CHAPTER ONE

Introduction

1.1 Background

Dimensioning a new network determines the minimum capacity requirements that will still allow the Teletraffic Grade of Service (GoS) requirements to be met[1].To do this, dimensioning involves planning for peak-hour traffic, i.e. that hour during the day during which traffic intensity is at its peak [1] [2].The dimensioning process involves determining the network's topology, routing plan, traffic matrix, and GoS requirements, and using this information to determine the maximum call handling capacity of the switches, and the maximum number of channels required between the switches [1].This process requires a complex model that simulates the behavior of the network equipment and routing protocols. A dimensioning rule is that the planner must ensure that the traffic load should never approach a load of 100 [1].To calculate the correct dimensioning to comply with the above rule, the planner must take on-going measurements of the network's traffic, and continuously maintain and upgrade resources to meet the changing requirements [1] [2] Another reason for over provisioning is to make sure that traffic can be rerouted in case a failure occurs in the network. Because of the complexity of network dimensioning, this is typically done using specialized software tools. Whereas researchers typically develop custom software to study a particular problem, network operators typically make use of commercial network planning software.

1.2 Problem Definition:

In network design and planning the most important is the combination of low cost and flexibility. By installing few wireless base stations providing coverage to the surrounding area with multifunctional application: high-speed Internet, telephone service, voice and data transfer, and video applications.

The need to enables high-speed voice and data transfer over long distances in remote and scarcely populated areas, as well as in densely populated areas. The wireless connectivity is not affected by the weather conditions and does not need direct line in order to work; it allows real access to end users through its own infrastructure.

1.3 Objectives:

1.3.1 General Objectives :

To program and simulate the WIMAX and Microwave profiling for a different geographical areas and calculate the cost effectiveness of the two solutions by calculating the Tower and equipment costs.

1.3.2 Specific Objectives :

Study the Microwave and WIMAX technology and the requirements used to construct a network, Analysis of the cost effectiveness e network such as Towers and other equipment, Program a calculation procedures into simulation software such as MATLAB to evaluate the cost of the two networks in different areas based on a random area generator code.

1.4 Methodology:

In this project a descriptive analysis of WIMAX and Microwave is done to develop planning tool capable of calculating the cost of the network, different areas were applied to evaluate the system and the simulation is based on MATLAB moreover the study will cover the network planning methodology and the layers of planning as shown in the following paragraph:

Planning methodology involves five layers of planning, namely: business planning, long-term and medium-term network planning, short-term network planning , IT asset sourcing and Operations and maintenance [1].

Each of these layers incorporates plans for different time horizons, i.e. the business planning layer determines the planning that the operator must perform to ensure that the network will perform as required for its intended life-span. The Operations and Maintenance layer, however, examines how the network will run on a day-to-day basis.

The network planning process begins with the acquisition of external information. This includes: forecasts of how the new network/service will operate; the economic information concerning costs; and technical details of the network's capabilities [1] [2]

Planning a new network/service involves implementing the new system across the first four layers of the OSI Reference Model [1]. Choices must be made for the protocols and transmission technologies [1] [2]

Network planning process involves three main steps:

Topological design: This stage involves determining where to place the components and how to connect them. The (topological) optimization methods that can be used in this stage come from an area of mathematics called Graph Theory. These methods involve determining the costs of transmission and the cost of switching, and thereby determining the optimum connection matrix and location of switches and concentrators [1]. Network-synthesis: This stage involves determining the size of the components used, subject to performance criteria such as the Grade of Service (GOS). The method used is known as "Nonlinear Optimization", and involves determining the topology, required GoS, cost of transmission, etc., and using this information to calculate a routing plan, and the size of the components [1] . Network realization: This stage involves determining how to meet capacity requirements, and ensure reliability within the network. The method used is known as "Multi commodity Flow Optimization", and involves determining all information relating to demand, costs and reliability, and then using this information to calculate an actual physical circuit plan[1] .These steps are performed iteratively in parallel with one another the role of forecasting [1] [2]

There are a lot of thesis that have discussed the wireless communication system generally or transmission methods in the wireless communication system. But all this thesis used some cases like increase the bandwidth or decrease the costs or transfer rate, and so on. But our research we'll look at all wireless communication system Medias studying them and describing their .Functions and compare according to specific conditions.

1.6 Thesis Layout:

Chapter One: introduction and background

Chapter Two: Wireless communication Systems

Chapter Three: Back Haul Techniques and Evaluation

Chapter Four: Results and Discussion

Chapter Five: Conclusion and Recommendation

CHAPTER TWO

Wireless Communication Systems

2.1Overview:

The last few years have witnessed a phenomenal growth in the wireless industry, both in terms of mobile technology and its subscribers. There has been a clear shift from fixed to mobile cellular telephony, especially since the turn of the century. By the end of 2010, there were over four times more mobile cellular subscriptions than fixed telephone lines. Both the mobile network operators and vendors have felt the importance of efficient networks with equally efficient design. This resulted in Network Planning and optimization related services coming in to sharp focus .With all the technological advances, and the simultaneous existence of the 2G, 2.5G and 3G networks, the impact of services on network efficiency have become even more critical. Many more designing scenarios have developed with not only2G networks but also with the evolution of 2G to 2.5G or even to 3G networks. Along with this, inter-operability of the networks has to be considered (Harvey (2006)). 1G refers to analog cellular technologies; it became available in the 1980s. 2G denotes initial digital systems, introducing services such as short messaging and lower speed data. CDMA2000 1xRTT and GSM are the primary 2G technologies, although CDMA2000 1xRTT is sometimes called a 3G technology because it meets the 144 kbps mobile throughput requirement. EDGE, however, also meets this requirement. 2G technologies became available in the 1990s. 3G requirements were specified by the ITU as part of the International Mobile Telephone 2000 (IMT-2000) project, for which digital networks had to provide 144 kbps of throughput at mobile speeds, 384kbps at pedestrian speeds, and 2 Mbps in indoor environments. UMTS-HSPA and CDMA2000 EV-DO are the primary 3G technologies, although recently WIMAX was also designated as an official 3G technology. 3G technologies began to be deployed last decade. The ITU has recently issued requirements for IMT-Advanced, which constitutes the official definition of 4G. Requirements include operation in up-to-40 MHz radio channels and extremely high spectral efficiency. The ITU recommends operation in up to-100 MHz radio channels and peak spectral efficiency of 15 bps/Hz, resulting in a theoretical throughput rate of 1.5Gbps. Previous to the publication of the requirements, 1Gbps was frequently cited as a 4G goal [2] No available technology meets these requirements yet. It will require new technologies such as LTE-Advanced (with work already underway) and IEEE802.16m. Some have tried to label current versions of WIMAX and LTE as “4G”, but this is only accurate to the extent that such designation refers to the general approach or platform that will be enhanced to meet the 4G requirements. With WIMAX and HSPA significantly outperforming 3G requirements, calling these technologies 3G clearly does not give them full credit, as they are a generation beyond current technologies in capability. But calling them 4G is not correct. Unfortunately, the generational labels do not properly capture the scope of available technologies and have resulted in some amount of market confusion (Harvey (2006)).

2.2 Evolution Of Mobile Cellular Networks:

Mobile Cellular Network evolution has been categorized in to ‘generations’ as shown in Fig. (2.1)

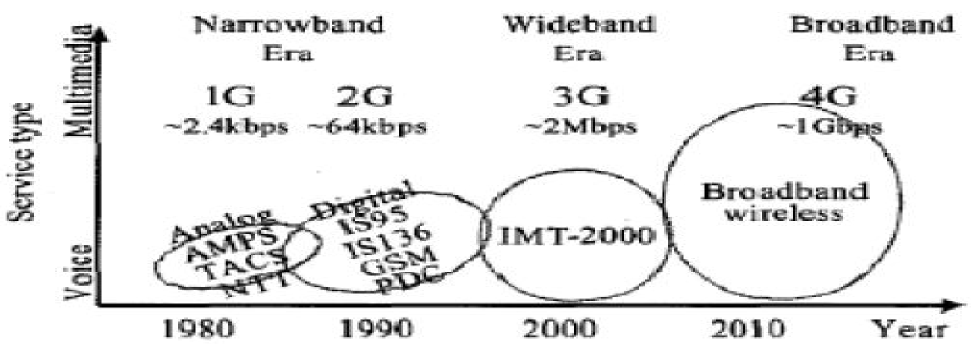


Figure (2.1)Evolution of Mobile Cellular Networks.

2.2.1 The First Generation System (Analog):

In 1980 the mobile cellular era had started, and since then mobile communications have undergone significant changes and experienced enormous growth. Fig. 2.1 shows the evolution of the mobile networks. First-generation mobile systems used analog transmission for speech services. In 1979, the first cellular system in the world became operational by Nippon Telephone and Telegraph (NTT) in Tokyo, Japan. Two years later, the cellular epoch reached Europe. The two most popular analogue systems were Nordic Mobile Telephones (NMT) and Total Access Communication Systems (TACS). Other than NMT and TACS, some other analog systems were also introduced in 1980s across the Europe. All of these systems offered handover and roaming capabilities but the cellular networks were unable to interoperate between countries. This was one of the inevitable disadvantages of first-generation mobile networks. In the United States, the Advanced Mobile Phone System (AMPS) was launched in 1982. The system was allocated a 40-MHz bandwidth within the 800 to 900 MHz frequency range by the Federal Communications Commission (FCC) for AMPS. In 1988, an additional 10 MHz bandwidth, called Expanded Spectrum (ES) was allocated to AMPS. It was first deployed in Chicago, with a service area of 2100 square miles2. AMPS offered 832 channels, with a data rate of 10 kbps. Although Omni directional antennas were used in the earlier AMPS implementation, it was realized that using directional antennas would yield better cell reuse. In fact, the smallest reuse factor that would fulfill the 18db signal-to-interference ratio (SIR) using 120-degree directional antennas was found to be 7. Hence, a 7-cell reuse pattern was adopted for AMPS. Transmissions from the base stations to mobiles occur over the forward channel using frequencies between 869-894MHz. The reverse channel is used for transmissions from mobiles to base station, using frequencies between 824-849MHz. AMPS and TACS use the frequency modulation (FM) technique for radio transmission. Traffic is multiplexed onto an FDMA (frequency division multiple access) system [3]

