INTERNSHIP REPORT

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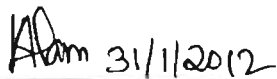Drive test, Survey, Single site verification and Optimization in Wimax Technology

By

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Department of Electrical and Electronic Engineering
Faculty of Sciences and Engineering
East West University
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APPROVAL LETTER:

UCE

Date : June 06,2011

UCE Telecom Solutions Ltd.
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To whom it may concern

Subject: Internship Letter for Shah md. Imran (For the purpose of University use only)

This letter certifies that Shah Md. Imran has completed his 100 hours of internship in **UCE Telecom Solutions Limited (UCE)** under supervision of Md. Jahiruddin Bhuiyan

If you need additional information regarding his internship with Uce, please do not hesitate to contact us via email or telephone

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Last but not the least I would like to thank Almighty Allah for giving me the blessings, dedication and the motivation to fulfill my goals in completing the Internship report.

EXECUTIVE SUMMARY:

Wimax (Worldwide Interoperability for Microwave Access) technology is the topic of my internee work. Drive test, survey, single site verification and optimization is the main subject of my internee work.

I was under a senior RF engineer and had the full scope and independence to work on the project. While working on the project I had the scope to come cross many new things of the Wimax technology. This internship report provides the detail about the mobile Wimax system and its overall working procedure to maintain the drive test, survey, single site verification and optimization and also designing in a proper network planning which is helpful to offer better throughput broadband wireless connectivity at a much lower cost.

During my internee period I have spent a superior time in learning and performing. I had the experience of corporate reporting working environment which affects an employee performance and approach to work. I also had the opportunity to work in practical field, which will be very helpful in my professional life.

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Company profile:

1.1 Overview:

UCE (Universal cellular engineering) was incorporated in 1998 in Malaysia. Today, it has four operational offices in Kuala Lumpur, Hong Kong, Surabaya and Bangalore with headquartered office in Kuala Lumpur to support it's on-going projects in different countries. It's core expertise is providing cellular network engineering, consultancy and project management services for cellular network operators, equipment vendors and system integrators in the wireless telecommunications industry.

UCE technical team is comprised of fully qualified professionals with extensive knowledge, hands-on experience and expertise in the field of cellular engineering. With the experienced management team and a highly competent technical team, UCE will be able to provide optimum solutions to meet the customer demands in this dynamic industry environment.

UCE Bangladesh is one of the largest sub corn in the country. It is operating its activity by two offices with a large number of qualified engineers from both home and abroad. Its main two project are Wimax and GSM. It does its operation mainly under two vendor Huawei and Zte.

1. 2 Services:

UCE offers four main categories of services to wireless telecommunications industry – network design & optimization, network deployment, network auditing, consultancy and network benchmarking. Its end-to-end services are all supplemented with complete program and project management expertise to ensure that every service will result in good quality. Its expertise covers most technologies in the world now, ranging from different voice switched networks to packet switched networks, namely GSM(Global System for Mobile), GPRS(General packet radio service), EDGE(Enhanced data rates for GSM evolution), CDMA(Code division multiple access)and Wimax(Worldwide Interoperability for Microwave Access).

1.3 List of Customers:

Vendors	Operators
Huawei	Grameen Phone
Zte	Airtel
Ericsson	Robi

UCE provides the solutions to plan, implement, test, and optimize the 2G, 2.5G, 2.75G and 3G networks.UCE has inventory of in house wireless test tools to perform services like TSS(Technical site survey), model tuning, drive testing and network benchmarking. UCE provides its customers:

- Network Planning
- RF Planning & Design
- RF Optimization
- Network Support Services
- Transmission Planning
- In-building solution

Network Design
and Optimization

Program
Management

Network
Deployment

Network
Benchmarking

Network Auditing
and Consultancy

Figure 1 : Services of UCE

Chapter 2

2.1 Wimax

2.1.1 Overview:

Wimax (Worldwide Interoperability for Microwave Access) unites the technologies of wireless and broadband to provide high-speed internet access across long distances. The name was christened by Wimax forum that promotes interoperability and conformity of the standard. The forum defines the technology as "A standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL". With the guarantee of Wimax forum the vendors are authorized to sell their Wimax certified products so they can enjoy operability with other products of same type. It is a telecommunication protocol capable of providing internet access to fixed and mobile users. For an outstanding performance like Wi-Fi networks along with QoS (Quality of Service) and coverage this Wireless Broadband Access technology is assembled around IP (internet protocol).

IEEE (Institute of Electrical and Electronics Engineers) names this wireless digital communication system 802.16. IEEE also fixed some standards for Wimax. The standards are given below:

	802.16	802.16a	802.16e
Spectrum	10-66 GHz	2-11 GHz	<6 GHz
Configuration	Line of Sight	Non-Line of Sight	Non-Line of Sight
Bite Rate	32 to 134 Mbps (28 MHz Channel')	$\leq$ 70 or 100 Mbps (20 MHz Channel)	Up to 15 Mbps
Modulation	QPSK, 16- QAM, 64-QAM	256 Sub-Carrier OFDM using QPSK, 16- QAM, 64-QAM, 256-QAM	Same as 802.16a
Mobility	Fixed	Fixed	$\leq$75 MPH
Channel Bandwidth	20,25,28 MHz	Selectable 1.25 to 20 MHz	5 MHz (Planned)
Typical cell Radius	1-3 miles	3-5 miles	1-3 miles
Completed	Dec, 2001	Jan, 2003	2nd Half of 2005

Table 1: IEEE 802.16 Standards related to Wimax

These standards are issued by IEEE 802.16 work group that originally covered the wireless local loop (WLL) technologies in the 10.66 GHz radio spectrum, which were later extended through amendment projects to include both licensed and unlicensed spectra from 2 to 11 GHz.

2.1.2   What is 802.16a ?

Wimax is such an easy term that people tend to use it for the 802.16 standards and technology themselves, although strictly it applies only to systems that meet specific conformance criteria laid down by the Wimax forum. The 802.16a standard for 2-11 GHz is a wireless metropolitan area network (MAN) technology that will provide broadband wireless connectivity to Fixed, Portable and Nomadic devices. It can be used to connect 802.11 hot spots to the Internet, provide campus connectivity, and provide a wireless alternative to cable and DSL for last mile broadband access.

2.1.3   Comparison between Wimax and Wi-Fi:

Wimax is similar to the wireless standard known as Wi-Fi, but on a much larger scale and at faster speeds. A nomadic version would keep Wimax-enabled devices connected over large areas, much like today's cell phones. We can compare it with Wi-Fi based on the following factors:

2.1.3.1   IEEE Standards:

Wi-Fi is based on IEEE 802.11 standard where as Wimax is based on IEEE 802.16. However both are IEEE standards.

2.1.3.2   Range:

Wi-Fi typically provides local network access for around a few hundred feet with speeds of up to 54 Mbps, a single Wimax antenna is expected to have a range of up to 40 miles with speeds of 70 Mbps or more. As such, Wimax can bring the underlying internet connection needed to service local Wi-Fi networks.

2.1.3.3 Scalability:

Wi-Fi is intended for LAN(Local area network) applications, users scale from one to tens with one subscriber for each CPE(consumer premises equipments) device. Fixed channel sizes (20MHz).Wimax is designed to efficiently support from one to hundreds of consumer premises equipments (CPE) s, with unlimited subscribers behind each CPE. Flexible channel sizes from 1.5MHz to 20MHz.

2.1.3.4 Bit rate:

Wi-Fi works at 2.7 bps/hz and can peak up to 54 Mbps in 20 MHz channel. Wimax works at 5 bps/Hz and can peak up to 100 Mbps in a 20 MHz channel.

2.1.3.5 Quality of service:

Wi-Fi does not guarantee any QoS but Wimax provides several level of QoS. As such, Wimax can bring the underlying internet connection needed to service local Wi-Fi networks. Wi-Fi does not provide ubiquitous broadband while Wimax does.

