CHAPTER-7
RF Planning of WiMAX

7.1 RF Planning :

The RF and data network engineering designs include development of overall system architecture, which will support features and requirement developed in the strategy and planning phase. RF design include propagation prediction for coverage (Fixed, Mobile, Indoor, Outdoor) ,
Frequency planning, capacity planning , model calibration and field measurement integration and design of new WiMAX-based services including data, voice and video for various applications such as consumer ISP, enterprise redundancy ,public safety surveillance ,and back haul services to name just a few.

7.2 Performing Site Survey

Before any equipment is deployed, there must be a site survey to determine what is needed in order to have a successful wireless operation. By understanding the dynamics of the market where the deployment will take place and planning accordingly, the service provider can ensure success on Day One of operations.

7.3 Link Budget

The figure above illustrates a link budget. It is the equation of the power of a signal transmitted minus detractions between the transmitter and receiver (rain, interference from other broadcasters, vegetation, gain at the antennas ate either end) and what signal is received at the receiver.

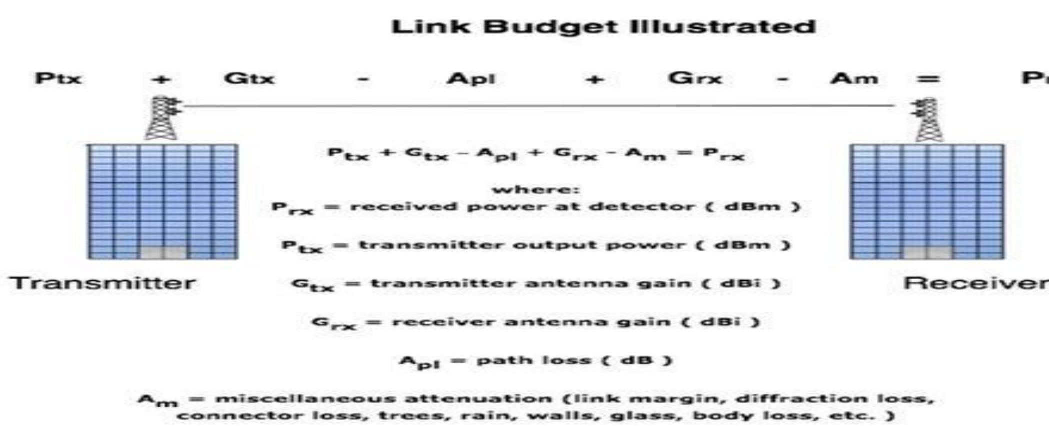


Fig: 7.3 Link Budget

7.4 Frequency Plan

Part of the site survey process is to determine a viable frequency plan. The wireless op-erator must make maximum use of limited spectrum assets.

The diagram above illustrates how a wireless operator (cellular, WiMAX, etc) uses their limited spectrum allocation to deliver the best service possible while avoiding interference between their base stations. Note there are nine different base stations with three different frequencies but no similarly shaded circle touches another. If they did touch, there would be interference between base stations because they would be operating on the same frequency.

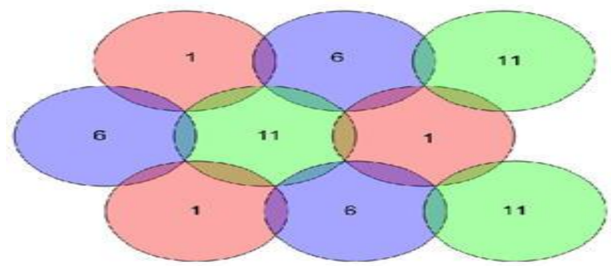


Figure : 7.4 By reusing frequencies at different base station for WiMAX

7.5 Fractional-Frequency Reuse in WiMAX

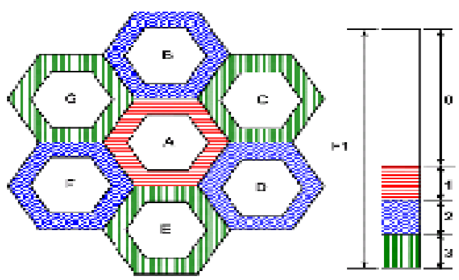


Fig :7.5Example of FFR Scheme in case that FRF in Cell core is one and FRF in cell boundary is 1/3