2.2.2 The Second Generation & Phase 2+ Systems (Digital):

Second-generation (2G) mobile systems were introduced in the end of 1980s. Low bit rate data services were supported as well as the traditional speech service. Compared to first-generation systems, second-generation (2G) systems use digital multiple access technology, such as TDMA (time division multiple access) and CDMA (code division multiple access). Consequently, compared with first-generation systems, higher spectrum efficiency, better data services, and more advanced roaming were offered by 2G systems. In Europe, the Global System for Mobile Communications (GSM) was deployed to provide a single unified standard. This enabled seamless services throughout Europe by means of international roaming. Global System for Mobile Communications, or GSM, uses TDMA technology to support multiple users During development over more than 20 years, GSM technology has been continuously improved to offer better services in the market. New technologies have been developed based on the original GSM system, leading to some more advanced systems known as 2.5 Generation (2.5G) systems. In the United States, there were three lines of development in second-generation digital cellular systems. The first digital system, introduced in 1991, was the IS-54 (North America TDMA Digital Cellular), of which a new version supporting additional services (IS-136) was introduced in 1996. Meanwhile, IS-95 (CDMA One) was deployed in 1993. The US Federal Communications Commission (FCC) also auctioned a new block of spectrum in the 1900 MHz band (PCS), allowingGSM1900 to enter the US market. In Japan, the Personal Digital Cellular (PDC) system, originally known as JDC (Japanese Digital

Cellular) was initially defined in 1990. Since the first networks appeared at the beginning of the 1991, GSM gradually evolved to meet the requirements of data traffic and many more services than the original networks [3]

2.2.3GSM (Global System For Mobile Communication):

The main element of this system are the BSS (Base Station Subsystem), in which there are BTS (Base Transceiver Station) and BSC (Base Station Controllers); and the NSS (Network Switching Subsystem),in which there is the MSC (Mobile Switching Centre); VLR (Visitor Location Register); HLR (Home Location Register); AC (Authentication Centre) and EIR (Equipment Identity Register). This network is capable of providing all the basic services up to 9.6kbps, fax, etc. This GSM network also has an extension to the fixed telephony network. A new design was introduced into the mobile switching center of second-generation systems. In particular, the use of base station controllers (BSCs) lightens the load placed on the MSC (mobile switching center) found in first generation systems. This design allows the interface between the MSC and BSC to be standardized. Hence, considerable attention was devoted to interoperability and standardization in second-generation systems so that carrier could employ different manufacturers for the MSC and BSCs. In addition to enhancements in MSC design, the mobile-assisted handoff mechanism was introduced. By sensing signals received from adjacent base stations, a mobile unit can trigger a handoff by performing explicit signaling with the network [3]

2.2.4 GSM and VAS (Value Added Services):

The next advancement in the GSM system was the addition of two platforms, called Voice Mail Service (VMS) and the Short Message Service Centre (SMSC). The SMSC proved to be incredibly commercially successful, so much so that in some networks the SMS traffic constitutes a major part of the total traffic. Along with VAS, IN (Intelligent services) also made its mark in the GSM system, with its advantage of giving the operators the chance to create a whole range of new services. Fraud management and ‘prepaid’ services are the result of the IN service. GSM and GPRS (General Packet Radio Services): As requirement for sending data on the air-interface increased, new elements such as SGSN (Servicing GPRS) and GGSN (Gateway GPRS) were added to the existing GSM system. These elements made it possible to send packet data on the air-interface. This partof the network handling the packet data is also called the ‘packet core network’. In addition to the SGSN and GGSN, it also contains the IP routers, firewall servers and DNS (Domain Name Servers). This enables wireless access to the internet and bit rate reaching to 150 kbps in optimum conditions. The move into the 2.5G world began with General Packet Radio Service (GPRS). GPRS is a radio technology for GSM networks that adds packet-switching protocols, shorter setup time for ISP connections, and the possibility to charge by the amount of data sent, rather than connection time. Packet switching is a technique whereby the information (voice or data) to be sent is broken up into packets, of at most a few Kbytes each, which are then routed by the network between different destinations based on addressing data within each packet. Use of network resources is optimized as the resources are needed only during the handling of each packet. GPRS supports flexible data transmission rates as well as continuous connection to the network. GPRS is the most significant step towards 3G [3]

2.2.5 GSM and EDGE (Enhanced Data Rates in GSM Environment):

With both voice and data traffic moving on the system, the need was felt to increase the data rate. This was done by using more sophisticated coding methods over the internet and thus increasing the data rate up to

384 kbps. Implementing EDGE was relatively painless and required relatively small changes to network hardware and software as it uses the same TDMA (Time Division Multiple Access) frame structure, logic channel and 200 kHz carrier bandwidth as today's GSM networks. As EDGE progresses to coexistence with 3G WCDMA, data rates of up to ATM-like speeds of 2 Mbps could be available. Nowadays, second-generation digital cellular systems still dominate the mobile industry throughout the whole world. However, third generation (3G) systems have been introduced in the market, but their penetration is quite limited because of several techno-economic reasons [3]

2.2.6 The Third Generation (WCDMA in UMTS, CDMA2000 & TD-SCDMA):

In EDGE, high-volume movement of data was possible, but still the packet transfer on the air-interface behaves like a circuit switch call. Thus part of this packet connection efficiency is lost in the circuit switch environment. Moreover, the standards for developing the networks were different for different parts of the world. Hence, it was decided to have a network which provides services independent of the technology platform and whose network design standards are same globally. Thus, 3G was born . The International Telecommunication Union (ITU) defined the demands for 3G mobile networks with the IMT-2000 standard. An organization called 3rd Generation Partnership Project (3GPP) has continued that work by defining a mobile system that fulfills the IMT-2000 standard. In Europe it was called UMTS (Universal Terrestrial Mobile System), which is ETSI-driven. IMT2000 is the ITU-T name for the third generation system, while cdma2000 is the name of the American 3G variant. WCDMA is the air-interface technology for the UMTS. The main components includes BS (Base Station) or nod B, RNC (Radio Network Controller), apart from WMSC (Wideband CDMA Mobile

Switching Centre) and SGSN/GGSN. 3G networks enable network operators to offer users a wider range of more advanced services while achieving greater network capacity through improved spectral efficiency. Services include wide-area wireless voice telephony, video calls, and broadband wireless data, all in a mobile environment. Additional features also include HSPA (High Speed Packet Access) data transmission capabilities able to deliver speeds up to 14.4 Mbps on the downlink and 5.8 Mbps on the uplink. The first commercial 3G network was launched by NTT DoCoMo in Japan branded FOMA, based on W-CDMA technology on October 1, 2001 . The second network to go commercially live was by SK Telecom in South Korea on the 1xEV-DO (Evolution-Data Optimized) technology in January 2002 followed by another South Korean 3G network was by KTF on EV-DO in May 2002. In Europe, the mass market commercial 3G services were introduced starting in March 2003 by 3 (Part of Hutchison Whampoa) in the UK and Italy. This was based on the W-CDMA technology. The first commercial United States 3G network was by Monet Mobile Networks, on CDMA2000 1x EV-DO technology and the second 3G network operator in the USA was Verizon Wireless in October 2003 also on CDMA2000 1x EVDO. The first commercial 3G network in southern hemisphere was launched by Hutchison Telecommunications branded as three using UMTS in April 2003. The first commercial launch of 3G in Africa was by EMTEL in Mauritius on the W-CDMA standard. In North Africa (Morocco), a 3G service was provided by the new company WIMAX in late March 2006. Roll-out of 3G networks was delayed in some countries by the enormous costs of additional spectrum licensing fees. In many countries, 3G networks do not use the same radio frequencies as 2G, so mobile operators must build entirely new networks and license entirely new frequencies; an exception is the United States where carriers operate 3G service in the same frequencies as other services. The license fees in some European countries were particularly high, bolstered by government auctions of a limited number of licenses and sealed bid auctions, and initial excitement over 3G's potential. Other delays were due to the expenses of upgrading equipment for the new systems. Still several major countries such as Indonesia have not awarded 3G licenses and customers await 3G services. China delay edits decisions on 3G for many years. In January 2009, China launched 3G but interestingly three major companies in China got license to operate the 3G network on different standards, China Mobile for TD-SCDMA [3]

2.2.7 Fourth Generation (All-IP):

The emergence of new technologies in the mobile communication systems and also the ever increasing growth of user demand have triggered researchers and industries to come up with a comprehensive manifestation of the up-coming fourth generation (4G) mobile communication system [9]. In contrast to 3G, the new 4G framework to be established will try to accomplish new levels of user experience and multi-service capacity by also integrating all the mobile technologies that exist (e.g. GSM - Global System for Mobile Communications, GPRS - General Packet Radio Service, IMT-2000 – International Mobile Communications, Wi-Fi - Wireless Fidelity, Bluetooth)(see Fig. 2) The fundamental reason for the transition to the All-IP is to havea common platform for all the technologies that have been developed so far, and to harmonize with user expectations of the many services to be provided. The fundamental difference between the GSM/3G and All-IP is that the functionality of the RNC and BSC is now distributed to the BTS and a set observers and gateways. This means that this network will be less expensive and data transfer will be much faster . 4G will make sure - “The user has freedom and flexibility to select any desired service with reasonable QoS and affordable price, anytime, anywhere.” 4G mobile communication services started in 2010 [4]

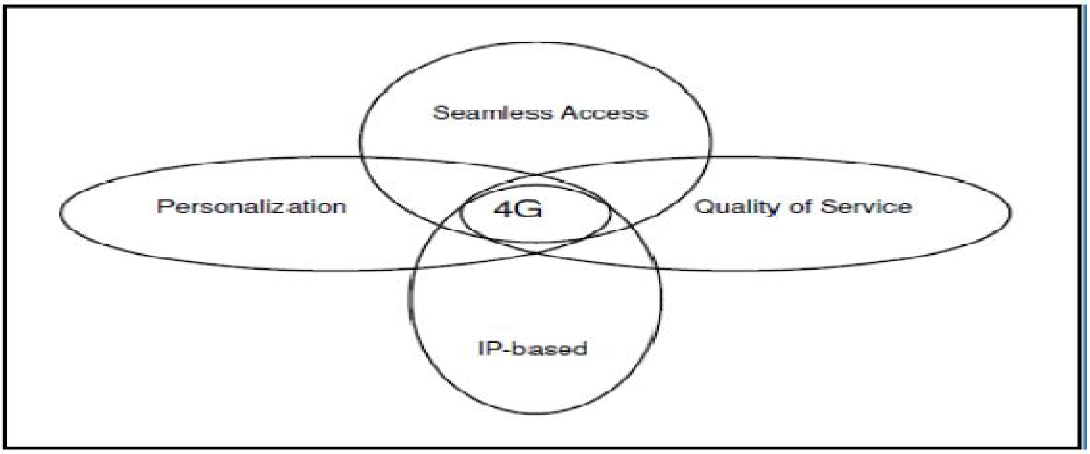


Figure.(2.2):The next Generation Mobile Communication Systems Features

IMT-Advanced 4G standards will usher in a new era of mobile broadband communications, according to the ITU-R. IMT Advanced provides a global platform on which to build next generations of interactive mobile services that will provide faster data access, enhanced roaming capabilities, unified messaging and broadband multimedia. According to ITU, “ICTs and broadband networks have become vital national infrastructure — similar to transport, energy and water networks— but with an impact that promises to be even more powerful and far-reaching. These key enhancements in wireless broadband can drive social and economic development, and accelerate progress towards achieving the United Nations’ Millennium Development Goals, or MDGs [5] . The current agreements on the requirements for IMT-Advanced are: Peak data rate of 1 Gbps for downlink (DL) and 500 Mbps for uplink (UL),Regarding latency, in the Control plane the transition time from Idle to Connected should be lower than 100ms. In the active state, a dormant user should take less than 10ms to get synchronized and the scheduler should reduce the User plane latency at maximum [4] Downlink peak spectral efficiency up to 15 bps/Hz and uplink peak spectral efficiency of 6.75 bps/Hz with an antenna configuration of 4 × 4 or less in DL and 2 ×

