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A Comparative Study of the Third-Generation Long Term Evolution (LTE) and the IEEE 802.20 Mobile Broadband Wireless Accesses (MBWA)

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Abstract: *In the world of telecommunication the 3G (3rd Generation) standards are currently dominating the service area as well as the end user arena. Two of the most emerging and suitable standards for this genre are3GLTE (3rd Generation Long Term Evolution) and IEEE 802.20 MBWA (Mobile Broadband Wireless Access). Both technologies has their own scope in terms of the system architecture and radio interference from both service provider and end user perspective. This paper provides a comparative study of these two next generation wireless. It gives an introduction with the purpose and scope of those standards. The technical aspects brief the differences in the system architecture and air interface details of both the standards. Finally, the differences between the standards are discussed.*

Keywords: *IEEE 802.20, OFDM, Wi-Fi, WiMAX, MIMO, SAE, Transmission bandwidths, MAC Layer.*

1. Introduction

3GLTE (3rd Generation Long Term Evolution) is the next major step in mobile radio communications, and will be introduced in 3rd Generation Partnership Project (3GPP) Release 8. LTE uses Orthogonal Frequency Division Multiplexing (OFDM) as its radio access technology, together with advanced antenna technologies.

3GPP is a collaboration agreement, established in December 1998 that brings together a number of telecommunications standards bodies, known as 'Organizational Partners'. 3GPP is also defining IP-based, flat network architecture. This architecture is defined as part of the System Architecture Evolution (SAE) effort. The LTE–SAE architecture and concepts have been designed for efficient support of mass-market usage of any IP-based service. The architecture is based on an evolution of the existing GSM (Global System for Mobile communication) and WCDMA (Wideband Coded Division Multiple Access) core network, with simplified operations and smooth, cost-efficient deployment.

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On the other hand, the IEEE 802.20 was developed to support high speed data services and to support full user mobility. 802.20 MBWA (Mobile Broadba Wireless Access) is a mobile fidelity which increases the coverage and mobility than existing 802.11 and 802.16, and sits on existing cellular towers, promising the same coverage area as a mobile phone system with the speed of a Wi-Fi (Wireless Fidelity) connection [1]. It can provide a high speed data rate of 20 Mb/s. The packet based air interface access of MBWA helps the transport of IP-based services to enable the implementation on MBWA networks worldwide. IEEE working group concluded five necessary criteria for IEEE 802.20. They are Broad market potential, Compatibility, Distinct identity, Technical feasibility and Economic feasibility.

2. 3G LTE

LTE (Long Term Evolution) is the next major step in mobile radio communications. 3G LTE (or 3GPP LTE) will be introduced in 3rd Generation Partnership Project (3GPP) Release 8. 3GPP LTE is one of five major wireless standards sometimes referred to as"3.9G." The other so-called 3.9G standards are:

- 3GPP Evolved High-Speed Packet Access (HSPA+)
- 3GPP Enhanced Data rates for GSM Evolution (EDGE)
- 3GPP2 Ultra Mobile Broadband (UMB)
- Mobile Worldwide Interoperability for Microwave Access (WiMAX - IEEE 802.16e)

All have similar goals in terms of improving spectral efficiency, with the widest bandwidth systems providing the highest single-user data rates. Spectral efficiencies are achieved primarily through the use of less robust, higher-order modulation schemes and multi-antenna technology that ranges from basic transmit and receive diversity to the more advanced MIMO (Multiple Input Multiple Output) spatial diversity.

Of the 3.9G standards, EDGE evolution and HSPA+ are direct extensions of existing technologies. Mobile WiMAX is based on the existing IEEE 802.16d standard and has had limited implementation in WiBro (Wireless Broadband). Both UMB and LTE are considered "new" standards.

3G LTE has introduced a number of new technologies compared to the previous cellular systems. They enable LTE to be able to operate more efficiently with respect to the use of spectrum, and also to provide the much higher data rates that are being required.

