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An Overview of Mobile Broadband in 4G Long Term Evolution and Emerging Strategies for Resolving Deployment Limitations in Developing Countries

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Abstract

The role of mobile broadband in the society cannot be overemphasized in the global internet ecosystem. Its deployment and penetration is basically to satisfy end users increasing demand for data services and improve their quality of life. Therefore the need for a fast and reliable mobile broadband connection is an important driver of business and economic advancement of any nation. The increasing demand of data for new applications and request for more services by end users in global mobile competitive market motivated the Third Generation Partnership Project (3GPP) to introduce Long Term Evolution (LTE). This unique ability of LTE technology to offer a flexible spectrum support between 1.25MHz – 20MHz bandwidth makes it very attractive to both operators and the subscribers when compared to UMTS with a fixed bandwidth of 5MHz. However, with these vast opportunities lies an array of limitations, restrictions and challenges to both the operators and the subscribers.This paper provides a technological overview of LTE network as well as the challenges and solutions towards its deployment in developing countries.

Keyword: Mobile broadband, 3GPP, LTE, MIMO

INTRODUCTION

The growth of mobile broadband has brought a radical change in the way people communicate in terms of voice and data. The evolution of mobile communication from the first generation (1G) to the fourth generation (4G) is due to the improvement in the wireless technology which has followed many evolutionary paths with all of these developments aiming at unified target of achieving a better performance and efficiency in mobile environment [1]; such that end users have global access to more sophisticated and useful information on their mobile devices.

Mobile Broadband is an internet connection that supports voice, data and video transmission at very high speed.It can be deployed with the use of different types of infrastructures such as wired or wireless access since different type of network have their unique capability, strength, flaws and inherent costs involved.

It encompasses the use of several devices, networks and applications. The intensive usage of data services in mobile broadband has significantly reduced the volume of voice services traffic [2].The need for a faster and a more reliable and affordable broadband connectivity is becoming certain with growth in global economy and the universal human desire to improve on their quality of life with affordable access to health services, banking and education which are largely powered by latest advances in information technology.

Over the years the quest for higher bandwidth, faster connection times, and seamless handoffs brought about Long Term Evolution (LTE). This evolution will keep increasing with higher data usage over wireless networks driven by higher end user engagement with more interactive applications and rich multimedia on their mobile devices. To meet these exponential data traffic growth, there is a huge requirement for significant capital investments to build novel capacity along the value chain in order to deliver new and better mobile computing service.

MOBILE BROADBAND ECOSYSTEM

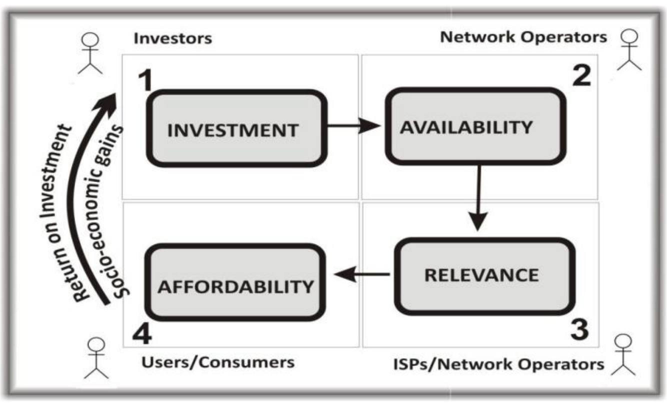


Figure 1: Economies of Broadband Ecosystem [3]

The Mobile Broadband Ecosystem (MBE) is a holistic view of different components required in delivering of end-to-end solutions for the provision of premium broadband services. The first component is ***Investment*** which refers to the fund required to obtain the network infrastructure. These can be acquired from numerous sources such as government, public private partnership or private sectors. The second component in the MBE is the ***availability of the network infrastructure*** that gives access to the broadband. The infrastructure can be in form of wireless, wire line, satellite.

The ***relevance of the service*** to the user is another vital component in the ecosystem. This is due to the fact that it is not enough for the end users to be aware of the broadband availability only, but to also see the relevance and attractiveness of the application and services offered. However,to enhance the relevance and attractiveness of the services, there must be wide sample preferences and variety of services, application and content in the mobile broadband market. The fundamental goal of any mobile communication system is the delivery of services to the end users.