4 or less in UL, The average user spectral efficiency in DL (with inter-site distance of 500m and pedestrian users) must be 2.2 bps/ Hz/cell with MIMO 4× 2, whereas in UL the target average spectral efficiency is 1.4 bps/Hz/cell with MIMO 2 × 4,In the same scenario with 10 users, cell edge user spectral efficiency will be 0.06 in DL 4 × 2. In the UL, this cell edge user spectral efficiency must be 0.03 with MIMO 2 × 4, Mobility up to 350 km/h in IMT-Advanced,IMT-Advanced system will support scalable bandwidth and spectrum aggregation with transmission bandwidths more than 40MHz in DL and UL. Backward compatibility and inter-working with legacy systems. After completion of its Release-8 specifications, Third Generation Partnership Project (3GPP) has already planned for a work item called LTE-Advanced to meet the IMT-Advanced requirements for 4G. Also, WIMAX Forum and IEEE are also evolving WIMAX through IEEE 802.16m or WIMAX-m to satisfy 4G requirements. Table (2.1) summarizes the generations of wireless technology [4]

Table (2.1): compare between mobile generations

Generation	Requirements	Comments
1G	No official requirements. Analog technology.	Deployed in the 1980s.
2G	No official requirements. Digital Technology.	First digital systems. Deployed in the 1990s. New services such as SMS and low-rate data. Primary technologies include IS-95 CDMA and GSM.
3G	ITU's IMT-2000 required 144 kbps mobile, 384 kbps pedestrian, 2 Mbps indoors	Primary technologies include CDMA2000 1X/ EVDO and UMTS-HSPA. WIMAX now an official 3G technology.
4G	ITU's IMT-Advanced requirements include ability to operate in up to 40 MHz radio channels and with very high spectral efficiency.	No technology meets requirements today. IEEE 802.16m and LTE-Advanced being designed to meet requirements.

CHAPTER THREE

Back Haul Techniques and Evaluation

3.1 Backhaul Technologies:

FSO Free space optics ,Point-to-point microwave radio relay transmission (terrestrial or, in some cases, by satellite),Point-to-multipoint microwave-access technologies, such as LMDS, WIFI, WIMAX, etc., can also function for backhauling purposes, DSL variants, such as ADSL and SHDSL,PDH and SDH/SONET interfaces, such as (fractional) E1/T1, E3, T3, STM-1/OC-3, etc. and Ethernet Backhaul capacity can also be leased from another network operator, in which case that other network operator generally selects the technology [3]

3.2 MICRO WAVE:

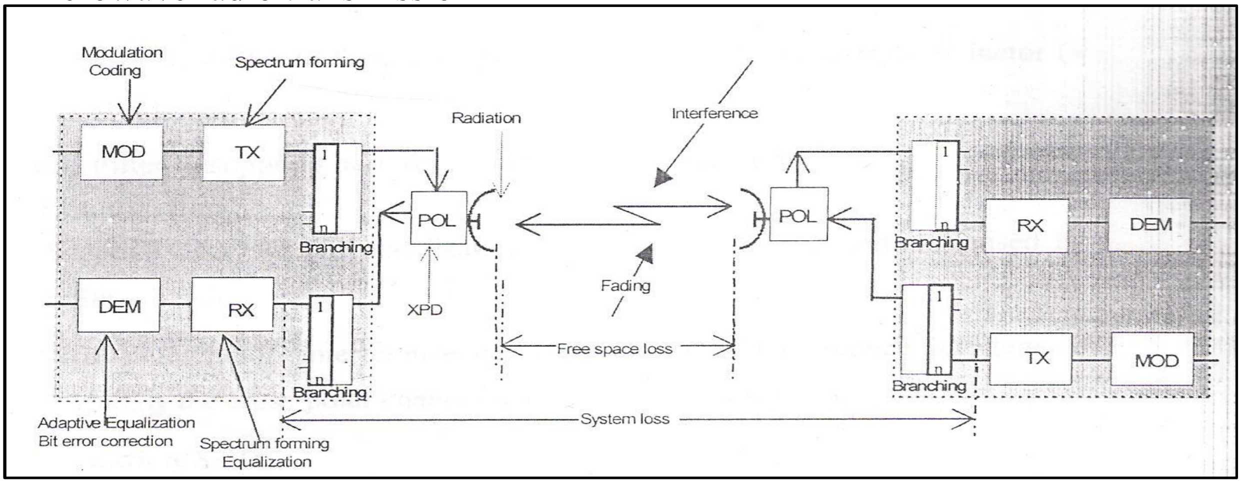
The existence of electromagnetic waves, of spectrum, was predicted by James Clerk Maxwell in 1864 from his equations. In 1888, Heinrich Hertz was the first to demonstrate the existence of electromagnetic waves by building an apparatus that produced and detected microwaves in the UHF region [3].The microwave range includes ultra-high frequency(UHF) (0.3—3 GHz), super high frequency (SHF) (3—30 GHz), and extremely high frequency (EHF) (30—300 GHz) signals [4]. Above 300 GHz, the absorption of electromagnetic radiation by Earth’s atmosphere is so great that it is effectively opaque, until the atmosphere becomes transparent again in the so-called infrared and optical window frequency ranges [4]

Microwave radio is used in broadcasting and telecommunication transmissions because, due to their short wavelength, highly directive antennas are smaller and therefore more practical than they would be at longer wavelengths (lower frequencies). There is also more bandwidth in the microwave spectrum than in the rest of the radio spectrum; the usable bandwidth below 300 MHz is less than 300 MHz while many GHz can be used above 300 MHz Typically, microwaves are used in television news to Transmit a signal from a remote location to a television station from a specially equipped van [3].

The microwave spectrum is usually defined as electromagnetic energy ranging from approximately I GHz to 1000 GHz in frequency, but older usage includes lower frequencies. Most common applications are within the 1 to 40 GHz range [3]. Before the advent of fiber optic transmission, most long distance telephone calls were carried via microwave point-to-point links through sites like the AT&T Long Lines. Starting in the early 1950's, frequency division multiplex was used to send up to 5,400 telephone channels on each microwave radio channel, with as many as ten radio channels combined into one antenna for the hop to the next site, up to 70 km away. Most of US know that clear line of sight is required between two antennas, but there is a lot more to it than that. In this chapter, the basics of designing and planning a microwave radio link will be discussed [3].

3.1.1 Main Characteristics Of Microwave Radio Transmission:

(Figure 3-1) shows the components of a microwave radio system, general transmission characteristics and propagation effects on microwave radio transmission



3.1.1.1 Modulation/Coding /FEC:

Coding for spectrum forming and synchronization, DPSK- and QAM (TCM)-Modulation are used in general for digital radio transmission PSK and 4 QAM for low and medium bit rates 16 QAM for medium bit rates 32QAM, 64 QAM and 128 TCM for high bit rates [5]. SDH-Radio Transmission needs additional requirements to match the existing frequency plans and BER threshold 64-QAM with Gray Coding or 128-QAM with Trellis Coding (4D-128-TCM) .FEC to improve the performance Spectrum forming [6].

3.1.1.2 Spectrum Forming:

BB and IF-Filter to form the spectrum with small cosine roll-off factor(≈O.4...O.2). RF-Filter to suppress harmonics and unwanted radiation .

3.1.1.3Equalization:

Adaptive time domain equalization (ATDE) to reduce distortion caused by multipath fading. Cross-polarization interference cancellations (XPIC) to i-educe interference caused by the cross-polar channel in case of frequency re-use [6]

3.1.1.4Radiation/XPD:

High performance antennas to suppress interference by co- and adjacent-channels. High XPD (cross polarization discrimination) to suppress interference by cross-polar channels [4].

3.1.1.5 Fading and Interference:

Flat fading is caused by multipath propagation, diffraction, and rain. Selective fading is caused by multipath propagation with large delays between direct and reflected signal Diversity, RPS arrangements and equalization to improve the performance and availability.

Antenna height and antenna pattern reduces the influence of multipath fading and interference, Interference is caused by adjacent radio systems [6] .

3.1.1.6 Line Of Sight:

The Earth atmosphere influences the propagation of radio waves in different ways. The radio waves travel with different velocities in different parts of the atmosphere, due to the variations in the electrical characteristics, which cause refraction.

Under normal condition the radio optical line of sight reaches further than the geometrical line of sight.

The standard atmosphere and other atmospheric conditions affecting the refraction factor and which occurs at a given site is described by the Earth radius factor k. The k value depending on the climatic conditions is 4/3 When applied to a standard atmosphere [6].

