LTE Radio Network Planning and Designing

Internship Report

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To Whomsoever It May Concern

This is to certify that **Mr. Prashant Gandhi** has undergone his training with the **Network Division, Gujarat Circle Office, M/S Airtel, Ahmedabad, India** for a duration of 4 weeks from 30th May' 2016 to 1st July' 2015.

He worked on **"Understanding of Network 2G/3G/LTE.**

He was sincere, hardworking and honest during his training. We would like to appreciate his quality of work and the result orientation he displayed.

We wish him all the best for his future endeavors.

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ABSTRACT

Data communication is growing rapidly, to keep pace with the increasing demands being placed on mobile radio systems, an improved standard was created by the 3rd Generation Partnership Project (3GPP) referred to as Long Term Evolution (LTE) that provides higher throughputs and lower latencies. LTE brings many technical benefits to cellular networks and improves the spectral efficiency in 3G networks, allowing carriers to provide more data and voice services over a given bandwidth. In this work, a detailed LTE radio network dimensioning procedure including frequency, coverage and capacity analysis has been performed in order to prepare a radio planning guideline considering possible network implementation in the cities. At the end, the link level of the LTE network is simulated for both scenarios Uplink and Downlink, to get a closer view to the impact of the Signal to Noise Ratio (SNR) on Bit Error Rate (BER) and Block Error Rate (BLER).

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Chapter 1

Introduction

1.1 Overview

There has been a burgeoning demand for faster data transmission with unprecedented penetration of Smartphone and tablets in both the developed and developing economies all across the world. This need has exponentially increased with ever-increasing processor speeds in mobile devices and expected evolution of cloud computing. In fact, Strategy Analytics forecasts that demand for data traffic will grow by 10-12 times by 2015. Therefore, there is a perpetual requirement for technologies that support faster transmission. Even though global expansion of 3G networks continue to drive this decade, upgrade from 3G to 4G is inevitable as need for more efficient data transmission becomes a necessity.

LTE is a set of enhancements to the Universal Mobile Telecommunications System (UMTS) which was introduced in 3rd Generation Partnership Project (3GPP) Release 8. The main advantages with LTE are high throughput, low latency, plug and play, FDD and TDD in the same platform, an improved end-user experience and a simple architecture resulting in low operating costs. LTE downlink transmission scheme is based on Orthogonal Frequency Division Multiple Access (OFDMA) which converts the wide-band frequency selective channel into a set of many at fading sub channels. The LTE specification provides downlink peak rates of at least 100 Mbps, an uplink of at least 50 Mbps and RAN round-trip times of less than 10ms. LTE supports scalable carrier bandwidths, from 1.4 MHz to 20 MHz and supports both frequency division duplexing (FDD) and time division duplexing (TDD). LTE will also support seamless passing to cell towers with older network technology such as GSM, CDMAOne, W-CDMA (UMTS), and CDMA2000. The next step for LTE evolution is LTE Advanced and is currently being standardized in 3GPP Release 10.

1.2 4G-LTE standards and requirements

Long Term Evolution (LTE) is a mobile communication standard that has been set by the Third Generation Partnership Project (3GPP) as an upgrade from 3G technologies. The enhancements from 3G technology are mainly in the form of increased peak data rates, greater spectral efficiency, reduced latency and increased throughput. Additionally, International Telecommunication Union (ITU) has included

LTE-Advanced as one of the approved IMT-Advanced 4G technologies. It is critical for an LTE-Advanced network to be backward compatible with LTE network in the sense that it should be possible to deploy LTE-Advanced on existing LTE spectrums. This backward compatibility ensures smooth and cost-effective transitions to LTE advanced capabilities. It is also required that LTE-Advanced should have peak data rates as high as 500 Mbps in the uplink and 1 Gbps in the downlink and high average data rates. Advantages of LTE-Advanced are:

1. **Improved data transfer rate through multi-antenna solutions**: Antennae are one of the most important components in radio communications and 4G technology plans to use antenna in a more efficient way for faster data rates, better long range connectivity and high reliability. Currently, LTE supports up to 4 antenna ports. LTE-Advanced looks to increase the support for the antenna. This also enhances beam-forming capabilities which imply better Signal-to-Noise Ratio (SNR).
2. **Higher spectral efficiency through wider transmission bandwidth**: The high peak data rates for LTE-Advanced can be fulfilled in a reasonable way if the transmission bandwidth is enhanced. This will not only help in reaching the requirements of peak data rate but also extend the average data rates.
3. **Better power management**: CoMP (Coordinated multi-point transmission), a new technology based on MIMO (Multi Input Multi Output), helps improve the data transmission rates, quality of service and throughput. In other words, it means that the connection is more reliable as users access and share videos, photos, play network games or use any of the bandwidth intensive services.
4. **Increased communication reliability**: The idea of using relay is to make the infrastructure denser so as to reduce the transmitter to receiver distance, thereby allowing higher data rates and better connectivity. Femtocells, small cellular base stations, are one of the key components that can be installed either as standalone items or in clusters in residential or business environments. They prove to be a very cost-effective way to improve coverage.
5. **Enhanced network coverage**: Heterogeneous networks (HetNet) often indicate the use of multiple types of access nodes in a wireless network. A wide area network can use macrocells, picocells, and/or femtocells in order to offer wireless coverage in an environment with a wide variety of wireless coverage zones, ranging from an open outdoor environment to office buildings, homes, and underground areas.
6. **Improved network deployment**: All operational base stations will regularly self-optimize parameters and algorithmic behavior in response to observed network performance and radio conditions.
7. **Better network security**: With seamless interoperability, and more open platforms coming into the

scenario the threat to security is a matter of great concern. 4G networks enable secure domain name registration, automatic VPN, allowing communication with only other secure domain names/sites.

1.3 WCDMA vs. OFDMA

WCDMA (Wideband Code Division Multiple Access) and LTE (Long Term Evolution) are mobile communication technologies that falls under the 3rd Generation Partnership Project (3GPP) releases. LTE standards are part of the latest 3GPP releases, which are considered as 4th Generation (4G), and WCDMA is the older technology which was specified as 3rd Generation (3G) technologies. LTE release provided number of architectural changes when compared with the WCDMA network.

WCDMA: WCDMA is the European standard that fulfils the 3G specifications published by IMT-2000 (International Mobile Telecommunication). WCDMA was developed to achieve data rates up to 2Mbps in the stationary environments, while 384kbps in the mobile environment. WCDMA uses pseudo random signal to modulate the original signal into a higher bandwidth, where original signal sink in the noise. Each user will get a unique pseudo random code to separate the original signal from the air interface. WCDMA uses Quadrature Phase Shift Keying (QPSK) as modulation scheme, while using Frequency Division Duplexing (FDD) as duplexing method. WCDMA architecture consists of separate Circuit Switched (CS) core network and Packet Switched (PS) core network. CS core consists of Media Gateway (MGw) and MSC-S (Mobile Switching Centre-Server), while PS core consist of Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN). Radio access network of WCDMA consists of Radio Network Controller (RNC) and Node-B. In here, RNC integrates with MGw and SGSN for CS data and for PS data respectively.

