A Detail Qualitative Survey on WiMAX and WiMAX-2

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***Abstract*—In the telecommunication industries is expected to continue to grow as demand increases for cable and high-speed Internet in previously subserviced locations and as local telephone companies upgrade their lines in response to increasing competition. This paper provides an extended overview of the IEEE 802.16m (WiMAX) Worldwide Interoperability for Microwave Access and its related technologies and issues. It also provides higher generation wireless networks as a cost effective results to answering the security issues posed by the digital media. This paper also provides at the technology behind IEEE 802.16m and networks design and also some deployment factors that concern with IEEE 802.16m. A cell site coverage simulation at different frequency bands using Wireless simulation tool is presented. Also the paper makes a comparison of IEEE 802.16m with two enhanced third generation (3G) technologies that are potential competitors to IEEE 802.16m. It then goes on describe the relay models in WiMAX and states some of the benefits and drawbacks of a IEEE 802.16m.**

Keywords: WiMAX, MIMO, OFDM, TDD,FDM, QPSK, QAM

I. INTRODUCTION

WiMAX has the potential to allow the broadband service providers to provide fast and reliable wireless broadband. WiMAX was first established as a Standard for wireless Metropolitan Area Networks by IEEE and based on 802.16 protocol family. The first WiMAX protocol was developed for fixed wireless broadband access and later approved by IEEE in 2005 with mobility support and named IEEE 802.16e [2]. The first WiMAX operate the range of 10-66 GHz and lower band operates in frequency range from 2-11 GHz. WiMAX technology is based on point to multi point technology. WiMAX2 or IEEE 802.16m is the advance version of WiMAX which is based on its previous version IEEE 802.16e with added features such as it supports 300 Mbps data rates with mobility whereas 802.16.2-2004 supports data rate of 100 Mbps. Therefore, IEEE 802.11 can increase VoIP capacity with low latency to meet the requirement of 4G (International telecommunication union). WiMAX forum has name IEEE 802.16m as WiMAX2. WiMAX2 uses the OFDM (orthogonal frequency division multiplex) and other advance antenna technology like MIMO (multiple inputs and multiple outputs) for better performance. The main purpose of IEEE 802.16m WiMAX standard is to improve spectral efficiency, improve VoIP capacity, handover, and speed coverage range. The IEEE 802.16m works with the radio frequency range from 2 to 6 GHz as well as it also supports scalable bandwidth of range 5 to 20MHz.

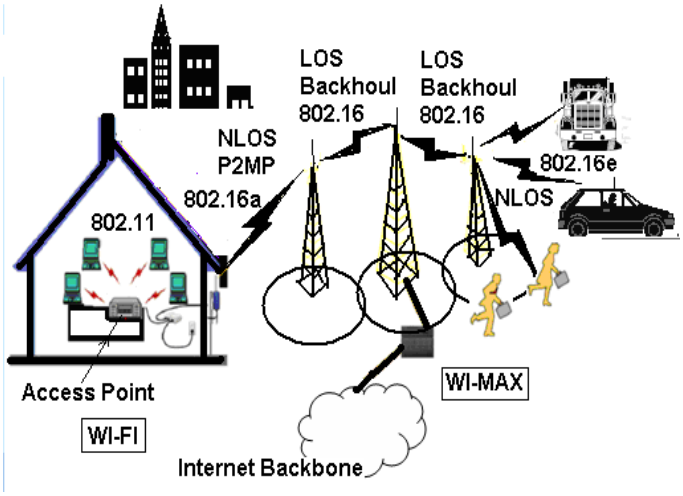

Figure:1 Fixed and Mobile WiMAX

II. WiMAX and WiMAX2

IEEE 802.16m also called WiMAX2, enhanced version of existing WiMAX with the new and enhanced features. It works on peak rates of its capacity that is 300 Mbps that step-upVoIP capacity with low latency to meet the heighten of 4G (International telecommunication union). IEEE 802.16m uses the OFDM and MIMO to achieve the performance, importance to support advance services in featuring for emerging broadband mobile communication applications. VoIP capacity, spectral efficiency, coverage range handover is heighten by IEEE 802.16m WiMAX. Its physical layer support both TDD (time division duplexing) and FDD (frequency division duplexing) modes in to optimized multipoint application. The architecture of IEEE 802.16m works with the radio frequency which ranges at same standard from 2 to 6 GHz as well as bandwidth is also supported by WiMAX of range 5 to 20MHz. .

