WiMAX vs. LTE: an Analytic Comparison

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***Abstract*— In this paper, we have discussed the capacity and efficiency, complexity, and coverage features of both Worldwide Interoperability for Microwave Access (WiMAX) and Long Term Evolution (LTE) wireless communications technologies. As these features influence the performance of the two technologies, it is important to know each technology advantages and disadvantages from these characteristics point of view. The paper delves into the intricacies of the two technologies to find out which is the next generation leading wireless technology, through finding the key parameters which make the one of driven technologies appear powerfully in the lead.**

Keywords*— *Long Term Evolution, LTE, Worldwide Interoperability for Microwave Access, WiMAX; Broadband Wireless Technologies.

I. OVERVIEW

During the last few years, the need for making the internet a part of the mobile system has been increased. Because of this evolution, the telecommunication companies motivated hard to look for a new air interface for mobile communication .This motivation was to present a frame which could provide a wide range of service with high mobility. In addition, this frame would increase the total capacity of the system, reduce latency, get better spectral ability and better performance of the cell-edge. [2]

There are two new technologies which aim to offer mobile audio and video data services by supporting the development in minimum money cost and the model service using Internet friendly structure and underlines. These two technologies are the IEEE 802.16 WiMAX and the 3GPP LTE. The WiMAX and LTE technologies are applications used for the new technology in mobiles called the fourth generation (4G) network. [2]

In this paper, we have presented a comparing between LTE and WiMAX basics, and investigate into the details of each of them. We have began with a short overview of the history of WiMAX and LTE. Then, we have performed a comprehensive evaluation of the capacity and efficiency, complexity, and coverage for each of the two technologies, and argue the faultless mixing of WiMAX and LTE technologies into the advanced networks of the 3GPP. We have performed a specific study of the previous features as these features impact the performance of the two technologies. Towards the end, we have summarized the evaluation of the performance of the two technologies.

II. INTRODUCTION TO WIMAX AND LTE

The technology of communication is inventing new levels to professionally provide high speed for mobile access with low cost operations and end users in a uni air interface and network architecture. WiMAX of The IEEE 802.16 and LTE of 3GPP standards are guiding towards developing the next development of mobile standards in network. [2]

WiMAX is part of IEEE with larges the ability of wireless in access form the local area network, which is based regulations of the IEEE on the Metropolitan Area Networks and Wide Area Networks. A new physical layer in radio access technology is been used in WiMAX for uplink and downlink which is called (Orthogonal Frequency Division Multiple Access). The 802.16-2005 which is called 802.16e or being referred to as Mobile WiMAX, which is newer and a redeveloped version than the 802.16-2004, which is called 802.16d or being known as fixed WiMAX. The old version took in consideration the fixed access and the nomadic access only, while the later edition 802.16-2005 include many new countenance and functions which is necessary to keep the good quality of service and and wide range of services within speed more than 120 Km/h. The WiMAX in mobile uses the technology of IP backbone that gives ability of downlink and uplink with maximum data rate reaches to 75 Mbps, depending on the place of installing the antenna and the lines, workable 10 Mbps within a radius of 6 miles (10 Km). The TDMA, Time Division Duplex and FDD were the first to accept the iterations of WiMAX, within sight line spread across the frequency range of 10 to 66 GHz which was later extended to contains processing with the 2 - 11 GHz range, with non line of sight (NLOS) capability using the robust OFDMA PHY (Physical) layer, with directed permitting dynamic distribution of time and frequency resources to many users. [2]

In the last years, the target was to improve networking. The 3G cellular system, Wi-Fi and Bluetooth are new technologies that the 802.16m is trying to let coming people live along with it, and improve the rates of peak to 4G standards that are set by the ITU (International Telecommunication Union) under 'IMT-Advanced' which determines rates for each kind, for the high mobility 100 Mbps and fixed/nomadic wireless access for 1 Gbps. [2]

On the other side, 3G technology was the mother of the LTE, which was built based on (Wideband Code Division Multiple Access), and determination of the long term evolution of the 3GPP UMTS/HSPA as cellular technology. Evolved of UMTS

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terrestrial radio access and UMTS access network are known as the stipulation of these efforts, and is usually been referred to as the 3GPP project LTE.