LTE: LTE was introduced in 3GPP release 8 in December 2008. LTE uses Orthogonal Frequency Division Multiplexing (OFDM) for downlink, and Single Carrier Frequency Division Multiple Access (SC-FDMA) for uplink access. LTE Category 3 user equipment should support up to 100Mbps in downlink, and 50Mbps in uplink. LTE has a more flat architecture with eNode-B, System Architecture Evolution Gateway (SAE-GW), and Mobile Management Entity (MME). eNode-B connects with both MME and with SAE-GW for control plane data transfer (Signalling), and for user plane data transfer (user data) respectively. LTE was able to achieve high spectral efficiency with OFDM, while providing robustness for multipath fading. LTE supports services like VoIP, Multicasting, and Broadcasting more efficiently than the previous 3GPP specifications.

WCDMA vs LTE: WCDMA was specified in the 3GPP release 99 and 4 of the specification, while LTE was specified in the 3GPP release 8 and 9. Unlike WCDMA, LTE supports variable bandwidth from 1.25MHz to 20MHz. When the data rates are compared, LTE provides massive downlink and uplink speeds than WCDMA. Also, the spectral efficiency is much higher in LTE than that of the WCDMA. LTE provides much simpler and flat network architecture than that of the WCDMA. CS core network part of WCDMA, which includes MGW and MSC Server is completely replaced by PS core in LTE using the SAE-GW and MME. Also, the PS core nodes of WCDMA that consists of GGSN and SGSN are replaced by the same SAE-GW and MME respectively. RNC and Node-B nodes in WCDMA architecture are completely replaced by more flat architecture with only eNode-B in LTE. New interface between eNode-B's are introduced in LTE, which is not available under WCDMA. LTE is more optimized for IP packet based services; there is no circuit switch core with the WCDMA. LTE provides more flexibility than that of WCDMA when comes to network topology and scalability. In general, WCDMA is considered as 3G technology while LTE is considered as 4G technology. LTE provides higher data rates than WCDMA by achieving higher spectral efficiency. Also, LTE technology provide more flat architecture that is mainly focused on IP packet based services than that of the WCDMA. LTE topology is much more flexible and scalable than of the WCDMA due to the flat nature of architecture.[7]

1.4 Why radio network planning is necessary?

In mobile communication first and most important step is radio network planning. In radio network planning market requirements, coverage planning, design goals and capacity planning are define as an input and as result of this inputs number of sites, physical cell ids, and physical neighbor id we are getting which is also referred as output.

By radio network planning one can estimate number of sites required to provide maximum coverage and capacity. Also planning should not be overloaded meaning number of sites should not be more than the requirement and it should not be under loaded. Due to the planning cost also reduce. Proper radio planning gives minimum interference in networks. This is done by suitable allocation of physical cell ids in network.

1.5 Overview of radio network planning process

Radio Network Planning contains number of phases: 1) Site survey-which includes collection of pre-planning information that will be used in the Link Budget preparation and Coverage and Capacity planning calculations. 2) Frequency and spectrum planning- in this phase a variety of parameters' values will be chosen, and according to these parameters the rest of the calculation is processed. 3) Link Budget and Coverage planning, and 4) Capacity planning- these two steps involve propagation model tuning, defining thresholds from Link budget, creating detailed radio plan based on the thresholds, checking network capacity against more detailed traffic estimates, and configuration planning.

Chapter 2

LTE Radio Planning

2.1 Site Survey

This is first stage of radio network planning of LTE or any other technology in which we collect the information of particular interest of our city. The information includes the area of the city, population of that city, where it is located (longitude and latitude), average age of the population which would be able to use the technology, penetration of LTE mobile in that city. For example, The city of Tripoli is located in the North West of the country on the coasted area and centered by longitude line of 13°11’9"E and at latitude line of 32°54’8"N, with population of 2,2 00,000 and having an average building height of 20 meters. The area of Tripoli is 517.6 km2. In this network design, Tripoli has been divided into four main sections according to the population distribution over the city. These sections are dense urban, urban, suburban, and rural areas. Dense urban is 30.4 km2, Urban is 116.4 km2, and Suburban is 370.8 km2. (Source: HUAWEI ICT Company – Libya Branch Office, Date: Jan/2013).

2.2 Frequency and spectrum planning

In this section, the spectrum is managed; the available frequency band is chosen to be the frequency band for LTE network, the bandwidth, duplex mode, SFR, and Cyclic Prefix are specified also:

1. Frequency band of 1800 MHz is used.
2. System bandwidth is 20 MHz
3. The duplex mode is FDD.
4. Soft frequency reuse of (SFR 1*3*1) is used.
5. Cyclic prefix is chosen to be normal.

2.3 Link Budget and coverage planning

The link budget calculations estimate the maximum allowed signal attenuation, called path loss, between the mobile and the base station antenna. The maximum path loss allows the maximum cell range to be estimated with a suitable propagation model, such as Cost231–Hata model (1500-2300 MHz) and Okumura-Hata model (150-1500 MHz). The cell range gives the number of base station sites required to cover the target geographical area. The link budget calculation can also be used to compare the relative coverage of the different systems.[6]

Procedure: Link budget and coverage planning is calculated for each scenario separately, for both cases "UL & DL". The procedure steps are**:**

1. Step 1: Calculate the Max Allowed Path Loss (MAPL) for DL and UL.
2. Step 2: Calculate the DL and UL cell radiuses by the propagation model equation and the MAPL.
3. Step 3: Determine the appropriate cell radius by balancing the DL and UL radiuses.
4. Step 4: Calculate the site coverage area and the required sites number.

Maximum Allowed Path Loss (MAPL) has different values for dense urban, urban and suburban (UL & DL). So the calculation must be done to every condition and scenario apart, and from these results the cell radius can be calculated for each case. At the end, the minimum cell radius from UL& DL cell radiuses is chosen for each scenario. There are three different cell radiuses, each scenario has its own cell radius. The basic input parameters are as shown in table 1.

Table-1 Input parameters for each scenario

Morphology	Dense urban		Urban		Suburban	
Channel Type	UL	DL	UL	DL	UL	DL
Channel model	ETU 3		ETU 60		ETU 120	
MIMO	1x2	2x2	1x2	2x2	1x2	2x2
Cell edge rate (kbps)	256	1024	256	1024	256	1024
MCS	QPSK 3/4	QPSK 1/2	QPSK 3/4	QPSK 1/2	QPSK 3/4	QPSK 1/2

In order to calculate the MAPL; the EIRP, MRRSS, Extra Gain, and Extra Margin and Loss must be calculated first as follows:

EIRP = Max Tx Power + Total Tx Gain - Total Tx Loss

MRRSS = Rx Sensitivity – Total Rx Gain + Total Rx Loss

Extra Gain=Hard Handoff Gain+ MIMO Gain + Other Gain

Extra Margin & Loss = Shadow Fading Margin + Penetration Loss + Other Loss.

Then the MAPL is calculated by this equation:

MAPL=EIRP - MRRSS + Extra Gain - Extra Margin & Loss.

