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Swati Juneja
Student Department of ECE, swatijuneja@gmail.com

Abhinav Juneja
HOD of CSE and IT, Department of CSE, abhinavjuneja@gmail.com

Mohit Juneja
PG Student, Department of CSE, mohitjuneja@gmail.com

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Comparison of 3GPP LTE and 3GPP2 UMB

Swati Juneja
Student
Department of ECE

Abhinav Juneja
HOD of CSE and IT
Department of CSE

Mohit Juneja
PG Student
Department of CSE

Abstract-In the last years, technology evolution in mobile communications is mainly motivated by three relevant agents: (1) the market globalization and liberalization and the increasing competence among vendors and operators coming from this new framework, (2) the popularization of IEEE 802 wireless technologies within the mobile communications sector and, finally, (3) the exponential increase in the demand for advanced telecommunication services. Concerning the last item, the envisaged applications to be supported by current and future cellular systems include Voice over IP (VoIP), videoconference, push-to-talk over cellular (PoC), multimedia messaging, multiplayer games, audio and video streaming, content download of ring tones, video clips, Virtual Private Network (VPN) connections, web browsing, email access, File Transfer Protocol (FTP). Thus, the race towards IMT-Advanced was officially started in March 2008, when a Circular Letter was distributed asking for the submission of new technology proposals. Previous to this official call, the 3rd Partnership Project (3GPP) established the Long Term Evolution (LTE) and the 3rd Partnership Project 2 (3GPP2) established the Ultra Mobile Broadband. In this paper we have conducted a comparative study between UMB and 3GPP LTE by focusing on their first layers, i.e. Physical layer. The comparison specifically includes system architecture, radio aspects of the air interface such as radio access modes, multiple access technologies, multiple antenna technologies, modulation and mobility.

1. Introduction

The Ultra Mobile Broadband (UMB) system [1] is a next generation MIMO-OFDMA based Wireless WAN (WWAN) standard being developed by the 3rd Generation Partnership Project 2 (3GPP2), to enable ultra-high data rate mobile wireless connectivity. It is designed for robust mobile broadband access and is optimized for high spectral efficiency and short latency using advanced modulation, link adaptation and multi-antenna transmission techniques. In addition, fast handoff, fast power control, and inter-sector interference management are embedded in the design to facilitate communication in highly mobile environments.

The UMB system uses Orthogonal Frequency Division Multiplexing (OFDM) as the main modulation technique [2]. It employs sophisticated channelization techniques to facilitate high throughput and high reliability. It incorporates adaptive coding and modulation with synchronous Hybrid ARQ (HARQ) and turbo coding with variable retransmission latency. The UMB forward link supports MIMO (both single codeword with closed loop rate and rank adaptation and multi-codeword (layered) with per-layer rate adaptation) with closed loop precoding and space division multiple access (SDMA). The peak rate reaches 300 Mbps on forward link in a 20MHz system. The reverse link supports quasi-orthogonal transmission: orthogonal transmission based on OFDMA technique and non-orthogonal across multiple receives antennas.

The reverse link employs CDM waveform for the control segment to allow statistical multiplexing of various control channels, fast access, and request. The CDMA reverse link control segment also provides a wideband reference for power control, subband scheduling and efficient handoff support. The UMB standard can operate in a wide range of deployments, thereby providing WWAN operators great flexibility in optimizing their networks. For example, UMB can operate in a wide range of bandwidths (1.25 MHz – 20 MHz); this flexibility enables an operator to customize a UMB system for the spectrum available to the operator. The UMB system has a unified design for full and half duplex FDD and TDD and a scalable bandwidth from 1.25 to 20 MHz for variable deployment spectrum needs.

LTE is the part of 3GPP and evolved from the evolution of UMTS/HSPA cellular technology to meet current user demands of high data rates and spectral efficiencies. LTE specifications are jointly based on E-UTRA and E-UTRAN. The version specification for LTE is released in 3GPP Release 8. LTE uses OFDMA radio access technology in downlink and SC-FDMA in the uplink. The use of SC-FDMA in the uplink reduces PAPR as compared to OFDMA. The downlink peak data rates range from 100 Mbps to 326.4 Mbps depending on the modulation technique and antenna configuration used. LTE aims at providing data rates, IP backbone services, flexible spectrum, lower power consumptions and simple network architecture with open interfaces.

2(a) ARCHITECTURE of UMB

UMB supports a flat all IP architecture where all packets, voice, or data go through the same path .Flat networks provides faster responses, and therefore more applications can be offered. UMB architecture consists of Access Terminals (ATs) and Access Networks (ANs) as shown in Fig.1.

