FINAL YEAR PROJECT REPORT

(Maximizing Throughput with Fairness in LTE)

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(Maximizing Throughput with Fairness in LTE)

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Abstract

With an increase in the number of mobile users, capacity requirements on wireless communication systems has increased to a very high level especially in terms of data rates. This report proposes a feedback based resource scheduling technique for maximizing data rates from a quality of service point of view. This aims at having better mobility, improved coverage and fairness among wireless users. The proposed methodology results in increased throughput for the users without compromising on fairness and QoS. A sub optimal scheduling technique for wireless mobile users is proposed having a low implementation complexity without compromising on throughput for improved QoS. Performance of the proposed algorithms is evaluated by means of simulations. Comparison to theoretical achievable throughput is also presented. The investigation and results reveals the possibility of utilizing a suboptimal scheme to maximize user throughput, thereby pointing at directions to efficiently improve performance in system.

Dedication

First of all we are very thankful to ALLAH ALMIGHTY who has given us enough courage to complete this task. Then it is dedicated to our kind teacher **Sir Jawwad Nasar Chattha, Sir Muhammad Basit Shahab &Our Parents** who enlightened our minds with Knowledge, tried to include the spirit of hard work so that we could have a bright future in terms of being good human and turn out to be competent Engineers with powers to take challenging engineering problems.

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List of abbreviations

3GPP	3rd Generation Partnership Project
UMTS	Universal Mobile Telecommunication System
AMPS	Advance Mobile Phone System
EDGE	EnhancedData rates for GSM Evolution
HSPA	High Speed Packet Access
HSCSD	**High Speed Circuit Switched Data**
QoS	Quality of Service
LTE	Long Term Evolution
GSM	Global System for Mobile Communication
GPRS	Global Packet Radio Service
HSDPA	High Speed Downlink Packet Access
MIMO	Multiple Input Multiple Output
OFDM	Orthogonal Frequency Division Multiplexing
TDMA	Time Division Multiple Access
CDMA	Code Division Multiple Access
FDMA	Frequency Division Multiple Access
HSS	Home Subscriber Service
ENodeB	Evolved Node B
UE	User Equipment
SGW	Serving Gateway
SGSN	Serving GPRS Support Node
MME	Mobility Management Entity
MSC	Mobile Switching Centre

List of abbreviations

BSC	Base Station Controller
PDNG	Packet Data Network Gateway
CQI	Channel Quality Indicator
BLER	Block Error Ratio
BER	Bit Error Ratio
PedA	pedestrian A
PedB	Pedestrian B
VehA	Vehicular A
VehB	Vehicular B
SNR	Signal to Noise Ratio

Chapter 1

Introduction

1 Introduction

1.1 Historical introduction

The Long Term Evolution of UMTS is just one of the latest steps in an advancing series of mobile telecommunications system.

LTE (Long Term Evolution) also known as 4G is a wireless based network for mobile phones and data terminals. In LTE, capacity and speed has been increased because of the new modulation techniques. It is based on the UMTS and GSM networks. 3GPP has described its standard in Release 8

The early systems were confined within national boundaries. They attracted only a small number of users, as the equipment on which they relied was expensive, cumbersome and more power consumption.

The first mobile communication systems commercial launched in the 1980s and became known as the ‘First Generation’ systems. Global roaming first became a possibility with the development of the digital ‘SecondGeneration’ system known as GSM. There is another generation which is called 2.5G. Mainly 2.5G had not brought any new evolution. This only comes with some new standards which in modified form of 2G. It support higher data rate with respect to 2G and it also support E-mail traffic, mobile commerce and location based mobile services.

For the improvement in technology and standards there are currently three main organizationsresponsible for developing the standards meeting IMT requirements, and which are continuingto shape the landscape of mobile radio systems, which also shown in fig 1.1