HATA-Model:

Carrier Frequency: 150 MHz $\leq$ fc $\leq$1500 MHz

Base Station (BS) Antenna Height: 30 m ≤hb ≤200 m

Mobile Station (MS) Antenna Height: 1 m ≤hm ≤10 m

Transmission Distance: 1 km ≤d ≤20 km

Lp(dB) =A + B log10 (d) for urban areas

Lp(dB) =A + B log10 (d) – C for suburban area

Lp(dB) =A + B log10 (d) – D for open area

Where:

A = 69.55 +26.161log10 (fc) – 13.82 log10 (hb) – a (hm)

B = 44.9 – 6.55 log10 (hb)

C = 5.4 + 2 [log10 (fc/ 28)]2

D = 40.94 + 4.78 [log10 (fc)]2– 18.33 log10 (fc)

Where, a (hm) = [1.1log10 (fc) –0.7] hm – [1.56log10 (fc) –0.8] for medium or small cities

8.29[log10 (1.54 hm)]2– 1.1 [for large city and fc ≤ 200 MHz]

3.2 [log10 (11.75hm)]2 – 4.97 [for large city and fc ≥ 400 MHz]

COST231-HATA model (1500 – 2300 MHz):

COST231-HATA path loss equation

$$\mathbf{PL(dB) = 46.3 + 33.9\log_{10}(f) - 13.82\log_{10}(htr) - a(hm) + (44.9 - 6.55\log_{10}(hrx)\log_{10}(d)) + C(dB)}$$

Where, f = frequency of transmission(Mhz)

htr = Base station antenna effective height(m)

D = Distance between transmitter and receiver

hrx = UE antenna height

a(hrx) = UE height correction

C(dB) = 0 dB for sunurban or open environment

For urban area : a(hrx) = 3.2 (log11.75ha)^2

For suburban area : a(hrx) = 1.1(logf)hr – (1.56log – 0.8)

where., ha=hr=receiving antenna height.

Using Cost231-Hata model equations, the maximum distance between the terminal and the base station is calculated, which is the cell radius.

Total = L – α(HSS) + Cm

After determining the cell radius for each scenario, sites number and sites coverage areas are calculated by the equations below:

Site coverage area = $\frac{9}{8}$ **x** $\sqrt{3}$ **x R**^{2}

Required sites number = $\frac{Area\ to\ be\ covered}{\text{Site coverage area}}$

2.4 Capacity Planning

The purpose of capacity dimensioning is to get the number of sites that satisfies the capacity requirement. Capacity dimensioning for single site is performed to get the cell average throughput by using simulation tools. Total traffic volume calculation is performed based on service model and traffic model. Firstly the single user throughput is calculated. Then the total network throughput is output. The number of eNodeB by capacity is the result that the total traffic volume is divided by the single site capacity.[6]

1) Estimating number of users

The network designed must be able to meet the needs of traffics increase in the next few years. The total population ofan area for the next few year can be estimated by using below equation

Pn=Po(1+GF)^n

Pn=Population on nth year

Po=Population of present year

GF=Population growth factor

Po is the population of the present year.

Not all the population use the LTE services. The number of LTE users can be predicted by using:

Total user=Pn*A*B*C

A=the percentage of productive age

B=the percentage of market share of operator of x

C=the percentage of LTE penetration

2) Calculating Throughput per Service

LTE has a lot of services like VoIP, video conference, video call, and etc. Those services have a different throughput needs. The needs of throughput for each services can be estimated by using

Throughput= $\frac{\text{ST}*\text{SDT}*\text{Bearer rate}}{1-\text{BLER}}$

ST (Session Time) =Avg. duration of the use of the every service

SDT (Session Duty Ratio) =Ration of transmitted data in each session

BLER=Numbers of Block error in one session

3) Single user and Network throughput

$$\textbf{SUT}= \frac{\sum(\textbf{throughput}*\textbf{BHSA}*\textbf{PR})*(1+\textbf{PAR})}{1-\textbf{BLER}}$$

BHSA=initiation of use of service in busy hours

PR=Penetration ratio of the use of the services

PAR=Percentage of traffic burst (0% for rural)

Network throughput=Total user*SUT

4) Cell capacity/Cell throughput:

DL.cap + CRC = (168-36-12)*Cb*Cr*Nrb*C*1000

UL.cap + CRC = (168-24-12)*Cb*Cr*Nrb*C*1000

Where, CRC=24

Cb=Code bit-modulation efficiency

Cr=code rate

Nr=Number of resource block

C=MIMO mode

5) Cell dimensioning

$$\textbf{Number of cells}= \frac{\textit{Network Throughput}}{\textit{Cell capacity}}$$

$$\textbf{Radius}= \frac{\left(\frac{\textit{Cell Capacity}}{\textit{Network Throughput}}\right)^{1/2}}{\textit{DL.cap}+\textit{CRC}}$$

Comparing the number of sites calculated from the capacity planning and coverage planning we choose maximum to accommodate more traffic and provide efficient coverage.

2.5 Physical cell IDs planning

The LTE radio interface is based on Orthogonal Frequency Division Multiplex (OFDM), OFDM Access (OFDMA) in DL and Single Carrier Frequency Division Multiple Access (SC-FDMA) in UL. These techniques are well suited for flexible bandwidth operation. This enables operators to deploy LTE in different regions with different frequency bands and bandwidths available. So for this network, physical cell ID (PCI) planning is more important because if optimal PCI is not assigned to eNodeB the signals will overshoot and cause interference. First, let us discuss the concept of PCI. The PCI is combination of two synchronization signals: primary synchronization signals, PCI- ID (PSS) and Secondary synchronization signals, PCI- group (SSS). PSS is used to identify the cell id and SSS is used to identify the group in which that ID present. This two signals are used while mobile is searching and wants to access any cell. PSS is present in sub frame 0 and 5 (OFDM symbol 6) and is mapped on 72 subcarriers in the middle of the band. The PSS is 3 sequence number (0, 1 and 2). SSS is present in sub frame 0 and 5 (OFDM symbol 5), and is also mapped on 72 subcarriers in the middle of the band as shown in figure 1.The SSS is 168 sequence number (0 to 167).

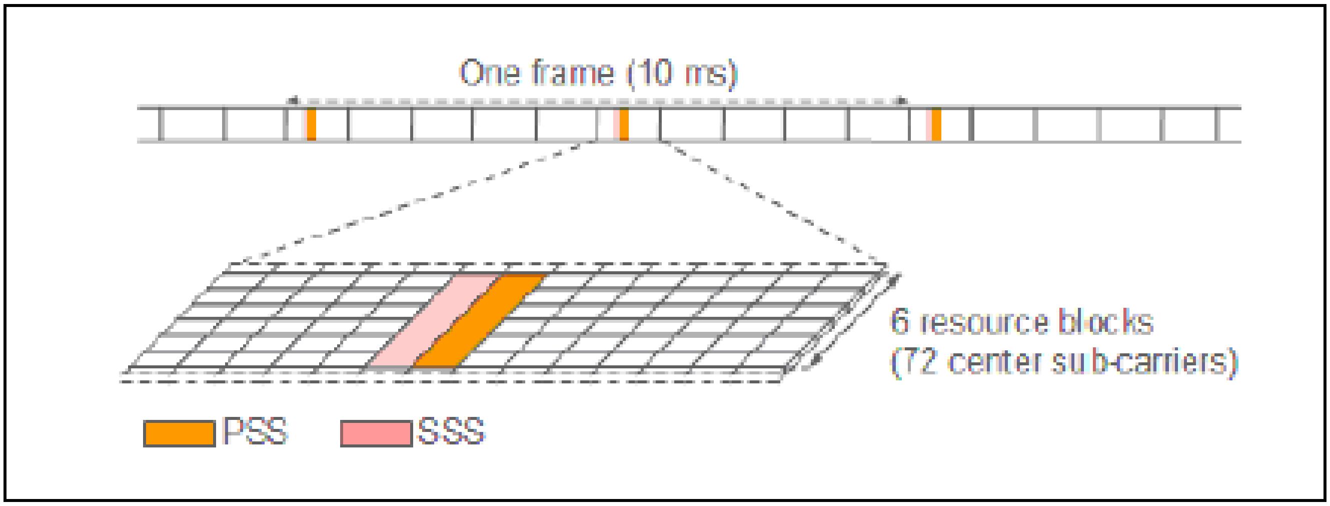

Figure-1 Position of PSS and SSS in one frame[7]

