LONG TERM EVOLUTION OR 4G

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ABSTRACT

Long term evolution (LTE) is the next major step towards 4th generation of mobile communications. LTE introduces a new radio access network with technologies that offer higher data rates, efficiency and quality of services as well as lower costs and the integration with the existing open standards. An acronym for Long Term Evolution, LTE is a 4G wireless communications standard developed by the 3rd Generation Partnership Project (3GPP) that's designed to provide up to 10x the speeds of 3G networks for mobile devices such as smartphones, tablets, notebooks and wireless hotspots. 4G technologies are designed to provide IP-based voice, data and multimedia streaming at speeds of at least 100 Mbit per second and up to as fast as 1 GBit per second.4G LTE is one of several competing 4G standards along with Ultra Mobile Broadband (UMB) and WiMax (IEEE 802.16). The leading cellular providers have started to deploy 4G technologies, with Verizon and AT&T launching 4G LTE networks and Sprint utilizing its new 4G WiMax network.

Keywords: OFDM, LTE Architecture, Packet Data Network Gateway.

I INTRODUCTION

As Internet generation accustomed to access broadband wherever they go, mobile broadband, instead of only at home and in the office, has become a reality. Therefore, the Global System for Mobile Communications family constantly develops new mobile technologies to achieve better performance, such as higher speed, larger capacity and so forth. LTE is a step beyond 3G and towards the 4G, evolved after EDGE, UMTS, HSPA and HSPA Evolution. The contributions of LTE make sure that the users are able to request more mobile applications like interactive TV, mobile video blogging, advanced games or professional services.

It is primarily described around its background, technology, specifications. In section three, it aims to LTE technical theories such as LTE architecture, physical and transport channels of Downlink (DL) and Uplink (UL), multiple access principles (OFDMA and SC-FDMA).

II LTE BACKGROUND

LTE was proposed in 2004 Toronto conference for the sake of achieving higher speed and lower packets latency in UMTS 3G systems. Hence, LTE has to satisfy a set of high-level requirements, shown as below:

i. Reduced cost per bit

ii. Simple architecture and open interfaces
iii. Flexibility usage of existed and future frequency bands
iv. Reasonable terminal power consuming
v. Enhanced user experience-more services with lower cost and high speed

As for the motivations and targets, 3GPP LTE aims to superior performance compared with HSPA technology. The main performance targets are listed as below:

i. 2 to 4 times more spectral efficiency than HSPA Release 6
ii. Peak rates beyond exceed 100 Mbps in DL and 50 Mbps in UL
iii. Round trip time < 10 ms
iv. Optimized packet-switching
v. High-level mobility and security
vi. Efficient terminal power-consuming optimized
vii. Flexible frequency with 1.5 MHz to 20 MHz allocations

2.1 LTE Technology

LTE is composed of many new technologies compared with the previous generation of cellular systems. These new technologies are used to generate more efficiency with regards to spectrum and higher data rates as expected by designers. Here are only snapshots of the technologies.

OFDM (Orthogonal Frequency Division Multiplex: In order to gain high data bandwidth when transmitting packets, LTE integrates OFDM technology which can provide high-degree resilience to reflections and interference at the same time. Furthermore, the access schemes can be divided into two access approaches used in the DL and UL respectively. The first one for the DL is OFDMA (Orthogonal Frequency Division Multiple Access); the second one for the UL is SC-FDMA (Single Carrier- Frequency Division Multiple Access), which has the advantages of smaller peak to average power ratio and more constant power able to get high RF power amplifier efficiency in the mobile handsets

2.2 LTE Architechture

The currently agreed LTE architecture adopts a flat architecture, which can be illustrated via four functional elements as below:

2.2.1 Evolved Radio Access Network (RAN):

It mainly consists of a single RAN node named as eNodeB (eNB). The eNB interfaces with the User Equipment (UE) and hosts the physical layer (PHY), Medium Access Control (MAC), Radio Link Control (RLC), and Packet Data Control Protocol (PDCP) layers. Its functions include radio resource management, admission control, scheduling, and enforcement of negotiated UL QoS and compression/decompression of DL/UL user plane packet headers.

2.2.2 Serving Gateway (SGW):

It performs as the mobility anchor for the user plane during inter-eNB handovers and as the anchor for mobility between LTE and other 3GPP technologies. At the same time, it routes and forwards user data packets. The SGW controls the termination of the DL data path and paging while DL data comes to UE and replicates the user traffic when lawful and rational interception.

