Traffic Modeling of LTE Network under User Group of Dissimilar Bandwidth

This project is a partial fulfillment for the award of the degree of Bachelor of Science in Information and Communication Engineering

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DECLARATION

We hereby declare that we carried out the work reported in this thesis in the Department of Electronics and Communications Engineering, East West University, under the supervision of **Dr. M. Ruhul Amin and Dr. Md. Imdadul Islam**. We solemnly declare that to the best of our knowledge, no part of this report has been submitted elsewhere for award of a degree. All sources of knowledge used have been duly acknowledged.

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CERTIFICATE

This is to certify that the major thesis entitled **"Traffic Modeling Of LTE Network Under User Group Of Dissimilar Bandwidth"** being submitted by Shyama Reza, Mst. Fatematuzzohara and Eseta Jahan Khadiza of Electronics and Communications Engineering Department, East West University, Dhaka in partial fulfillment for the award of the degree of Bachelor of Science in Information and Communication Engineering, is a record of major research project carried out by them. They have worked under our supervision and guidance and have fulfilled the requirements which to our knowledge have reached the requisite standard for submission of this dissertation.

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ACKNOWLEDGEMENT

The completion of our project work brings with it a sense of satisfaction, but it is never complete without thanking everyone who made it possible and whose constant support has crowned our efforts with success.

Our deepest gratitude to the Almighty God for helping and guiding us throughout our lives.

We would like to sincerely thank **Dr. M. Ruhul Amin,** Professor, Dept. of Mathematics and Physical Sciences, East West University and **Dr. Md. Imdadul Islam**, Professor, Dept. of Computer Science and Engineering, Jahangirnagar University for allowing us to carry out the project work and by providing guidelines and supervision whenever it was necessary.

Our deepest regards to **Dr. M. Mofazzal Hossain**, Professor & Chairperson of the Electronics and Communications Engineering Department for encouraging and inspiring us to carry out the project work.

We would also like to thank all the faculty and staff members of ECE Department for providing us with the required facilities and support towards the completion of the research project.

We feel extremely happy to acknowledge and express our sincere gratitude to our parents for their constant support and encouragement and last but not the least, friends and well-wishers for their help, cooperation and constant encouragement during the course of the project.

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ABSTRACT

In LTE (Long Term Evolution) a user has the provision of use of dissimilar bandwidth. Hence the traffic model of such network is different compared to previous generations. In this project work, we have provided a new modified Markov chain which matches the traffic model of LTE. The Markov chain is solved using node equations where all the linear equations are represented in generalized form so that the chain of any length can be solved using the model of the project work. The standard software MATLAB has been used for our numerical calculations. Finally, the probability states, blocking probability of narrow and wideband traffic are plotted against both call arrival rate and call termination rate. The modified Markov chain provides diverse results in context of bandwidth, compared to that of previous work of 2G/3G mobile.

CONTENTS

Chapter-1

INTRODUCTION

In telecommunication, Long-Term Evolution (LTE) is a standard for high-speed wireless communication for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA technologies.

Long term evolution (LTE) standard is currently being developed by the third generation partnership project (3GPP) with target of increasing peak user throughput, enhancing spectral efficiency and reducing latency. LTE uses Orthogonal Frequency Division Multiple Access (OFDMA) and Single Carrier Frequency Division Multiple Access (SC-FDMA) as the transmission schemes for the downlink and the uplink, respectively [1].

In order to select the best networks, some authors [2] have analyzed the power of the received signal and the available bandwidth (TBNS) of dissimilar network systems while others [3-5] have taken into account the interference in the selection techniques on the basis of the signal to interference plus noise ratio (SINR), which allowed them to improve the connection loss probability during a vertical handover. However, these authors did not considered the blocking parameters developed by the authors of [6] who got better results. Among the backup transmission methods and bandwidth sharing, the best network selection technique was chosen. This technique is based on the SINR and bit error rate (BER) whose selection parameters are the blocking probabilities and connection loss. By knowing how the profile of a LTE mobile device differ from Universal Mobile Telecommunications system (UMTS) mobile device, a manufacturer would be able to use this information in the design of resource allocation algorithms in base stations and other mobile device. By understanding about the distribution size of objects transferred, one would be able to minimize protocol overhead and adapt holding times for design power saving on mobile devices battery [7]-[9]. For future wireless networks, it is crucial to identify traffic characteristics in order to improve or design new PHY and MAC layer techniques. In [10] described the system architecture of a conventional server in more details.

The project report is organized as follows: Chapter 2 provides the basic theory of LTE traffic, Chapter 3 provides the generalized form of Markov Chain, Chapter 4 provides the algorithm of solution of Markov Chain, Chapter 5 provides the results based on analysis of Chapter 4, and finally Chapter 6 concludes the entire analysis with some recommendation for future work.

CHAPTER-2

LTE SYSTEM

2.1 FEATURES

The highlights of 4G frameworks may be outlined with single word Integration. The 4G Frame works are about flawlessly coordinating terminals, systems and applications to fulfill expanding client requests. There are three important feature of 4G/LTE system.

They are-

- Femtocell deployment
- OFDMA-based physical layer access and
- MIMO

▪ Femtocell Deployment

Femtocell is a low power base station which is sent inside the structures to upgrade the indoor scope and flag quality. As maximum people stays indoor region about $2/3^{rd}$ portion of a day. Therefore a huge amount of phone calls and data services are done in indoor region.

The indoor wall penetration loss and low signal strength hamper the communication. In order to reduce the distance between the end users and Macro Base Station (MBS) femto cells is one of the solutions to overcome such problem. A Femto Base Station (FBS) is a low power base station which is deployed inside the buildings to enhance the indoor coverage and signal strength. Femtocells are different in the sense that they are installed by customers in an ad hoc fashion without any RF planning. Objective of e-NodeB Femtocells lies in off-loading of traffic.

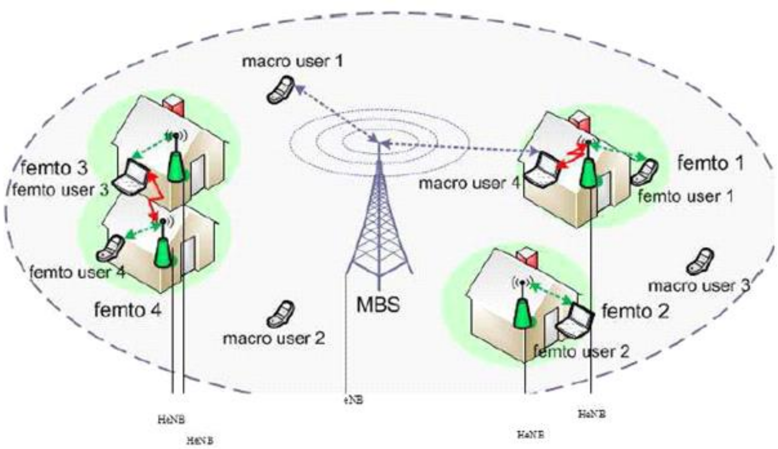


Fig 2.1: Femtocell deployment

▪ OFDMA-Based Physical Layer Access

The idea of versatility was acquainted with the IEEE 802.16 Wireless-MAN Orthogonal

Recurrence Division Multiplexing Access (OFDMA) mode by the 802.16 Assignment Gathering e (TGe). OFDMA can-

- Minimizes separation between carrier that are orthogonal over symbol interval

- Carrier orthogonality leads to frequency domain spacing $\Delta f = 1/T$, where T is the symbol time.
- In LTE carrier spacing is 15KHz and useful part of the symbol is 66.7 microsec.