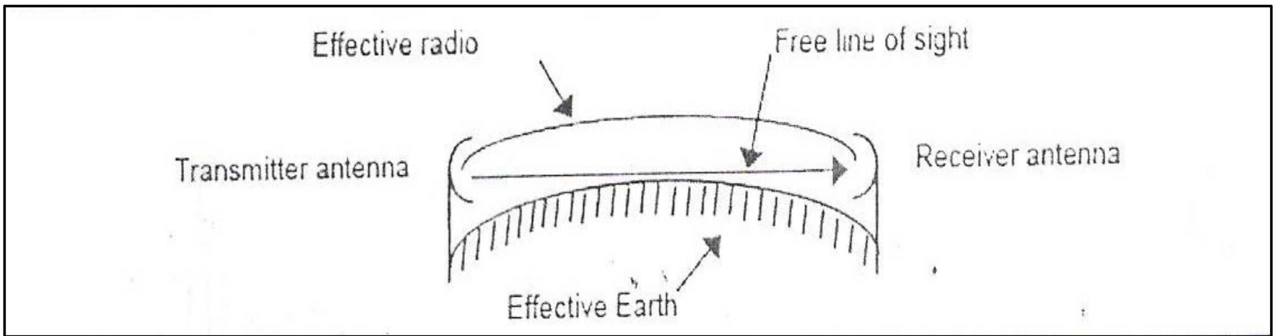


Figure (3.2) line of sight

The radio optical Earth radius can be described using the effective Earth radius factor according to section 2.5 Retraction.

$Re = k \times R$

For tie Earth radius k = 1

Re The radio optical Earth radius

R The true Earth radius (6,370km)

K The effective Earth radius factor

3.1.1.7 Fresnel Zone:

As explained before, the transmission medium is not a free space medium, but anyhow, the free space loss will he obtained between two antennas, if the direct line-of-sight between the antennas is not obstructed, and furthermore, A specific region around the line-of-sight, Fresnel zone, is cleared from any obstacles [6]

This ellipsoid is the set of all points around the LOS where the total length of the connecting lines to the transmitter and the receiver is longer than the LOS length by exactly half a wavelength. It can be shown that this region is carrying the main power flow from transmitter to receiver.

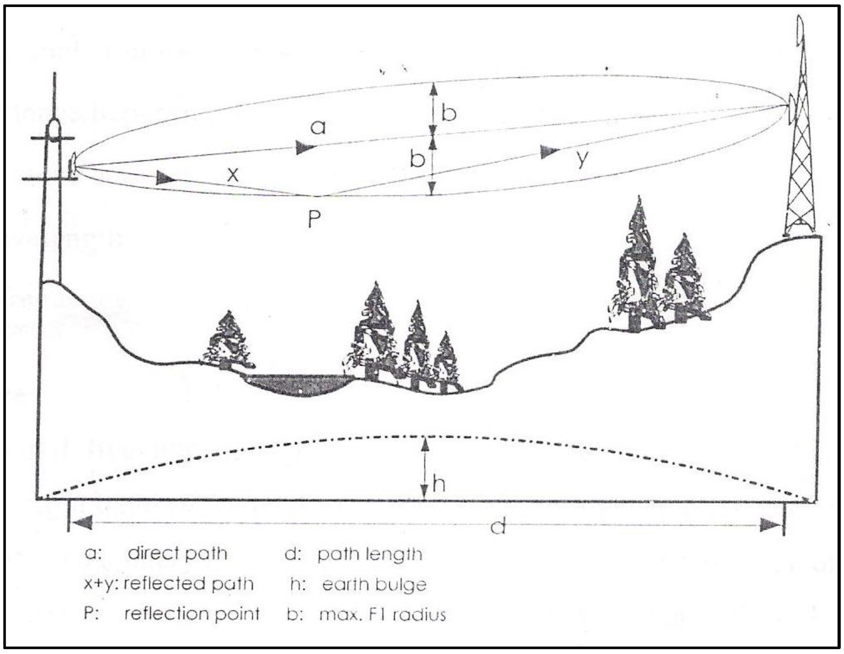


Figure (3.3) . Fresnel zone for microwave

The cross section of the Fresnel ellipsoid at any point between transmitter and receiver is a circle with radius F1. Equation to Fresnel Ellipsoid Radius.

$$F_1 = \sqrt{\frac{d_1\ d_2\lambda}{d_1\ d_2}} \qquad \text{Equation (3.1)}$$

$$\sqrt{\lambda} = \sqrt{\frac{c}{f}} = \sqrt{\frac{300000.10^3 ms^{-1}}{f}} = 17.3.10^3 \sqrt{\frac{ms^{-1}}{f}} \qquad \text{Equation (3.2)}$$

$$\Rightarrow F_1 = 17.3 \times \sqrt{\frac{d_1 \times d_2}{(d_1 \times d_2) \times f}} \qquad \text{Equation (3.3)}$$

F_1 [m] Fresnel ellipsoid radius

d_1 [m] distance between transmitter and the considered point

d_2 [m] distance between considered point and receiver

λ [m]wavelength

f [GHz] frequency[7]

3.1.1.8Clearance:

Even if free line of sight is available on the entire path, close—by obstacles might have an attenuating effect if they are located close enough to the path. It is customary to define a Fresnel zone around the centerline of the path. The first Fresnel zone is defined as a zone shaped as an ellipsoid *with* its focal points at the antennas on both ends of the path [7]

3.1.1.9 Antenna Gain:

Antenna gain is the ratio of how much an antenna boosts the RF signal over a specified low-gain radiator. Antennas achieve gain simply by focusing RF energy. If this gain is compared with an isotropic (no gain) radiator, it is measured in dBi. If the gain is measured against a standard dipole antenna, it is measured in dBd. Note that gain applies to both transmit and receive signals.

$$G = 10 \times log \frac{4 \times \pi \times A \times e}{\lambda^2} [dBi] \qquad \text{Equation (3.4)}$$

G = gain over isotropic, in dBi

A = area of antenna aperture

e = antenna efficiency (<1), due to losses within the antenna

λ= wavelength, in the same units as A [7]

3.1.1.10 Effective Isotropic Radiated Power:

Effective isotropic radiated power (E1RP) is the actual .RF power as measured in the main lobe (or focal point) of an antenna. It is equal to the sum of the transmit power into the antenna (in dBm) added to the dBi gain of the antenna. Since it is a power level, the result is measured in dBm.figure 3 shows how +24dBm of power (250mW) can be boosted' to +48dBm or 64 Watts of radiated power [7] .

3.1.2 Components of Microwave Radio System:

In general there are two types of microwave radios in use:

Indoor-outdoor systems, where parts of the active components are housed Outside near the antenna in order to save the installation of waveguides. Fully indoor systems, where all active components are housed inside and only the antenna is mounted outside, connected via a coaxial cable (< 3 GF-Iz) or a waveguide (> 3GHz) with the equipment [7].

3.1.3 Microwave Radio Characteristics:

Each radio system is characterized by a set of transmitter and receiver Parameter. In microwave radio systems, the parameter must be suitable designed in order to allow two—way communication considering the Requested capacity, and the required performance and availability objectives. In the following the parameter necessary for planning procedures are described [8]

3.1.3.1 Transmitter Output Power:

Necessary for calculation of the link budget . In data sheets normally the output power at antenna port is stated (includes the diplexer loss). Depending on the system the fixed output power value can be decreased by adding additional attenuation [8].

3.1.3.2 Receiver Threshold:

Necessary for calculation of the link budget.It is defined for, a specific bit error rate (e.g. 10j, and depends on the frequency band, type of modulation (C/N) noise figure, and the capacity (noise bandwidth). It includes as well the loss between antenna port and receiver input [8].

3.1.3.3Bandwidth:

Necessary for frequency planning It depends on the capacity (bit rate) and the type of modulation (4 QAM, 16 QAM, etc) [8].

3.1.3.4 Frequency Plan:

Necessary for frequency planning For each system several plans according to ITU- and ETSI-standards are applicable covering different national requirements [8].

3.1.3.5 System Gain:

Difference between transmitter output power and receiver threshold. This parameter is not used for calculations, but is stated as a system grade [8].

3.1.3.6 Signature:

Necessary for calculation of performance, affected by selective fading Selective fading has no appreciable effect on narrow band systems with capacities below 34 Mbit/s [8].

3.1.3.7 Branching loss:

Necessary for calculation of the link budget .It depends on the designed configuration (1+0, 1+1 FD, etc) [8].

3.1.3.8 Interference Reduction:

Necessary for interference calculation .It determines the reduction of inter1èence due to receive filtering and equalization methods [8].

3.1.3.9 MTBF:

Necessary for availability calculation .The MTBF is stated for the different sub units in order to calculate the availability of a certain configuration (1+0, 1+1, etc) [8].

3.1.3.10 Power Consumption:

Necessary for calculation of power supply and power hack up and for the total consumption of a station [8].

3.1.3.11 Weight:

Determines the pole dimension or additional tower load (static) [8].

3.1.3.12 Dimension:

Determines the necessary space in” the equipment room and at antenna location

3.1.4 Antennas and Feeders:

Antennas convert guided waves, fed via coaxial cables or waveguides into free-space waves. Engineers who are involved in microwave planning have mainly to deal with parabolic antennas.

Feeders are applied for the transmission of the energy between transmitter/receiver and the antenna [8].

Two general types of feeders are in use: Coaxial feeders for frequencies below 3 GHz and, Waveguides for frequencies above *3* GHz For indoor-outdoor. Systems waveguide feeders are used only to connect separate antennas [8].

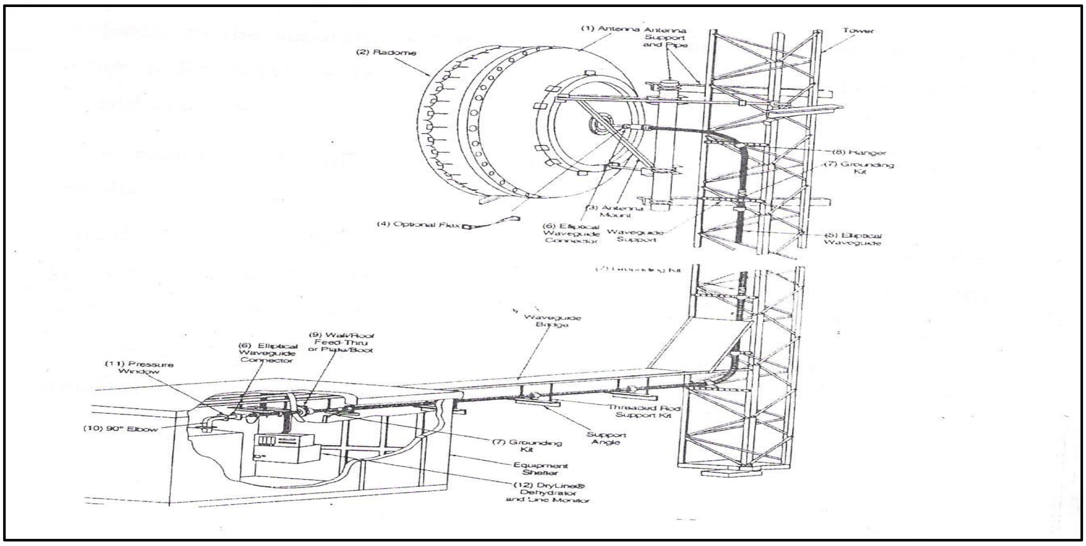


Figure (3.4) Antenna and feeder system

3.1.4.1 Installation of Antennas:

The most important topic relating installation of antennas is the static capacity of the construction (tower, building wall etc), where the antennas will be installed. The resulting necessary static capacity is affected by : The weight of the outdoor radio and antenna ,The wind load of the antenna, and , The quantity of radios and antennas to be mounted at a certain height If a single pipe on a roof top carrying the radio facilities, its diameter depends as well on the above mentioned points.

