THE TECHNICAL ASPECTS OF LONG TERM EVOLUTION

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ABSTRACT

With lower latency and higher bandwidth than its previous 3G networks, the latest cellular technology LTE has been appealing many new users. However, the interactions among application layer, network transport protocol, and the radio layer still remain undetermined. In this paper, we represent the technical aspects of Long Term Evolution, its architecture, and its differences with earlier 3G systems.

Keywords: LTE, Bandwidth Estimation, TCP Performance, Resource Underutilization, OFDM, MIMO, SC-FDMA.

I. INTRODUCTION

LTE is the latest disposed cellular network technology that provides high-speed data services for mobile devices with broadcasted bandwidths matching and even exceeding the home broadband network speeds. Recent work [11] has indicated the power model of the LTE network. Compared to 3G, LTE provides the guarantee of higher energy efficiency as a result of a new resource management policy and higher attainable throughput. However, this new technology has not been broadly studied empirically in a displayed commercial network setting to understand how network resources are being utilized across different protocol layers for real users. It is important to figure out the benefits of increased bandwidth for known too mobile applications and essential network protocols such as TCP to identify its limitations for needed improvements. Possibly, network protocol overheads can be significant enough to avoid efficient usage of available network resources [12]. This has been shown in network settings with high network capacity but potentially uncertain network conditions. We are motivated by the fact that LTE uses unique black hole and radio network technologies, and has many unique features distinguishing it from other access technologies (e.g., much higher bandwidth and lower RTT), requiring some existing topics to be revisited.

Also, the popularity of these problems in commercial LTE networks is very important for both academia and in industry. In this work, we look after the use of LTE network resources by analyzing an extensive data trace collected at a commercial LTE network.

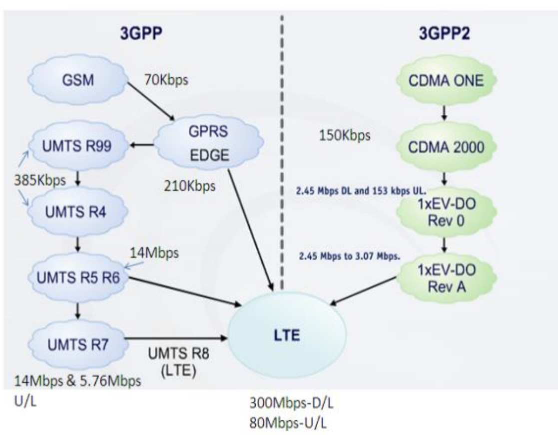
As far as we know, this is the first in-deep analysis of deployed LTE technology in a commercial setting. We systematically complement the data analysis with local experiments using controlled traffic patterns to confirm or further investigate our observations based on data sets. Given the prevalence of proxy deployment in cellular networks for improving user perceived performance due to inherently limited radio network resources, we also study the impact of such middle boxes on performance.

The LTE network can be upgraded by software, and a new service layer offers a dedicated network element for the implementation of end-to-end LTE Broadcast services. LTE broadcast provides a flexible and lower deployment cost as compared with previous mobile-broadcast options by leveraging OFDMA (Orthogonal Frequency-Division Multiple Access) and wider bandwidths available in LTE. On user devices, LTE Broadcast does not requires a separate device chipset and can use common middleware.

II. EVOLUTION OF LTE FROM DIFFERENT TECHNOLOGY

LTE supports deployment on a range of bandwidths and spectrum. LTE defines both FDD (Frequency Division Duplex) and TDD (Time Division Duplex) modes, and supports a a range of bandwidths from 1.25 Mhz upto 20 Mhz by using a scalable form of OFDMA [1] as shown in Fig 1.

III. LTE ARCHITECTURE



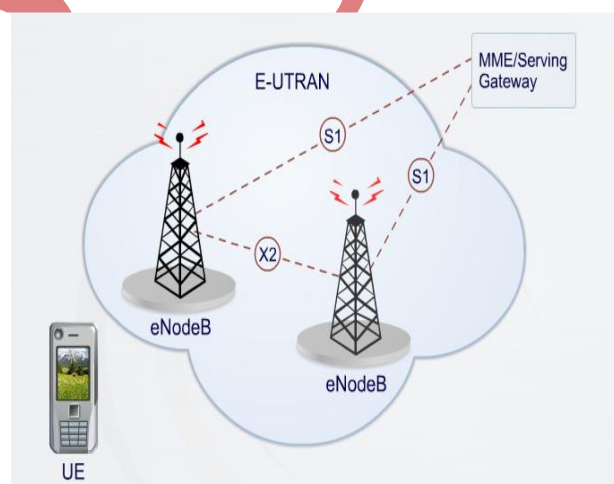


Fig 1: Evolution of LTE from Different Technology **Fig 2: LTE Architecture**

The E-UTRAN consists of only eNodeBs. This is a big change from previous UMTS release since there is no Radio Network Controller(RNC) in the architecture[4] as shown in Fig 2. eNodeB has to support all the standard NodeB and RNC functions such as:

- Radio interface Physical layer OFDMA functions
- Coding
- Modulation
- Scheduler for Down link and uplink
- Radio resource management
- Call Admission Control
- Handover support

eNodeB supports two new interfaces, S1 and X2 in LTE. The S1 interface is located between the eNodeB and the MME and Serving gateway(S-GW) nodes (jointly referred to as a Mme/S-GW)in the EPC[7]. The S1 interface supports the attach operation the results in the authentication and IP address allocation for UEs. The new X2 interface is necessiatated by the removal of the RNC. When a UE moves from one cell in an eNodeB to another cell in a different eNodeB, mobility related signaling and traffic exchange is supported by the X2 interface.

IV. TECHNOLOGIES UNDER LTE

4.1 OFDM (Orthogonal Frequency Division Multiplexing)

OFDM (Orthogonal Frequency Division Multiplexing) is an appealing technology used for high speed data-communication systems. It evolved from two important techniques, Frequency division Multiplexing(FDM) and Multicarrier Communication[3].

The FDM technique has been widely used in communication systems. It divides the available bandwidth into many subcarriers and allows multiple users to access a system simultaneously. Each user transmits their data on a different subcarrier. To avoid interference, guard bands are assigned between subcarriers. Since guard bands do not transmit any information, they introduce spectrum inefficiency.

Fig 3: FDM

With Multicarrier communication, a user can split the data into multiple sub streams and transmit them in parallel. In multicarrier FDM, the user data is converted from serial to parallel [5]. Then, the parallel data sub streams are sent over multiple subcarriers. At the receiver, the parallel data is combined back into a serial data stream. A higher data rate can be achieved by using multicarrier communication.

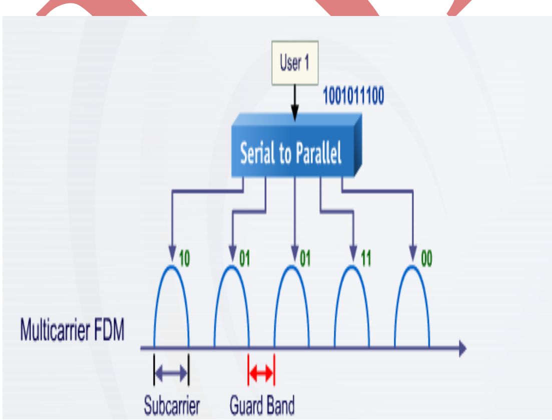


Fig 4: Multicarrier FDM

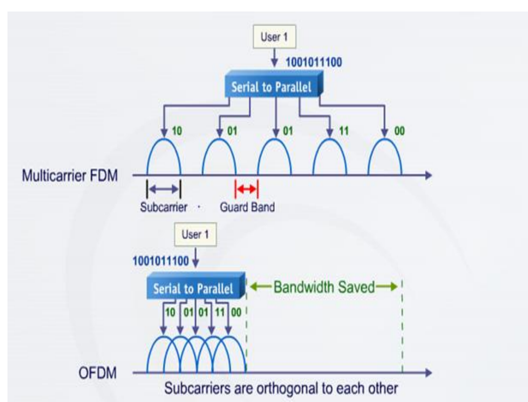


Fig 5: OFDM

OFDM adds the orthogonal feature into multicarrier FDM. Orthogonality means "do not cause inference with each other". In OFDM, the subcarriers are designed to be orthogonal. This allows subcarriers to overlap and saves bandwidth. Therefore, OFDM obtains higher data rates and good spectrum efficiency.

4.2 Sc-Fdma Concept

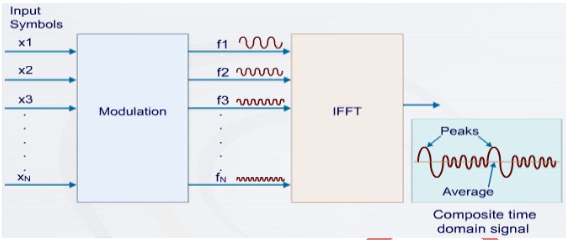


Fig 6: Sc-Fdma Concept

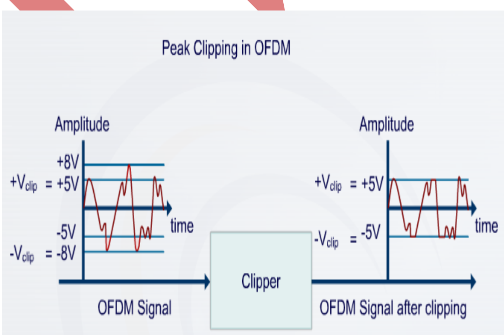
Peak-to Average Power ratio (PARP) is a typical problem in multicarrier modulation. PARP is due to the summation of a large number of independent data symbols for transmission [9].