OFDM (Orthogonal Frequency Division Multiplex): OFDM technology has been incorporated into LTE because it enables high data bandwidths to be transmitted efficiently while still providing a high degree of resilience to reflections and interference. [2]

MIMO (Multiple Input Multiple Output): One of the main problems that previous telecommunications systems have encountered is that of multiple signals arising from the many reflections that are encountered. By using MIMO, the additional signal paths (which were the problems of previous telecommunications systems) can be used to advantage and are able to be used to increase the throughput.

SAE (System Architecture Evolution): One change of this evolution is that a number of the functions previously handled by the core network have been transferred out to the periphery. This provides a much "flatter" form of network architecture. In this way latency times can be reduced and data can be routed more directly to its destination. [3]

3. MBWA (IEEE 802.20)

The IEEE 802.20 (or Mobile Broadband Wireless Access - MBWA) Working Group was established with the aim to develop a specification for an efficient packet based air interface that is optimized for the transport of IP based services. The goal is to enable worldwide deployment of affordable, always-on, and interoperable BWA (Broadband Wireless Access) networks for both business and residential end user markets. The group will specify the lower layers of the air interface, operating in licensed bands below 3.5 GHz and enabling peak user data rates exceeding 1 Mbit/s at speeds of up to 250 km/h. [4]

The goals of 802.20 and 802.16e are similar. However, 802.16e is much more mature, whereas even the standardization process of 802.20 is far from complete. A draft version of the specification was, though it was approved on January 18, 2006. And still it is a new concept in the arena of telecommunications. [4]

4. Architecture

4.1. 3G LTE

In parallel with the LTE radio access, packet core networks are also evolving to the flat SAE architecture. This new architecture is designed to optimize network performance, improve cost-efficiency and facilitate the uptake of mass-market IP based services.

There are only two nodes in the SAE architecture user plane: the LTE base station (eNodeB) and the SAE Gateway, as shown in Figure 1. The LTE base stations are connected to the Core Network using the Core Network–RAN interface, S1. This flat architecture reduces the number of involved nodes in the connections. Existing 3GPP (GSM and WCDMA/HSPA) and 3GPP2 (CDMA2000 1xRTT, EV-DO) systems are integrated to the evolved system through standardized interfaces providing optimized mobility with LTE. For 3GPP systems this means a signaling interface between the SGSN and the evolved core network and for 3GPP2 a signaling interface between CDMA RAN and evolved core network. Such integration will support both dual and single radio handover, allowing for flexible migration to LTE.

Control signaling for mobility, is handled by the Mobility Management Entity (MME) node, separate from the Gateway. This facilitates optimized network deployments and enables fully flexible capacity scaling. The Home Subscriber Server (HSS) connects to the Packet Core through an interface based on Diameter, and not SS7 as used in previous GSM and WCDMA networks. Network signaling for policy control and charging is already based on Diameter. This means that all interfaces in the architecture are IP interfaces.

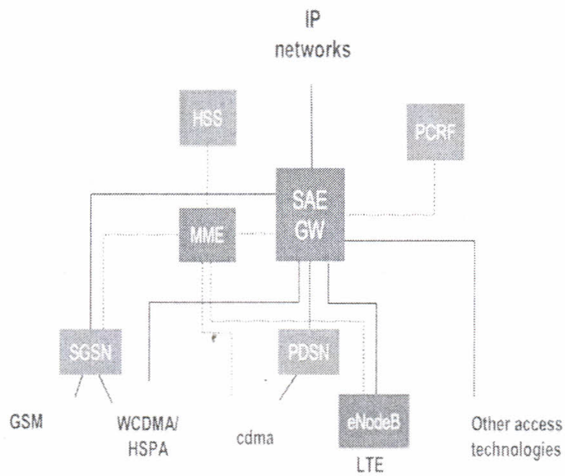

Fig 1: 3GLTE flat architecture

Existing GSM and WCDMA/HSPA systems are integrated to the evolved system through standardized interfaces between the SGSN and the evolved core network. It is expected that the effort to integrate CDMA access also will lead to seamless mobility between CDMA and LTE. Such integration will support both dual and single radio handover, allowing for flexible migration from CDMA to

LTE. LTE–SAE has adopted a Class-based QoS concept. This provides a simple, yet effective solution for operators to offer differentiation between packet services. Fig 1 shows the flat architecture of 3GLTE.