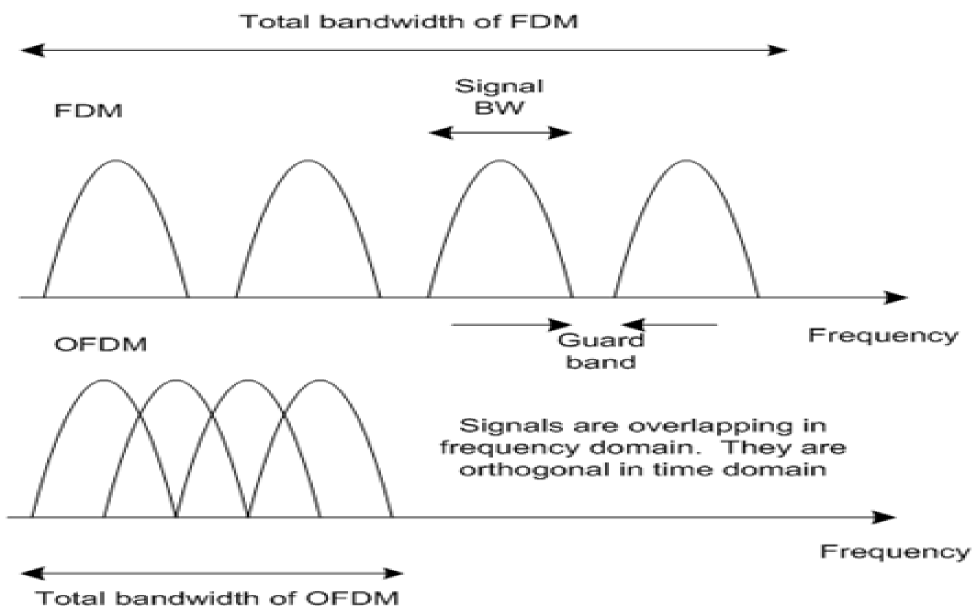


Fig 2.2: OFDMA Based Physical Layer

▪ MIMO (Multiple Input Multiple Output)

MIMO enables base stations and portable units to send and get information utilizing numerous receiving wires. LTE as of now bolsters some MIMO, however just for the download stream. Also, it confines the quantity of radio wires to four transmitters in the base station and four collectors in the handset. It takes place between e-NodeB and user equipment.

LTE standard requires support for:

- e-NodeB can have maximum 4 antennas
- UE can have maximum 2 antennas.

A base station with eight transmitters, for example, it can send eight streams at the same time to a cell phone with eight recipients. Since each stream lands at every recipient at a marginally extraordinary point, quality, and time, handling calculations in the cell phone can consolidate these sources of info and utilize the distinctions to deal with the first streams.

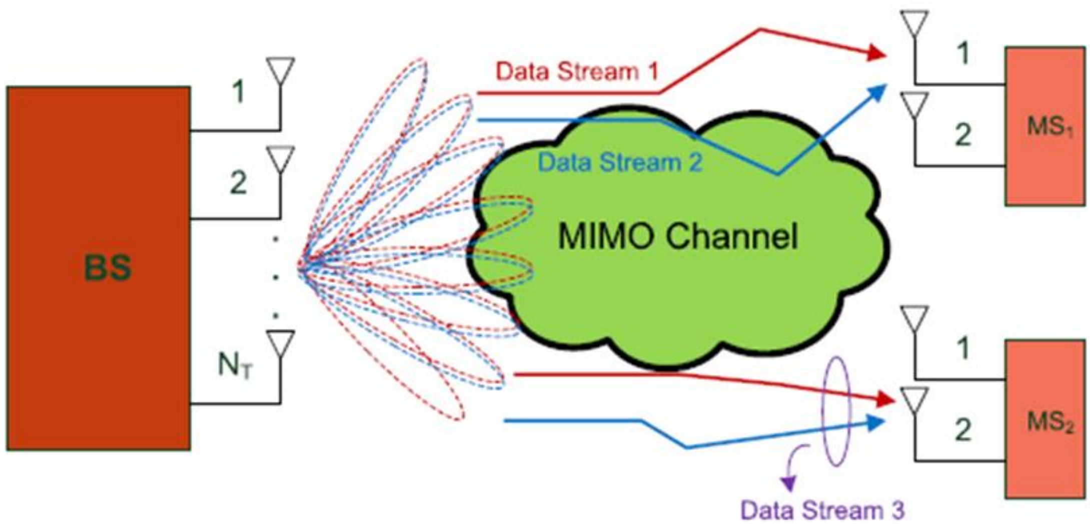


Fig 2.3: MIMO Communication

2.2 Architecture of LTE Traffic:

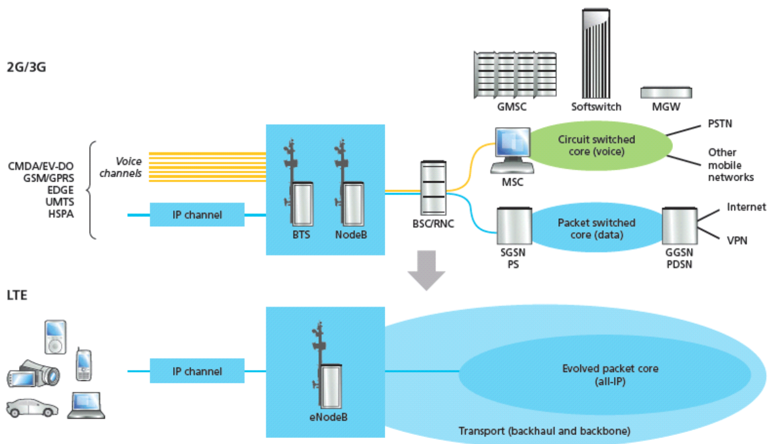


Fig 2.4: LTE Traffic Architecture

The architecture of LTE consists of two major parts: the E-UAN TR (Evolved Universal Terrestrial Radio Access Network) and the EPC (Evolved Packet Core).

The first part provides air interface between MS or UE to BS and the second part is interconnected switching network called backbone or core network.

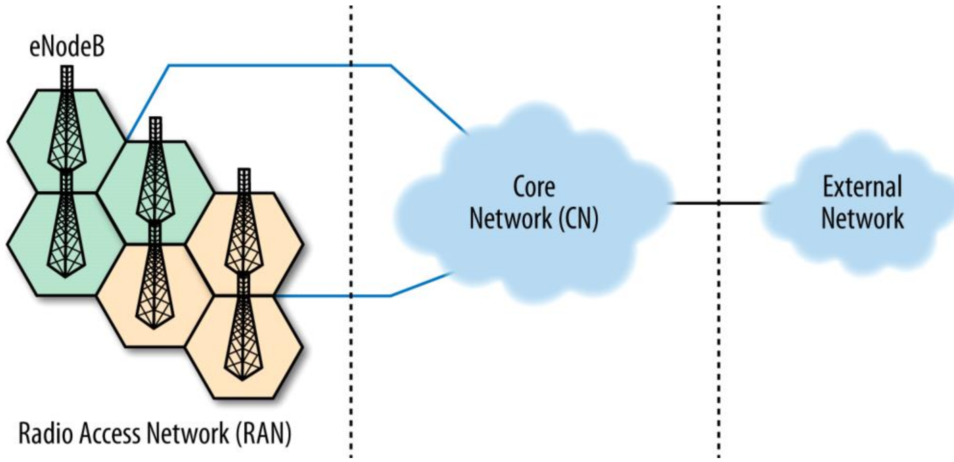


Fig 2.5: Architecture of LTE

User Equipment(UE):

A UE is the actual device that the LTE customers use to connect to the LTE network and establish their connectivity. The UE may take several forms; it can be a mobile phone, a tablet, or a data card used by a computer/notebook.