The first edition of LET was launched and mentioned in Release 8 of the 3GPP classification. It uses a new technology in radio access for the downlink based on Division in Frequency Multiple Access, and for uplink the PHY layer of mobile WiMAX is using the single Carrier Frequency Division Multiple Access.[2]

LTE technology backed up the high performance of mobile access that reach up to 350Km/h with 500Km/h. The peak data rates differently between the uplink and downlink. The scale for uplink is 50 to 86.4 Mbps, and 100 to 326.4Mbps for downlink depending on the places of antenna and its depth. The LTE target is to achieve the standards of 4G 'IMT-Advanced'. [2]

The evolution of the 3GPP system and structural evolution is the beginning of the development of the LTE interface. The LTE has many goals and some of them are to provide IP basic with decrease in the cost per bit and providing better service. More than that, the LTE target is to provide an easy use for the costumers, and a simple network structure with better using. The first development of LTE was launched in 2010.[2]

Fig.1 Explains the evolution of wireless technology path for WiMAX and LTE.

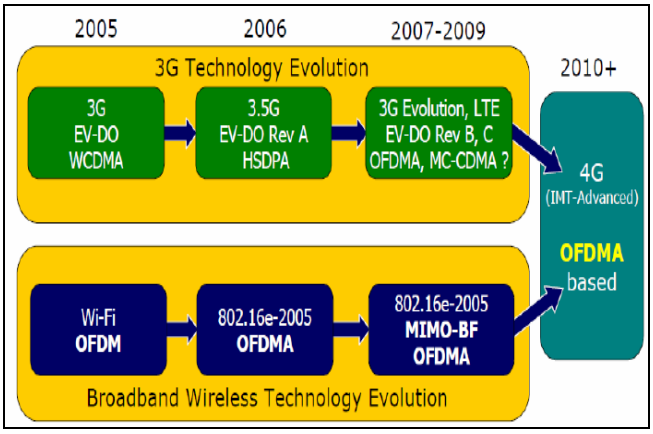

Fig. 1. The Evolution path in wireless technologies towards 4G in mobile system. [2]

III. Comparison Between Wimax and Lte

LTE and WiMAX have many common things like adopting OFDMA (supports advanced antenna technologies, such as MIMO, STC, and Beamforming). While the OFDMA is the basic of WiMAX, the LET tends to combine OFDMA7. Another thing that the two technologies share is the IP, LET is changing from circuit to all-IP. At the end, users wants to live the technology experience on the mobile as same in the home and office.

To have better performance, we need the following requirements:

1. Peak data rate

This includes:

- Immediate downlink peak data rate of 100 Mb/s within a 20 MHz downlink spectrum distribution.
- Immediate uplink peak data rate of 50 Mb/s within a 20MHz uplink spectrum distribution.

2. Cell capacity

The minimum number of users that the active state for spectrum allocations should be supported up to 5 MHzs is 200 users per cell.

3. Latency: Less than 5 ms.

4. User productivity.

- Downlink: average user productivity per MHz.
- Uplink: average user productivity per MHz.

5. Ability of movement

- E-UTRAN have to be leading for lower mobile speed from 0 to 15 km/h.
- The high mobile speed that should be supported from 15 to 120 km/h with good performance.
- The mobility across the cellular network that shall be maintained is 120km/h to 350km/h or even up to 500km/h depending on the band frequency.

6. Coverage

Productivity, efficiency of the spectrum and mobility targets have to be above 5 km cells, with a small deterioration for 30 km cells, while the range of cells that are up to 100 km should not be precluded.