If there is any doubt about the construction a static analyst has to be consulted .Relating to the separation of microwave radio antennas mutually, or with other radio services (e.g. mobile antennas), some aspects have to be considered: For regions 1liIF the microwave radio antenna a spec lie clearance is required ,The distance between antennas should be ≥ 20 cm in order to get access to the antenna without affecting the adjacent antenna, and to void mutual contact during strong wind. The direction of radiation from sector antennas (GSM, PMP) have to be considered in order to avoid shielding [9].

3.1.4.2 Antenna Camouflages:

In certain cases antennas have to be covered by a camouflage in order to protect e.g. monuments or historical buildings.

The camouflage produces additional losses which have to be considered in power budget calculations [9] .

A waveguide is a metallic tube with a good conductivity of the inner surface.

The transmitter output initiates an electromagnetic field, which travels through the waveguide like in a limited free space area (e.g. in a duct). Waveguides have to be operated in a specific frequency range. Below the cut-off frequency, the loss increases rapidly, above the upper limit other wave modes can exist causing interference. For the most applied elliptical waveguides with an axis ratio b/a=0.52 the Operating frequency range is according Error! Reference Source not found [9].

Equation Operating frequency of elliptical waveguides

$1.48\times f_c \leq f \leq 1.8\times f_c$

f operating frequency

f_c cut-off frequency

The cut-off frequency is in general a function of the axis a and b of the waveguide [6]

Flat fade margin The calculation of the system loss results in the nominal receiver level[9]

Nominal receiver level:

$P_{RX} = P_{TX} - a_s$ Equation (3.5)

P_{RX} Transmitter output level (dBm)

P_{TX}Nominal receiver input level (dBm)

The difference between the nominal receiver level and the receiver threshold determines the flat fade margin. The receiver threshold has to be selected for a specified bit error rate. in case, the quality calculations are performed according ITU-T G.821, a hit error rate of 10^{-3}' is recommended. If the quality calculations are performed according ITU-T G.826, the bit error rate depends on the capacity(Jenny R (2000)).

Flat fade margin:

FM_{-3}=P_{-RX} - $P_{-RX(-3)}$ Equation (3.6)

FM_{-3}= Flat Fade Margin, e.g. for BER 10^{-3} (dB)

$P_{-RX(-3)}$ = Receiver threshold, e.g. for BER 10^{-3} (dB) [4]

Receiver threshold:

Even if the receiver threshold values are stated in relating data sheets, hereafter the calculation method is explained.

$P_{-RX(-3)}$= $N + C / N$ [dBm] Equation (3.7)

$P_{-RX(-3)}$= Receiver threshold for a given BER (e.g. 10^{-3})

N = Thermal noise level of receiver (dBm)

C/N = Carrier-to-noise ratio (dB), which depends on the type of modulation and is stated in the data sheets [6]

Thermal noise level:

$N=10x1og(k\times T_0)+F+B=-1l4+F+B$[dBm] Equation (3.8)

k Boltzmann factor ($1.38*10^{-23}$ (J/K))

T_0 noise temperature (°K)

F noise figure of the receiver (dB)

B 10*log (f) (dB) = noise bandwidth

f_s = $f_B/ln_2(n)$ = symbol bit rate

f_B bit rate (Mbit/s) [6]

3.1.5 Link Budget and Fade Margin:

Frequency planning the objective of frequency planning is to assign as few frequencies to a network in such a way as to obtain an interference level sufficiently low not to affect the availability of the microwave radio link Hops. The frequency planning must consider near and far interference [9]

3.3 WIMAX:

3.3.1 INTRODUCTION:

3.3.1.1 Development of Cellular Wireless Technology:

It started with analogue transmission 1G and moved forward to 2G which was digitalized transmission. 2G is found in most basic cell phones, and features slow transmission of data (10 kb/s), phone calls, reception of basic emails and voice mails. Due to demand for fast transmission, 2G was replaced by 2.5G and with it came the very familiar GPRS. General Packet Radio Service took the mobile phone technology higher than before as now it offered better services and faster transmission. It supported emailing, web browsing and surfing, SMS, MMS and WAP access. This upgraded tech offered a speed of 56 kb/s to 114 kb/s. With the ever evolving technology, demand for better and quicker transmission kept growing. To cater this requirement of users, mobile technology developers came up with 2.75G introducing EDGE; Enhanced Data rates for GSM Evolution. EDGE is not only regarded as 2.75G feature but also a 3G feature. The main attributes were voice mails, phone calls, fax, rich emailing, maps and navigation, web browsing and a speed of 64 kb/s to 144 kb/s [10]

3G technology was being considered the best available tech for cellular phones till this year. The 3G tech introduced UMTS networks. It catered to most of the essentialities of corporate life like internet access, intranet access, interactive app sharing and video conferencing. Moreover, it offered global roaming, HSPA (High Speed Packet Access), TV streaming and a speed of 144 kb/s – 2 MB/s. Now, we are on the edge of a new revolutionary technological development i.e. 4G. Highlighting features of 4G are multi-carrier transmission and ultra-broadband i.e. gigabit speed [10]

3.3.1.2 Features of 4G technology:

This approaching technology has some awesome features that are attracting users towards it. Though 3G is already doing a fine job there is always room for better services and development; this is why people do not stop working after reaching a goal as goals are unlimited. Aims keep on appearing on after another. So is the case with mobile network technology [10].Basically, 4G will be emphasizing on high speed data transmission without interruption. The ultra-broad band will provide speedier internet experience to the users and thus, better live streaming. This network is going to be IP based; i.e. packet switched. Though the data transfer rates are higher, charges will be low as there will be more and higher bandwidth. Video conferencing is also expected which will revolutionize the concept of e-commerce and corporate world. Also, it is going to create big difference in the teaching methodology and distant learning programs. Options are unlimited. Another important feature is global roaming, which is yet one more necessity for high officials, corporate personnel and professionals. Due to faster data transmission, video streaming will be more like fun. Let us get ourselves prepared for smoother, uninterrupted and continual web streaming experience. There is a word about video chat, too. This is a great feature for those who have relatives and friends living far away in other countries, and cannot see them unless they have a computer and internet access for video chat. Indeed, 4G sounds intelligent and genius [10]

3.3.1.3 Kinds of 4G Technology:

Basically, there are two kinds of this technology. These kinds are LTE and WIMAX. Let us have a look at both of these [10]

3.1.1.3.1 LTE:

Though this is a pre-4G technology, it is associated with 3G and not with 3G. LTE stands for Long Term Evolution. This is being so much liked all around the US that most of the mobile carriers in States have announced that they will convert their existing networks to the LTE. It is important to note that the LTE is such a network which treats each and everything that is transmitted by it as data, no matter it is voice. Theoretically talking, the LTE is capable of providing a high speed data transfer rate of 100MB/s regarding download and 50 MB/s while uploading, provided that a 20 MHz channel is used [10].The carriers that are planning to upgrade their networks to LTE include Verizon and AT&T. Verizon says that their network offers a 40 to 50 Mbps download speed and 20 to 25 Mbps upload speed. Don’t forget that these are “Words”; practically the scenario will be different. Expect a 5 to 12 Mbps upload and 2 to 5 Mbps upload speed. AT&T is yet planning to upgrade to LTE, but this is a long term planning [10]

3.3.1.3.2 WIMAX:

This long abbreviation stands for even longer term; Worldwide Interoperability for Microwave Access. It is better to associate it with Wi-Fi technology than to the cellular networks. It is capable of long distance transmission; 30 miles. The peak data transmission rates (as stated) are 128 Mbps downlink and 56 Mbps uplink. The only mobile phone carrier to embrace and accept WIMAX with heart is Sprint. Currently, Clear wire and Sprint hold their WIMAX network in around 27 cities. More cities are yet to be included in this list. Right now, Sprint does not possess a 4G phone. To treat this issue, they have introduced WIMAX capable router. Sprint declares that with WIMAX, they will be offering an average speed of 3 Mbps to 6 Mbps, with a peak speed of 10 Mbps [10]

(a)IEEE 802.16:

The IEEE 802.16 Working Group is the IEEE group for wireless metropolitan area network. The IEEE 802.16 standard defines the Wireless MAN (metropolitan area network) air interface specification (officially known as the IEEE Wireless MAN* standard). This wireless broadband access standard could supply the missing link for the "last mile" connection in wireless metropolitan area networks [10] .Wireless broadband access is set up like cellular systems, using base stations that service a radius of several miles/kilometers. Base stations do not necessarily have to reside on a tower. More often than not, the base station antenna will be located on a rooftop of a tall building or other elevated structure such as a grain silo or water tower. A customer premise unit, similar to a satellite TV setup, is all it takes to connect the base station to a customer. The signal is then routed via standard Ethernet cable either directly to a single computer, or to an 802.11 hot spot or a wired Ethernet LAN [10] .The IEEE 802.16 designed to operate in the 10-66 GHz spectrum and it specifies the physical layer (PHY) and medium access control layer (MAC) of the air interface BWA systems. At 10-66 GHz range, transmission requires Line-of-Sight (LOS) [10]

IEEE 802.16 is working group number 16 of IEEE 802, specializing in point-to-multipoint broadband wireless access. The IEEE 802.16 standard provides the foundation for a wireless MAN industry. However, the physical layer is not suitable for lower frequency applications where non-line-of-sight (NLOS) operation is required. For this reason, the IEEE published 802.16a standard to accommodate NLOS requirement in April 2003. The standard operates in licensed and unlicensed frequencies between 2 GHz and 11 GHz, and it is an extension of the IEEE 802.16 Standard [10] The IEEE 802.16 Working Group created a new standard, commonly known as WIMAX, for broadband wireless access at high speed and low cost, which is easy to deploy, and which provides a scalable solution for extension of a fiber-optic backbone. WIMAX base stations can offer greater wireless coverage of about 5 miles, with LOS (line of sight) transmission within bandwidth of up to 70 Mbps [10]

WIMAX is supported by the industry itself, including Intel, Dell, Motorola, Fujitsu, AT&T, British Telecom, France Telecom, Reliance In for come, Price Warehouse Coopers and Tata Teleservices – forming an alliance called WIMAX Forum. It represents the next generation of wireless networking. WIMAX original release the 802.16 standard addressed applications in licensed bands in the 10 to 66 GHz frequency range. Subsequent amendments have extended the 802.16 air interface standard to cover non-line of sight (NLOS) applications in licensed and unlicensed bands in the sub 11 GHz frequency range. Filling the gap between Wireless LANs and wide area networks, WIMAX-compliant systems will provide a cost-effective fixed wireless alternative to conventional wire-line DSL And cable in areas where those technologies are readily available. And more importantly the WIMAX technology can provide a cost-effective broadband access solution in areas beyond the reach of DSL and cable. The ongoing evolution of IEEE 802.16 will expand the standard to address mobile applications thus enabling broadband access directly to WIMAX-enabled portable devices ranging from smart phones and PDAs to notebook and laptop computers [10]

Table 3.1.Below from the WIMAX Forum summarizes the 802.16 standards.