An Access Terminal has a radio interface to communicate with the Access Networks. An AN is a network entity that contains an Access Network Route Instance (ANRI) for the purpose of logically communicating with the AT. An AT maintains an In Use instance (akaRoute) that is associated with each AN it is in communication with. ANs may talk to each other through Route Protocol using Inter-Route Tunneling Protocol. Thus, AT may initiate multiroute with different ANs at a given time. UMB utilizes CAN as an Access Network.

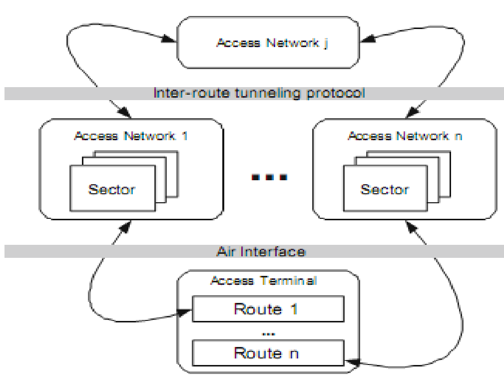

Figure 1: UMB Architecture

Converged Access Network (CAN)

CAN architecture is composed of Access Gateways (AGWs), evolved Base Stations (eBSs), and Session Reference Network Controllers (SRNCs) in addition to Access Terminals (ATs), Home Agent (HA), AAA server etc as shown in figure 2. The CAN architecture, as defined by 3GPP2, does not require a centralized entity such as a BSC in the exiting architecture. In CAN architecture, there is no need to coordinate the connection state across the UMB's BS equivalent, the Evolved Base Station (eBS). The eBSs of the UMB radio access network connect to a common access gateway (AGW), which provides a point of IP attachment for the AT to the packet data network.

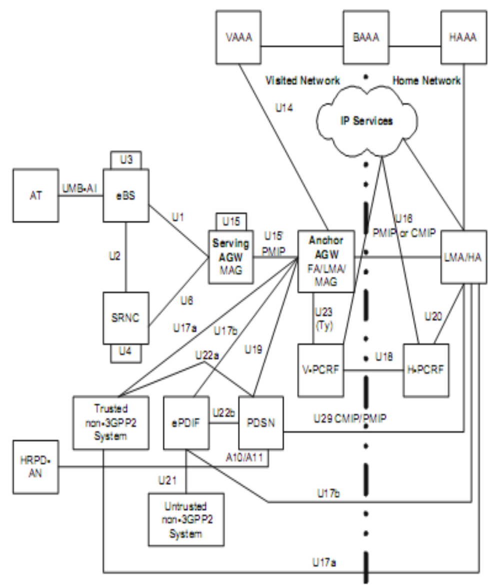

Figure 2: CAN architecture

2(b) ARCHITECTURE of LTE

LTE ARCHITECTURE:-The architecture is mainly divided into two parts -a radio access network part and a core network part. Functions like modulation, header compression and handover belong to the access network, whereas other functions like charging or mobility management are part of the core network. In case of LTE, the radio access network is E-UTRAN and the core network EPC [3].

RadioAccessNetwork

The radio access network of LTE is called E-UTRAN and one of its main features is that all services, including real-time, will be supported over shared packet channels. This approach will achieve increased spectral efficiency which will turn into higher system capacity with respect to current UMTS and HSPA. An important consequence of using packet access for all services is the better integration among all multimedia services and among wireless and fixed services. The main philosophy behind LTE is minimizing the number of nodes. Therefore the developers opted for single-node architecture. The new base station is more complicated than the Node B in WCDMA/HSPA radio access networks, and is consequently called eNB (Enhanced Node B). The eNBs have necessary functionalities for LTE radio access network including the functions related to radio resource management.

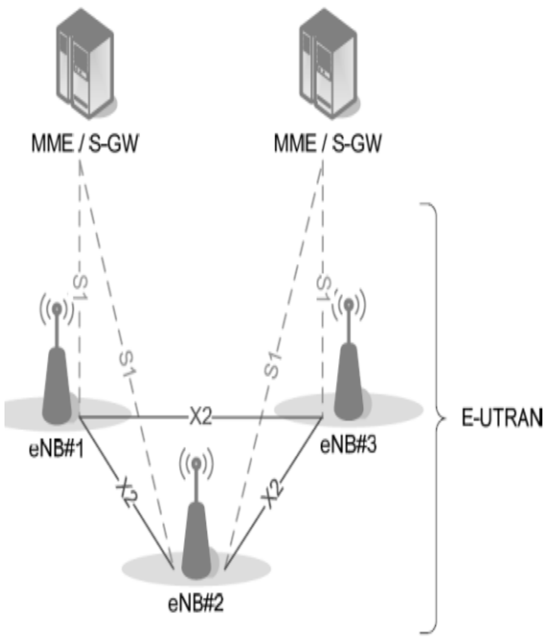

Figure 3: LTE (release 8) architecture

Core Network

Core network is known as EPC in SAE. The key responsibilities of CN include bearer establishment and control of UE. EPC is made of various logical nodes.