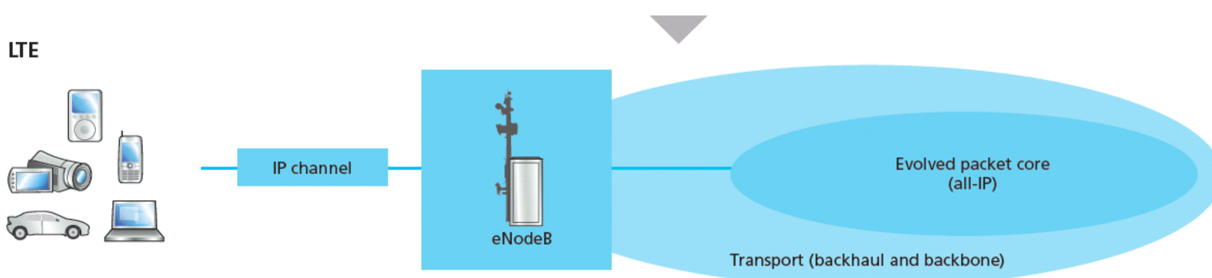


Fig 2.6: User Equipment(UE)

- UE is similar to all other 3GPP systems, the UE consists of two main entities: a SIM-card or what is also known as User Service Identity Module (USIM), and the actual equipment known as Terminal Equipment (TE).

- SIM-card carries the necessary information provided by the operator for user identification and authentication procedures. The terminal equipment on the other hand provides the users with the necessary hardware (e.g., processing, storage, operating system) to run their applications and utilize the LTE system services.

Evolved UTRAN(E-UTRAN):

- The E-UTRAN in LTE consists of directly interconnected e-nodeB’s which are connected to each other through the X2 interface and to the core network through the S1 interface.

- This eliminates one of the biggest drawbacks of the former 3GPP systems (UMTS): the need to connect and control the NodeBs through the Radio Network Controller (RNC),which make the system vulnerable to RNC failures.

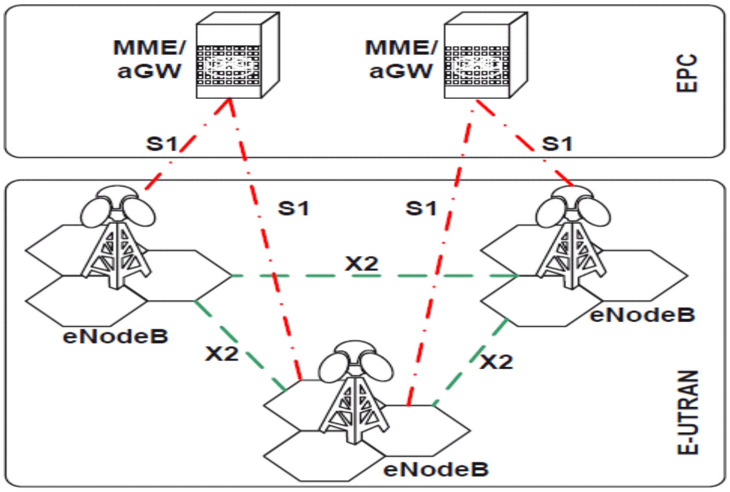


Fig 2.7: E-UTRAN

Evolved Packet Core (EPC):

- The EPC (also known as the LTE core network) consists of three main entities: Mobility Management Entity (MME), Serving Gateway (S-GW) and the Packet Data Network Gateway (PDN-GW). In addition, there are some other logical entities like the Home Subscriber Server (HSS) and Policy and Charging Rules Function (PCRF).The EPC consists of six nodes:

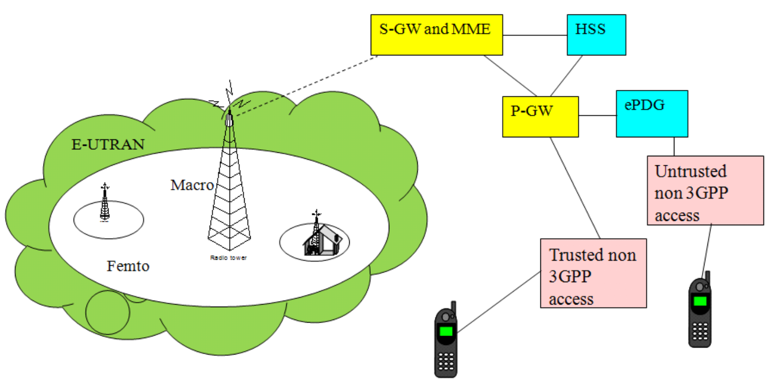


Fig 2.8: EPC

The serving Gateway(S-GW):

- The SGW is the termination point of the packet data network interface towards E-UTRAN. When terminals move across areas served by eNodeB elements in E-UTRAN, the SGW serves as a local mobility anchor. This means that packets are routed through this point for intra E-UTRAN mobility and mobility with other 3GPP technologies, such as 2G/GSM and 3G/UMTS.

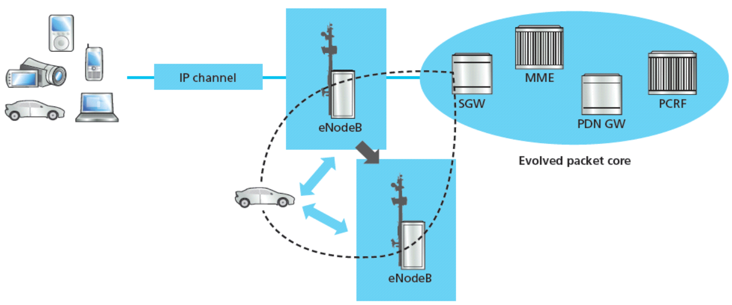


Fig 2.9: S-GW

Packet Data Network Gateway:

- Like the SGW, the Packet Data Network Gateway (PDN GW) is the termination point of the packet data interface towards the Packet Data Network(s). As an anchor point for sessions towards the external Packet Data Networks.

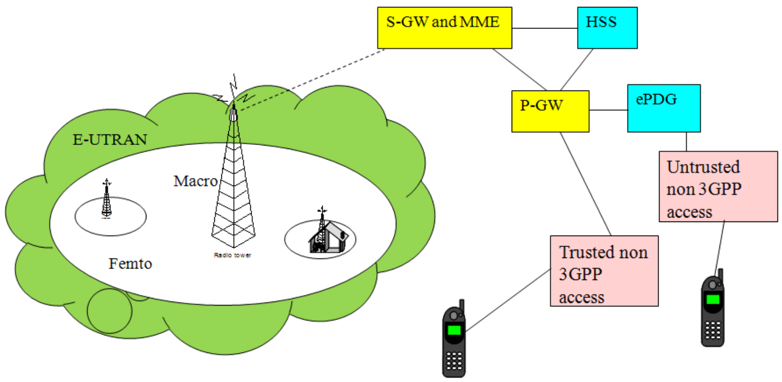


Fig 2.10: PDNG

Home Subscriber Server(HSS):

- Home subscriber server is like the combination of HLR and AUC of UMTS or GSM .

MME(Mobility Management Entity):

- MME is responsible for initiating paging and authentication of the mobile device.
- MME retains location information at the tracking area level for each user and then selects the appropriate gateway during the initial registration process. (A large geographical region can be divided into multiple tracking areas and each tracking area may have hundred of cells.)
- MME supports roaming of subscribers from other LTE/EPC systems and legacy networks.
- Assignment of network resources.
- Security for E-UTRAN access (for example *negotiation of ciphering)*.

The Policy Control And Charging Rules Function

- This module works like: Packet filtering and billing on flow basis.

Evolved Packet Data Gateway (EPDG):

- This provides secured data transmission between UE to un-trusted non-3GPP access through EPC.