PCI is combination of PSS and SSS. The 168 Physical-Layer Cell-Identity groups with 3 Physical-Layer Identities per group makes 168 x 3 = 504 Physical-Layer Cell Identities (PCI). Mathematically:

PCI = PSS + 3*SSS

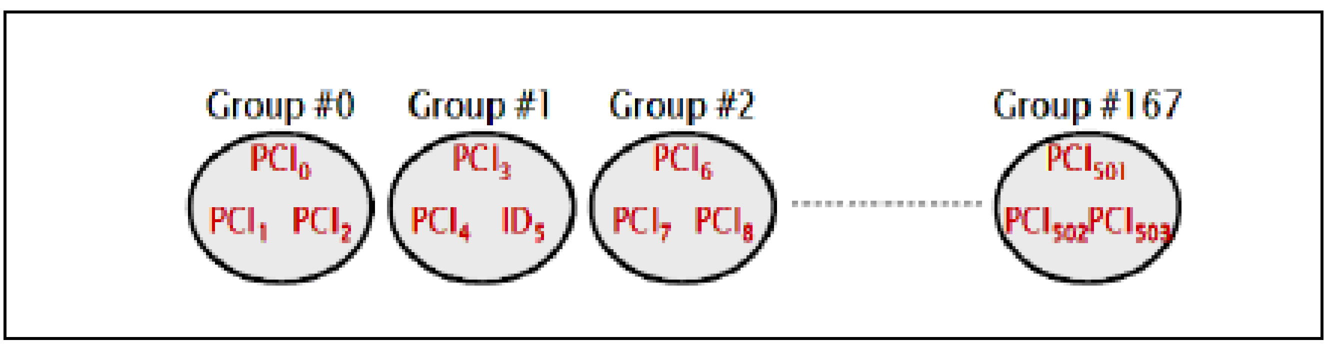

Figure-2 LTE network we have PCI 0 (PSS = 0, SSS = 0) to PCI 503 (PSS =2, SSS = 167).[7]

PCI assigning problem formulation

Let us say that we are going to deploy an LTE network in a city that needs 6000 cells. Each of the 6000 cells will have their own PCI, but since there are only 504 physical cell IDs, we will need to repeat them. The key is that the two cells that share a PCI cannot be geographically close or otherwise they will interfere with each other. It is quite expensive to use RF DTs at each cell location to determine cell overlap and interference. A better approach is predicting in advance and such algorithm is implemented so that two cells having same PCIs should not be close to each other. Once assigned, cells need not constantly reconfigure when the network is expanded thus the network remains stable with regard to IDs. (No reassignment influenced by a neighboring cell change). There is more that operators can do to manage RF (QAM) and physical IDs from a centralized perspective within the specifications, including client density and cell throughput via algorithms planned before a deployed network and layered on RF spectrum limitations. There are things that must be kept in mind: eNodeB should be collision free and confusion free PCI. Collision free PCI means that two cells adjacent to each other do not have same PCI, while confusion free PCI means that the cell may not have a neighbor with same PCI. Also frequency shift plays an important role during the PCI assignment. The PCI itself gives the frequency shift through the formula given below:

$P0=PCImod6+k.6$

$P1 = (PCImod6)\ mod3 +k.6$

Where k = 0 or 1, P0= 1st reference Signal position and P1 = 2nd reference signal position. So eNodeB with same frequency shift cause interference.

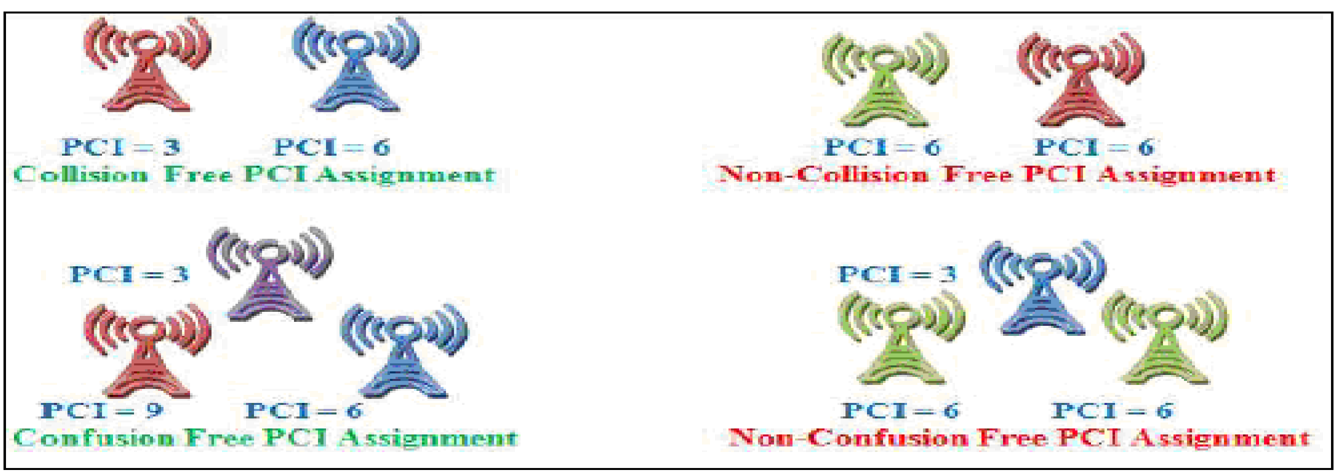

Figure-3 PCI assignment problem of collision and confusion[7]

Approach

For the green field network, the first consideration is that you need to clear the dense area. Most of the clashes of physical IDs occur in dense areas. Now question arises on how we can find the dense area. The logic for PCI assignment is divided into the following broad categories:

- Identifying the number of PCIs to be used and the PCI spacing
- Identifying the first site to be selected for PCI assignment
- Allocating PCI to the first batch (cluster) of sites
- Assigning PCI for the remaining network using minimum tier and maximum distance concept, and maintaining a uniform PCI RE-USE pattern

Identifying available PCI pool

Out of the total available pool of 504 PCI, some can be reserved for the future use. So some SSS are reserved and the network is planned using the remaining available SSS.

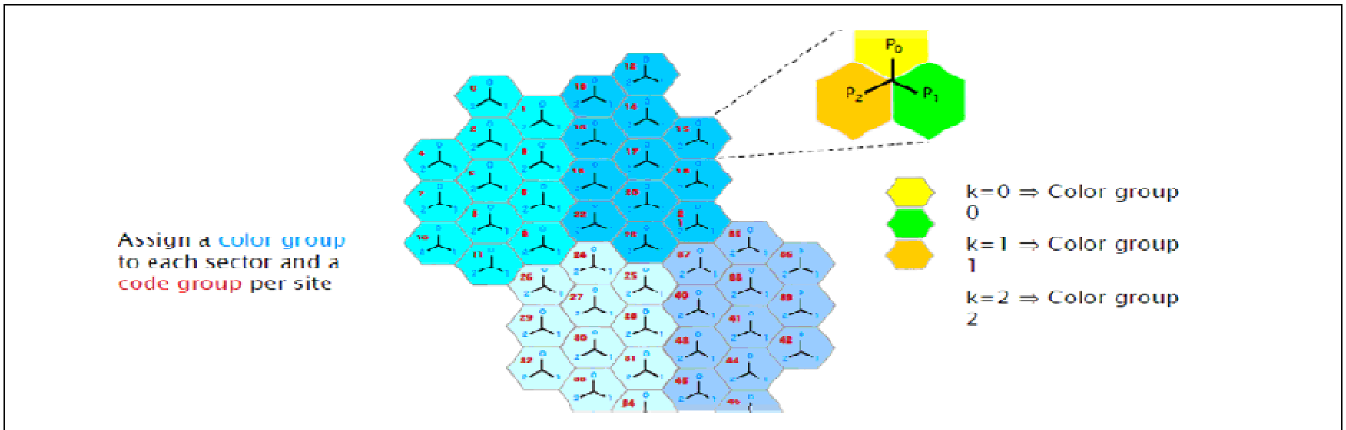

Figure-4 Color group of PCI pool[7]

The user may specify the number of Colour Code Groups to remain reserved and unassigned to allow for future manual planning. As each Site Group contains three PCIs, the number of reserved PCIs will be three times the value entered. Groups are reserved from the bottom.

