ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 9, September 2013

A Comprehensive Study on 4G Broadband Networks: WiMAX and LTE

Kiran Gowda H N[1], Kusuma M[2], Udaya Kumar C[3]

PG Student, Department of Information Science & Engineering, Acharya Institute of Technology, Bangalore, India[1]

PG Student, Department of Information Science & Engineering, Acharya Institute of Technology, Bangalore, India[2]

PG Student, Department of Information Science & Engineering, Acharya Institute of Technology, Bangalore, India[3]

Abstract: The 3G technologies and application have encountered obstacles that have stalled both the technology development and user acceptance. There are 2.4 billion internet users around the world, total continuous to grow apes. Mobile usage is expanding rapidly as a results of these trends, there is eager anticipation for introduction of mobile communications system that surpass existing once in speed ,capacity, coverage area. In this paper we described the WiMAX and LTE technologies with respect to features, architecture, standards, modulation techniques, protocols and security threats.

Keywords: Worldwide Interoperability for Microwave Access, Long Term Evolution, Orthogonal Frequency Division Multiple, Line-of-Sight, Non-Line-of-Sight

I. INTRODUCTION

In the marketplace, there are various types of wireless and mobile networks that cover different areas, support different levels of mobility and provide different data rates. The demands for accessing services at high data rates while on the move, anyplace and anytime, triggered research efforts to go for 4G wireless broadband networks.

WiMAX is defined as Worldwide Interoperability for Microwave Access by the WiMAX forum, formed in June 2001. It provides wireless broadband to fixed and mobile terminals in a large geographical area. It operates over licensed and non-licensed frequencies using line –of-sight and non-line-of-sight technologies. It promises to deliver last-mile wireless broadband internet access capable of carrying data intensive applications. The 2005 version of WiMAX provides data rate up to 40Mbits/s and 2011 version can support data rate up to 1 Gbit/s for fixed stations [1]. It is one of the latest developments and considered as a 4G (Fourth Generation) technology. WiMAX supports data rate up to 75 Mbit/s which is higher than conventional cable modem and digital subscriber line (DSL) connections which are all wired access technologies [1]. WiMAX is based on Wireless Metropolitan Area Network (WMAN). IEEE 802.16 group developed WMAN and it is adopted by ETSI (European Telecommunication Standard Institute) in HiperMAN group i.e. High Performance Radio Metropolitan Area Network [2]. WiMAX system uses OFDM in the physical layer. OFDM is based on the adaptive modulation technique in non-line-of–sight (NLOS) environments. Base stations of WiMAX can provide communication without the need of line-of-sight (LOS) connection. WiMAX base station has enough available bandwidth so at a time it can serve large number of subscribers and also cover large area range.

Long Term Evolution (LTE) is the mobile network technology for the next generation mobile communications, as defined by the 3rd Generation Partnership Project (3GPP). In addition to features such as increased data-rates, lower latencies and better spectral efficiency, one of the most interesting aspects is the radically novel all-IP core network architecture, known as Evolved Packet Core (EPC). LTE is expected to make extensive use of user-installed femtocells, in order to achieve its goals of spectral efficiency and high-speed for a greater number of users. It is clear that the sensitivity and confidentiality of users and data transiting in such digital cellular networks is paramount both to businesses and private users [3].

The rest of this paper is organized as follows. We describe the Architecture of WiMAX and LTE network in section II, Standards for WiMAX and LTE in section III, Features of WiMAX and LTE section IV, Modulation and Multiplexing schemes in section V, Protocols in section VI, Security threats in WiMAX and LTE are explained in section VII and Comparison in section VIII. Finally, we conclude our paper.

II. ARCHITECTURE

A. Architecture of WiMAX network

All WiMAX devices such as MS, BS, AAA server, HA server, ASN Gateway are IP based nodes. These nodes can directly plugged into IT backbone network. The BS is used to perform the air interface and manage the radio resources. The data is being received from mobile stations and send to mobile stations by air interface. The ASN Gateway performed QOS policy management and mobility management between BSes, is also used to bridged multiple BSes to backend core service network. A server is an authentication server. It is an open source software which performs authentication process, HA performs mobile IP. Its function is to implement roaming between ASN Gateways. HA is also an open source software [4].