- IEEE
- 3GPP
- 3GPP2

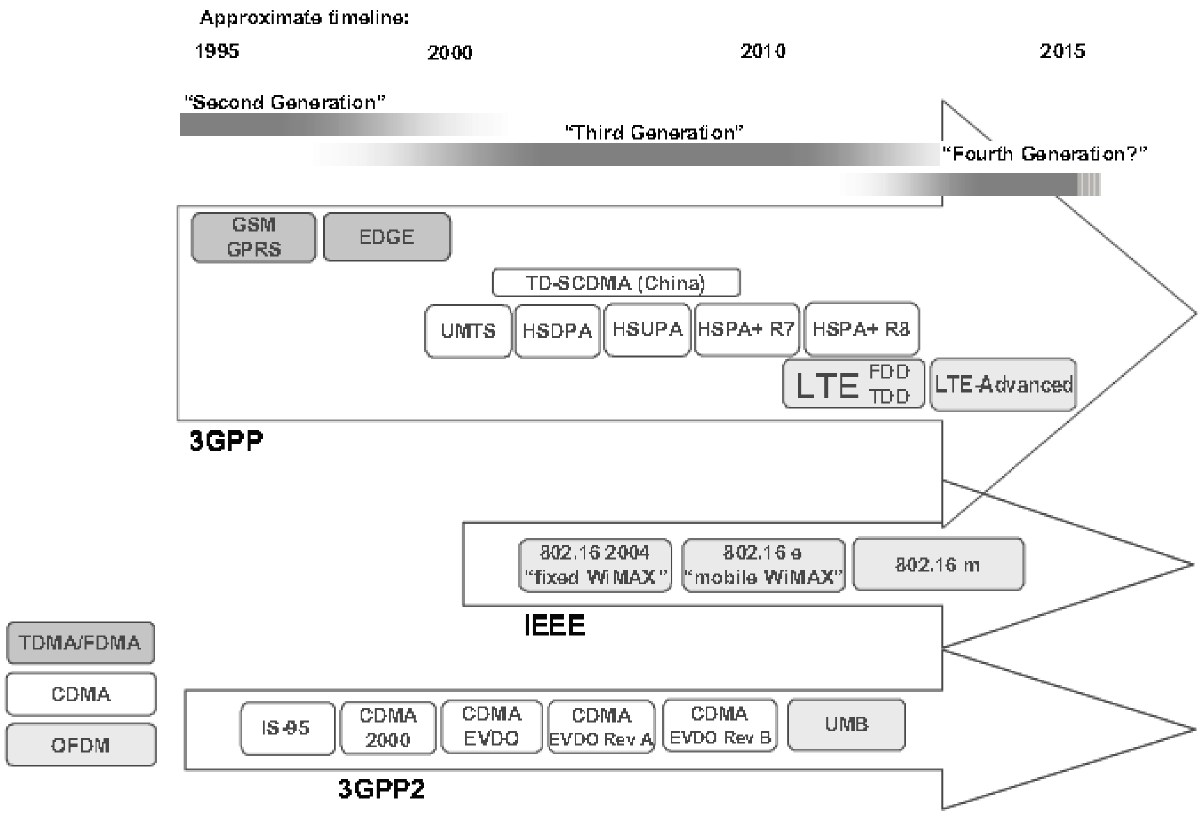

Figure 1.1 Approximate timeline of the mobile communications standards

1.2 Evolution of Wireless Technologies

In 1895, Guglielmo Marconi opened the way for modern wireless communications by transmitting the three-dot Morse code for the letter „S over a distance of three kilometers using electromagnetic waves. From this beginning, wireless communications has developed into a key element of modern society. From satellite transmission, radio and television broadcasting to the now ubiquitous mobile telephone, wireless communications has revolutionized the way societies function. The evolution of wireless begins here. Then with each passing year further improvement came in wireless communication like 1G. 2G, 2.5G, 3G and 4G.

1.2.1 First Generation (1G)

The 1st generation was pioneered in early 1980's. First generation cellular mobile telephones developed around the world using different, incompatible analogue technologies. It support speed up to 2.4kbps. Major contributors were AMPS, NMT, and TACS. In terms of overall connection quality, 1G compares unfavorably to its successors. It has low capacity, unreliable handoff, poor voice links, and no security at all since voice calls were played back in radio towers, making these calls susceptible to unwanted eavesdropping by third parties.

1.2.2 Second Generation (2G)

The 2nd generation was accomplished in later 1990's. 2G mobile telephones used digital technology. (GSM) was first developed in the 1980s and was the first 2G system. Mainly used for Voice communication and supports speed up to 64kbps. Another advantage of 2G over 1G is that the battery life of a 2G handset lasts longer, again due to the lower-powered radio signals. Since it transmitted data through digital signals, 2G also offered additional services such as SMS and e-mail. Major prominent technologies were GSM, CDMA.

1.2.3 GPRS (2.5G)

In term "2.5G" usually describes a 2G cellular system combined with General Packet Radio Services (GPRS), or other services not generally found in 2G or 1G networks. A 2.5G system may make use of 2G system infrastructure, but it implements a packet-switched network domain in addition to a circuit-switched domain. It can support data rate up to 144kbps.GPRS, EDGE, & CDMA 2000 were the focal 2.5G technologies. This does not necessarily give 2.5G an advantage over 2G in terms of network speed, because bundling of timeslots is also used for circuit-switched data services (HSCSD).