PCI spacing

The sector spacing of 1, 4 and 8 can be used to plan the sites as per the design requirement.

PCI Spacing = 4									
SSS / PSS	0	1	2	3	....	164	165	166	167
0	0	3	6	9	....	492	495	498	501
1	4	7	10	13	....	496	499	502	1
2	8	11	14	17	....	500	503	2	5

Table-2 PCI spacing 4[7]

How to find the densest site?

The dense area identification helps in clean PCI assignment. For PCI assignment we select the first densest site from the network. Solution to the above question is explained in a diagram. Draw a circle of 1 to 2 Km around each and every site. Then count the number of sites coming in that circle. The site which has highest count is actually densest site. The site with maximum site count is selected as the first site to be given PCI 0.

Assigning PCIs to densest area: There are two possibilities: the user may want to use all SSS or reserve some of them. So for this paper we keep 20 SSS reserve. Now we are left with 148 SSS, and one SSS is already used for densest site. Next step is to find the 147 nearest sites to the densest site. Assign next SSS to these sites. Densest cluster have unique 148 SSS. The advantage of planning the first dense cluster is that the cluster has collision and confusion free PCIs.

Chapter 3

3.1 LTE Network Architecture

The high-level network architecture of LTE is comprised of following three main components:

- The User Equipment (UE).
- The Evolved UMTS Terrestrial Radio Access Network (E-UTRAN).
- The Evolved Packet Core (EPC).

The evolved packet core communicates with packet data networks in the outside world such as the internet, private corporate networks or the IP multimedia subsystem. The interfaces between the different parts of the system are denoted Uu, S1 and SGi as shown below:

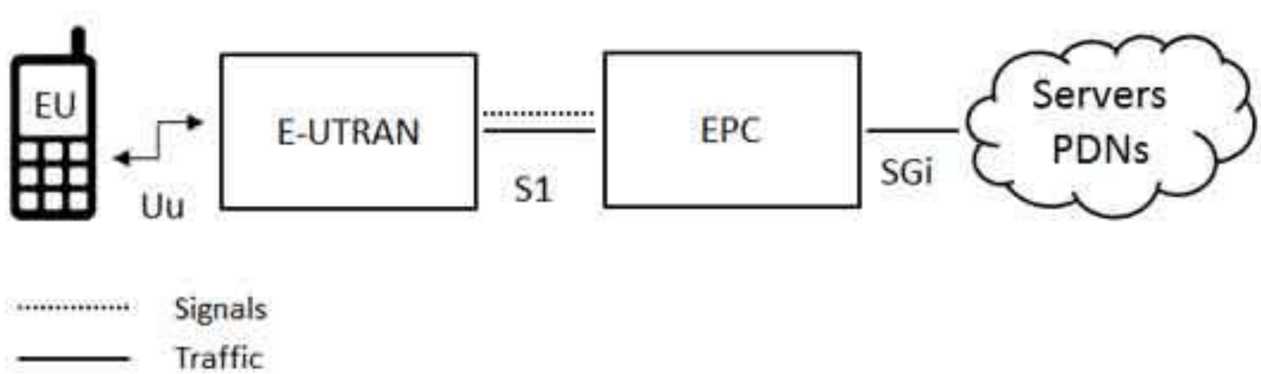

Figure-5 Overview[2][4][5]

The User Equipment (UE)

The internal architecture of the user equipment for LTE is identical to the one used by UMTS and GSM which is actually a Mobile Equipment (ME). The mobile equipment comprised of the following important modules:

- **Mobile Termination (MT)**: This handles all the communication functions.
- **Terminal Equipment (TE)**: This terminates the data streams.

- **Universal Integrated Circuit Card (UICC)**: This is also known as the SIM card for LTE equipment's. It runs an application known as the Universal Subscriber Identity Module (USIM).

A **USIM** stores user-specific data very similar to 3G SIM card. This keeps information about the user's phone number, home network identity and security keys etc.

The E-UTRAN (The access network)

The architecture of evolved UMTS Terrestrial Radio Access Network (E-UTRAN) has been illustrated below.

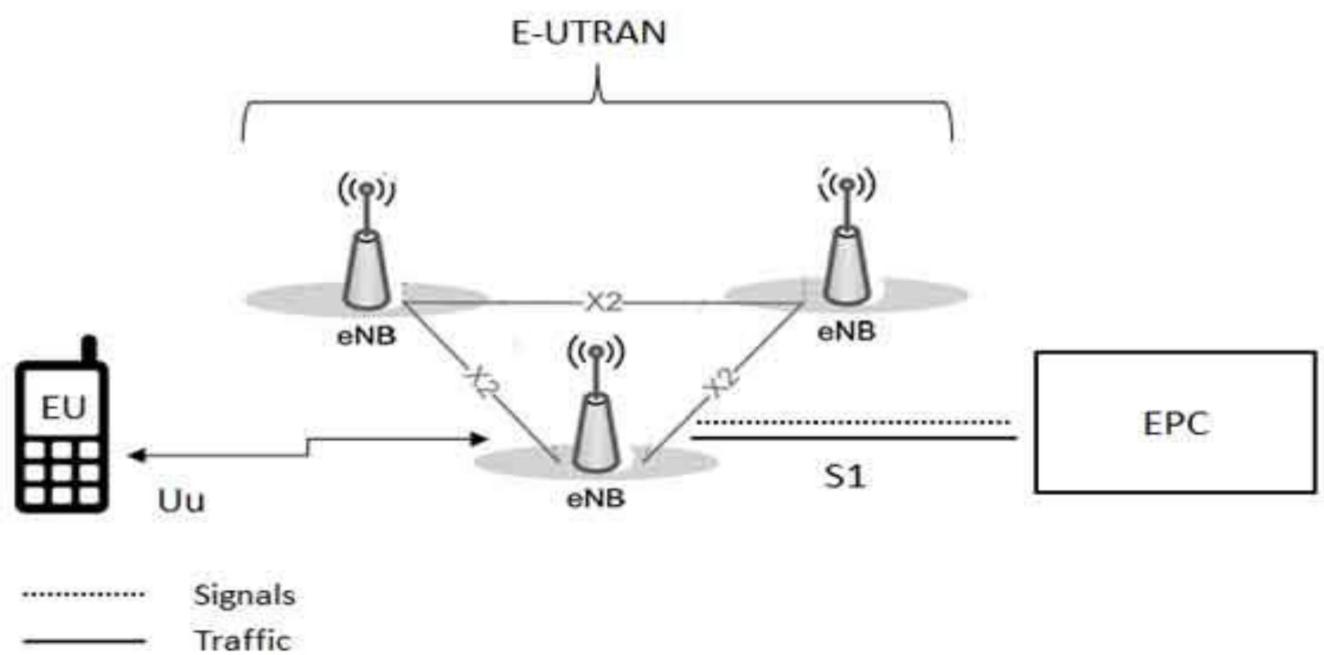

Figure-6 E-UTRAN[2][4][5]

The E-UTRAN handles the radio communications between the mobile and the evolved packet core and just has one component, the evolved base stations, called **eNodeB** or **eNB**. Each eNB is a base station that controls the mobiles in one or more cells. The base station that is communicating with a mobile is known as its serving eNB.