Finally, ***affordability and adoption*** is the last component in a MBE that can determine the usage of broadband services. If the least option available is too expensive for the majority of a consumer market to afford, the demand for broadband services will be low and will negatively impact investment decisions. This has been a major factor for the low adoption of broadband services in developing countries.

LONG TERM EVOLUTION

LTE is the evolution of 3G mobile cellular communications technology that offers new standard in mobile communication with respect to the obtainable bandwidth to provide up to 10times the speed of 3G network connection. LTE network architecture is designed to support only packet switched service with seamless mobility through the use of Internet Protocols (IP) technology to transfer voice, data and video traffic via packet connection only and as well connect end users to the internet to access real time applications [4].

LTE technology offers the following benefits for both the operators and subscribers [5]:

1. ***Peak data rate***: To support 100Mbps for its downlink transmission and 50Mbps for uplink transmission
2. ***Control Plane Capacity***: To sustain at least 200 active voice users in every 5MHz bandwidth in an active state.
3. ***Reduced Latency*:** To allow 100 ms transmission from camped state to active state and less than 50 ms from dormant state to active state
4. ***Spectrum Flexibility***: To allow radio network operation in various ranges of spectrum allocations between 1.25MHz to 20MHz in both downlink and uplink direction
5. ***Improved spectrum efficiency*** which allows more information to be transmitted in a given bandwidth, while increasing the number of users and services the network can actually support
6. ***Efficient IP routing***: It supports IP packets only thereby reducing latency.
7. ***Enhanced support for end-to-end quality of service*:** Reduction in handover latency and packet loss is of vital importance in order to deliver good quality of service.
8. ***Mobility*:**To sustain network communication at speeds of up to 500km/h and improve performance for mobile speed between 15 and 120km/hr

LTE DEVELOPMENT TECHNOLOGIES

LTE is quite different from other networks due to the use of Multiple-Input Multiple-Output (MIMO) antenna technology, Orthogonal Frequency Division Multiplexing (OFDM) technology and its new network architecture known as System Architecture Evolution (SAE).

Multiple Input Multiple Output (MIMO)

This is a signal processing technique over multiple antennas and has emerged as a new model in achieving increased capacity, throughput and overall spectral efficiency. The use of multiple antennas at the transmitter and receiver end to transfer data on the same frequency in less time is one of the most crucial distinctions between LTE 4G and 3G network. Thus, it has brought significant improvement in the coverage area of the network. The two major categories of MIMO transmission schemes are spatial diversity and spatial multiplexing. In spatial diversity, the same data streams is transmitted over each of the multiple paths thus helping to stabilize the transmission link, reduce error rate and improve system performance. On the other hand, spatial multiplexing involves the transmission of different data streams over the multiple paths thereby increasing the system throughput and cell capacity [6].

Multiple antenna configurations in MIMO systems help to overcome the effects of interference, multi path and fading. Also the use of multiple antennas at the transmitter and receiver end helps to create multiple independent channels for transmitting multi data streams thus offering peak data rates and reliability without the need of additional bandwidth or transmit power [7].

Also, MIMO systems uses space-time coding of the same data stream mapped onto multiple transmit antennas to increase the coverage area capacity of the cell, thus providing additional diversity against fading on the radio channel as against the traditional reception diversity where just one transmit antenna is deployed to extend the coverage area of the cell. Furthermore, the use of beam-forming method in MIMO by means of multiple antenna arrays helps to recover cell-edge coverage by directing the transmit power in the path of the targeted receiver which leads to minimal interference with other radio links and thereby improving the overall signal to interference ratio in the entire system[8].