4.2. IEEE 802.20 (MBWA)

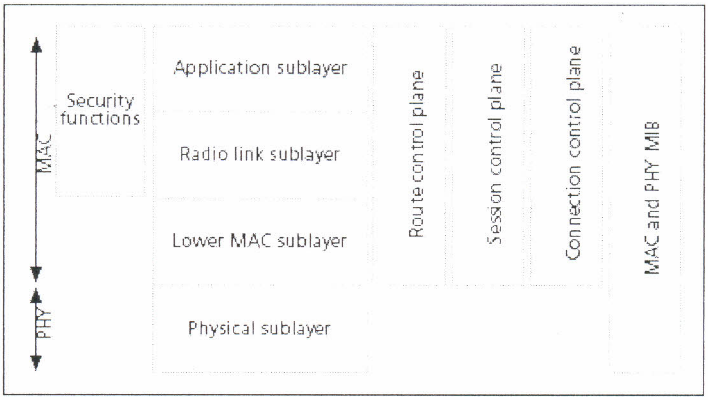

Fig 2. 802.20 layering architecture

The design of IEEE 802.20 standard should consider a clear separation of functionality in the system between the user, data, and control. The MAC layer should be optimized to support a specific PHY implementation. If more than one PHY implementation is to be used, the MAC layer should be designed so that it has a PHY-specific layer as well as a more general part [6].

4.2.1. 802.20 Physical Layer

The physical (PHY) layer of 802.20 comprises two duplex modes: Time Division Duplex (TDD) and Frequency Division Duplex (FDD), two forward link hopping modes: Symbol Rate Hopping and Block-Hopping, two synchronization modes: Semi Synchronous and Asynchronous, and two multi-carrier modes: Multi-Carrier On and Multi-Carrier Off. Modulation uses OFDM with QPSK, 8PSK, 16QAM, and 64QAM modulation formats [7].

4.2.2. 802.20 MAC Layer

The MAC layer of 802.20 consists session, convergence, security, and lower MAC functions. The lower MAC sub layer controls operations of data channels: Forward Traffic Channel and Reverse Traffic Channel [6]. It includes control channel MAC protocol, access channel MAC protocol, shared signaling MAC protocol, forward traffic channel MAC protocol, reverse control channel MAC protocol, and reverse traffic channel MAC protocol. Forward- and reverse-link transmissions are divided into units of superframes, which are further divided into units of PHY frames. FDD and TDD superframe timing are used. An FDD forward-link superframe consists of a superframe preamble followed by several forward frames, and an FDD reverse-link superframe consists of several reversed frames. A TDD forward-link superframe consists of a superframe preamble and several forward frames, and a TDD reverse-link superframe consists of several reversed frames. The default access channel MAC protocol provides an access terminal to transmit by initial access or handoff via sending an access probe. After receiving the access probe, the network responds with an Access Grant [7].

5. Radio Interface

5.1. 3G LTE

5.1.1. Radio access modes

The LTE air interface supports both FDD and time division duplex (TDD) modes, each of which has its own frame structure. Additional access modes may be defined, and half-duplex FDD is being considered. Half-duplex FDD allows the sharing of hardware between the uplink and downlink since the uplink and downlink are never used simultaneously. This technique has uses in some frequency bands and also offers a cost saving at the expense of a halving of potential data rates.

The LTE air interface also supports the multimedia broadcast and multicast service (MBMS), a relatively new technology for broadcasting content such as digital TV to UE using point-to-multi-point connections. The 3GPP specifications for MBMS first appeared for UMTS in Release 6. LTE will specify a more advanced evolved MBMS (eMBMS) service, which operates over a Multicast/Broadcast over single-frequency network (MBSFN) using a time-synchronized common waveform that can be transmitted from multiple cells for a given duration. The MBSFN allows over-the-air combining of multi-cell transmissions in the UE, using the cyclic prefix (CP) to cover the difference in the propagation delays. To the UE, the transmissions appear to come from a single large cell.

