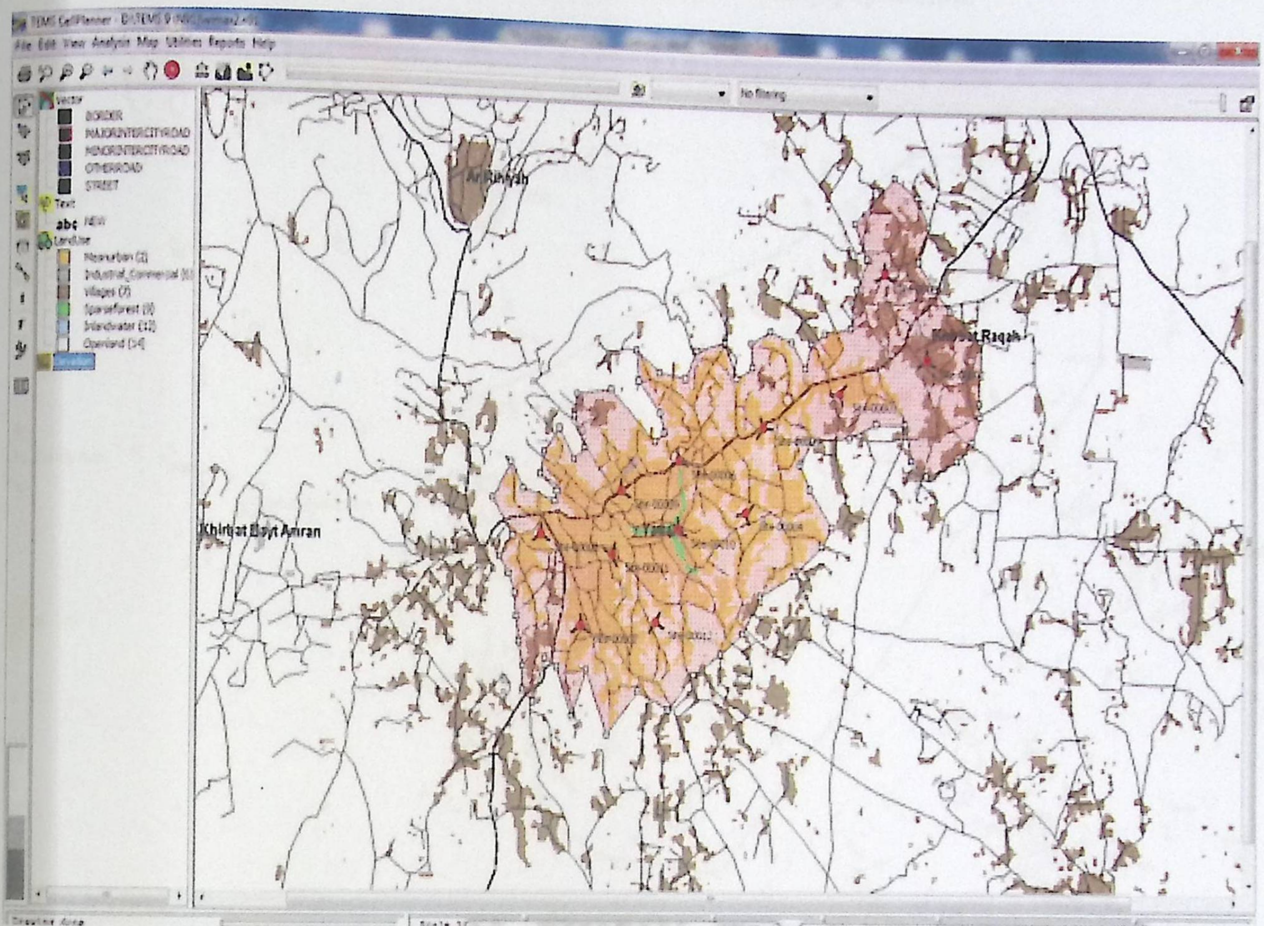

Figure 3.3 nature of the geographic area (YATTA region) .

3.3.1.1 Population Distribution

In this figure show the population distribution in YATTA region, the yellow color show the high density population, and other color show the lower density population.

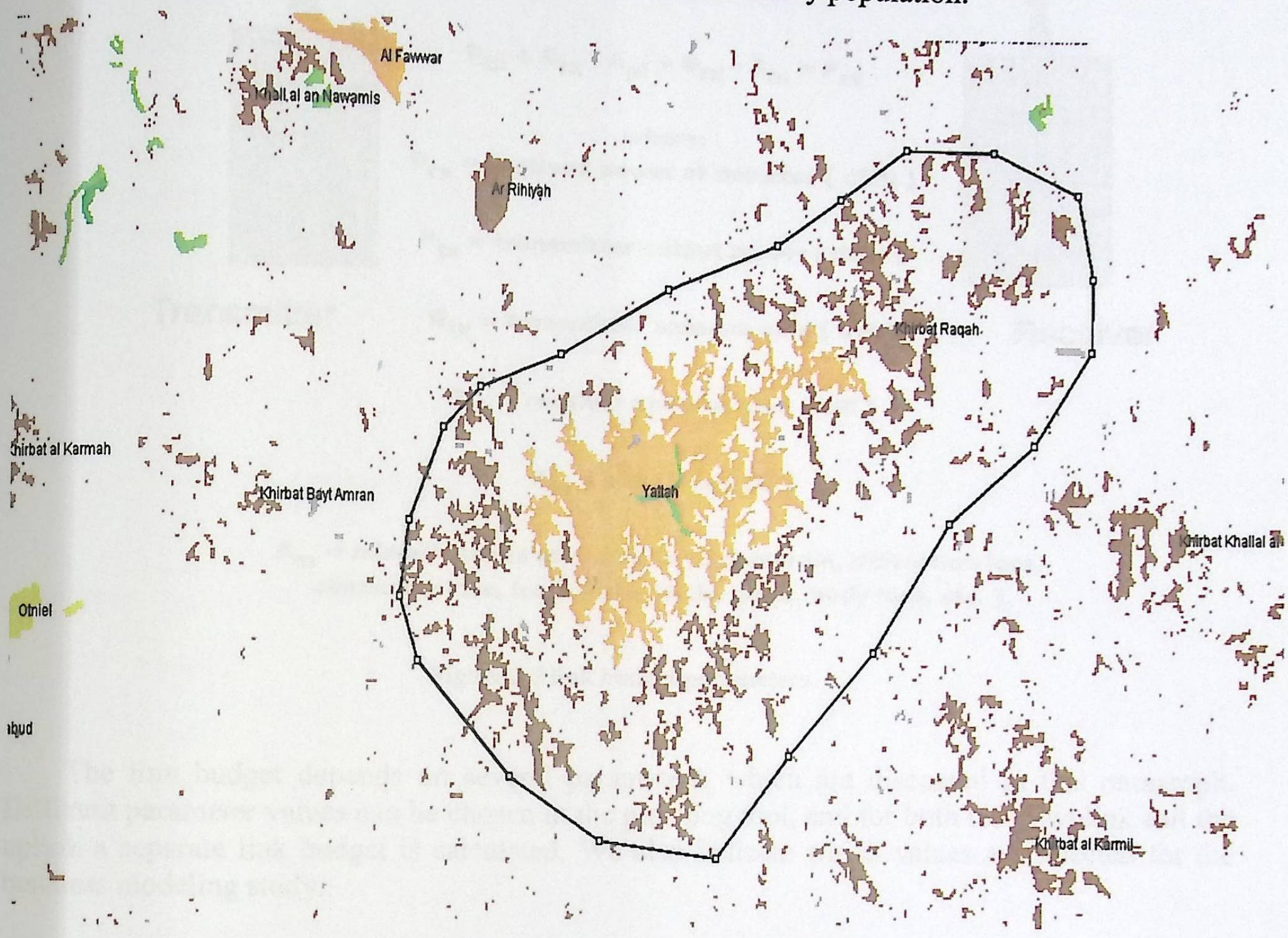

Figure 3.4 Population Distribution.

3.3.2 Link budget

A link budget is the accounting of all of the gains and losses from the transmitter, through the medium(free space, cable, waveguide, fiber, etc.) to the receiver in a telecommunication system (Figure 3.3). It accounts for the attenuation of the transmitted signal due to propagation, as well as the antenna gains, feed line and miscellaneous losses. Randomly varying channel gains such as fading are taken into account by adding some margin depending on the anticipated severity of its effects. The amount of margin required can be reduced by the use of mitigating techniques such as antenna diversity or frequency hopping.

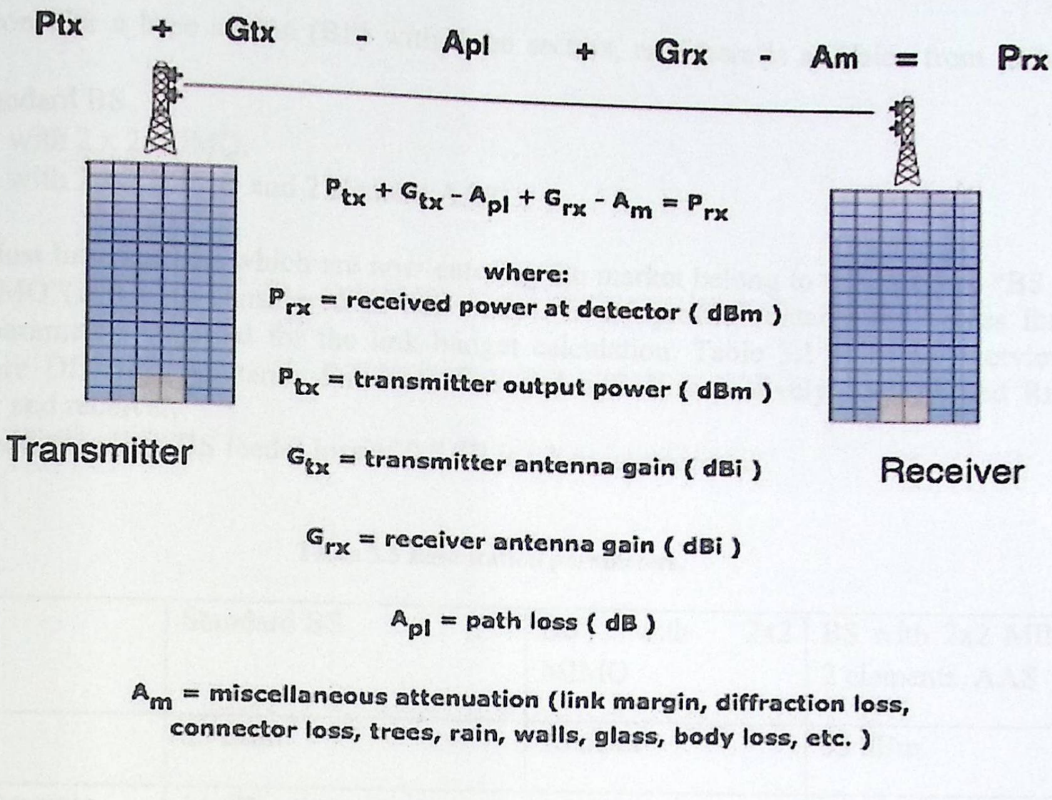

Figure 3.5 link budget parameters.

The link budget depends on several parameters, which are discussed in this paragraph. Different parameter values can be chosen in the planning tool, and for both the downlink and the uplink a separate link budget is calculated. We also indicate which values are selected for the business modeling study.

A link consists of three parts:

1. Transmitter.
2. Receiver.
3. Media.

The very simplest form of a link equation is written as:

$P_{recevied}$ = Power of the transmitter + Gain of the transmitting antenna + Gain of the Receiving antenna – Sum of all losses **Eq.(3.1)**

This equation of course only talks about the signal power. We have not accounted for noise yet.

3.3.2.1 Base station

We consider a base station (BS) with three sectors, and there is a choice from three BS profiles:

- Standard BS.
- BS with 2 x 2 MIMO.
- BS with 2 x 2 MIMO and 2 element AAS.

Most base stations which are now entering the market belong to the category "BS with 2 x 2 MIMO"(which is considered in our study). Every profile contains the values for six different parameters required for the link budget calculation. Table 3.1 gives an overview of them, where DL and UL stands for down link and uplink respectively, and Tx and Rx for transmitter and receiver.
Note that additionally a BS feeder loss of 0.5 dB is taken into account.

Table 3.1 Base station parameters.

	Standard BS	BS with 2x2 MIMO	BS with 2x2 MIMO and 2 elements AAS
DL Tx power	35 dBm	35 dBm	35 dBm
DL Tx antenna gain	16 dBi	16 dBi	16 dBi
Other DL Tx gain	0 dB	9 dB	15 dB
UL Rx antenna gain	16 dBi	16 dBi	16 dBi
Other UL Rx gain	0 dB	3 dB	6 Db
UL Rx noise figure	5 dB	5 dB	5 dB

3.3.2.2 Customer Premises Equipment (CPE)

With regard to the CPE, we can choose from two profiles:

- Portable CPE.
- Mobile CPE.

The first type is comparable with e.g. as usual cable modem: they are installed indoors, have their own power supply and are usually connected via an Ethernet cable to the computer. They do not guarantee any form of mobility. Solutions with PCMCIA cards and receivers integrated in e.g. a laptop belong then to the second type. Every profile contains again six parameters (Table 3.2).

Table 3.2 CPE parameters

	Portable CPE	Mobile CPE
UL Tx power	27 dBm	27 dBm
UL Tx antenna gain	6 dBi	2 dBi
Other UL Tx gain	0 dB	0 db
DL Rx antenna gain	6 dBi	2 dBi
Other DL Rx gain	0 dB	0 dB
DL Rx noise figure	6 dB	6 dB

3.3.2.3 EIRP

In radio communication systems, Equivalent isotropic radiated power (EIRP) or, alternatively, Effective isotropic radiated power is the amount of power that a theoretical isotropic antenna (that evenly distributes power in all directions) would emit to produce the peak power density observed in the direction of maximum antenna gain. EIRP can take into account the losses in transmission line and connectors and includes the gain of the antenna. The EIRP is often stated in terms of decibels over a reference power emitted by an isotropic radiator with equivalent signal strength. The EIRP allows comparisons between different emitters regardless of type, size or form. From the EIRP, and with knowledge of a real antenna's gain, it is possible to calculate real power and field strength values.

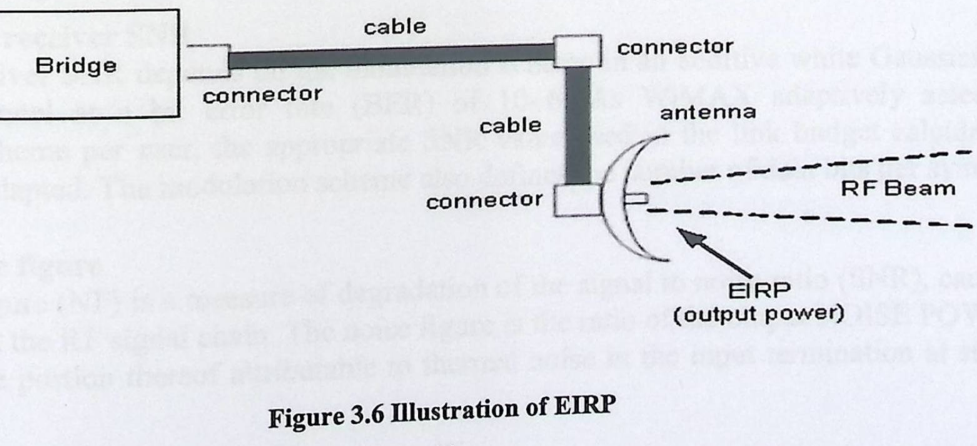

Figure 3.6 Illustration of EIRP

EIRP [dB] = Tx power [dBm] – Cable and Connector losses [dB] + Antenna gain [dBi] **Eq.(3.2)**

3.3.2.4 Receiver Sensitivity

The receiver sensitivity is defined by:

- The thermal noise.
- The receiver SNR.
- The noise figure.
- The implementation loss.

Now, the receiver sensitivity can be calculated as:

Receiver sensitivity (Sr) = thermal noise+ Rx SNR + Rx SNR noise figure + implementation losses **Eq.(3.3)**

3.3.2.4.1 The thermal noise

The thermal noise is dependent on the channel bandwidth and can be estimated as (in dBm):

Thermal noise $= -174 + 10\log_{10} f$ **Eq.(3.4)**

where f is the bandwidth in hertz over which the noise is measured. As physical bandwidth (BW), there is a choice from 1.25 MHz, 5 MHz, 10 MHz and 20 MHz, where today 10 MHz is the most standard value. For the calculation of the thermal noise, the bandwidth f has to be scaled to the effectively used bandwidth.

3.3.2.4.2 The receiver SNR

The receiver SNR depends on the modulation scheme in an additive white Gaussian noise (AWGN) channel at a bit error rate (BER) of 10- 6. As WiMAX adaptively selects the modulation scheme per user, the appropriate SNR value used in the link budget calculation is dynamically adapted. The modulation scheme also defines the number of data bits per symbol.

3.3.2.4.3 Noise figure

Noise figure (NF) is a measure of degradation of the signal to noise ratio (SNR), caused by components in the RF signal chain. The noise figure is the ratio of the output NOISE POWER of a device to the portion thereof attributable to thermal noise in the input termination at standard noise temperature *T*0 (usually 290 K). The noise figure is thus the ratio of actual output noise to that which would remain if the device itself did not introduce noise.

$$(NF) \cong \frac{Nout}{Nin} \cong \frac{Nout}{KTB}$$

Eq.(3.5)

3.3.2.4.4 The Implementation loss

The implementation loss includes non-ideal receiver effects such as channel estimation errors ,quantization errors, and phase noise.

3.3.3 Margins

Is defined as the amount by which a received signal level may be reduced without causing system performance to fall below a specified threshold value. To calculate the link budget, we have to consider several margins, such as the fade margin, the interference margin and a Building penetration loss (BPL) factor.

3.3.3.1 Fading margin

Fading covers the effect of the variation of the signal strength during the time on a fixed location. In contrast to shadowing which takes into account the variation of the signal strength between different locations on the same distance from the transmitter, fading is not incorporated in the propagation model.

3.3.3.1.1 Slow fading margin (lognormal fading margin)

Slow fading or log-normal fading is the variation of the local mean signal level over a wider area, and has been observed by Young. The local mean is the mean value of the Rayleigh or Rician fading signal amplitude. This log-normal fading is caused by the obstacles (buildings, trees, etc.) that changes the average received signal level and thus bring about shadowing. The variation of the signal amplitude local mean value over the wider area is log-normally distributed and thus it is called lognormal fading.

3.3.3.1.2 Fast fading margin

The mobile station or base station receives in one moment the same signal arriving via different radio paths as mentioned in the previous section. The total received signal is a contribution of all the arrived signal multipath components based on the superposition principle. The different signal components, arriving via different radio paths, have different amplitude and phase due to the different lengths of the radio path and different reflection and diffraction properties.

3.3.3.2 Interference margin

Two type of interference, common channel interference ,result from cells that use same channel in an area, it can be reduced by increasing distance between cells that use same channel, second type adjacent channel interference ,it result from signal which adjacent in frequency to the desired signal, it need perfect filtering to not allows near frequency to leak into the pass band.