2.1.3.6 Comparsion Table:

Feature	Wimax 802.16a	Wi-Fi (802.11b)	Wi-Fi (802.11a/g)
Primary Application	Broadband Wireless Access	Wireless LAN	Wireless LAN
Frequency Band	Licensed/Unlicensed 2 GHz to 11 Ghz	2.4 GHz ISM	2.4 GHz ISM (g) 5 GHz U-NII (a)
Channel Bandwidth	Adjustable 1.25 MHz to 20 MHz	25 MHz	20 MHz
Half/Full Duplex	Full	Half	Half
Radio Technology	OFDM (256-channels)	Direct Sequence Spread Specturm	OFDM (64-channels)
Bandwidth Efficiency	<= 5bps/Hz	<= 0.44 bps/Hz	<= 2.7 bps/Hz
Modulation	BPSk, QPSk, 16-,64-, 256-QAM	QPSK	BPSK, QPSK 16-,64-QAM
FEC	Convolutional Code Reed-Solomon	None	Convolutional Code
Encryption	Mandatory-3DWS Optional-AES	Optional-RC4 (AES in 802.11i)	Optional-RC4 (AES in 802.11i)

Table 2: Comparison between Wimax and Wi-Fi

2.1.4 Wimax services:

Wimax broadband internet access is deployed simply by using the wireless signals emerging from nearby base station. This wireless connection can be accessed on a fixed desktop PC as well as portable devices like laptop and palm top. Wimax can also be used as a successful landline telephone detour. For this purpose a central IP transport communicates to the base station, this base station provides telephone signals to Wimax telephone. Wimax can also be used as cable and satellite bypass as well. An IPTV server is used to provide these services. This server sends the signal to Wimax tower or base station and the end user receive TV connection. Wimax is also a major replacement for mobile phone technologies like CDMA and GSM. This is the reason why IP transport backup set is often used to provide mobile wireless signals to cell phone users. Wimax connection is able to replace any existing telephone communication network. As explained earlier in fixed communication technologies it can replace copper wire and traditional coaxial cable set up. Wimax can also enable ISPs to provide internet access services.

2.1.4.1 Multimedia Wimax Services:

Wimax has set new trends in communication technologies. This wireless connection has opened new markets for manufacturers and service providers. This is a diversified wireless service which can be source of offering various other multimedia services. Wimax is supposed to have amazing potential to support IP multimedia services. Wimax is making use of OFDM and SOFDM that is why it is more compatible to offer multimedia services like voice over the internet, video conferencing, voice chat and text and data transmission. The Wimax operates at relatively larger range of frequencies. Hence it is able to deliver more services. Wimax is preferred source of communication because it can carry bulk of data traveling at both ends (receiver and sender). It is based on the principle of quality of service and prioritization of data. It can provide telecommunication services to rural areas where there is no supporting infrastructure available. Like it did in the past during tsunami typhoon and provided the communication needs for the people in problem.

2.1.4.2 Wimax Broadband Services:

The range of the Wimax is measured in miles besides foot. It is a sort of metropolitan area network. It is competitive enough to provide various services like telephone, internet access, calls and cellular services. Wimax covers a couple of frequency ranges like 10 GHz to up to 66

GHz then 2 GHz to 11 GHz range. Wimax supports services like IPv4, atm, Ethernet. Wimax can also become a backup support for 802.11 wireless LAN services. It can be used to connect plenty of hotspots and inter access points. The Wimax set up is more like a cellular set which requires the services of a base station. Some important services of broadband Wimax includes mesh and smart antenna technology, video streaming, voice quality of service, fast downloading and cellular mobile access. It can be used with or without a variety of cellular applications like CDMA and GSM. Hence Wimax provides plenty of opportunities to the service providers to deliver accurate and consistent services.

2.1.5 Potential Applications of Wimax:

Mobile Wimax is the embodiment of Wimax that has wide commercial interest nowadays and employed in a number of countries. Although its functions resemble to Wi-Fi but it gives longer access range. With greater coverage the service is also cost-effective. Some of the applications are as follows:

• A variety of devices enable Wimax to provide portable mobile broadband connectivity across cities and continents. The markets that have only DSL operators for broadband provision have seen the growing competition with the advent of Wimax.
• A connection that grows with the expansion of business.
• For last mile broadband the wireless Wimax would most probably substitute cable and DSL or would be instilled for increasing capacity. In developed and developing countries, fixed Wimax has been taken as a backhaul technology for 2G, 3G and 4G.
•It supports QoS and multicasting technologies that are helpful in triple-play services: telecommunications, data.

2.1.6 Salient Features of Wimax:

Wimax is a wireless broadband solution that offers a rich set of features with a lot of flexibility in terms of deployment options and potential service offerings. Some of the more salient features that deserve highlighting are as follows:

2.1.6.1 OFDM-based physical layer:

The Wimax physical layer (PHY) is based on orthogonal frequency division multiplexing, a scheme that offers good resistance to multipath, and allows Wimax to operate in NLOS

conditions. OFDM is now widely recognized as the method of choice for mitigating multipath for broadband wireless.

2.1.6.2 Very high peak data rates:

Wimax is capable of supporting very high peak data rates. In fact, the peak PHY data rate can be as high as 74Mbps when operating using a 20MHz wide spectrum. More typically, using a 10MHz spectrum operating with a 3:1 downlink-to-uplink ratio, the peak PHY data rate is about 25Mbps and 6.7Mbps for the down-link and the uplink, respectively. Under very good signal conditions, even higher peak rates may be achieved using multiple antennas and spatial multiplexing.

2.1.6.3 Scalable bandwidth and data rate support:

Wimax has a scalable physical-layer architecture that allows for the data rate to scale easily with available channel bandwidth. This scal-ability is supported in the OFDMA mode, where the FFT (fast fourier transform) size may be scaled based on the available channel bandwidth. For example, a Wimax system may use 128,512, or 1,048 bit FFTs based on whether the channel bandwidth is 1.25MHz, 5MHz, or 10MHz, respectively. This scaling may be done dynamically so support user roaming across different networks that may have different bandwidth allocations.

2.1.6.4 Adaptive modulation and coding (AMC):

Wimax supports a number of modulation and forward error correction coding schemes and allows the scheme to be changed on a per user and per frame basis, based on channel conditions. AMC is an effective mechanism to maximize throughput in a time-varying channel. The adaptation algorithm typically calls for the use of the highest modulation and coding scheme that can be supported by the signal-to-noise and interference ratio at the receiver such that each user is provided with the highest possible data rate that can be supported in their respective links.

2.1.6.5 Link-layer retransmissions:

For connections that require enhanced reliability, Wimax supports automatic retransmission requests (ARQ) at the link layer. ARQ-enabled connections require each transmitted packet to be acknowledged by the receiver; unacknowledged packets are assumed to be lost and are

retransmitted. Wimax also optionally supports hybrid-ARQ, which is an effective hybrid between FEC and ARQ.

2.1.6.6 Support for TDD(Time division duplexing) and FDD(Frequency division duplexing):

IEEE 802.16-2004 and IEEE 802.16e-2005 supports both time division duplexing and frequency division duplexing, as well as a half-duplex FDD, which allows for a low-cost system implementation. TDD is favored by a majority of implementations because of its advantages:
(1) Flexibility in choosing uplink-to-downlink data rate ratios,
(2) Ability to exploit channel reciprocity,
(3) Ability to implement in no paired spectrum,
(4) Less complex transceiver design. All the initial Wimax profiles are based on TDD, except for two fixed Wimax profiles in 3.5GHz.
Mobile Wimax uses OFDM as a multiple-access technique, whereby different users can be allocated different subsets of the OFDM tones.

2.1.6.7 Flexible and dynamic per user resource allocation:

Both uplink and downlink resource allocation are controlled by a scheduler in the base station. Capacity is shared among multiple users on a demand basis. When using the OFDMA-PHY mode, multiplexing is additionally done in the frequency dimension, by allocating different subsets of OFDM subcarriers to different users. Resources may be allocated in the spatial domain as well when using the optional advanced antenna systems (AAS). The standard allows for bandwidth resources to be allocated in time, frequency, and space and has a flexible mechanism to convey the resource allocation information on a frame-by-frame basis.

2.1.6.8 Quality-of-service support:

The Wimax MAC layer has a connection-oriented architecture that is designed to support a variety of applications, including voice and multimedia services. The system offers support for constant bit rate, variable bit rate, real-time, and non-real-time traffic flows, in addition to best-effort data traffic. Wimax MAC is designed to support a large number of users, with multiple connections per terminal, each with its own QoS requirement.

2.1.6.9 Robust security:

Wimax supports strong encryption, using Advanced Encryption Standard (AES), and has a robust privacy and key-management protocol. The system also offers a very flexible authentication architecture based on extensible authentication protocol (EAP), which allows for a variety of user credentials, including username/password, digital certificates, and smart cards.