1.2.4 LTE (3.9G)

3GPP LTE is the evolution of the Third-generation of mobile communications, UMTS. LTE is designed to increase data rates and cell edge Bitrates, improve spectrum and allow spectrum flexibility. LTE has also to reduce packet latency and reduce radio access network cost.A set of high level requirements was identified to improve serviceand reduce user and operator costs. Main objectives andtargets of LTE development can be stated as follows:

- Increase in system capacity and reduced cost per bit.
- Goal of achieving data rate 100Mbps in uplink and over 50Mbps in downlink.
- Greater coverage by providing higher data rates over wider areas and flexibility of use of existing and new frequency bands.
- Reduced delay in terms of both connection establishment and transmission
- Increased cell edge bit-rate

1.3 LTE Environment Structure

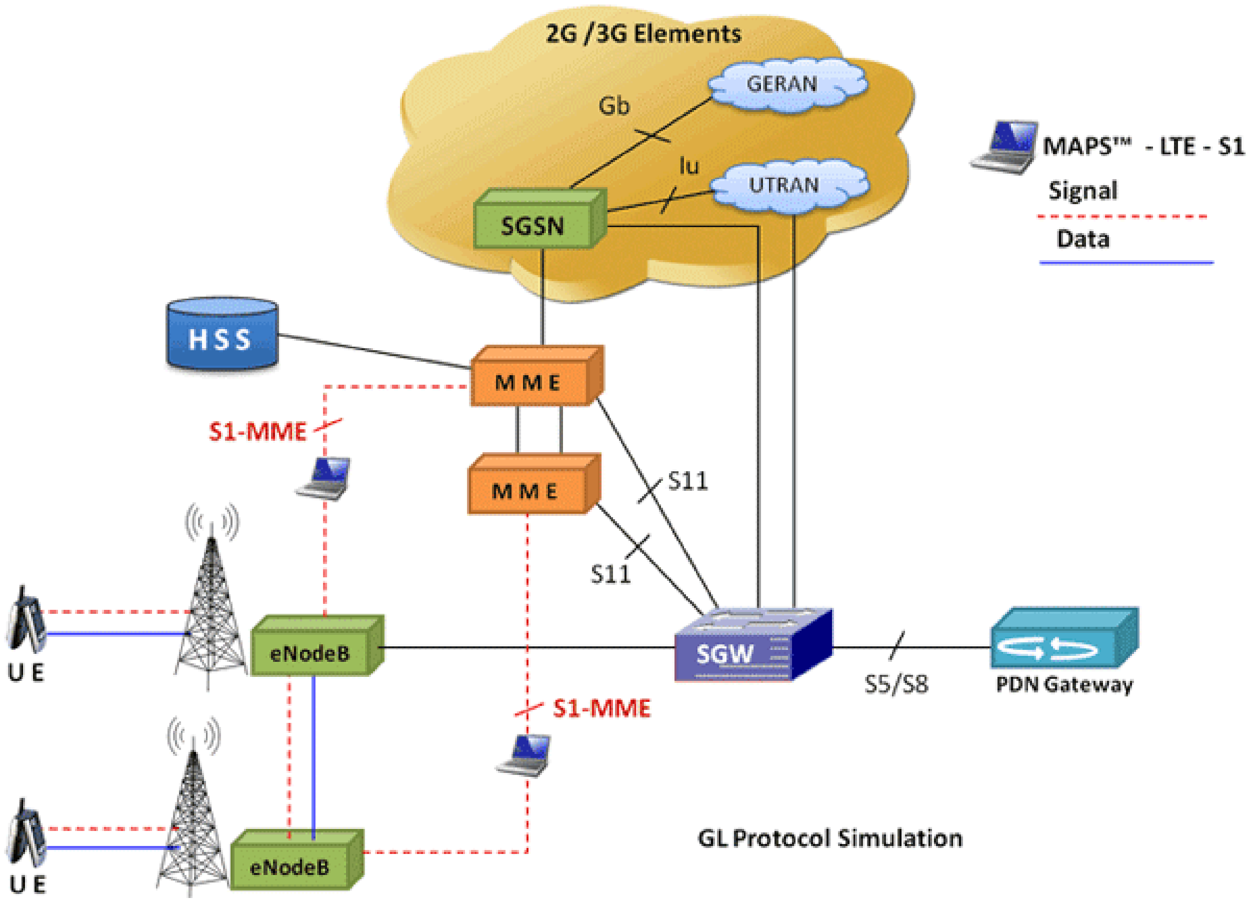

Fig 1.2 LTE Structure

1.3.1 Mobility Management Entity (MME)

The MME is the main control node for the LTE access-network. Through the Non Access Stratum (NAS) protocol, the MME is responsible for authenticating, tracking and paging procedures, generation and allocation of temporary identities to UE's, beareractivation/deactivation process and for choosing the SGW for a UE during the initial attach procedure. The MME is the termination point in the network for ciphering/integrity protection for NAS signaling and handles the security key management.

1.3.2 Serving Gateway (SWG)

The SGW is a data gateway for user data packets. The SGW routes encapsulated IP data to a PDN gateway to access an IP network. Responsibilities of the SGW include setting up and removing bearer routes on MME request, forwarding user data and acting as an anchor for Intra

E-UTRAN handover. The SGW manages data resources by terminating the downlink data path to idle UE's and triggering paging procedures when downlink data arrives.