LTE Mobile communicates with just one base station and one cell at a time and there are following two main functions supported by eNB:

- The eBN sends and receives radio transmissions to all the mobiles using the analogue and digital signal processing functions of the LTE air interface.

- The eNB controls the low-level operation of all its mobiles, by sending them signalling messages such as handover commands.

Each eBN connects with the EPC by means of the S1 interface and it can also be connected to nearby base stations by the X2 interface, which is mainly used for signalling and packet forwarding during handover.

A home eNB (HeNB) is a base station that has been purchased by a user to provide femtocell coverage within the home. A home eNB belongs to a closed subscriber group (CSG) and can only be accessed by mobiles with a USIM that also belongs to the closed subscriber group.

The Evolved Packet Core (EPC)

The architecture of Evolved Packet Core (EPC) has been illustrated below. There are few more components which have not been shown in the diagram to keep it simple. These components are like the Earthquake and Tsunami Warning System (ETWS), the Equipment Identity Register (EIR) and Policy Control and Charging Rules Function (PCRF).

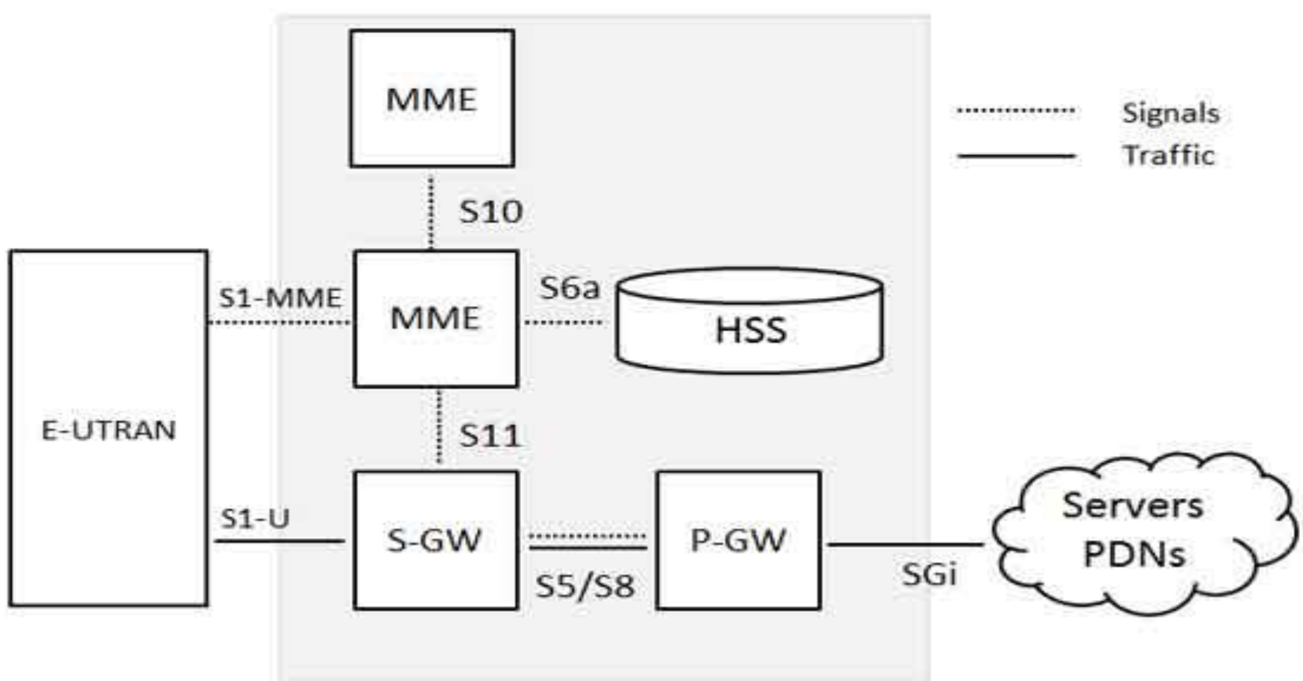

Figure-7 EPC[2][4][5]

Below is a brief description of each of the components shown in the above architecture:

- The Home Subscriber Server (HSS) component has been carried forward from UMTS and GSM and is a central database that contains information about all the network operator's subscribers.

- The Packet Data Network (PDN) Gateway (P-GW) communicates with the outside world ie. Packet data networks PDN, using SGi interface. Each packet data network is identified by an access point name (APN). The PDN gateway has the same role as the GPRS support node (GGSN) and the serving GPRS support node (SGSN) with UMTS and GSM.

- The serving gateway (S-GW) acts as a router, and forwards data between the base station and the PDN gateway.

- The mobility management entity (MME) controls the high-level operation of the mobile by means of signalling messages and Home Subscriber Server (HSS).

- The Policy Control and Charging Rules Function (PCRF) is a component which is not shown in the above diagram but it is responsible for policy control decision-making, as well as for controlling the flow-based charging functionalities in the Policy Control Enforcement Function (PCEF), which resides in the P-GW.

The interface between the serving and PDN gateways is known as S5/S8. This has two slightly different implementations, namely S5 if the two devices are in the same network, and S8 if they are in different networks.

3.2 Frame Structure

Type 1 Frame structure (FDD)

The duration of one LTE radio frame is 10 ms. One frame is divided into 10 subframes of 1 ms each, and each subframe is divided into two slots of 0.5 ms each. Each slot contains either six or seven OFDM symbols, depending on the Cyclic Prefix (CP) length. The useful symbol time is 1/15 kHz= 66.6 mircosec. Since normal CP is about 4.69 microsec long, seven OFDM symbols can be placed in the 0.5-ms slot as each symbol occupies (66.6 + 4.69) = 71.29 microseconds. When extended CP (=16.67 microsec) is used the total OFDM symbol time is (66.6 + 16.67) = 83.27 microseconds. Six OFDM symbols can then be placed in the 0.5-ms slot. Frames are useful to send system information. Subframes facilitate resource allocation and slots are useful for synchronization. Frequency hopping is possible at

