Journal of Al-Qadisiyah for Computer Science and Mathematics
Vol. 3 No.1 Year 2011

Page 221-230

Wireless Telecommunications uprising though 4G Long Term Evolution (LTE)

Ali Abdul Hussien Abdul Wahed
Computer Department
Collage of Education for Girls
Kufa University

Abstract

Due to the high importance of the scientific research in Iraq and its subject's modernity which must involve the newest technologies in the research process, this research presenting the Long Term Evolution (LTE) which is the latest and most up-to-date wireless technology from the fourth wireless telecommunications generation (4G) in wide world. The major advantage of this technology is providing in one hand a very secure, reliable and competitive/cheap telecommunications prices with many multi-media features and variant services to the end user and in other hand less establishing cost for the operator and wider coverage. In order to demonstrate LTE standers key features; an overview of telecommunications generations evolution along the last decade will presented with definition for 4G aspects in addition to list its most important goal and its performance target, then the light will be spotted on the LTE technical specifications and their advantages.

Introduction

Telecommunications Wireless systems are regularly classified by a specific term "*Generation*" which is indicate telecommunications development schema and also generally refers to a change in the fundamental nature of the service. Along the last three decades since early 1980s wireless communications standers and algorithms was stepped forward in three steps/generation, 1G First generation wireless represent voice-only simple analog cellular systems, 2G second generation wireless systems conduct digital transmission technologies to meet the required voice services, 3G third generation differs from second generation systems more in the ability to integrate voice and data applications than in essential differences in transmission technology.

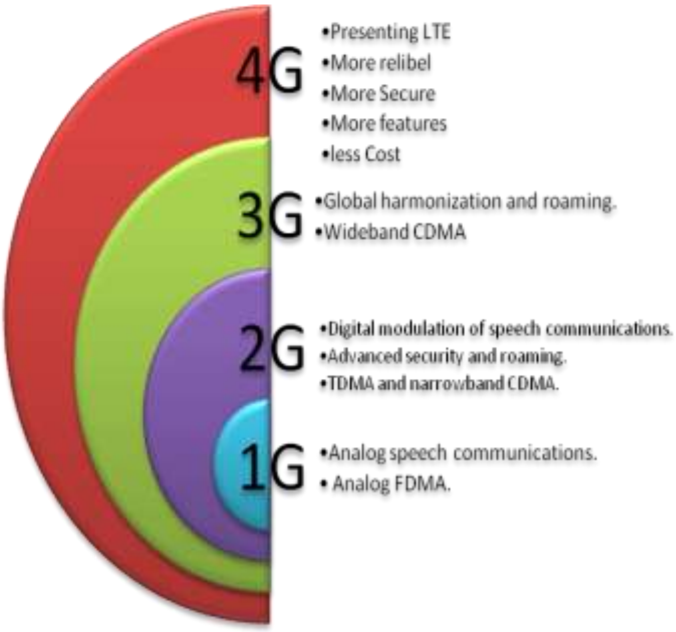

Figure 1 - Wireless Telecommunication generations Evolution

Fourth Generation 4G

The previous three generations was followed by multi-media support, spread spectrum transmission and at least 200 kbit/s (3G) and now 4G, which refers to all IP packet-switched networks, mobile ultra-broadband (gigabit speed) access and multi-carrier transmission.

The recent increase of mobile data usage and emergence of new applications such as MMOG (Multimedia Online Gaming), mobile TV, Web 2.0, and streaming contents, [1) all these factors have motivated the 3rd Generation Partnership Project (3GPP) to work on demanded evolution and requested shifting to beyond 3G as shown in (Figure 2). Universal Mobile Telecommunications System (UMTS) with High Speed Packet Access (HSPA) technology and its evolution to beyond Third Generation (3G) is becoming the primary global mobile-broadband solution.

Building on the phenomenal success of Global System for Mobile Communications (GSM), the GSM/UMTS network is becoming the most successful communications technology family ever. UMTS/HSPA, in particular, has many key technical and business advantages over other mobile wireless technologies. [2) Operators worldwide are now deploying High Speed Downlink Packet Access (HSDPA), one of the most powerful cellular-data technologies ever developed till 2009. HSDPA, already widely available, follows the successful deployment of UMTS networks around the world and, for many of these networks, is a relatively straightforward upgrade.

