Erlang-B Based Optimization of Blocking Probability for Multiple Loads

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Abstract— As technological advances are made in the world, communication needs tend to extend with the technology available. Mobile communications has potential for very rapid growth. Many researchers are participating in ventures, experiments, and developments that will expand mobile communications services globally. This paper discusses progress made in cellular systems, satellite systems, and the networking between them. The functionality of the cellular system and the satellite system is explained, followed by a description of a simulation study involving the hand-off aspect between the cellular and satellite systems. According to previous approaches the occurrence of traffic congestion and blocking probability in network is analyzed. Under this study it was found that on varying demand size (small or large), delay, loss rate and load balancing problem exists in network. To minimize the traffic congestion and improving network performance the traffic demand is split over multiple paths and also routing algorithm is presented. Improve QoS based on parameters like delay, probability of blocking, channel utilization and load balancing. The proposed approach performs better in reducing handoff blocks at the cost of increased new call blocks.

Index Terms—Cellular System, Handoff, Multi-Protocol Label Switching (MPLS), Erlang-B Method, Matlab.

1 Introduction

Cellular systems saw their conception in the 1940's. The concept of cellular radio stemmed from radio broadcasting which was used by police in the early 1920's. Extensive planning and development took place in the 1960's and the first analog system was deployed in the 1980's. With the deployment in the 1980's, the early stage of mobile communications was a slow booming business. In today's market, mobile telephony is looked upon as one of the places for rapid investment and growth. However like any other business, mobile telephony has suffered its share of ups and downs due to several major reasons such as:

- Multipath Fading
- Co-Channel Interference
- Limited System Bandwidth and Capacity

In order to understand why some of these difficulties arise, a full overview of cellular systems and their operational environment will now be discussed. Some of the problems mentioned above will be examined in greater depth.

2 Cellular System

The concept of cellular mobile systems developed with the advent of mobile radio systems. The cellular system consists of three main components: Mobile Switching Center (MSC), Cell Site (Base Station Equipment), and Mobile User Equipment. The three components work together to provide cellular service. The system can be visualized functionally as seen in figure 1(Walker, 1988). The MSC coordinates all cellular system activities between mobile users, cell sites and the Public Switched Telephone Network (PSTN). These activities include establishing connections, assigning channels, verification of users and handoff coordination to name a few. These activities and others will be discussed in further detail later in this chapter. The MSC incorporates the features of a regular telephone switching center with added capabilities to handle the activities throughout the system. The MSC software controls the necessary signaling needed to perform the activities which are sent to the cell sites and the mobile users. Cellular systems operate in the frequency region of 825-890 MHz with a difference of 45 MHz between transmitting and receiving frequencies. In the cellular system, the MSC provides connection to the PSTN via land lines and to the cells sites and other MSC's via land lines or microwave links.

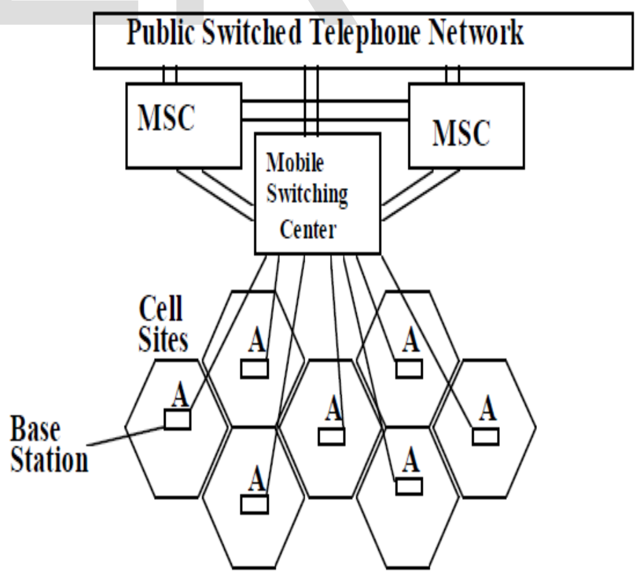

Figure 1: Cellular System Structure.