2.1.6.10 Support for mobility:

The mobile Wimax variant of the system has mechanisms to support secure seamless handovers for delay-tolerant full-mobility applications, such as VoIP. The system also has built-in support for power-saving mechanisms that extend the battery life of handheld subscriber devices. Physical-layer enhancements, such as more frequent channel estimation, uplink sub channelization, and power control, are also specified in support of mobile applications.

2.1.6.11 IP-based architecture:

The Wimax Forum has defined a reference network architecture that is based on an all-IP platform. All end-to-end services are delivered over an IP architecture relying on IP-based protocols for end-to-end transport, QoS, session management, security, and mobility. Reliance on IP allows Wimax to ride the declining cost curves of IP processing, facilitate easy convergence with other networks, and exploit the rich ecosystem for application development that exists for IP.

2.1.7 Advantage:

Wimax has lots of benefits which helped in increase usability of Wimax around the world. It is still not been used to its full potential that's why there may be more features which may not be known as yet, more and more exploration is required to get Wimax technology to its full use, however we know some of its significant features which are important enough to mention.

2.1.7.1 Long Rang:

Connectivity from long range is much highlighted feature of Wimax. Theoretically it is believed that Wimax technology provides range up 30 miles (50 Km). However in practical experience it

is observed that it provides range up to 10 km which is still huge breakthrough in long range connectivity.

2.17.2 Mobility:

Another significant feature of Wimax technology is the connectivity on move. This technology amaze the world hence increasing the use of Wimax in some parts of the world dramatically. Especially to the urban places where cables and other network equipments are not feasible to install. Using its long range feature it provides connectivity on such area where other means of high speed Internet are not available. The other major mobility feature of Wimax technology is that connecting devices (Laptops, PDA etc) can move in certain area and still be connected to the network.

2.17.3 Interfacing:

Wimax radio signals are broadcasted to its subscribers from base stations. Base stations are area where all necessary hardware is installed to provide Wimax within its range. Since one Base station covers limited range so connecting multiple base stations to each other increase that much range for connectivity. Connecting multiple base stations to each other is not big task and can be performed in few hours.

2.17.4 Accessibility:

Accessing Wimax base station is not a difficult task, its long range capability provides connectivity at home from base stations within the range. To get high speed internet it's only required to become subscriber to Wimax service providers. They will provide you appropriate hardware to beome a subscriber. Installing the hardware is very easy; it is just plug and play. Hardware mostly connects through usb ports or ethernet and connection can be made by clicking just a button. There may be several other features which will surely come up as the growth of Wimax technology increases.

Chapter 3

How Wimax work ?

3.1 Two major part of Wimax connectivity:

Wimax network connectivity constitutes of two parts, one can define as Wimax tower or Wimax booster, it is known as Wimax Base station, whereas the other portion is Wimax receiver.

3.1.1 Wimax base station:

Wimax base station is a place from where Wimax signals are broadcasted. It consists of electronic devices and Wimax Tower. This tower works exactly like GSM network phones towers standing high up in the air to broadcast radio signals. Wimax tower base station can cover up to 10Km radius. In theory it suggests to cover a lot more distance than just 10Km, it can reach some where about 50 km (30 miles), but in fact due to certain geographical limitations it goes as far as 10 km or approx. 6 mils. Any wireless connecting device for Wimax will connect to Wimax network if fallen in to the range.

3.1.2 Wimax Receiver:

It is device or devices which receives the signals from Wimax base station and connects to the Wimax networks. These devices are usually stand alone Antenna or PCMCIA slot card for laptops or computers. Connecting to Wimax base stations works as similar as connection of Wi-Fi to access point works, the only difference is that Wimax covers much wider area. One Wimax base stations can be connected to several other base stations using high speed microwave link, this link is usually known as backhaul. This way Wimax roaming can be achieved and connections can be maintained on move.

3.2 Standard Wimax Architecture:

The connectivity of Wimax network with an IP based network normally selected by the operator serving as ISP (Internet Service Provider) could be understood by the architecture proposed by Wimax Forum. Along with packet switched mobile network, the Wimax BS(base station) is capable of integration with other architectures. Reference points and some components are defined between the labels of R1 to R5 and R8:

- The Access Service Network (ASN)
- The Subscriber Station/Mobile Station (SS/MS)
- Base Station (BS)
- The Connectivity Service Network (CSN)
- Home Agent (HA)
- A part of ASN, its Gateway (ASN-GW)
- Authentication, Authorization and Accounting (AAA)
- NSP (Network Service Provider)
- NAP (Network Access Provider)

Wimax network is based on three basic components like ASN gateway, CSN and MS. The basic network has a central IP core which is surrounded by an ASN gateway, which is connected to service network or CSN. The main IP core is attached to the internet backbone for help and coverage. The Wimax network which is also part of the ISP network is known as access service gateway. This ASN handles the micro and macro base stations, which provide Wimax access to end users. The connectivity service network or CSN is an important part of Wimax architecture which provides the authentication to the user devices. CSN is also responsible for providing roaming among the network service providers. It is CSN which is responsible for user security and quality for service for this purpose it uses several protocols. The IP address management is also handled by CSN. IP core is in the middle of CSN and ASN. CSN provides the internet and telecommunications connectivity. ASP communicates to the base stations and the mobile stations. At the users end the Wimax architecture may further contain firewall for security. Wimax architecture provides discretion at user end to make possible amendments.
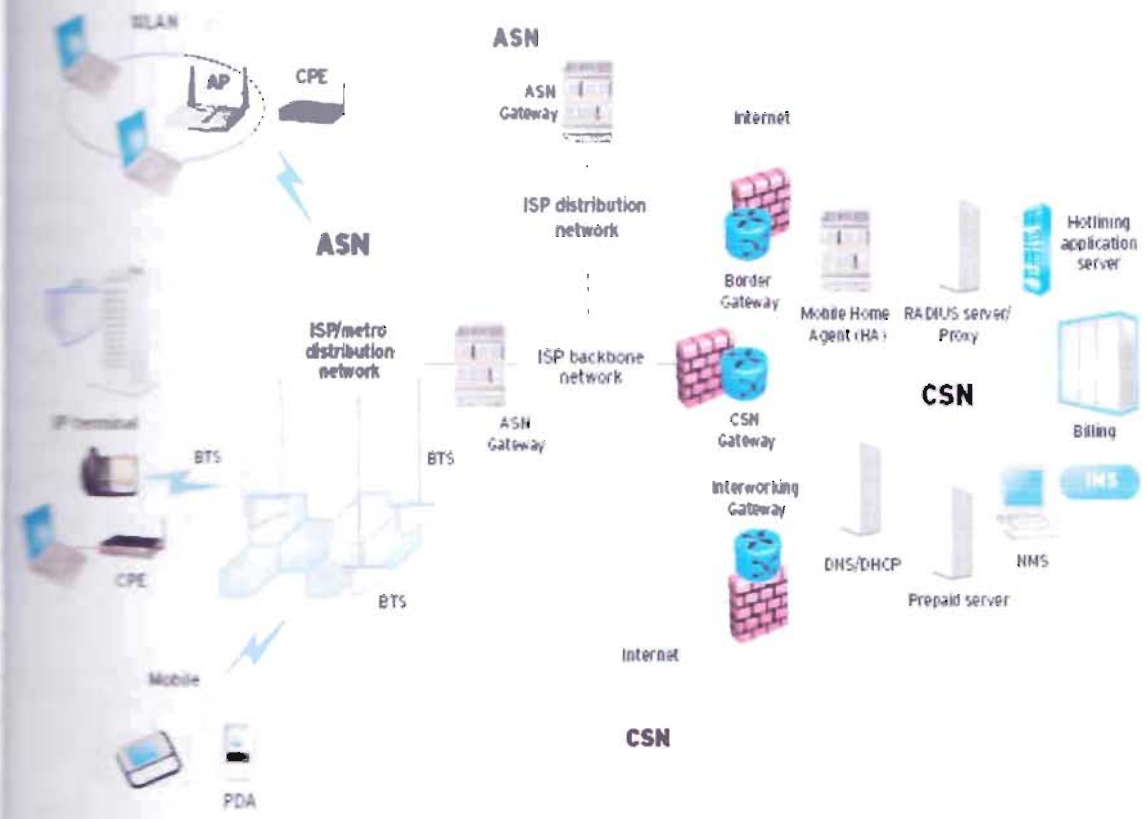
Figure 2: Complete Architecture Diagram of Wimax

The Wimax Forum has proposed an architecture that defines how a Wimax network can be connected with an IP based core network, which is typically chosen by operators that serve as Internet Service Providers (ISP). It is important to note that the functional architecture can be designed into various hardware configurations rather than fixed configurations. It is possible to shape the functional architecture not into fixed configurations but into a number of hardware configurations: the flexible architecture allows BS of different sizes and static/moving stations of changing scale and functionality.