2.2.3 Mobility Management Entity (MME):

The key control-node for the LTE access network. It tracks and pages the idle mode UE, even retransmission. MME selects the SGW for a UE at initial attach and at time of intra-LTE handover involving Core Network (CN) node relocation. When authenticating the user, it interacts with the HSS master user database supporting IP Multimedia Subsystem and including subscriber information) through the specified interface.

2.2.4 Packet Data Network Gateway (PDN GW):

It has two key roles in terms of functionality. First, the PDN GW supports the connectivity to the UE and to the external packet data networks via the entry and exit of UE traffic. The other key role of the PDN GW is acting as the anchor for mobility between 3GPP and non-3GPP technologies such as WiMAX and 3GPP2 (CDMA 1X and EvDO).

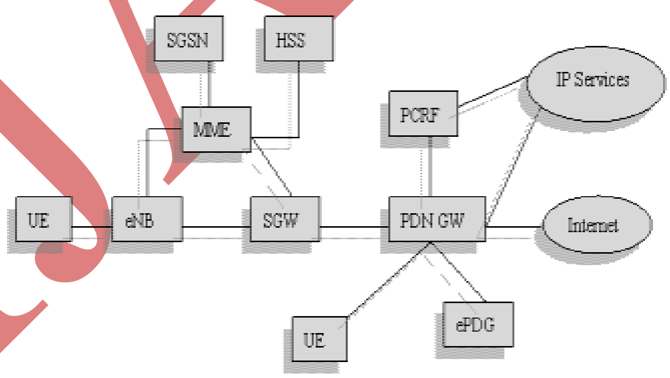
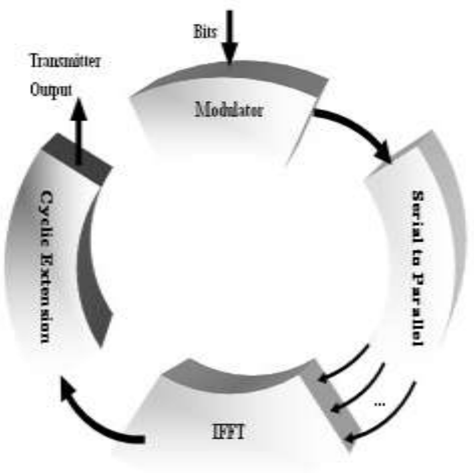


Fig.1 High Level Architecture for 3GPP LTE

LTE architecture running normally and efficiently must have the well-designed physical and transport channels between DL and UL, since all the packets transmissions are inevitably involved both two links and then how the channels to be designed to enable dynamic resource utilization naturally becomes important. The LTE PHY DL and UL are quite different and treated separately within the specification documents Therefore, the physical and transport channels for DL and UL are also different for achieving the different goals in transmission, which are simply introduced in the following subsections.

III OFMDA IN LTE

The principle of the OFDMA focuses on the usage of narrow, mutually orthogonal sub-carriers. And the OFDM signal used in LTE consists of a maximum of 2048 different sub-carries spacing typically 15 kHz regardless of the total transmission bandwidth. At the sampling instant of a single sub-carrier and the other sub-carriers having a zero value, different sub-carriers maintain orthogonality. Then the actual signal is transmitted after the Fast Fourier Transform (FFT) block, used to change between time and frequency domain representation of the signal. In the transmitter side, the OFDMA system uses inverse FFT (IFFT) block to create signals. The data bits through Modulator feed to the Serial-to-Parallel conversion and then to the IFFT block. As shown in Figure2 , the IFFT block goes to the cyclic extension, which aims to avoid inter-symbol interference.



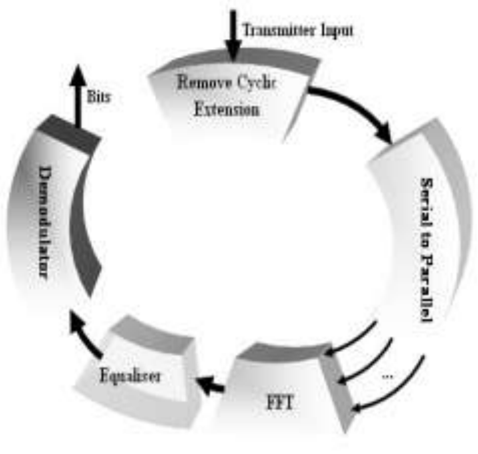


Fig.2 OFDMA Tansmitter **Fig 3.OFDMA Receiver**

In the receiver side (see Figure 3), FFT is used again to convert back from the frequency domain and single signal to the time domain representation of multiple sub-carriers. The equaliser in Figure 3, as a typical solution of receiver reverts the channel impact for each sub-carrier. It refers to the estimator to cancel out the complex-valued multiplication caused by the frequency-selective fading of the channel and does not present a great complexity. These simple operations are just to multiply each sub-carrier (with the complex-valued multiplication) based on the estimated channel frequency response (the phase and amplitude adjustment each sub-carrier has experienced) of the channel.