The cell site serves as the location for the base station equipment. The base station equipment consists of antenna (about 30 to 91 m. or 100 to 300 ft. high), transmitters, receivers, combiners and a power supply. The cell site also has a computer processor equipped with software to handle the necessary functions it has to perform. The cell site has 16 about channels,

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1 control channel for signaling and 15 voice channels. These channels are usually full duplex allowing two way communications and having two different frequencies ranges, one for transmitting and one for receiving. At the base station, it is possible to have an amplifier for each channel that feeds into a single combiner for a transmitting antenna or a single amplifier for all channels that use a single transmitting antenna. The first scenario is known as a channelized scheme and the latter scenario is known as a frequency division multiplexed scheme as seen in Figure 2. The dashed lines in each scheme are control channels. The base station antenna has several set ups, the most common being an omnidirectional combination of antennas, with two antennas for receiving and one for transmitting. Depending on the placement of the antennas, cells are considered center excited, edge excited, or umbrella cells. The center excited cells use the omnidirectional configuration discussed above. Edge excited cells use directional antennas placed in the corner of a cell site, which is best for co-channel interference.

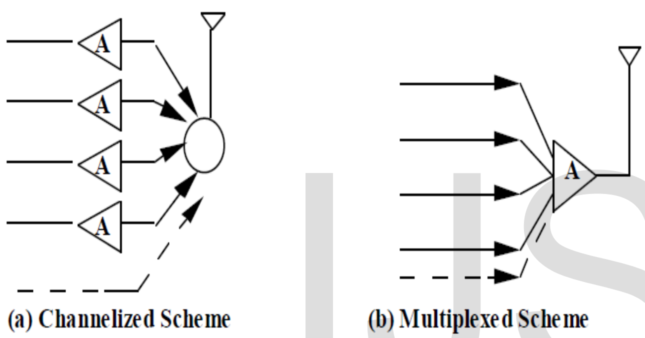

Figure 2: Channel Schemes.

The umbrella cells use tilted beam pattern antennas that provide a shadow effect of the cell site area. The amplifier(s) in each scheme provide enough gain to each channel frequency. The combiner then serves the function of combining all individual channels and sending them to the transmitting antenna. The receivers at the base station receive the incoming electromagnetic signals and convert them to perceptible forms.

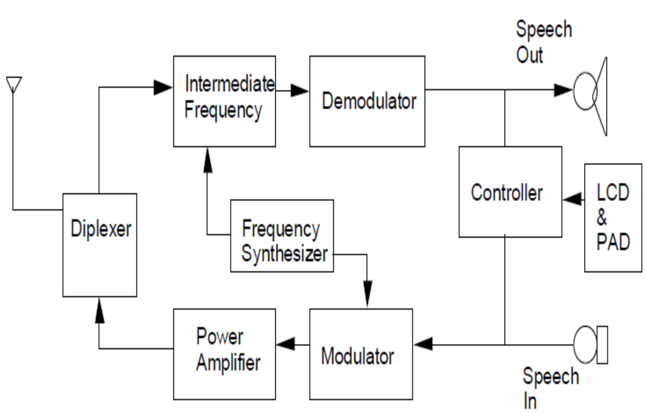

Figure 3: Mobile Equipment.

The mobile user unit equipment consists mainly of an antenna, transceiver circuitry, diplexer, feed line with handset. The handset consists of a microphone, an earphone, a liquid crystal display and an array of buttons. The transceiver circuitry has the main functions of frequency synthesizing, intermediate frequencies, and power amplifier. Within the mobile unit there are also demodulator and modulator units. These functional components can be seen in Figure 3. There are three main types of mobile unit antennas: roof mounted whips, roof mounted gain, and glass mounted gain antennas. The roof mounted whips are the least used antennas because of the low gain that is achievable. The roof mounted gain provides better service, however, the mounting usually requires the user to drill a hole into the roof top of the vehicle. Therefore, this is the least popular among consumers. The most common antenna used is the glass mounted gain. The antenna is coupled to the transceiver through the glass with the pad on the outside and the coupler on the inside. There are also portable mobile units available with built in circuitry, an antenna and rechargeable power batteries.

3 Handoff

During the call, the mobile user will probably move throughout several cells. As the mobile user travels from cell to cell within the cellular network, the call will be transferred between base stations within the network. This process is known as handoffs. The process is initiated when the signal strength of the mobile users call fall below a certain threshold level, usually around 32 dB.