A. WiMAX Physical Layer

WiMAX2 or IEEE 802.16m is compatible with IEEE 802.16e 2005 specification and three different physical layers

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characteristics Single carrier transmission that is defined by WiMAX2.

- OFDM("Orthogonal frequency division multiplexing")
- OFDMA("Orthogonal frequency division multiple access")
- SCOFDMA("Scalable orthogonal frequency division multiple access")

B. Frequency Division Multiplexing (FDM)

As the name suggest, In FDM signal transmitted over different frequencies at the same time slot or carrier and each sub carrier is modulated by different individually data stream. Figure 2.1 shows five FDM carriers.

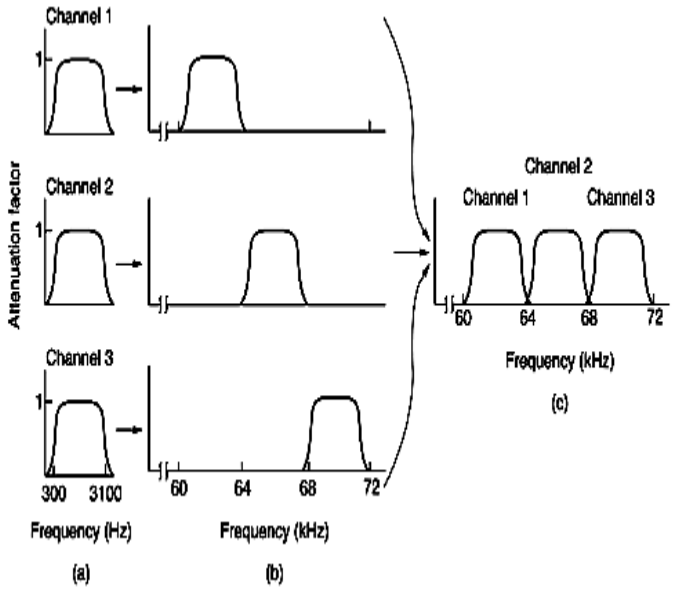

Figure 2.1 FDM (Frequency Division Multiplexing)

C. Orthogonal Frequency Division Multiplexing (OFDM)

In OFDM the frequencies are combined and are orthogonal with each other for data to be transmitted over a radio resource.

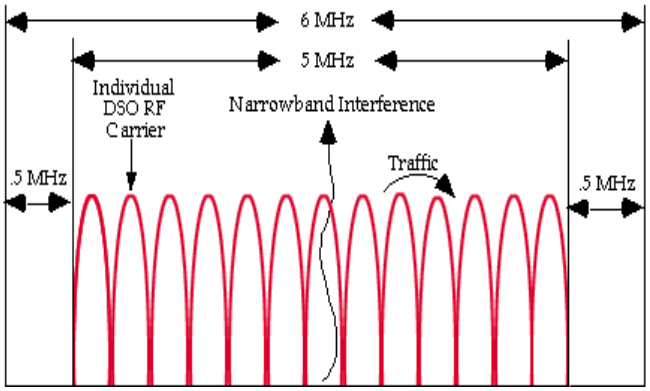

Figure 2.2 OFDM modulation techniques

The Figure 2.2 showing the multiple coincided subcarriers combined with each other without causing interference. The main advantage of using OFDM is the data stream can be divided into low rate streams then each stream is converted to sub carrier with the help of adaptive modulation scheme.

D. Orthogonal Frequency Division Multiple Access (OFDMA)

As compare to OFDM, the OFDMA combined subcarriers into groups of sub carriers which is also called s ub channel and using sub channel all the user can send and receive data at same time and all the users can be accommodated at the same channel. OFDMA is used by WiMAX as different FFT (fast Fourier transform) modes used in different standards of WiMAX e.g. WiBRO uses 1024 FFT whereas IEEE802.16d support 256 FFT.

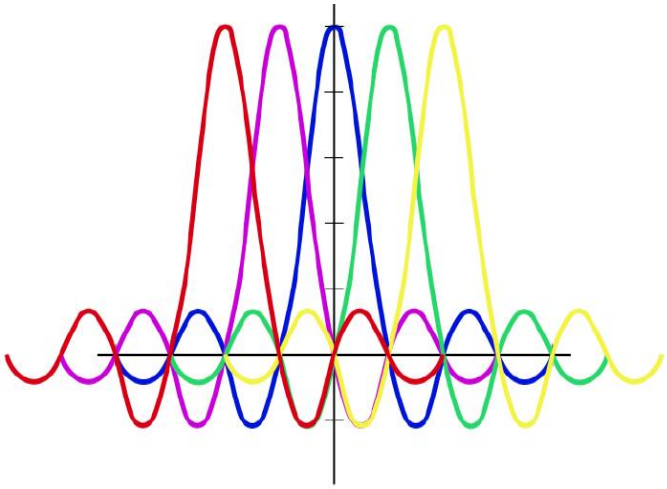

Figure 2.3 below shows where five subcarriers are overlapped and not interfering with each other at peak where it carries data.