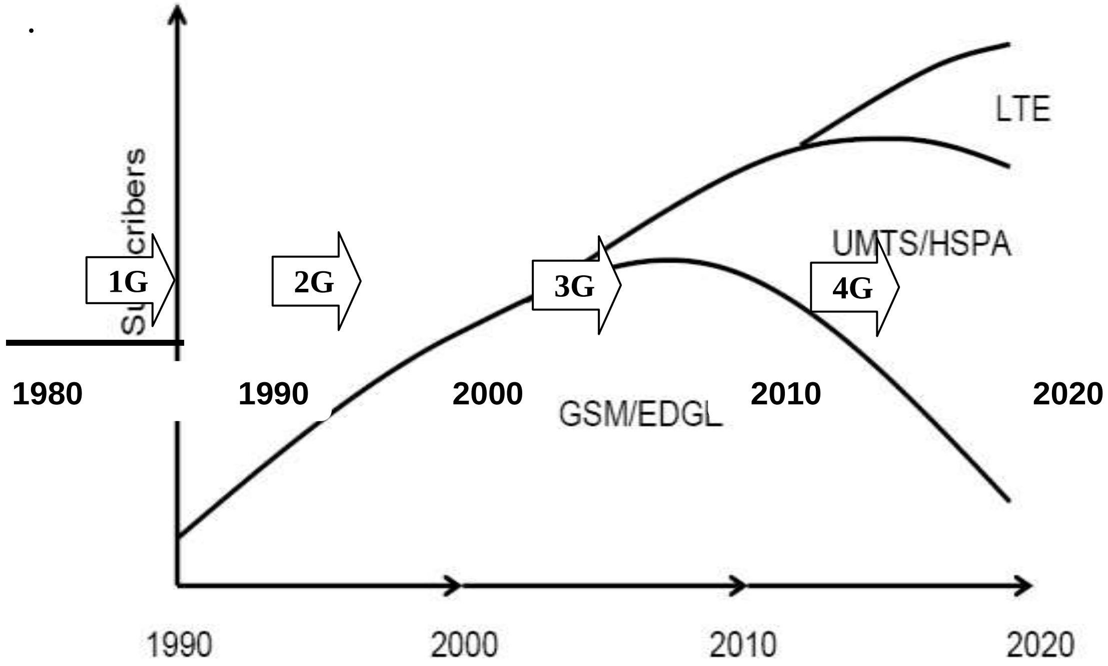

Figure 2 – Subscribers Demands for Wireless Telecommunication Technologies

Any operator deploying UMTS today is doing so with HSDPA. The UMTS-to-HSPDA upgrade is similar to Enhanced Data Rates for GSM Evolution (EDGE), which has already proven to be a remarkably effective upgrade to GSM networks, and HSPDA is now supported by an overwhelming number of operators and vendors worldwide.

High Speed Uplink Packet Access (HSUPA) is poised to follow HSDPA, with the combination of the two technologies called simply HSPA. HSPA is strongly positioned to be the dominant mobile-data technology for the rest of the decade. To leverage operator investments in HSPA, standards bodies are examining a series of enhancements to create "HSPA Evolution," also referred to as "HSPA+." HSPA Evolution represents a logical development of the Wideband Code Division Multiple Access (WCDMA) approach, and it is the steppingstone to an entirely new Third Generation Partnership Project (3GPP) radio platform called Long Term Evolution (LTE). [2]

Long Term Evolution Overview

LTE (Long Term Evolution) is the trademarked project name of a high performance air interface for cellular mobile telephony. It is a project of the 3rd Generation Partnership Project (3GPP), operating under a named trademarked by one of the associations within the partnership, the European Telecommunications Standards Institute.