The Introduction of spatial multiplexing, transmit diversity, receive diversity and beam forming techniques in MIMO technology helps to boost transmission performance by providing peak data rate and improved system efficiency. Fig 2 below illustrates a MIMO system

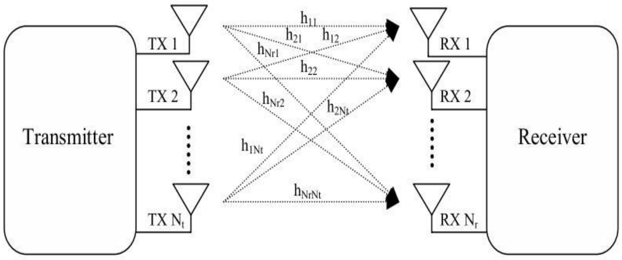
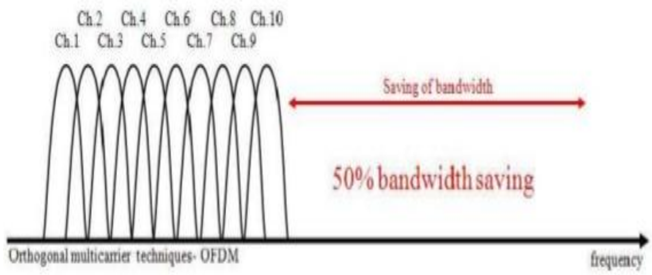


Figure 2: MIMO System [9]

Orthogonal Frequency Division Multiplexing (OFDM)

The choice of a suitable modulation along with multiple carrier modulation (MCM) transmission technique is of vital importance to achieve a reliable system of preference and throughput in mobile wireless communication system. Also, the use of multi carrier technique helps to increase the overall transmission bandwidth without the system undergoing increased signal corruption as a result of radio channel selectivity [9].

OFDM is a form of data transmission multicarrier modulation technique employed in 4G LTE network. The overriding concept behind OFDM is to divide the available spectrum into several narrowband parallel subcarriers such that low data rate streams can be transmitted on the subcarriers; this relatively helps in achieving high data rates. The subcarriers are independently modulated and are orthogonal to each other.



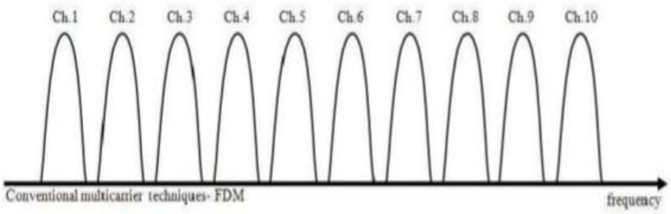


Figure 3: Comparison of OFDM and FDM techniques

The orthogonal property in OFDM allows multiple data to be transmitted over the same channel for successful detection unlike the conventional FDM multicarrier technique [1] as shown in fig 3. This orthogonal alignment between the subcarriers is prone to inter-symbol interference (ISI) due to leakage of one symbol into another when the signal passes through a time dispersive channel [10]. This effect is highlighted when the transmitted signal propagates to the receiver through multiple paths with different delays.

However, to remove the effect of inter-symbol interference (ISI) which is a critical impediment to high speed transmission over wireless channels, a subtle addition of cyclic prefix in the guard interval of OFDM symbols is recommended. This is positioned prior to each OFDM symbol to help moderate the difference in the propagation delay in the radio channel thereby making the transmission robust to time dispersion on the radio channel without the need for advanced and complex receiver channel equalization.

There are numerous benefits associated with the use of OFDM which include its robustness against multipath fading, the capability for carrying high data rates, ability to support both FDD and TDD schemes, efficient receiver architecture and compatibility for efficient broadcasting. [11]

The multiple access scheme used on the air interface in the downlink is based on Orthogonal Frequency Division Multiple Access (OFDMA) which permits the attainment of higher spectral efficiency with lower overall complexity and channelization flexibility while the uplink access is based on Single carrier frequency division multiple access (SC-FDMA) which is used to analyse Peak Average Power Ratio (PAPR) and resource allocation. The major advantages of SC-FDMA over OFDMA is the low signal PAPR due to its single carrier transmission property and ability to eliminate ISI between two symbols thereby using different orthogonal subcarriers to transmit in parallel. Studies have shown that SC-FDMA provides 2.5 dB lower PAPR than PAPR of an OFDM signal [12]

MAJOR CHALLENGES TO LTE DEPLOYMENT

The technical advantage of LTE over other wireless technologies can be attributed to factors which include high throughput, improved coverage, cell performance and low cost of data transmission[5]. Unlike the traditional cellular networks that encounter challenges of providing improved minimum throughput in a cost effective manner, extended cell coverage and improved system capacity [1], LTE has been able to address most of these challenges adequately.