As we have mentioned before, there are many common things between the two technologies. However, there are many differences between Wimax and LTE. The difference between them comes in many features like capacity and efficiency, complexity, and coverage. In this paper, we have discussed productivity, latency, spectral efficiency, and other features, where these features could impact the performance of the two technologies to know the best one of them.

As it is summarized in table I, LTE is targeted to exceed mobile WiMAX in all previous aspects.

Table I. LTE and WIMAX Differences Summary [8]

Aspect	WiMAX	LTE
Capacity and efficiency		
Coverage		
Complexity		

A. Capacity and Efficiency

1) Data Throughput

The productivity of the data is important for quantitative network productivity and performance. Unfortunately the way that the organizations gain acceptable productivity are different in many ways, and this often leads to misleading. In this paper, we have shown the realistic capabilities of the two technologies.

The fastest available transmission speed over the radio links is called "peak productivity" or "peak network speed, and this is one of the ways to represent the technology throughput, and it is based in the first place on the most higher order modification existing and the less coding overhead. The speed of network is also moved at layer 2 of the radio link, and because of the overhead in protocol, the productivity will be reduced 10-20 percent than this layer - value.

In case the network in radio delivers the needed speed, some other things in the network like the backhaul which often could cause in to constrain throughput rates to be lower than the level in radio-link rate.

There is another method to show the actual productivity, that is measured in deployed networks with many applications and one of them is File Transfer Basics. Under favorable conditions which works with the assumption of low network (low means one active data user in the section of the cells) loading and favorable of spreading the single, and this number helps us because it shows the high-end and real ability of this technology ,but the average rate is acuity lower than peak rate, and no accurate guideline could be provided.

Table II presents WiMAX and LTE technologies in terms of peak network productivity rates. As it is shown in table II, LTE provides outstanding Data Rates, due to less overhead. WiMAX and LTE uses different technologies.

The WiMAX and LTE technologies brings the end user data rates in the downlink. There is a technique called multiple output (MIMO) that is used to transmit the multiple parallel data streams into single terminal. Mixed with higher order to adjust the techniques. The 2x2 MIMO uses the multiple transmit and receiving of the channel and antennas to improve the performance and productivity, to double the potential downlink data rate. Separately, using multi-carrier technology, the LTE downlink could reach the higher data rates. Two frequency channels could be received to consumers by Multi carrier technology. This helps to double the user data rate in the coverage of an LET network and in the cell edge, and that is where users usually experience the lower data rates. The new structure of LTE network is supporting the high-throughput/low latency access system. The OFDMA offers improved spectral efficiency, capacity, etc. That is what the LTE downlink depends on, the OFDMA and SC-FDMA are similar in many ways but the SC-FDMA is more suitable for uplink, the transition of data is done through using multiple antennas and as more antennas used, and more data is transferred. On the other hand, the downlink in WiMAX could reach speed up to 75 Mbps by using modified antenna.

TABLE II. THROUGHPUT PERFORMANCE OF WIMAX AND LTE. [8]

Technology	Downlink Peak Network Speed	Uplink Peak Network Speed
LTE (2X2 MIMO)	173 Mbps	58 Mbps
LTE (4X4 MIMO)	326 Mbps	86 Mbps
WiMAX expected Wave 1 (10 MHz TDD DL/UL=3, 1X2 SIMO)	23 Mbps	4 Mbps
WiMAX expected Wave 2 (10 MHz TDD DL/UL=3, 2x2MIMO)	46 Mbps	4 Mbps

2) Spectral Efficiency

The understanding of reasons of developments in the varied technologies to be cabled to know the evolution of the ability for these technologies is a better way. It is useful to be known with the effectiveness of the specrtal. The number of users increment by using ever-higher bandwidth demands will affect the evolution of data services. When the wireless-data market grows, this causes to develop technologies that have high efficiency. The importance of retention like frequency radius, quantity of spectrum and evenness of cell site spacing. The increment in spectral efficiency causes increments in proportional, and the amount of supported users at the same rhythm for load per user, or the increments of productivity available for each user by delivering a wide range of service to more users can be done by high spectral efficiency system, because of the usage of more spectrum and deploying more cell sites by other alternatives.

