Comparison of LTE and WiMAX on the Basis of Qualities

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Abstract- The explosive growth of the mobile broadband usage and that increases the traffic volume. To better meet these future requirement various technology standard explore options for 4G technology. The explored new emerging wireless broadband technologies are LTE and WiMAX. The next-generation mobile broadband technologies i.e. LTE and WiMAX are leading technologies which are technological foundation for 4G wireless broadband network. QoS structure is essential element of next-generation i.e. 4G broadband wireless network to better meet to the current and future needs and mobile internet applications. In this paper, described is next-generation leading technologies wireless broadband. These technologies are designed to support current and future QoS. QoS structure and aspect of 4G mobile broadband technologies that are LTE, IEEE 802.16E and IEEE 802.16M (WiMAX) to sustain various applications of QoS needs.

Keywords- Long Term Evolution, Worldwide Interoperability of Microwave Access, QoS

I. INTRODUCTION

Long Term Evolution shortened as LTE was developed by the 3rd Generation Partnership Project (3GPP) working in association with the European Telecommunications Standards Institute. It was released in the 4th quarter of 2008.LTE is a set of enhancements to the Universal Mobile Telecommunications System (UMTS) which was introduced in 3rd Generation Partnership Project (3GPP).LTE supports various technologies like OFDM,SC-FDMA and MIMO. The LTE uses OFDM on the downlink. OFDM is a particular form of multicarrier modulation (MCM).SC-FDMA uses on uplink. The SC-FDMA signal seems to be like a single-carrier therefore the “SC” within the SC-FDMA name with each data symbol being represented by one wide signal. MIMO employs multiple transmit and receive antennas to substantially enhance the air interface. Multiple Input Multiple Output (MIMO) is multi antenna technology which is a essential part of LTE in order to achieve the requirements for throughput and spectral efficiency.LTE use frames for reserving resource allocation or connection. LTE similarly divides the time into frames. Each frame lasts 10 ms and consists of 10 subframes each of 1 ms. Subframes 0 and 5 are always reserved for downlink. The base station transmits any special information to manage the subsequent transmissions.

A WiMAX stand for Worldwide Interoperability of Microwave Access and it is based on the 802.16 standards was developed by the Institute of Electrical and Electronics Engineers (IEEE) for 802.16 wireless networks. The forum describes WiMAX as a standard-based technology facilitates to provide of last mile wireless broadband access as an alternative option to cable and digital subscriber line (DSL). WiMAX also supports same radio access technology are Orthogonal Frequency Division Multiplex (OFDM) for both the uplink and downlink transmission. WiMAX is categorized in to two forms –fixed and mobile. Fixed WiMAX, which is based on the IEEE 802.16-2004 standard. It perfect suited for delivering wireless, last-mile access for fixed broadband services. The another form is mobile WiMAX, which is based on the IEEE 802.16-2005 standard, supports both fixed and mobile applications .There are various WiMAX various standards are available. WiMAX also uses frames for uplink and downlink transmission, divides the time into frames. The downlinks transmission starts from base station (BS) to the mobile station (MS) and the uplink transmission are opposite to downlink transmission i.e. from MS to BS. A frame starts at the base station and then transmits the downlink (DL) and uplink (UL) map.

The LTE and WiMAX are designed to support QoS to better meet the user future requirements. QoS is the group of techniques to manage network resources. QoS has capability to provide a required level of service for a data traffic transmission over the network. QoS provides service levels which are mentioned in terms of throughput, latency (i.e. delay), jitter (i.e. delay variation) and packet loss or error occurred [9]. The LTE is designed support to end to end [12] QoS in terms of bearer; which separates data traffic and that enable differential traffic with QoS requirements. Bearer provides end to end path to transfer information (i.e. data, voice, and video) with the associated QoS in between the user equipment (UE) and packet data network gateway (PDN-GW). QoS in LTE is considered as a QoS class identifier (QCI), parameter allocation retention priority(ARP).There are two types of bearers are available in LTE like a guaranteed bit rate(GBR) and non-GBR.