3.3.3.3 Building penetration loss(BPL):

Buildings obstruct the transmitted electromagnetic signals. Since the used propagation model does not sufficiently take into account this effect, an extra correction on the link budget is added. The different possibilities are summarized in Table 3.3

Table 3.3 Urban corrections

Urban type	Correction
Rural	12 dB
Suburban	15 dB
Urban	18 dB
Dense urban	20 dB

3.4 Propagation Model

Median path loss in a radio channel is generally estimated using analytical models based on either the fundamental physics behind radio propagation or statistical curve fitting of data collected via field measurements. For most of the practical deployment scenarios, particularly non line- of-sight scenarios ,statistical models based on empirical data are more useful.

Although most of the statistical models for path loss have been traditionally developed and tuned for a mobile environment, many of them can also be used for an NLOS fixed network with some modification of parameters. In the case of a line-of-sight based fixed network, the free-space radio propagation model can be used to predict the median path loss. Since WiMAX as a technology has been developed to operate efficiently even in an NLOS environment, We describe a few of the path loss models that are relevant to NLOS WiMAX deployments.

The best model for wimax network planning is ersic model, but in our project we use cost 231- hata model, because the version of tems cell planner program dosnt support the ersic model.

3.4.1 COST-231 Hata Model

The WiMAX Forum recommends using this COST-231 Hata model for system simulations and network planning of macro cellular systems in both urban and suburban areas for mobility applications.

The median path loss for the COST-231 Hata model is given by

$$PL = 46.3 + 33.9\log_{10} f - 13.82\log_{10} h_b + (44.9 - 6.55\log_{10} h_b)\log_{10} d + C_F - a(h_m) \quad \textbf{Eq.(3.6)}$$

Where f=3500MHz and MS antenna correction factor $a(h_m)$ is given by:

$$a(h_m) = (1.11\log_{10} f - 0.7)h_m - (1.56\log_{10} f - 0.8) \quad \textbf{Eq.(3.7)}$$

For urban and suburban areas, the correction factor *CF* is 3dB and 0dB, respectively.

Chapter Four

WiMAX IN TEMS CellPlanner

4.1 About TEMS CellPlanner.

4.2 WiMAX in TEMS CellPlanner.

4.3 WiMAX Sites.

4.4 WiMAX Analysis.

Chapter four

4.1 About TEMS CellPlanner

TEMS CellPlanner Universal is an advanced tool for designing and planning network Designed and developed by Ericsson, TEMS CellPlanner Universal provides superior planning capabilities to save time and money during network deployment.

TEMS CellPlanner Universal meets the needs of today's complex radio networks. It features open interfaces, a new more flexible architecture, and support for all major technologies. It also utilizes unique, patented algorithms for accuracy and speed. The modular platform makes it easy to customize and add new functionality

TEMS CellPlanner Universal provides a flexible system configuration and an efficient working environment. Operators can choose stand-alone configuration for quick and easy planning in the field no database installation is required. Choosing network configuration allows multiple users, as part of a team, to share network data and simultaneously plan a common network. This team approach is regulated by a unique system of security features for safe and secure handling of data.

TEMS™ Cell planner is a graphical application for designing implementing, and optimizing mobile radio networks. It assists you in performing complex tasks, including network dimensioning, traffic planning, site configuration frequency planning, and network optimization.

TEMS cell planner can do planning of many radio technology, GSM, WCDMA, LTE, AND WIMAX.

4.2 WiMAX in TEMS CellPlanner

The WiMAX module in TEMS CellPlanner allows you to build a WiMAX network plan based on geographical data, analyze the network plan with a variety of propagation models, present analysis results in plots and reports, and export/import WiMAX data to/from Excel or text files.

4.2.1 Wimax project

This chapter describes how to initiate and save a project, and how to configure the WiMAX specific project parameters. After having setup your project using the procedures in this chapter, proceed with the subsequent chapters to build your WiMAX network plan.

To create a new project, see Define General Project Settings

4.2.1.2 Define Project Specific Information

Procedures :

Use the following procedures to define project specific information:

1. Define General Project Settings
2. Select Coordinate System for Project
3. Add Map Layers to Project
4. Define Object Names
5. Configure technology dependent information,

4.2.1.3 WiMAX Project Parameters

All users of a WiMAX project must select from the same set of Modulation and Coding Schemes (MCSs) and use some other global WiMAX parameters. These parameters are configured as project parameters, The default MCSs in the table below appear the first time you configure the WiMAX project parameters.

Table 4.1 wimax project parameter.

MCS name	Bit rate (kbps)	Bit rate with cyclic prefix	Receiver threshold (dBm)	C/(I+N) threshold (dB)
BPSK 1/2	1500.0	1312.5	-90.9	6.4
QPSK 1/2	2900.0	2537.5	-87.9	9.4
QPSK 3/4	4400.0	3850.0	-85.1	11.2
16QAM 1/2	5800.0	5075.0	-79.9	16.4
16QAM 3/4	8700.0	7612.5	-77.7	18.2
64QAM 2/3	11600.0	10150.0	-73.3	22.6
64QAM 3/4	13100.0	11462.5	-71.5	24.4

These default MCSs are valid for a WiMAX system with a channel bandwidth of 3.5 MHz operating on the 3.5 GHz band, when the whole carrier bandwidth is utilized 100% of the time with the cyclic prefix 12.5%

Cyclic prefix (%):A repetition of the last samples of the data symbol attached to the beginning of the data symbol. The cyclic prefix can completely eliminate inter-symbol interference, as long as the cyclic prefix duration is longer than the channel delay spread.

4.2.2 WiMAX System Data and Services

Before adding sites, RBSs and cells you need to define the system data and services to be used in your WiMAX network. System data may be common for WiMAX and other technologies. Services are technology dependent, that is, the WiMAX services defined in a WiMAX network plan only.

The standard flow of planning system data and services in a WiMAX network with TEMS CellPlanner is reflected in the order of procedures in this chapter and in the list below:

1. WiMAX carrier mappings - UL and DL sub-carriers and sub-channels.
2. Frequency bands - WiMAX frequency bands with carrier selection.
3. WiMAX bearers - UL and DL bit rates and frequency bands.
4. WiMAX MCS selections - allowed sets of modulation and coding schemes.
5. Propagation models - land use category dependent radio wave behavior.
6. Traffic density maps - optional, land use category dependent traffic density.
7. Traffic demand mix - a mix of traffic with different traffic demands.
8. Traffic demand - distribution of terminal types in the WiMAX network, optionally with geographical distribution.

4.2.3 WiMAX Carrier Mappings

A WiMAX carrier mapping defines a single configuration including UL and DL sub-carriers and sub-channels, and the time fraction used for UL and DL traffic respectively.

Table 4.2 WiMAX Carrier Mappings

Field	Description
Total number of sub-carriers	Range: 0 - 10000. Default = 1024.
Time fraction used for DL traffic	Range: 0 - 100%. Default = 90%. In S-TDD and half-duplex FDD mode, the carrier mapping parameters Time fraction used for DL traffic and Time fraction used for UL traffic must have a sum less than or equal to 100%.
Number of DL sub-channels	Range: 1 - 1000. Default = 30.
Number of DL sub-carriers per sub-channel	Range: 1 - 1000. Default = 24.
Time fraction used for UL traffic	Range: 0 - 100%. Default = 90%. In S-TDD and half-duplex FDD mode, the carrier mapping parameters Time fraction used for DL traffic and Time fraction used for UL traffic must have a sum less than or equal to 100%.
Number of UL sub-channels	Range: 1 - 1000. Default = 35.
Number of UL sub-carriers per sub-channel	Range: 1 - 1000. Default = 16.

4.2.4 WiMAX Frequency Bands

A WiMAX frequency band consists of a number of configurable carriers .In FDD mode, different carriers are used for downlink and uplink respectively, with a frequency distance defined by the duplex distance. In S-TDD mode, the same carrier is used for downlink and uplink.

The carriers are defined in a carrier mapping. A WiMAX frequency band can be assigned one carrier mapping.

4.2.4.1 Predefined WiMAX Frequency Band

TEMS CellPlanner provides a predefined frequency band, with parameter values according to the table below:

Table 4.3 Frequency Band parameter

Parameter	Initial Value
Base frequency	3500 MHz
Duplex type	FDD
Duplex distance (MHz)	50.0 MHz
Carrier bandwidth	5 MHz

4.2.5 WiMAX Equipment Types

Before adding sites and cells with physical equipment to your network project, you need to define the equipment types to be used. The equipment types include data about vendor, product id and so on.

You can add or delete equipment types using the right-click mouse menus in the Equipment explorer. In the figure below, the equipment types relevant for WiMAX are highlighted:

The standard flow of planning equipment types in a WiMAX network with TEMS CellPlanner is reflected in the order of procedures in this chapter and in the list below:

1. Antenna types
2. TMA types (optional)
3. Feeder cable types (optional)
4. WiMAX terminal types.

4.2.5.1 Antenna Types

You can define the WiMAX antenna types either manually or by import from antenna files.

- Define Antenna Types
- Specify Antenna Bands
- Define Antenna Lobes
- Define Antenna Horizontal Patterns
- Define Antenna Vertical Patterns

4.2.5.2 WiMAX Terminal Types

To get accurate WiMAX Analysis results you need to define the most common mobile terminal (MS) types and fixed subscriber terminal (SS) types expected in your radio network. You define those devices as Terminals in the Equipment explorer.

The capabilities of the terminal types are, as part of selected traffic cases, considered in analysis functions.

4.2.5.2.1Suggested WiMAX Terminal Types

The following terminal types are suggested for a WiMAX project:

Mobile terminals (MS):
- indoor mobile
- in-car
- outdoor

Fixed subscriber terminals (SS):
- indoor fixed
- roof-top
- window

A terminal type is characterized by its antenna height, gain and loss. A WiMAX terminal type is also defined by its diversity gain, Rx and Tx loss, supported bearers and MCS in UL and DL. You must set these parameters to give correct input to the analysis calculations.

Table 4.4 WiMAX Terminal Types

Field	Description
Antenna height	Height of terminal antenna, above ground level. Range 0 - 100. Default = 1.5 m. Note: The antenna height defined here is relevant only for mobile terminals. For a fixed subscriber, this value is overridden by the height configured for that fixed subscriber.
Gain (dBi)	Antenna gain. Range: 0 - 100. Default = 0.
Max output power (dBm)	The maximum transmit power of the terminal. Range: 0 - 40. Default = 24.

4.3 WiMAX Sites

A site is defined by its position (longitude and latitude) and antenna height. There are two different types of sites in a WiMAX network plan:

- WiMAX RBS sites with WiMAX RBSs, cells and antenna branches, accompanied by an antenna system
- WiMAX fixed subscriber sites, the TEMS CellPlanner name of non-mobile terminals. Fixed subscribers are modeled as sites as they have fixed positions and use another propagation model than mobile terminals.

The reason for distinguishing between these two types is that the analysis result depends on the mobility and antenna height of the terminal. By modeling fixed subscribers separately, with specific antenna height and point-to-point propagation model, the analysis results become more realistic than if the fixed subscribers were treated as ordinary mobile terminals.

The example below shows a mix of RBS sites and fixed subscriber sites:

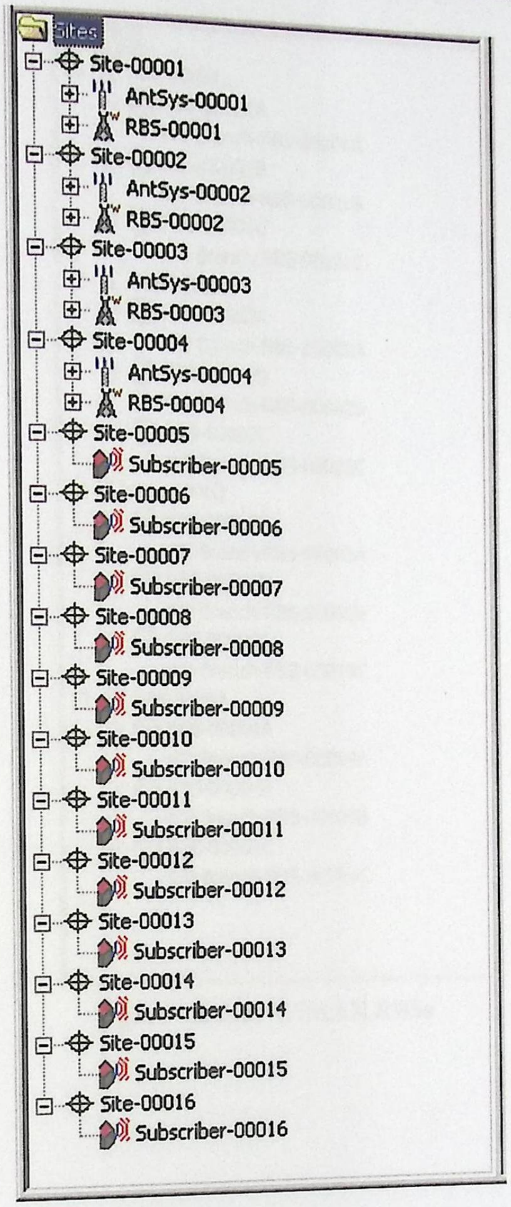

Figure 4.1 RBS sites and fixed subscriber sites

4.3.1 WiMAX RBS Sites

A WiMAX RBS site includes the following network elements:

1. One WiMAX RBS hosting a number of cells with one radio and one antenna branch each
2. One antenna system with antennas, optionally also with feeder cable and TMA.

In the example below, four WiMAX RBSs are defined:

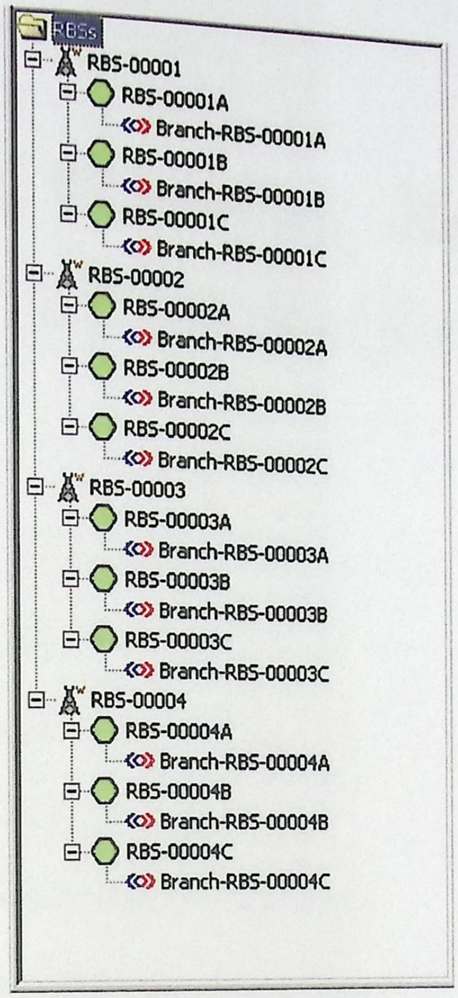

Figure 4.2 four WiMAX RBSs

4.4 WiMAX Analysis

TEMS CellPlanner offers several analysis functions for your WiMAX network plan. The analysis is performed by complex algorithms, based on how you have configured your WiMAX network. By using these analysis functions you obtain plots and reports of coverage, interference and traffic performance.

To perform a complete analysis of a WiMAX network plan, take the following steps in the mentioned order:

1. WiMAX Best Server Analysis.
2. WiMAX Interference Analysis, considering PUSC/FUSC
3. WiMAX Fixed Subscriber Analysis, coverage excluding mobile terminals.
4. WiMAX Traffic Performance Analysis, with or without interference.

Chapter Five

WIMAX Planning Results in YATTA Region

5.1 Coverage performance

5.2 Capacity performance

5.3 WIMAX analysis and plots

5.4 Network Topology And Microwave Links

5.5 Optimization and monitoring

Chapter Five

WIMAX Planning Results in YATTA Region

5.1 Coverage performance

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5.4 Network Topology And Microwave Links

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Chapter Five

5.1 Coverage performance

From the a below image we can see that the whole city will be covered with no less than -75 dB signal level which means that - in addition to traffic analysis- everyone in the city will be able to connect via good signal level.

As you seen in picture its include different colours , each colour represent different signal strength depending on the distance from base station ,the red colour (-75 dBm) show the storngest signal strength and the the yellow (-85 dBm) colour show the weakness signal from the same base station .

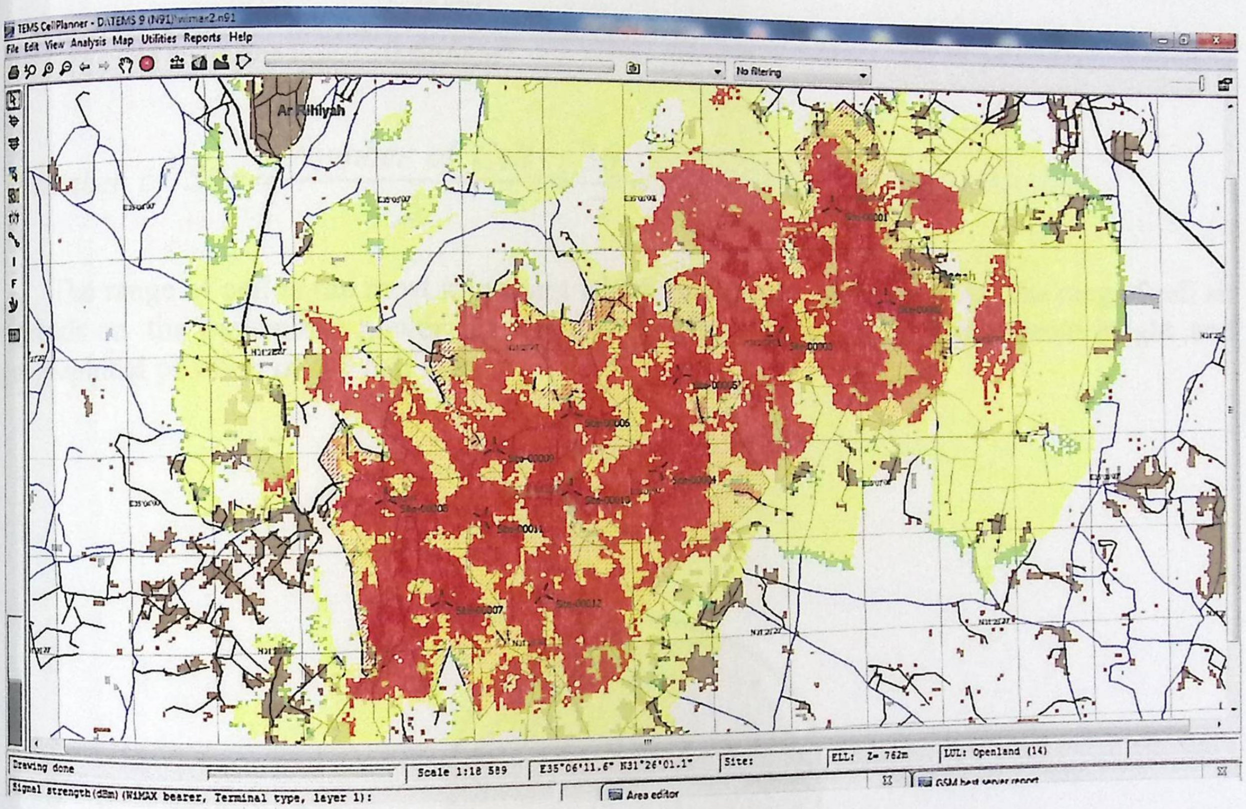


Figure 5.1 Coverage performance

5.1.1 Required Number of Sites and Sectors

The final goal of the planning tool is to deliver the number of sites and sectors required to cover a particular region, and this information will then be used to formulate different business scenarios. The area of the region, the user density and the desired downlink and uplink bit rate per user are additional input parameters. Operators also take into account that not every user simultaneously uses his connection, and for this purpose a parameter for simultaneous usage (overbooking) is introduced, which defines the percentage of the users that effectively use the service . As already mentioned, WiMAX dynamically selects the best possible modulation scheme per user.

