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Long Term Evolution Protocol: An Overview

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ABSTRACT

Wireless communications is becoming more essential than ever in today's modern society and access to information and knowledge will be of crucial differences between success and failure. We have already begun to see clear tendencies that the wireless communications is taking over more and more and makes by no means difference between different application areas. LTE (Long Term Evolution) is the newest radio access system technology based on OFDM, which aims at providing higher data rate services with lower latency. LTE can support not only fundamental telecommunication services but also interactive multimedia applications, and thus will become the main stream of broadband wirelesscommunications in the future.

INTRODUCTION

Long Term Evolution (LTE), commonly referred to as 4G - next generation wireless communications is the new standard for nationwide public safety broadband. This standard will allow access to digital technologies and deliver expanded capabilities to public safety practitioners in the field. LTE is the avenue for bringing public safety fully into the digital age. Technology devices and applications now being released on a daily basis, rival those that could be run only on in-office servers and desktops afew short years ago. This network will foster further development of applications customized for public safety and help make first responders' operations more effective and efficient.

The LTE standard supports fast speeds and holds great promise for first responders, yet there are limitations to using the associated technology in the public safety arena. The transition to LTE will not be as simple as flipping a switch. It will involve an extensive and complex build-out as well as an implementation process that will unfold over the years to come. It will require a great deal of coordination and adjustment among current public safety broadband users now operating across a patchwork of commercially and publicly supported networks on non-contiguous bands of spectrum. Ultimately, however, LTE and the nationwide network will help even the playing field, enabling agencies of all sizes including those in remote rural jurisdictions without current wireless coverage to leverage emerging broadband technology and to access increasingly powerful devices running operationally relevant applications. Unlike the currentwireless environment, where interoperability among publicsafety devices and across jurisdictions is deficient, the nationwide network built on the LTE standard will provide truenationwide interoperability. This network will foster furtherdevelopment of applications customized for public safetyand help make first responders' operations more effectiveand efficient.

This Issue Brief discusses the advantages and limitations ofLTE technologies for public safety and provides an overviewof the current state of affairs in this crucial transition period.

In future wireless communications, the demand for multimedia streaming services is expected to increase dramatically. To meet this demand, a broadband wireless communication system must increase the transmission rate and enhance the bandwidth efficiency. The orthogonal frequency division multiplexing (OFDM) technology is a promising solution for future broadband wireless communications because of its high bandwidth efficiency and superior resistance to multipath interference. Being standardized by the 3GPP (3rd Generation Partnership Project) community.

TECHNOLOGIESADOPTED

In this section, we first discuss the two generic technologies of OFDM and MIMO that are adopted by standards LTE and then look into the details the proposed architectural frameworkproposed specifically for LTE.

OFDM

Orthogonal Frequency Division Multiplexing is a superior air access method compared to its predecessor CDMA.Also OFDM is one of the key technologies which enable non-line of sight wireless services making it possible toextend wireless access system over wide-areas. It is a variant of the Frequency Division Multiplexing scheme inwhich the frequency channel is divided into multiple smaller sub-channels. In FDM, sub-channelization requires
provisioning of guard bands between two sub-channels to avoid interference between them. OFDM (as shown inFigure 3) divides the frequency bandwidth in narrow orthogonal sub-parts called sub-carriers. A sub-channel

is anaggregation of a number of these sub-carriers. The sub-carriers include data carriers, pilot carriers and a DC. Thedata carriers are used to carry data, the pilot carriers are used for channel sensing purposes and the DC mark thecentre of the channel. Each subcarrier is modulated with conventional modulation scheme such as QuadratureAmplitude Modulation or Phase Shift Keying at a low symbol rate. Each user is provided with a integer number ofsub-channels which is composed of a number of sub-carriers. User data is carried parallely on each sub-carrier at alow rate. The combination of the parallel sub-carriers at the destination provide for the high data rates.

Since the sub-carriers carry data at a low rate and thus higher symbol time it is more resilient to multi-path effects,thus making it more suitable for wide-area non-line of Sight wireless access technology. Also, the use of overlappingorthogonal sub-carriers without guard bands make it more efficient than FDM scheme. OFDM resembles CDMA inthat it is also a spread-spectrum technology in which energy generated at a particular bandwidth is spread across awider bandwidth making it more resilient to interference and "jamming". However, unlike CDMA, OFDM allowsadaptive assignment of sub-carriers to sub-channels based on channel conditions making it more robust andachieving higher spectral efficiency than CDMA.The Multi-User version of OFDM is called OFDMA(Orthogonal Frequency Division Multiple Access).

