# CHAPTER I
# INTRODUCTION

In Section 1.1, the background of the mobile communication systems related with this PhD study is given; Section 1.2 gives a short introduction of 3GPP standards evolution, their major features; the purpose of theses is described in section 1.3; Section 1.4 summarizes the contributions in the thesis and Section 1.5 provides an outline of the chapters.

## 1.1 PRELIMINARIES

Wireless technology began around the time when James Maxwell proved the existence of electromagnetic waves in 1860. Heinrich Hertz confirmed the existence of the electromagnetic wave in 1888.in 1896; the first wireless network was demonstrated by Guglielmo Marconi. He sent Morse code on radio wave over more than a mile.

There have been so many great contributions since then. In 1906; Lee De Forest who invented the Audion (electronic amplifying vacuum tube). Audion is the first electrical device which can amplify weak electrical signal to strong signal. Edwin Armstrong who created FM radio, among others in 1935.The first commercial radio broadcast was deployed in 1920. After that, the first interconnection of mobile users to public switched telephone network (PSTN) is started in 1941.

In 1947; Walter H. Brattain, William B. Shockley, and John R. Bardeen invented the transistor which developed from semiconductor material replacing vacuum tubes. The transistor was the first electronic device than can amplify an electrical signal and turn it on or off, allowing current to flow or to be blocked. Claude Elwood Shannon published papers on information theory in 1948. He was known as the father of information theory.

Mobile networks have experienced great rising during the past centuries. The current mobile networks can provide users with a wide variety of new services from high quality voice to high definition video to high data rate transmission. These services include web browsing, video streaming, file downloading etc. The capability of high data rate transmission is one of the most important enablers for the wide application of wireless networks. It ultimately determines the kind of service that can be provided to the users and the service quality each user will experience.

It is important to understand where mobile-communication systems start from and how cellular systems have developed. The mission of developing mobile technologies has also changed complex task undertaken by global standards developing organizations such as the Third Generation Partnership Project (3GPP) and involving thousands of people [1].

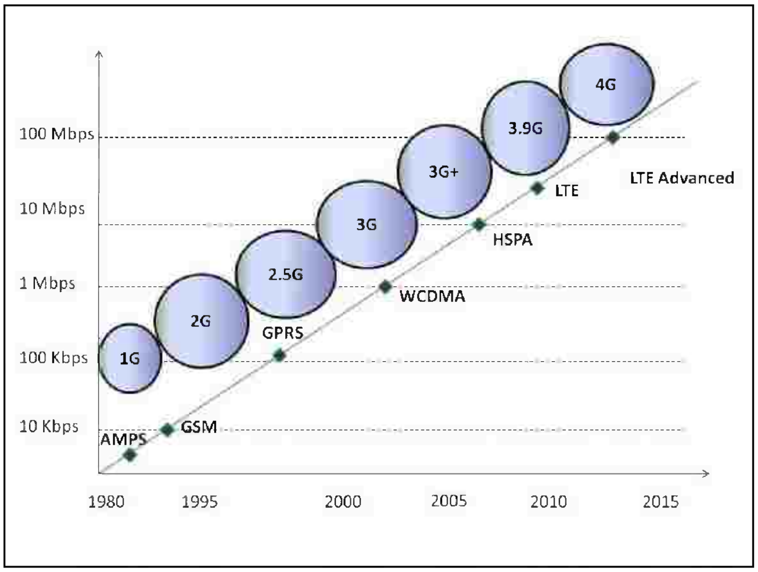


**Figure 1.1 Evolution of mobile communication**

Mobile communication technologies are often divided into generations; a brief illustration of the evolution of the mobile networks can be found in figure 1.1, 1G is the analog cellular radio systems, the first digital mobile systems is being labeled 2G, and 3G is the first mobile system that handling broadband data.