5.1.2 Cell area

Mobile WiMAX uses a cellular network structure and we consider a hexagonal cell area, defined as:

$$A=\frac{3}{2}\sqrt{3}\times R^2 \qquad \textbf{Eq.(5.1)}$$

$$R=0.506\,km^2$$

$$A=\frac{3}{2}\sqrt{3}\times(0.506)^2=0.666km^2$$

$$\text{Number of cell}=\frac{area_{yatta}}{area_{cell}}=\frac{24km^2}{0.666km^2}=36\,cell$$

$$Number\ of\ Site=\frac{Number\ of\ Cell}{3}=\frac{36}{3}=12$$

The range of cell is the most important which is concerned with cell site. The rang of cell sit depends on the transmitter power, size of antenna ,the direction of antenna ,antenna height ,and geographical position of the cell site.

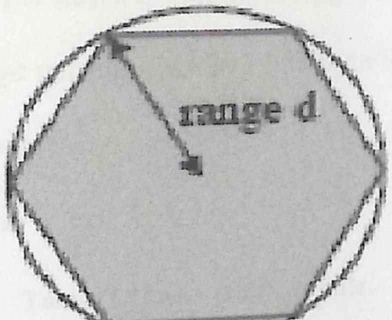


Figure 5.2 Illustration of cell area calculation.

5.2 Capacity performance

Radio access networks are dimensioned to provide both sufficient coverage and capacity to the service area (YATTA region), we must balance between coverage and capacity ,if the number of site in capacity less than the number of site in coverage I will choose the largest and vice versa, in this section we will study capacity needed to our WIMAX network.

5.2.1 Competition model and WIMAX operators market

To forecast the market evolution of the WIMAX operator, taking into account the broadband service penetration, competition level, and the DSL availability, In areas with no DSL coverage, the WIMAX operator is assumed to all user to use WIMAX , In areas with existing DSL coverage, the WIMAX network operator has to compete these network, so not all of user use our WIMAX network, then before deployment a network we must study a competition for other operators.

In our project we will plane a WIMAX in YATTA city, but in YATTA we have DSL and WIFI serves, but not spread in all places , so we don't expect that all user will access the network, and WIMAX is a new technology and it has advantages than DSL and WIFI , so we will expect percentage of user that access the network as we will explain later.

5.2.2 User traffic profile

Assumed subscriber usage per month is 10,000,000 KByte/month.(minimum).

Subscriber usage per day=usage per month/30 day=333,333.33KByte/day.

Subscriber usage per hour=usage per day/24=13,888.89Kbyte/hour.

Subscriber usage per second=usage per hour/3600=3.85Kbyte/S.

Then subscriber usage is 30.86Kbits/S.

Table (5.1) show these assumption.

Table (5.1) user traffic profile.

Sub usage Kbyte/month	Sub usage Kbyte/day	Sub usage Kbyte/hour	Sub usage Kbyte/second	Sub usage Kbits/second
10,000,000	333,333.33	13,888.89	3.85	30.86

Number of human in YATT **100,000** ,and we assumed each house include **7** person .

$$Number\ of\ subscriber = \frac{100,000}{7} \cong 14,300$$

and if we assume that **10%** of subscriber only use WIMAX network,

$$Number\ of\ users = 14,300 * 0.10 = 1,430$$

Total required capacity=Total number of user * User usage (Kbits/s).

$$Total\ capacity = 1,430 * 30.86(kbit/s) = 44,185.8Kbits/s$$

5.2.3. WIMAX sector capacity

The capacity of a single base station sector depends on the channel bandwidth and the spectral efficiency of the utilized modulation and coding scheme. WIMAX systems take advantage of adaptive modulation and coding, meaning that inside one BS sector each CPE may use the most Suitable modulation and coding type .

To account for the adaptive modulation, the capacity of a single BS sector is calculated as the average of link capacities of all the CPEs in the sector area. For example, in a sector dimensioned for maximum range, approximately 69% of the users have to utilize the more robust modulation types BPSK and QPSK, decreasing the average sector capacity to only 39% of the maximum link capacity, This tradeoff between relative sector range and capacity is illustrated in Figure 5.3 separately for deployments using indoor and outdoor CPEs. The actual cell range depends on the utilized frequency band, propagation environment, and system performance characteristics.

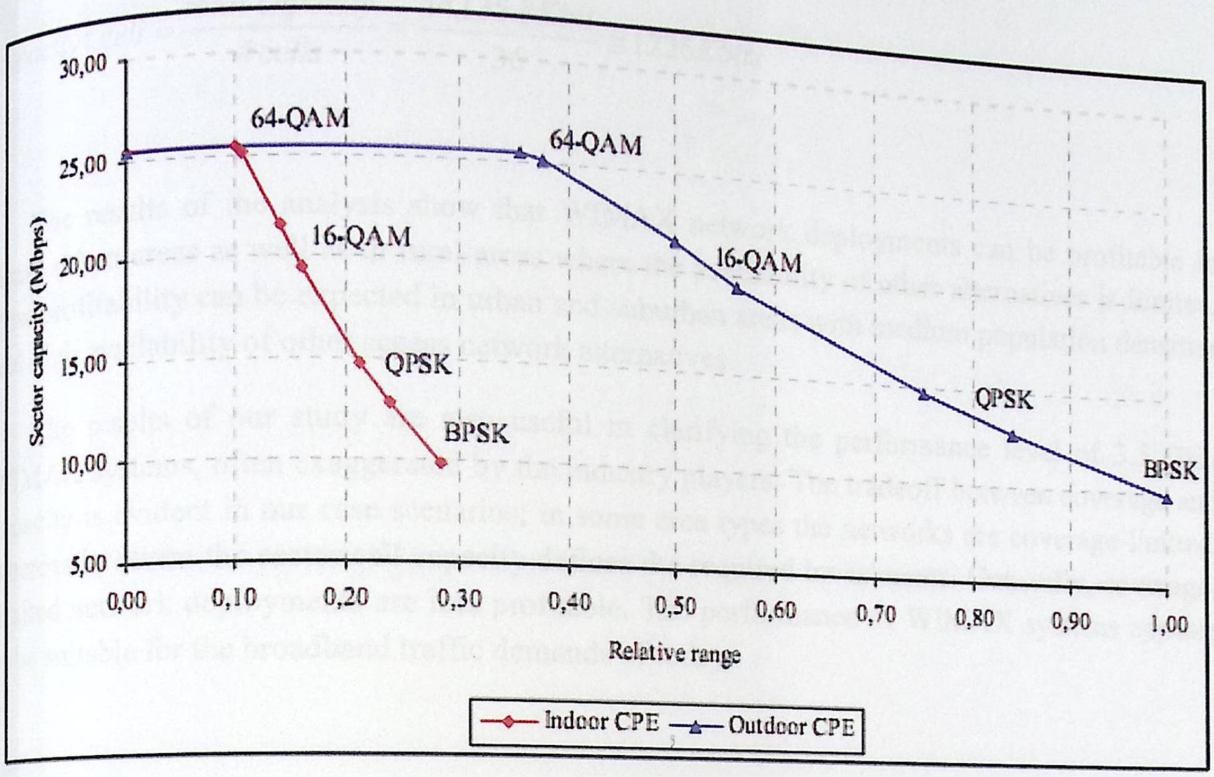


Figure 5.3 Average sector capacity as a function of cell range of wimax system.

For WIMAX systems operating on the sub-10 GHz frequency bands, service offerings with data rates above 2 Mbps may become problematic. Although the average data rate in a coverage-limited BS sector would be around 10 Mbps, the subscribers in the cell edge utilizing BPSK modulation are capable of transmitting/receiving at data rates of less than 3 Mbps. This means that 4 Mbps services can be offered only for subscribers located sufficiently near the base station, utilizing e.g. 16-QAM or 64-QAM modulation[14].

5.2.4 required number of site and sector

The final goal of the planning tool is to deliver the number of sites and sectors required to match capacity, and this information will then be used to formulate different business scenarios. The area of the region, the user density and the desired downlink and uplink bit rate per user are additional input parameters. Operators also take into account that not every user simultaneously uses his connection.

In coverage prediction we find that 12 sites (36 sectors) is required to cover YATTA city, so we will to find if its sites is enough to capacity calculation .

$$capacity/cell = \frac{total\ capacity}{\#cells} = \frac{44{,}135.8Kbit}{36} \cong 1226Kbits$$

The results of the analysis show that WIMAX network deployments can be profitable in dense urban areas as well as in rural areas where the availability of other alternatives is limited. Low profitability can be expected in urban and suburban areas with medium population densities and high availability of other access network alternatives.

The results of our study are also useful in clarifying the performance level of 3.5 GHz WIMAX systems, often exaggerated by the industry players. The tradeoff between coverage and capacity is evident in our case scenarios; in some area types the networks are coverage-limited, whereas in others the sector/cell capacity defines the required investments. Generally, coverage-limited network deployments are less profitable. The performance of WIMAX systems appears to be suitable for the broadband traffic demands of today.

5.3 WIMAX analysis and plots

TEMS Cell Planner offers several analysis functions for your WIMAX network plan. based on how you have configured your WIMAX network. By using these analysis functions you obtain plots and reports of coverage, interference and traffic performance. To perform a complete analysis of a WIMAX network plan, take the following steps in the mentioned order:

1. WIMAX Best Server Analysis.
2. WIMAX Interference Analysis.
3. WIMAX Traffic Performance.

5.3.1 WIMAX best server analysis:

In a multi-sector communication system such as WIMAX the performance of the network is heavily influenced by the traffic load on each sector as well as the ability of mobile units to smoothly move from one sector to another. Accurately knowing how a sector will serve a particular geographic area is fundamental to understanding these two issues when planning or designing a network. Much of this challenge is answering the "Best Server" question. Knowing which sector is the primary server for a mobile unit will greatly enhance the understanding of the effect of that mobile's data needs on the networks well as how to properly provide a smooth mobile handoff as it moves among sectors. This report explores the Best Server issues that are important to WIMAX and shows a way to more effectively use a planning tool to model the operation of the network.

The purpose of the WIMAX best server analysis is to find the best serving cells in a WIMAX and create plots displaying the best servers. The best server analysis optionally produces a Received power per carrier required by WIMAX Interference Analysis, The results of Best Server Plots showing the coverage, data rate and the best MCS anywhere in the network. The result from Calculate WIMAX Best Server may be displayed as plots, color coded for every bin.

A. Best server by cell

This plot display the downlink coverage of the very best, 2nd best, 3rd best serving cell and so on, depending on the value of the parameter Depth of best server list(Determines the number of plots to generate, which for every bin on the map shows the identity or signal strength of the first, second, and third ranked cell that may serve a terminal located in the bin).we see from figure1 we have 36 cells each cell represent with different color each color give the coverage where each cell coverage. The figure1 below shows a best server plot (by cell).

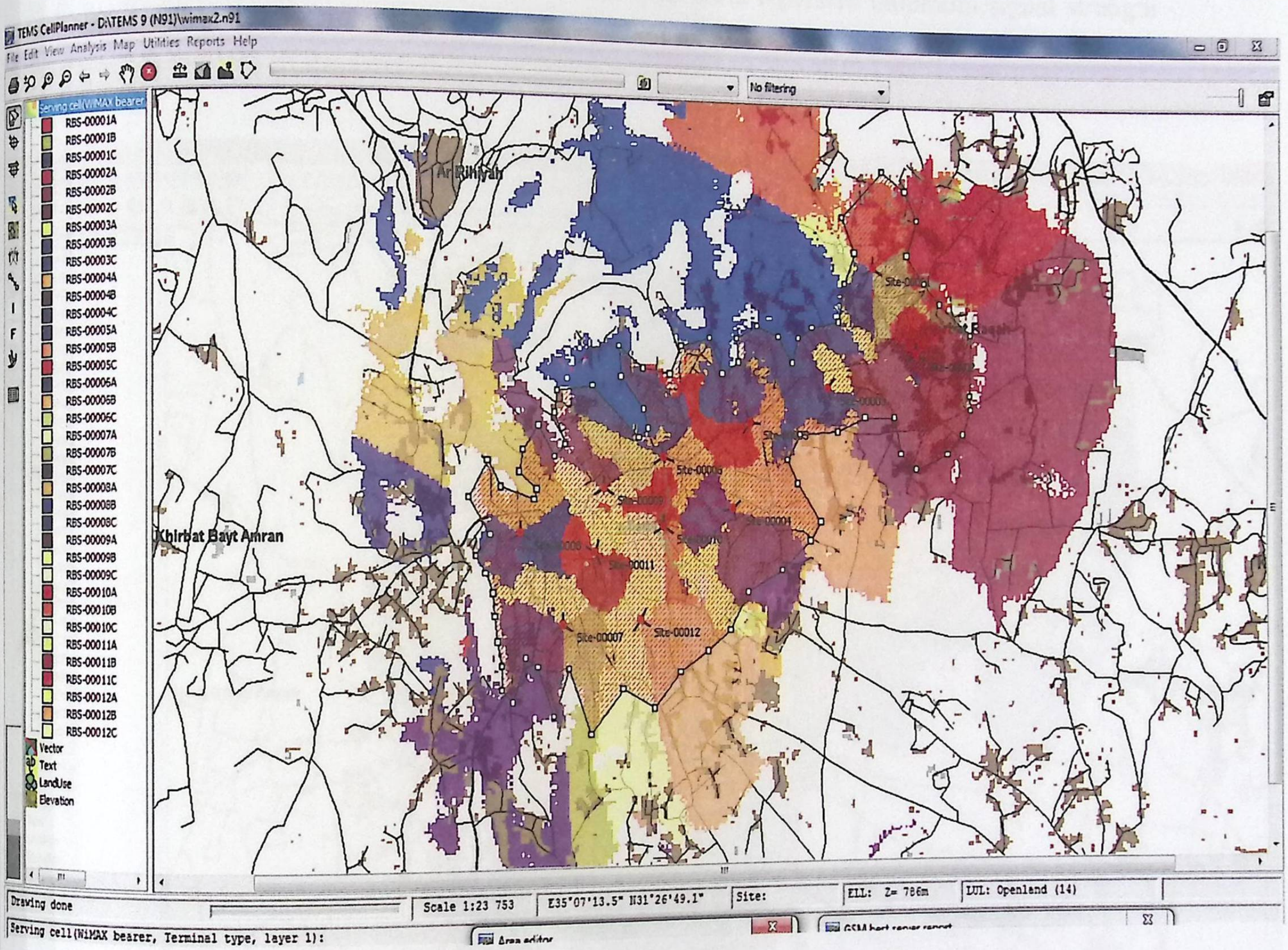


Figure 5.4 Best server by cell.

B. Best server composite:

This plot display the downlink composite coverage of the very best, 2nd best, 3rd best serving cell and so on, depending on the value of the parameter Depth of best server list, The received signal strength is displayed on the status bar together with the identity of the best serving cell, as you seen from the bins each color determine the signal strength, , so the maximum signal strength be when the receiver be close to the base station (the red color represent the maximum signal strength, -44.5dBm), and the lowest signal strength when the receiver be far away from the base station (the blue color represent minimum signal strength -90.9), and the signal strength graduate between two these rang.

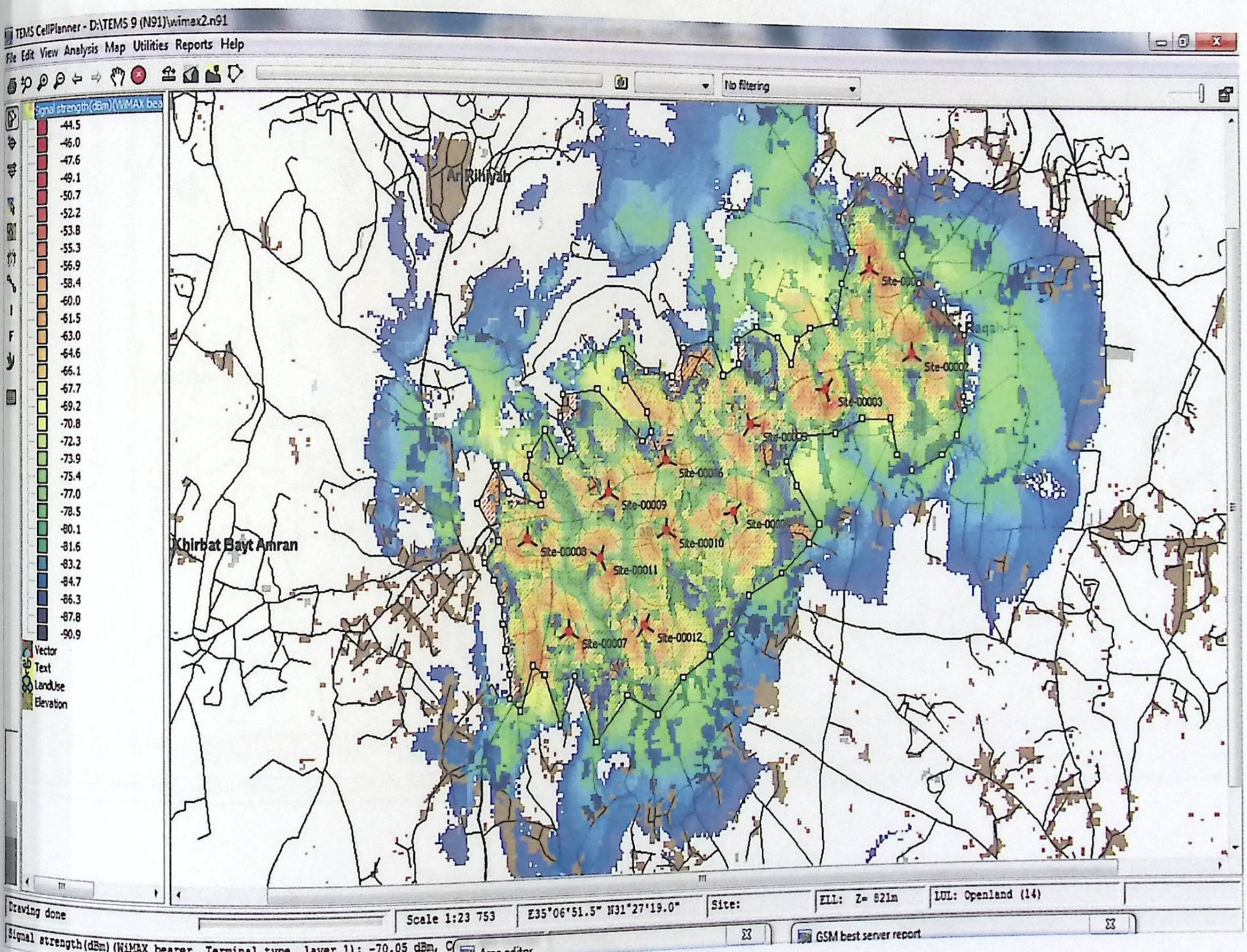


Figure 5.5 Best server composite.