Completion Date	802.16 Dec 2001	802.16a/ 802.16REVd 802.16a: Jan 2003 802.16Revd: Q3 2004	802.16e 2005
Spectrum	10 to 66 GHz	< 11 GHz	< 6 GHz
Channel Conditions	Line-of-Sight only	Non-Line-of-Sight	Non-Line-of-Sight
Bit Rate	32 to134 Mbps	75 Mbps max 20-MHz channelization	15 Mbps max 5-MHz channelization
Modulation	QPSK 16QAM 64QAM	OFDM 256 subcarrier QPSK 16QAM 64QAM	Same as 802.16a
Mobility	Fixed	Fixed	Pedestrian mobility Regional roaming
Channel Bandwidths	20, 25 and 28 MHz	Selectable between 1.25 and 20 MHz	Same as 802.16a with uplink subchannels
Typical Cell Radius	1 to 3 miles	3 to 5 miles (30 miles max based on tower height, antenna gain, and power transmit)	1 to 3 miles

Table (3.1). WIMAX Forum summarizes

(b) IEEE 802.16a:

The IEEE 802.16a standard allows users to get broadband connectivity without needing direct line of sight with the base station. The IEEE 802.16a specifies three air interface specifications and these options provide vendors with the opportunity to customize their product for different types of deployments [10]. The three physical layer specifications in 802.16a are**:** Wireless MAN-SC which uses a single carrier modulation format. Wireless MAN-OFDM which uses orthogonal frequency division multiplexing (OFDM) with 256 point Fast Fourier

Transform (FFT). This modulation is mandatory for license exempt bands [10].Wireless MAN-OFDMA which uses orthogonal frequency division multiple accesses (OFDMA) with a 2048 point FFT. Multiple accesses are provided by addressing a subset of the multiple carriers to individual receivers (Steven *et al.,* (2007)).In 1998, the IEEE (The Institute of Electrical and Electronics Engineers) began a standards project to specify a point-to-multipoint broadband wireless access system suitable for the delivery of data, voice, and video services to fixed customer sites. The initial standard, designated IEEE 802.16, was developed for the higher microwave bands (> 10 GHz) where line-of-sight between system antennas is required for reliable service. Despite the availability of licensed spectrum for potential deployments, completion of the standard in 2001 failed to have a significant impact; most vendors abandoned their proprietary equipment and did not attempt to implement high-frequency multipoint systems based on the 802.16 standard [10] Factors beyond equipment cost (e.g., installation, roof rights, backhaul, spectrum costs) were significant contributors to the poor economics of the high-frequency multipoint systems [10].In early 2000, work on a low-frequency (<11 GHz) revision of the 802.16 standard was begun by the IEEE working group. This revision (designated 802.16a) incorporated new radio link system options more suitable for low-frequency service while maintaining most of the access control system specifications of the original standard [10].Completed in January 2000, the 802.16a standard included features supporting, Non-line-of-sight service capability , Multiple radio modulation options (single carrier, OFDM) , Licensed and unlicensed band implementations , Versatile access control and QoS features, including TDM and packet services, Advanced security A corrected and modified version of 802.16a (designated 802.16-REVd) was completed in June 2004. Initial WIMAX profiles are a subset of the

802.16-REVd standard. A mobile extension to the low-frequency 802.16 standard is now being developed by the IEEE 802.16e working group. This extension will support delivery of broadband data to a moving wireless terminal, such as a laptop computer with an integrated WIMAX modem being used by a passenger on a commuter train. The WIMAX Forum expects to endorse a mobile profile following completion of the 802.16e standard [10].

3.3.2 WIMAX vs. WLAN:

Unlike WLAN, WIMAX provides a media access control (MAC) layer that uses a grant-request mechanism to authorize the exchange of data. This feature allows better exploitation of the radio resources, in particular with smart antennas, and independent management of the traffic of every user [10].

This simplifies the support of real-time and voice applications.

One of the inhibitors to widespread deployment of WLAN was the poor security feature of the first releases [10]

WIMAX proposes the full range of security features to ensure secured data exchange: Terminal authentication by exchanging certificates to prevent rogue devices, User authentication using the Extensible Authentication Protocol (EAP).,Data encryption using the Data Encryption Standard (DES) or Advanced Encryption Standard (AES), both much more robust than the Wireless Equivalent Privacy (WEP) initially used by WLAN. Furthermore, each service is encrypted with its own security association and private keys [10]

3.3.3 WIMAX VS. Wi-Fi:

WIMAX operates on the same general principles as Wi-Fi -- it sends data from one computer to another via radio signals. A computer (either a desktop or a laptop) equipped with WIMAX would receive data from the

WIMAX transmitting station, probably using encrypted data keys to prevent unauthorized users from stealing access [8]

The fastest WI-FI connection can transmit up to 54 megabits per second under optimal conditions. WIMAX should be able to handle up to 70 megabits per second. Even once those 70 megabits is split up between several dozen businesses or a few hundred home users, it will provide at least the equivalent of cable-modem transfer rates to each user.

The biggest difference isn't speed; it's distance. WIMAX outdistances WI-FI.by miles. WI-FI 's range is about 100 feet (30 m). WIMAX will blanket a radius of 30 miles (50 km) with wireless access. The increased range is due to the frequencies used and the power of the transmitter. Of course, at that distance, terrain, weather and large buildings will act to reduce the maximum range in some circumstances, but the potential is there to cover huge tracts of land [10] WIMAX is not designed to clash with Wi-Fi , but to coexist with it. WIMAX coverage is measured in square kilometers, while that of Wi-Fi is measured in square meters. The original WIMAX standard (IEEE 802.16) proposes the usage of 10-66 GHz frequency spectrum for the WIMAX transmission, which is well above the Wi-Fi range (up to 5GHz maximum). But 802.16a added support for 2-11 GHz frequency also. One WIMAX base station can be accessed by more than 60 users. WIMAX can also provide broadcasting services also [9]. WIMAX specifications also provides much better facilities than Wi-Fi , providing higher bandwidth and high data security by the use of enhanced encryption schemes. WIMAX can also provide service in both Line Of Sight (LOS) and Non-Line of Sight (NLOS) locations, but the range will vary accordingly. WIMAX will allow the interpenetration for broadband service provision of VoIP, video, and internet access – simultaneously [9].

WIMAX can also work with existing mobile networks. WIMAX antennas can "share" a cell tower without compromising the function of cellular arrays already in place [9] Mobile Communications systems are undoubtedly an essential part of modem society and are becoming more so as we move towards the “information society” and demand access to more information more immediately and in more places. Concurrently, technological developments are making new applications possible, opening up new markets, and promising significant economic benefits.

One of challenge faces telecommunication systems is to reach high quality service that characterized by speed accuracy security, so it is important to develop in industry multiple types of media because the customer or subscriber desire in unique services & speed. That lead telecommunication companies to complete in improving transmission media type. This needs lead to use the air as a transmission media for data & known as wireless telecommunication & this process done by increase the frequency of the origin signal to high frequency (short wave length) & that known as microwave, far grantee the signal to reach destination without distorted or to reduce noise. The new technology (microwave) allowed connection far base station with each other via point to multipoint. The space age opened many new opportunities for radio communications between widely separated locations. Instead of high-frequency (HF) terrestrial systems with limited bandwidth or a large number of short- range microwave relays, satellites can link distant locations from a point high above the Earth.

The fiber optics is used in various applications. Presently, it is relevant to say the telecommunication industry is the dominant user for the optical fiber technology because the demand is high. Why is the demand high? :a;: reason is speed. People like high speed because they can get things done quickly. Through optical fiber, information can transfer at much greater speeds due to the Fact that information is transmitted through coded flashes and lights (which travel at approximately the speed of light e = 3.0 x 10exp8 m/s).

Fiber optics has extremely high bandwidth. High bandwidth means they have greater capacity to carry more in information at a faster rate, and this is the ideal that the telecommunication industries are striving towards. Presently optical fiber can carry about 300 television channels and 45,000 phone conversations at single instance in time.

Table (3.2) transmission media data rate:

Type of media	**Data rate**
Microwave	2*2.048Mb/s for 2E1link up to 140Mb/s for E4 (PDH)
VAST	Typically range from narrow band up to 2.048 Mb/s.
Optical fibers	155.5 Mb/s for STM-1, digital signal hierarchies of higher level such as 622Mb/s for STM-4, 2.5Gb/s for STM-16.&10Gb/s for STM-64
WIMAX	74 Mb/s for STM-1

In microwave we need indoor unit and outdoor unit also we need frequency and repeaters.

But in VSAT we need frequency and the two stations, any station transmit and receive the data in the same lime (transponder).

In WIMAX we need frequency and point to point station or point to multi point station (either line of sight LOS or NON line of sight NLOS).

CHAPTER FOUR

Methodology

4.1 Descriptive Analyses:

In this project a descriptive analysis of WIMAX and Microwave is done to develop planning tool capable of calculating the cost of the network, different areas were applied to evaluate the system and the simulation is based on MATLAB software, the software will be capable of calculating the tower height of WIMAX and Microwave and also it has the ability to generate a random geographical area.

Parameters that used in this simulation are the transmitter antenna height for WIMAX and Microwave and it is entered to the system manually after generating profile of the area also the maximum beam width of WIMAX is 200 with a random distance depending on the generated geographical area the frequency and power is fixed.