E. Scalable OFDMA (SOFDMA)

Scalable OFDMA is widely used in new technologies like IEEE802.16m and LTE advance as it has the extra features compared to OFDM and OFDMA.

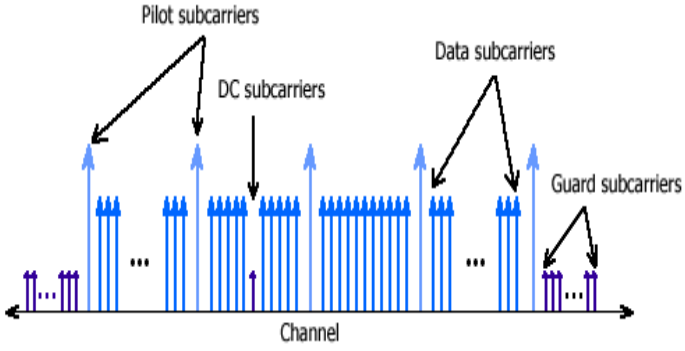

Figure 2.4 Scalable OFDMA

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In this scheme there are multiple FFT sizes supported such as 128 FFT, 512FFT and 2k FFT to address bandwidth up to 20MHz. From all of the mentioned above technologies, WiMAX forum selected OFDMA, because as compare to TDMA (time division multiple access) based technology, OFDMA based system leads to cell range extension on the UL, however cell range extension can also be achieved and enhanced on the DL if we allocate extra power to the carrier group delegated to users with high distance.

III. Modulation Scheme in WiMAX

In wireless communication system, radio resource management is used to manage the selection of modulation scheme the that includes both modulation and channel schemes. The WiMAX use OFDM which is most efficient schemes used by advance wireless technologies [22]. One of the major advantages of OFDM is frequency signals with data can be transmitted by using different modulation schemes depending on uncommitted resources and SNR As it depends on SNR like if the value of SNR is high then the powerful modulation can be used, however when the SNR is low then the lower type of modulation scheme can be used. In WiMAX, there are four different modulation schemes used which are as follows:

A. Quadrature Phase Shift Keying (QPSK)

It uses four different possible phases, making it possible to send two bits for every symbol. The QPSK is popular scheme where two bits conciliate one symbol. These two bits send data by changing the phase of the radio wave. In the constellation diagram of QPSK, we have four different points showing in the figure 3.1. QPSK efficiently used spectrum as compared to BPSK, however it cannot guarantee against noise.

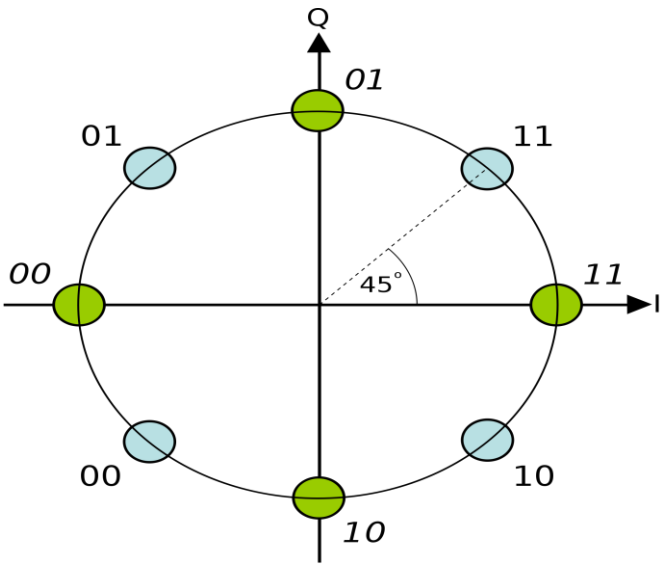

Figure 3.1 QPSK constellation

B. Quadrature Amplitude Modulation (QAM)

QAM is combination of phase shift keying and amplitude modulation is the efficient and reliable scheme which is used by WiMAX. In WiMAX, the domain where have high SNR, the QAM can be utilize for better performance and throughput. In QAM, the amplitude and phase by adjusting signal wave and by combining these two phases a symbol can be generated.