C. DL MCS Without Interference :

This plot displays the coverage of the best possible downlink MCSs, The best DL MCS is displayed on the status bar together with the identity of the serving cell, The figure3 below shows a DL MCS plot without interference, also this figure show that we use adaptive transmitter depends on the distance between base station and mobile station.

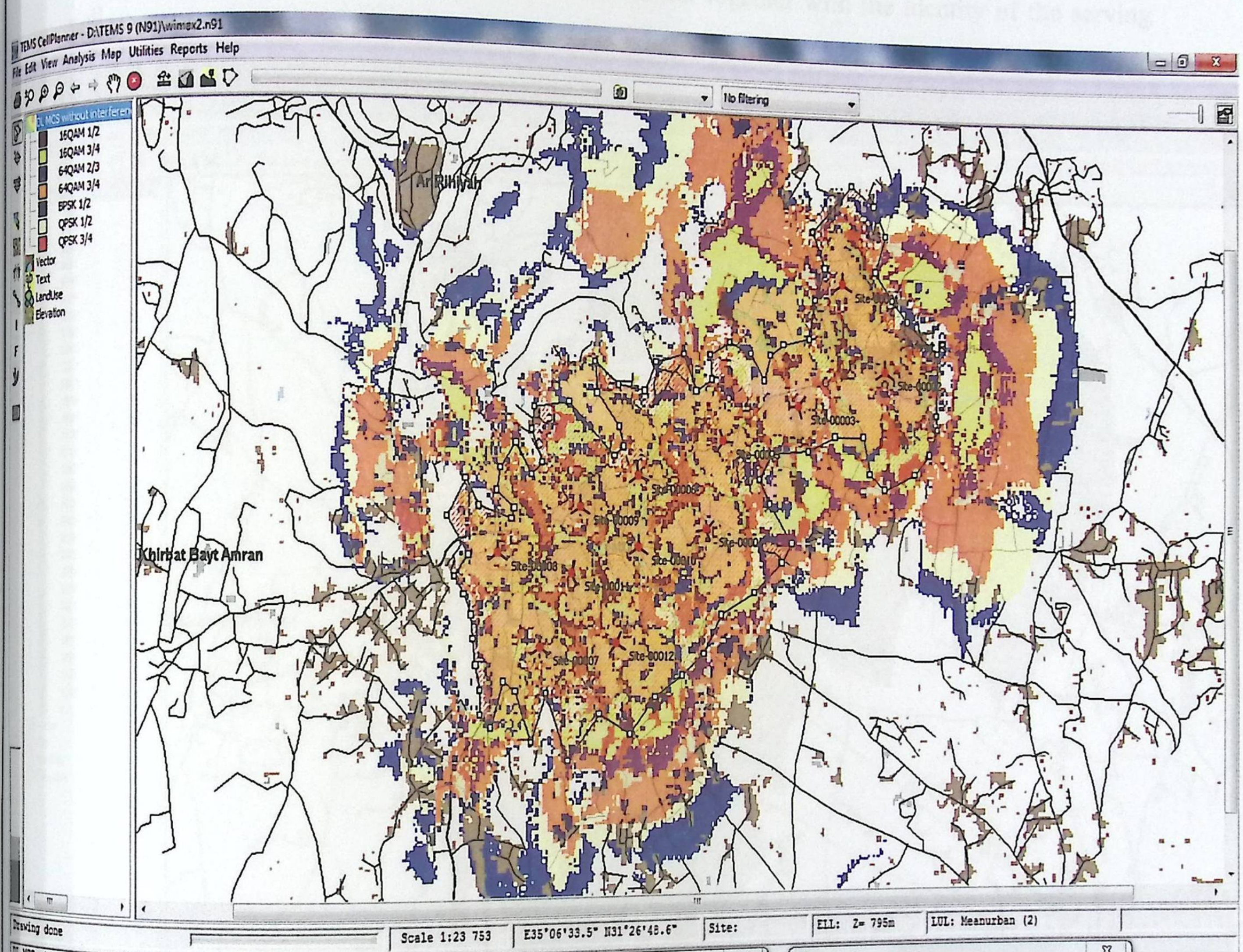


Figure 5.6 DL MCS Without Interference.

D. DL Data Rate Without Interference

This plot displays the achieved downlink data rate for the full carrier bandwidth, using the best DL MCS. The achieved downlink data rate of a terminal is the number of K bits per second of traffic data received by the terminal. Only pure traffic data is counted, signaling overhead is excluded.

The DL data rate is displayed on the status bar together with the identity of the serving cell.

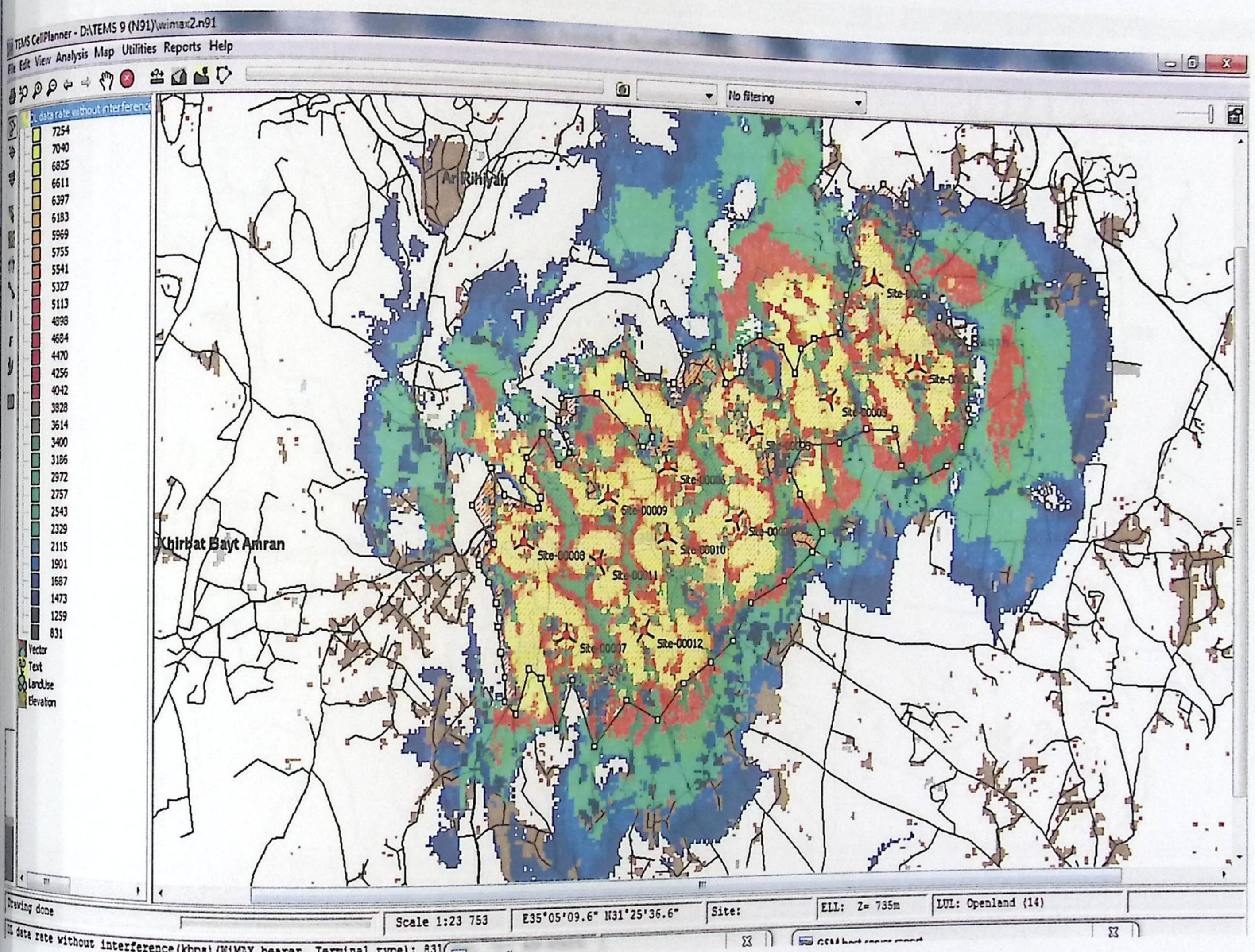


Figure 5.7 DL Data Rate Without Interference.

E. UL MCS Without Interference:

This plot displays the coverage of the best possible uplink MCSs. . The best UL MCS is displayed on the status bar together with the identity of the serving cell.

For example with near to cell we use 16QAM, and with other places we use other type of modulation.

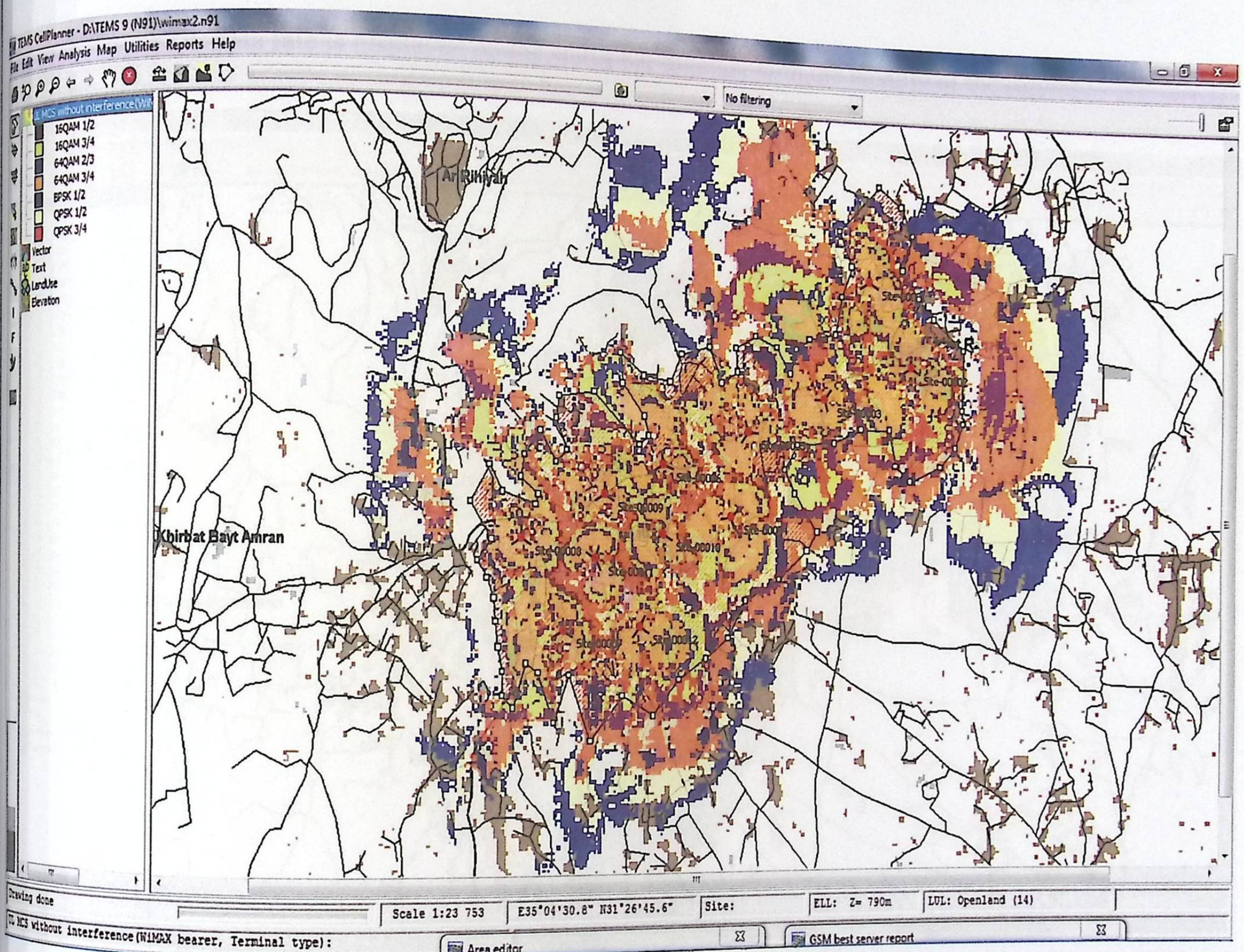


Figure 5.8 UL MCS Without Interference.

F. UL Data Rate Without Interference:

This plot displays the achieved uplink data rate for the terminal type when the best UL MCS is used.

The achieved uplink data rate of a terminal is the number of bits per second of traffic data transmitted on all UL sub-channels of the terminal. The UL sub-channels are defined by the carrier mapping of the bearer(s). Only pure traffic data is counted, signaling overhead is excluded.

The UL data rate is displayed on the status bar together with the identity of the serving cell.

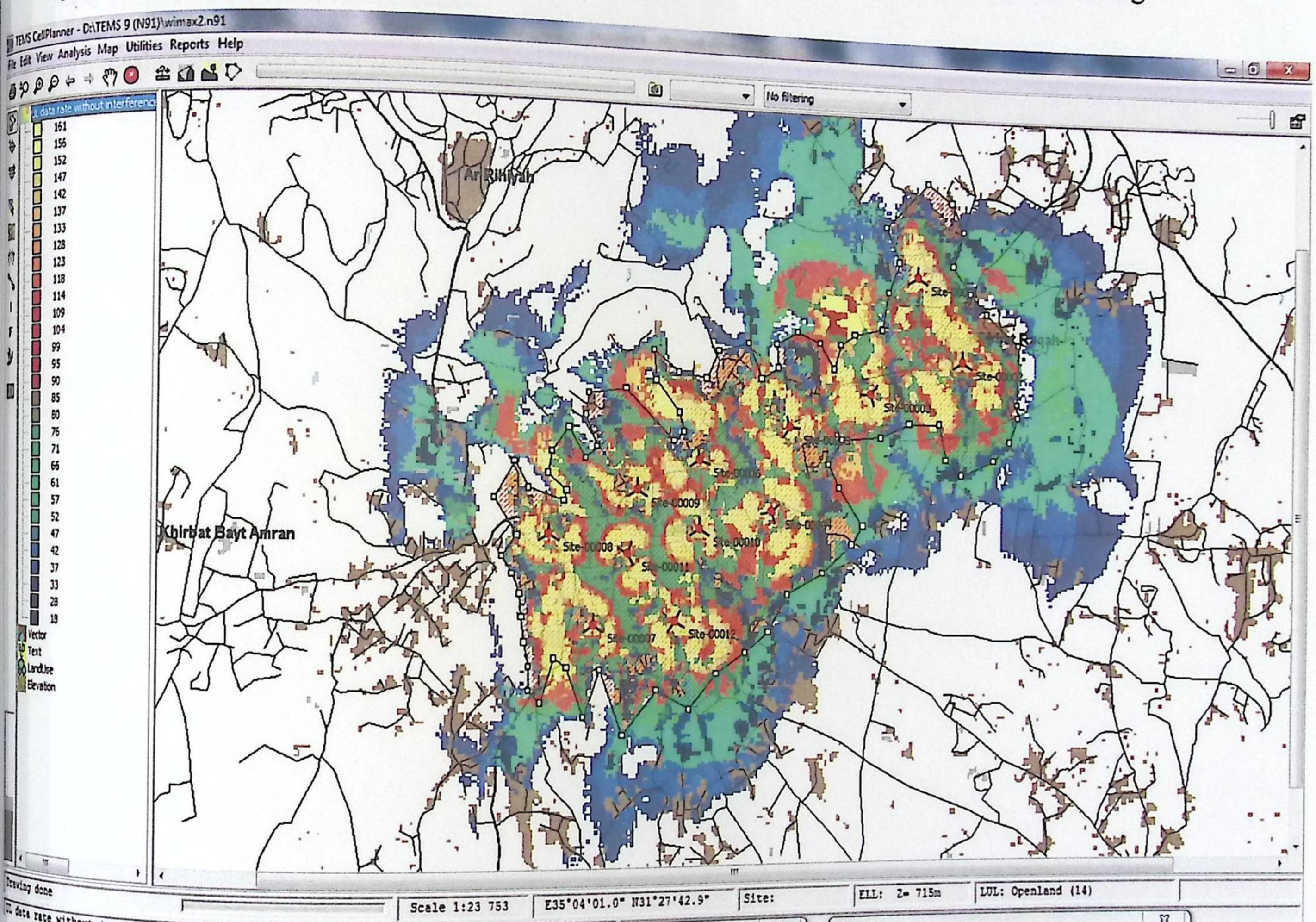


Figure 5.9 UL Data Rate Without Interference.

We see for example from figure that data rate that close to cell (161Kbit/s) , is higher at the edge of cells(18Kbit/s).

5.3.2 WIMAX Interference Analysis:

The purpose of the interference analysis is to analyze the downlink interference in a WIMAX network and create interference plots. The interference can be calculated for a WIMAX network plan using FDD or synchronized TDD, but not for unsynchronized TDD. It is possible to use PUSC mode for terminals in the more interfered parts of the cells and FUSC mode for terminals in the less interfered parts of the cells.

The following interference plots may be generated per traffic case:

- Downlink interference
- Downlink MCS with interference
- Downlink data rate with interference.

A. Downlink interference

This plot displays the C/(I+N) value in dB on the radio channel of the serving cell, without using PUSC. The C/(I+N) value is displayed on the status together with the identity of the serving cell .