The spectral efficiency in general, provides greater complexity for the users and base station, but it has a large price, some problems could be caused because of the rise of the calculations done on the process signals and from the additional radio components. For that, the operator and marketers must balance between the market need and the equipment cost. One of the sides of improving the wireless technology is managing the problems with the achievement of higher spectral. The main reason that the OFDMA technology is attractive for users, is that it allows high spectral efficiency with much less problems and because of that their use different technologies.

The map of LTE provides a large portfolio to help increase the efficiency of spectral. To develop these options, time is the most important thing, but that is hard to be predected, because many things are depending on the development in wireless data marketing and what application is going to be popular.

When the design focused in the technology future. It's good to know that WiMAX have the best links, that is, physical layers, the WiMAX link layer performance is reaching the limits, but in theoretical case as what has been defined by Shannon bound (the rate for theoretical limits about the transfer

rate are defined by Shannon bound) [bandwidth per unit]. The bounds are functions of Signal to Noise Ratio of the links in communication. WiMAX is within 2 - 3 decibels of the Shannon bound. Referring to that, there is no big space for improvements on the link layer perspective.

The Efficiency is to be determined by the reuse of frequency feature set (e.g. FSPS, MIMO, …). LTE will cause more spectral efficiency gains, LET will become more efficient with wider channels with initially 2X2 MIMO and with options within 4X4 and 4X2 MIMO. The efficient spectral in LTE are such as 10 and 20 MHz, the same thing for WiMAX, some gains are available and also gains experiences in efficiency like MIMO and MRxD are been used. The second wave WiMAX include 2X2 MIMO. Increasment of WiMAX will come from new potintials, and in addition, there is a new version for WiMAX standard which will match LTE efficiency.

The LTE MIMO technology back up the operation of closed loop with precede weighting and multimode MIMO. That is the most important reason that the LTE MIMO is more efficient than WiMAX and MIMO. The other thing about LTE MIMO is that it can make the SIC receivers easy. Many other reasons are there, some of them is that LTE supports incremental-redundancy HARQ. On the other hand WiMAX is better in the downlink.

The pilot in WiMAX which calculate for up more than 33 percent of tones is one of the causes of that the WiMAX uplink efficiency is lower than the LTE employing the less cancellation. WiMAX has more efficient pilot structure execution and that is why the WiMAX uplink efficiency will be more Nominal.

A very important result of this comparison is that both WiMAX and LTE have comparable spectral efficiency in wireless technologies which is been achieved by the usage of techniques of comparable radio, but LTE is working well to provide higher efficiency than WiMAX in the future. The opportunities for making an improvement in voice capacity using VoIP (Voice over IP) over HSPA (High Speed Packet Access) channels will be bigger. By depending on the increment in specific implement, the existing circuit switch could be doubled by the voice capacity, gains are related to the improvement on radio techniques applied to data channels and their not related specially to the use of VoIP. Some of this progress could be used in current circuit switch. VoIP is used in some areas like driving the migration to packet voice. Other use is the compact IP basic network for operators and evolution of the multimedia in applications for users.

Voice capacity is a direct function of the data rate or productivity. Current circuit switched approaches with LTE is more spectrally efficient than the initial versions of VoIP with WiMAX, but although of that its expected that the future version of the WiMAX will be better and more efficient in this issue . Table III summarizes the differences between WiMAX and LTE regarding the VoIP Performance.

TABLEIII. WIMAX AND LTE VOIP PERFORMANCE. [8]

WiMAX	LTE
16 concurrent users/cell/MHz, Focus on nomadic mobility, also vehicular speeds up to 120 km/h	24 concurrent users/cell/MHz, 350 km/h target speed

3) Scheduling

WiMAX: Being fast in data scheduling, uplink and downlink, reasonable resource distribution, QoS oriented the scheduling of the selective frequency; current applications may require increscent.