5.1.2. Transmission bandwidths

3GPP has defined the LTE air interface to be "bandwidth agnostic," which allows the air interface to adapt to different channel bandwidths with minimal impact on system operation.

The smallest amount of resource that can be allocated in the uplink or downlink is called a resource block (RB). An RB is 180 kHz wide and lasts for one 0.5 ms timeslot. For standard LTE, an RB comprises 12 subcarriers at 15 kHz spacing, and for eMBMS with the optional 7.5 kHz subcarrier spacing an RB comprises 24 subcarriers for 0.5 ms. Subcarrier spacing is constant regardless of the channel bandwidth. The maximum number of RBs supported by each transmission bandwidth is given in Table 1.

Table 1: Transmission bandwidth configuration [1]

Channel Bandwidth (MHz)	1.4	3	5	10	15	20
Resource Block	6	15	25	50	75	100

5.1.3. Supported frequency bands

The LTE specifications inherit all the frequency bands defined for UMTS [1], which is a list that continues to grow. There are now 13 FDD bands and 8 TDD bands [2]. Significant overlap exists between some of the bands, but this does not necessarily simplify designs since there can be band-specific performance requirements based on regional needs. There is no consensus on which band LTE will first be deployed, since the answer is highly dependent on local variables. This lack of consensus is a significant complication for equipment manufacturers and contrasts with the start of GSM and W-CDMA, both of which were specified for only one band. What is now firmly established is that one may no longer assume that any particular band is reserved for any one access technology.

5.1.4. OFDM Downlink Transmission

In the downlink, OFDM is selected to efficiently meet E-UTRA performance requirements. With OFDM, it is straightforward to exploit frequency selectivity of the multi-path channel with low complexity receivers. This allows frequency selective in addition to frequency diverse scheduling and one cell reuse of available bandwidth. Furthermore, due to its frequency domain nature, OFDM enables flexible bandwidth operation with low complexity. Smart antenna technologies are also easier to support with OFDM, since each sub-carrier becomes flat faded and the antenna weights can be optimized on a per sub-carrier (or block of sub-carriers) basis. In addition, OFDM enables broadcast services on a synchronized single frequency network (SFN) with appropriate cyclic prefix design [3]. This allows broadcast signals from different cells to combine over the air, thus significantly increasing the received signal power and supportable data rates for broadcast services.

5.1.5. SC-FDMA Uplink Transmission

In the uplink, Single-Carrier Frequency Division Multiple Access (SC-FDMA) is selected to efficiently meet E-UTRA performance requirements. SC-FDMA has many similarities to OFDM, chief among them for the uplink that frequency domain orthogonally is maintained among intra-cell users to manage the amount of interference generated at the base. SC-FDMA also has a low power amplifier de-rating (Cubic Metric / PAPR) requirement, thereby conserving battery life or extending range [5].

5.1.6. MIMO Solutions

Advanced multi-antenna techniques will play an important role in fulfilling the 3G LTE requirements on increased data rates and improved coverage and capacity. Increasing data rates can be achieved by transmitting multiple parallel streams or layers to a single user. The preferred use for MIMO is in conditions with favorable signal-to-noise ratio and rich scattering in the radio channel, e.g., small cells or indoor deployments. Multi-layer transmission may be applied for downlink as well as uplink transmission. The receiver has the possibility to separate the multiple data streams by using the channel properties and knowledge of the coding scheme. In order for the receivers to solve this task it is necessary to standardize the multi-layer transmission scheme selected for the long-term 3G. Selective per-antenna rate control (S-PARC) [8] is an interesting technique where the number of layers and the data rate per layer, is adapted to the instantaneous channel conditions.