The main technological difference that distinguishes 3G technology from 2G technology is the use of packet switching rather than circuit switching. The Long-Term Evolution (LTE) is often called "4G", but LTE release 10, also referred to as LTE-Advanced, is the 4G evolution step, while the first release of LTE (release 8) is being labeled as "3.9G". This continuing race of increasing sequence numbers of mobile system generations is in fact just a matter of labels.

## 1.2 3GPP Standard Releases For LTE

The 3rd Generation Partnership Project (3GPP) is cooperation between groups of telecommunications associations, known as the Organizational Partners. The initial scope of 3GPP was to make a globally applicable third-generation (3G) mobile phone system specification based on evolved Global System for Mobile Communications (GSM) specifications within the scope of the International Mobile Telecommunications-2000 project of the International Telecommunication Union (ITU) [2]. Figure 1.2 illustrates the short summary of the 3GPP releases relevant to LTE and LTE advanced, including their main contents [3].

The project covers cellular telecommunications network technologies. It provides complete system specifications including radio access, the core transport network, and service capabilities - including work on codec, security, quality of service. The specifications also provide details for non-radio access to the core network, and for interworking with Wi-Fi networks.

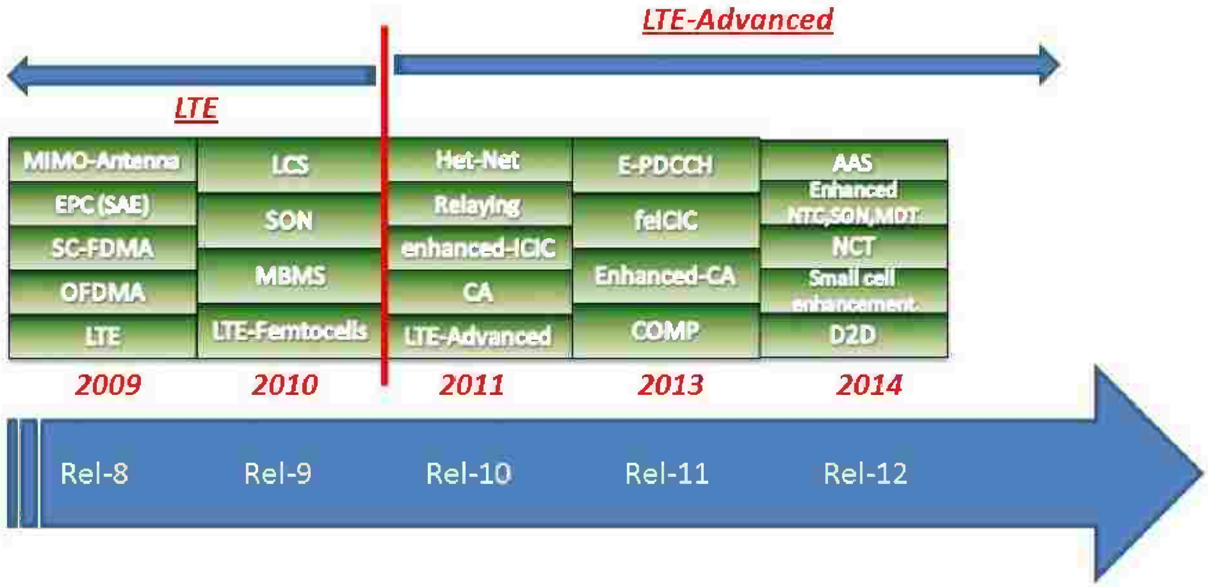


**Figure 1.2 Evolution of 3GPP standards**

### 1.2.1 3GPP Release 8

Release 8 introduced LTE for the first time, with a completely new radio interface and core network, enabling substantially improved data performance compared with previous systems. Some of key technologies introduced in release 8:

- Peak data rates up to 300 Mbps in the downlink and 75 Mbps in the uplink.
- Adoption of OFDMA for the downlink and SC-FDMA for the uplink air interfaces to enable narrowband scheduling and efficient support of spatial multiplexing.
- Implementation in bandwidths of 1.4, 3, 5, 10, 15 or 20MHz, for allowing different deployment scenarios.
- Support Multiple Input Multiple Output (MIMO) antennas.
- Evolved packet core (EPC) is the outcome of the 3GPP System Architecture Evolution (SAE) technical study and specification work. 3GPP decided to use IP (Internet Protocol) to transport all services. It is IP architecture through which LTE and other 3GPP and non-3GPP access connects. Also EPC provided solution for security, QoS, Mobility, and connection to various IP based service for multiple access technologies.