B. Architecture of LTE network

LTE also has IP based architecture .It is quite different from WiMAX in security mechanism. It cannot meet the enterprise security requirement and authenticate only identity (IMSI) and key in SIM card. An enhanced security method has been proposed which not only authenticate identity and key but also the enterprise certificates [5]. By using Orthogonal Frequency Division Multiple Access (OFDMA),for the highest category terminals LTE will be able to provide download rates of 150 Mbps for multi-antenna (2x2) multiple-input multiple-output (MIMO) . The non-compatibility of the 3G standards and demand for higher data rates has shifted industry focus to fourth generation (4G) wireless networks and it finally support data rates above 100 Mbps.It integrate all wireless network. The high bandwidth provides an ideal mode for data transport. The Orthogonal Frequency Division Multiplexing (OFDM) and Orthogonal Frequency Division Multiple Access (OFDMA) effectively allocate network resources to multiple users and provide high quality video and audios. Moreover, 4G have better security and low latency data transmission. The 4G is an entirely packet- switched network with digital network elements .The 4G support global mobility and service portability [6].

III. STANDARDS

A. Standards for WiMAX

IEEE 802.16 is a series of Wireless Broadband technologies, standardized by the Institute of Electrical and electronics Engineers (IEEE).The IEEE 802.16 group was formed in 1998 to develop wireless broadband. The following Table.1 shows the IEEE 802.16 standard [7].

B. Standards for LTE

LTE Advanced is a mobile communication standard, formally submitted as a candidate 4G system to ITU-T in late 2009, was approved into ITU, International Telecommunications Union, IMT-Advanced and was finalized by 3GPP in March 2011. It is standardized by the 3rd Generation Partnership Project (3GPP) as a major enhancement of the Long Term Evolution (LTE) standard. The technology received its first implementation in October 2012 by Russian network.

IV. FEATURES

A. Features of WiMAX

WiMAX is a wireless network that has a high class set of features with a lot of flexibility in terms differentiates it from other metropolitan area wireless access technologies are: 1.OFDM-based physical layer, 2. Very high peak data rates, 3. Scalable bandwidth and data rate support, 4. Adaptive modulation and coding (AMC), 5. Link-layer retransmissions, 6.Support for TDD and FDD, 7.Orthogonal frequency division multiple access (OFDMA), 8.Flexible and dynamic per user resource allocation, 9. Support for advanced antenna techniques, 10. Quality-of-service support, 11.Robust security, 12. Support for mobility, 13. IP-based architecture [7].

B. Features of LTE

LTE supports several features that exploit instantaneous radio conditions in a constructive way. Channel-dependent scheduling allocates the very best resources to users; multi-antenna technologies are employed to make fading conditions on resources even more favorable; and link-adaptation techniques adapt the modulation and coding scheme to the achieved signal quality. In the uplink, a power-control mechanism is employed to allow very high average signal quality, and to control interference.

V. MODULATION AND MULTIPLEXING SCHEMES

To transfer data over the “air interface”, modulation schemes are used. A combination of varying modulation schemes are used in LTE and WiMAX networks. These modulation schemes can be QPSK (Quadrature Phase-Shift Keying) or QAM (Quadrature Amplitude Modulation), and the multiplexing schemes such as

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 9, September 2013

SI. No		Year	Features	Status
1	802.16	2001	Fixed Broadband wireless Access (10-66GHz)	S
2	802.16.2	2001	Recommended practice for coexistence	S
3	802.16c	2002	System profiles for 10-66 GH z	S
4	802.16a	2003	Physical layer and MAC definitions for 2-11 GHz	S
5	P802.16b		License-exempt frequencies(Project withdrawn)	W
6	P802.16d		Maintenance and System profiles for 2-11GHz(project merged into 802.16-2004	M
7	802.16	2004	Air Interface for Fixed Broadband Wireless Access System(rollup of 802.16-2001,802.16a,802.16c and P802.16d)	S
8	P802.16.2a		Coexistence with 2-11 GHz and 23.5-43.5GHz(project merged into 802.16.2-2004	M
9	802.16.2	2004	Recommended practice for coexistence(Maintenance and rollup of 802.16.2-2001	C
10	802. 16f	2005	Management Information Base (MIB) for 802.16-2004	S
11	802.16-2004/Cor.1	2005	Corrections for fixed operations(co-published with 802.16e-2005)	S
12	802.16e	2005	Mobile Broadband Wireless Access System	S
13	802.16k	2007	Bridging of 802.16(an amendment to IEEE 802.1D	C
14	802.16g	2007	Mobile Management Information Base(Project merged into 802.16-2009	M
15	802.16	2009	Air Interface for Fixed and Mobile Broadband Wireless Access System	C
16	802.16j	2009	Multihop relay	C
17	802.16h	2010	Improved Coexistence Mechanisms for License-Exempt Operation	C
18	802.16m	2011	Advanced Air Interface with data rates of 100Mbits/s mobile and 1Gbits/s fixed.	C
19	P802.16n		Higher Reliability Networks In Progress	P
20	P802.16p		Enhancements to support Machine –to-Machine Applications	P