Frequency spectrum is a limited and increasingly expensive resource. Wireless network operators or WISPs often have to compete in acquiring licenses to operate on frequencies of
their choice. Of course, they still have another alternative, that's using free spectrum in license-exempt bands. But then, they have to find the means to control interference from other networks sharing the same band and to limit spillover to other users of the band

Mobile WiMAX in mobile mode (remember, Mobile WiMAX also supports fixed mode) will be deployed lijte a cellular network (2G, 3G), requiring a large number of base stations to have a considerable coverage. So in most cases it will operate in licensed bands. Operation in unlicensed bands may be
Considered only for greenfield deployment where there are no other users of the same spectrum.

To get rid of the interference of cell users in cell boundary, Fractional frequency reuse has been proposed.

In the above figure, Fl, F2, and F3 are different sets of sub-channels, allocated to users at cell edge.

F = F1+F2+F3. The whole sub-channels (F) are allocated to users at cell centers.

Regardless of licensed or unlicensed spectrum, frequencies have to be used efficiently. Therefore, it's crucial to maintain frequency reuse one. Frequency reuse one is achieved when all sectors within a cell and all cells within a network operate on the same frequency channel.
However, frequency reuse one in a cellular network implies that users at a cell edge may get degraded signals due to interference from adjacent cells.

Mobile WiMAX addresses this issue by "tweaking" the frequency reuse one. It works by allowing users at a cell center to operate on all available sub-channels. Cell center is the area closer to a base station (BS) that is particularly immune to co-channel interference. While users at a cell edge are only allowed to operate on a fraction of all available sub-channels. This sub-channels fraction is allocated in such a way that adjacent cells' edges will operate on different sets of sub-channels (see picture above). This is called fractional frequency reuse.

Fractional frequency reuse takes advantage of the fact that a Mobile WiMAX user transmits on sub-channels (because in OFDMA, a channel is divided into sub channels) and doesn't occupy an entire channel such as in 3G (CDMA2000 or WCDMA). Fractional frequency reuse maximizes spectral efficiency for users at a cell center and improves signal strength and throughput for users at a cell edge.

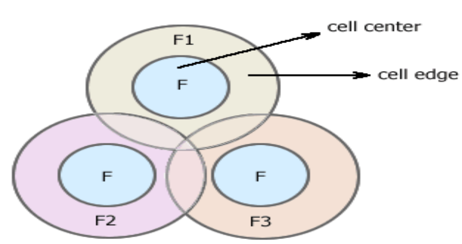
7.6 Virtual-Cell frequency reuse for WiMAX as an OFDM based wireless technology:

A subset 0 of system channel bandwidth, F1, is for inner region so that FRF is one. And the other subsets 1, 2 &3 of F1 is allocated in partitioned three outer regions in a cell, respectively, so FRF is also one.

In this scheme, frequency subsets allocated in a part of outer regions are different among cells.

For example,

Sector A_1 in cell A uses a subset 1,



A_2 uses a subset 2,

A_3 uses a subset 3.

In an adjacent cell B:

B_1 uses a subset 3,

B_2 uses a subset 1,

B_3 uses a subset 2.

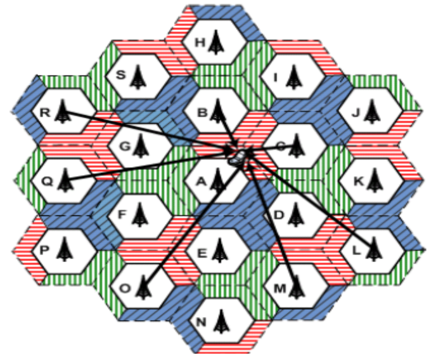


Fig: 7.6.a Fractional frequency reuse

In other adjacent cell C:

C_1 uses a subset 2,

C_2 uses a subset 3,

C_3 uses a subset 1.