5.2. MBWA

5.2.1. Air Interface characteristics of PHY layer

When characteristics of PHY portion of the air interface is considered, the channel bandwidth (for FDD) should be of the paired spectrum variety, consisting of two 1.25 MHz channels that use FDD. The system should have the ability to support six or more sectors per cell yet should be able to scale downward in order to accommodate a more typical load of three sectors per cell [7]. A Doppler tolerance of greater then 400 Hz is needed in order to satisfy the requirement for full vehicular mobility. At a carrier frequency of 2 GHz, the system will be able to support a Doppler tolerance of 400 Hz, thus enabling support of vehicular speeds at 228 km/h. A frequency reuse factor of one or less is needed so that the same frequencies can be reused in all cells and sectors. Through the employment of directed adaptive antennas, it may be possible to use the same frequency band more than once in the same cell or sector [5].

5.2.2 Air Interface characteristics of MAC layer

Table 2: Air Interface characteristics of MAC layer

Parameter	Proposed value
Number of active users per sector/cell	> 100
Transition from active on to active hold state	< 100 ms
Transition time from active hold state to active on state	< 50 ms
Transition time from active hold state to inactive sleep state	< 100 ms.
Access time from inactive sleep state to active on state	< 200 ms
Paging signal periodicity	< 100 ms
Paging signal duration	< 1 ms
Minimum scheduling interval	< 2 ms
UL request time	< 10 ms
Intersector/cell handoff time	< 200 ms

Table 2 gives the characteristics that the MAC layer is responsible for in the air interface [5]. The air interface should support MAC protocol's On, Hold and Sleep states with fast transitions among them. In the On state, client uses the system resources actively to transmit and receive data. In order to get higher system efficiency, the Hold state should be initiated whenever the client doesn't use the system. The sleep state is initiated when the user is completely inactive. Transitions between the states should be fast and dynamic. Total system efficiency is increased when the air-link resources that are consumed by users are few. Testing has shown that 100 concurrent active users are required to fully utilize the 1 Mb/s to 2 Mb/s bandwidth available to a given sector or cell [6]. Paging mechanism is used to wake up the users from sleep state and bring them into ON state. It allows a mobile station to conserve energy with the help of Sleep state and still allows for Table 2 gives the characteristics that the MAC layer is responsible for in the air interface [5]. The air interface should support MAC protocol's On, Hold and Sleep states with fast transitions among them. In the On state, client uses the system resources actively to transmit and receive data. In order to get higher system efficiency, the Hold state should be initiated whenever the client doesn't use the system. The sleep state is initiated when the user is completely inactive. Transitions between the states should be fast and dynamic. Total system efficiency is increased when the air-link resources that are consumed by users are few. Testing has shown that 100 concurrent active users are required to fully utilize the 1 Mb/s to 2 Mb/s bandwidth available to a given sector or cell [6]. Paging mechanism is used to wake up the users from sleep state and bring them into ON state. It allows a mobile station to conserve energy with the help of Sleep state and still allows for the mobile station to receive incoming packets. This is an important real-time application in which the station needs to be active at all times. In order to reduce the delay associated with waking a user up, the MBWA air interface should support the ability to send paging signals as often as once every 100 ms [1]. To have minimal packet loss and latency, the air interface should support both inter-sector and inter-cell handoff in a time that is comparable to the state transition time: 200 ms [5].the mobile station to receive incoming packets. This is an important real-time application in which the station needs to be active at all times. In order to reduce the delay associated with waking a user up, the MBWA air interface should support the ability to send paging signals as often as once every 100 ms [1]. To have minimal packet loss and latency, the air interface should support both intersector and inter-cell handoff in a time that is comparable to the state transition time: 200 ms [5].

6. Comparison

3GLTE and IEEE802.20 seem to be same but they differ in many ways. This can be discussed under End-user, Service provider and Technology categories.

In the End user arena, the data services of 3GLTE are required by the voice-users. The End user devices must be initially data enabled handsets to provide this though the data services are highly asymmetric. It has a lack of support for low latency services. On the other hand IEEE 802.20 is very much effective for the fully mobile and high throughput data users, as it is designed for the mobility from the ground up of IEEE standards, which uses the symmetric data services. End-user devices are initially PC Card enabled data devices. Unlike the 3GLTE, it supports the low-latency data services. In the area of the Service Providers, both the 3GLTE and IEEE802.20 provides global mobility and roaming support. Apart from this, 3GLTE is very much suitable for the cellular voice service providers evolving to data support, where as the IEEE 802.20 is much effective with the wireless data service provider.