OFDM (Orthogonal Frequency Division Multiplexing) and MIMO (Multiple

S=Superseded, W=Withdrawn, M=Merged, C=Current, P=Progress
Table 1. WiMAX Standards

Input Multiple Output). OFDMA in the physical layer is used by mobile WiMAX and OFDM and SC-FDMA in the physical layer is used by LTE which allows the deployment in different frequency ranges.

A.QPSK

QPSK is a phase-shifting modulation scheme. To send data the carrier frequency phase is shifted. Here in QPSK we can send two symbols by shifting the frequency in four different phases (0, 90, 180, 270 degrees)[8]

B. QAM

QAM is a combination of two techniques, i.e. PSK (Phase-Shift Keying) and ASK (Amplitude-Shift Keying) for modulation. Hence it allows higher transfer rates. To distinguish between symbols (high = 1, low = 0) ASK uses different frequency amplitudes. More symbols can be transferred by varying number of amplitudes and phases. Wireless telecommunication networks widely uses digital 16-QAM (16 Symbols, 4 Bits) or 64-QAM (64 Symbols, 6Bits) modulation schemes [8].

C. OFDM

OFDM is a frequency division multiplexing modulation scheme which divides the data transmission over several streams, and assigns one for each orthogonal subcarrier. In wireless technologies such as WLAN, DVB-T or DAB OFDM is already been successfully used. Also it allows a large number (several hundreds) of narrow-band subcarriers. In comparison with other multi-carrier extension such as the WCDMA (Wideband Code Division Multiple Access) multicarrier evolution, a 20 MHz bandwidth could consist of four 5 MHz (sub)carriers. OFDM uses IFFT (Inverse Fast Fourier Transform) and FFT (Fast Fourier Transform) for signal modulation. Figure 1 shows the OFDM spectrum with the subcarrier division and the subcarrier spacing _f = 1=Tu, where Tu is the per-subcarrier modulation symbol time. The subcarrier spacing can range from a few kHz up to several hundred kHz. The subcarrier spacing for 3GPP LTE is about 15 kHz, whereas WiMAX uses 11 kHz. Figure also shows the orthogonality between the subcarriers that allows for high spectral efficiency. Major disadvantage of OFDM is that it has a higher PAPR (Peak-to-average power ratio, also

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 9, September 2013

referred as the crest factor or PAR) which leads to a higher power consumption.

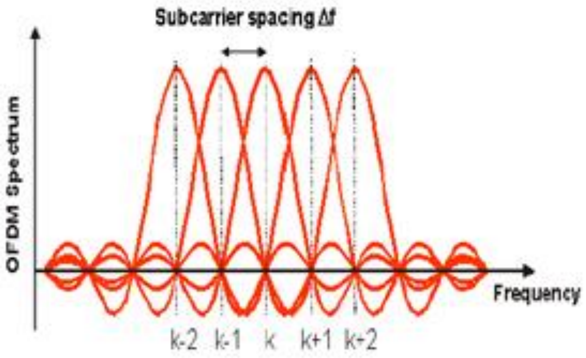

Fig.1 OFDM spectrum

D. OFDMA

Often OFDMA and OFDM are used as synonymous. OFDMA allows the use of OFDM modulation for multiple user access. Users can be allocated to any of the subcarriers in the used frequency band to enable this. In addition, it allows a flexible and better scheduling of resource allocation and services. Subcarriers are pooled to resource blocks to provide a good applicability (12 subcarriers per time slot). These blocks can be scheduled to different users as shown in figure 2. Furthermore certain enhancements or variations are used in LTE and WiMAX, such as SOFDMA (Scalable OFDMA) and SC-FDMA (Single Carrier – Frequency Division Multiple Access).