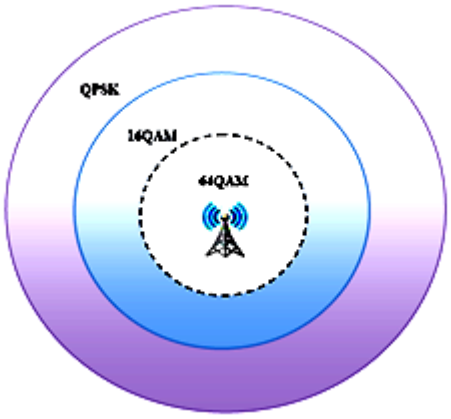

Figure 3.2 Adaptive modulation and coding transmission of BS

The figure 3.2 shows the different region of AMC scheme as we can see the domain near to BS can have better capacity but less coverage and in domain in 16QAM have less capacity and more coverage as compare to 64QAM. And in QPSK represent where it has large coverage domain but less capacity**.**

C. Quality of Service in WiMAX and Relay Station:

WiMAX allows the network operators to provide better services which differentiate them from operators using other technologies; this edge draws a range of subscribers. Optimized data, video and voice service is provided by the provider with the help of flow types. In WiMAX traffic can be prioritized via four services classes, each class prioritizes particular traffic such as voice, video or data. These classes are listed below.

- UGS (Unsolicited Grant Service)
- rtPS (real-time Polling Service)
- nrtPS (non-real-time Polling Service)
- BE (Best Effort) The second phase of WiMAX with the support of mobility has added fifth class which is extended real time polling service (ertPS);

a. Unsolicited Grant Service (UGS):

The UGS scheduling service suitable is when the constant data stream is required hence it is suitable for VoIP. It is important to mention that in UGS, packets are sent at persistent intervals. In UGS, fixed size packets are sent with as low jitter and response time as possible. UGS packets have higher priority over BE and nrtPS and system first transmit the UGS packets and then transmit the BE or nrtPS packets.

b. Real-Time Polling Service (rtPS):

This service supports real time service flows where variable size data packets are generated. It is important to mention that these packets are generated periodically. Video transmission,

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such as MPEG (Moving Pictures Experts Group) videos is supported by this service.

c. **Non-Real-Time Polling Service (nrtPS):**

The nrtPS supports data streams which consist of variable size packets tolerate delay. This service guarantees minimum data rate. FTP is supported by this service.

d. **Best Effort (BE):**

The basic service class of QoS does not guarantee minimum data rate, meaning at one instance data rate can be very low or idle and as soon as network becomes less congested data rates heightened allowing the traffic to move faster. Voice and video is not supported by this service as at low data rates it cause interruptions. BE packets have lowest priority over the network and these packets are only transmitted if no packets of UGS, rtPS, nrtPS and ertPS are waiting for transmission. It is more suitable for data streams which can be dealt on best available basis.

IV. Advance antenna technology

WiMAX2 supports advanced antenna technology including enhanced MIMO, directional antenna with diversity techniques.

A. Directional Antennas

An antenna gives three fundamentals in WiMAX technology which are based on direction of antenna, antenna gain and polarization. The antenna gain can be measure by increasing the power to boost the signal and making the antenna direction in the shape where it directs the antenna lobe for signal power and cover large domain as shown in figure 4.1.

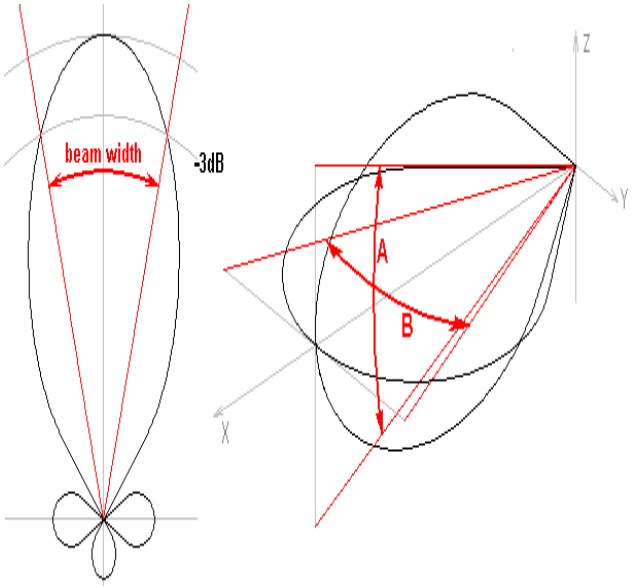

Figure 4.1 Beam width of directional antenna

The larger the beam width can decrease the area and smaller beam width can heighten domain. The beam width power can be measured in dBm where it increase or decrease the power with 3 or -3 dBm

A directional can enhance the throughput as it radiates power in one or more directions as equated to an Omni directional antenna that radiates equal power in all direction.