1.3.3 PDN Gateway (PGW)

The PDN Gateway provides a termination point for tunneled user data from a UE to an external IP data network. A PDN gateway is typically responsible for allocating IP addresses to UE.

1.3.4 Home Subscriber Server (HSS)

The HSS is a central database that contains subscriber account information. Functions of the HSS include: mobility management, call and session establishment support, user authentication and access authorization.

1.4Technologies involved in LTE

LTE uses different technologies such as OFDM, OFDMA, and MIMO .These technologies briefly described here.

1.4.1 OFDM

OFDM is a digital multi-carrier modulation scheme that distributes the data over a large number of carriers closely spaced. The orthogonal property which prevents from interference.
The two main characteristics are that each subcarrier is modulated using different levels of QAM modulation and each OFDM symbol is preceded by a cyclic prefix (CP) used to effectively eliminate ISI.

OFDM has several advantages such as can easily adapt to severe channel conditions, is strong against ISI and fading caused by multipath and give high spectral efficiency. But it also has disadvantages as is sensitive to Doppler shift, defined as the change in frequency of a wave for an observer moving relative to the source of the waves. It is also sensitive to frequency synchronization problems.

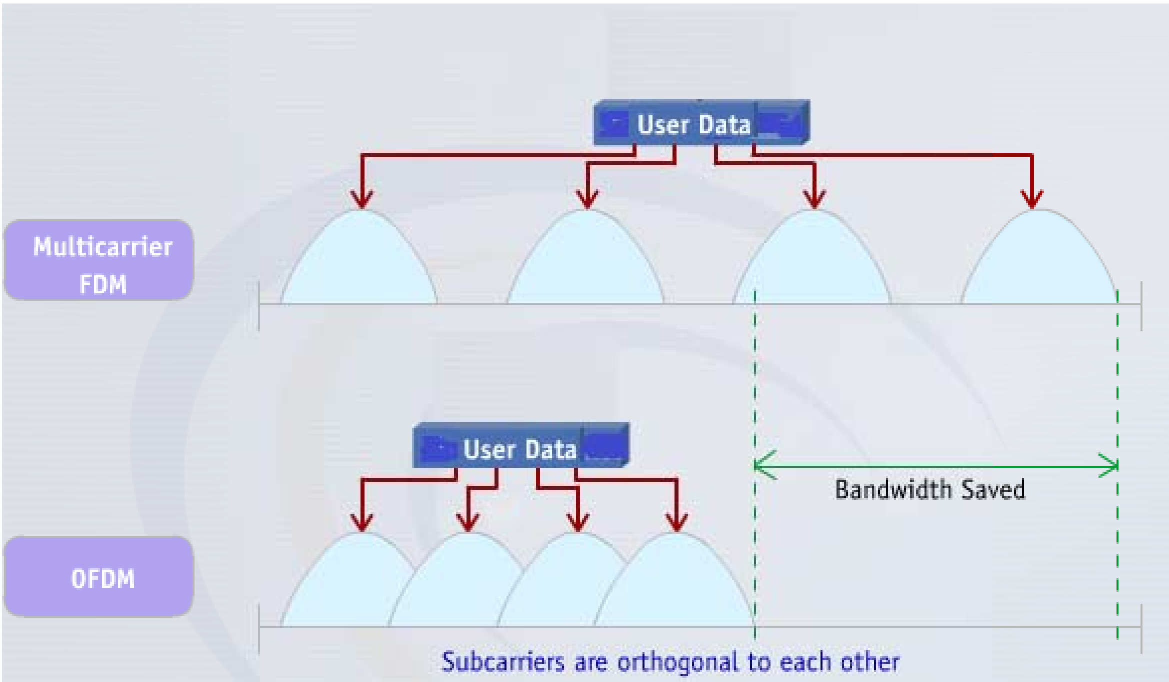

Fig 1.3 OFDM

1.4.2 OFDMA

Orthogonal Frequency Division Multiple Access (OFDMA) is a multi-user scheme of OFDM. Multiple accessesare achieved by assigning different OFDM sub-channels to different users.

Among the advantages of OFDMA, can be emphasized that improves OFDM strength to fading and interference. It also reduces the interferences within the cells. OFDMA is used as the multiplexing scheme in the LTE downlink.

1.4.3 MIMO

MIMO technology offers significant increases in data throughput and link range without additional bandwidth or transmitted power. There are multiple transceivers at both the base station and UE in order to enhance link robustness and increase data rates for the LTE downlink.