3.3 Components of Wimax Network Architecture:

There are three main components of Wimax network architecture. The first component is the mobile stations which are used as a source of network connection for end user. The second network is an access service network which is formed of more than two or three base stations. It also contains ASN gateways which build the radio access at the end.

The third component is connectivity service network which is responsible for providing IP functions. The base station provides the air interface for the mobile stations. The base stations also provide mobile management functions, triggering and tunnel establishment, radio resource management, dynamic host control protocol proxy, quality of service enforcement and multicast group management. ASN is responsible for radio resource management, encryption keys, routing to the selected network and client functionality. Connectivity service network is responsible for internet connections, corporate and public networks and many other user services.

3.3.1 Physical layer:

The Wimax physical layer is based on orthogonal frequency division multiplexing. OFDM is the transmission scheme of choice to enable high-speed data, video, and multimedia communications and is used by a variety of commercial broadband systems, including DSL, Wi-Fi, Digital Video Broadcast-Handheld (DVB-H), and MediaFLO, besides Wimax. OFDM is an elegant and efficient scheme for high data rate transmission in a non-line-of-sight or multipath radio environment. Because the physical layer of Wimax is quite flexible, data rate performance varies based on the operating parameters. Parameters that have a significant impact on the physical-layer data rate are channel bandwidth and the modulation and coding scheme used. Other parameters, such as number of sub channels, OFDM guard time, and oversampling rate, also have an impact. Table 3 shows the PHY-layer data rate at various channel bandwidths, as well as modulation and coding schemes:

Channel Bandwidth	3.5MHz		1.25MHz		5MHz		10MHz	
PHY mode	256 OFDM		128 OFDMA		512 OFDMA		1,024 OFDMA	
Oversampling	8/7		28/25		28/25		28/25	
Modulation & Code Rate	PHY-Layer Data Rate (kbps)							
	DL	UL	DL	UL	DL	UL	DL	UL
BPSK, ½	946	326	Not applicable					
QPSK, ½	1,882	653	504	154	2,520	653	5,040	1,344
QPSK, ¾	2,822	979	756	230	3,780	979	7,560	2,016
16QAM, ½	3,763	1,306	1,008	307	5,040	1,306	10,080	2,688
16QAM, ¾	5,645	1,958	1,512	461	7,560	1,958	15,120	4,032
64QAM, ½	5,645	1,958	1,512	461	7,560	1,958	15,120	4,032
64QAM, 2/3	7,526	2,611	2,016	614	10,080	2,611	20,160	5,376
64QAM, ¾	8,467	2,938	2,268	691	11,340	2,938	22,680	6,048
64QAM, 5/6	9,408	3,264	2,520	768	12,600	3,264	25,200	6,720

Table 3: PHY-layer data rate at various channel bandwidths

3.3.2 MEDIA ACCESS CONTROL, MAC (data link) layer:

The IEEE 802.16 MAC was designed for point-to-multipoint broadband wireless access applications. The primary task of the Wimax MAC layer is to provide an interface between the higher transport layers and the physical layer. The MAC layer takes packets from the upper layer. These packets are called MAC service data units (MSDUs) then organizes them into MAC protocol data units (MPDUs) for transmission over the air. For received transmissions, the MAC layer does the reverse. The IEEE 802.16-2004 and IEEE 802.16e-2005 MAC design includes a convergence sublayer that can interface with a variety of higher-layer protocols, such as ATM TDM Voice, Ethernet, IP, and any unknown future protocol. The 802.16 MAC is designed for point-to-multipoint (PMP) applications and is based on collision sense multiple accesses with collision avoidance (CSMA/CA).The MAC incorporates several features suitable for a broad range of applications at different mobility rates, such as the following:

- Privacy key management (PKM) for MAC layer security. PKM version 2 incorporates support for extensible authentication protocol (EAP).

- Broadcast and multicast support.
- Manageability primitives.
- High-speed handover and mobility management primitives.
- Three power management levels, normal operation, sleep and idle.
- Header suppression, packing and fragmentation for efficient use of spectrum.
- Five service classes, unsolicited grant service (UGS), real-time polling service (rtPS), non-real-time polling service (nrtPS), best effort (BE) and Extended real-time variable rate (ERT-VR) service.

These features combined with the inherent benefits of scalable OFDMA make 802.16 suitable for high-speed data and bursty or isochronous IP multimedia applications. Support for Qos is a fundamental part of the Wimax MAC layer design. Strong QoS control is achieved by using a connection-oriented MAC architecture, where all downlink and uplink connections are controlled by the serving BS. Wimax also defines a concept of a service flow. A service flow is a unidirectional flow of packets with a particular set of QoS parameters and is identified.

Chapter 4

Survey:

4.1 Basic of Survey:

A RF survey provides the necessary information for a complete Wimax network blueprint, or design, which is needed in order to minimize hurdles and costly mistakes as the network is being built-out. There are many tools, databases and mapping resources available that were developed specifically for Wimax network. Different steps of survey are given below:

4.1.1 RF Survey:

RF engineers are provided nominal id, site id, site address, current position of the site etc. When an engineer reaches at the site(roof top), his first duty is to draw a layout of the roof top in a paper. Then he chooses where the antenna will be set and draw the antenna position in the paper. There will be three antenna covering 360^0. Each antenna is 120^0 apart. The north antenna is called sector 0 the next one called sector 1 and the last one called sector 2. The engineers have to find whether there is any obstacle in front of the antenna. If any then he has to write detail about the obstacle. Finally the engineer has to take picture of the site, of the GPS and 12 panoramic pictures to show the surrounding environment.

In my internee experience, I once went in a RF survey. All the work were done smoothly, but suddenly we found that there is an under construction building and if it goes over 7 floor then it will block sector 1 to pass signal. We wrote about this problem at the paper. Later the office takes detail information about the ongoing building. The building is about to be 10 floor. So it will definitely bock sector 1. So, the antenna position has to change later.
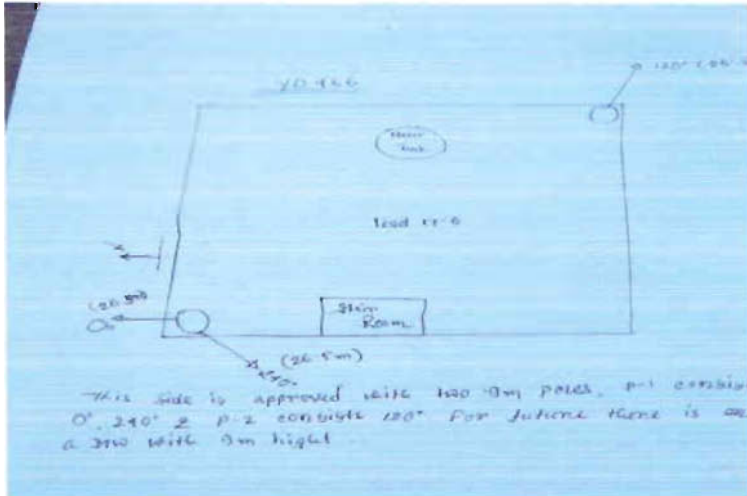
Figure 3 : Position of antena in a RF survey

4.1.2 TSS Survey:

It's a post BTS installment work. RF engineers are provided previous RF survey report, from where all information can be found that they need during this technical Site Survey (TSS). Operator RF engineer and civil engineer team also present on the site. Site technical works are same as the RF survey.

In my internee duty I have the experience to go in TSS survey. In the spot the engineer decide where the antenna will be established and draw a layout picture of the roof and point where the antenna will be situated. We also noted special notification like if there is any obstacle to scene of a chance to be an obstacle.

4.1.3 RF Verification:

RF verification is a process where the antenna's real parameter is measured. The antenna height, azimuth and tilt are measured. RF verification is a post installment work. The main purpose of RF verification is to check whether the antenna position, height, azimuth and tilt are properly steeled or not. Normally there is some change in the real time.