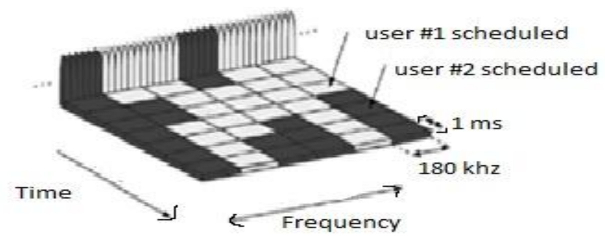

Fig.2 OFDMA Resource Block Scheduling

E. SOFDMA

SOFDMA provides scalability support to OFDMA. Both OFDMA-based systems, LTE and WiMAX support variable bandwidth sizes. The main goal of SOFDMA is to keep the subcarrier spacing constant [9].

F. SC-FDMA

The basic obstacle of OFDM is high power consumption. The power consumption of the data transmission is very crucial in the uplink where often mobile terminals are especially used. For this reason, 3GPP LTE uses Single Carrier FDMA, which is also referred as DFTS-OFDM (Discrete Fourier Transform Spread OFDM). SC-FDMA is a single carrier modulation which is basically a normal OFDM with a DFT-based precoding. The main advantage of this approach is that it reduces the variations of instantaneous transmit power, which eventually implies an increase of power amplifier efficiency. With this approach LTE is able to avoid the obstacles of OFDM in the aspect of power consumption [9].

G. MIMO

MIMO (Multiple Input Multiple Output) is one of the fundamental technologies used in the 4G networks which is already used in 802.11n (WLAN-n standard). The basic principle behind this technology is the spatial multiplexing. Multiple antennas at the sender and the receiver side are needed for this approach. The data stream is divided into multiple smaller data streams in MIMO where in these smaller data streams are then sent and received over multiple antennas. This approach takes advantage of the multi-path propagation of radio signals and the peak data rates increase, because of the multiple antennas. However, with the use of multiple antennas also the power consumption increases. There are several different configurations for MIMO. The often used terms 4x4 (4 sending antennas, 4 receiving antennas), 4x2 or 2x2 represent the MIMO configuration. Similar approaches are SIMO (Single Input Multiple Output) which is often used in battery powered User Terminals, MISO (Multiple Input Single Output) or the well-known approach with one antenna on each side SISO (Single Input Single Output).

VI. PROTOCOLS

A. WiMAX Protocols

WiMAX has two main topologies namely Point to Point for backhaul and Point to Multi Point Base station for Subscriber station. Multiple input and multiple output antennas are used in each of these situations. The protocol structure of IEEE 802.16 Broadband wireless MAN standard is shown in fig.3. It shows four layers Convergence, MAC, Transmission and Physical. These layers map to two of the lowest layers i.e., physical and data link layers of the OSI model. WiMax provides many user applications and interfaces like Ethernet, TDM, ATM, IP, and VLAN. The IEEE 802.16 standard is versatile enough to accommodate time division multiplexing (TDM) or frequency division duplexing (FDD) deployments and also allows for both full and half-duplex terminals. IEEE 802.16 supports three physical layers. The mandatory physical mode is 256-point FFT

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 9, September 2013

OFDM (Orthogonal Frequency Division Multiplexing). The other modes are Single carrier (SC) and 2048 OFDMA (Orthogonal Frequency Division Multiplexing Access) modes. The corresponding European standard - the ETSI Hiperman standard defines a single PHY mode identical to the 256 OFDM modes in the 802.16d standard. The MAC was developed for a point-to-multipoint wireless access environment and can accommodate protocols like ATM, Ethernet and IP (Internet Protocol). The MAC frame structure dynamic uplink and downlink profiles of terminals as per the link conditions. This is to ensure a trade-off of capacity and real-time robustness.

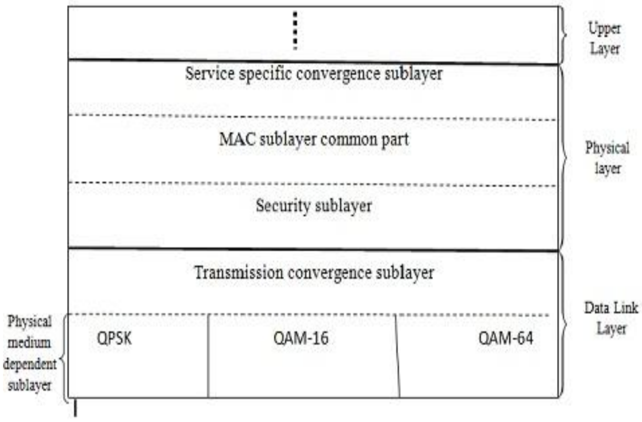

Fig 3. The protocol structure of IEEE 802.16 broadband wireless MAN standard

B. LTE Protocols

In the user plane, the protocols that are included are the Packet Data Convergence Protocol (PDCP), the Radio Link Control (RLC), Medium Access Control (MAC), and Physical Layer (PHY) protocols. Fig. 3 gives a graphical overview of protocol stacks and control plane stack additionally includes the Radio Resource Control (RRC) protocols. The main functionalities carried out in each layer are summarized in the following [10].

