An Overview of 3GPP Long Term Evolution (LTE)

Elisavet Grigoriou
CSSN Research Lab, Department of Informatics, Alexander TEI of Thessaloniki, Greece

Periklis Chatzimisios
CSSN Research Lab, Department of Informatics, Alexander TEI of Thessaloniki, Greece

1. INTRODUCTION

Long Term Evolution (LTE)-Advanced was introduced in 3rd Generation Partnership Project (3GPP) Release 10. As the Evolution of LTE, LTE-Advanced includes all the features of Releases 8 and 9 and also adds new features for improving performance. The most significant new features are Carrier Aggregation (CA), improved support for heterogeneous deployments, enhanced multi-antenna support and relaying techniques. Furthermore, LTE-Advanced provides backward compatibility with previous Releases. Furthermore, it should be noted that most of the LTE-Advanced features can be introduced into the network as simple software upgrades. In October 2009, the 3GPP Partners formally submitted LTE-Advanced to the ITU Radio communication Sector (ITU-R) as a candidate for the Fourth Generation (4G) International Mobile Telecommunications-Advanced (IMT-Advanced). Since then, many wireless operators have announced plans to deploy LTE in their next-generation networks leading to a growing interest in LTE-Advanced.

2. BACKGROUND

During the last few years, we have experienced major changes in the telecommunications industry. Various mobile and wireless communication technologies are widely deployed, such as WiMAX (IEEE 802.16), Wi-Fi (IEEE 802.11), LTE (Long Term Evolution), 3G mobile networks (UMTS, cdma2000) and 4G as well as escort networks, such as personal area networks or sensor networks. Mobile terminals include variety of interfaces,, which are based on old-fashioned circuit switching, the technology that is going into its last decade of existence. These technologies (mainly cellular generations) differ from each other based on four main aspects: bandwidth, radio access, data rates and switching schemes. These differences have been noticed in previous generations (1G, 2G, 2.5G and 3G etc.).

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3. LTE-ADVANCED

3.1. Introduction

LTE-Advanced (LTE-A) is the evolution of LTE. Release 10 enhances some of the features introduced in Releases 8 and 9 (Table 1). LTE-Advanced meets the requirements of IMT-Advanced of ITU-R for the 4G of mobile technologies. LTE-Advanced is anticipated to be the radio-access technology submitted to ITU as the 3GPP candidate for IMT-Advanced radio access. 3GPP actions for LTE-Advanced have been published in 3GPP TR 36.912 and 36.913. Nowadays, 3GPP evolves to Release 12.

3.2. Features

The specifications of all the Releases are updated after Technical Specification Group (TSG) meetings that take place four times every year. The 3GPP documents are separated into Releases, where each Release has some additional features compared with the previous ones. The features of Releases are defined in Work Items (WI) agreed and undertaken by the TSGs. The Releases from 8 and onwards contain some main features listed for LTE. Release 10 is the one approved by ITU-R as an IMT-Advanced technology and is therefore also named LTE-Advanced (LTE-A).

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Table 1. Comparison between 3GPP Rel-8 and Rel-10

Feature	LTE Rel-8	LTE Rel-10
Network Architecture	Very-flat, IP-based eNB, S-GW	Same as LTE Rel-8but there are certain differences for heterogeneous network architecture.
Access Technology	Downlink: Scalable OFDMA Uplink: scalable SC-FDMA	Same as LTE Rel-8 but single-carrier property is not preserved for SC-FDMA uplink
Channel Bandwidth	1.4, 1.6, 3, 5, 10, 15, & 20MHz	Additionally supports up to 100 MHz for downlink and 40MHz for uplink and 40MHz for uplink with carrier aggregation
Spectrum	Licensed IMT-2000 bands	Licensed IMT-2000 bands
Total overhead	Downlink overhead ~31%–33%	Downlink overhead 25%–28%

LTE-A supports peak data rates of 100 Mbps in downlink (DL) and 50 Mbps in uplink (UL), both achieved with a 20 MHz spectrum. If LTE employs Multiple Input Multiple Output (MIMO) techniques, data rates can reach up to 300 Mbit/s downlink when a 4X4 antennas scheme is utilized. LTE-A supports a variable range of spectrum, which can be used with 1.25, 2.5, 5, 10, 15 and 20 MHz. A sector can cover up to 100 km area, with slight degradation after 5 km and over 68 users can be supported per sector. LTE-A is optimized for low speeds (0 - 15 km/h) but it supports also speeds up to 350 km/h (depending on the frequency band). Table 1 provides a comparison between 3GPP Release-8 and Release-10.

LTE-A enhances LTE spectrum flexibility through Carrier Aggregation (CA), where two or more Component Carriers (CCs) are aggregated in order to support larger transmission bandwidths up to 100MHz and for spectrum aggregation, enabling peak target data rates in excess of 1 Gb/s in the DL and 500 Mb/s in the UL. Carrier Aggregation is supported for both contiguous/non-contiguous CC and can be used to efficiently support different CCs types that may be deployed in heterogeneous networks. Carrier Aggregation also allows operators to deploy a system with extended bandwidth by aggregating several smaller CCs while providing backward compatibility to legacy users. As a result, data processing at the Physical Layer can be thought of as independent per carrier. More technical features can be found in Table 2.

Within a CC, LTE-A supports multi-carrier transmission through clustered Discrete Fourier Transform Spread OFDM (DFT-S-OFDM) in DL. DFT-S-OFDMA compared to the Carrier Aggregation technique improves user throughput and capacity in UL through flexible radio resource allocation.

LTE-A supports Single-User MIMO (SU-MIMO) multiplexing with up to eight antennas in DL and four antennas in UL. Multi-User MIMO (MU-MIMO) is also being utilized in order to increase the system capacity. Moreover, the Coordinated Multi-Point transmission/reception (CoMP) technique is introduced, which coordinates communication among multiple cells, in order to improve the cell-edge throughput and to provide high data rates. In order to facilitate network performance and minimize operational effort, LTE-A supports self-optimization features such as coverage and capacity optimization, mobility robustness optimization as well as mobility load balancing. Capacity and coverage enhancement can also be achieved by using a heterogeneous network, which is a collection of low-power nodes distributed across a macrocell (homogeneous) network.

In addition, LTE-A supports Quality of Service (QoS) by employing reservation-based access and by

Table 2. Other Technical features of 3GPP Release 10

	Downlink	Uplink
Peak Spectrum Efficiency [bps/Hz]	30	15
Average Spectrum Efficiency [bps/Hz/cell]	2 x 2 : 2,4 4 X 2 : 2,6 4 X 4 : 3,7	1 X 2: 1,2 2 X 4: 2,0
Cell-Edge User Throughput [bps/Hz/Cell/user]	2 X 2: 0,07 4 X 2: 0,09 4 X 4: 0,12	1 X 2: 0,04 2 X 4: 0,07