Chapter 5

Drive Test

5.1 Drive Test overview:

Drive-test (DT) plays an important role in creating and maintaining a strong Wimax network. In mobile communication system drive test should be used to collect real-time RF information from the field. Generally this is done using a vehicle, but it can also be carried out on foot where circumstances dictate (like inside a building for ibs Testing).

In any case, keeping Wimax network optimized is vital. Changes in the environment continually affect network performance. Operator can't afford to have unhappy subscribers because there are holes in their coverage or because interference is causing dropped or blocked calls. To migrate to new technologies and applications operators need a drive-test system that will expand with their needs.

Doing drive test is a very challenging work. My first drive test was in Motijhil region in technical term it is called cluster 8. The term cluster means an area with some site (bts). Normally pre-dt held before the cluster or site is on air. So, the whole site turns on only for DT. The bts power on, the radio signal starts working. Its cost huge. So, it's very important to finish DT timely but properly. At the beginning of DT, I connect the converter, GPS, modem with the laptop. Then prepare the laptop for DT by opening XCAL-X and imported the bts info, DT route.

During the DT I carefully observe that is everything going well or not. I have to be very careful about the gps. Sometimes it goes out of connection then the port connection has to be configured again. To ensure a good log data the vehicle speed should be under 30 km /hr. Many more things to care in DT. There are three sector (antenna) covering 180^0. When the vehicle goes one sector coverage area to another sector coverage area then normally handover occurred. If it doesn't then the log data shows poor signal. To avoid this, I stop taking data and reconnect the modem. Then the handover happened. To get a better log result, I start download and upload.

5.1.1 Drive Test Hardware:

5.1.1.1 Power Inverter:

Inverter inverts DC power to AC power. Normally a DT takes place for 7 or 8 hours. The laptop cannot back up for the whole time. So inverter is used to give power supply to the laptop from the battery of the car. Inverter insures continuous power flow to the laptop.

Figure 4: Power inverter

5.1.1.2 Laptop:

Laptop is used in DT to collect data. The DT laptop should be high configured.

5.1.1.3 GPS:

The Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS) that provides location and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites. GPS is generally used for positioning purpose. In DT, positioning is very important both for visualization (current position during DT) and analytical point of view.

5.1.1.4 Modem:

One of the most important hardware for drive test is modem. It gathered data from the base station.

5.1.2 Drive Test Software:

5.1.2.1 Digital Map:

During drive test digital map is necessary for finding the way to reach the selected site/cluster and do DT according to some predefined routes. We can load the digital map of the whole region or we can load the map of some specific roads that is required for drive test. This map comprises all the accessible DT routs.

5.1.2 .2 Cell file:

We must load the cell file into the data collection software. A cell file contains all the necessary information related to the site, like ID of that site, assigned frequencies of that site, direction of the antennas of that site etc. Whenever we load the cell file we can see the position of that site in the digital map. Then we can easily find out our required sites from the map and also the roads to be covered for that site.

5.1.2 .3 XCAL-X:

X CAL-X is a real time, mobile data collection tool supporting mobile Wimax. XCAL- X enables the user of a service provider, system or mobile vendor to troubleshoot, maintain, optimize and benchmark mobile wimax systems and networks with one revolutionary tool. Logging and decoding PHY and MAC layer information, and also packet data of at command. XCAL automatically records and deciphers messages from the air-interface to detect network bottlenecks and impediments to delivering high quality voice and data services. The subsequent measurement results are a valuable input across the network enterprise from network planning and optimization, roll-out, new service verification and maintenance division. Key parameters from XCAL may be stored for more in-depth analysis in XCAP, accuser's leading post-processing solution.
Features of XCAL-X:

- XCAL supports Wimax standard
- Supports Wimax scanner
- Logging and decoding PHY and MAC layer information, and also packet data of at command.
- Status and information statistics.
- Voice alarm and information

- Log files reply function with adjustable speed.
- End to end application testing (SMS,Ping, E-Mail, VoIP etc)

5.1.2.4 XCAP-X:

XCAP-X is a powerful post- processing engine that enables the user such as a service provider, system vendor, mobile vendor and application provider to mine data gathered from XCAL-X. Designed to support RF optimization engineers with all levels of engineering expertise, the easy to use 'drag and drop' means that it can be mastered quickly and can be immediately utilized through all network. CAP-X presents data in various forms: tables, graphs, maps, message list and even powerful correlation graphs. As such it delivers an unsurpassed ability to analyze and visualize drive-test data both spatially and geographically.
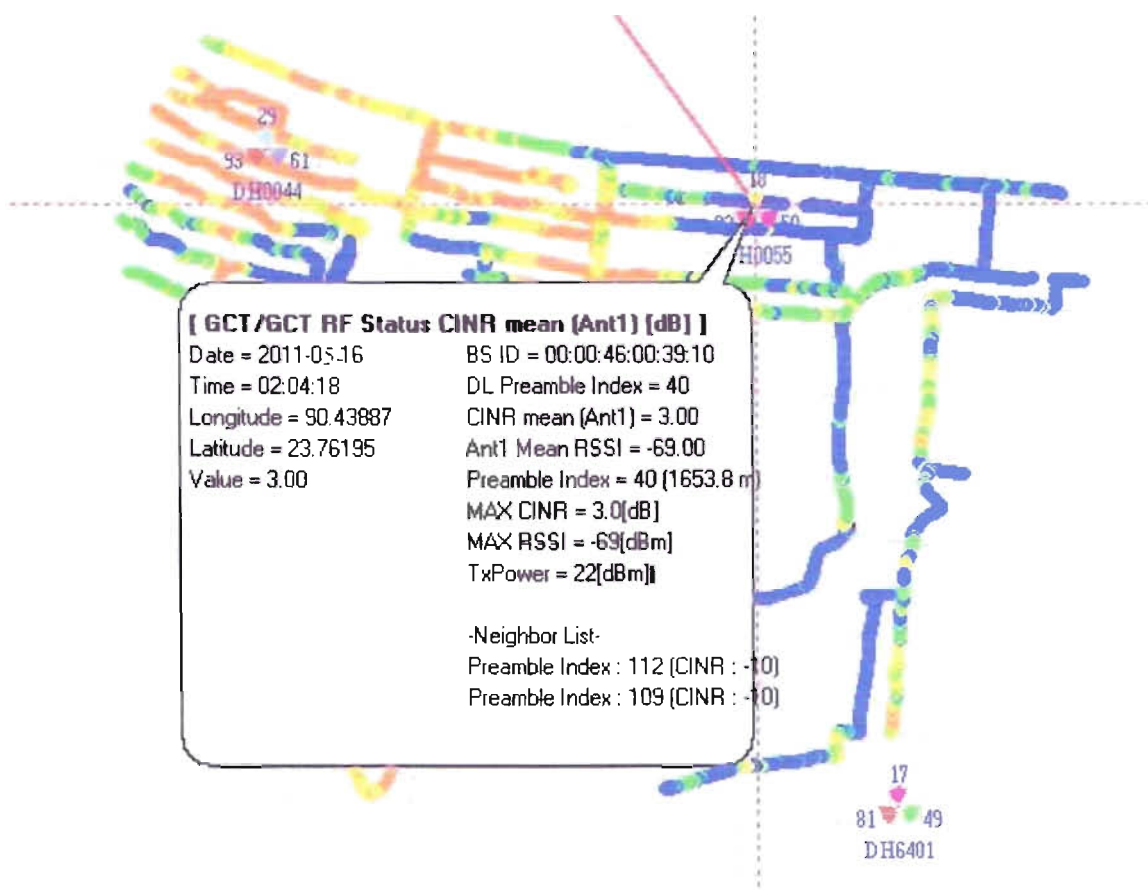

Figure 5: X Cap view

5.1.2.4.1 Carrier-to-noise ratio(CINR) :

In telecommunications, the carrier-to-noise ratio, often written CNR or C/N, is the signal-to-noise ratio (SNR) of a modulated signal. The term is used to distinguish the CNR of the radio frequency pass band signal from the SNR of an analogue base band message signal after demodulation, for example an audio frequency analogue message signal. If this distinction is not necessary, the term SNR is often used instead of CNR, with the same definition.

Digitally modulated signals are basically made of two CW carriers (the I and Q components, which are out-of-phase carriers). In fact, the information (bits or symbols) is carried by given combinations of phase and/or amplitude of the I and Q components. It is for this reason that, in the context of digital modulations, digitally modulated signals is usually referred to as carriers. Therefore, the term carrier-to-noise-ratio (CNR), instead of signal-to-noise-ratio (SNR) is preferred to express the signal quality when the signal has been digitally modulated.