2.3 Frame Structure of LTE traffic

Types: There are two types of LTE frame structures that are currently defined in the LTE specifications.

Type 1: used for the LTE FDD mode systems.

Type 2: used for the LTE TDD systems.

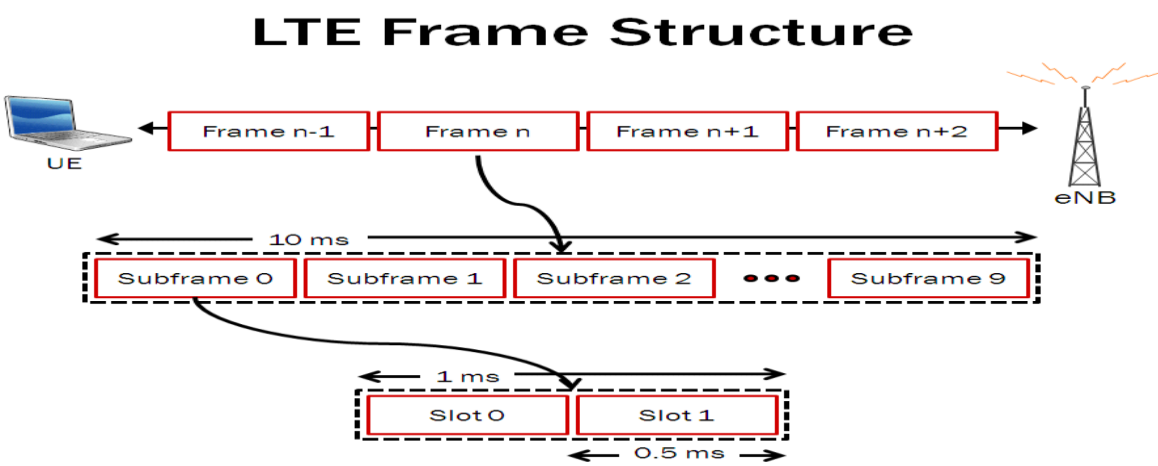
Both frame structures use a 10 ms frame structure that is subdivided into ten subframes (1 ms each) with each subframe further divided into two slots (0.5 ms each). **DwPTS** (Downlink Pilot Time Slot) and **UpPTS** (Uplink Pilot Time Slot) provide control channel information and GP (Guard Period) is the "quiet time" that is inserted between downlink and uplink transmissions to ensure that the two transmissions do not occur at the same time. The LTE specifications support some flexibility in the length of each of these parameters.

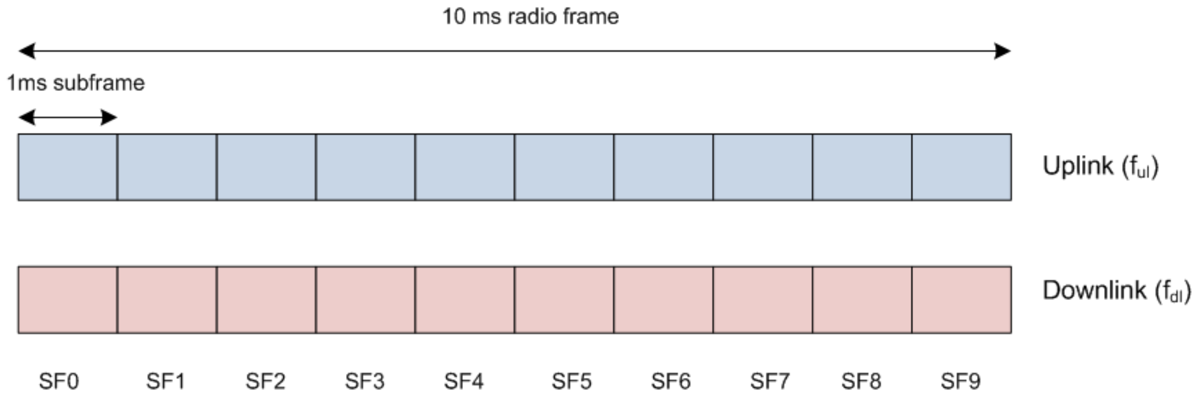
This structure consists of ten 1 ms sub-frames, each composed of two 0.5 ms slots, for total duration of 10 ms. The FSQ is the same in the uplink and downlink in terms of frame, sub-frame, and slot duration, although the allocation of the physical signals and channels is quite different. Uplink and downlink transmission are separated in the frequency domain.

Sub-frames consist of either an uplink or downlink transmission or a special sub-frame containing the downlink and uplink pilot timeslots (**DwPTS** and **UpPTS**) separated by a transmission gap guard period (GP). The allocation of the sub-frames for the uplink, downlink, and special sub-frames is determined by one of seven different configurations.

- ## Type 1 LTE 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.





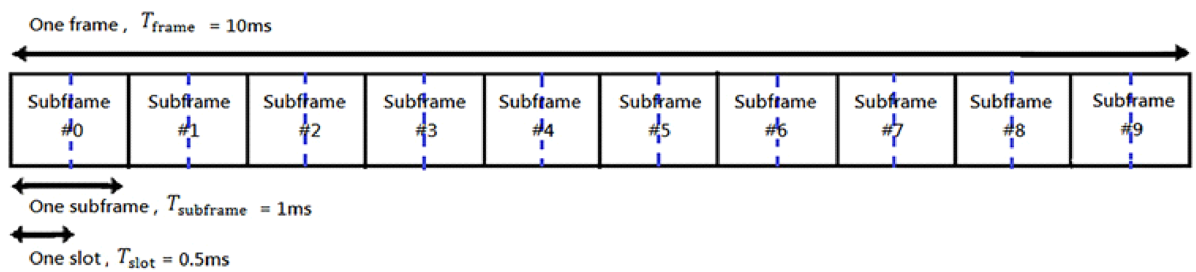


Fig 2.11: Type 1 Frame Structure

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 microsec. Since normal CP is about 4.69microsec long, seven OFDM symbols can be placed in the 0.5-ms slot as each symbol occupies (66.6 + 4.69) = 71.29 microseconds.

Now, 71.29 ×7 = 500 microseconds = 0.5ms = Length of slot

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.

Now, 83.27 ×6 = 500 microseconds = 0.5ms = Length of

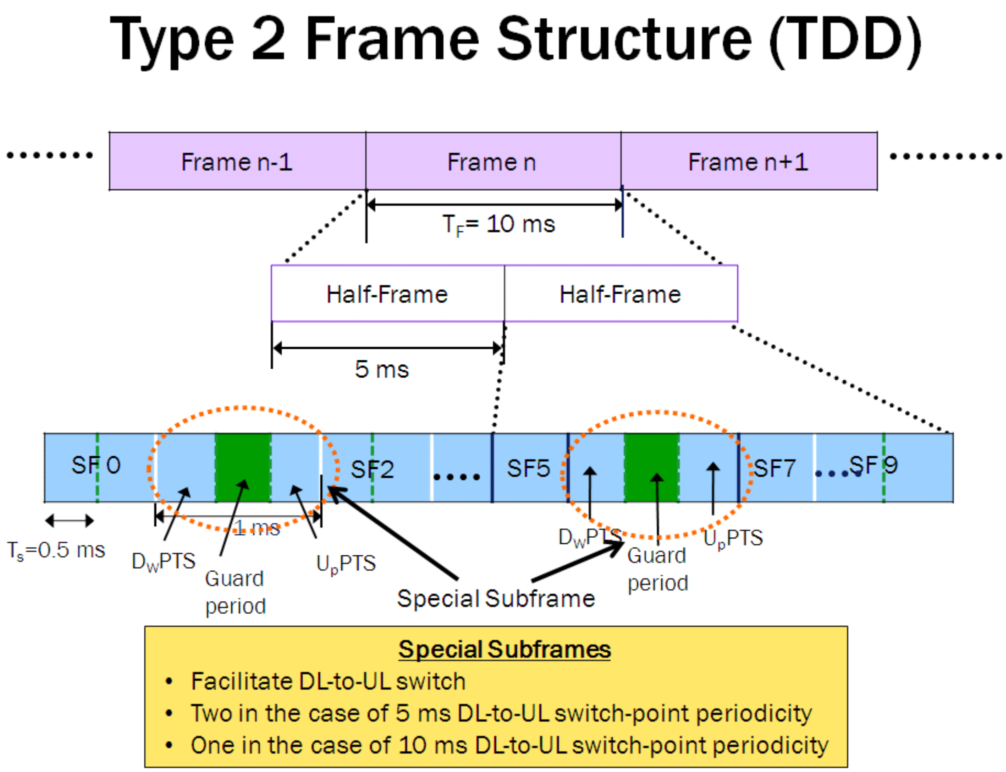


Fig 2.12: Type 2 Frame Structure

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.