We can consider LTE is the first step toward the 4th generation (4G) of radio technologies designed to increase the capacity and speed of mobile telephone networks. Where the current generation of mobile telecommunication networks are collectively known as 3G, LTE is marketed as 4G. Ideally, LTE is a 3.9G technology since it does not fully comply with the IMT Advanced 4G requirements. [3]

Due to LTE promises features Global Major Telecommunications companies like Verizon Wireless and AT&T Mobility in the United States and several worldwide carriers announced plans, beginning in end of 2009, to convert their networks to LTE. The world's first publicly available LTE-service was opened in the two Scandinavian capitals Stockholm and Oslo only five months ago on the 14th of December 2009. [4]

The latest standard in the mobile network technology tree is Long Term Evolution stander also is a set of enhancements to the Universal Mobile Telecommunications System (UMTS) which was introduced in 3rd Generation Partnership Project (3GPP) Release 8. Much of 3GPP Release 8 focuses on adopting 4G mobile communications technology, including an all-IP flat networking architecture. [3]

LTE Technical Specifications

Radio access for LTE is named Evolved UMTS, global Radio Access Network (E-UTRAN), is conducted substantially improve end-user throughputs, sector capacity and reduce user plane latency, leading to significantly improving for user experience with full mobility. With the emergence of Internet Protocol (IP) as the protocol of choice for carrying all types of traffic, LTE is provide support for IP-based traffic with end-to-end Quality of service (QoS).

3GPP LTE Protocol Architecture

According to 3GPP LTE 4G technical Overview [5], LTE use three layer protocol as shown in Figure 3, including Logical, Transport and Physical channels which corresponding the Control / Measurements Levels in

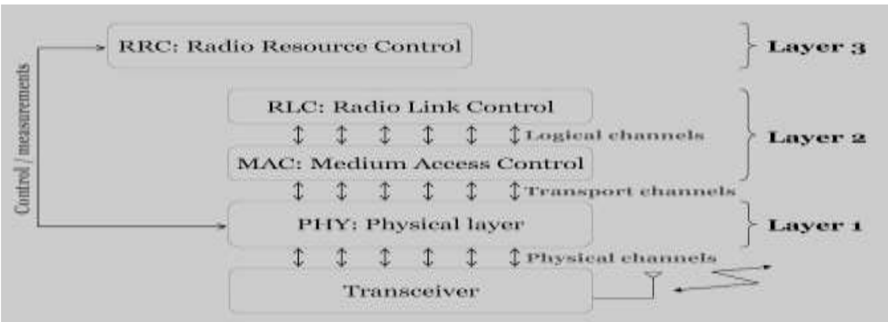

Figure 3 - LTE protocol Architecture.

LTE protocol Architecture that includes Radio (RRC and RLS), Media (MAC) and physical layer control.

LTE protocol enabling several new Technologies through the next coming decade (2011 – 2020) such as:

- OFDM (Orthogonal Frequency Division Multiplexing)
- Frequency domain equalization
- SC-FDMA (Single Carrier FDMA)
- MIMO (Multi-Input Multi-Output)
- Multicarrier channel-dependent resource scheduling
- Fractional frequency reuse
- Single Carrier FDMA (SC-FDMA)
    - SC-FDMA is a new single carrier multiple access technique which has similar structure and performance to OFDMA.
- Utilizes single carrier modulation and orthogonal frequency multiplexing using DFT-spreading in the transmitter and frequency domain equalization in the receiver. [6]
- Voice traffic will be supported mainly as Voice over IP (VoIP)
- Enabling better integration with other multimedia services. [2]`

Network Architecture

Unlike HSPA (High Speed Packet Access), 3GPP is specifying a new Packet Core in its Technical Stander TS 36.300 for Dec 2009 [5], the Evolved Packet Core (EPC) network architecture [6] as shown in Figure 4, to support the E-UTRAN through a reduction in the number of network elements, simpler functionality, improved redundancy but most importantly allowing for connections and hand-over to other fixed line and wireless access technologies, giving the service providers the ability to deliver a seamless mobility experience.