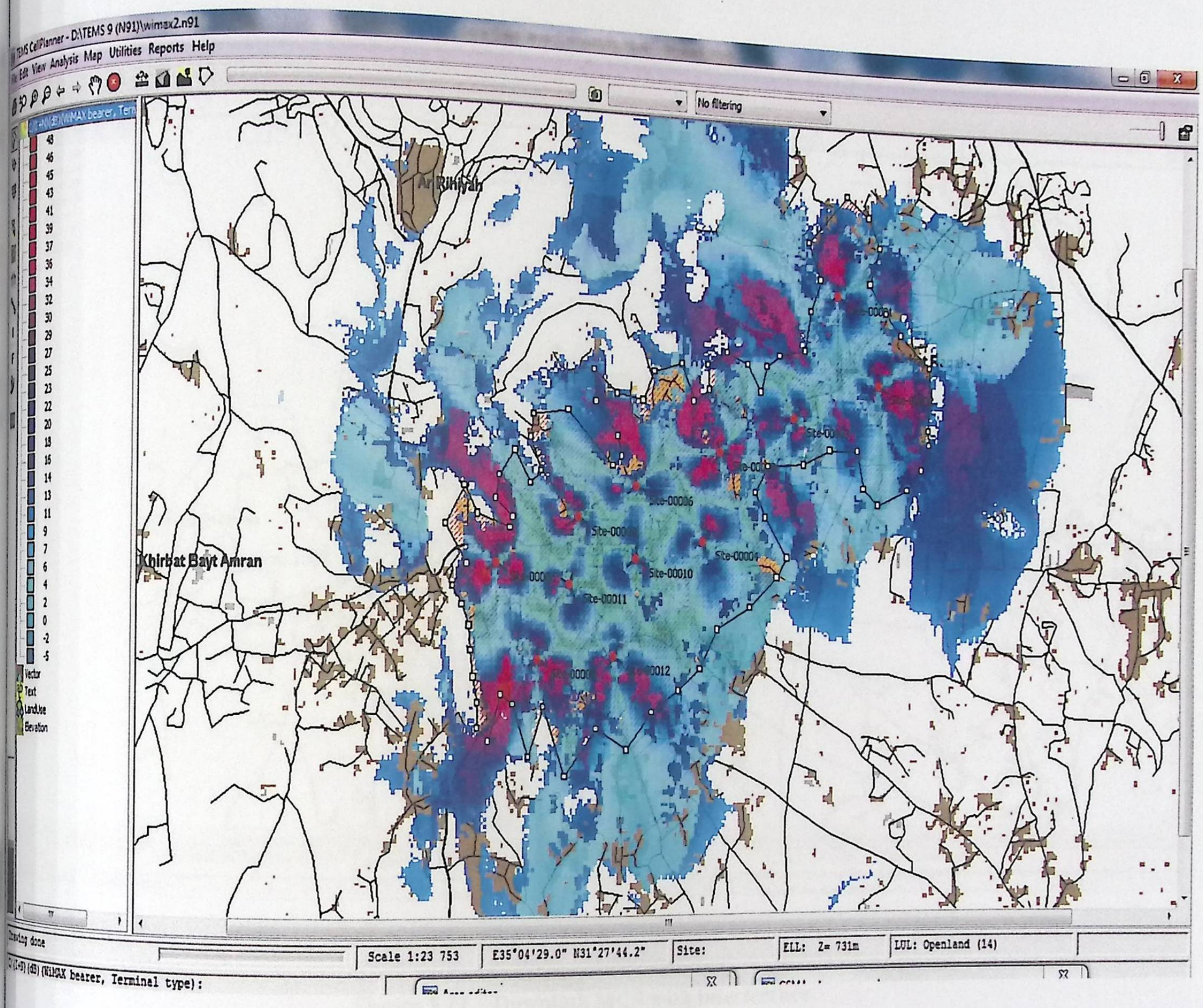


Figure 5.10 Downlink interference

B. Downlink MCS with interference:

This plot displays the identity of the best MCS that can be used for the calculated PUSC/FUSC C/(I+N) on the radio channel of the serving cell. The MCS is displayed on the status bar together with the identity of the serving cell. The figure10 below shows a DL MCS plot with interference.

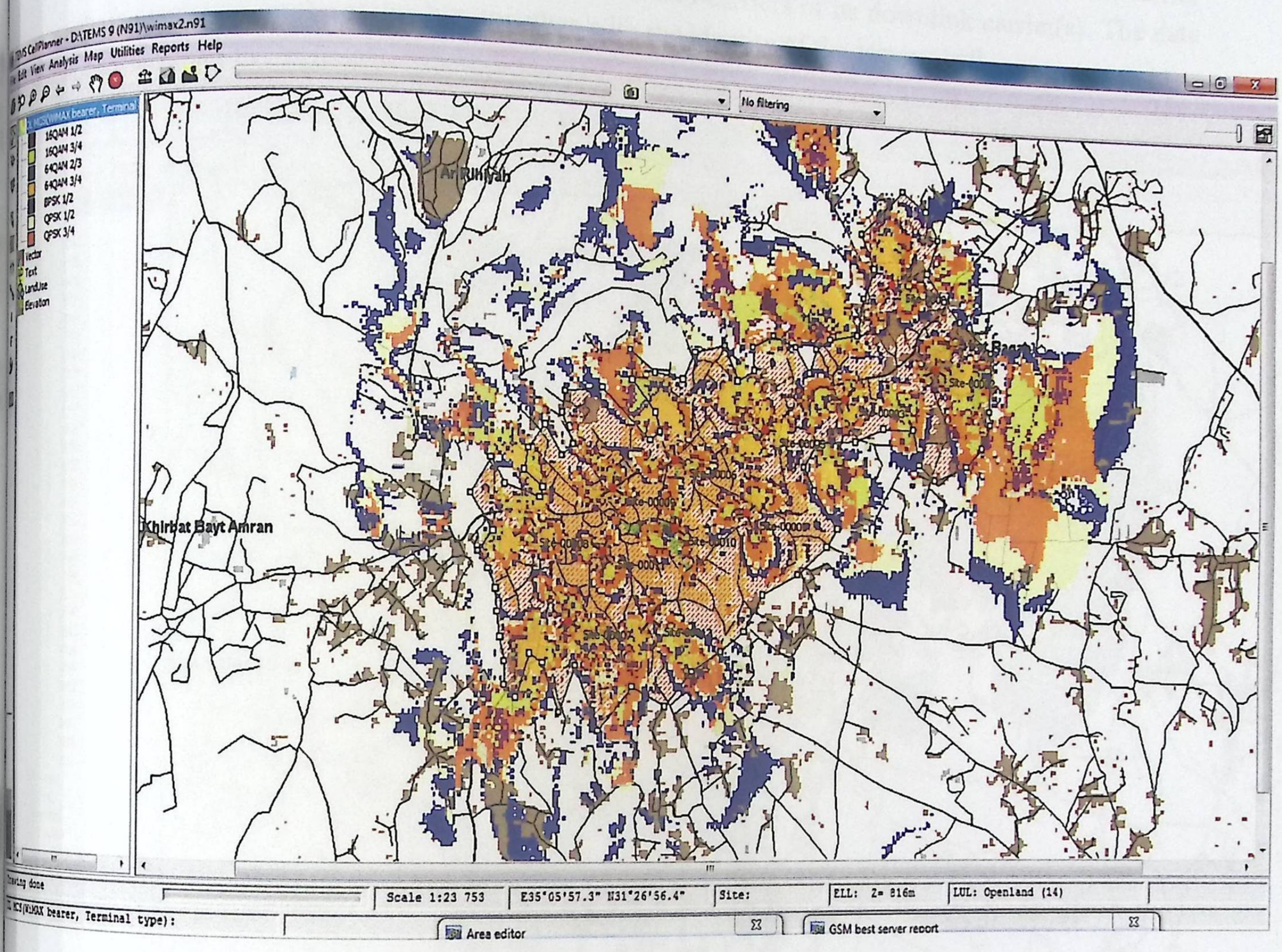


Figure 5.11 Downlink MCS with interference.

C. Downlink data rate with interference:

This plot displays the achieved data rate for the full carrier bandwidth when the best MCS is used, and with the calculated PUSC/FUSC C/(I+N) on the radio channel of the serving cell. The achieved downlink data rate of a terminal is the number of bits per second of traffic data received by the terminal. Only pure traffics data is counted, signaling overhead is excluded. Full carrier bandwidth means that the terminal listens to all sub-carriers of its downlink carrier(s). The data rate is displayed on the status bar, together with the identity of the serving cell.

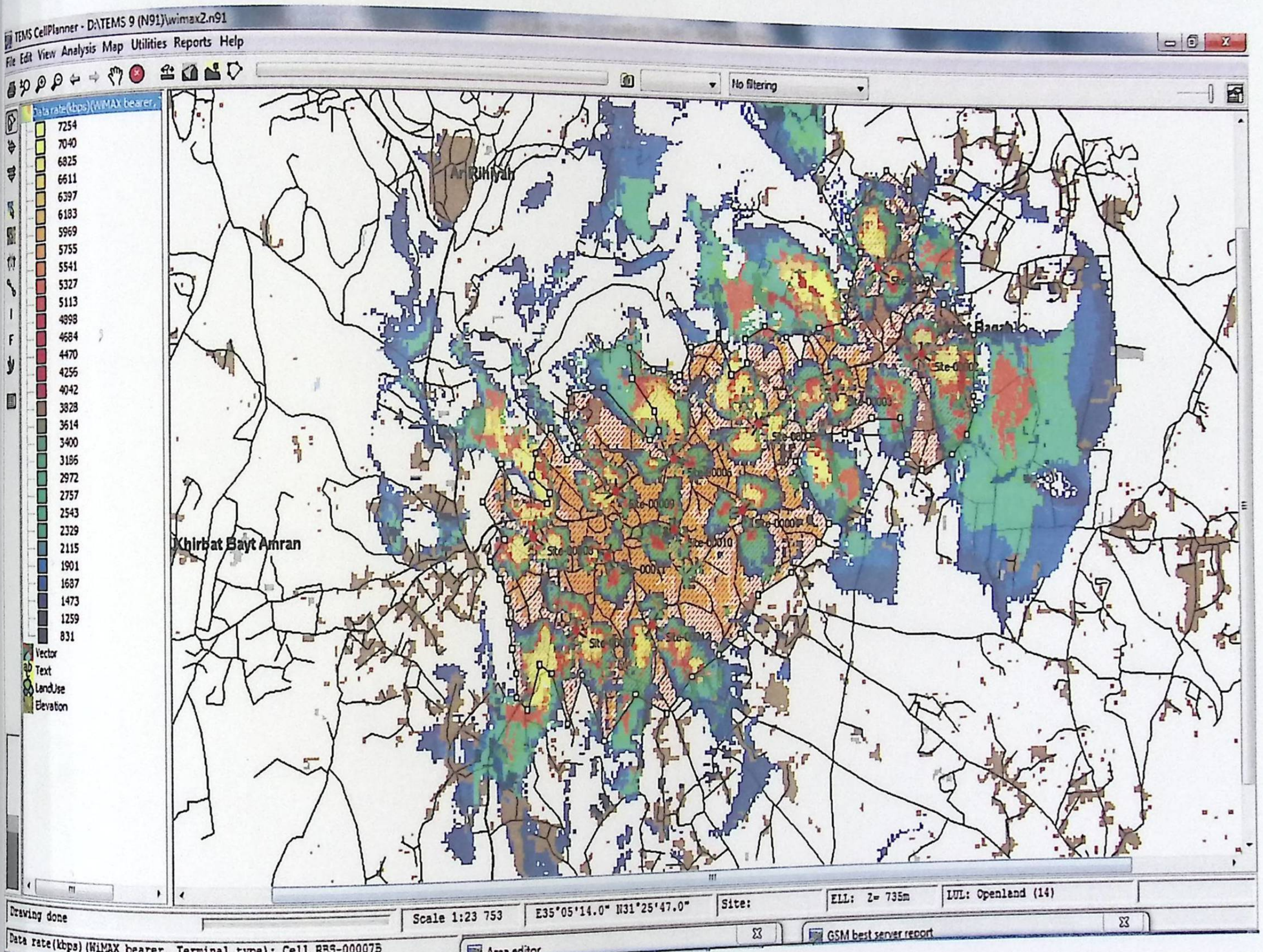


Figure 5.12Downlink data rate with interference

5.3.3 WIMAX Traffic Performance

The result from Calculate WIMAX Traffic Performance can be displayed as plots, color coded for all bins served by the cell.

The following traffic performance plots may be generated per traffic case:

- DL traffic (by cell or composite)
- DL utilization (by cell or composite)
- UL traffic (by cell or composite)
- UL utilization (by cell or composite)

A .DL Traffic (by Cell)

The identity of the serving cell is displayed on the status bar, together with the total DL traffic in kbps of the serving cell.

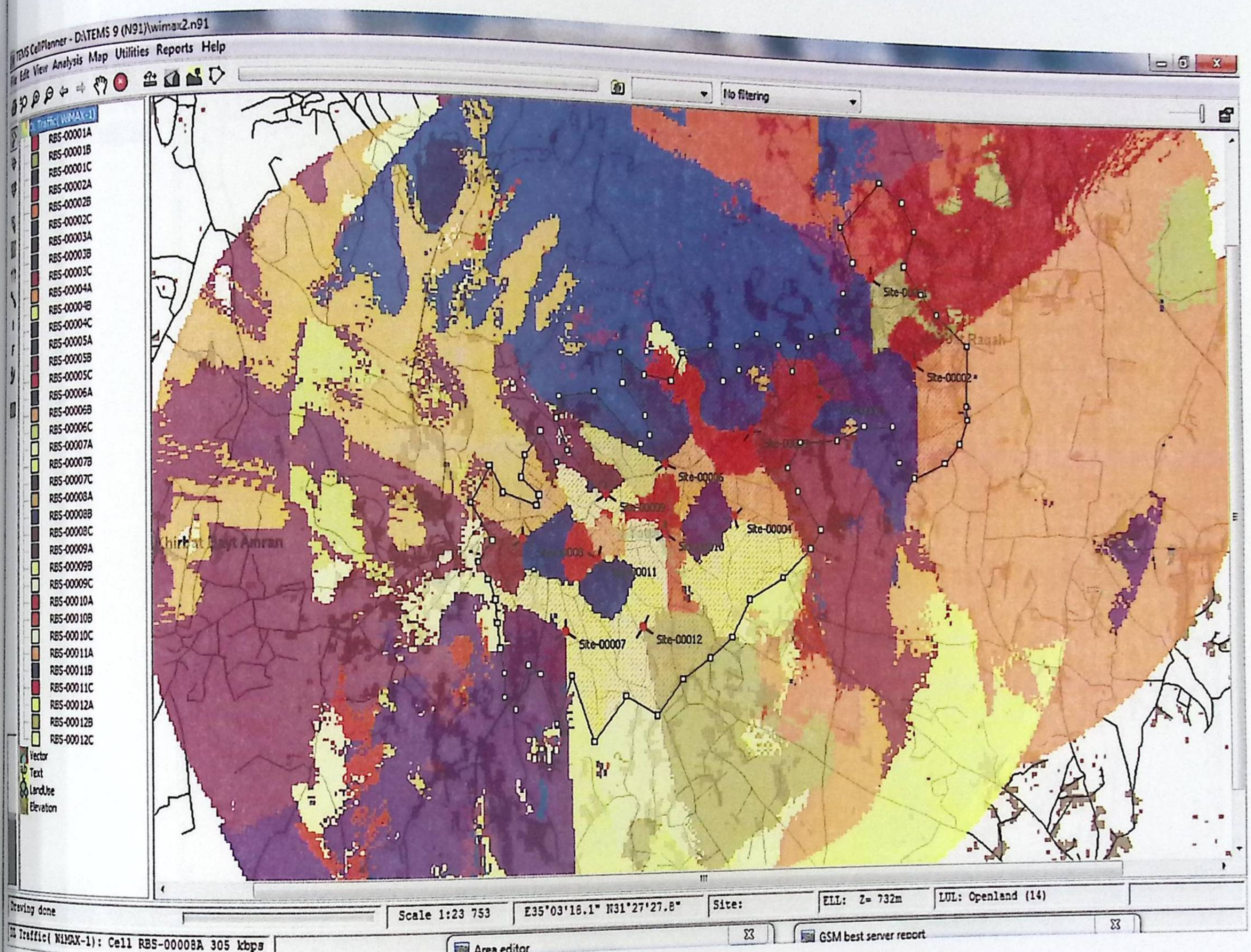


Figure 5.13 DL Traffic (by Cell).

B. DL Traffic (Composite)

This plot displays the total downlink traffic from the serving cell, measure in kbps.

The total DL traffic in kbps of the serving cell is displayed on the status bar, together with the identity of the serving cell.

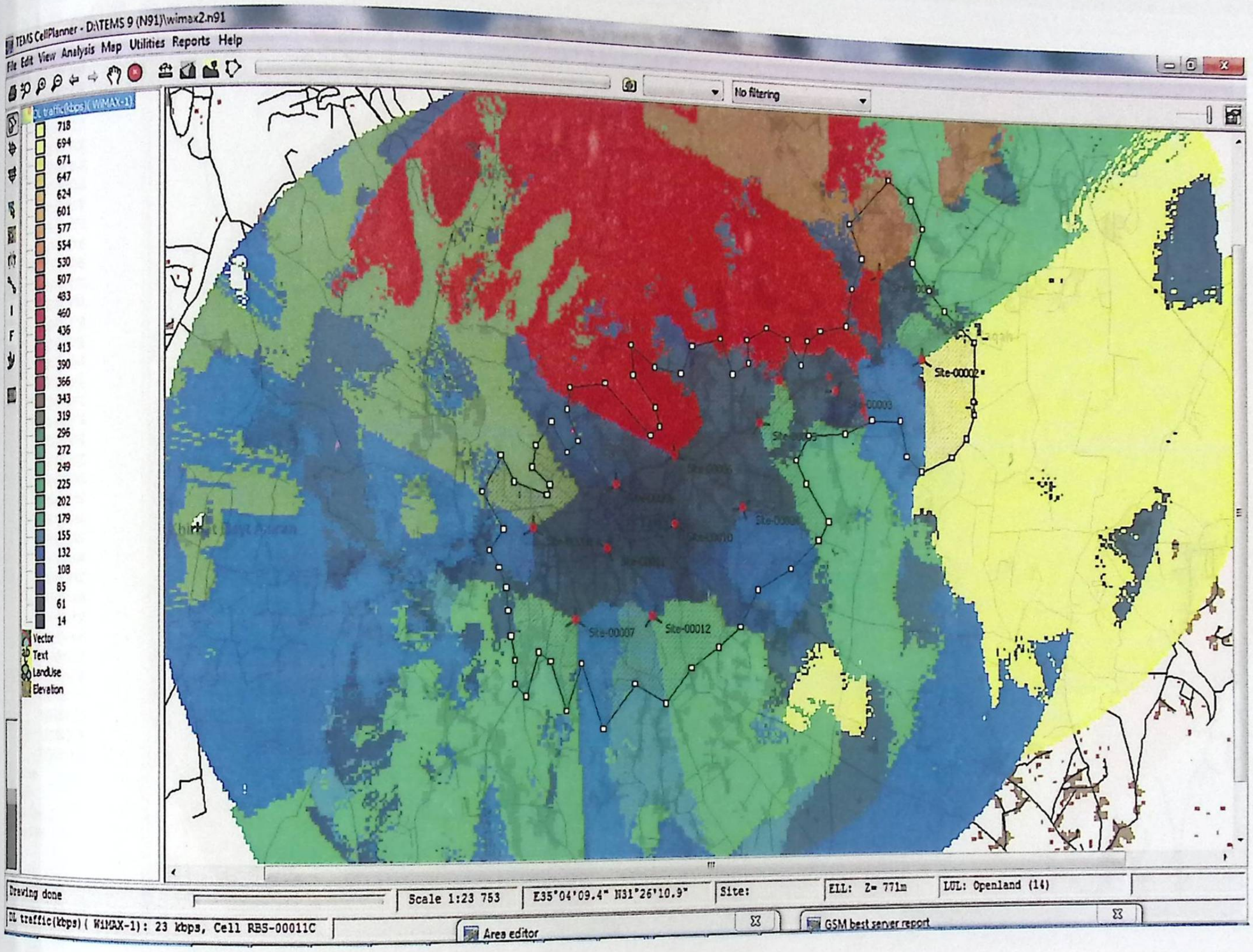


Figure 5.14 DL Traffic (Composite).

C . DL Utilization (by Cell)

The identity of the serving cell is displayed on the status bar, together with the used percentage of the DL capacity of the serving cell when each connected terminal uses its best possible MCS.