LTE TDD / TD-LTE sub frame allocations:

One of the advantages of using LTE TDD is that it is possible to dynamically change the up and downlink balance and characteristics to meet the load conditions. In order that this can be achieved in an ordered fashion, a number of standard configurations have been set within the

LTE standards. A total of seven up / downlink configurations have been set, and these use either 5 ms or 10 ms switch periodicities. In the case of the 5ms switch point periodicity, a special subframe exists in both half frames. In the case of the 10 ms periodicity, the special subframe exists in the first half frame only. It can be seen from the table below that the subframes 0 and 5 as well as DwPTS are always reserved for the downlink. It can also be seen that UpPTS and the subframe immediately following the special subframe are always reserved for the uplink transmission.

UPLINK-DOWNLINK CONFIGURATION	DOWNLINK TO UPLINK SWITCH PERIODICITY	SUBFRAME NUMBER									
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

Where:

D is a subframe for downlink transmission, S is a "special" subframe used for a guard time U is a subframe for uplink transmission.

2.4 LTE Frame Structure and Bandwidth Concepts:

In LTE, ten 1 ms subframes compose a 10 ms frame. Each subframe divides into two slots. The smallest modulation structure in LTE is the Resource Element. A Resource Element is one 15 kHz subcarrier by one symbol. Resource Elements aggregate into Resource Blocks. A Resource Block has dimensions of subcarriers by symbols. Twelve consecutive subcarriers in the frequency domain and six or seven symbols in the time domain form each Resource Block. The number of symbols depends on the Cyclic Prefix (CP) in use. When a normal CP is used, the Resource Block contains seven symbols. When an extended CP is used, the Resource Block contains six symbols. A delay spread that exceeds the normal CP length indicates the use of extended CP.

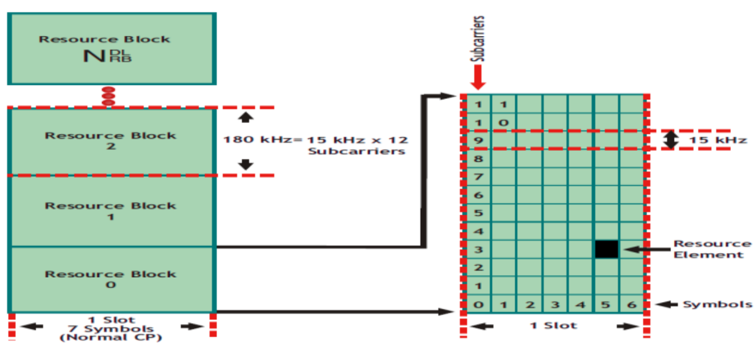
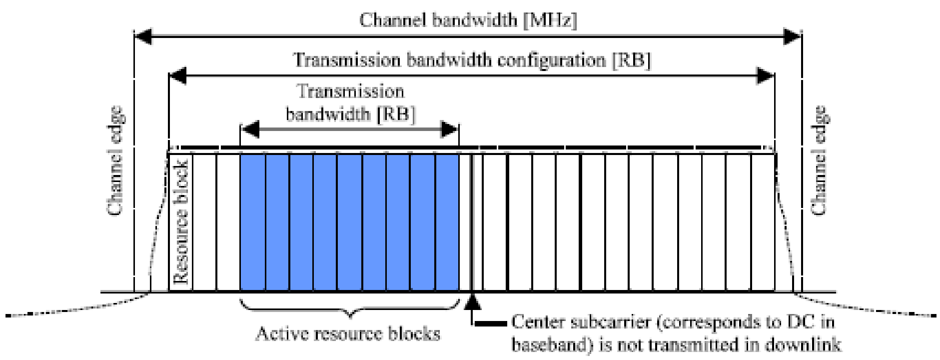


Fig 2.13: Downlink Resource Block

Channel Bandwidth is the width of the channel as measured from the lowest channel edge to the highest channel edge. The channel edge is the center frequency ± (channel bandwidth/2). Transmission Bandwidth is the number of active Resource Blocks in a transmission. As the bandwidth increases, the number of Resource Blocks increases. The Transmission Bandwidth Configuration is the maximum number of Resource Blocks for the particular Channel Bandwidth. The maximum occupied bandwidth is the number of Resource Blocks multiplied by 180 kHz.



Channel bandwidth (MHz)	1.4	3	5	10	15	20
Transmission bandwidth configuration (MHz)	1.06	2.7	4.5	9	13.5	18
Transmission bandwidth configuration (RB)	6	15	25	50	75	100

Fig 2.14: Transmission Bandwidth Configuration

CHAPTER-3

TRAFFIC MODELING OF LTE

3.1 MARKOV CHAIN

The Markov chain matches the traffic model of LTE and it is solved by using node equations where all the linear equations are also represented in generalized form so that the chain of any length can be solved using the model of the project work.