4.2 Mathematical Model:

The equation that the code based on is straight line equation These equations can take various forms depending on the facts we know about the lines. So to start, suppose we have a straight line containing the points in the following list.

$$\text{M} = \frac{y2 - y1}{x2 - x1} \qquad \text{Equation(4.1)}$$

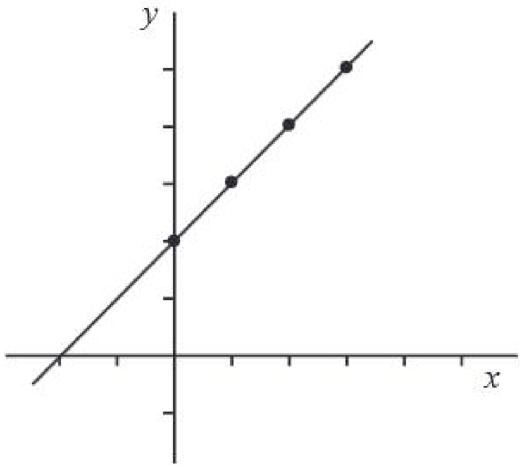
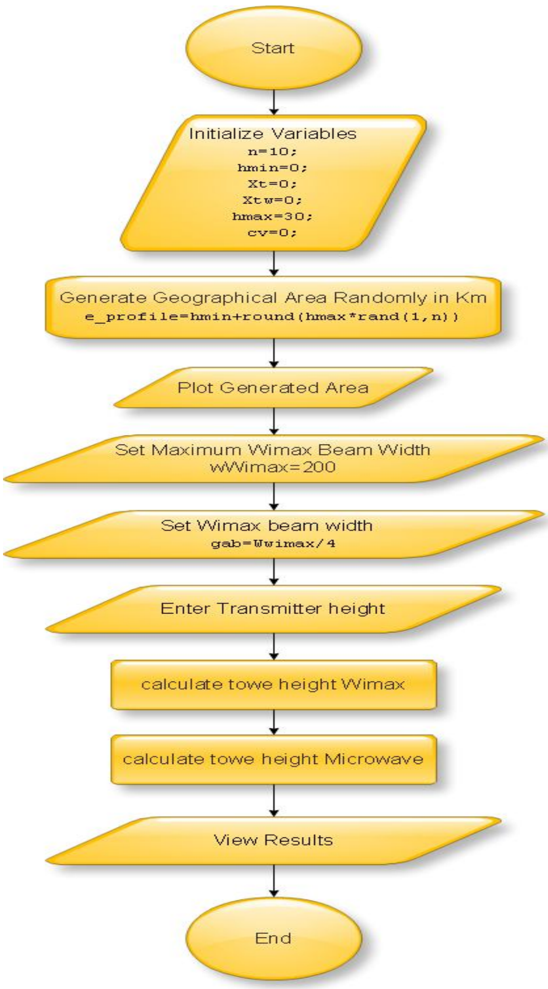


Figure (4.1) straight line into axis

4.3 Computer Model:

The computer model describes the steps processing the simulation code.



4.4 Simulation:

Using MATLAB 2010 to simulate the project. It shows in appendix A&B.

4.5 Results:

After execution of the simulation code the system waits the user to enter transmitter height for WIMAX and microwave and the program starts calculating the height of the receiver antenna.

4.6 Results Discussion:

The code starts generating a random geographical area to calculate the requirements of the system in different parameters.

4.6.1 Generating Random Geographical Area:

The following graphs represents a graphical presentation of geographical area the X axis represents the distance in Km and the y Axis represent the height in meters, the randomized area can be made several times to cover all the situational geographical changes.

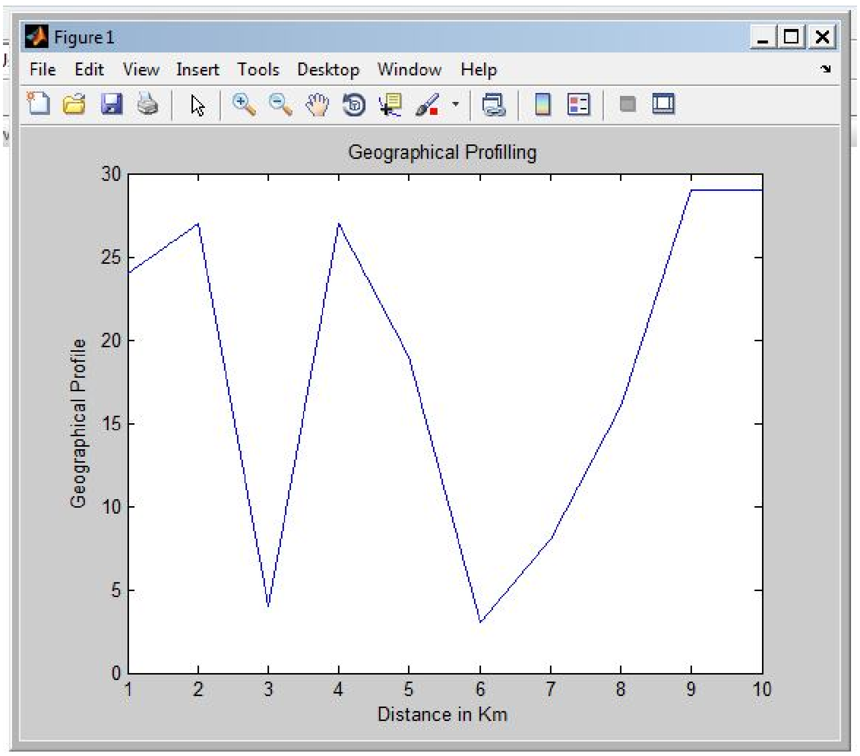


Figure (4.1) random generated area [1]

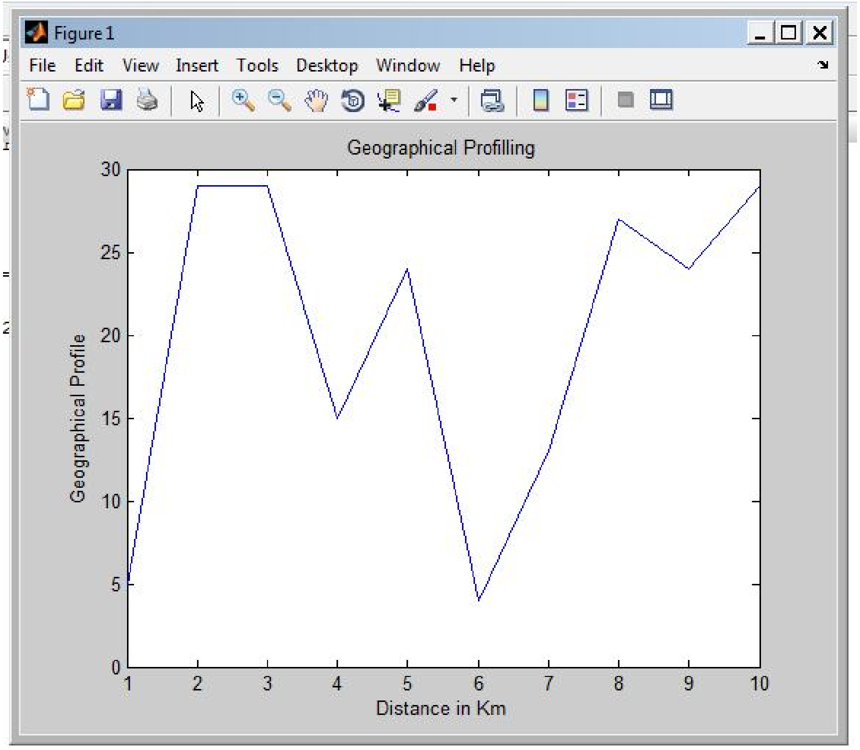


Figure (4.2) random generated area [2]

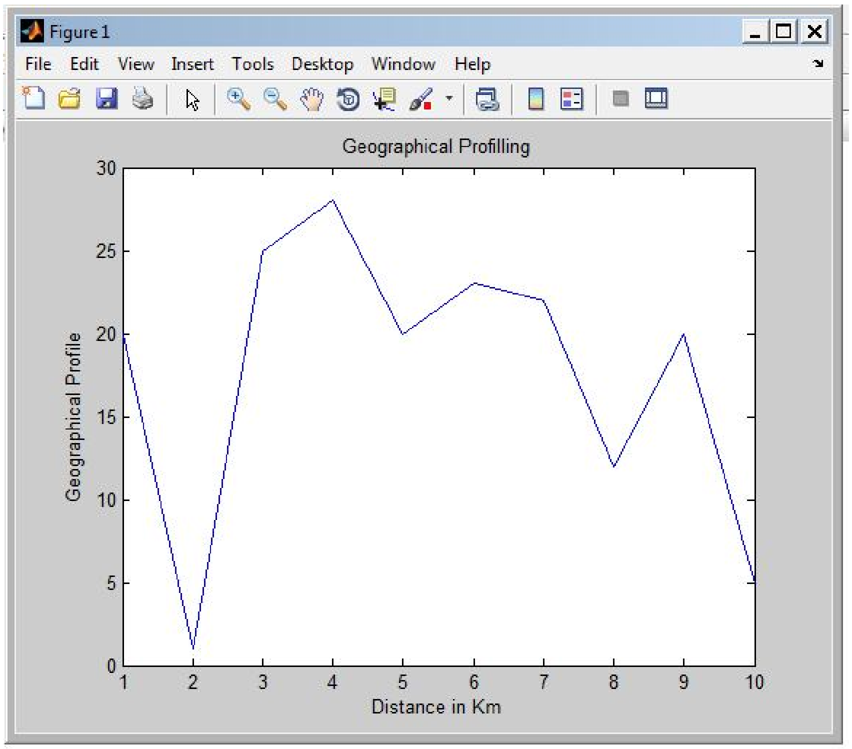


Figure (4.3) random generated area [3]

Table (4.1) transmitter and receiver tower heights in different geographical area In this table an assumption of tower height had been used to calculate the tower height for WIMAX and Microwave.

