

## **Long Term Evolution (LTE)**

### **Introduction**

Long Term Evolution (LTE) is a standard developed by the 3<sup>rd</sup> Generation Partnership Project (3GPP) for high-speed data communication for cellular phones. It is an evolution of the GSM standards, following GSM, EDGE, UMTS, HSPA and HSPA Evolution (HSPA+) [1]. LTE and Mobile WiMax standard are the only two forerunner versions of fourth generation (4G) mobile communication technology standards that is currently commercially deployed in United States. Sprint, the only national mobile carrier that uses WiMax standard is already in the process of phasing out WiMax [2]. This will leave LTE to be the only forerunner of 4G standard in United States until LTE Advanced is commercially deployed. This paper briefly reviews the commercial applications of LTE standard, explains the underlying technology and describes the building blocks for implementation of LTE.

### **Commercial Applications**

For many years, voice calls used to dominate the telecommunication network traffic. But, with the advent of smartphones, the need for mobile data has increased dramatically. In the period from January 2007 to July 2011 itself, the amount of data traffic has increased by a factor of over 100 [3]. This trend is expected to continue and forecasts expect the monthly data traffic to increase from 400 petabytes in 2011 to 3000 petabytes in 2016 [4]. This has led to congestion in the network. There is huge demand to increase the network capacity. Network capacity can be increased mainly by three ways: increasing the bandwidth, use of smaller cells, and improvement in communication technology. Bandwidth is limited, so telecom companies are focusing on smaller cells that allows faster data off-loading, and improvement in communication technology, which allows higher exploitation of the given bandwidth. LTE is the latest commercial improvement in the communication technology. It increases the network capacity and helps meet the mobile data demand.

Besides the application of increasing network capacity, LTE also allows operators to run only one core network. A 2G or 3G operator maintains two core networks: packet switched domain for data and circuit switched domain for voice. LTE allows to transport voice calls over packet switched domain by using technologies such as voice over IP (VoIP). This can help operators reduce their capital and operational expenditure. 3G networks also introduce delays of order of 100 milliseconds for data applications, in transferring data packets between network elements [5]. LTE reduces this end-to-end

delay, helping demanding applications such as video-conferencing grow more. These characteristics of LTE has led major network providers to start upgrading from 3G to LTE. Analysts have estimated the cost of upgrading from 3G to LTE to be \$19.5 billion in Europe [6] and \$3.8 billion in US by AT&T [7]. The other competing standard for pre-4G technology is WiMax which didn't see much commercial success in United States and is in the stages of being phased out.

### **Underlying Technology**

The most important upgrade of LTE over its predecessors is the improvement in the downlink and the uplink speeds. Downlink speed is the speed of data transfer from a base station to the user device (cell phones), whereas uplink is the speed of data transfer from user device to base station. Theoretical peak data rates of LTE are more than 325Mbps in downlink and more than 80Mbps in uplink [8]. In comparison, HSPA (3G) supports peak data rate of less than 15Mbps [9]. These improvement in peak data rates were possible due to advanced signal processing techniques. Orthogonal frequency-division multiplexing access (OFDMA) is the core of the LTE downlink technology. OFDM transmission simplifies the receiver baseband processing and reduces the terminal cost along with power consumption [10]. For uplink, LTE uses single carrier frequency division multiple access (SC-FDMA) that has the same benefits as OFDMA but is more power efficient [11]. LTE can also operate in different frequencies and in bandwidths ranging from 1.4 MHz to 20 MHz [12]. This allows better utilization of bandwidth. Another important advancement in LTE is the support for multi-antenna transmission. Multiple antenna transmission enables more efficient use of antennas improving the link (down/up) quality and reliability. Various techniques are used to enable the multiple antenna transmission; these techniques are grouped as multiple-input multiple-output (MIMO) [13].

### **Implementation of Technology**

Implementation of LTE requires device as well as network upgrades. LTE is architecturally different from 3G networks and requires an overhaul of the already built network. Most of the devices that are currently in the market for customers don't have LTE chips in them, and thus they cannot use LTE network. So, to implement LTE and ensure usage of LTE network, phone manufacturers need to develop more phones that are LTE capable. Also, due to customers still needing to use 3G network, network companies need to buy new spectrum to accommodate LTE along with their 3G spectrum [14]. Companies also need an extensive fiber-optic infrastructure to deploy LTE. In the infrastructure side, companies will also need to upgrade their base transceiver station devices.

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