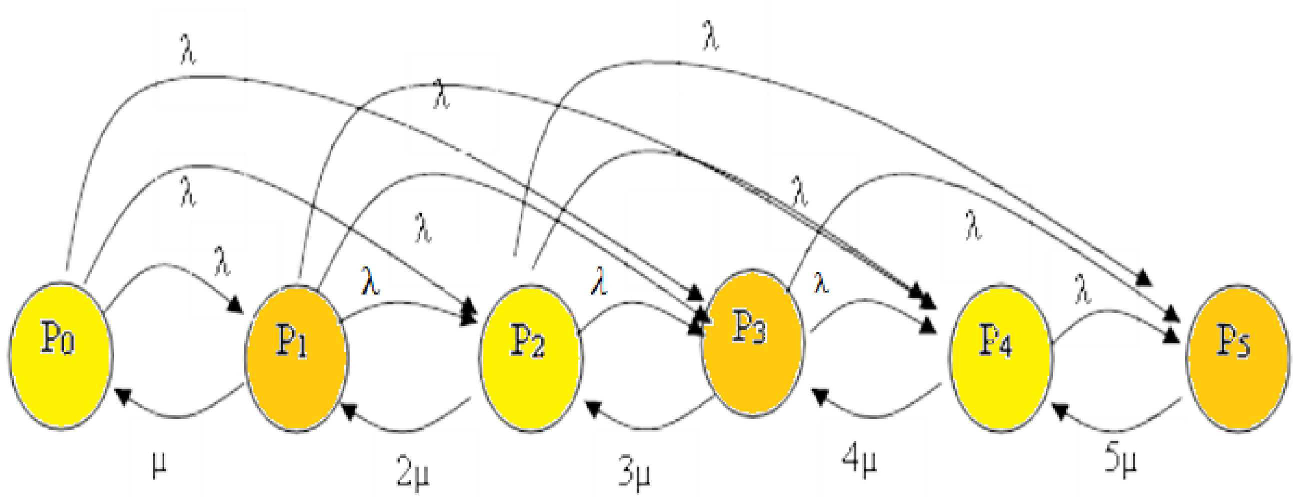


Fig 3.1: Markov Chain

3.2 GENERALIZED FORM OF MARKOV CHAIN

Let us apply node equation at node 0,

$P_0 3\lambda = P_1 \mu$

$\Rightarrow P_1 = \frac{3\lambda}{\mu} P_0$

- At node 1,

$P_1\{3\lambda + \mu\} = P_0\lambda + P_2 2\mu$

$\Rightarrow P_2 = \{P_1(3\lambda+\mu) - P_0\lambda\} \frac{1}{2\mu}$

- At node 2,

$P_2\{3\lambda + 2\mu\} = P_3 3\mu + P_1\lambda$

$\Rightarrow P_3 = \{P_2(3\lambda + 2\mu) - P_1\lambda\} \frac{1}{3\mu}$

- At node 3,

$P_3\{3\lambda + 3\mu\} = P_4 4\mu + P_2\lambda$

$\Rightarrow P_4 = \{P_3(3\lambda + 3\mu) - P_2\lambda\} \frac{1}{4\mu}$

- At node 4,

$P_4\{3\lambda + 4\mu\} = P_5 5\mu + P_3\lambda$

$\Rightarrow P_5 = \{P_4(3\lambda + 4\mu) - P_3\lambda\} \frac{1}{5\mu}$

- At node 5,

$P_5\{3\lambda + 5\mu\} = P_6 6\mu + P_4\lambda$

$\Rightarrow P_6 = \{P_5(3\lambda + 5\mu) - P_4\lambda\} \frac{1}{6\mu}$

- At node 6,

$P_6\{3\lambda + 6\mu\} = P_7 7\mu + P_5\lambda$

$\Rightarrow P_7 = \{P_6(3\lambda + 6\mu) - P_5\lambda\}\,\frac{1}{7\mu}$

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- At node x,

$P_x = [P_{x-1}\{3\lambda + (x-1)\mu\} - P_{x-2}\lambda]\,\frac{1}{x\mu}$

Chapter-04

ALGORITHM OF SOLUTION OF MARKOV CHAIN

4.1 COMBINED TRAFFIC

Step 1: Initialization

Let us take the initial value of traffic parameter. For example λ=1.2calls/min, μ=1.5 calls/min and N=3; where N is the highest *BW* i.e. the number of *BW* is 3*RB.*

Step 2: Expression of first 4 states

$p(1)=1;$

$p(2)= p(1)*N*\lambda /\mu;$

$p(3)= (p(2)*(N*\lambda +\mu) - p(1)*\lambda)/(2*\mu);$

$p(4)= [p(3)*(N*\lambda+(2*\mu)) - (p(1)+p(2))*\lambda]/(3*\mu);$

Step 3: Expression of states i=4 to 18 in generalized form like,

$p(i+1)=(p(i)*(N*\lambda+(i*\mu))-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda)/((i+1)*\mu);$

Step 4: The Step probability states of (N-1) is,

$p(i+1)=[p(\mathrm{i})*\{(N-1)*\lambda+(i*\mu)\}-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda]/\{(i+1)*\mu \};$

Step 5: The probability states of (*N*-2) is,

$p(i+1)=[p(i)*\{(N-2)*\lambda+(i*\mu)\}–\{p(i-1)+p(i-2)+p(i-3)\}*\lambda]/\{(i+1)*\mu \};$

Step 6: The sum of the states,

s=0;

For *j*=1:21;

s=*s*+*p*(*j*);

End

Step 7: The states are normalized as,

pn(1)=1/*s*;

For *j*=2:21;

pn(*j*)=*p*(*j*)**pn*(1);

End

Step 8: The possible states of probability,

m=0:1:20;

p1=pn;

Again,

Step 1: Initialization

Let us take the initial value of traffic parameter. For example λ=1.8calls/min, μ=1.5 calls/min and *N*=3; where *N* is the highest *BW* i.e. the number of *BW* is 3*RB*.

Step 2: Expression of first 4 states

p(1)=1;

p(2)= *p*(1)**N**λ /μ;

$p(3) = (p(2)*(N*\lambda + \mu) - p(1)*\lambda)/(2*\mu)$;

$p(4) = [p(3)*(N*\lambda+(2*\mu)) - (p(1)+p(2))*\lambda]/(3*\mu)$;

Step 3: Expression of states i=4 to 18 in generalized form like,

$p(i+1)=(p(i)*(N*\lambda+(i*\mu))-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda)/((i+1)*\mu)$;

Step 4: The Step probability states of (N-1) is,

$p(i+1)=[p(\mathrm{i})*\{(N-1)*\lambda+(i*\mu)\}-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda]/\{(i+1)*\mu\ \}$;

Step 5: The probability states of (*N*-2) is,

$p(i+1)=[p(i)*\{(N-2)*\lambda+(i*\mu)\}–\{p(i-1)+p(i-2)+p(i-3)\}*\lambda]/\{(i+1)*\mu\ \}$;

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Step 8: The possible states of probability,

m=0:1:20;

p2=pn;

and,

Step 1: Initialization

Let us take the initial value of traffic parameter. For example λ=2.2calls/min, μ=1.5 calls/min and N=3; where N is the highest *BW* i.e. the number of *BW* is 3*RB.*

Step 2: Expression of first 4 states

$p(1)=1;$

$p(2)= p(1)*N*\lambda /\mu;$

$p(3)= (p(2)*(N*\lambda +\mu) - p(1)*\lambda)/(2*\mu);$

$p(4)= [p(3)*(N*\lambda+(2*\mu)) - (p(1)+p(2))*\lambda]/(3*\mu);$

Step 3: Expression of states i=4 to 18 in generalized form like,

$p(i+1)=(p(i)*(N*\lambda+(i*\mu))-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda)/((i+1)*\mu);$

Step 4: The Step probability states of (N-1) is,

$p(i+1)=[p(\mathrm{i})*\{(N-1)*\lambda+(i*\mu)\}-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda]/\{(i+1)*\mu \};$

Step 5: The probability states of (*N*-2) is,

$p(i+1)=[p(i)*\{(N-2)*\lambda+(i*\mu)\}–\{p(i-1)+p(i-2)+p(i-3)\}*\lambda]/\{(i+1)*\mu \};$

Step 6: The sum of the states,

$s=0;$

For $j=1:21;$

$s=s+p(j);$

End

Step 7: The states are normalized as,

pn(1)=1/*s*;

For *j*=2:21;

pn(*j*)=*p*(*j*)**pn*(1);

End

Step 8: The possible states of probability,

m=0:1:20;

p3=pn;

Step 9: Plot of the possible axis,

```
plot(m,p1,'-r<',m,p2,'-bd',m,p3,'-ks','LineWidth',3,...

                'MarkerEdgeColor','k',...

                'MarkerFaceColor','g',...

                'MarkerSize',10)

xlabel('State i')

ylabel('Probability of states P(i)')

grid on

hold on

legend('λ=1.2', ' λ =1.8',' λ =2.2')
```

Step 10: Repeat step 1 to 9 for differentiate the value of λ and μ

Step 11: [stop].

4.2 TERMINATION RATE

Step 1: Initialization

Let us take the initial value of traffic parameter. For example, λ =1.8calls/min, and N=3; where N is the highest *BW* i.*e*. the number of *BW* is 3*RB*.