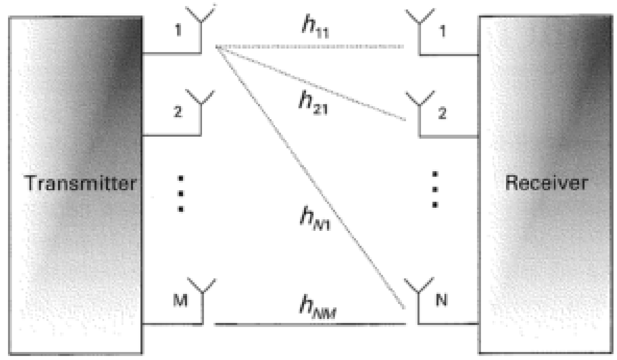

Fig 1.4 MIMO

1.4.4 Channel Quality Indicator (CQI)

Channel quality indicator indicates the condition and quality of wireless channel. Modulation scheme have to apply depends upon the value of CQI. Higher value of CQI indicates the better channel quality and lower value indicates the lower quality of channel. The value of CQI computed by performance matrices by calculating SNR, SINR, and SNDR according to these values CQI value can be calculated. The table 1.1 given below shows the modulation scheme applied according to the value of CQI.

CQI index	Modulation	Coding rate	Efficiency [b/s/Hz]
0		Out of range	
1	QPSK	78/1024	0.1523
2	QPSK	120/1024	0.2344
3	QPSK	193/1024	0.3770
4	QPSK	308/1024	0.6016
5	QPSK	449/1024	0.8770
6	QPSK	602/1024	1.1758
7	16 QAM	378/1024	1.4766
8	16 QAM	490/1024	1.9141
9	16 QAM	616/1024	2.4063
10	64 QAM	466/1024	2.7305
11	64 QAM	567/1024	3.3223
12	64 QAM	666/1024	3.9023
13	64 QAM	772/1024	4.5234
14	64 QAM	873/1024	5.1152
15	64 QAM	948/1024	5.5547

Table 1.1 CQI

1.4.5 Pre-coding Matrix Indicator(PMI)

A pre-coding matrix is determined in multiple transmit antenna communication system which have a number of sub-carriers M, of resource blocks. This involves determininga frequency selectivity of a channel through which received signals have propagated. PMI used in wireless communication system to select which pre-coding matrix will be used for given channel in base station.PMI value refers to codebook.

1.4.6 Rank Indicator (RI)

Rank indicator calculates the number of independent rows in the pre-coding matrix. It tells number of preferred layers to be used in next downlink transmission. It also tell maximum number of parallel channels.

1.5Multiple Access Techniques

Frequency division multiple access (FDMA), time division multiple access (TDMA), and code division multiple access (CDMA) are three major access technique used to share available bandwidth in wireless communication.

1.5.1 Frequency division multiple access (FDMA)

Frequency division multiple access assign individual channel to individual user. In this each user is allocated a unique frequency band or channel. These channels are assigned on demand to user who request. During the period of the call no other can share the same medium. It can carry one phone circuit at a time. It has less complexity with respect to TDMA.

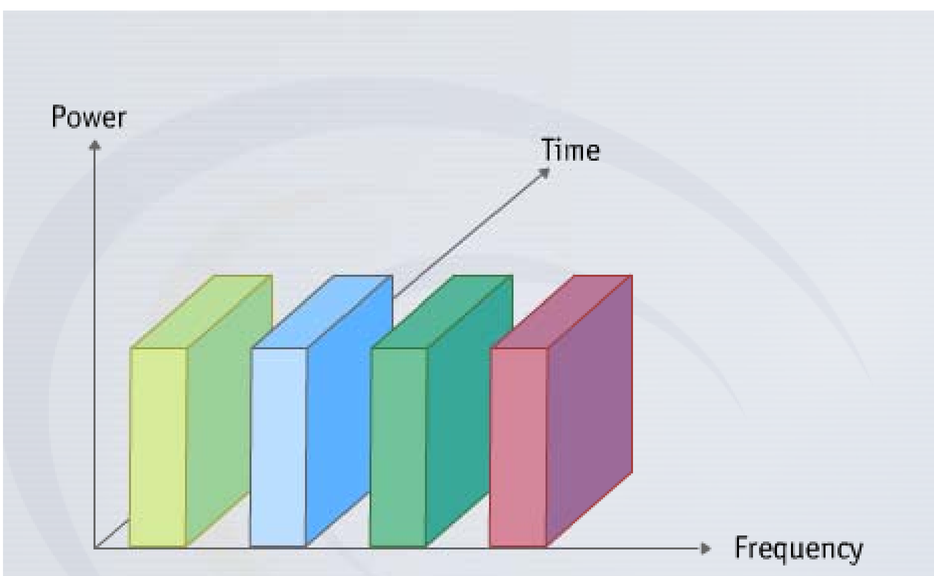

Fig 1.5 FDMA

1.5.2 Time Division Multiple Access (TDMA)

Time division multiple access system divide the radio spectrum in to time slots and in each slot only one user is allowed either transmit or receive. TDMA system transmit data in buffer and burst method so transmission for any user in non continuous. It sends data in frames. TDMA is an efficient way of utilizing a bandwidth. In TDMA user capacity increased with respect to FDMA.