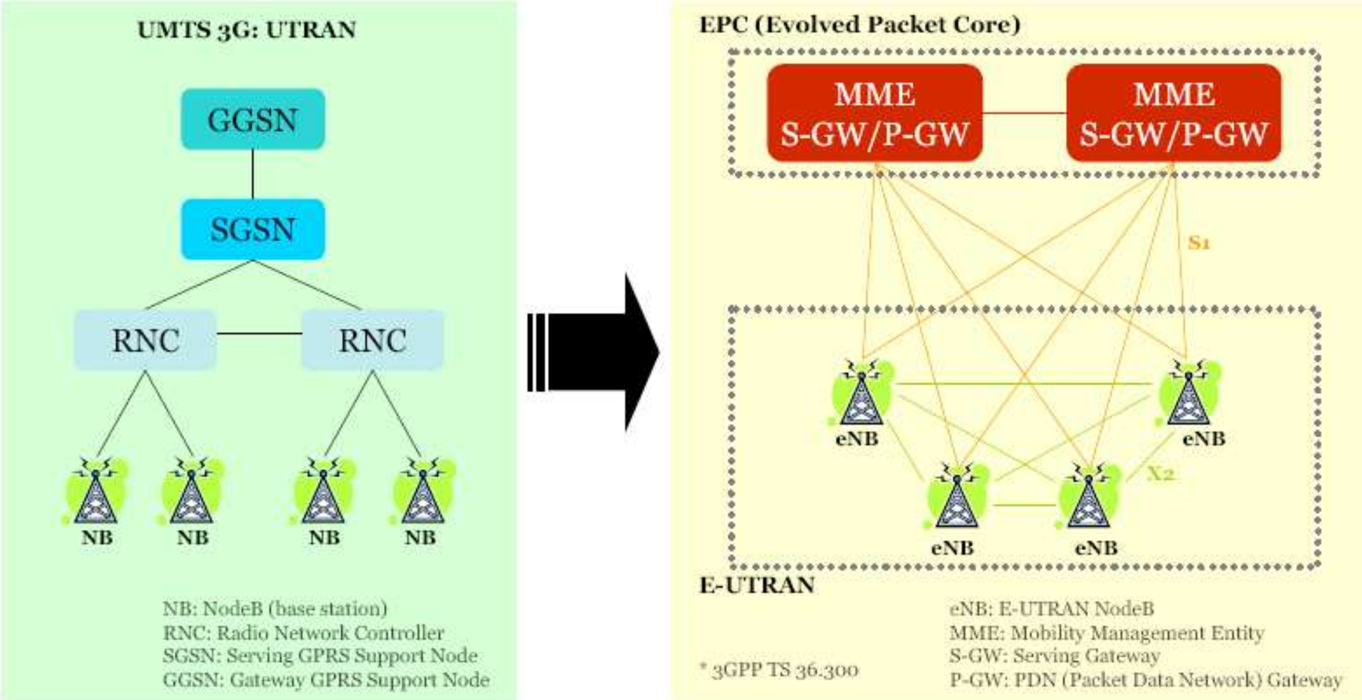

Figure 4 – LTE Network Architecture

LTE has been set aggressive performance requirements that rely on physical layer technologies, such as, Orthogonal Frequency Division Multiplexing (OFDM) and Multiple-Input Multiple-Output (MIMO) systems, Smart Antennas to achieve these targets. The main objectives of LTE network architecture are to minimize the system and User Equipment (UE) complexities, allow flexible spectrum deployment in existing or new frequency spectrum and to enable co-existence with other 3GPP Radio Access Technologies (RATs). [1]

As shown in Figure 4 E-UTRAN Node B's are responsible on all radio interface-related functions, MME Manages the mobility features, UE identity, and security parameters, where S-GW in charged on Node that terminates the interface towards E-UTRAN and P-GW accountable on Node that terminates the interface towards PDN. Figure 5 shows detailed core architecture's interconnection between E-PC with E-UTRAN.