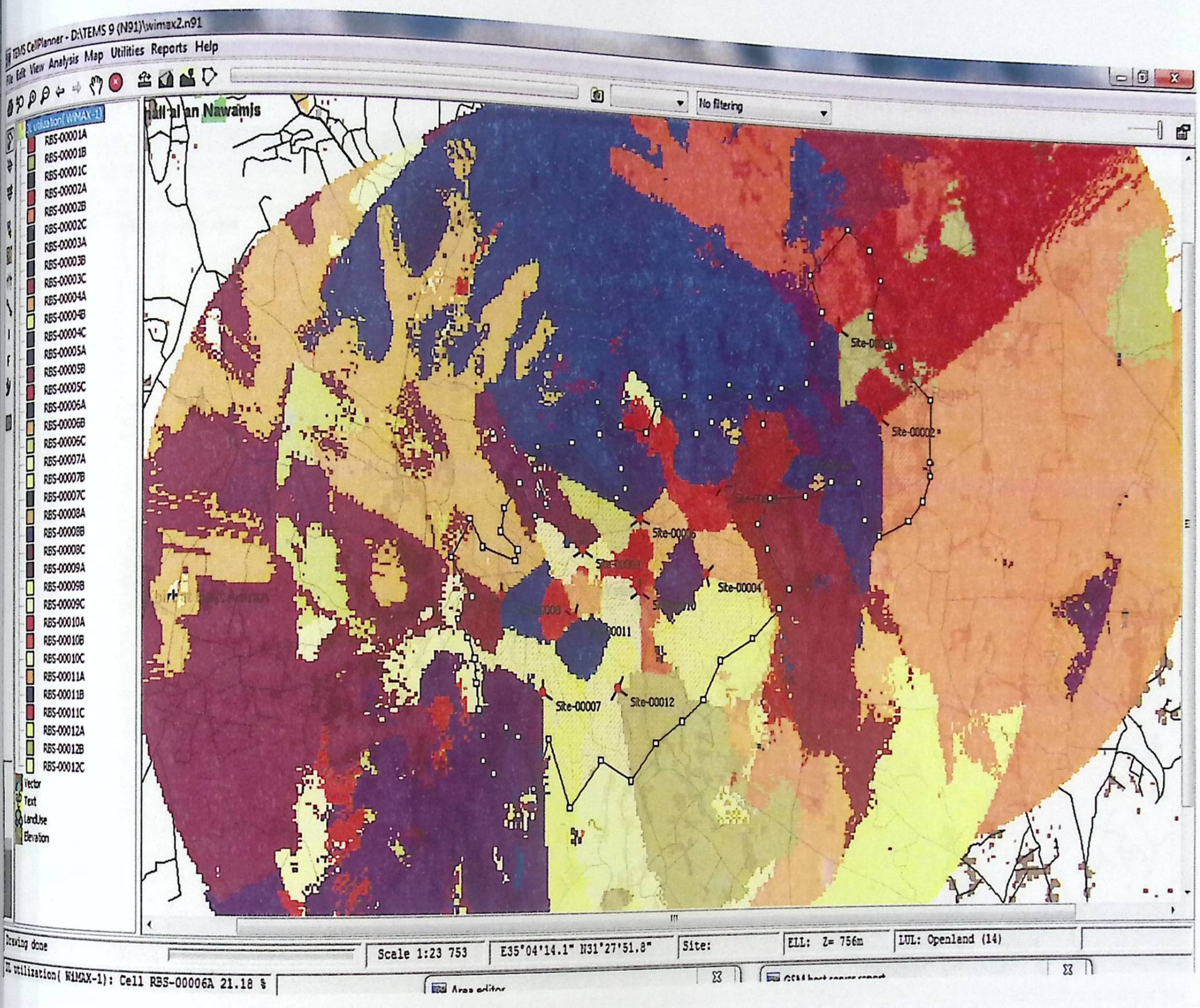


Figure 5.15 DL Utilization (by Cell).

D . DL Utilization (Composite)

This plot displays the used percentage of the downlink capacity of the serving cell, when each connected terminal uses its best possible MCS. 100% utilization of a cell's downlink capacity is reached when all downlink traffic

Sub-carriers are used all the time. Only pure traffic data is counted, signaling overhead is excluded .The DL utilization is displayed on the status bar, together with the identity of the serving cell.

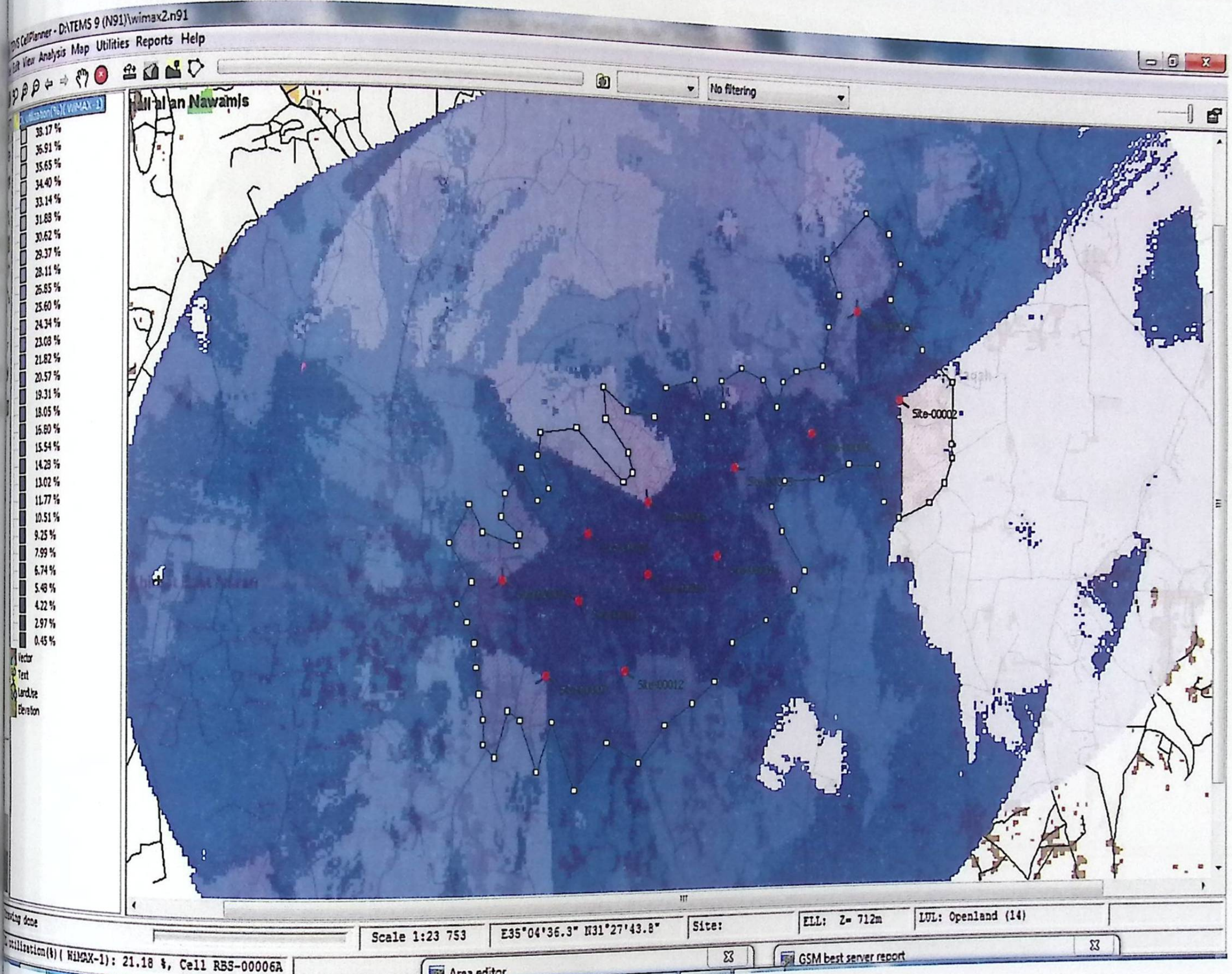


Figure 5.16 DL Utilization (Composite)

E. UL utilization (composite)

This plot displays the used percentage of the uplink capacity of the serving cell when the best MCS is used.100% utilization of a cell's downlink capacity is reached when all downlink traffic sub-carriers are used all the time. Only pure traffic data is counted, signaling overhead is excluded.

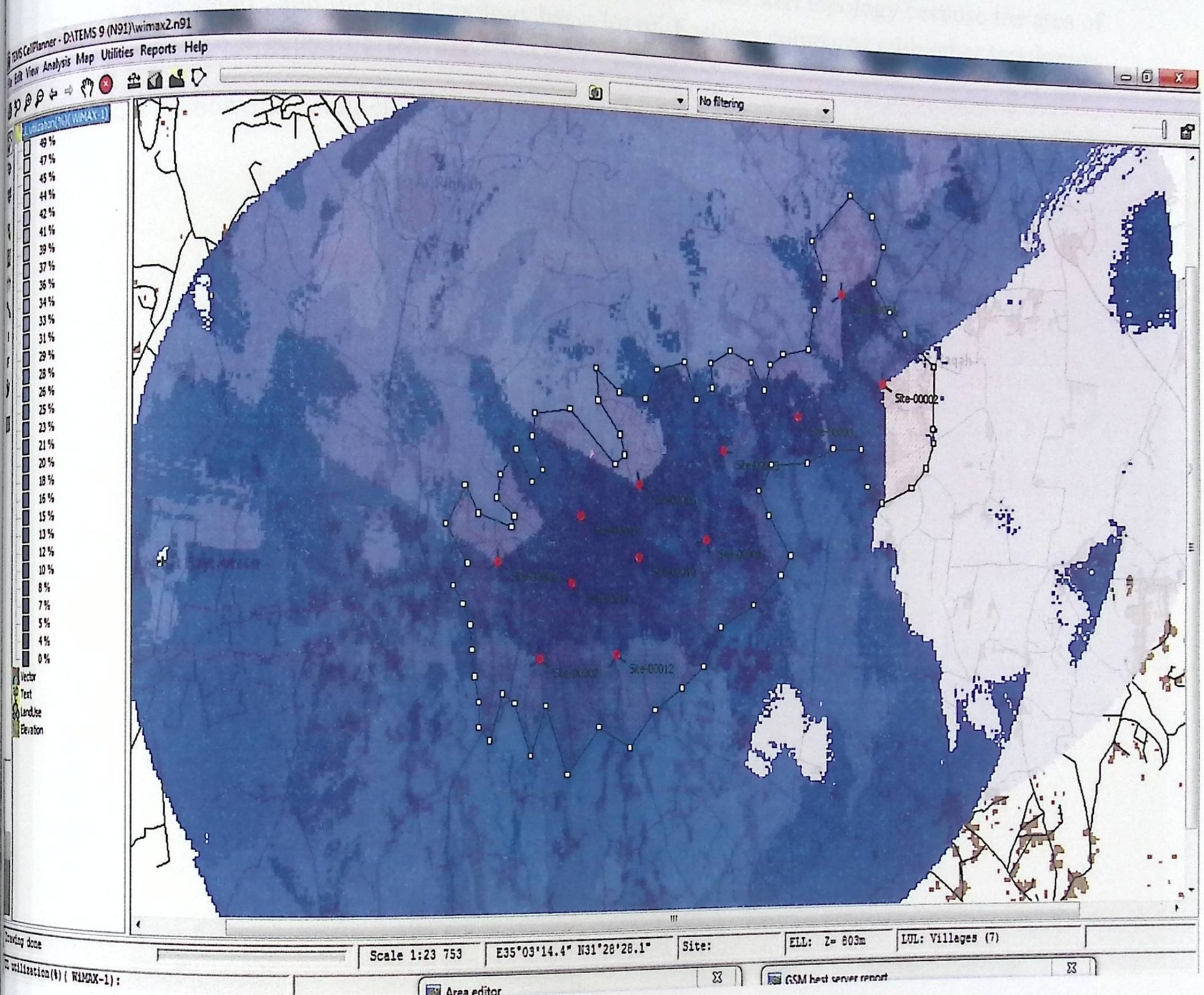


Figure 5.17 UL utilization (composite).

5.4 Network Topology And Microwave Links

This plot shows the structure (topology) of the network which used to connect different sites with each other by using microwave links by using **Mentum ellipse** software , this program used to built the microwave link between sites so we can determine the capacity ,the long of each link and the characteristic of each link, In our network we used start topology because the area of project is too small , and the start topology has a lot of Features compared with other topologies, we see that site 6 is center of network.

Appendix A show the parameters for each link.

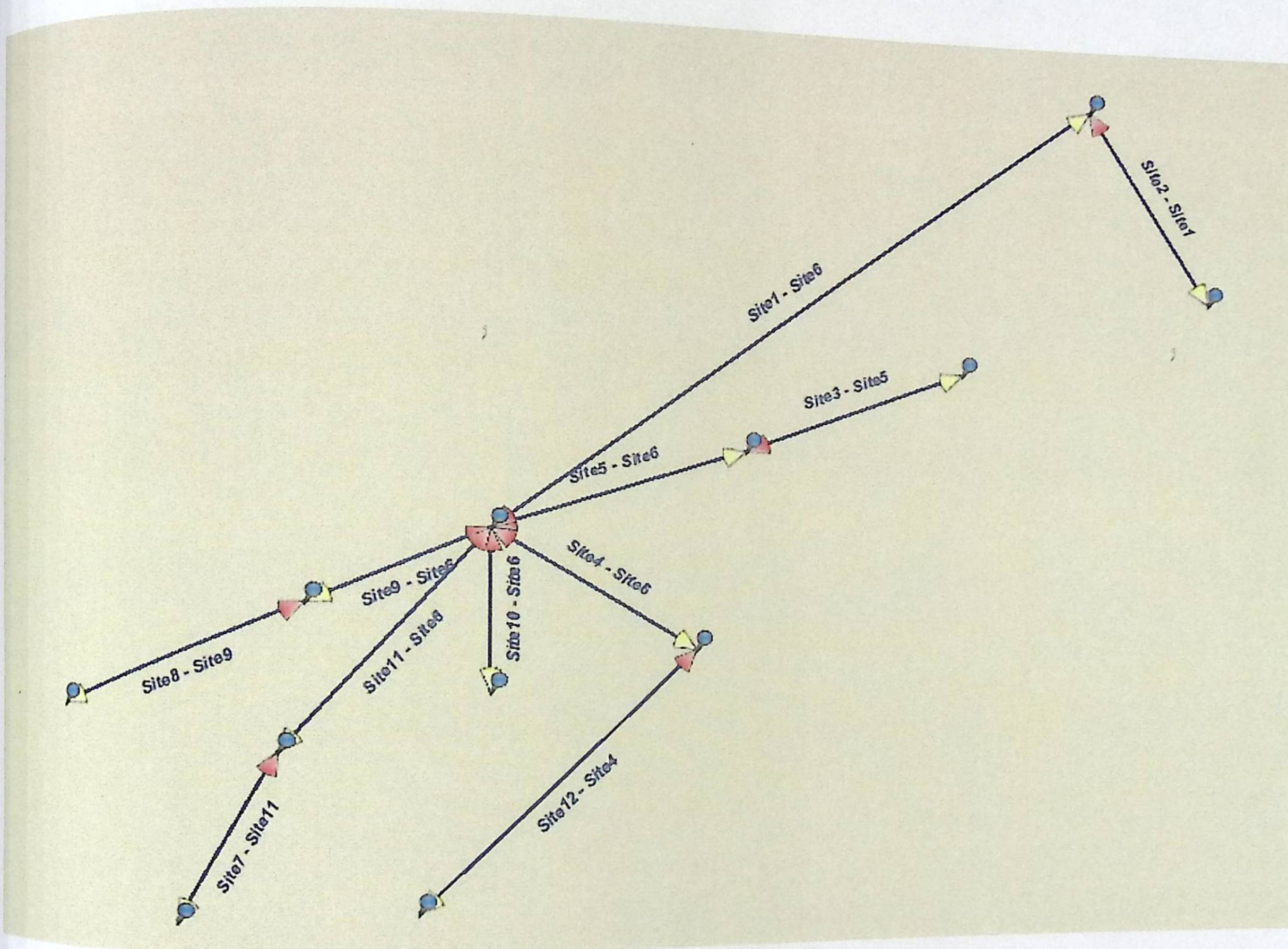


Figure 5.18.a Network Topology.

This plot shows the structure (typology) of the network dropped on the google Earth after we designed it by using **Mentum ellipse** software, also shows all links in our network, as you noticed from picture all links have line of sight, also each base station has different height to achieve (LOS).

For more details and to show the picture in zoom in and the reality height for all microwave links , look for google earth file (all links) that is attachment in the Appendix A.