The main Advantages of a directional antenna are Less interference

- Higher gain
- Higher adaptive modulation coding(AMC)

B. Overview of WIMAX Relay station

A middle node used to transmits the BS data to SS is called RS technology ,which is can be out of the range of BS or in the domain where signal intensity level is very low. The RS are widely used in all the main today's wireless technologies such LTE advance and WiMAX2. A RS does not have backhaul connectivity as it get the signal from BSs in line of sight connectivity and it can be connected with a BS through a wired, leased cable or radio link [2]. Two types of connections that are supported by RS known as access link and relay link and which can be further define as, the communication path between RS and BS is called a relay link where communication is possible from BS to RS or RS to BS. The second path can be identified as the communication path between RS and EN is called access link. To extend the coverage, throughput and minimize the coverage gaps is the main advantage of RS. The BS usually covered a cell territory, however in NLOS communication due to tall buildings, forest and mountains can cause in coverage gap where RS can be used to fill the gap and meliorate overall system performance. There are different types of scenarios in wireless communication where RS plays vital role to overcome and provide better performance, some of the key factors are:

- Low coverage due to poor SNR at the cell boundary.
- Less coverage or very low signal reception in dense urban area.
- Cost of BS deployment too high in rural area.

RS can be deployed at the edge of the cell to exsert the coverage or top of the building in NLOS communication of BS for EN.

C. Multi-hop Communications

Multi-hop communications is a way where users get the services from BS through different hops. In IEEE 802.16a standard introduced multi-hop communication in WiMAX as mesh mode and later in IEEE 802.16e in acquainted mobile multi-hop relay topology. Figure 4.2 shows the difference between PMP, Mesh and relay topologies.

Point to multipoint

In point to multi point communication is a topology where BS communicate with end users in LOS and NLOS environment. The typical range of BS in PMP topology can be up to 8km.

Relay Topology

This is based on tree topology, where relay communicate as a middle node between BS and MS where one end is connected with BS and other with MS. The BS provides resources to RS for the MS out of the range of BS. Next generation mobile

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networks need very high data rates to enhance the overall network performance. So, relay Topology is also called cost effective topology.

Mesh Topology

In mesh topology, all the devices can be connected with each other within the Lapp network. In mesh every node is connected to other nodes within the same topology or network. The mesh topology can further extend into two categories called as partial full mesh which can be described as if the all the nodes have a connection with each other then it will be full mesh.. However it is very expensive to implement. And the partial mesh topology which is less expensive to implement as in this mode some node are organized as full mesh and some are connected with one or two only in the network. The different topologies above shows the different communication methods used in WiMAX system. Use of multi hop relays raises in MS of Routing or "Relay Selection". Because the relays operate at baseband layer, so the Power, QoS and delay constraints should be taken into account for routing. The deployment of WiMAX technology without RS can be more expensive as BSs cost is almost three times more than a RS. The communications methods of RS are based on single hop or with multi-hop.

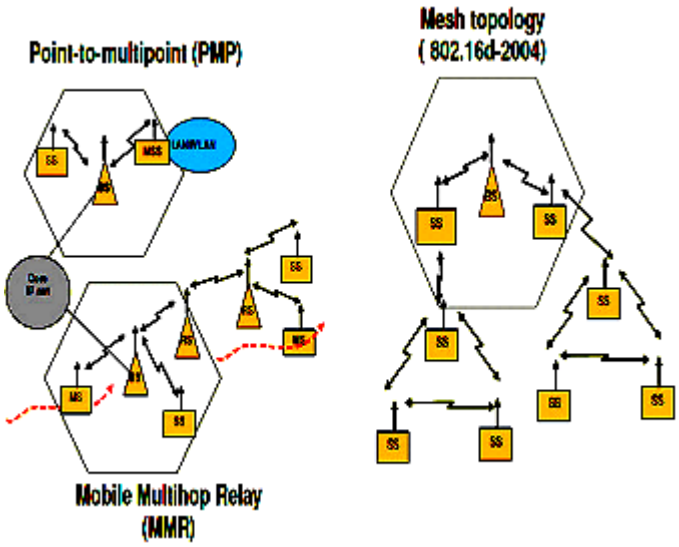

Figure 4.2 Different WiMAX topologies

D. Relay stations Modes

RS can be further described in two different modes depends on its usage. The two modes are [2]