LTE stands out in terms of its technical superiority and spectral efficiency. This evolving standard is posing significant challenges to operators in both the developed and developing countries in an unequal measure. While the developed countries have been able to master these challenges and deploy the technology, their developing counterparts are facing these main barriers for LTE network deployment due to the following reasons:

1. Complexity and Backward Compatibility

One of the major challenges faced by operators is in the selection of the appropriate approach towards building up a LTE network. It is possible for operators to build a converged network upgrade such that existing technologies can efficiently work together or directly opt for a completely new 4G LTE network. An upgrade within 3G may not require too much change in the network architecture while transformation to a completely new 4G LTE network will require new radio access technology and core network expansion, which is capital intensive and highly complex.

In addition, since the existing 3G will not be phased out completely at once, operators will be faced with additional burden of maintaining the existing 2G/3G network together with 4G, in order to support interoperability, seamless roaming and handover across multiple communication service providers. Managing the huge capital outlay, maintenance of the network and the quality of service during transition will be critical for successful deployment of LTE.

2. Fragmentation of spectrum band

Another big challenge faced by operators is the range of spectrum bands available to support the technology. The LTE network across the globe is being deployed on different frequency bands as different regulators free up and auction different spectrum bands. For instance, in North America the dominant band ranges between 700/800MHz and 1700/1900MHz while in Europe, 800/900/1800/2600MHz is the available band. Also 1800/2600MHz is the common spectrum in Asia while Australia networks power the technology on 1800MHz.In contrast to all these different bands, China and Japan are on completely distinct ones. It is vitally important to know that even within some geographical locations such as USA; there is disparity in LTE deployment frequencies between the operators [13].

Globally LTE deployments lack regulatory uniformity on a standard frequency band and this increases complexity for telecommunication operators, device manufacturers and chip vendors in terms of roaming difficulties and multi band support for devices and chipsets.

3. Return on Investment (ROI)

Migration to LTE network requires a high capital investment due to huge spectrum and infrastructural cost when compared to other networks. It is expected that applications and services offered by LTE network will disrupt the conventional business model of voice calls and sms as end users will be more inclined to make prompt use of LTE applications such as *whatsapp* for instant messaging service rather than SMS. This will surely bring about a drastic revenue drop for the SMS platform.

The behavioural change of end users in the usage of application and services with faster mobile data connectivity on LTE network poses critical questions to operators on how to recoup and profit from their huge investment in LTE networks deployment.

4. Management of Backhaul Cost

The advent of LTE has brought about drastic increase in mobile data traffic due to bandwidth-guzzling applications and services [14].This surely will exert further strain on the operators existing backhaul capacity and leaves the operators with the choice of upgrading their backhaul infrastructure to either fiber, E1/T1 leased lines or microwave as failure to upgrade will have negative impact on the end user experience and quality of service rendered.

However, backhaul of the network could be a hybrid of fiber; E1/T1 leased lines or microwave depending on the type of environment, capacity and the available funds [9].

5. High Power Consumption

The power consumption levels of LTE device chipset are on the high side due to the use of the technology employed thus limiting the battery life of LTE devices. According to Nokia Siemens network study, LTE devices approximately consume 5% - 20% more battery power than other generation phones depending on the applications running on them [15].

Also, the use of MIMO technology on these devices also increases power consumption of LTE devices due to power amplifier required by each of the antenna.

EMERGING STRATEGIES FOR A SUCCESSFUL LTE DEPLOYMENT

To reap the true potential benefits offered by LTE and successfully mitigate the challenges, operators can adopt the following strategies to ensure smooth network expansion, rapid return on investment and an enhanced 4G end user experience:

1. Pricing

In order to manage network traffic volume effectively and justify the high cost of network capacity upgrade it is critical for operators to get their LTE data price model right and maintain very high quality of service. They should try and adopt a value based pricing model where users pay a premium for superior experience since higher speed and reduced latency is the unique selling proposition of LTE technology.