Like the End-user and Service provider point of view, the technical specifications of both of these standards also show some distinguish as well some similar features. Key technologies for both 3GLTE and IEEE 802.20 are OFDMA and

MIMO. In addition, of OFDMA, 3GLTE is also designed to support SC-FDMA (Single Carrier Frequency Division Multiple Access). IEEE 802.20 has been fully optimized for the mobility where as 3GLTE can be considered as the evolving GSM standard. Both of them use TDD and FDD for the communication channel. The channel bandwidth for 3GLTE is 1.25 ~ 20 MHz and for IEEE 802.20 the bandwidth is 5 ~ 20 MHz. The standard downlink and uplink of 3GLTE is 100 Mbps and 50 Mbps respectively. The standard downlink and uplink of IEEE 802.20 is 46 Mbps and 60 Mbps respectively. The highest range of mobility is 250 Km/h for both the standards. The coverage area for 3GLTE service can be fitted into the MAN (Metropolitan Area Network) scale. In case of IEEE 802.20, WAN (Wide Area Network, < 20Km) is more applicable. Although 3GLTE uses the licensed bands below 2.7 GHz, IEEE 802.20 uses the licensed bands below 3.5 GHz. 3GLTE incorporates quite a handful of modulation techniques, such as for the downlink, it uses OFDM with QPSK (Quadrature Phase Shift Keying), 16QAM (Quadrature Amplitude Modulation) and 64QAM and for the uplink it uses SC-FDMA BPSK (Binary Phase Shift Keying), QPSK, 8PSK (Phase Shift Keying) and 16QAM. On the other hand, IEEE 802.20 uses OFDM with QPSK, 8PSK, 16QAM, 64 QAM for both uplink and downlink. As an example, data rate on the 5MHz channel for 3GLTE is 25 Mbps [1] where as for IEEE 802.20 it is 18 Mbps[6].

7. Conclusions

The purposes of LTE and MBWA are very much alike; both allows reasonable terminal power consumption, both are IP-based and increased service provisioning, both supports high vehicular mobility, both are interoperable. Every service providers and manufacturers strategize towards high mobility and high data rates whether it is 3GPP, WiMAX or even WiBro oriented. However, the mainstream of service providers concern about regulation, uncertainty of market, and economic burden. There is also new spectrum allocation issue which should be resolved and determined, much as the technology feasibility. IEEE 802.20 has not been able to gain the upper hand in the battle for the next generation wireless network standard yet. It remains to be seen whether or not MBWA plays a role in this 3GPP vs IEEE race towards the next generation wireless standard.

8. References

[1] *"3GPP Long Term Evolution: System Overview, Product Development"*, Agilent Technologies Inc. USA, 2008.

[2] *"Long Term Evolution (LTE): Overview of LTE Air-Interface"*, Technical White Paper; Motorola Inc. USA, 2007.

[3] 3GPP TR 25.913, *"Requirements for Evolved UTRA (E-UTRA) and Evolved UTRAN (E-UTRAN)*, v.7.3.0", Motorola Inc. USA, March 2006.

[4] 3GPP TR 25.814, *"Physical Layer Aspects for Evolved UTRA"*, v.2.0.0, Motorola Inc. USA, June 2006.

[5] IEEE 820.20 WG, *"Desired Characteristics for an MBWA Air Interface"*, March, 2003.

[6] IEEE 820.20 WG, *"User Data Models for an IP-based Cellular Network"*, March, 2003

[7] Walker Bolton, Yang Xiao, Mohsen Guizani, *"IEEE 802.20: Mobile Broadband Wireless Access*, Wireless Communications", IEEE, Vol. 14, No. 1. (2007), pp. 84-95.

[8] S. Grant, J.-F. Cheng, L. Krasny, K. Molnar and Y.-P. E. Wang, *"Per antenna-rate-control (PARC) in frequency selective fading with SICGRAKE receiver"*, Proceedings of IEEE VTC2004 Fall, pp. 1458-1462, September 2004.