- Mobility Management Entity (MME).
- Packet Data Network Gateway (P-GW).
- Serving Gateway (S-GW).
- Policy Control and Charging Rules Function (PCRF).
- Home Subscriber Server (HSS).

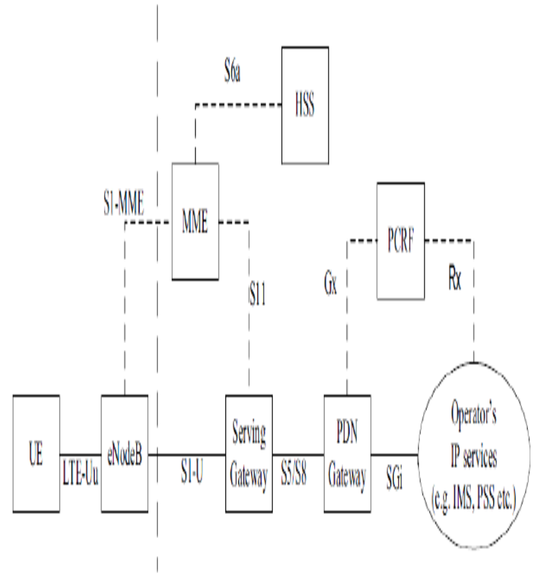

Figure 4:

3. RADIO ASPECTS OF AIR INTERFACE

A. Radio Access Modes: - UMB was originally destined to support both FDD and TDD modes, but later on more attention was paid to the development of the FDD mode. In TDD mode the ANs must be synchronized with each other, but in FDD mode they may or may not be synchronized. While in LTE, both TDD and FDD can be used. In FDD, BS and mobile user transmit and receive simultaneously due to allocation of separate frequency bands. While in TDD, downlink and uplink transmit in different times due to sharing of same frequency.

B. Data Rates

The peak data rates of LTE and UMB depend upon multiple antenna configuration and modulation scheme used. The peak data rates of LTE and UMB in DL and UL are given in table 1[4]

Technology	Downlink(DL)	Uplink(UL)
LTE	350(Mbps) 4×4 MIMO	200(Mbps)4×4 MIMO
UMB	288	75

Table 1: Data Rates of LTE and UMB

C. Multiple Access Technology

The multiple access technologies used by LTE and UMB are quiet similar except with some difference in the uplink. In UMB

Uplink/Downlink and LTE downlink we use OFDMA. While in LTE uplink we use SC-FDMA. The benefit of SC-FDMA in the uplink is the reduction of the PAPR.

OFDMA

It is an extension of OFDM and is used in downlink of LTE and uplink/downlink of UMB. In OFDMA, subcarriers are allocated dynamically to users in different time slots.

SC-FDMA

SC-FDMA is an extension of OFDMA and is used in the uplink of LTE. SC-FDMA significantly reduces PAPR as compared to OFDMA by adding additional blocks of DFT and IDFT at transmitter and receiver. However, due to existing similarities with OFDMA, parameterization of LTE in the uplink and downlink can be harmonized

4. Modulation Parameters

UMB and LTE support flexible bandwidth from 1.25 MHz to 20 MHz's. There are various modulation parameters (such as subcarrier spacing, FFT size etc.) which are given in table 2.

	3GPP LTE	3GPP2 UMB
Channel bandwidth	1.25, 2.5, 5, 10, 15, and 20 MHz	1.25, 2.5, 5, 10, and 20 MHz
DL (FL) multiple access	OFDMA	OFDMA
UL (RL) multiple access	SC-FDMA	OFDMA & CDMA
Subcarrier (tone) mapping	Localized (block)	Distributed & block
Subcarrier hopping	Yes	Yes
Data modulation	QPSK, 16-QAM, and 64-QAM	QPSK, 8-PSK, 16-QAM, and 64-QAM
Subcarrier spacing	15 kHz	9.6 kHz
FFT size / usable subcarriers†	512 / 301 samples	512 / 256~480‡ samples
Channel coding	Convolutional coding & turbo coding	Convolutional coding, turbo coding, & LDPC coding
MIMO	SCW & MCW Precoding, SFBC/STBC, Switched TxD, & CDD	SCW & MCW Precoding, STTD, SDMA, & Beamforming

Table 2: Modulation Parameters of LTE and UMB

5. Multiple Antenna Techniques

UMB and LTE use multiple antenna configurations in uplink and downlink in order to increase capacity, diversity, data rates and efficiency as compared to single antenna systems. The advanced antenna techniques used by LTE are beamforming, Spatial Division Multiple Access (SDMA) and MIMO. The antenna configuration supported by LTE DL is (2x2) and (4x4) having 2 or 4 antennas at eNodeB and 2 or 4 antennas at UE. The UL of LTE supports 2x2 MIMO having 2 antennas at UE as well as at eNodeB. In addition, the number of code words used by LTE is 2 which are independent of the antenna configuration. UMB simultaneously supports multiple antenna operations including MIMO, SDMA, and beamforming. MIMO procedures consist of (a) single-code word (SCW) or multicode word (MCW) operations, (b) precoding, (c) permutation matrices for multicode word MIMO and/or SDMA. There are multiple physical antennas and a logical antenna is defined as a linear combination of physical antennas that is slowly varying over time and frequency.