Step 2: Expression of first 4 states,

for k=1:10,

μ=3+k/2;

$A(k)=\mu$;

$p(1)$=1;

$p(2)=p(1)*N*\lambda/\mu$;

$p(3)=(p(2)*(N*\lambda+\mu)-p(1)*\lambda)/(2*\mu)$;

$p(4)=[p(3)*(N*\lambda+(2*\mu))-(p(1)+p(2))*\lambda]/(3*\mu)$;

Step 3: Expression of states *i*=4 to 18 in generalized form like,

$p(i+1)=(p(i)*(N*\lambda+(i*\mu))-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda)/((i+1)*\mu)$;

Step 4: The Step probability states of (N-1) is,

$p(i+1)=[p(i)*\{(N-1)*\lambda+(i*\mu)\}-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda]/\{(i+1)*\mu\}$;

Step 5: The probability states of (*N*-2) is,

$p(i+1)=[p(i)*\{(N-2)*\lambda+(i*\mu)\}-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda]/\{(i+1)*\mu\}$;

Step 6: The sum of the states,

s=0;

For j=1:21;

```
s=s+p(j);
End
```

Step 7: The states are normalized as,

```
pn(1)=1/s;
For j=2:21;
pn(j)=p(j)*pn(1);
End
```

Step 8: The possible states of probability,

```
Pn=pn;
B1(k)=Pn(21);
B2(k)=Pn(20)+Pn(21);
B3(k)=Pn(20)+Pn(20)+Pn(21);
end
```

Step 9: Plot of the possible axis,

```
plot(A, B1,'-r<',A,B2,'-bd',A,B3,'-ks','LineWidth',3,...
                'MarkerEdgeColor','k',...
                'MarkerFaceColor','g',...
                'MarkerSize',10)
xlabel('Termination rate')
ylabel('Blocking Probability')
grid on
```

hold on

legend('Blocking of single BW', 'Blocking of twice BW','Blocking of thrice BW')

Step 10: Repeat step 1 to 9 for differentiate the value of λ and μ.

Step 11: [stop].

4.3 ARRIVAL RATE

Step 1: Initialization

Let us take the initial value of traffic parameter. For example, μ=1.5 calls/min and N=3; where N is the highest *BW i.e*. the number of *BW* is 3*RB*.

Step 2: Expression of first 4 states,

for k=1:10,

λ=2+k/5;

A(k)=λ;

$p(1)=1;$

$p(2)=p(1)*N*\lambda /\mu;$

$p(3)=(p(2)*(N*\lambda +\mu) - p(1)*\lambda)/(2*\mu);$

$p(4)=[p(3)*(N*\lambda+(2*\mu)) - (p(1)+p(2))*\lambda]/(3*\mu);$

Step 3: Expression of states i=4 to 18 in generalized form like,

$p(i+1)=(p(i)*(N*\lambda+(i*\mu))-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda)/((i+1)*\mu);$

Step 4: The probability states of (N-1) is,

$p(i+1)=[p(i)*\{(N-1)*\lambda+(i*\mu)\}-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda]/\{(i+1)*\lambda\};$

Step 5: The probability states of (N-2) is,

$p(i+1)=[p(i)*\{(N-2)*\lambda+(i*\mu)\}-\{p(i-1)+p(i-2)+p(i-3)\}*\lambda]/\{(i+1)*\mu\};$

Step 6: The sum of the states,

$s=0;$

For $j=1:21;$

$s=s+p(j);$

End

Step 7: The states are normalized as,

$pn(1)=1/s;$

For $j=2:21;$

$pn(j)=p(j)*pn(1);$

End

Step 8: The possible states of probability,

Pn=pn;

B1(k)=Pn(21);

B2(k)=Pn(20)+Pn(21);

B3(k)=Pn(20)+Pn(20)+Pn(21);

end

Step 9: Plot of the possible axis,

```
plot(A, B1,'-r<',A,B2,'-bd',A,B3,'-ks','LineWidth',3,...
                'MarkerEdgeColor','k',...
                'MarkerFaceColor','g',...
                'MarkerSize',10)
xlabel('Arrival Rate')
ylabel('Blocking Probability')
grid on
hold on
legend('Blocking of single BW', 'Blocking of twice BW', 'Blocking of thrice BW')
```

Step 10: Repeat step 1 to 9 for differentiate the value of λ and μ.

Step 11: [stop].

4.4 ALGORITHMIC STEPS

- Take the initial value of traffic parameter
- Expression of first 4 states
- Expression of states *i*=4 to 18 in generalized form
- The Step probability states of (*N*-1)
- The probability states of (*N*-2)
- The sum of the states
- Normalized sates
- The possible states of probability
- Plot of the possible axis
- Repeat step 1 to 9 for differentiate value
- stop

Chapter-5

RESULTS and DISCUSSION

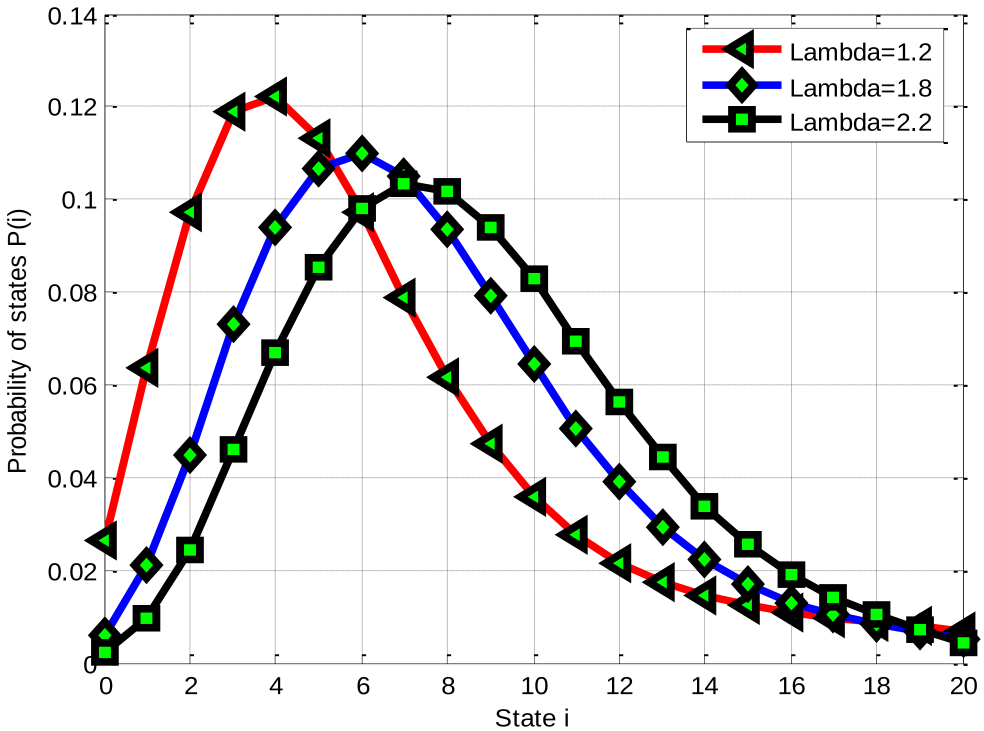

Fig.5.1 Probability states of Combined traffic

The above figure, Fig.5.1 shows the probability of states versus the state number, taking the traffic arrival rate λ as a parameter. The horizontal X-axis denotes the states number i and the vertical Y-axis denotes the probability of states $P(i)$. From the figure, we observe that for the small value of traffic arrival rate λ, the probability of states gets large. Furthermore, as we increase the traffic arrival rate λ the maxima of the curves of the probability of states shift to the right, *i.e,* towards the higher values of the state numbers. It is noticed that the maxima of the curves of the probability of states at $P(i)$=0.12, 0.11 and 0.10 for the traffic arrival rates λ=1.2, 1.8 and 2.2 respectively for i=4, 6 and 7.