### 1.2.2 3GPP Release 9

Release 9 brought a number of refinements to features introduced in Release 8, along with new developments to the network architecture and new service features. These included:

- LTE Femtocell (HeNB).
- Self Organization Network (SON); is an automation technology designed to make the planning, configuration, management, optimization and healing of mobile radio access networks simpler and faster.

- Multimedia Broadcast and Multicast Service (MBMS) support for the efficient delivery of the same multimedia content to multiple destinations.
- Location Services (LCS), it is used to exchange messages between a handset and base station in order to provide location information.

### 1.2.3 3GPP Release 10

Release 10 provided a substantial uplift to the capacity and throughput of the LTE system, also known as LTE-Advanced. Table 1.1 compares between performance requirements of LTE with some of the current agreements of LTE Advanced.

**Table 1.1 Differences between LTE and LTE-A [4]**

| Technology | LTE | LTE-A |
|---|---|---|
| Peak data rate Down Link ( DL) | 150 Mbps | 1 Gbps |
| Peak data rate Up Link (UL) | 75 Mbps | 500 Mbps |
| Transmission bandwidth DL | 20MHz | 100 MHz |
| Transmission bandwidth UL | 20MHz | 40 MHz |
| Mobility | Optimized for low speeds <15 km/hr<br>High Performance at speeds up to 120 km/hr<br>Maintain Links at speeds up to 350 km/hr | Same as that in LTE |
| Coverage | Full performance up to 5 km | a) Same as LTE requirement<br>b) Should be optimized or deployment in local areas /micro cell environments |
| Scalable Band Widths | 1.3,3, 5, 10, and 20 MHz | Up to 20–100 MHz |
| Capacity | 200 active users per cell in 5 MHz. | 3 times higher than in LTE |

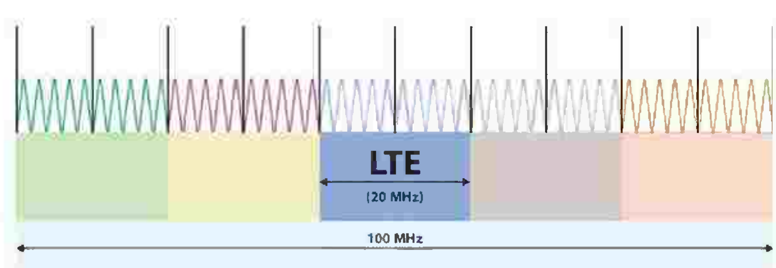


**Figure 1.3 LTE-Advanced Bandwidth [4]**

Notable features included:

- Up to 1Gbps downlink are expected from LTE-A bandwidths of 100 MHz and 500 Mbps uplink as shown in figure 1.3.
- Carrier Aggregation (CA), allowing the combination of up to five separate carriers to enable bandwidths up to 100MHz.
- Enhanced MIMO.
- Relaying. The most basic relay method is the use of a repeater, which receives, amplifies, and then retransmits the downlink and uplink signals to overcome areas of poor coverage. The repeater could be located at the cell edge or in some other area of poor coverage.
- Enhanced Inter-Cell Interference Coordination (eICIC).
- Heterogeneous Networks. By Release 10 a variety of new base station types were introduced including the afore-mentioned local area BS (picocell), home BS (femtocell), and relay node.

### 1.2.4 3GPP Release 11

LTE-Advanced as specified in the 3GPP Release 11 timeframe comprises a number of improvements based on existing features, and new technology components added:

- Coordinated Multi-Point Operation for LTE (CoMP). The goal of CoMP is to improve the coverage of high data rates and cell-edge throughput, and also to increase system throughput.
- LTE carrier aggregation enhancements
- Further enhanced non CA-based ICIC (feICIC)
- Enhanced physical downlink control channel (E-PDCCH): new Ctrl channel with higher capacity.