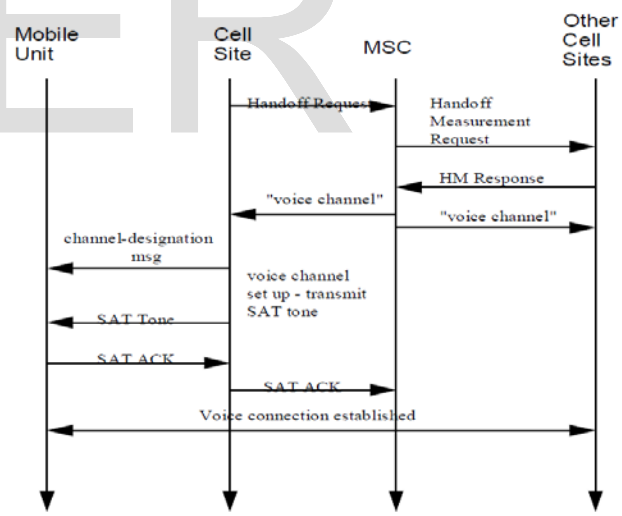

Figure 4: Mobile Call Handoff.

The base station then notifies the MSC that a call handoff will be necessary The MSC then sends out a handoff measurement request to the adjacent base stations for a measurement of the strength on a specific channel. In return, all the base stations send the signal strength level on the channel. The MSC then goes through a selection process to select the base station with the best signal level. Once the base station is selected, it is notified of the call transfer that is necessary and the channel it will be on. The MSC also forwards the same information to the base station that is currently carrying the call, which forwards the information about the new channel to the mobile unit. Once the mobile is tuned to the new channel the process is completed. This process may happen several times within a call due to the mobile user's movement. Since the handoff process is initiated by a drop in signal strength, base stations generally look for a consistent pattern of decrease in the signal strength around 10 dB per decade. The assumption made by the base station monitoring this pattern is that the mobile unit is moving toward the boundary of the cell. Figure 1.10 shows the process of a call handoff within the coverage of a single MSC.

Within the network, several things affect a call and its signal strength. The most common of these problems include:

- Propagation Path Loss
- Co-Channel Interference
- Multipath Fading
- Raleigh Fading
- Doppler Shifts

Propagation path loss is the dropping of the signal level due to the terrain and manmade noise (buildings, bridges, etc.). The main drivers of propagation path loss are the distance of the mobile unit from the base station and the frequency of the channel. Co-channel interference involves disturbances occurring from two mobile units operating on the same channel. Another type of channel interference is adjacent channel interference, which occurs when energy from a carrier spills over into another carrier. Solutions to deal with channel interference involve a method of channel schemes either multiplexed or channelized, which was previously discussed. Multipath Fading involves disturbances due to the multiple paths of the signals between the transmitter and the receiver as a result of the terrain and man-made noise. Raleigh Fading are rapid fluctuations in the signal strength that occur in statistical distribution known as Raleigh. Finally, Doppler Shifts are variations in the frequency of the received signal caused by the relative motion of the mobile unit. These problems all bear an effect on the signal strength of the mobile unit.

5 Methodology

Traffic engineering has become a very important issue in optical networks. In this research work on load congestion and blocking probability is done. This work also represents MPLS contributing high scalability in computer networks. MPLS in networks are generally used to provide a very high speed of data transmission for huge amount of data. It is a type of data-carrying technique for high-performance telecommunications networks that directs data from one network node to the next bases on short path labels rather than long network addresses, avoiding complex lookups in a routing table. MPLS in optical are generally used to provide a very high speed of data transmission for huge amount of data. So the performance optimization of MPLS is very much required. The performance of MPLS network can be measured on various parameters such as blocking probability, traffic congestion, load balancing, packet loss etc. Various algorithms and techniques have been proposed to measure and control and improve all these parameters. But still lot of improvements can be done on these techniques to achieve desired results.

There are following steps as follow as:

Step 1: Study the QoS parameter in depth.

Step 2: Analyze network using MPLS to improve QoS.

Step 3: QoS of network based on MPLS depends on three parameters fault tolerance, performance characteristics, security.

Step 4: Performance of MPLS based system is inversely proportional to blocking probability.

Step 5: Design MPLS based network with initial parameters Mean arrival time, call duration, call duration, traffic intensity and channel utilization.

Step 6: Analysis of blocking probability on the basis traffic intensity versus traffic load on given number of channels.

Step 7: Performance evaluation of proposed Erlang b method with existing frequency reuse based RCT method on the basis of parameters like blocking probability and number of channels.