Therefore, adjacent three sectorized outer regions from three different cells, A_1,B_2, and C_3 ,make a virtual cell using same subset of system channel bandwidth. And this reuse pattern repeats through all the system.

VCFR enhance the spectral efficiency compared with fractional frequency reuse (FFR). Because VCFR scheme can utilize all the sub-carriers allocated in a cell while FFR unable to use a part of it. And reuse distance of outer region is increased as illustrated by Fig. 2 (b), so it overcomes CCI in cell boundary compared with sectorization scheme.

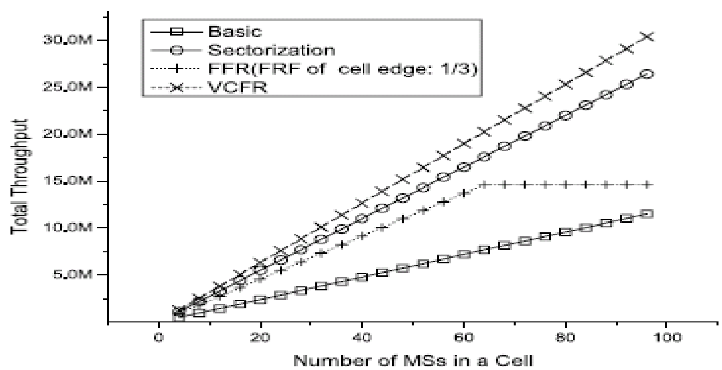


Fig. 7.6..b Shows the throughput of four scheme, basic, sectorization, FFR, and VCFR.

- In the basic scheme entire cells in the system use the same channel bandwidth. Therefore the throughput for basic scheme is worst since there is inevitably, inter-cell interference.
- FFR reduce Co-channel interference in cell boundary, however, interference in cell core exist like basic scheme as FFR of cell core is one.

- In sectorization scheme , interference from other cell is alleviated by using directional antenna, it achieves better performance compared with basic and FFR schemes. However, sectorization scheme do not consider users in cell boundary, so that throughput of it less than that of proposed VCFR.

7.7 Base Station:

WiMAX base stations transmit up to 30 miles, but because it is a cell-based topology, would yield a more typical range of 3 to 5 miles. WiMAX systems can deliver a capacity of up to 75 Mbps per channel, for fixed and portable access applications. As such, WiMAX can bring the underlying Internet connection needed to service local Wi-Fi networks.

7.7.1 Base station Frequency Assignment:

-Optimize frequency use compared to simple reuse methods.

-Fully automatic or with manual adjustment.

-Reassign entire networks or assignment of added stations.

- Automatically assign polarization.

For Fixed WiMAX preferred Frequency Bands to the Base station 2.5GHz,3.4-3.6 GHz,5.8GHz (uplink & down link).For Mobile WiMAX preferred Frequency Bands to the Base station 2.3-2.4 GHz,2.5-2.7 GHz,3.3-3.4 GHz,3.4-3.8 GHz.

7.7.2 Base station Location:

A WiMAX base station comprises of internal devices and a WiMAX tower. A base station can normally covers the area of about 50 kilometers or 30 miles radius, but some other and environmental issues bound the limits of WiMAX range to 10 km or 6 miles. Any wireless user within the coverage area would be able to access the WiMAX services.

7.8 Coverage capacity:

-Calculations of sector coverage based on power.

-Finding the best spots for base stations (where the most of client locations).

-Finding suitable spots for clients.

- Determination of required antenna heights.

-Populations coverage.

-Address search supports marketing.

7.9 Tariff planning:

- Search in address databases of population databases for possible Subscribers covered.

-Tariff maps with subscriber’s penetration per terrain class and user defined hot-spots.

7.10 Handoff Strategy in WiMAX

Handoff is a process to transfer the information of the MS from one cell to another as soon as the MS trying to access a new cell. Two types of handoffs such as Break-Before-Make (**BBM**) handoff and Make-Before-Make (**MBB**) handoff are used in WiMAX.