The WiMAX is also designed to support QoS and QoS structure in WiMAX is based on service flow which is differentiated in to 5 types: the first service flow type is unsolicited grant service (UGS), second is real time polling service (rtPS), third is non-real time polling service (nrtPS), fourth is extended real-time polling service (ertPS) and finally fifth is best effort (BE).

II. LONG TERM EVOLUTION (LTE)

A. Standardization of LTE

The LTE was developed by Third Partnership Project (3GPP).LTE supports various radio access technologies such as orthogonal frequency division multiplexing (OFDM) and single carrier frequency division multiple access (SC-FDMA) it also supports to the advanced multiple antenna technology i.e. multiple input multiple output (MIMO) technology. There are some important performances requirements of LTE such as increased data rates, reduce latency, improved spectrum efficiency, high cell range and capacity, provides mobility and minimizes the complexity.

B. LTE Architecture

The LTE architecture with the evolved – universal terrestrial radio access network (E-UTRAN) main components are evolved NodeB (e-NB), Mobility management entity (MME), S1and X2 are interfaces. The e-NB which provides the E-UTRAN user and control plane extinction to User Equipment (UE)[2].It also consist of S1 and X2 are the interfaces. The e-NBs are connected together via X2 interface which provides function for user plane and control plane. The S1 is also interface between eNB and mobility management entity (MME) and serving gateway(S-GW). The following Fig. 1shows the LTE architecture with E-UTRAN and each component function mentioned as follows:

The e-NB distinct functions are:

- Radio resource management.
- Radio bearer and admission control.
- IP header encryption and compression.
- Routing the data of user plane to the serving gateway(S-GW).

The MME distinct functions are:

- Authentication.
- UE reach ability in idle mode.
- Tracking of area list management.
- Controls SAE bearer.
- Paging message distribution to e-NBs.

The S1 interface distinct functions are:

- Security and roaming.
- UE identification and capability.
- Paging.
- Modification and release initiated by control plane.

The X2 interface distinct functions are:

- Guaranteed delivery of control plane.
- Non-guaranteed delivery of user plane.

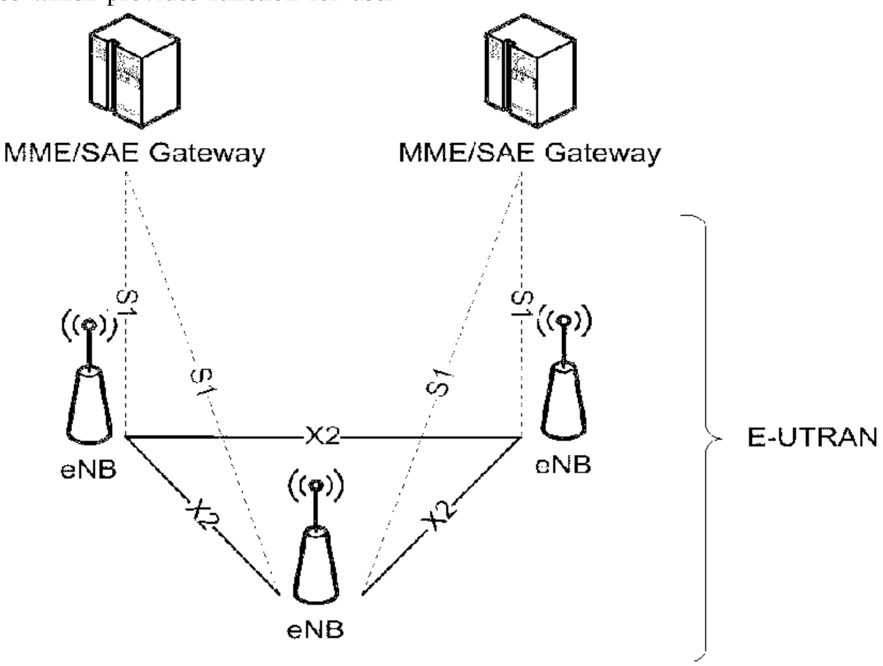

Fig.1 LTE architecture with E-UTRAN

The System Architecture Evolution (SAE) is the central part of the LTE network architecture of 3GPP's.LTE-SAE has espouse a class based Qos concept. SAE supports Packet Switched domain only, it doesn't support circuit switched domain. Therefore SAE offered the enhancement of Packet Switched domain which provides higher data rates, low latency. The major objectives LTE-SAE architecture are:

- A common anchor point and gateway node for all access technologies.
- It supports IP based protocols on all interfaces.
- Simplified network architecture.
- All services are via Packet Switched Domain.
- Divide between control and user plane in the mobility management entity (MME) and the gateway.
- Amalgamation of non-3GPP access technologies using client and network based mobile IP.