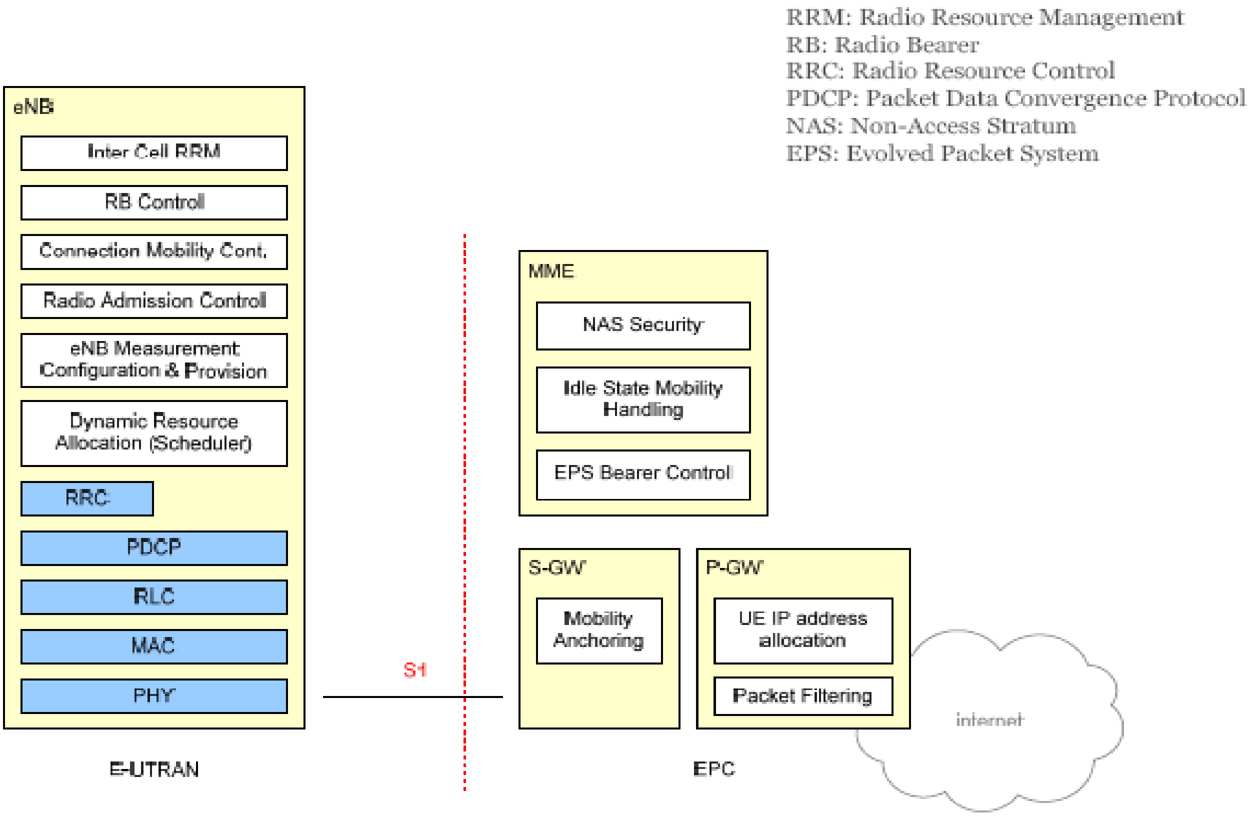

Figure-5 E-PC with E-UTRAN Interconnection

This network architecture is providing LTE many 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 1.25, 2.5, 5, 10, 15, and 20 MHz in the study phase. Channels that are 1.6 MHz wide are under consideration for the unpaired frequency band, where a TDD approach will be used.
- Increased spectral efficiency over Release 6 HSPA by a factor of two to four.
- Reduced latency, to 10 msec round-trip time between user equipment and the base station, and to less than 100 msec transition time from inactive to active.

The overall intent is to provide an extremely high-performance radio-access technology that offers full vehicular speed mobility and that can readily coexist with HSPA and earlier networks. Because of scalable bandwidth, operators will be able to easily migrate their networks and users from HSPA to LTE over time.

Below table shows LTE peak data rates based on different downlink and uplink designs.