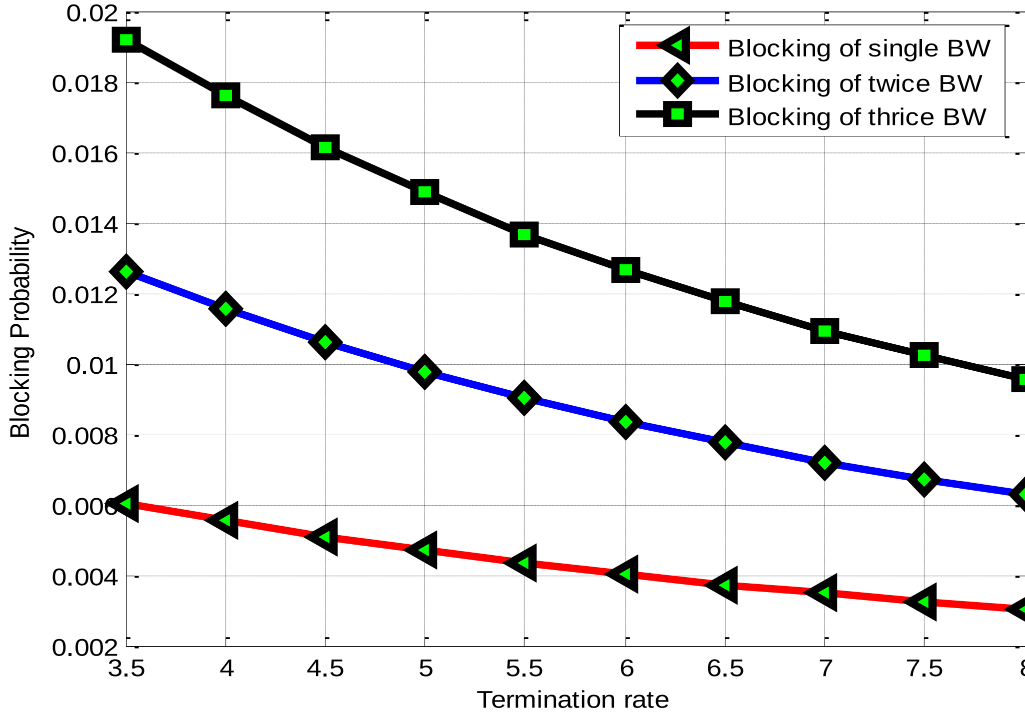

Fig.5.2 Variation of blocking probability against Termination rate

The above figure, Fig.5.2 shows the variation of blocking probability against termination rate, taking blocking of single BW as a parameter. The horizontal *X*-axis denotes the termination rate and the vertical *Y*-axis denotes the blocking probability. For the blocking of single *BW*, the curve becomes more flat. For the blocking of twice *BW*, the blocking probability becomes more higher than the blocking of single *BW*. Finally for the blocking of the thrice *BW*, blocking probability becomes highest. Furthermore, by increasing the blocking probability termination rate decreases.

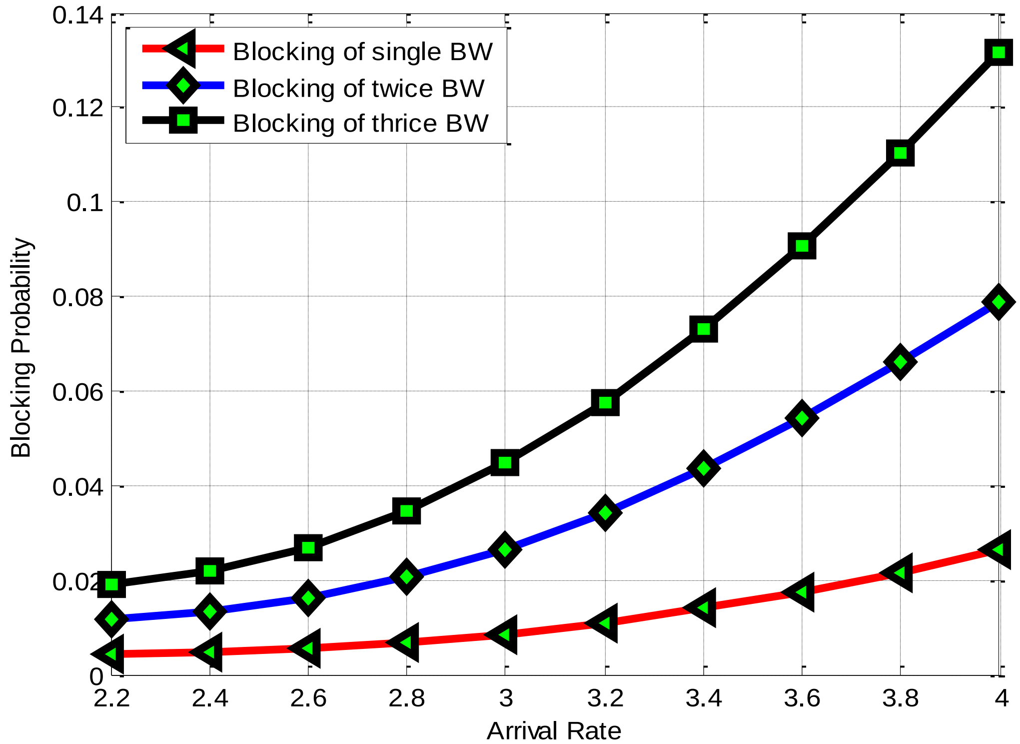

Fig.5.3 Variation of blocking probability against Arrival rate

The above figure, Fig.5.3 shows the variation of blocking probability against arrival rate, taking blocking of single *BW* as a parameter. The horizontal *X*-axis denotes the arrival rate and the vertical *Y*-axis denotes the blocking probability. For the blocking of single *BW*, the arrival rate increases slowly; for the blocking of twice *BW*, the arrival rate increases more than the blocking of single *BW*. Finally For the blocking of thrice *BW*, the arrival rate becomes highest. Furthermore, by increasing the blocking probability arrival rate also increases.

Chapter-6

CONCLUSION

This paper provides a comprehensive conclusion of the traffic Modeling of LTE Network under User Group of Dissimilar Bandwidth. LTE network structure is designed to be as simple as possible to deploy and operate, through flexible technology that can be deployed in a wide variety of frequency bands. The main goal of our research is to develop a traffic model of LTE network and try to evaluate and investigate User Group of Dissimilar Bandwidth that have been developed. Deployment of femto cells is one of the solutions to overcome such problem. A femto Base Station (FBS) is a low power base station which is deployed inside the buildings to enhance the indoor coverage and signal strength. In order to enable femto cells to operate within a variety of networks standard femtocell network architecture is required. It enables base stations and portable units to send and get information utilizing numerous receiving wires. MIMO can be utilized to expand information rates, or the quantity of clients, for a given measure of range. Then we have been developed architecture of LTE structure that first part provides air interface between MS or UE to BS and the second part is interconnected switching network called backbone or core network. Both frame structures use a 10 ms frame structure that is subdivided into ten subframes. This structure consists of ten 1 ms sub-frames, each composed of two 0.5 ms slots, for total duration of 10 ms and downlink and uplink pilot timeslots (DwPTS and UpPTS) separated by a Transmission gap guard period (GP).

Future Trends of LTE Networks Traffic

(1) Increasing Adoption of Mobile Broadband Devices.

(2) Growth in Global Connected Car Sales.

(3) Changing Consumer Habits and Preferences.

(4) The Global Shift towards VoD over LTE Networks.

(5) OTT Voice/Message Consumption.

(6) Dramatic Increase in Data Consumption.

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