High C/N ratios provide good quality of reception, for example low bit error rate (BER) of a digital message signal, or high SNR of an analogue message signal.

The carrier-to-noise ratio is defined as the ratio of the received modulated carrier signal power C to the received noise power N after the receive filters:

CNR = C/N

When both carrier and noise are measured across the same impedance, this ratio can equivalently be given as:

$$\mathbf{CNR= (V_c/V_N)^2}$$

Where V_C and V_N are the root mean square (RMS) voltage levels of the carrier signal and noise respectively.

C/N ratios are often specified in decibels (dB):

$$\mathbf{CNR_{dB}=10\ log_{10}\ (\ C/N)= C_{dB}-N_{dB}}$$
or in term of voltage:

$$\mathbf{CNR_{dB}=10\ log_{10}(V_c/V_N)^2=20\ log_{10}(V_c/V_N)}$$

The C/N ratio is measured in a manner similar to the way the signal-to-noise ratio (S/N) is measured, and both specifications give an indication of the quality of a communications channel.

In the famous Shannon–Hartley theorem, the C/N ratio is equivalent to the S/N ratio. The C/N ratio resembles the carrier-to-interference ratio (C/I, CIR), and the carrier-to-noise-and-interference ratio, C/(N+I) or CINR.

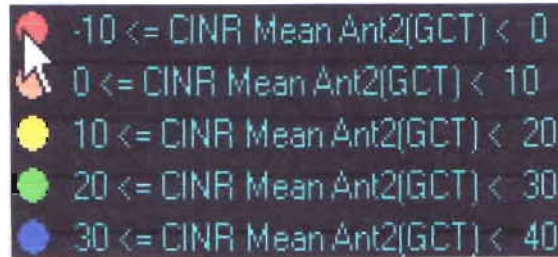The value of CINR for different color is given below:

Figure 6 : Color parameters of CINR

The values of CINR range from −10 dB to 40 dB, depending on terminals. The quality standard of CINR should be defined as follows:

Good: CINR = 20 dB
Fair: 10 dB = CINR < 20 dB
Poor: CINR < 10 dB

5.1.2.4.2 Received signal strength indicator:

In telecommunications, received signal strength indicator (RSSI) is a measurement of the power present in a received radio signalers' is generic radio receiver technology metric, which is usually invisible to the user of the device containing the receiver, but is directly known to users of wireless networking of IEEE 802.11 protocol family.

RSSI is often done in the intermediate frequency (IF) stage before the IF amplifier. In zero-IF systems, it is done in the baseband signal chain, before the baseband amplifier. RSSI output is often a DC analog level. It can also be sampled by an internal ADC and the resulting codes available directly or via peripheral or internal processor bus.

In an IEEE 802.11 system RSSI is the relative received signal strength in a wireless environment, in arbitrary units. RSSI is an indication of the power level being received by the antenna. Therefore, the higher the RSSI number (or less negative in some devices), the stronger the signal.

RSSI can be used internally in a wireless networking card to determine when the amount of radio energy in the channel is below a certain threshold at which point the network card is clear to send (CTS).Once the card is clear to send, a packet of information can be sent. The end-user will likely observe a RSSI value when measuring the signal strength of a wireless network through the use of a wireless network monitoring tool. RSSI measurements are unit less and in the range 0 to 255, expressible as a one-byte unsigned integer. The 802.11 standard does not define any relationship between RSSI value and power level in mW or dBm. Vendors provide their own accuracy, granularity, and range for the actual power (measured as mW or dBm) and their range of RSSI values (from 0 to RSSI_max).

RCPI (Received Channel Power Indicator) is an 802.11 measure of the received RF power in a selected channel over the preamble and the entire received frame.

RCPI is exclusively associated with 802.11 and as such has some accuracy and resolution enforced on it through 802.11k. A similar, but not identical, metric is the RSSI (received signal strength indication), which also aims to provide some level of classification of the received signal. Both have their respective merits and uses.

Indeed, received signal power level assessment is a necessary step in establishing a link for communication between wireless nodes. However, a power level metric like RCPI generally can't comment on the quality of the link like other metrics such as travel time measurement.
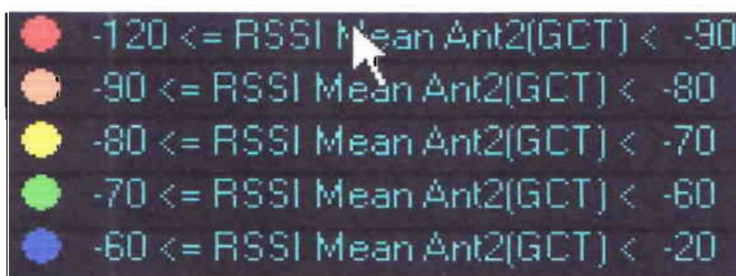The value of RSSI for different color is given below:

Figure 7: Color parameters of RSSI

The quality standard of RSSI should be defined as follows:

Good: RSSI = –75 dB

Fair: –85 dB = RSSI < –75 dB

Poor: RSSI < –85 dB

5.1.3 Drive test Procedure:

5.1.3.1 BTS Information and Map Importing:

After opening the XCAL-X software to display the BTS(Base Transmission Station) information in the real time mapping, perform the settings as follows:
Choose Setting > BTS Manager. At the lower left corner of the displayed window, click import. In the displayed BtsImportDlg window, select the BTS information table and then click Import. The BTS information is imported.

5.1.3.2 Real Time Mapping:

After importing the BTS information and setting the map by using the methods described, the related information is displayed in the real time mapping window, as shown below. The real Time mapping includes the control icon, phone tab, parameters, legend and map.
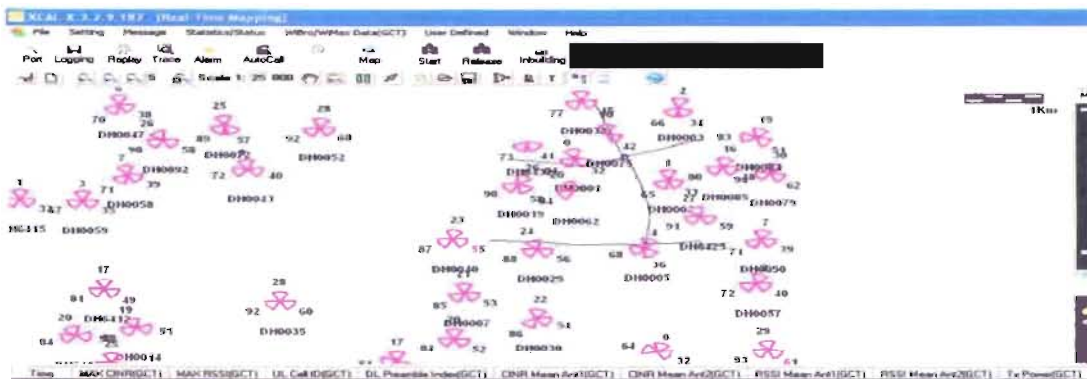

Figure 8: Bts information in real time mapping

5.1.3.3 Map:

By the help of map we can import the necessary roads and the cell files to click (+) import icon and then finally click OK to confirm about the map.
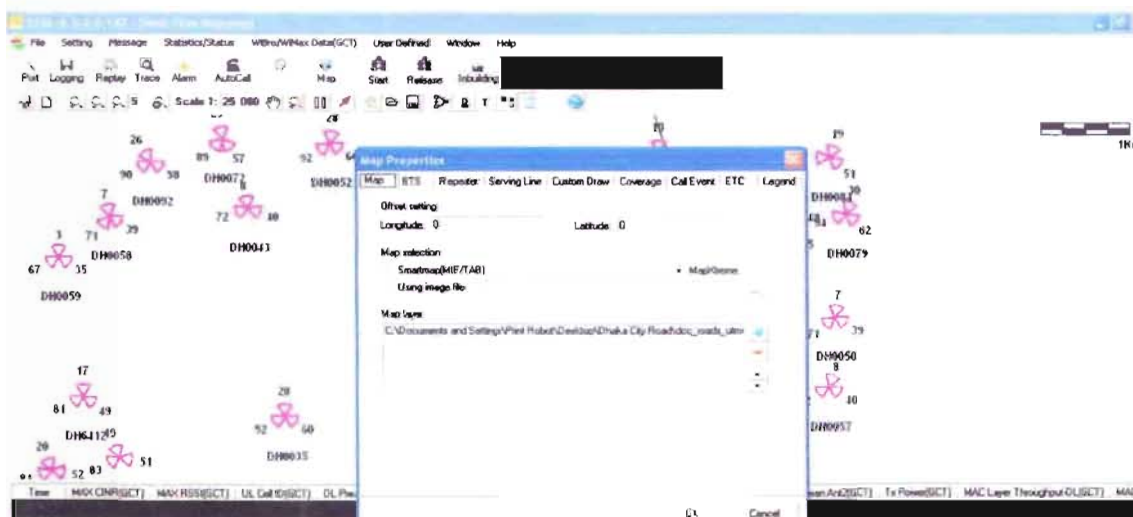