1. NAS (Non-Access Stratum): Provides connection or session management between UE and the core network. Authentication and registration will be carried out. It is also capable of Bearer context activation/deactivation and Location registration management.

2. RRC (Radio Resource Control): Provides Broadcast system information related to Non-Access Stratum (NAS) and Access Stratum (AS). It is capable of establishment, maintenance, and release of RRC connection. Security functions including key management, Mobility functions. QoS management functions. NAS direct message transfer between UE and NAS.

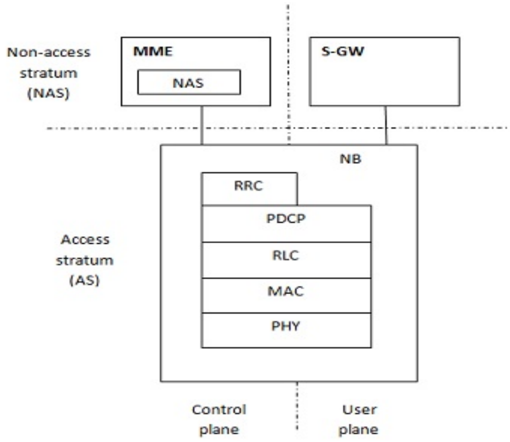

Fig 4. LTE protocols stack.

3. PDCP (Packet Data Convergence Protocol): The main features of PDC are Header compression; In-sequence delivery and retransmission of PDCP Session Data Units (SDUs) for acknowledge mode radio bearers at handover, Duplicate detection and Ciphering and integrity protection.

4. RLC (Radio Link Control): It provides Error correction through Automatic Repeat request (ARQ), Segmentation according to the size of the transport block and re-segmentation in case a retransmission is needed, Concatenation of SDUs for the same radio bearer, Protocol error detection and recovery and In-sequence delivery.

5. MAC (Medium Access Control): MAC provides Multiplexing/demultiplexing of RLC Packet Data Units (PDUs), Scheduling information, reporting Error correction through Hybrid ARQ (HARQ), Local Channel Prioritization and Padding.

VII. SECURITY THREATS

A. WiMAX Security Attacks

Jamming and packet scrambling are the general kinds of attacks that can most affect WiMAX's physical layer. Signals in the lower frequencies that cross or are in close proximity to the WiMAX antenna can produce second and third harmonic waves that interfere and can overload the WiMAX signal. Because WiMAX is transmitted over frequency bands that are licensed, unintentional jamming is rare. Taking a spectrum analysis at intervals can mitigate constant jamming, whether malicious or not [11]. Within the MAC Layer of the network stack, digital certificates work very well for establishing the identity of a mobile station to a base station. However, a simple one-way authentication could allow an opportunity for intruders to create a rogue base station and snoop traffic.

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 9, September 2013

Authentication using EAP-TLS will enable both the base station and the mobile station to use X.509 certificates to establish their legitimacy. Two of the most destructive attacks can be MITM (Man in the middle attack) and DoS (Denial of Service attack) attacks [12].

B. LTE Security Attacks

LTE ensures a trusted relationship between subscriber and home network by using contextual information such as node density, device speed and mobile pattern. Changing the mobile device-triggered ID can reduce the risk of being attack. By novel approach production of mobile networks against Internet-Based DDoS attacks can be reduced [13]. The 3GPP, Next Generation Mobile Network Alliance, and the ITU thoroughly analyzed LTE security risks, identified the specific threats and recommended solutions for each link in the three interface areas of LTE networks. These are summarized in below Table 2.