The following Fig. 2 shows the LTE-SAE architecture and Fig. 3 shows the Evolved Packet Core (EPC)

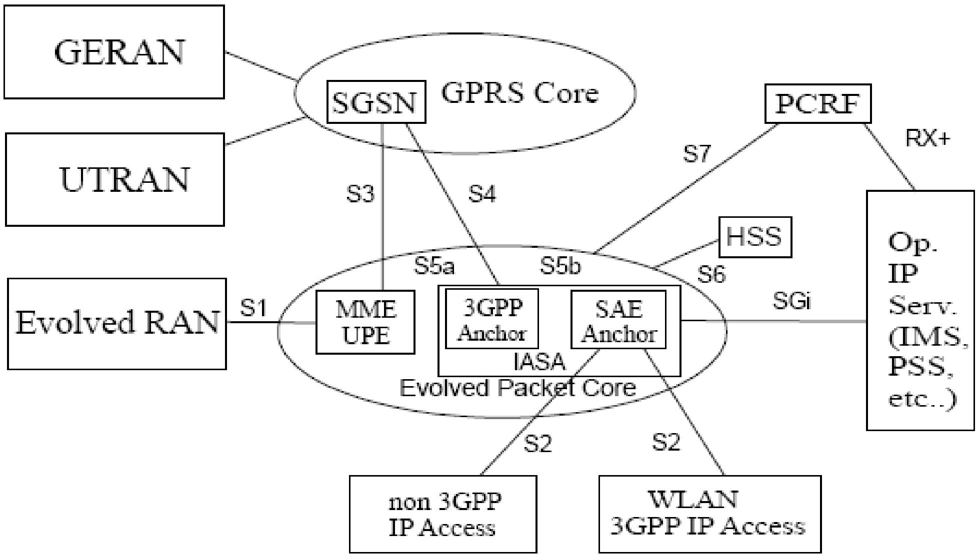

Fig. 2 LTE-SAE Architecture

S1: It provides access to Evolved RAN(Radio Access Network) radio resources for the transport of user plane and control plane data traffic. The S1 – control plane between eNB and Mobility Management Entity (MME) and S1-User plane between eNB and User Plane Entity (UPE).

S2: It provides mobility support between Wireless Local Area Network (WLAN) 3GPP IP access and non 3GPP IP access like WiMAX, WLAN and Inter AS Anchor.

S3: Enables user and bearer information exchange for inter 3GPP access system.

S4 : Mobility support between GPRS Core and Inter AS Anchor.

S5a: Provides the user plane with related control and mobility support between MME/UPE and 3GPP anchor.

S6: Provides transfer of subscription and authentication data for user access to the evolved system.

S7: provides transfer of (QoS) policy and charging rules from Policy and Charging Rule Function (PCRF) to Policy and Charging Enforcement Function (PCEF).

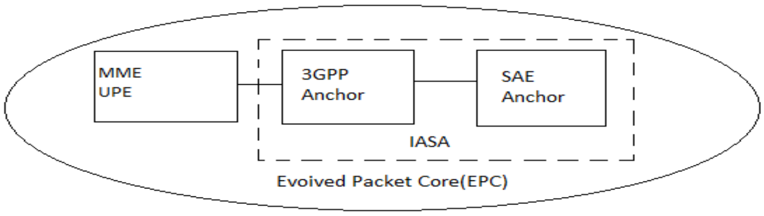

Fig. 3 Evolved Packet Core (EPC)

- MME (Mobility Management Entity): It manages and stores the User Equipment (UE) control plane,[13] generates temporary Id, provides UE authentication, authorization, mobility management.
- UPE (User Plane Entity): Manages and stores UE context, ciphering, mobility anchor, routing and forwarding of packet.
- 3GPP anchor: Mobility anchor between 2G/3G and LTE.
- SAE anchor: Mobility anchor between 3GPP and non 3GPP (WiMAX).