Figure 9: Importing roads and cell files

5.1.3.4 BTS:

By the help of BTS we can change the BTS width, color, size and measure the preamble, azimuth, and angle.
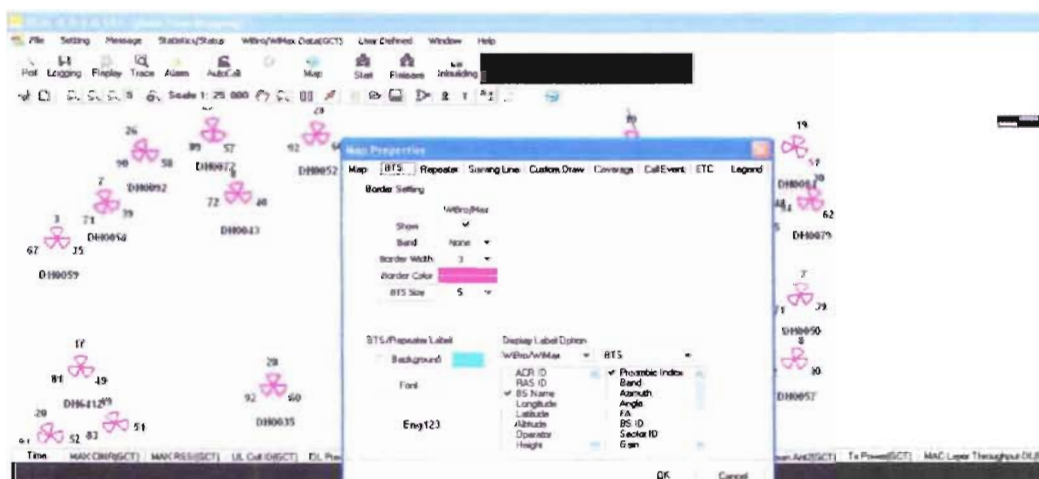

Figure 10: Changing BTS shape and size in real time mapping

5.1.3.5 Call Event:

By the help of call event we can measure how much call become success, failure, hand-over and over all call processing.
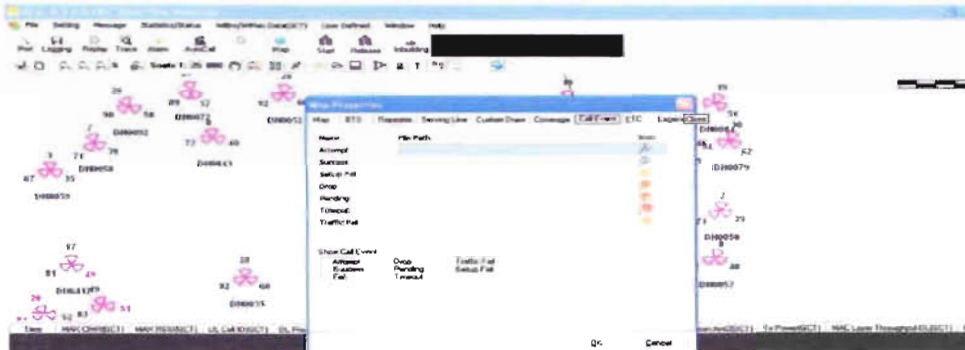

Figure 11: Call event setting

5.1.3.6 Legend:

By the help of legend we can change the CINR and RSSI values color which is helpful in the DT time.
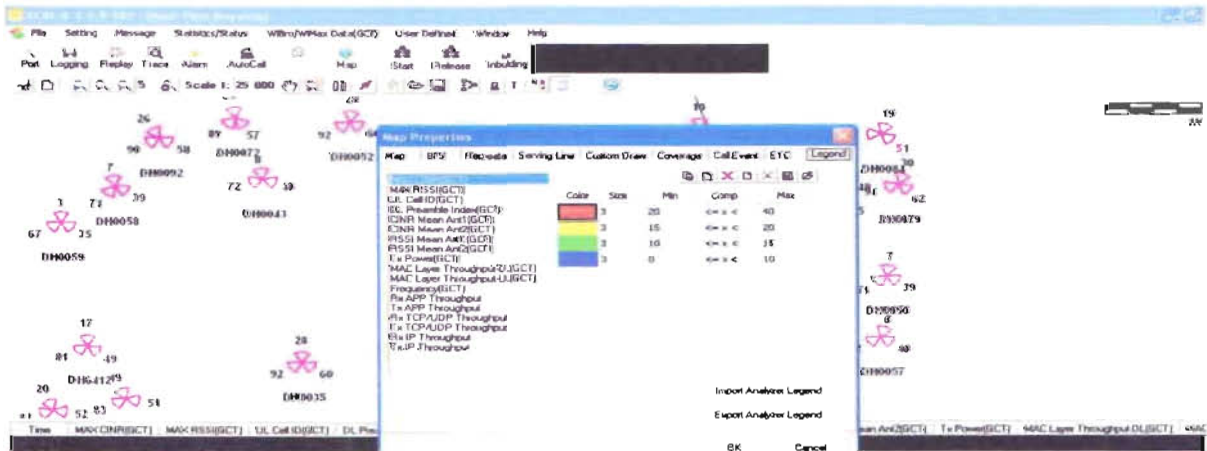

Figure 12: Color setting for CINR and RSSI value

5.1.3.7 Log Data and Test Items

After completing the above preparations choose setting > Log File Setting. From the save log file at the user defined path box in the displayed interface, select the path to save the test log file.
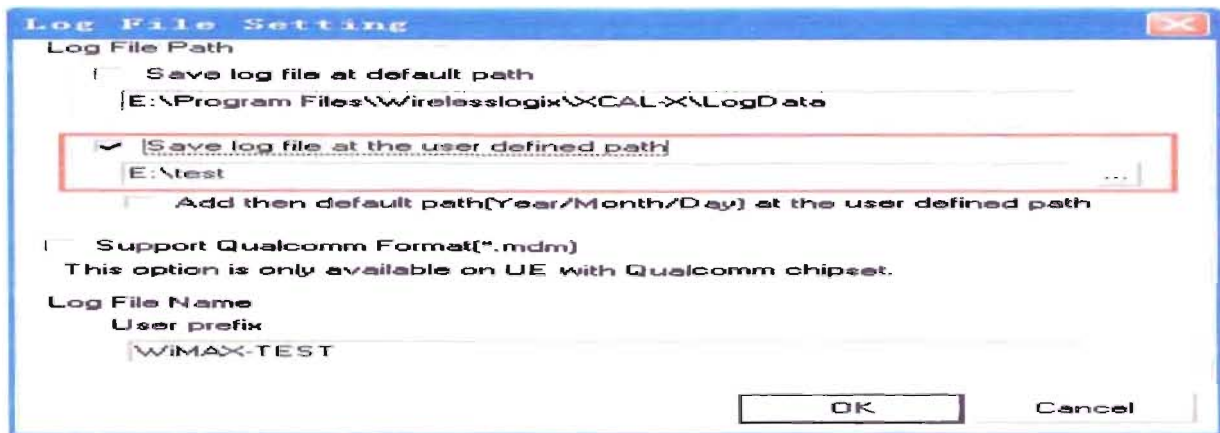

Figure 13: Save destination setting

5.1.3.8 Save and Stop the Log Data:

Log data must be saved during the test, click logging, and then select the path for saving the log data in the displayed window. After the test is complete, click logging again to stop the log data.

Figure 14: Start and stop log

Chapter 6

Single site verification (SSV)

6.1 SSV :

SSV means single site verification. The engineer verifies single sites by test and check the cell status and service connection conditions in the verification in idle mode and verification in connected mode. Check whether the frequency number of the cell to be measured is consistent with the planned data. Four things are done in SSV for each of three sectors.