No.	transmitter height (WIMAX)	transmitter height (Microwave)	Receiver (WIMAX)	Receiver (Microwave)
1	7	7	23.1250	45.6250
2	10	10	50.4000	59.6000
3	12	12	21.3750	47.3750
4	13	13	70.2500	67.2500
5	15	15	51.4000	58.6000
6	100	100	21.8333	69.8333

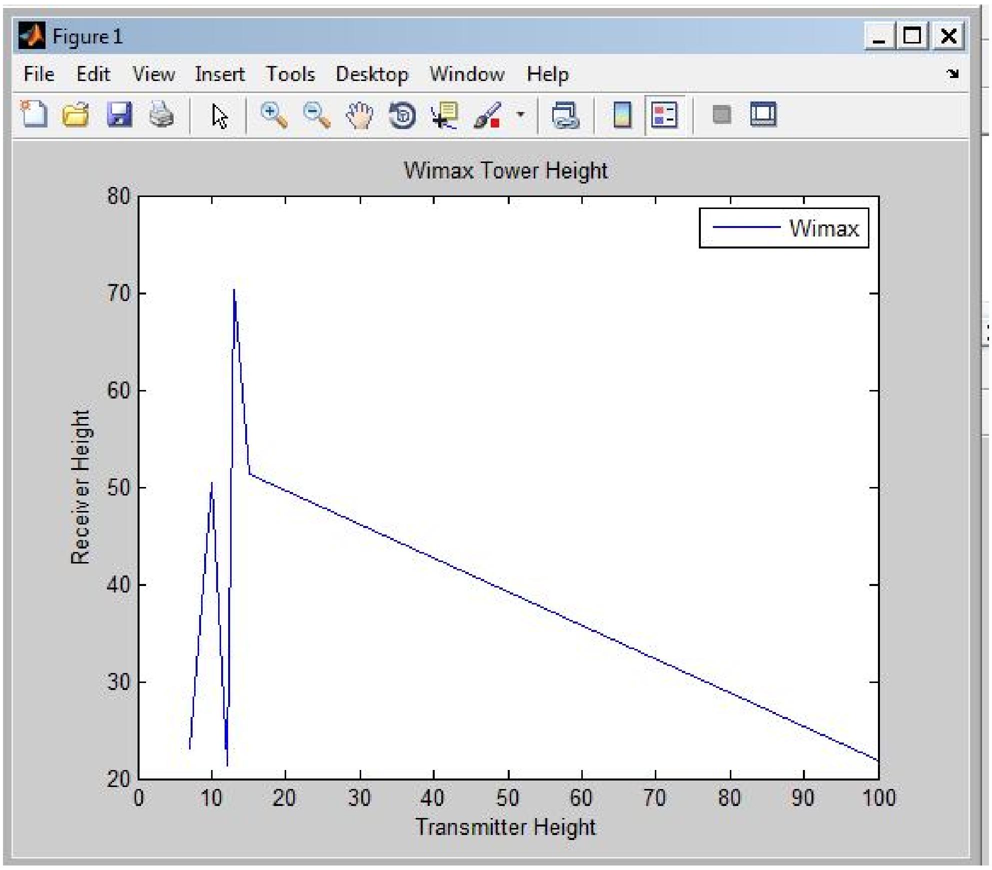


Figure (4.4) WIMAX Tower Height in different geographical area

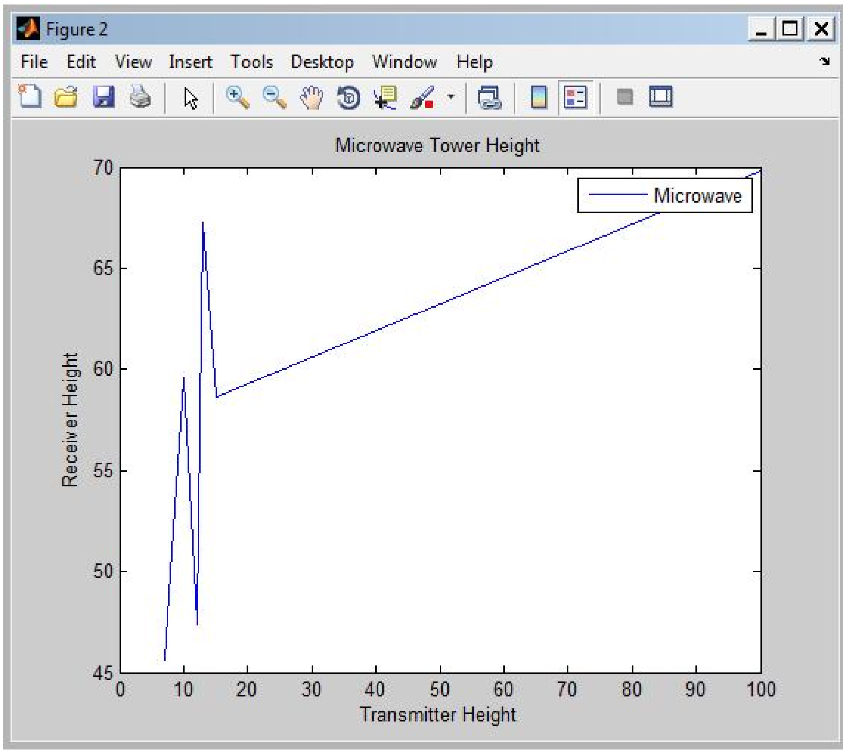


Figure (4.5) Microwave Tower Height in different geographical area

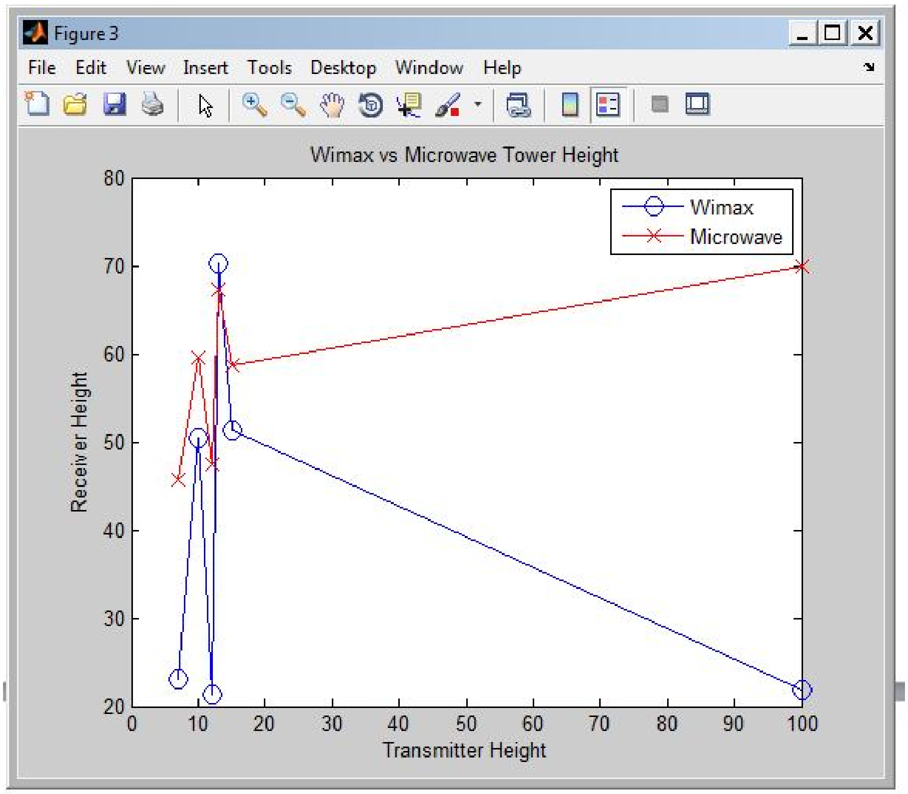


Figure (4.6) Comparison between WIMAX and Microwave Tower Height in different geographical area

CHAPTER FIVE

Conclusion and Recommendations

5.1Conclusion:

In this project the simulation was done using MATLAB software and the selected transmitter heights that involves in the simulation was 7,10,12,13,15,100 and the simulation output give an indication that each geographical area generated has a different parameters that vitiate the Tower Height, in the simulation results it was found that the tower height in the WIMAX is Lower than the microwave due to the non-line of sight technology used moreover the Microwave is a lower cost on equipment and the WIMAX tower is lower cost but the equipment are high cost.

5.2Recommendations:

Using a network simulation 2 to simulate the WIMAX and Microwave Link and calculate the system performance, Generate graphical user interface for MATLAB Code and Compare network structure in their infrastructure cost.

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Appendix A

```
%link simulation program
%---------------------
n=10;
hmin=0;
Xt=0;
Xtw=0;
hmax=30;
%maximum tower height
cv=0;
e_profile=hmin+round(hmax*rand(1,n))
plot(e_profile);
title('Geographical Profilling');
xlabel('Distance in Km');
ylabel('Geographical Profile');
%Wimax section
%----------------------------
Wwimax=200;
%4meter is the Wimax beam width
gab=Wwimax/4
% loop for max height
for i=1:n
ife_profile(i)>cv
Xin=i
```

```
cv=e_profile(i)
end
end
e_profilew(Xin)=e_profile(Xin)-gab
Yt=input('enter transmitter height:')
S=(e_profilew(Xin)-Yt)/(Xin-Xt)
C=e_profilew(Xin)-(S*Xin)
Yt=(S*1)+C
Yr=(S*n)+C

total_tower_height_for_Wimax=abs(Yt+Yr)
% Microwave section
%-------------------
Ytw=input('enter transmitter height:')
S=(e_profile(Xin)-Ytw)/(Xin-Xtw)
C=e_profile(Xin)-(S*Xin)
Ytw=(S*1)+C
Yrw=(S*n)+C
total_tower_height_for_microwave=abs(Ytw+Yrw)
total_tower_height_for_Wimax
```

Appendix B

```
clear all;

clc;

close all;

figure(1)% wimax

x=[7 10 12 13 15 100];

y=[23.1250 50.4000 21.3750 70.2500 51.4000 21.8333];

plot (x,y);

xlabel('Transmitter Height');

ylabel('Receiver Height');

title('Wimax Tower Height');

legend('Wimax');

figure(2) % microwave

x=[7 10 12 13 15 100];

y=[45.6250 59.6000 47.3750 67.2500 58.6000 69.8333];

plot (x,y);

xlabel('Transmitter Height');

ylabel('Receiver Height');
```

```
title('Microwave Tower Height');

legend('Microwave');

figure(3) % compare

x=[7 10 12 13 15 100];

y=[23.1250 50.4000 21.3750 70.2500 51.4000 21.8333];

plot (x',y','color','b','marker','o','MarkerSize',10);

hold on

x=[7 10 12 13 15 100];

y=[45.6250 59.6000 47.3750 67.2500 58.6000 69.8333];

plot (x',y','color','r','marker','x','MarkerSize',10);

xlabel('Transmitter Height');

ylabel('Receiver Height');

title('Wimax vs Microwave Tower Height');

legend('Wimax','Microwave');
```