2. Roll out strategies

Operators can either choose to leverage on all their existing network infrastructure assets to utmost advantage by adding LTE capability over their 3G network, or build a completely new network by substituting the current infrastructure with a single Radio Access Network (RAN).

Although, reusing the existing network infrastructure will result in higher cost savings and faster roll-out, yet the choice of building a new network will guarantee a clean, steady and more flexible upgrade on the long run. However, it is important for operators to justify their roll-out strategies with reliable information to aid decision-making processes regarding capacity planning. It is expected that Return on Investment on LTE data services in rural and semi urban areas will not be as attractive as urban areas.

Therefore it is important to first target end users in densely populated areas where maximum demand for LTE rich data services is high before gradual deployment and expansion to other areas.

3. Network Sharing

It is advisable for operators not to only share sites and infrastructure, but also engage in active network sharing to reduce the overall financial commitment in the deployment of LTE RAN equipment. This is an effective cost-saving strategy for operators to reduce the huge investment in LTE network rollout plan and maximize returns from its deployment. LTE network is suited to active network sharing due to its flat IP network architecture [16].

4. Spectrum Policy

Government and policy makers must be advised against prevailing models of licensing and start exploring the possibilities of spectral uniformity. LTE Spectrum harmonization will be of great importance for economies of scale and roaming capabilities for both operators and end users. This approach will encourage businesses and investors to deploy more investments for the provision of affordable mobile broadband services.

5. Seamless Service interoperability

Seamless service experience must be ensured to guarantee end to end solution across multiple domains. Since LTE network evolved in a complex and heterogeneous ecosystem interconnected with multi vendors of 2G/3G network, interoperability across these networks should provide a logical experience for the subscribers [17].

CONCLUSION

LTE deployment in developing nations is not as rapid as the developed ones due to socio- economic and technological challenges peculiar to these regions. However, the use of recent upgrades in technologies such as OFDM and MIMO in addition to other compelling developments of LTE has made it to be more attractive for investment considerations than previous mobile networks. On the socio-economic limitations, a combination of pricing strategy, encouraging government and regulatory policies on spectrum allocation backed with prudent adoption of network sharing options, positive roll-out strategies to drive a seamless user experience will encourage funding from investors to address and reduce the deployment limitations in these countries.

REFERENCES

[1] T.S Rapport, wireless communications principles and practice
[2] E. Dahlman, S. Parkvall,J. Skold and P.Beming, 3G Evolution HSPA and LTE for mobile broadband
[3] US Broadband Ecosystem
[4] D.Mahjabeen, A. Ahmed and S. Rafique, Use of LTE for the Interoperability between **Different Generations of Wireless Communication,** International Journal of Communications, Network and System Sciences, 2011
[5] "UTRA-UTRAN Long Term Evolution (LTE) and 3GPP System Architecture Evolution (SAE)," Technical Paper
[6] The future of mobile broadband technology whitepaper
[7] 4g Americas MIMO and smart Antennas for mobile broadband systems October 2012
[8] Qinghua Li and Guangjie Li MIMO Techniques in WiMAX and LTE: A Feature Overview
[9] F Khan, LTE for mobile Broadband Air interface technology and performance
[10] M. Ergen, Mobile Broadband Including WiMAX and LTE
[11] 4G Americans Mobile Broadband explosion
[12] M. Melood, A. Abdased, M. Ismail, PAPR Performance Comparison between Localized and Distributed-Based SC-FDMA Techniques, Proc. of World Cong. on Multimedia and Computer Science
[13] M.S Rani , Comparison of Standard Propagation Model (SPM) and Stanford University Interim (SUI) Radio Propagation Models for Long Term Evolution (LTE)
[14] Ericson Mobility Report on the pulse of the networked society june 2014
[15] Nokia Siemens Networks, The advanced LTE toolbox for more efficient delivery of better user experience
[16] Capgemini ,LTE Opportunities and challenges for Telecommunication operators whitepaper
[17] Astellia, Beyond the network, overcome 4G LTE challenges