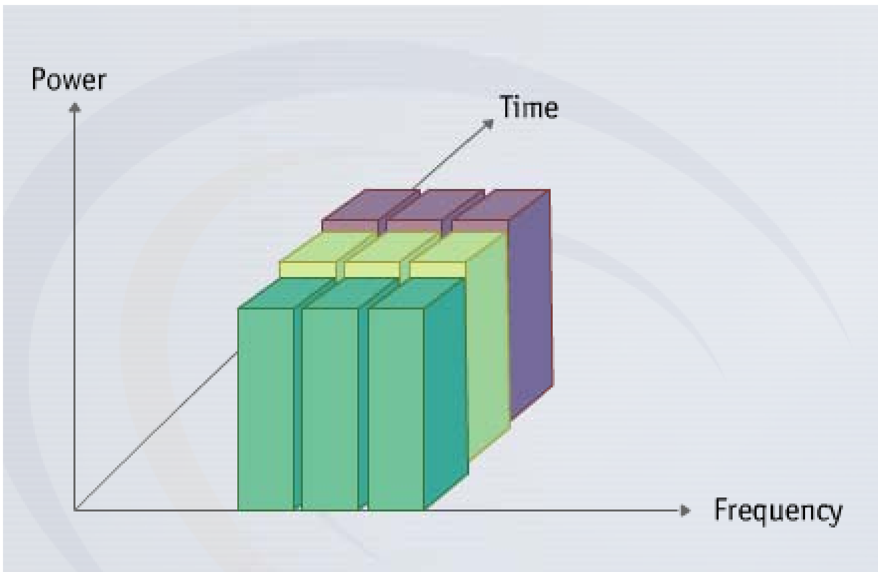

Fig 1.6 TDMA

1.5.3 Code Division Multiple Access (CDMA)

In code division multiple access technique available spectrum or bandwidth is used by all users all of the time. Unique digital codes are used to different users. The transmitter and receiver have the knowledge of these codes. The transmitter uses this unique code to transform each bit in to a multiple bit code. Only the receiver who knows the right digital code can extract the original signal.

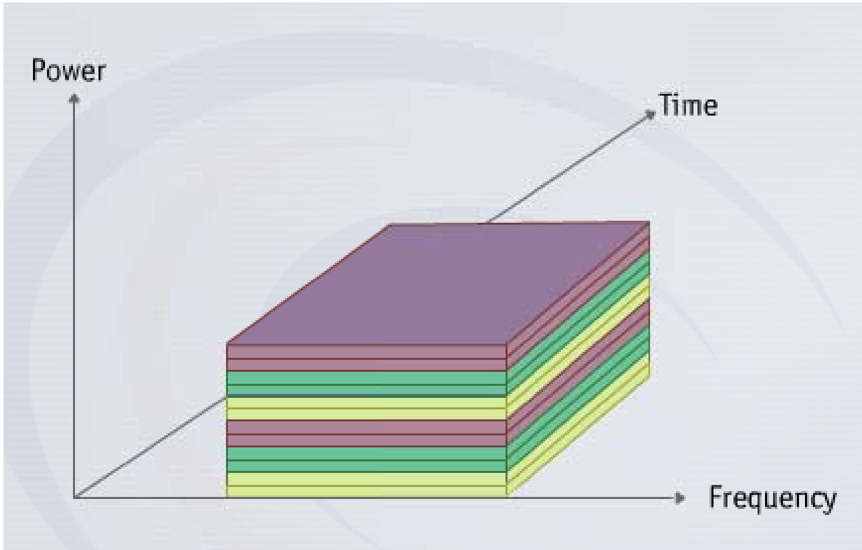

Fig 1.7 CDMA

1.6Cellular System Architecture

The design objective of early mobile radio was to achieve a large coverage area by using a single large high tower installed on hill or mountain with high power transmitter. But with increase in no of users this concept was failed because it have a many drawbacks, it can handle only a small no of users, it take high transmitted power. Then cellular concept introduced to overcome the draw backs of early mobile system. In cellular system we can accommodate many more users by increasing the no of cell in a cluster.

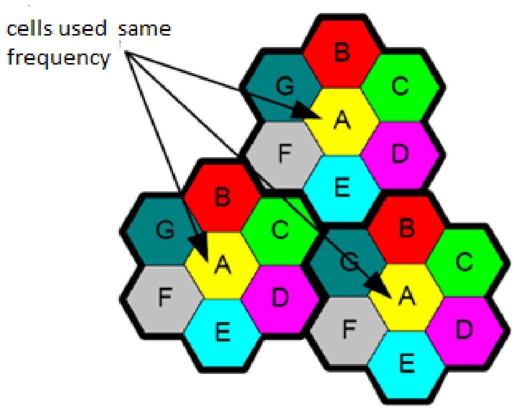

Fig 1.8 Cell Architecture

1.6.1 Cells

A cell is the smallest unit of cellular system. In the fig given above each alphabet shows an individual cell. Each cell have own base station and each cell have different frequency range with respect to neighborcell. Cell with the same letter use the same set of frequencies. With the increase in no of users we can increase the no of cells.