	Untrusted – Network	**Network – Network**	**Network – Service**
Threats / Risks	Physical Attack User Plane packet injection Packet modification Eaves Dropping DDOS attacks from network or UE, Unauthorized access	Roaming Partners Threats, Tampering, Hijacking	Unauthorized access, Phishing, Injection
Solutions	Strong Authentication Strong Authorization	NAT / Multi-Homing ACL	State full Firewall, NAT / Multi Homing, DoS Mitigation

Table 2. Security threats in LTE

VIII. COMPARISON

WiMAX and LTE are promising broadband wireless technologies. Both are compared with respect to speed, bandwidth, capacity, QOS, security [3].

A. Release and Deployment

In 2005 WiMAX was developed and released in 2009, which is much earlier than LTE. At present there are 592 WiMAX networks in 149 countries. In contrast, the commercial use of LTE just has started in 2009. Hence it is not much widespread yet. This is a huge success over LTE's deployment, which has recently started leading to a wider spread of WiMAX.

B. Transfer rates

WiMAX have transfer rates of 46 Mbps in the downlink and up to 4 Mbps in the uplink, whereas LTE offers up to 300 Mbps in the downlink and 75 Mbps in the uplink. LTE is definitely superior to WiMAX in this case. Also a bigger range of channel bandwidths from 1.4 MHz to 20 MHz than WiMAX with 3.5 MHz to 10 MHz is been supported.

C. Mobility

WiMAX and LTE offer better mobility features. The important aspects include the coverage of cells and the power efficiency of the devices.

1. *Coverage of cells:* WiMAX signals can reach up to 50 km but this is only acquirable with much loss in signal quality. WiMAX is more optimized for shorter distances like 1.5 to 5 km. LTE, on the other hand, can cover up to 100 km, which is twice as much as WiMAX' coverage. LTE also offers connectivity with speeds up to 350 kmph. So, it's even possible to be connected on a LTE-network when sitting in a high speed train. On the other hand, WiMAX supports speeds up to 120 kmph, because of its optimization for nomadic speeds.

2. *Power efficiency:* Both LTE and WiMAX offer power saving mechanisms. They can be both sent into an off-state where less or even no power is needed. LTE can also turn the transmitter off while having a call when there are longer breaks. Also LTE uses SC-FDMA in the uplink, which is more power efficient than OFDMA. This makes mobile devices use less power, which increases their battery life.

D. Quality of service

WiMAX and LTE use both reservation-based access which leads to achieving the quality of service. This provides services like video telephony and VoIP. A WiMAX frame is divided into a downlink and an uplink subframe that allocates resources for different users. In LTE frames are not divided as uplink and downlink subframes. Rather each frame contains 10 subframes where in only 2 of them are always reserved for the downlink. The other 8 subframes can be either uplink, downlink or switch point. LTE frames are more dynamic, hence delay is decreased.

E. Security

Both LTE and WiMAX, stands at the same level in the security aspects. Also they offer techniques and use a protocol, which ensure safe connections. All in all, Long-Term Evolution is superior to WiMAX when it comes to the technology it also have its downsides.

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 9, September 2013

Parameters	WiMAX	LTE
Release and Deployment	2005	2009
Generation	4G(Wimax 802.16m)	4G(Advanced LTE)
Transfer rates	46 Mbps in the downlink and up to 4 Mbps in the uplink	300 Mbps in the downlink and 75 Mbps in the uplink
Power efficiency	Both offer power saving mechanisms. They can be both sent into an off-state where less or even no power is needed	
Quality of service	Frame is separated in a downlink and an uplink subframe that allocates resources for different users	LTE frames don't separate their frames in uplink and downlink subframes.
Security	Concerning security aspects both, LTE and WiMAX, are on the same level	
Physical layer	DL:OFDMA UL:OFDMA	DL:OFDMA UL:SCFDMA
Duplex mode	TDD(Time Division Duplex)	TDD & FDD(Time & Frequency Division Duplex)
User mobility	60-120 kmps	Up to 350kmps
Coverage	Up to 50km	Up to 100km
Channel bandwidth	3.5,5,7,8.75,10MHz	1.4,3,5,10,15,20 MHz
Spectral efficiency	DL:1.91bps/Hz(2*2) UL:0.84 bps/Hz(1*2)	DL:1.91bps/Hz(2*2) UL:0.72 bps/Hz(1*2)
Latency	Link layer:about 20ms Handoff:about 35-50ms	Link layer:< 20ms Handoff:about:<50ms
VoIP capacity	20 Users per sector/MHz(TDD)	80 Users per sector/MHz(FDD)
Other qualities	Full IP-based architecture,3G compatible, QoS support	