In OFDM systems, the time domain signal transmitted over the air is the weighted sum of multiple subcarriers. As the number of subcarriers becomes large, a small percentage of the domain samples have high magnitudes (i.e. peak values) . These peak values can be much larger than the average value that leads to high PARP.

Since the practical power amplifier is linear in a certain range, the nonlinear distortion occurs at the peak values. Extending the linear range of a power amplifier significantly increases the cost and reduces power efficiency. Hence solving the PARP issue is a critical requirement for mobile stations in OFDMA systems.

Peak-to Average Power ratio(PARP) can be overcome using one of the following techniques:

- Peak Clipping Technique: here a threshold limit on power is set, and any peaks higher than this threshold are clipped. The main disadvantage with this scheme is power leakage which causes distortion as shown in Fig 6.1
- Peak Cancellation Technique: This technique uses reverse polarity signals to decrease the net effect of the peak due to summation as shown in Fig 6.2.



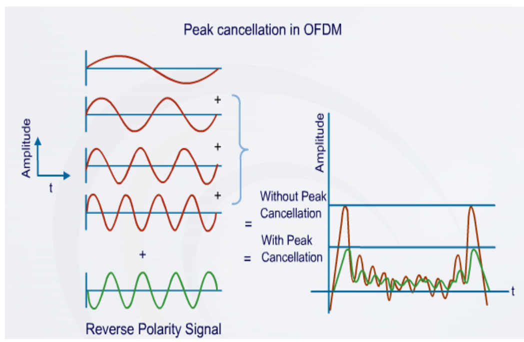


Fig 6.1: Peak Clipping Technique **Fig 6.2: Peak Cancellation Technique**

- DFT spread OFDMA technique: here time domain data symbols are transformed to frequency domain by a Discrete Fourier Transform (DFT) before OFDMA modulation as shown in Fig 6.3.

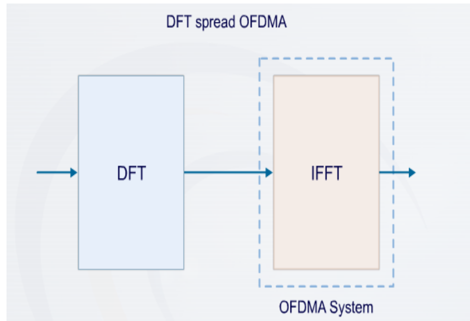


Fig 6.3: DFT Spread OFDMA Technique

4.3 MIMO

Multiple-input and multiple-output (MIMO) employs multiple transmit and receive antennas to substantially enhance the air interface. It uses space-time coding technique of the same data stream mapped onto multiple transmit antennas. This offers a substantial or vast improvement over traditional reception diversity schemes where only a single transmit antenna is deployed to extend the coverage of the cell. MIMO processing also makes use of spatial multiplexing, and allows different data streams to be transmitted simultaneously from different transmitter antennae. Spatial multiplexing increases the end-user data rate and cell capacity[9]. When knowledge of the radio channel is available at the transmitter, MIMO can implement beam-forming to further increase available data rates and spectrum efficiency. Multiple antennas are also used to transmit the same data stream, thus providing redundancy and improved coverage, especially close to cell edge.

V CONCLUSION

LTE seems to be a very challenging generation of wireless communication that will help to change the people's life to wireless world. There are many attractive features proposed for LTE which ensures a high data rate, global roaming and many more. New ideas are being introduced by researchers throughout the world, but these ideas introduce new challenges. There are many issues yet to be solved like incorporating the mobile world to the IP based core network, billing system, smooth hand off mechanisms etc. LTE is expected to be launched by 2010 and the world is curiously looking forward for the most intelligent technology that would connect the entire globe. Someday LTE networks may replace all existing 2G and 3G networks, even before a full implementation of 3G. Many 3G standards are springing up that would make it difficult for 3G devices to be truly global.

The main distinguishing factor between 3G and LTE is the data rates. LTE can support at least 100Mbps peak rates in full-mobility wide area coverage and 1Gbps in low-mobility local area coverage[12]. The speed of 3G can be up to 2Mbps, which is very much lower than the speeds of LTE. However, LTE standard will base on broadband IP-based entirely applying packet switching method of transmission with seamlessly access convergence. It means that LTE integrated all access technologies, features and applications can unlimitedly be run through wireless backbone over wire-line backbone using IP address. **But the perfect real world wireless or called "WWWW: World Wide Wireless Web" is yet to come.**

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