C. LTE supporting radio access technologies

LTE supports OFDM technology for downlink transmission and SC-FDMA technology for uplink transmission in LTE.

Orthogonal Frequency Division Multiplexing (OFDM) is using in LTE for downlink transmission i.e. from the base station to terminal. OFDM provides spectrum flexibility and the enables cost efficient of LTE for wide carriers with high peak rates OFDM transmits symbol in parallel, one per subcarrier.OFDM technology breaks the bandwidth into many narrow sub-carriers and transmits the data in the parallel stream.OFDM uses a large number of narrow sub-carriers for multicarrier transmission. In the frequency domain the spacing between sub-carriers is 15 KHz. To maintain the orthogonality between sub-carriers the cyclic prefix (CP) is used as guard time. The cyclic prefix is determined by the highest expected degree of delay spread for the targeted delay. Each subcarrier is modulated using varying level of QAM modulation e.g. QPSK, QAM, 64 QAM.

Single Carrier - Frequency Division Multiple Access (SC-FDMA) is using for uplink transmission i.e. from the terminal to base station. The SC-FDMA signal appears like single carrier hence the name SC in the SC-FDMA name each data symbol represented by one wide signal which transmitted serially. The SC-FDMA has Peak to Average Power Ratio (PAPR) which provides coverage performance. The SC-FDMA transmits the data symbols in series and data symbols occupy M*15 KHz. In SC-FDMA, after SC-FDMA symbol period has elapsed then the cyclic prefix (CP) is inserted the symbols and next four symbols

are transmitted in series. The CP contain copy of the end of the next symbol then the transmission is continues.

D. Multiple Antenna Technology

Multiple Input Multiple Output (MIMO) is a multi antenna technology systems form an essential part of LTE to achieve the requirements for throughput and spectral efficiency.MIMO employs multiple transmit and receive antennas to substantially enhance the air interface.MIMO processing also uses exploits spatial multiplexing, allowing different data streams to be transmitted simultaneously from the different transmit antennas, to increase the end-user data rate and cell capacity.Multiple antennas are also used to transmit the same data stream, thus providing redundancy and improved coverage.

III. WORLDWIDW INTEROPERABILITY OF MICROWAVE ACCESS (WiMAX)

A. Standardization of WiMAX

The 802.16 is a series of Wireless Broadband standard was developed by Institute of Electrical and Electronics Engineers (IEEE) in 1999.The 802.16 family of standards are formally known as WirelessMAN in IEEE then it has been commercialized under the name of WiMAX by the WiMAX Forum. These are the various IEEE standards [6] :

- IEEE Std 802.16–2001: The fixed broadband wireless access operation in 10 to 66 GHz.
- IEEE Std 802.16a–2003: Air interface support in physical and MAC layer for 2 to 11 GHz.
- IEEE Std 802.16b: Licences exempted frequencies (project withdrawn).
- IEEE Std 802.16d–2004: The fixed wireless maintenance and high-speed data rates for 2 to 11 GHz.
- IEEE Std 802.16e–2005: Improved air interface and capability for mobile broadband wireless access system.

- IEEE Std 802.16m- 2006: Advanced air interface for satisfy demands of next generation i.e. 4G technology.

B. WiMAX Architecture

WiMAX architecture consists of the ASN and the CSN, ASN, being the Access Services Network and CSN - Core service network. WiMAX architecture supports structure of packet switched network. WiMAX architecture is flexible which supports rural, urban radio propagation. The following Fig. 4 shows the WiMAX architecture.

Base Station (BS): Base station provides air interface with the MS.

Access Service Network (ASN): ASN provides away to combination functional entities and flow connected with the access service.

Connectivity Service Network (CSN): CSN provides IP service connectivity to WiMAX user. CSN performs various types of tasks like IP address management, management of roaming, location and mobility between ASNs.