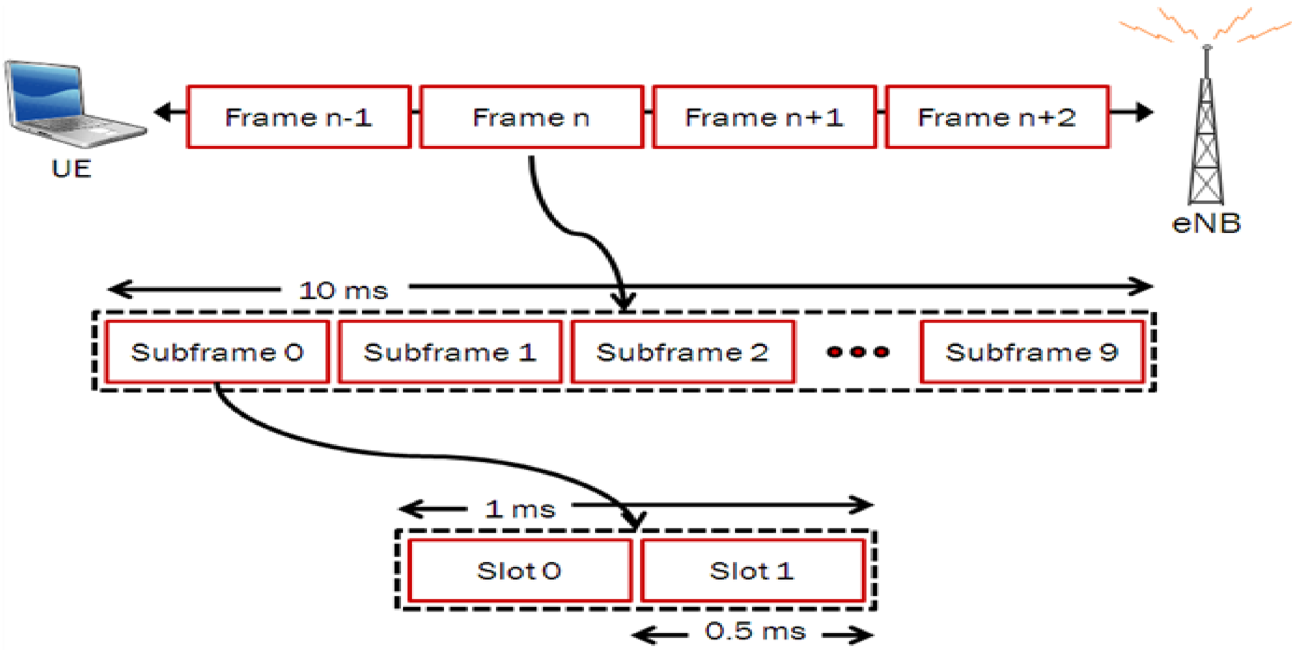

Figure-8 FDD frame structure[3]

the subframe and slot levels. In LTE, radio resources are allocated in units of Physical Resource Blocks (PRBs). Each PRB contains 12 subcarriers and one slot. If the normal Cyclic Prefix is used, a PRB will contain 12 subcarriers over seven symbols. If the extended CP is used, the PRB contains only six symbols. The UE is specified allocation for the first slot of a subframe. There is implicit allocation for the second slot of the subframe. For example, if the eNB specifies one RB as the resource allocation for the UE, the UE actually uses two RBs, one RB in each of the two slots of a subframe. When frequency hopping is turned on, the actual PRBs that carry the UE data can be different in the two slots. In a 10 MHz spectrum bandwidth, there are 600 usable subcarriers and 50 PRBs.

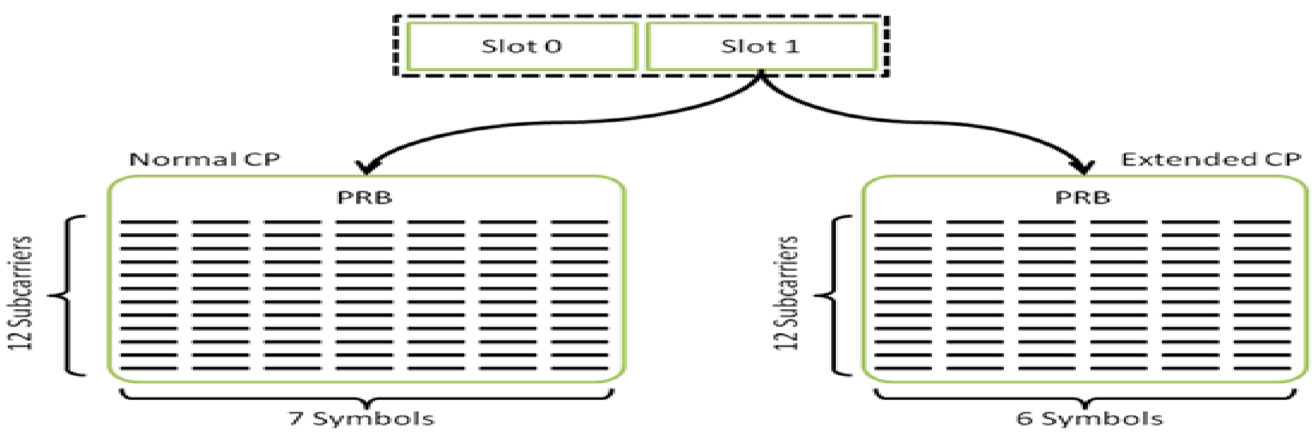

Figure-9 Resource Blocks (RBs)[3]

Type 2 Frame structure (TDD)

Frame structure Type 2 is applicable to TDD is as shown in the figure. Each radio frame of 10 ms in length consists of two half-frames of 5 ms in length. Each half-frame consists of eight slots of the length Ts=5 ms and three special fields DwPTS, GP, and UpPTS of 1 ms in length. Different configurations, numbered zero to six, are defined in the standard for the subframe number allocated for the uplink and downlink transmission. Subframe 1 in all configurations and subframe 6 in configurations 0, 1, 2 and 6 consist of DwPTS, GP and UpPTS. All other subframes are defined as two slots. Switch-point periodicities of 5 ms and 10 ms are supported. The standard defines the table for the uplink and downlink allocations for switch-point periodicity. In the case of a 5-ms switch-point periodicity, UpPTS and subframes 2 and 7 are reserved for uplink transmission. In the case of a 10-ms switch-point periodicity, UpPTS and subframe 2 are reserved for uplink transmission and subframes 7 to 9 are reserved for downlink transmission. Subframe 0 and 5 are always for the DL. The subframe following the special SF is always for the UL. The DwPTS field carries synchronization and user data as well as the downlink control channel for transmitting scheduling and control information. The UpPTS field is used for transmitting the PRACH and the Sounding Reference Signal (SRS).