1.6.2 Cluster

A cluster is consisting of N no of cells. Total available frequency range divided in a N cells of cluster. In the fig given above a cluster has 7 cells A to G. A cluster can be made of different size like 4.7,12,19.Fig 1.8 shows 3 clusters.

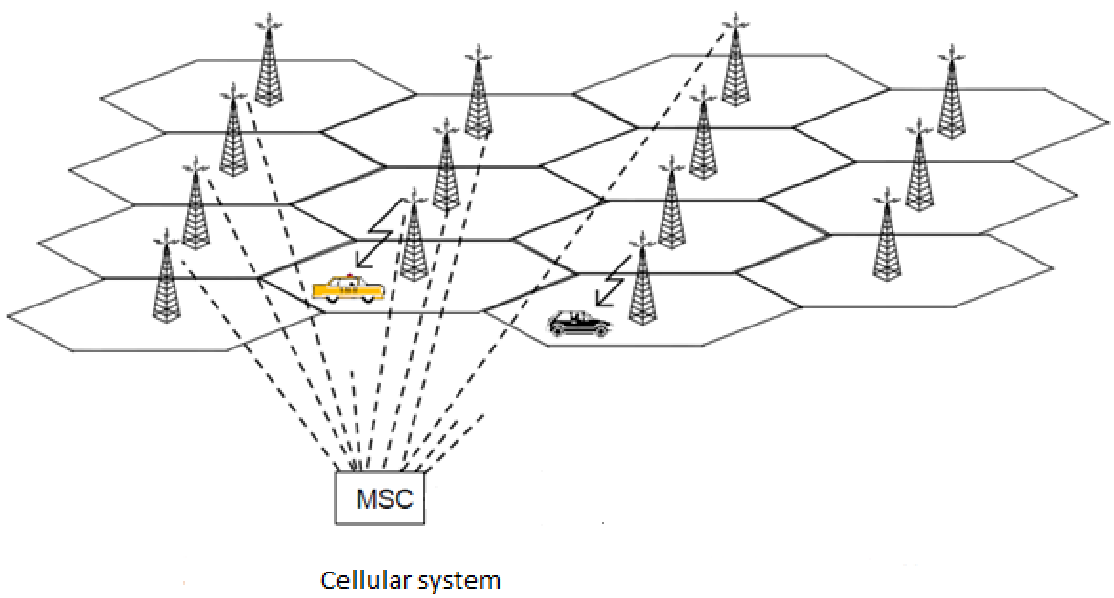

Fig 1.9Cellular Systems

1.6.3 Handoff

When a mobile user moves from one cell to another cell while a conversation is in progress and so the MSC (Mobile Switching Center) automatically assign a new channel belonging to the new base station of new cell. Handoff is required when a user is moved away from on base station and its singles gets weaker to a level where base station cannot provide a good quality signal strength then MSC (Mobile Switching Center) come to know thin mobile needed a handoff .Then MSC transfer the call to another base station which have a strong signal quality in that area.

1.6.4 Mobile Switching Centre (MSC)

Mobile Switching Center is a part of cellular network.It’s working as same as telephone exchange but MSC perform many more tasks. Like when a user have to made a call then a base station request to MSC to assign a channel for a connection and get him connect. Another purpose of MSC is switching. One purpose of MSC is handoff.Database management, traffic metering and measurement, collect call billing data these all works done by MSC.

1.7LTE Air Interface

LTE air interface use OFDM with advance antenna technique like MIMO with adaptive modulation technique to achieve maximum throughput and spectral efficiency. High spectral efficiency helps to send more data per MHz spectrum which reduce the cost per bit.LTE air interface uses a 1ms of time interval which designed in a way to provide low latency.Air interface are divided in to no of elementsfor downlink (eNodeB to UE) and uplink (UE to eNodeB) as shown in fig 1.10.