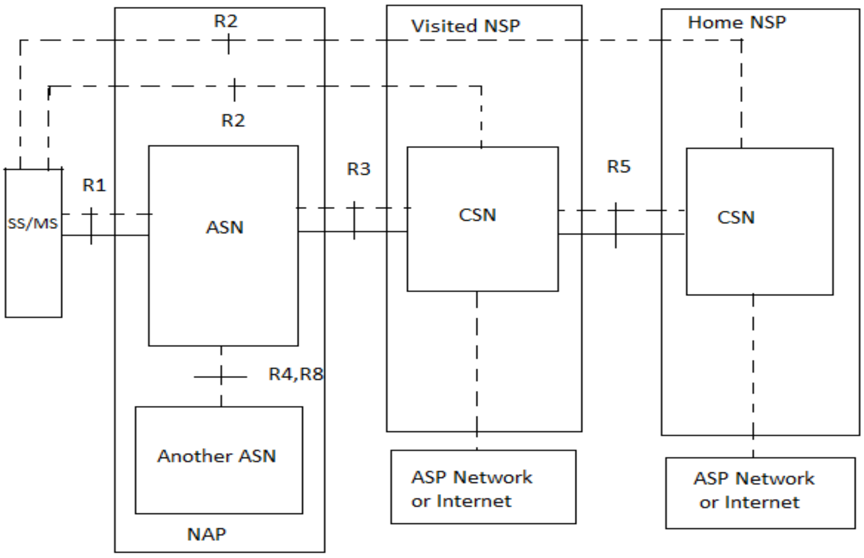

Fig. 4 WiMAX Architecture

SS/MS: Subscriber/MobileStation.
ASN: Access Service Network
NSP: Network Service Provider
NAP: Network Access Provider.
Data plane:----------------
Control plane: - - - - - - -

The WiMAX architecture provides flexibility to networking with other wireless networks. It supports to the fixed and mobile mobility, it also helps in the breakdown of the access network. The mobile station is user equipment (UE) in the WiMAX architecture which provides the wireless connectivity. The ASN is an interface or the connectivity between SS/MS. An ASN provides the entire group of distinct functions like authorization, accounting, authentication (AAA), QoS for admission control. The CSN is a group of functions, which provide distinct functions like an internet access, tunnelling support. The NAP and NSP brings the radio access technology structure. There is available eight reference point (RP) i.e. R1-R8 which provides the logical interface among all the components in WiMAX architecture.

C. WiMAX supporting radio access technology

WiMAX also supports the OFDM, for both the uplink and downlink transmission.

IV. QoS IN LTE AND WiMAX

A. QoS in LTE

LTE aim to support quality of service (QoS), allocating bandwidth to users to satisfy their demands. Quality of service (QoS) is a small particle in the LTE is bearer. A
bearer is the basic element for traffic separation which enables the differential treatment for traffic with differing QoS requirements Bearers provide a logical, end-to-end transmission path with defined QoS between the user equipment (UE) and packet data network gateway (PDN-GW). QoS in LTE the network can allocate service data flows (SDFs) to specific evolved packet system (EPS) bearers [8] with quality class indicators (QCIs) which are

assigned according to available network resources and evaluation made by the policy charging and control (PCC) architecture. Each bearer is associated with a set of QoS parameters that describe the properties of the transport channel, including bit rates, packet delay, packet loss, bit error rate, and scheduling policy in the radio base station. QCI values affect a numerous node-specific parameters, such as link layer configuration, scheduling weights, and queue management. The bearers can be classify into two categories are Guaranteed Bit Rate (GBR), and Non-Guaranteed Bit Rate (non-GBR).

The guaranteed bit rate (GBR) value dedicated to transmission resources which are permanently allocated at bearer establishment or modification. A maximum bit rate (MBR) parameter, which can also be associated with a GBR bearer, sets a higher limit on the bit rate that can be expected from a GBR bearer. [6]

A Non-Guaranteed Bit Rate (Non-GBR) bearer is called as default bearer. To the non-GBR bearers there are no bandwidth resources are assigned permanently to the bearer. [6] Each QCI is characterized by priority, packet delay budget and acceptable packet loss rate. The QCI for a bearer determines that how it is handled in the eNodeB. The QCIs have been standardized so that vendors can all have the same understanding of the underlying service characteristics and thus provide corresponding treatment, including queue management, conditioning and policing strategy. There are QoS attributes combine with the LTE bearer are as follows: *The Non-Guaranteed Bit Rate (Non-GBR)* bearers i.e. do not guarantee of any specific bit rate.