Break Before Make (BBM) handoff :

- In BBM handoff referred as hard handoff, serving base station connected to a user releases the allocated channel, before it transfer to target base station located in a cell that the user intends to move.

- In general, BBM handoff is used in the OFDMA- based wireless network because each cell used the same system channel bandwidth.

Make Before Break (MBB) handoff :

- In MBB handoff referred as soft handoff, the connection to the target base station is established before the connection to the serving base station is broken.

- Make Before Breake handoff, however, will be necessity for micro-cell environments, because handoff will frequently occur due to the very

- This concept can be applied to beyond 3G or 4G communication system including wimax and LTE.. As cell size decreases, frequency reutilization and capacity increase. However, this leads numerous BS and induces inter cell handoff frequently. If handoff has failed, the service may be temporarily disrupted or even terminated abnormally

- The smaller the cell size is, the more necessity of MBM handoff is required to provide seamless service.

- In IEEE 802.16e system, BBM handoff is default mode and MBB is optional. All the cells use the same frequency channel in OFDMA system, because its frequency reuse factor (FRF) becomes one.

- Hence ,BBM handoff is inevitable in sectotization and fractional frequency reuse scheme..

7.11 Complete Signal Chain Solution for WiMAX and Wireless Infrastructure:

- **Direct Conversion RX/TX**
- **Heterodyne RX/TX**
- **Hi-Perf WiMAX 802.16, 2.5-3.5GHz BTS RX/TX**
- **TD-SCDMA RX/TX**
- **WCDMA & CDMA2000 4/8-Carrier, Receive Diversity RX/TX**

For base station original equipment manufacturers looking for a complete signal chain offering, TI provides analog as well as the industry's highest performance DSPs and companion chip-rate solutions for WiMAX and Wireless Infrastructure. By providing high-performance solutions that allow more simultaneous voice and data calls, TI enables wireless service providers to reduce subscriber churn and generate more revenue. With multiple standards for the wireless infrastructure market, flexibility is essential, and TI offers solutions that can be customized for each cellular technology and standard, enabling network evolution in a cost-effective manner.

7.12 Wireless Service Provider Backhaul

Wireless Service Providers (WSPs) use WiMAX equipment to backhaul traffic from Base Stations in their access networks, as shown below:

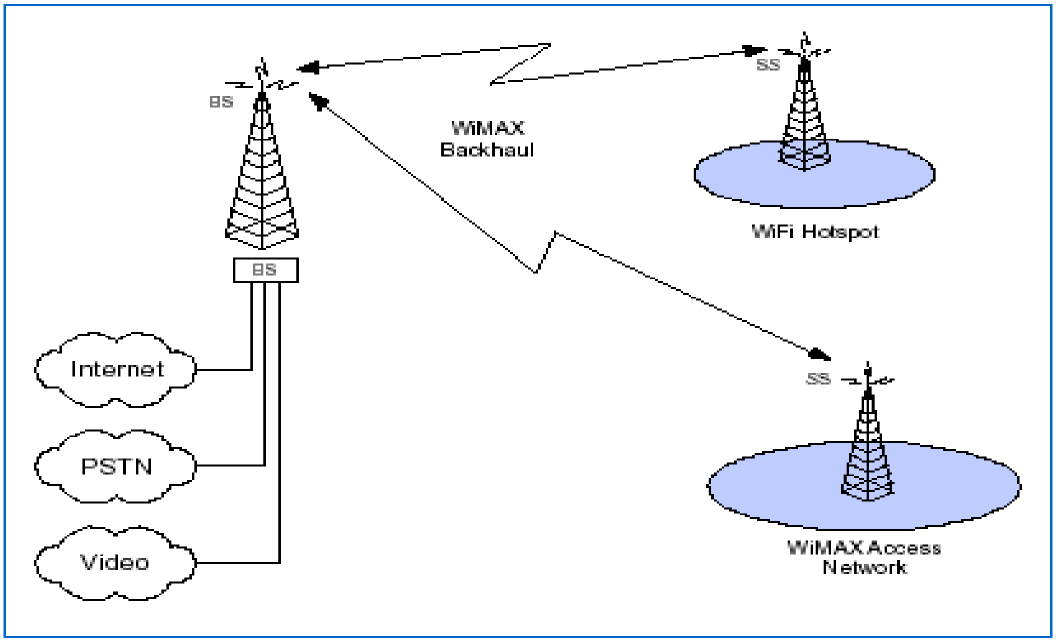


Fig: 7.12 Wireless Service Provider Backhaul

Access networks may be based on WiMAX or any proprietary wireless access technology. If the access network uses WiFi equipment, the overall WSP network is referred to as a Hot Zone. Since WSPs typically offer voice, data and video, the built-in QoS feature of WiMAX will help prioritize and optimize the backhauled traffic. WiMAX Equipment can be deployed quickly, facilitating a rapid rollout of the WSP network. Furthermore, fiber, DSL and cable are not cost-effective in rural and suburban areas, and most versions of DSL and cable technology will not provide the capacity required for these networks.

7.13 WiMAX deployment types for connectivity:

To address the challenges associated with traditional wired access Deployment types such as:

♦ **Backhaul**

- Point-to-point

♦ **Last mile**

- Point-to-multipoint

♦ **Large-area coverage**

- uses base-stations,
Subscriber stations and
Wi-Fi (mesh) solutions
to cover a large area.

7.14 WiMAX Access Point Controller

As part of the WiMAX distributed network architecture, WiMAX Access Point Controller (WiMAX APC) provides management of key security and mobility related functions in a WiMAX network deployment.

The WIMAX APC supports the following features:

- Authentication liaison between the user/device and the AAA server
- Security functions such as Local Key Distribution Function (LKDF) for delivering Authentication Keys
- Paging Controller (PC)
- QoS Policy Decision Point
- Flow admission control related to handovers
- Access Control
- Handover Decision Point
- Handoff Strategy
- Proxy Mobile IP Client Validation
- Context Repository (CR) function

The WIMAX APC is based on the ATCA platform architecture and designed to be highly scalable making it easy for operators to deploy in their networks. A deployment of Motorola WiMAX Access Points in conjunction with a WIMAX APC Controller and a separate bearer control path realized from standard IP routers and switches forms the Access Service Network as defined in the WiMAX Forum Reference Architecture.

7.15 Different types of antennas for wireless system

Corner Reflector Antenna : A directional antenna that is made up of a dipole driven element mounted in front of a 60-degree or 90-degree corner-shaped reflecting element.

Dipole Antenna: A two-piece (di = two; pole="pole" or "piece") antenna that is the basic "building block" antenna element. A dipole is normally used as the "driven element" in most antenna systems. A dipole is made up of two ¼ wavelength-long antenna pieces arranged in a straight line. A coax transmission line feeds power to the middle of the dipole.

Directional Antennas: An antenna with a radiation pattern that concentrates both the transmitting and receiving signal power into one favored direction. The power gain (the increase in signal power in the favored direction) is measured in dbi or dbd.

Isotropic Antenna: An isotropic antenna is a theoretical antenna. If it existed in the real world, it would radiate a wireless signal equally in all directions (front, back, left, right, up, and down). The signal strength from a theoretical isotropic antenna is used as a reference level to measure the gain (focusing power) of real-world antennas.

Omnidirectional Antenna: An antenna with a radiation pattern that, when viewed from above, is equally strong in all directions.

Panel Antenna: A directional antenna made up of several phased driven elements mounted in front of a flat reflecting element. Panel antennas usually have a plastic or fiberglass cover that gives the antenna a panel-like appearance.

Parabolic Antenna - A directional antenna made up of a dipole driven element mounted in front of a parabolic-shaped reflector. The reflector may be either a solid metal "dish" or a dish-shaped screen made of metallic rods or mesh.

Patch Antenna - A smaller version of a directional panel antenna often used indoors.

Yagi Antenna - A directional antenna made up of one "driven element" that is connected to the transmission line and one or more "reflectors" (signal reflecting elements) and/or "directors" (signal directing elements).