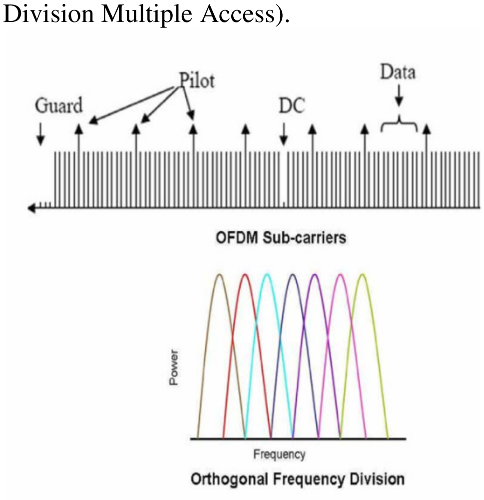


Fig. 1 OFDM

MIMO

Multiple Input Multiple Output (MIMO) is one of the most popular Advanced Antenna Technologies which issupported both by LTE and UMB. The salient features of MIMO is that it offers higher throughput for a givenbandwidth and higher link range for a given power value. A detailed discussion of the MIMO technology is beyondthe scope of this survey and we provide a cursory glance at the key features of the technology. In MIMO thetransceiver and receiver have multiple antennas giving MIMO multiple flavors based on the number of antennaspresent on each side. However, the key idea is that a transmitter sends multiple streams on multiple transmit antennasand each transmitted stream goes through different paths to reach each receiver antenna as shown in Figure 3.Thedifferent paths taken by the same stream to reach multiple receivers allow canceling errors using superior signalprocessing techniques.MIMO also achieves spatial multiplexing to distinguish among different symbols on the samefrequency. MIMO thus helps in achieving higher spectral efficiency and Link reliability.

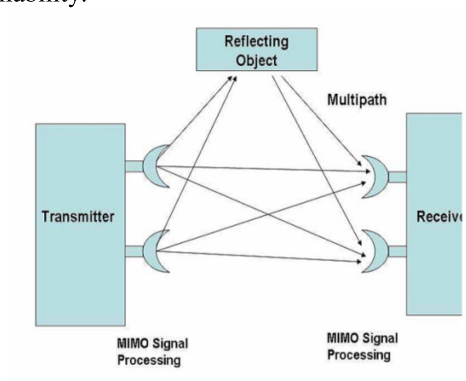


Fig. 2 MIMO

LTE Architecture

Fig 3.1provides a high-level view of LTE architecture and fig 3.2 shows a simple architecture of LTE. This is a snapshot of the part thatmost closely interacts withthe UE(UE: User Equipment), or mobile device. The entire architecture is much more complex; a complete diagram would show the entireInternet and other aspects of network connectivity supporting handoffs among 3G, 2G, WiMAX, and other standards.This particular device shows the eNodeB(eNB: Enhanced Node B, or basestation), which is another name for the base station, and the interfaces between theeNodeB and UEs. The E-UTRAN(E-UTRAN: Evolved UniversalTerrestrial Radio Access Network) is the entire network, which is the “official” standards name for LTE.

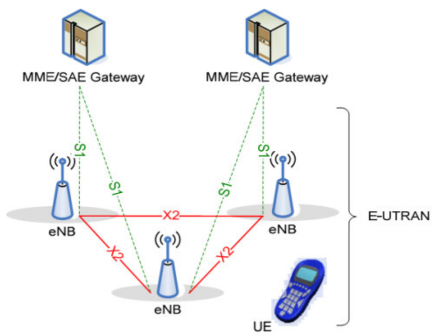
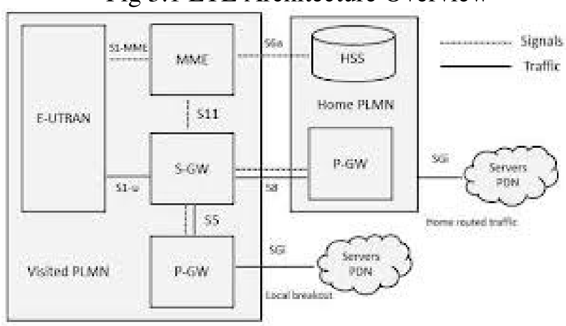