The OFDMA approach achieves high peak data rates in high spectrum bandwidth and also high flexibility in channelization. LTE therefore enables to boost spectral efficiency and operate in various radios channel sizes from 1.25 MHz to 20 MHz.

IV SC-FMDA IN LTE

In the UL direction, LTE uses SC-FDMA scheme, which is suitable to both FDD and TDD modes. This scheme is actually a hybrid format that combines the low peak to average ratio provided by single-carrier systems with the multi-path interference resilience and flexible sub-carrier frequency allocation that OFDM provides. In SC-FDMA, the practical transmitter makes use of FFT/IFFT blocks as well to place transmission in the correct position of the transmit spectrum in case of variable transmission bandwidth. The maximum transmission bandwidth is up to 20 MHz, while the minimum transmission bandwidth is down to 180 kHz. In the different uplink frequency blocks, different transmitters use the FFT/IFFT pair to place otherwise equal bandwidth transmissions via adjusting the sub-carrier mapping between FFT and IFFT blocks. As shown in Figure 4 and 5, the SC-FDMA is pretty similar to the DL OFDMA principle and the need for guard bands among different users can be avoided by adding the OFDMA property of good spectral waveform with a regular QAM modulator. The receiver still needs to process the inter-symbol interference as cyclic prefix prevents inter-symbol interference between a block of symbols.

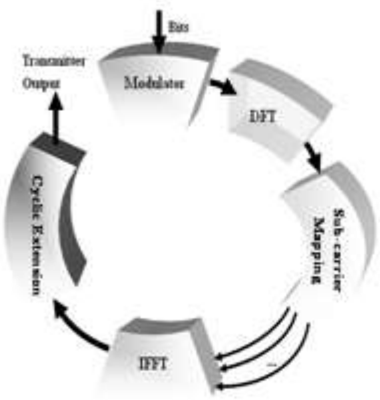


Fig4 SC-FDMA Transmitter

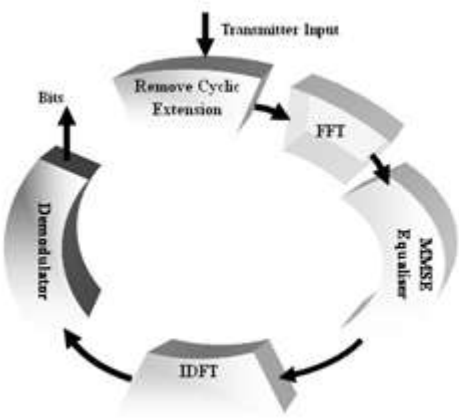


Fig5 SC-FDMD Receiver

V LTE TDD AND FDD DUPLEX SCHEMES

LTE can effectively be deployed in both the unpaired and paired spectrum according to 3GPP Release 8 specifications. The Time Division Duplex (TDD) is operated on the upaired spectrum, while the Frequency Division Duplex (FDD) is operated on the paired spectrum. These two duplex schemes provide deployment flexibility according to operator preference and spectrum allocation. LTE TDD and FDD modes share the same underlying framework and have very few differences as a whole. LTE FDD using paired spectrum plays a role in forming the migration path for the current 3G services. LTE TDD also known as TD-LTE is considered as providing the evolution or upgrade path for Time Division- Synchronous Code Division Multiple Access (TD-SCDMA).

VI CAPABILITIES

LTE capabilities include:

- Downlink peak data rates up to 326 Mbps with 20 MHz bandwidth
- Uplink peak data rates up to 86.4 Mbps with 20 MHz bandwidth
- Operation in both TDD and FDD modes
- Scalable bandwidth up to 20 MHz, covering 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, and 20 MHz in the study phase

VII CONCLUSION

In this paper, we have taken a glance at LTE background motivations, primary adopted technologies and DL/UL specifications in order to gain a general knowledge of LTE .Then, we have taken a close look at the major technical parts of LTE, for instance, LTE architecture, OFDMA, SC-FDMA, TDD and FDD so that we could further understand the detailed contents, i.e. what consists of LTE flat architecture, principles of LTE OFDMA and SC-FDMA . Finally, we also have examined the main end user application performance such as DL/UL peak data rates and low latency in real world. It is obvious that LTE makes a lot of innovations in terms of technology for the purposes of data rates and other performances as discussed above. Its peak throughputs have already exceeded what can be achieved by HSPA+. Moreover, LTE has obtained low cost per bit for a competitive service, enlarged the UL range and fulfilled the need for power-efficient device transmission

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