4. Standardization Organization

The introduction of Mobile WiMAX led both 3GPP and 3GPP2 to develop their own version of beyond 3G systems based on the OFDMA technology and network architecture similar to that in Mobile WiMAX. The beyond 3G system in 3GPP is called evolved universal terrestrial radio access (evolved UTRA) and is also widely referred to as LTE (Long-Term Evolution) while 3GPP2's version is called UMB (ultra mobile broadband) as depicted in Figure 5[5].

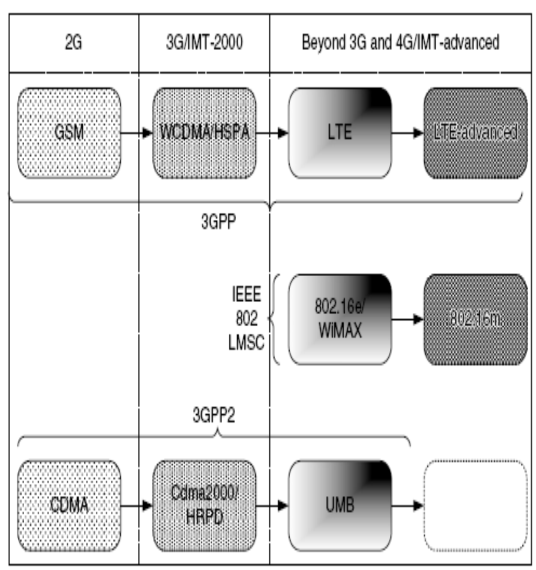

Figure 5:Standardization Organization of LTE and UMB

5. MOBILITY

LTE supports RRC_IDLE and RRC-CONNECTED modes to provide mobility. LTE supports Inter Cell Soft Handovers and Inter RAT handovers with mobility speeds up to 350 km/h. In UMB, mobility is supported at the link layer and in the IP layer through mobile IP. The mobility scenarios for UMB consider three types of mobility: within AGW domain, across AGW domain, and between different technologies. In UMB, there is a multiroute feature which is introduced to provide flexible and seamless handover experience. Multiroute functionality enables AT to establish more than one route with different eBSs in the active set. Route is defined as a protocol stack, which is instantiated per eBS. Maximum 6 routes are supported when active; however, in idle mode only one route with SRNC is supported. This allows AT to maintain FL with one eBS and RL with another eBS, simultaneously. Multiroute aims to provide fast switching between eBSs with low associated overhead. AT can communicate to eBS before any handoff and has the advantage of selecting the best serving eBS for optimized OTA performance with minimum overhead of switching.

6. COMPARATIVE SUMMARY

A brief comparative summary of both the technologies is given in table 3.

PROTOCOL	LTE	UMB
Standardization	2008	2007
Standardizing Organization	3GPP	3GPP2
Core Network	IP based	IP based
Multiple Access Techniques	UP: SC-FDMA DL: OFDMA	UP:OFDMA DL:OFDMA
Mode For Full Duplex Communication	FDD and TDD	FDD
Advanced Antenna Techniques	MIMO	MIMO,SDMA, Beamforming
Seamless Mobility	Yes	Yes
Power Saving	Yes	Yes
QOS	End to End	End to End
Bandwidth	1.25 to 20 MHz	1.25 to 20 MHz
Subcarrier spacing of OFDM	15KHz	9.6KHz
Scheduling method of users	Time and Frequency	Time and Frequency
Peak Data Rate	100 Mbps	288 Mbps
Positioning	Migration from W-CDMA	Migration from CDMA 2000
Delay Time	Access time of link layer,less than 5ms	AAccess time of link layer,less than 10ms,hand off less than 20 ms
Subcarrier number of OFDM	76-2048	128-2048
Supported speed of mobile vehicle	Stationary to 350 Km/hr	Stationary to 350 Km/hr
Others	DoComo to lanch service in 2009-2010	Qualacom n halted it as 4G in the end of 2009

Table 3: Comparative Summary of UMB and LTE

7. CONCLUSION

We conclude that both UMB and LTE are technically similar standards. However, there are some differences present in the uplink access method used by both technologies. LTE uses SC-FDMA whereas UMB uses OFDMA as an access method. We also conclude that, LTE gives better data rates in the uplink and downlink .From a market prospective, LTE has edge on UMB due to its early deployments.

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