- Transparent mode
- Non-transparent mode

Transparent Relay

We can extend the capacity of the network and to make the communication possible in NLOS environment with the help of Transparent mode of RS. [3] The BSs initial ranging request can be possible due to BS coverage but still RS needed to cover the coverage gap within cell. However, in the multi-hop scenario where the number of relays increases to further boost the signal but it can decrease the overall system capacity. To sustain the QoS and end users demands satisfactory based on transparent mode then are several key features to be discussed in detail in order to understand the transparent mode which are

- In this mode single relays data traffic can be transmitted to the BS and vice versa
- Transparent mode only operate in centralized scheduling
- Does not transmit preamble nor broadcast control message
- It can support multi-hop topologies
- Scheduling is not possible with transparent mode.
- Transparent mode only operate in centralized scheduling

Non Transparent Relay

The non transparent RS can be used to gallop the coverage of the cell by placing them on the cell boundary where BS signals fades and the signal quality is not very potent to cover the EN out of the cell. The EN cannot get the signal directly from BS as compared to transparent mode, so the RS has to send its control information to EN for connectivity. Following are the key features of non-transparent mode.

- Non transparent RS can operate as a BS for EN.
- Both distributed and centralized scheduling
- The purpose of this mode is to improve throughput and cell coverage enhancement.
- can be used in this mode
- It can be used for scheduling
- Non transparent mode sends its own preamble, FCH and MAP messages to SS
- Communication using the same or different carrier frequencies
- Participate in bandwidth allocation in distributed scheduling mode. Suitable for multi-hop scenario
- Suitable for multi-hop scenario.

When multiple number RS is colligated in non transparent modes can communicate with the EN out of the range of BS is called multi-hop system.

V. Relaying Techniques

Based upon relaying or forwarding schemes Relays can be broadly relegated in three categories where each category uphold its own functionality depends on QoS demands and link adaptation. The main techniques widely used in RS are

A. Amplify and Forward

In this technique, relays receive the signal, amplify it and retransmit it. It is the simplest form of relaying and minimum processing power is postulated by it at the RS. This is a non transparent technique which means BS has no knowledge of RS. One major demerit of this technique is that, since the

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relay amplifies the received signal, it also amplifies the noise received with the signal which can disgrace its performance.

B. Decode and Forward

This technique overcome the noise amplification problem by decoding the received data and error correction before forwarding it hence only error free data is forwarded. This kind of relaying is good if there is a good channel between BS and RS. If the channel is not good then this causes ARQ overhead and disgrace the performance.

C. Compress and Forward

In this technique RS compress the data before forwarding to EN or users. If MS also have direct transmission from BS this technique can be perform in the better way.

D. Adaptive Forwarding

This is additional technique used in new wireless standards such as 3GPP LTE and IEEE802.16m. In this technique the methods of transmission can be modified depends on the channel state information of both access link and relay link.

E. Pairing Schemes for Selection of Relay

Selection process of RS that is depend on two types of pairing schemes when more than two RS exist in the same cell.

F. Centralized Pairing Scheme

The BS collects data from all the neighboring RS and subscriber stations for paring of RS with mobile stations because BS have full access to all the RS and subscriber stations within the cell and range of BS. This scheme works with transparent RS mode and BSs updates pairing data frequently.

G. Distributed Pairing Scheme

In this scheme, two mechanisms for pairing with subscriber stations which are used in RS

- Contention based mechanism
- Local channel information In this pairing scheme BS has no fully access on all the subscriber stations because in this scheme paring scheme plowed by non transparent RS for selection and communication.

5.1 MIMO in Relay Station.

Multiple-input multiple-output (MIMO) technique can enhanced the spectral efficiency of wireless communication systems. The throughput, capacity, extend the coverage and uphold the link reliability can be enhanced by MIMO. High capacity with coverage extension and throughput enhancement of relay transmission is provided with the help of Relay Station with MIMO. The point to point MIMO channel or for the single antenna relay channel to the MIMO relay channel is complicated task in WiMAX communication networks and as equated to the single antenna relay channel, the MIMO relay channel introduces additional advantages to make it possible to perform more sophisticated encoding and decoding techniques to improve system performance. Figure 2.8 shows sending/receiving multiple MIMO antennas.