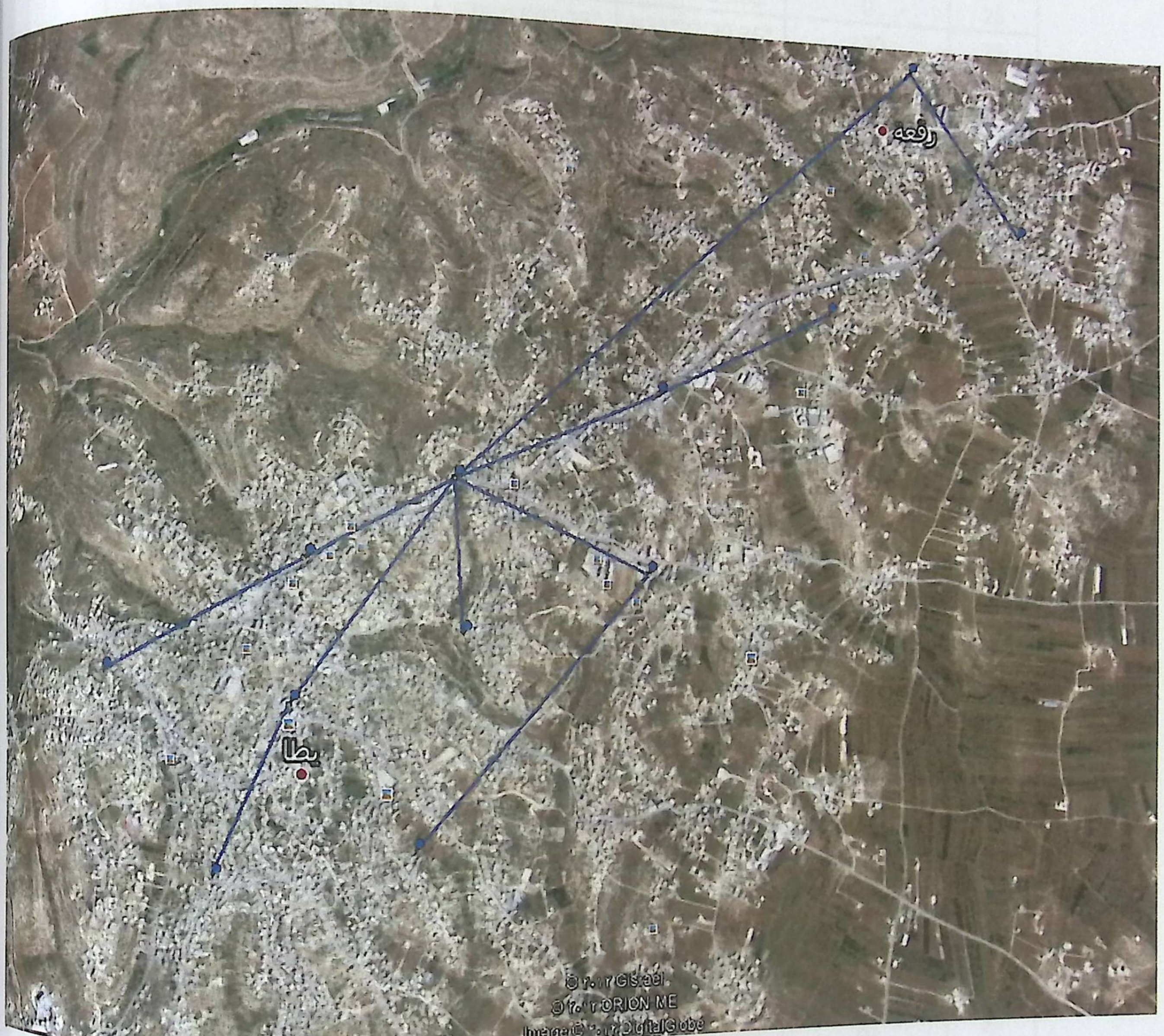


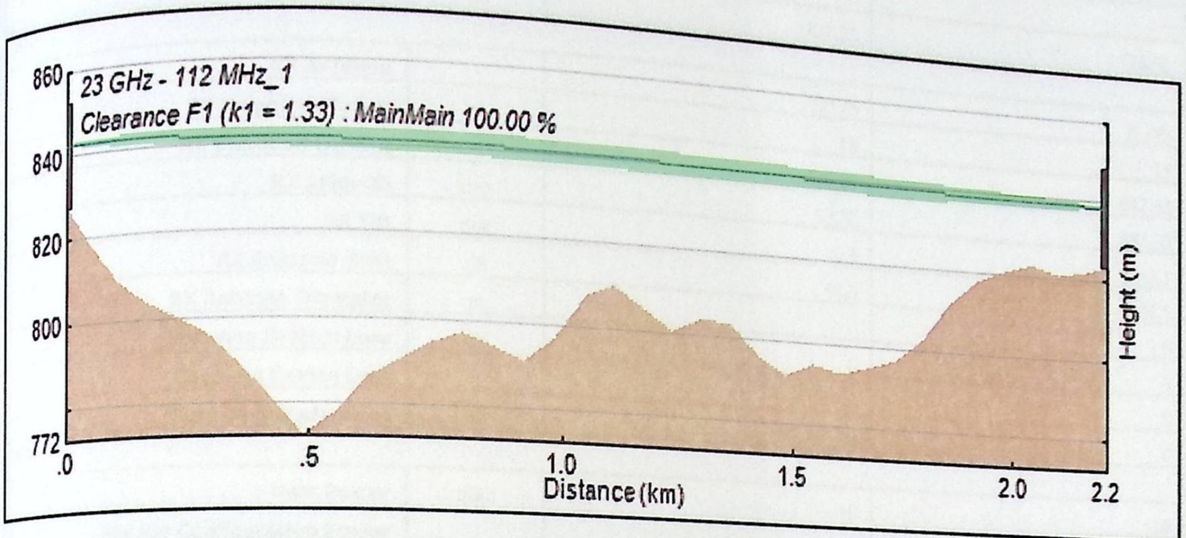
Figure 5.18.b Network Topology.

5.4.1 Coordinates of Wimax RBS

Table 5.2 Coordinates of wimax RBS.

SITE ID	Cell ID	Coordinates		Azimuth	Height
Site-0001	Site-0001A	E35°06'53.72"	N31°27'48.90"	0	25
Site-0001	Site-0001B	E35°06'53.72"	N31°27'48.90"	120	25
Site-0001	Site-0001C	E35°06'53.72"	N31°27'48.90"	240	25
Site-0002	Site-0002A	E35°07'07.23"	N31°27'29.36"	0	25
Site-0002	Site-0002B	E35°07'07.23"	N31°27'29.36"	120	25
Site-0002	Site-0002C	E35°07'07.23"	N31°27'29.36"	240	25
Site-0003	Site-0003A	E35°06'38.39"	N31°27'21.94"	40	25
Site-0003	Site-0003B	E35°06'38.39"	N31°27'21.94"	160	25
Site-0003	Site-0003C	E35°06'38.39"	N31°27'21.94"	270	25
Site-0004	Site-0004A	E35°06'10.10"	N31°26'55.70"	50	25
Site-0004	Site-0004B	E35°06'10.10"	N31°26'55.70"	160	25
Site-0004	Site-0004C	E35°06'10.10"	N31°26'55.70"	260	25
Site-0005	Site-0005A	E35°06'13.32"	N31°27'14.28"	100	25
Site-0005	Site-0005B	E35°06'13.32"	N31°27'14.28"	220	25
Site-0005	Site-0005C	E35°06'13.32"	N31°27'14.28"	340	25
Site-0006	Site-0006A	E35°05'45.45"	N31°27'07.03"	110	25
Site-0006	Site-0006B	E35°05'45.45"	N31°27'07.03"	240	25
Site-0006	Site-0006C	E35°05'45.45"	N31°27'07.03"	350	25
Site-0007	Site-0007A	E35°05'13.12"	N31°26'29.94"	0	25
Site-0007	Site-0007B	E35°05'13.12"	N31°26'29.94"	120	25
Site-0007	Site-0007C	E35°05'13.12"	N31°26'29.94"	240	25
Site-0008	Site-0008A	E35°05'00.38"	N31°26'50.71"	0	25
Site-0008	Site-0008B	E35°05'00.38"	N31°26'50.71"	120	25
Site-0008	Site-0008C	E35°05'00.38"	N31°26'50.71"	240	25
Site-0009	Site-0009A	E35°05'26.50"	N31°27'00.22"	0	25
Site-0009	Site-0009B	E35°05'26.50"	N31°27'00.22"	120	25
Site-0009	Site-0009C	E35°05'26.50"	N31°27'00.22"	240	25
Site-0010	Site-0010A	E35°05'45.09"	N31°26'51.34"	0	25
Site-0010	Site-0010B	E35°05'45.09"	N31°26'51.34"	120	25
Site-0010	Site-0010C	E35°05'45.09"	N31°26'51.34"	240	25
Site-0011	Site-0011A	E35°05'23.59"	N31°26'46.03"	20	25
Site-0011	Site-0011B	E35°05'23.59"	N31°26'46.03"	150	25
Site-0011	Site-0011C	E35°05'23.59"	N31°26'46.03"	300	25
Site-0012	Site-0012A	E35°05'37.45"	N31°26'30.49"	30	25
Site-0012	Site-0012B	E35°05'37.45"	N31°26'30.49"	120	25
Site-0012	Site-0012C	E35°05'37.45"	N31°26'30.49"	220	25

Site 6 is a main Site in network , the Table below define all parameter used to connect with site 1, and Appendix A show the parameters for each link.

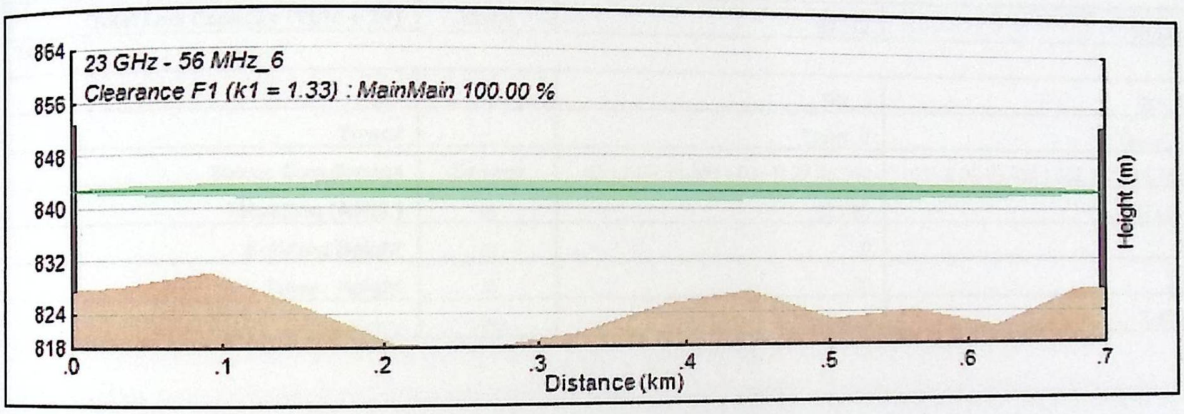


Parameter	Unit	A->B	B->A
Link			
Distance	km	2.22	2.22
Channel Bandwidth	MHz	14	14
TDM Capacity	Mbit/s	180.224 (88 E1)	180.224 (88 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	180.224	180.224
TX			
Site	-	Site_001	Site_6
Tower	-	Tower_0	Tower_5
Tower Coordinates	Degrees	035 E 06 53.720 | 031 N 27 48.900	035 E 05 45.450 | 031 N 27 07.030
Elevation (AMSL)	m	827.63	823.59
Building Height	m	0	0
Tower Height	m	25	25
Frequency	MHz	23086	22078
Polarization	-	V	V
Clearance	%	100	100
Microwave Radio Loss	dB	0	0
Coupling Device Loss	dB	0	0
Antenna System Loss	dB	0	0
TX Radio	-	E3H23_56M_182Mb	E3H23_56M_182Mb
TX Antenna	-	7217B	7217B
TX Height on Tower	m	15	15
TX Elevation (AMSL)	m	842.63	838.59
TX Azimuth	deg	233.32	53.32
TX Tilt	deg	-0.1	0.1
TX Antenna Gain	dB	40.5	40.5
TX Antenna Diameter	m	0	0

Propagation			
Free Space Loss	dB	126.58	126.19
Absorption Loss	dB	0.8	0.77
Diffraction Loss	dB	0	0
Total Loss	dB	127.38	126.96
RX			
RX Antenna	-	7217B	7217B
RX Height on Tower	m	15	15
RX Elevation (AMSL)	m	838.59	842.63
RX Azimuth	deg	53.32	233.32
RX Tilt	deg	0.1	-0.1
RX Antenna Gain	dB	40.5	40.5
RX Antenna Diameter	m	0	0
Antenna System Loss	dB	0	0
Coupling Device Loss	dB	0	0
Microwave Radio Loss	dB	0	0
Slot			
User Power	dBm	18	18
Use Per Configuration Power	-	FALSE	FALSE
Use ATPC	-	FALSE	FALSE
User Modulation	-	88E1-16QAM	88E1-16QAM
Use Adaptive Modulation	-	FALSE	FALSE
TDM Capacity	Mbit/s	4.096 (2 E1)	4.096 (2 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	154.096	154.096
Radio Data : 88E1-16QAM			
BER 10e-3			
TX Power	dBm	18	18
Transmitted Power	EIRP(dBm)	58.5	58.5
RX Level	dBm	-28.38	-27.96
Threshold	dBm	-76	-76
Thermal Margin	dB	47.62	48.04
Flat Margin	dB	47.62	48.04
Total Annual Availability	Unav. %	1.41E-05	6.97E-06
Total Worst Month Availability	Unav. %	1.69E-04	8.37E-05
Rain			
Annual	Unav. %	1.41E-05	6.97E-06
Worst Month	Unav. %	1.69E-04	8.36E-05
R(0.01)	mm/h	42	42
Multipath			
Annual Without Diversity	Unav. %	9.26E-12	7.92E-12
Annual With Diversity	Unav. %	9.26E-12	7.92E-12
Worst Month	%	7.18E-10	6.26E-10
BER 10e-6			
TX Power	dBm	18	18
Transmitted Power	EIRP(dBm)	58.5	58.5
RX Level	dBm	-28.38	-27.96

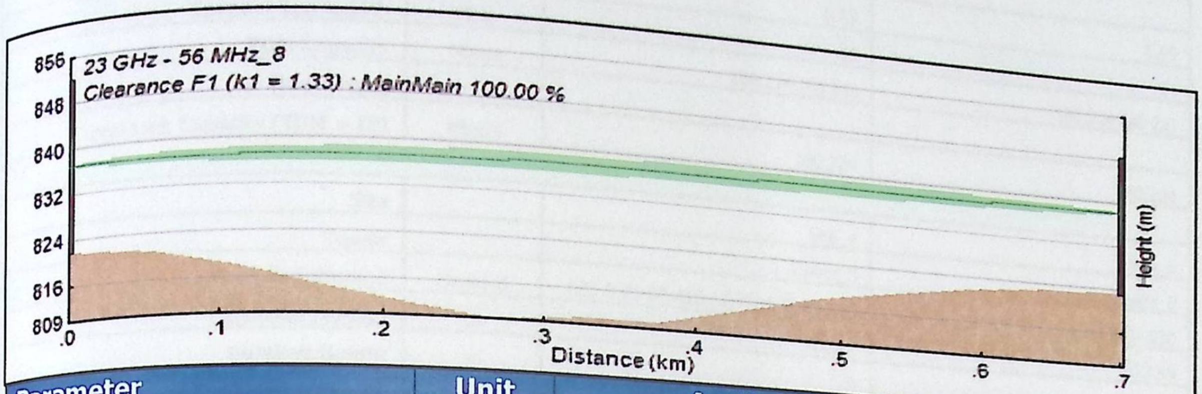
Threshold	dBm	-75.5	-75.5
Thermal Margin	dB	47.12	47.54
Flat Margin	dB	47.12	47.54
Total Annual Availability	Unav. %	1.53E-05	7.71E-06
Total Worst Month Availability	Unav. %	1.84E-04	9.25E-05
Rain			
Annual	Unav. %	1.53E-05	7.71E-06
Worst Month	Unav. %	1.84E-04	9.25E-05
R(0.01)	mm/h	42	42
Multipath			
Annual Without Diversity	Unav. %	1.11E-11	9.54E-12
Annual With Diversity	Unav. %	1.11E-11	9.54E-12
Worst Month	%	8.41E-10	7.36E-10

Site2-Site1



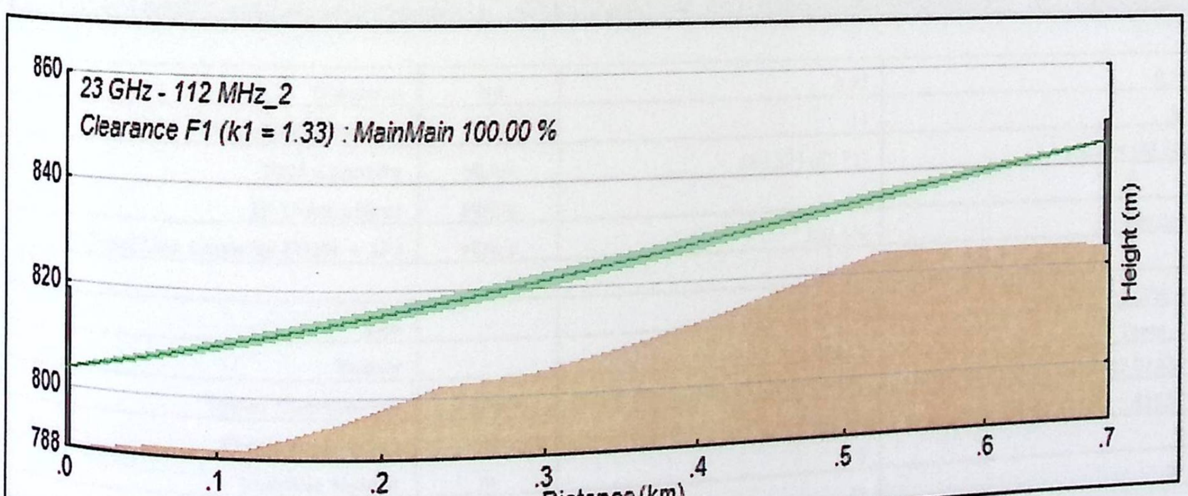
Parameter	Unit	A->B	B->A
Link			
Distance	km	0.7	0.7
Channel Bandwidth	MHz	14	14
TDM Capacity	Mbit/s	90.112 (44 E1)	90.112 (44 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	90.112	90.112
TX			
Site	-	Site_2	Site_001
Tower	-	Tower_1	Tower_0
Tower Coordinates	Degrees	035 E 07 07.230 | 031 N 27 29.360	035 E 06 53.720 | 031 N 27 48.900
Elevation (AMSL)	m	827.5	827.63
Tower Height	m	25	25
Frequency	MHz	22358	23366

Site3- Site 5



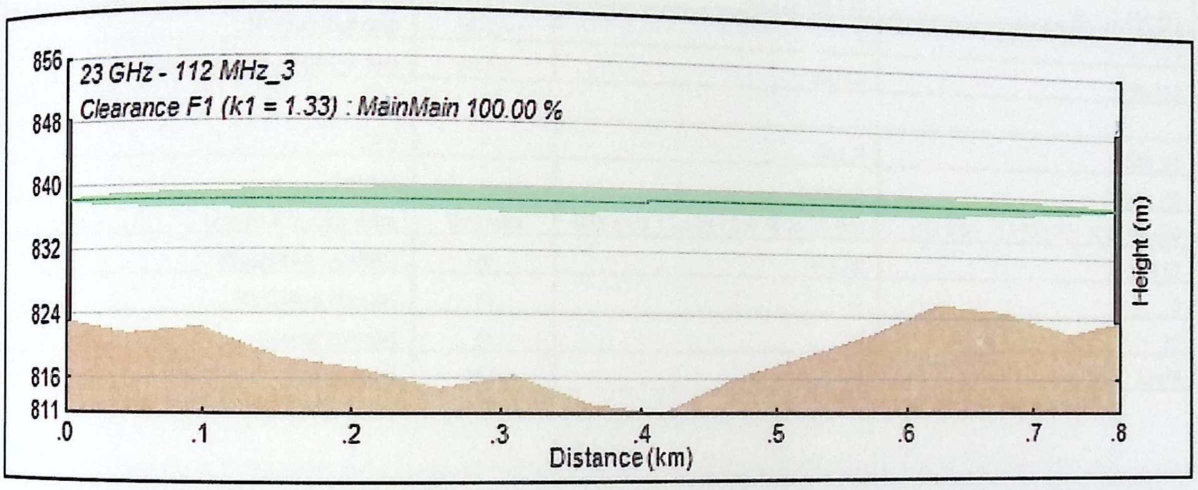
Parameter	Unit	A->B	B->A
Link			
Distance	km	0.7	0.7
Channel Bandwidth	MHz	14	14
TDM Capacity	Mbit/s	90.112 (44 E1)	90.112 (44 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	90.112	90.112
TX			
Site	-	Site_3	Site_5
Tower	-	Tower_2	Tower_4
Tower Coordinates	Degrees	035 E 06 38.390 | 031 N 27 21.940	035 E 06 13.320 | 031 N 27 14.280
Elevation (AMSL)	m	821.85	823.16
Building Height	m	0	0
Tower Height	m	30	25
Frequency	MHz	22470	23478