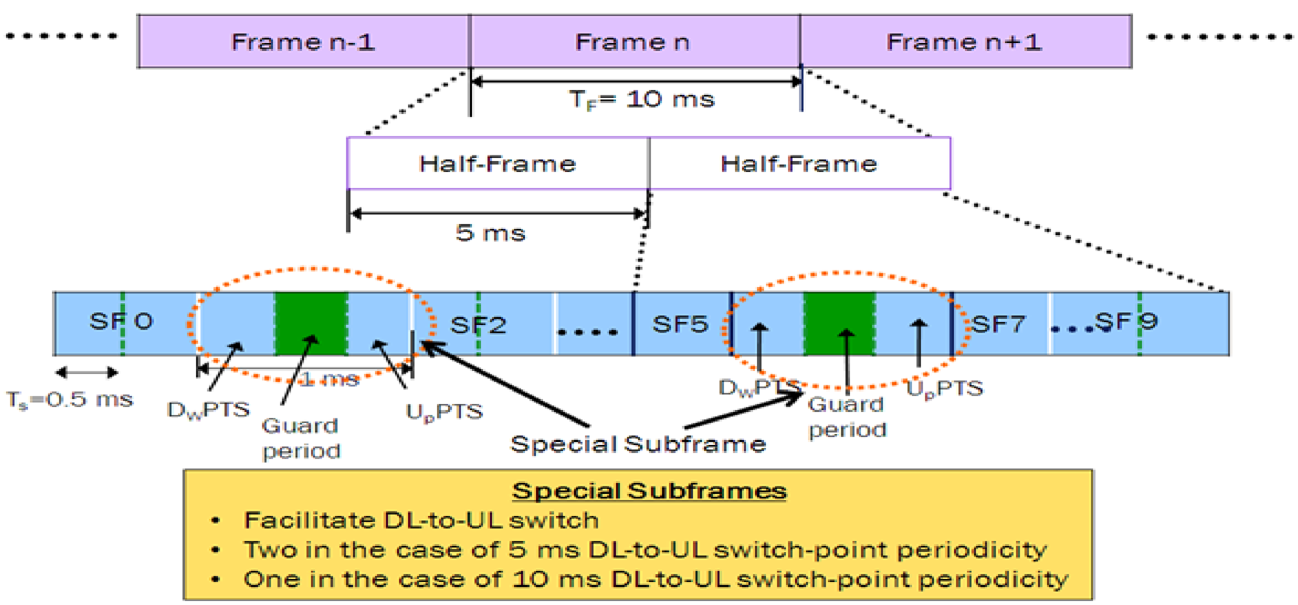

Figure-10 TDD Frame Structure[3]

3.3 LTE Channels

There are three categories into which the various data channels may be grouped.

Physical channels: These are transmission channels that carry user data and control messages.

Transport channels: The physical layer transport channels offer information transfer to Medium Access Control (MAC) and higher layers.

Logical channels: Provide services for the Medium Access Control (MAC) layer within the LTE protocol structure.

LTE Physical Channel

The LTE physical channels vary between the uplink and the downlink as each has different requirements and operates in a different manner.

Downlink:

Physical Broadcast Channel (PBCH): This physical channel carries system information for UEs requiring to access the network. It only carries what is termed Master Information Block, MIB, messages. The modulation scheme is always QPSK and the information bits are coded and rate matched - the bits are then scrambled using a scrambling sequence specific to the cell to prevent confusion with data from other cells. The MIB message on the PBCH is mapped onto the central 72 subcarriers or six central resource blocks regardless of the overall system bandwidth. A PBCH message is repeated every 40 ms, i.e. one TTI of PBCH includes four radio frames. The PBCH transmissions has 14 information bits, 10 spare bits, and 16 CRC bits.

Physical Control Format Indicator Channel (PCFICH): As the name implies the PCFICH informs the UE about the format of the signal being received. It indicates the number of OFDM symbols used for the PDCCHs, whether 1, 2, or 3. The information within the PCFICH is essential because the UE does not have prior information about the size of the control region. A PCFICH is transmitted on the first symbol of every sub-frame and carries a Control Format Indicator, CFI, field. The CFI contains a 32 bit code word that represents 1, 2, or 3. CFI 4 is reserved for possible future use. The PCFICH uses 32,2 block coding which results in a 1/16 coding rate, and it always uses QPSK modulation to ensure robust reception.

Physical Downlink Control Channel (PDCCH): The main purpose of this physical channel is to carry mainly scheduling information of different types:

- Downlink resource scheduling
- Uplink power control instructions
- Uplink resource grant
- Indication for paging or system information

The PDCCH contains a message known as the Downlink Control Information, DCI which carries the control information for a particular UE or group of UEs. The DCI format has several different types which are defined with different sizes. The different format types include: Type 0, 1, 1A, 1B, 1C, 1D, 2, 2A, 2B, 2C, 3, 3A, and 4.

Physical Hybrid ARQ Indicator Channel (PHICH): As the name implies, this channel is used to report the Hybrid ARQ status. It carries the HARQ ACK/NACK signal indicating whether a transport block has been correctly received. The HARQ indicator is 1 bit long - "0" indicates ACK, and "1" indicates NACK. The PHICH is transmitted within the control region of the sub frame and is typically only transmitted within the first symbol. If the radio link is poor, then the PHICH is extended to a number symbols for robustness.

Uplink:

Physical Uplink Control Channel (PUCCH): The Physical Uplink Control Channel, PUCCH provides the various control signaling requirements. There are a number of different PUCCH formats defined to enable the channel to carry the required information in the most efficient format for the particular scenario encountered. It includes the ability to carry SRs, Scheduling Requests.

Physical Uplink Shared Channel (PUSCH): This physical channel found on the LTE uplink is the Uplink counterpart of PDSCH

Physical Random Access Channel (PRACH): This uplink physical channel is used for random access functions. This is the only non-synchronized transmission that the UE can make within LTE. The downlink and uplink propagation delays are unknown when PRACH is used and therefore it cannot be synchronized.

The PRACH instance is made up from two sequences: a cyclic prefix and a guard period. The preamble sequence may be repeated to enable the eNodeB to decode the preamble when link conditions are poor.

LTE Transport Channel

The LTE transport channels vary between the uplink and the downlink as each has different requirements and operates in a different manner. Physical layer transport channels offer information transfer to medium access control (MAC) and higher layers.

Downlink:

Broadcast Channel (BCH): The LTE transport channel maps to Broadcast Control Channel (BCCH)

Downlink Shared Channel (DL-SCH): This transport channel is the main channel for downlink data transfer. It is used by many logical channels.

Paging Channel (PCH): To convey the PCCH

Multicast Channel (MCH): This transport channel is used to transmit MCCH information to set up multicast transmissions.

Uplink:

Uplink Shared Channel (UL-SCH): This transport channel is the main channel for uplink data transfer. It is used by many logical channels.

Random Access Channel (RACH): This is used for random access requirements.

LTE Logic Channel

The logical channels cover the data carried over the radio interface. The Service Access Point, SAP between MAC sub layer and the RLC sub layer provides the logical channel.

Control channels: these LTE control channels carry the control plane information:

Broadcast Control Channel (BCCH): This control channel provides system information to all mobile terminals connected to the eNodeB.

Paging Control Channel (PCCH): This control channel is used for paging information when searching a unit on a network.

Common Control Channel (CCCH): This channel is used for random access information, e.g. for actions including setting up a connection.

Multicast Control Channel (MCCH): This control channel is used for Information needed for multicast reception.

Dedicated Control Channel (DCCH) : This control channel is used for carrying user-specific control information, e.g. for controlling actions including power control, handover, etc..

Traffic channels: These LTE traffic channels carry the user-plane data:

Dedicated Traffic Channel (DTCH): This traffic channel is used for the transmission of user data.

Multicast Traffic Channel (MTCH): This channel is used for the transmission of multicast data.

It will be seen that many of the LTE channels bear similarities to those sued in previous generations of mobile telecommunications.[1]

Conclusion

Radio network planning is the first and the most important step while deploying any new wireless data communication technology. It gives information about how many sites will be needed for good coverage and also which can accommodate high traffic in channel. The main goal of LTE technology is to provide high data rate, high spectral efficiency and also it should provide efficient inter-technology overlay LTE network. Bandwidth is 10% of carrier frequency of the system so for higher bandwidth we are using 1800 MHz and 2300 MHz for the LTE. To decrease the latency and decrease the time for the cell search we are using only 504 unique physical cell IDs in LTE technology. Also architecture of the LTE network is very compact as compare the other technology which gives low latency. To provide better coverage and service LTE technology uses AMC (Adoptive Modulation Scheme). Depending upon the channel quality it automatically selects the modulation scheme. In TDD technique the TDD frame consists special subframe of 1ms for scheduling of uplink and downlink. All this things are selected while radio network planning.

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