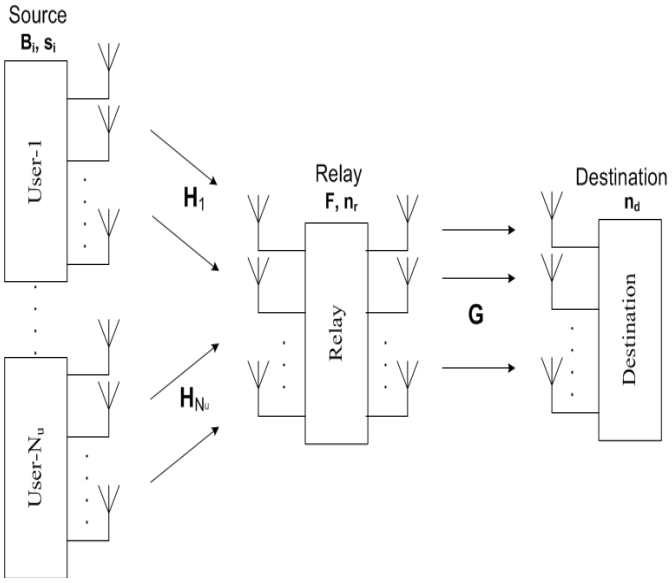

Figure 5.1 MIMO communications with multiple source antenna and designations

Conclusion

The IEEE 802.16m amendment to the IEEE 802.16 Wireless MAN-OFDMA specification is on track for completion in Q3-2010 with ratification in Q4-2010. This amendment will be the basis for WiMAX System Release 2. Currently 45 companies have actively supported the candidacy of IEEE 802.16m as an IMT-Advanced technology and expectations are that both LTE-Advanced and 802.16m will be included. The performance enhancements defined in IEEE 802.16m build on the capabilities established with IEEE 802.16e-2005, an OFDMA-based technology with 4 years of worldwide, field-proven experience. With assured backwards compatibility, WiMAX System Release 2 will provide a graceful migration path for today's WiMAX operators to further enhance current network performance and new operators can deploy WiMAX with the confidence that they have selected a proven technology that is structured to meet current and future network demands. With this evolutionary growth path, the WiMAX technology is well-positioned to meet the challenges and demands anticipated for the next generation of mobile networks.

REFERENCES

[1] K.M Gharaibeh, K.G Gard, M.B Steer, "Accurate estimation of digital communication system metrics - SNR, EVM and ρ in a nonlinear amplifier environment," 64th ARFTG Microwave

ISSN: 2278 – 7798

Measurements Conference, Fall 2004. , vol., no., pp. 41- 44, 2-3 Dec. 2004.

[2] F E Ismael - K. Syed Yusof and N Fisal "An efficient Bandwidth Demand Estimation for Delay Reduction in IEEE 802.16j MMR WiMAX Networks" International Journal of Engineering (IJE), Volume (3): Issue (6)

[3] D S Kumar and Dr. N.Nagarajan "Performance Analysis of IEEE 802.16j non Transparent mode Networks" Int. J. on Recent Trends in Engineering & Technology, Vol. 05, No. 01, Mar 2011

[4] N Poudyal, H C LEE, Y Jin KWON and B Seub LEE. "Delay-bound Admission Control for Real-time Traffic in Fourth Generation IMT-Advanced Networks based on 802.16m". (2011), pages 31-37.

[5] B. Bhattacharyya, I.S. Misra, S.K Sanyal, "The Effect of Varying Cyclic Prefix on Residual Constellation Error in OFDM technology using a novel Simulink-VSA based WiMAX Transceiver," 5th European Conference on Circuits and Systems for Communications (ECCSC) 2010, vol., no., pp.268-271, Serbia and Montenegro, 23-25 Nov. 2010.

[6] Michele Morelli and Umberto Mengali, Fellow, IEEE "A Comparison of Pilot-Aided Channel Estimation Methods for OFDM Systems", IEEE TRANSACTIONS ON SIGNAL PROCESSING, VOL. 49, NO. 12, december 2001.