### 1.2.5 3GPP Release 12

Potential features for Release 12 were discussed at a 3GPP workshop in June 2012. A strong requirement was the need to support the rapid increase in mobile data usage, but other items included the efficient support of diverse applications while ensuring a high quality user experience. Some of the candidates for Release 12 included:

- Small cells enhancement, A Physical Layer study seeks to improve system spectrum efficiency by increasing the transmission efficiency and/or reducing overhead.
- New Carrier Type (NCT), allows switching off cells, at least temporarily, and will reduce overhead and interference from Common Reference Symbols by maximizing the use of dedicated Demodulation Reference Symbols required for advanced antenna technologies.
- Active Antenna Systems (AAS). The AAS Base Station uses multiple transceivers on an antenna array to produce a radiation pattern that can be dynamically adjusted.
- Device to device (D2D) communication, to enable devices to express their identity to other UE in the local area and use including public safety involving communication in the absence of a network
- Continuous enhancements for:

- Machine Type Communications (MTC)
- Self Organizing Network (SON)
- Minimization of Drive Test (MDT)
- Advanced receiver

## 1.3 THESIS PURPOSE

The Objectives of thesis study:

- We investigate the effect of interference between home eNB and macro users in heterogeneous network; assist the effect of enhanced interference coordination techniques for mitigating interference between macro and femto.
- We Propose modified proportional fair scheduling (MPF). MPF is modified traditional proportional fair scheduling to give cell edge users more priority than cell center users.
- We present Non Orthogonal Multiple Access (NOMA) in heterogeneous LTE network where femto cells are randomly deployed in network. NOMA is scheme which utilizes additional new domain named power domain.
- We propose coordinated multipoint with non orthogonal multiple access (NOMA) in heterogeneous network.

## 1.4 SUMMARY OF CONTRIBUTION

This research contributes to the advancement of coordinated multipoint transmission and reception techniques using Non Orthogonal Multiple Access (NOMA) with superposition coding in heterogeneous network. First, this research proposes modified proportional fair scheduling to be used with conventional interference mitigation technique, namely Almost Blank subframe (ABS), to improve cell edge user throughput. Second, this research proposes transmit power allocated scheme for NOMA and compares with existing power allocation scheme showing the improvement of user throughput. Third, this thesis proposes coordinated multipoint with non orthogonal multiple access in macro-femto network and evaluates the performance of using NOMA.

## 1.5 THESIS OVERVIEW

This thesis is organized as follows:

In Chapter 2, we give a general overview of LTE-Advanced technology. We discuss the current scenario of LTE and then compare that with the ITU proposed LTE-Advanced. Some of the main key features of LTE and LTE Advanced have been discussed there. Apart from this, the femto technologies in IMT-Advanced as well as LTE-advanced standard are studied in this chapter.

In Chapter 3, we clarify the basic concept, the benefits, and motivations behind downlink non orthogonal multiple access (NOMA) as a potential candidate multiple access for future radio access (FRA).

In Chapter 4, novelty and contributions of PhD study are presented in this chapter.

In Chapter 5, simulation parameters are discussed in this chapter, the path loss models for different scenarios involved in this model as well as the applicability of the radio channel model are summarized. Also the network layout has been discussed briefly.

In Chapter 6, we discuss interference mitigation schemes which will be used in thesis research, explaining modified proportional fair scheduling algorithm. The simulation results have been discussed in this chapter.

In Chapter 7, the proposed transmit power allocation scheme is explained and compared to related work. We apply joint transmission scheme in heterogeneous network using non orthogonal multiple access, stating user and cell throughput.

In Chapter 8, the conclusions that have been drawn from all the results obtained in the course of this thesis work have been presented. Recommendations for the further future research involving this thesis are also proposed in this chapter.