A *QCI* is a scalar that is used as a reference to access node-specific parameters that control bearer level packet forwarding treatment (e.g. scheduling weights, admission thresholds, link layer protocol configuration, queue management thresholds, etc.), and that have been pre-configured by the operator owning the access node.

An *Allocation and Retention Priority* (ARP) contains information about the priority level, the pre-emption to the capability and vulnerability. The primary purpose of ARP is to decide whether a bearer establishment / modification request can be accepted or to be rejected. The priority level information of the ARP is used for decide to guarantee that the request of the bearer with the preferred higher priority level. The ARP can also be used to decide which bearer to drop during exceptional resource limitations. The pre-emption capability information of the ARP defines whether a bearer with a lower ARP priority level should be dropped to free up the required resources the pre-emption vulnerability information of the ARP defines whether a bearer is applicable for releasing by a pre-emption capable bearer with a higher ARP priority value. When the bearer's ARP successfully established, then do not have any impact on the bearer level packet forwarding treatment.

The packet forwarding process should be only determined by the other EPS bearer QoS parameters: QCI, GBR and Maximum Bit Rate (MBR) is limited the bit rate that can not go beyond to be provide via a GBR bearer and which only applicable to the GBR, and by the Aggregate MBR (AMBR) is the entire amount of the bit rate of the set of non-GBR bearer parameters. The ARP is not included within the EPS QoS Profile sent to the UE.

B. QoS in WiMAX

The QoS in WiMAX provides guarantee of distinct applications and service types while making efficient use of network resources. WiMAX, by using the connection oriented method makes accessible to the MAC layer QoS structure. Each frame that is sent to the air interface is associated with a Service Flow (SF). SF describes the transmission and scheduling on the air interface The QoS Service flows service in both uplink as well as downlink direction. A service flow can be only prerequisite through network management system, but resources are not reserved. When a service flow is activated, then the service flow cannot be used for delivery of traffic. Only an active service flow can forward frame using the allocated resources. The Table I [11] shows the WiMAX QoS service class. WiMAX offers 5 distinct categories of service flow type:

- Unsolicited Grant Service (UGS): It holds the real time data traffic comprising fixed size data packet on periodic intervals.
- Real-time Packet Service (rtPS): It is also holds a real time data traffic with the variable sized packet data on periodic intervals.
- Non-real time Packet Service (nrtPS): It consists of delay tolerated data streams with variable sized data packets.
- Extended real time Packet Service (ertPS): It supports real time data that generates variable size packets.
- Best Effort (BE): It supports the regular data stream.

Table I WiMAX QoS Service Class

QoS Service Class	**Uses**	**QoS Specification**
Unsolicited Grant Service (UGS)	VoIP	Jitter tolerance ,Maximum latency tolerance
Real-time Packet Service (rtPS)	Streaming Audio or Video	Maximum reserved rate, Traffic priority
Extended real time Packet Service (ertPS)	VoIP	Traffic priority, Maximum reserved rate, jitter tolerance
Non-real time Packet Service (nrtPS)	File and Data Transfer	Traffic priority, Maximum sustained rate
Best Effort (BE)	Data transfer, web browsing	Traffic priority, Maximum sustained rate

V. CONCLUSION

This paper describes LTE and WiMAX wireless broadband technologies in accordance to the radio access technologies, architecture and QoS structure. LTE is introduced after WiMAX hence LTE provides advanced features such as SC-FDMA, MIMO and SAE architecture. As compared to LTE, WiMAX is already deployed but LTE provides better and effective solution in terms of quality of service. This helps to reduce the latency, improve high data rate, cell range and capacity. LTE is quite faster and easy to deploy than WiMAX. LTE make available a better-quality combination of network performance and required least cost to reach future demands of users for wireless broadband services.

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