[7] Rebecca Morrison, Leonard J. Cimini, Jr., Sarah Kate Wilson "On the Use of a Cyclic Extension in OFDM",

[8] Z. Zhao-yang and L. Li-feng, "A Novel OFDM Transmission Scheme with Length-Adaptive Cyclic Prefix," Journal of Zhejiang University SCIENCE, vol. 2004, pp. 1336-1342, 2004.

[9] Andrea Goldsmith, "Wireless Communication" Stanford University, Cambridge University Press.

[10] T. S. Rappaport, "Wireless Communications: Principles & Practice", Prentice Hall, 1995

[11] OPNET Documentation. http://www.opnet.com

[12] Xinjie Chang. "Network simulations with OPNET". *Winter Simulation Conference* (WSC'99), pages 307-314, Phoenix, AZ, USA December 05- 08, 1999

[13] R.A Shafik; S. Rahman, AHM R.lslam , "On the Extended Relationships Among EVM, BER and SNR as Performance Metrics," International Conference on Electrical and Computer Engineering, 2006. ICECE '06., vol., no., pp.408-411, Dhaka, Bangladesh, 19-21 Dec. 2006.

[14] S Bhunia, I.S. Misra, S. K. Sanyal and A Kundu, "Performance study of Mobile WiMAX Network with Changing Scenarios under Different Modulation and Coding", Wiley Int. Journal of Communication System, DOl: 10.1002/dac.1217,201l.

[15] Iwan Adhicandra, Rosario G. Garroppo, Stefano Giordano, "Optimizing System Capacity and Application Delays in WiMAX Networks", in *Proc. ISWCS 2009*.

[16] Abdul Qadir Ansari, Dr. Abdul Qadeer .K Rajput, Dr. Manzoor Hashmani, "WiMAX Network Optimization -Analyzing Effects of Adaptive Modulation and Coding Schemes Used in Conjunction with ARQ and HARQ"in Proc. Seventh Annual Communications Networks and Services Research Conference, 2009.

[17] L Garber, "Mobile WiMax: The Next Wireless Battle Ground," computer, vo1.41, no.6, pp.16-18, June 2008

[18] C. Tarhini, T. Chahed. "On capacity of OFDMA-based IEEE802.16 WiMAX including Adaptive Modulation and Coding (AMC) and intercell interference". Proceedings of 15th IEEE Workshop on Local and Metropolitan Area Networks, Princeton, NJ, U.S.A., pp. 139-144, 10-13 June 2007.

[19] S D'Alessandro, AM Tonello, L. Lampe, "On power allocation in adaptive cyclic prefix OFDM," IEEE International Symposium on Power Line Communications and Its Applications (ISPLC), 2010, vol., no., pp.183-188, 28-31 March 2010.

[20] B. Dusza, K. Daniel and e. Wietfield, "Error Vector Magnitude Measurement Accuracy and Impact on Spectrum Flatness Behavior for OFDM Based WiMAX and LTE systems", Wireless Communications, Networking and Mobile Computing(WiCOM'09), Beijing, China, pp. 1114-1117, Sept 2009.

[21] Aphira ksatyakul D., Boon-Chong Seet, Chiew-Tong Lau, "Evaluation of Terrain Effects on Mobile WiMax in a Vehicular Environment", *ITS Telecommunications 2008*, pp.379-383, October 2008.

[22] Loutfi Nuaymi, ENST Bretagne, *WiMAX-Technology for Broadband Wireless Access*, Chapter 6, John Wiley & Sons Ltd, France, 2007.

[23] LaSorte, N.; Barnes, W.J.; Refai, H.H.; , "The History of Orthogonal Frequency Division Multiplexing," *Global Telecommunications Conference, 2008. IEEE GLOBECOM 2008. IEEE* , vol., no., pp.1-5, Nov. 30 2008-Dec. 4 2008.

[24] James, L.B.; Moore, A.W.; Wonfor, A.; Plumb, R.; White, I.H.; Penty, R.V.; Glick, M.; McAuley, D. , "Packet error rate and bit error rate nondeterministic relationship in optical network applications, "*Optical Fiber Communication Conference, 2005. Technical Digest*, vol.4, no., pp. 3 pp. Vol. 4, 6-11 March 2005.

[25] Bottomley, G.E.; Wilhelmsson, L.R.; , "Recovering Signal Energy From the Cyclic Prefix in OFDM," *Vehicular Technology, IEEE Transactions on* , vol.57, no.5, pp.3205-3211, Sept. 2008 doi: 10.1109/TVT.2007.914057

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