Table 3. Comparisons of WiMAX and LTE

IX.CONCLUSION

In this paper we have presented a brief overview of WiMAX and LTE technology with respect to features, architecture, standards, modulation techniques, protocols and security threats. Security threats are key issues for any wireless networks. With introduction of WiMAX and LTE technology it is expected that next 4G networks rule the world with a wireless broadband connectivity, these networks promises the full mobility with high speed data rata, high capacity and application with backward compatibility. LTE was released several years after WiMAX, so that many telecommunication companies already invested in WiMAX and already offer commercial services. It is harder for some telecommunication companies to switch from WiMAX and invest into a new technology.

ACKNOWLEDGEMENT

We sincerely acknowledge all the cited authors for giving us base papers with strong fundamental concepts, we would like to thank Mr. Ravichandra M, Department of Information Science and Engineering, Acharya Institute of Technology Bangalore for reviewing and providing invaluable minute details on organization of the paper and we thank all the members of Department of Information Science and Engineering Acharya Institute of Technology for providing valuable advise for a better structuring of the paper.

REFERENCES

[1] Anita Garhwal, ParthaPratim Bhattachary "Performance Enhancement of WiMAX System using Adaptive Equalizer" , Department of Electronics and Communication Engineering, Faculty of Engineering and Technology Mody Institute of Technology & Science (Deemed University).
[2] Jeffery G. Andrews, ArunabhaGhosh, RiasMuhamed, "Fundamentals of WiMAX: Understanding Broadband Wireless Networking", Prentice Hall, 2007.
[3] Igor Bilogrevic, MurtuzaJadliwala and Jean-Pierre Hubaux "Security Issues in Next Generation Mobile Networks: LTE and Femtocells" Laboratory for computer Communications and Applications (LCA1), EPFL, Lausanne, Switzerland 2010.
[4] MayuriRao, Manish Panchal "4G Wireless Technology: A Survey Paper" Proceedings of the National Conference "NCNTE-2012" at Fr. C.R.I.T., Vashi, Navi Mumbai, Feb. 24-25, 2012
[5] Leo yi, Kai Miao, Adrian Liu "A Comparative Study of WiMAX and LTE as the Next Generation Mobile Enterprise Network" Feb. 13~16, 2011 ICACT 2011.
[6] Odinma, A.C. 2006. "Next Generation Networks: Whence, Where and Thence".Pacific Journal of Science and Technology. 7(1):10-16.
[7] Mr. Ajay Roy, Dr. A K Jain, Professor and Head "Survey of WiMAX Networks" International Journal of Research in Management, Science & Technology (E-ISSN: 2321-3264) Vol. 1; No. 1, June 2013
[8] S. W. Ho, "Adaptive Modulation (QPSK, QAM)," Intel Corporation,Tech. Rep., 2004.
[9] "WiMAX, HSPA+ and LTE - A Comparative Analysis," WiMAX Forum, Tech. Rep., November 2009.
[10] Ian F. Akyildiz∗, David M. Gutierrez-Estevez, Elias Chavarria Reyes "The evolution to 4G cellular systems: LTE-Advanced" School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA 30332, United States 2010.

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 9, September 2013

[11] JunaidQayyum, Muhammad Lal , Faheem Khan, Muhammad Imad "Survey & Assessment of Wimax ,its Security Threats and Their Solutions" Gandhara University Of Sciences 25000, Peshawar, Pakistan 2011.
[12] Parampreet Singh, JyotsnaSengupta "A Survey of Security Threats and Authentication Schemes in WiMAX" Dept. Computer Science Punjabi University, Patiala India 2013.
[13] Dieter Eberle "LTE vs. WiMAX 4th generation telecommunication networks" Computer Engineering B.Sc. Berlin Institute of Technology, Germany 2011.

BIOGRAPHY

Mr. kiran Gowda H N, pursuing Master of Technology in Computer Network and Engineering, Department of Information Science and Engineering, Acharya Institute of Technology, Bangalore, Karnataka, India.

Ms.Kusuma M, pursuing Master of Technology in Computer Network and Engineering, Department of Information Science and Engineering, Acharya Institute of Technology, Bangalore, Karnataka, India.

Mr.Udaya Kumar C, pursuing Master of Technology in Computer Network and Engineering, Department of Information Science and Engineering, Acharya Institute of Technology, Bangalore, Karnataka, India.