LTE Configuration	**Downlink (Mbps) Peak Data Rate**	**Uplink (Mbps) Peak Data Rate**
Using 2X2 MIMO in the Downlink and 16 QAM in the Uplink	172.8	57.6
Using 4X4 MIMO in the Downlink and 64 QAM in the Uplink	326.4	86.4

Peak Throughput Rates Table

LTE is not only efficient for data but, because of a highly efficient uplink, is extremely efficient for VoIP traffic. In 10 MHz of spectrum, LTE VoIP capacity will reach almost 500 users. [7] LTE implements OFDM in the downlink. The basic principle of OFDM is to split a high-rate data stream into a number of parallel low-rate data streams, each a narrowband signal carried by a sub carrier. The different narrowband streams are generated in the frequency domain and then combined to form the broadband stream using a mathematical algorithm called an Inverse Fast Fourier Transform (IFFT) that is implemented in digital-signal processors. In LTE, the sub carriers have 15 kHz spacing from each other. LTE maintains this spacing regardless of the overall channel bandwidth, which simplifies radio design, especially in supporting radio channels of different widths. The number of sub carriers ranges from 75 in a 1.25 MHz channel to 1,200 in a 20 MHz channel. [7]

Conclusions and Recommendations

1- **LTE** is the latest wireless telecommunication technology suggested on early 2008 and implemented five months ago in 2010.

2- Key technologies of LTE system
- Multicarrier-based radio air interface (OFDMA and SC-FDMA)
- IP-based flat network architecture
- Multi-input multi-output (MIMO)
- Active interference avoidance and coordination (Fractional frequency re-use (FFR)).
- Fast frequency-selective resource scheduling.

3- Recommending LTE wireless telecommunication to be conducted and used by the Iraqi government because its reliability, efficiently, high security powerfully features and to its Multimedia variant services.

References

[1] Motorola, Inc., TECHNICAL OVERVIEW, *“Long Term Evolution (LTE): A Technical Overview”*, Dec, 2009

[1] Peter Rysavy, 3G Americas research center, *“EDGE, HSPA, LTE: The Mobile Broadband Advantage”*, Sep. 2008.

[3] Rumney Moray , *” 3GPP Long Term Evolution - Agilent Technologies”* Augest 2008

[4] Betanews, *“European Commission pumps €18 million into LTE research”* - Wireless News,http://www.betanews.com/article/European-Commission-pumps-a18-million-into-LTE-research/1250618141, Retrieved March 2010.

[5] Neate, Rupert. *"Slough accepts the call to be 4G mobile phone trailblazer"*. *The Daily Telegraph*., http://www.telegraph.co.uk/finance/newsbysector/mediatechnologyandtelecoms/6797198/Slough-accepts-the-call-to-be-4G-mobile-phone-trailblazer.html. April 2010.

[6] Hyung G. Myung, *“3GPP Technical Overview”*, Dec 2008.

[7] Peter Rysavy, Rysavy and 3G Americas research Center *“EDGE, HSPA, LTE: The Mobile Broadband Advantage”,* Sep. 2008

Journal of Al-Qadisiyah for Computer Science and Mathematics
Vol. 3 No.1 Year 2011

التطور المتميز للاتصالات اللاسلكية من خلال تقنية التطور الطويل الأمد (الجيل الرابع)

علي عبد الحسين عبد الواحد
قسم الحاسبات. كلية التربية للبنات. جامعة الكوفة

الخلاصة

نظرا لأهمية البحث العلمي في العراق وحداثة موضوعاته والتي يجب أن تنطوي على أحدث التقنيات في عملية البحث ،يقوم هذا البحث بتقديم تقنية (التطور طويل الأمد) من الجيل الرابع والذي يمثل أحدث وأكثر ما توصلت إليه تكنولوجيا التقنيات والاتصالات اللاسلكية في جميع أنحاء العالم. الميزة الرئيسية لهذه التكنولوجيا أنها من جهة آمنة جدا وموثوقة العمل بالإضافة إلى كونها تنافسية التكاليف في الاتصالات السلكية واللاسلكية مع مميزات الوسائط المتعددة والخدمات العديدة للمستخدم النهائي ومن جهة أخرى فهي الأقل من حيث تكلفة الإنشاء للمشغل وتوفر تغطية أوسع. من أجل إظهار الملامح الرئيسية لتقنية التطور طويل الأمد ، قدم هذا البحث لمحة عامة عن تطور الأجيال الاتصالات السلكية واللاسلكية على طول العقد الماضي مع تعريف تقنية الجيل الرابع وجوانبه التقنية، ثم سيتم تسليط الضوء على المواصفات الفنية لهذه التقنية ومزاياها.