Fig 3.1 LTE Architecture Overview



3.2 Simple Architecture of LTE

The Advantages of LTE

LTE-based networks have upload and download speedsunheard of in the past. LTE opens the gate for many new,exciting, and more robust public safety applications. Forexample:

1. Real-time video will become more robust and widelyavailable in the field on mobile terminals, tablet devices,and smartphones, resulting in increased situationalawareness for first responders.
2. Police officers will be able to view and exchange digitalphotographs (e.g., mug shots) and fingerprint technology, greatly improving on-the-spot suspect identificationand resulting in savings of time and resources.
3. Fire personnel will have digital access to "as-built" building drawings and mapping programs in real time toimprove fire ground situational awareness.
4. Incident commanders and emergency managers willcommunicate through enhanced incident managementsoftware that will bridge the gap from the incident tothe emergency operations center, greatly improvingdecision-making.
5. Applications such as automated license plate recognition (LPR) systems and GPS-enabled navigation systemswill provide real time notifications and alerts, includingemerging hazards and geographically specific be-on-the-look-out (BOLO) transmissions, all contributing toimprovements in officer and civilian safety.

With LTE and the nationwide network, first responderswill gain access to innovative tools to assist them with theircritical missions. They will be in a better position to takeadvantage of fast changing digital technology. LTE will revolutionize the way public safety responds to emergencies.Figure 4 illustrates how data speeds are enhanced through LTE technology.

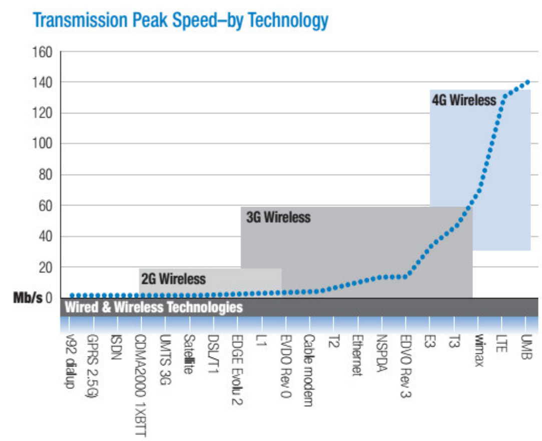


Fig 4 data speeds

COMPARISION

Feature	GSM	UMTS (3GSM)	IS-95 (CDMA one)	IS-2000 (CDMA 2000)	LTE
Technology	TDMA and FDMA	W-CDMA	CDMA	CDMA	OFDMA
Generation	2G	3G	2G	3G	4G
Encoding	Digital	Digital	Digital	Digital	Digital
Year of First Use	1991	2001	1995	2000 / 2002	2009

SUMMARAY

The principal of LTE is that the LTE network, like all cellular systems, is designed to operate in scarce and valuablelicensed spectrum. This means that it is highly optimized and a lot of complexity is necessary for the highest possible efficiency. When the standards body has to choose between efficiency and simplicity, they always choose efficiency tomake the best use of this spectrum.

LTE uses all the time on the downlink for conveying data; the downlink PHY is fully scheduled so there are no gaps dueto arbitration or contention except for the initial access on the random access procedure. The downlink carries multiplelogical channels over one link, so a lot of information is multiplexed together in one transport block, as opposed to othernetworks where any given packet is only carrying one type of information at a given time, such as in a control plane or auser plane.

CONCLUSION

Building a Nationwide Public Safety Wireless BroadbandNetwork based on LTE standards for the wireless environment will enable public safety to greatly enhance both theefficiency and effectiveness of public safety response. Fieldresponders and managers will share the same tools in thefield as they currently have within the "wired environment"at their agency. Real-time video, photographs, mappingsoftware, access to external databases, and a host of newapplications can be brought directly to the field. However,careful planning of construction, security and encryption,and lifecycle replacement and funding is needed to ensurethat LTE meets agencies' individual business needs.

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