6.1.1 Download:

Download implies specifically receive and save. Download means to receive data to a local system from a remote system or to initiate such a data transfer. In contrast, the term downloading is distinguished from the related concept of streaming, which indicates the receiving of data that is used near immediately as it is received, while the transmission is still in progress.

In SSV download log is measured by special process. Normally to measure download in SSV 20 mbps speed is used. For this test, special account is used. Starting to take the download log the engineer first changes the modem account from 4mbps to 20 mbps. Then he tries to increase the download rate by starting various download option by using internet download manager, torrent and special dedicated server by Huawei. When the download rate reached at least 14 mbps. Then the log file to save for 3 minutes.

In my internee duty when I was taking log data from down load I faced some problem. First I have to increase the download speed at least 14 mbps. I used DU meter to see the download speed also started the stop watch from DU meter. I collect download log data for 3 minutes. During this time I carefully noticed the download speed. If the speed decreases below 14 mbps even for a few second the log data is rejected. So many time in my duty I reject the log data for this reason and done it again.

6.1.2 Upload:

Upload can refer to the sending of data from a local system to a remote system such as a server or another client with the intent. In SSV after taking the download log file upload log file is

taken. During this all the download option is stopped. When taking log file the upload speed should must be above of 4 mbps. The log file is saved for 3 minutes.

In my work when taking log data during upload the most challenge is to keep the upload rate above 4 mbps. If it decreases below 4 mbps the data is rejected. Upload task is similar as the download.

6.1.3 Handover:

One of the special features of Wimax is mobility. If a user change his position from one sector to another sector then automatically hand over occur. Engineer collects the handover log file separately.

In the real time work upload and down load log data is saved using mega account. But in case of handover the account is changed into normal account. First I create 6 folder to save 6 different handover log data. In X-cal there is a line which shows which sector(antenna) is serving in the network. If the serving line change from one sector to another sector then the log data is saved.

6.1.4 Auto Call Test:

During auto call test multiple types of automatic calls, such as FTP (File Transfer Protocol), HTTP (Hypertext Transfer Protocol) and Ping. Engineer has to change setting, fixed parameters like server name, no of counted call, time of taking data etc. Here is an interface of auto call set up.
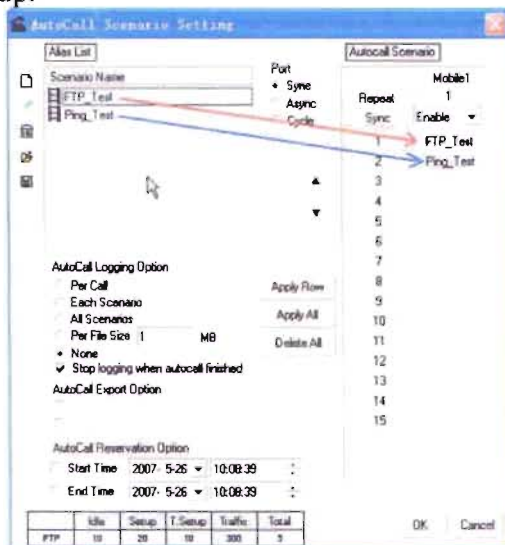

Figure 15: Auto call test interface

Chapter 7

Optimization

7.1 Optimization:

When the number of users increases, the system performance deteriorates and therefore RF optimization is necessary. The purpose of the RF optimization is to control the interference and the handover. Reduce the poor coverage area to ensure that signals can cover the area continuously. Control the coverage of each cell and overlap area.

7.1.1 Work Flow of RF Optimization:

- The data collection.
- Problem analysis.
- Adjustment.

7.1.1.1 The data collection:

RF optimization focuses on the strength of wireless signals on the network. Test methods mainly include DT test. Before the test, an engineer gets the test devices and determines the test route. In addition, co-operate with other engineers to check the gateway, BS work properly. If any problem is reported, solve the problem before performing the test. Make record during the test and record reported problems. After all preparations are completed, an engineer does DT test. Collect the wireless signal data received by scanner or terminal through the DT test. Analyze the test data for signal coverage, handover, and interference.

When I go in optimization drive test although every thing is same to the normal drive test but we were very careful about the log data. We have to take the best log result after optimization. To achieve good result we instruct the driver to drive the vehicle very slow and not more than 20 km/h. Because if the speed of the car get increased then it affects the log result. Even sometime we collect data more than one time to get the better result.

7.1.1.2 Problem analysis:

Three types of analysis is there for optimization:

- Coverage Analysis
- Interference Analysis
- Handover Analysis

Problem analysis is much difficult process and the most senior engineers take care of this sector. I don't learnt much more of problem analysis.

7.1.1.2.1 Coverage Analysis:

Coverage analysis is the major task of RF optimization. Coverage analysis focuses on signal distribution. Poor coverage, cross-cell coverage, and unbalance of uplink and downlink are the objects of coverage analysis.

7.1.1.2.1.1 Poor coverage:

Poor coverage means the RSSI of signals in covered areas is less than –85 dB, and the CINR of signals is less than 10 dB. Inside of tall buildings, elevator wall, tunnel, underground garage, basements are often areas with poor coverage. In these areas, the values of RSSI and CINR are very low. Too low CINR cannot meet the minimum requirement for network access. Thus, the successful rate of network access in these areas is low, or network disconnection occurs immediately after successful access.

7.1.1.2.1.2 Cross-Cell Coverage:

Cross cell coverage is mainly caused by the interaction of multiple sites. Cross cell coverage between sites mainly occurs in the urban areas where sites are installed densely, and the areas where the terrain is complicated. Cross cell coverage will degrade CINR, and decrease the network throughput. When strong cross cell coverage, the terminal may not access the dominate sector, or cannot access the network at all.

7.1.1.2.1.3   Unbalance of Uplink and Downlink and the Effect:

Unbalance of uplink and downlink means that the distance for downlink signals to be identified is more than the transmission distance for uplink signals to be identified. That is, the coverage range is determined by the weakest signals. In the case of unbalance of uplink and downlink, the terminal can receive signals but cannot process the services. The terminal can demodulate the signals of the site but cannot access the network. The rate of network disconnection increases. Increase the transmit power of terminals and Improve the receiver sensitivity of the site is the solution of this problem.

7.1.1.2 .2   Interference analysis:

Radio interference refers to interference that is generated during the radio communication, and can reduce the strength of useful signals, damage useful signals, or block the normal communication. It can affect the receiving of signals required for radio communication so that the performance is lowered, the quality is degraded, the information is erroneous or lost, and the communication is blocked. Therefore, the fact that useless radio signals cause lower quality or damage of received useless radio signals is called interference. . Interference will lead the degradation of CINR, hard to access network and decrease the network capacity.

7.1.1.2.3   Handover Analysis:

During RF optimization, main handover problems are related to the neighbor cell optimization and control of handover success rate in the drive test. The size and location of handover areas can be controlled by adjusting the RF parameters. In this way, the network disconnection caused by sudden changes of signals can be reduced, and the handover success rate can increase.

7.1.1.3 Adjustment:

Besides the neighbor cell list, engineering parameters can also be adjusted in RF optimization to solve the problem. Most problems about coverage and interference can be solved through the following methods:

- Adjust the antenna down tilt angle.
- Adjust the antenna azimuth.
- Adjust the antenna height.
- Relocate the antenna.
- Change the antenna type.
- Add the antenna baffle or install the antenna against the wall.
- Relocate the site.
- Add a site or RRU.
- Relocate the terminal.
- Use the terminal with high gain antenna.
- Use outdoor type terminal.

Chapter 8

Conclusion:

In conclusion I have to attest my UCE Telecom Solution Pvt Ltd. I really appreciate the way I have been guided through this internship program at UCE, beginning from the opportunity to take the time I needed to refresh and expand my knowledge in several issues concerning survey,drive test, single site verification and optimization. During my internee period I discover and learn to value my new working environment and finally earned the confidence to deal with assignments myself. It is through the UCE team that I did enjoy my work every day. Having a rare opportunity to use the knowledge and skills that I had acquired, I learned how to handle critical network faults and got new ideas.

Career-wise, the internship program undoubtly will enrich my curriculum vitae. Also, got a chance to interact with most staff, I have had an insight on how to shape my career towards a humanitarian job in the near future.

The internship program gave me a chance not only to work with UCE but also a chance to learn from the good experts. This would reflect much onto my experience. Working with different business organizations was a rare chance for me. It's a great opportunity to work with the highly efficient professional people.

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