Site4- Site 6



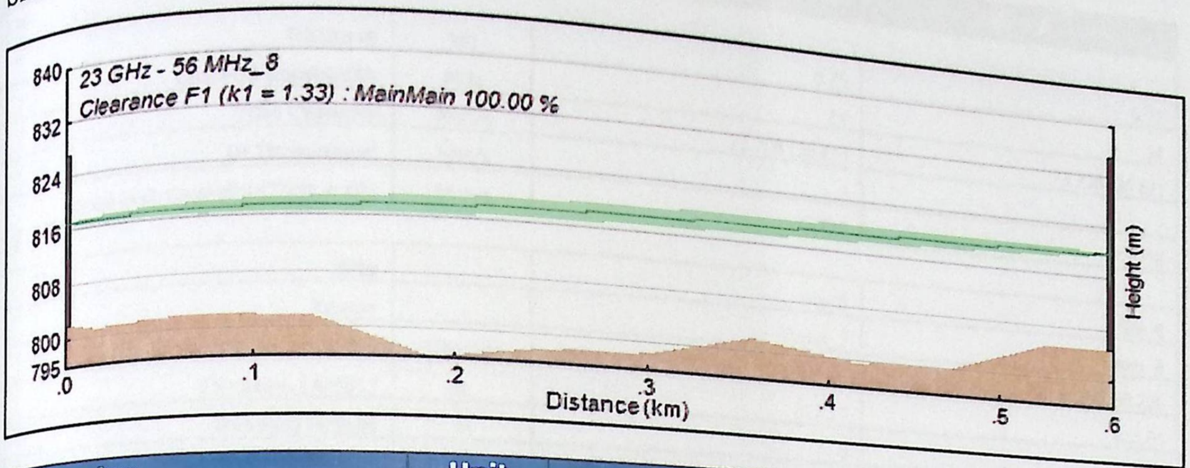
Parameter	Unit	A->B	B->A
Link			
Distance	km	0.69	0.69
Channel Bandwidth	MHz	14	14
TDM Capacity	Mbit/s	180.224 (88 E1)	180.224 (88 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	180.224	180.224
TX			
Site	-	Site_4	Site_6
Tower	-	Tower_3	Tower_5
Tower Coordinates	Degrees	035 E 06 07.410 | 031 N 26 54.980	035 E 05 45.450 | 031 N 27 07.030
Elevation (AMSL)	m	788.42	823.59
Building Height	m	0	0
Tower Height	m	30	25
Frequency	MHz	23198	22190

Site5- Site 6



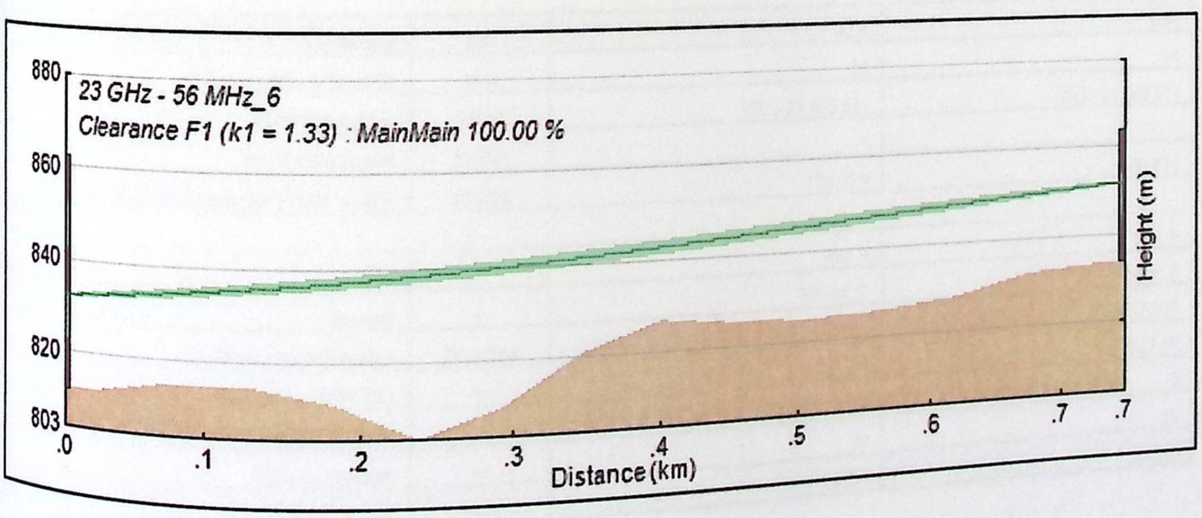
Parameter	Unit	A->B	B->A
Link			
Distance	km	0.77	0.77
Channel Bandwidth	MHz	14	14
TDM Capacity	Mbit/s	180.224 (88 E1)	180.224 (88 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	180.224	180.224
TX			
Site	-	Site_5	Site_6
Tower	-	Tower_4	Tower_5
Tower Coordinates	Degrees	035 E 06 13.320 | 031 N 27 14.280	035 E 05 45.450 | 031 N 27 07.030
Elevation (AMSL)	m	823.16	823.59
Building Height	m	0	0
Tower Height	m	25	25
Frequency	MHz	23310	22302

Site7- Site 11



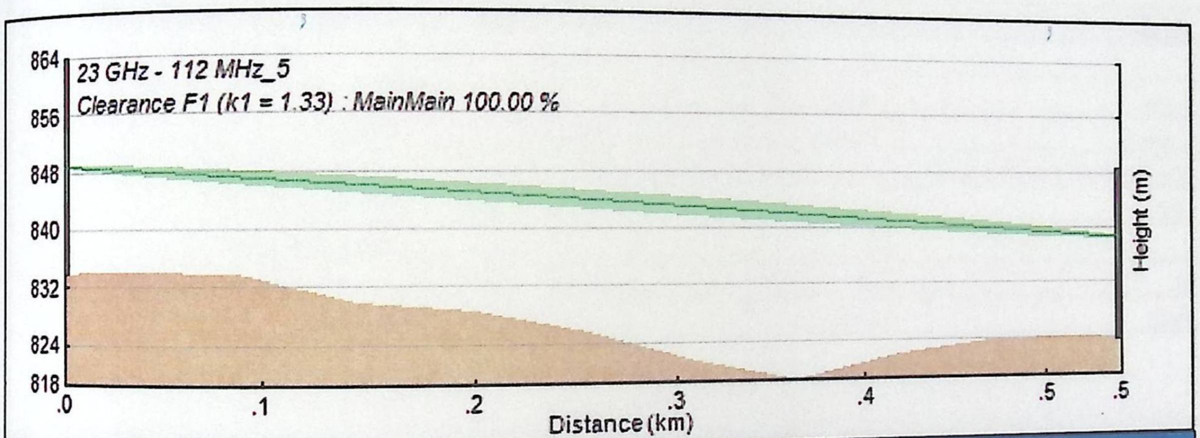
Parameter	Unit	A->B	B->A
Link			
Distance	km	0.57	0.57
Channel Bandwidth	MHz	14	14
TDM Capacity	Mbit/s	90.112 (44 E1)	90.112 (44 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	90.112	90.112
TX			
Site	-	Site_7	Site_11
Tower	-	Tower_6	Tower_10
Tower Coordinates	Degrees	035 E 05 13.120 | 031 N 26 29.940	035 E 05 23.590 | 031 N 26 46.030
Elevation (AMSL)	m	801.98	804.87
Building Height	m	0	0
Tower Height	m	25	30
Frequency	MHz	22470	23478

Site-8- Site 9



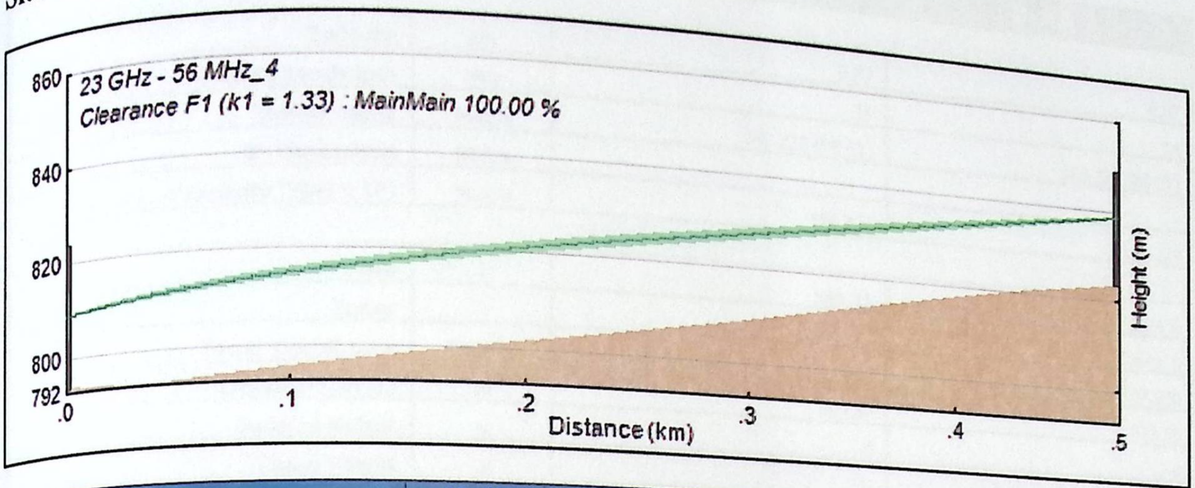
Parameter	Unit	A->B	B->A
Link			
Distance	km	0.75	0.75
Channel Bandwidth	MHz	14	14
TDM Capacity	Mbit/s	73.728 (36 E1)	73.728 (36 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	73.728	73.728
TX			
Site	-	Site_8	Site_9
Tower	-	Tower_7	Tower_8
Tower Coordinates	Degrees	035 E 05 00.380 | 031 N 26 50.710	035 E 05 26.500 | 031 N 27 00.220
Elevation (AMSL)	m	812.17	833.84
Building Height	m	0	0
Tower Height	m	50	30
Frequency	MHz	22358	23366

Site9- Site 6



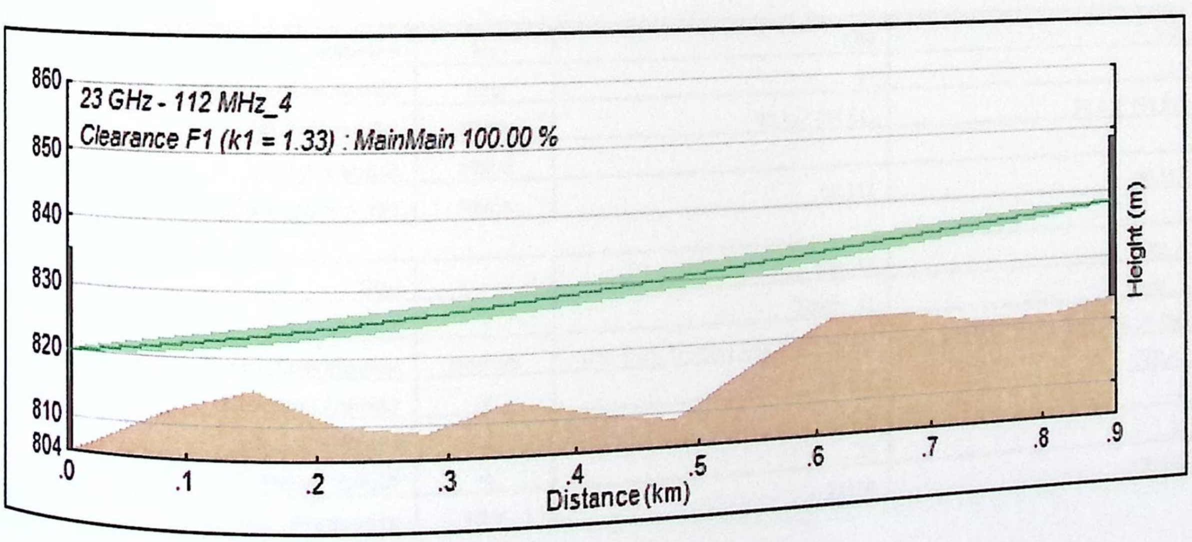
Parameter	Unit	A->B	B->A
Link			
Distance	km	0.54	0.54
Channel Bandwidth	MHz	14	14
TDM Capacity	Mbit/s	180.224 (88 E1)	180.224 (88 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	180.224	180.224
TX			
Site	-	Site_9	Site_6
Tower	-	Tower_8	Tower_5
Tower Coordinates	Degrees	035 E 05 26.500 | 031 N 27 00.220	035 E 05 45.450 | 031 N 27 07.030
Elevation (AMSL)	m	833.84	823.59
Building Height	m	0	0
Tower Height	m	30	25
Frequency	MHz	23534	22526

Site10- Site 6



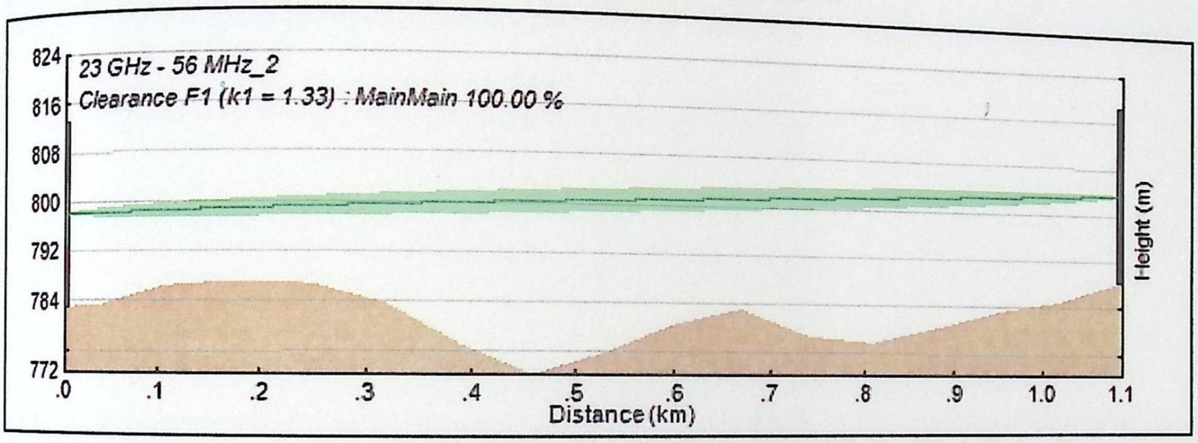
Parameter	Unit	A->B	B->A
Link			
Distance	km	0.48	0.48
Channel Bandwidth	MHz	14	14
TDM Capacity	Mbit/s	180.224 (88 E1)	180.224 (88 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	180.224	180.224
TX			
Site	-	Site_10	Site_6
Tower	-	Tower_9	Tower_5
Tower Coordinates	Degrees	035 E 05 45.090 | 031 N 26 51.340	035 E 05 45.450 | 031 N 27 07.030
Elevation (AMSL)	m	793.72	823.59
Building Height	m	0	0
Tower Height	m	30	25
Frequency	MHz	23254	22246

Site 11- Site 6



Parameter	Unit	A->B	B->A
Link			
Distance	km	0.87	0.87
Channel Bandwidth	MHz	14	14
TDM Capacity	Mbit/s	180.224 (88 E1)	180.224 (88 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	180.224	180.224
TX			
Site	-	Site_11	Site_6
Tower	-	Tower_10	Tower_5
Tower Coordinates	Degrees	035 E 05 23.590 | 031 N 26 46.030	035 E 05 45.450 | 031 N 27 07.030
Elevation (AMSL)	m	804.87	823.59
Building Height	m	0	0
Tower Height	m	30	25
Frequency	MHz	23422	22414

Site 12- Site 4



Parameter	Unit	A->B	B->A
Link			
Distance	km	1.09	1.09
Channel Bandwidth	MHz	14	14
TDM Capacity	Mbit/s	90.112 (44 E1)	90.112 (44 E1)
IP Throughput	Mbit/s	-	-
Total Link Capacity (TDM + IP)	Mbit/s	90.112	90.112
TX			
Site	-	Site_12	Site_4
Tower	-	Tower_11	Tower_3
Tower Coordinates	Degrees	035 E 05 37.450 | 031 N 26 30.490	035 E 06 07.410 | 031 N 26 54.980
Elevation (AMSL)	m	783.01	788.42
Building Height	m	0	0
Tower Height	m	30	30
Frequency	MHz	22134	23142

5.5 Optimization and monitoring

In order to achieve the target performance of the network, we conducted a network optimization Process. In network optimization, there are two different types – RF optimization and System optimization. RF optimization is the overall process of improving the RF parameters (such as CINR and RSSI). Specifically, the process includes the adjustment of antenna such as gain, tilt(mechanical and electrical) and direction; relocation of equipments; and implementation of additional antennas. System optimization is the process of upgrading the software package in the system. It adjusts the system parameters such as output, timer, and so on. The optimization process fits the designed radio network to the actual coverage demands and traffic, after the insulation done the first step is to verify the coverage and analyze whether it good enough. Next traffic over a certain area is studies and if the BS coverage area is overloaded (BS congested) it has to be analyzed whether , the traffic has to be balance between the BS, or more frequency has to be assign, or more BS have to be implemented. the optimization phase is an adjustment process based on real life changes that were not taken into account in original radio system planning, which was based on the coverage threshold and traffic .

Chapter sex

Conclusion

6.1 Conclusion

6.2 Future work

Chapter Sex

6.1 Conclusion

- WIMAX Planning aspects and PTP links design and, tools were covered in this report, The planning tools were built to develop network planning, for all wireless network, and network designs, Coverage, capacity, and techno-economical issues were, considered as they are crucial in planning. The planning tool support several types of analysis, including, population density, LoS, power, interference, etc.

- The resulting analysis allows us to see how the several, parameters could influence the network planning.

- We see that the number of sites of WIMAX network is larger than than the number of sites of GSM network , the number of WIMAX sites is 12 , but for example Wataniya mobile use 4 sites in YATTA city , because the frequency of WIMAX is higher than the frequency of GSM, this prove that the high frequency is small cover distance and less frequency cover large distance .

- From image of WIMAX coverage and other image of best server, we see that we can't cover the city 100%, this depend Nature of the area geographically , if this city is flat we can cover it 100%, we can see from coverage image expected coverage is nearly 80%, to cover it 100% we use other type of cells after deployment and testing.

- In planning network we can't separated between capacity and coverage , so in capacity calculation we have share capacity , because I must follow the number of sites in coverage.

- We compare in WIMAX analysis between result with effect and without effect of interference and we see the difference , for example we can see the difference between the DL data rate without interference and with interference (yellow color is more clear by DL data rate without interference than DL with interference, this cause by interference).

- We choose a star topology to this network its more suitable form of network than other topology , we choose the site6 is the center because it's in the middle of the city , and we show the microwave links and how connect between sites, and parameters of each link.
- Data that have been adopted in the chapter four affect on the results.
- We see that all wimax analysis depend in wimax Coverage so the first and the important step in planning wireless network is coverage and the distribution of sites.

6.2 Future work

In our project we focus on planning tool that use as a first step necessary before deployment a network, that give the most information about area and how distribute the sites and show the coverage and how to connect sites to each other and other thing, but we can't end the planning to the last step, we can do it as a future work, last step it means to design IP of the wireless WIMAX network, and show how to buy these IP , and how distributed between users, and study more detailed about WIMAX equipment , and study the billing and charging , and the programs software that use in any wireless company, to control the number of user and how user access the network.

APPENDIX A

All of the Results attached with a CD.

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