LTE: effective scheduling / multiplexing the data, ~100% effective target.

B. Complexity

When talking about complexity, the most important thing to discuss is Latency. The productivity is as important as the network latency, and that is been defined as the round trip time that it takes data to travel through the network. Undoubtedly, Better latency means better network utilization and better QoS (Quality of Service). latency could be reduced from forwarding the successive technology of GPRS.

The WiMAX has a latency value of 30 msec, LTE has a latency less than the WiMAX the lower value of the LTE latency is coming from the high data productivity in the other hand the WiMAX has lower data productivity because of the high latency

The new developments on in this technology means that all these values are going to go down as sellers and operates smooth their systems.

C. Coverage

We will focus on two important points to determine the differences between WiMAX and LTE from the coverage perspective. The max cell range per area and the cell edge performance. Table 4 shows the differences between the two technologies. As it is shown in table 4, LTE have higher cell range per area up to 50 – 100 km2. It is so high value in compared with WiMAX which can provide only 20 km2 at the best case. Also, LTE guarantees high performance (user throughput bps/ Hz), while WiMAX performance drop off sharply toward the cell edge even it is improved by MIMO Multiple-Input Multiple-Output. WIMAX throughput performance is reduced if trade-offs are made to extend cell range. Generally, the reason before the previous values which implies better coverage of LTE than WiMAX is the improved architecture of the LTE networks and the high data throughput (peak network speed).

TABLE IV. WIMAX VS. LTE COVERAGE. [8]

	WiMAX	LTE
Max Cell Range / Area	~3.3km / ~20km²	up to 30-100km (~5km w/ peak performance) / ~50km² - 100's km²
Cell Edge	Steep drop-off	Expected 2.5x HSPA

Performance	towards cell edge – improved with MIMO	performance (user throughput, bps/Hz)

IV. Comparison Summery

The following table summarizes a general comparison between WiMAX and LTE in several areas including the performance. The table enhances the idea that LTE will be the leading next-generation wireless technology.

TABLE V. COMPARISON SUMMARY [1]

		LTE	WiMAX Mobile
Spectrum	IMT2000 other	✓ ✖	WiMax IMT-2000 member ✓ (2.3, 2.5 & 3.5 GHz)
Services	Circuit Switched, Voice Packet Switched, Data	✓✓✓ (VoIP) ✓✓✓	✓✓ (VoIP) ✓✓✓
Mobility	Full Mobility Nomadic Mobility	✓✓ ✓✓	✓ ✓✓
Backwards Compatibility		✓✓ full 3GPP interoperability	✖
Roaming		✓✓	(✓) WiMax to WiMax
Performance	Coverage	✓✓ ✓✓✓ (LTE-900)	✓ ✓✓ if f < 3.5GHz
	Capacity	✓✓✓	✓✓(✓)
	Latency	✓✓✓	✓✓(✓)
Availability		2009/2010	2007/2008

V. Key Conclusions

* Reasonable trade-offs of key parameters make current WiMAX less competitive than LTE due to additional site costs even for Greenfield deployments especially for existing LTE operators there is likely no economic case for migration to WiMAX.

* Both technologies have their place and will co-exist in the mid-term, but LTE driven technologies appear firmly in the lead.

* LTE aims at gaining advantage over WiMAX in all areas – capacity, coverage and complexity.

* Mobile WiMAX can capture the market that depends on the availability of spectrum, confirmation of performance.

* The low cost of the WiMAX equipment does not affect

* The competition between the two technologies is not strong because each one of the two technologies serves different customers in different fields.

VI. Conclusion

Detailed comparison is been presented of the WiMAX and LTE features which impact the performance of the two technologies. We discussed the capacity and efficiency, complexity, and coverage for both technologies. We present a simulation graphs of WiMAX and LTE which results in enhancing the idea that LTE will be the leading 4th generation wireless technology. Future work will focus on discussing other features, like Quality of Service (QoS), Security, and Market Analysis and challenges for both technologies.

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