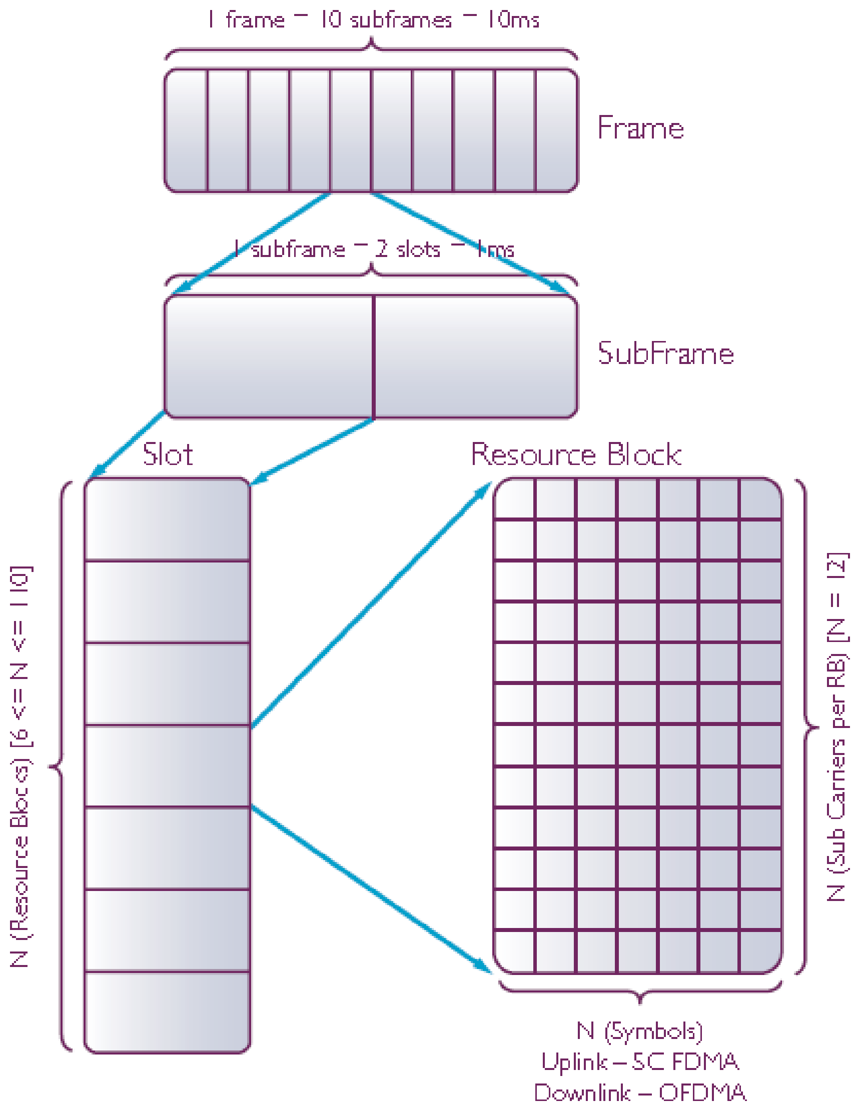

Fig 1.10LTE Air interface Elements

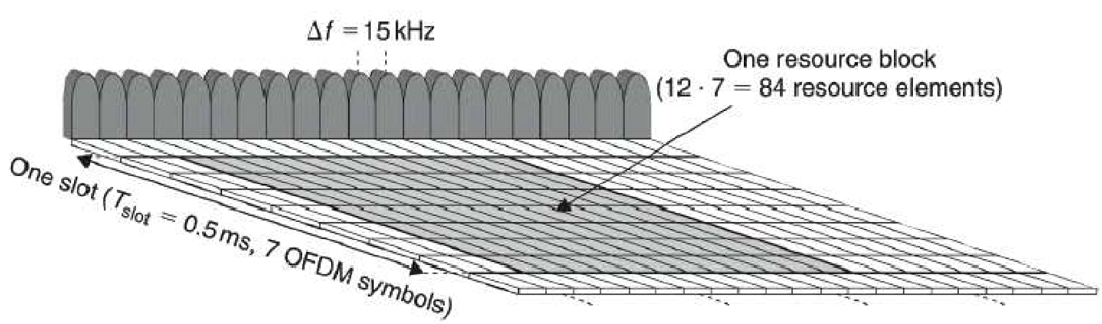

Fig 1.11 Resource Block Allocation

1.7.1 Frame

A frame is 10ms in length. Each frame is divided (in the time domain) into 10 sub frames.

1.7.2 Sub-frame

A sub-frame is 1ms in length. Each sub-frame is divided (in the time domain) into 2 slots.

1.7.3 Slot

A slot is 0.5ms in length. Each slot is divided (in the frequency domain) into a number of resource blocks. The number of resource blocks in a slot depends on the channel bandwidth.
As shown in Table 1.2

Bandwidth (MHz)	1.4	3	5	10	15	20
Number of Resources Blocks	6	15	25	50	75	100
Number of occupied subcarriers	72	180	300	600	900	1200
IFFT/FFT Size	128	256	512	1024	1536	2048
Subcarrier Spacing (KHz)	15	15	15	15	15	15

Table 1.2 Resource Block Allocations

1.7.4 Resource block

A resource block is 0.5ms in length and contains 12 subcarriers from each OFDM symbol. The resource block is the main unit used to schedule transmissions over the air interface. Structure of resource blocks are shown in Fig 1.10