6 Multi-Protocol Label Switching using Erlang-B

Multi-Protocol Label Switching (MPLS) was developed as a packet-based technology and is rapidly becoming key for use in core networks, including converged data and voice networks. MPLS does not replace IP routing, but works alongside existing and future routing technologies to provide very high-speed data forwarding between Label- Switched Routers (LSRs) together with reservation of bandwidth for traffic flows with differing Quality of Service (QoS) requirements.

MPLS uses a technique known as label switching to forward data through the network. A small, fixed-format label is inserted in front of each data packet on entry into the MPLS network. At each hop across the network, the packet is routed based on the value of the incoming interface and label, and dispatched to an outgoing interface with a new label value. The path that data follows through a network is defined by the transition in label values as the label is swapped at each LSR. Since the mapping between labels is constant at each LSR, the complete path is determined by the initial label value. Such a path is called a Label Switched Path (LSP). A set of packets that should be labeled with the same label value on entry to the MPLS network, and that will therefore follow the same LSP, is known as a Forwarding Equivalence Class (FEC).

6.1 Call Blocking Probability In MPLS System

The blocking probability describes the probability of call loses in a group of identical parallel resources (telephone lines, circuits, traffic channels). The formula for the blocking probability is known as Erlang B formula. The mathematical representation of blocking probability is given below. Where A is the traffic intensity and C is the number of channels. The formula applies under the condition that an unsuccessful call, because the line is busy, is not queued or retried, but instead really disappears forever. It is assumed that call attempts arrive following a Poisson process, so call arrival instants are independent.

6.2 Erlang Method in MPLS System

E is a unit of telecommunications traffic measurement. It represents the continuous use of one voice path or it can be said that it is used to describe the total traffic volume in one hour. For example a channel that is occupied for 30 minutes during one hour carries 30/60 = 0.5 Erlang of traffic. The Erlang is defined as dimensionless unit of traffic intensity. It is dependent on observation time. The maximum that a facility can be in use is 100% of the time.1 Erlang is defined as, if the observation time is 10 minutes. The following formula is used to calculate this blockage known as the Erlang B formula:

$$P_B(C,A) = \frac{A^C/C!}{\sum_{k=0}^{c} A^k/k!}$$

where
A = traffic density
P_B = probability that calls will be lost (blocked)
c = number of channels (server)
k = variable representing the number of busy channels (user)

Blocked call happens if a user requests to make a call when all the channels are occupied by other users. The likelihood that a call is blocked because there is no available channel. Traffic Intensity is a measure of channel time utilization (traffic load / amount of traffic), which is the average channel occupancy measured in Erlang. Erlang is a Dimensionless. It is denoted by denoted by A. Blocked Call is a call which cannot be completed at time of request, due to congestion also referred to as a lost call. Grade of Service (GOS) is a term used to measure of congestion which is specified as the probability of a call being blocked (for ErlangB).
Assumptions for this method:

1) Blocked calls cleared.
2) No queuing for call requests.
3) For every user who requests service, there is no setup time and the user is given immediate access to a channel if one is available. If no channels are available, the requesting user is blocked without access and is free to try again later.
4) Calls arrive as determined by a Poisson process.
5) There is memory less arrivals of requests, implying that all users, including blocked users, may request a channel at any time.
6) There are an infinite number of users (with finite overall request rate).
7) The finite user results always predict a smaller likelihood of blocking. So, assuming infinite number of users provides a conservative estimate.
8) The duration of the time that a user occupies a channel is exponentially distributed, so that longer calls are less likely to occur.

6.3 Traffic Engineering Techniques in MPLS

Traffic engineering uses statistical techniques such as queuing theory to predict and examine the behavior of telecommunications networks such as telephone network and the internet. The motivation of traffic engineering is to reduce the overall cost of operations by more efficient use of bandwidth resources. It means that to manage the traffic and distribute in such a way that channels are neither be over utilized nor underutilized. So some segments of a network can be very congested while other segments along alternative routes are underutilized. To optimize the utilization of resources in a network, an important network optimize technique Traffic Engineering is introduced.

6.4 Congestion Control

Congestion occurs when a node or a link carries so much data that it may decline the network service quality. The primary cause of the network congestion is the unbalanced distribution of the network traffic. Traditional routing algorithm like OSPF computes the shortest way to reach destination which is based on destination address. It means that traffic from different sources passing through a router with the same destination assembled and sent through the same path. By these two problems arises, first one the shortest paths from different sources overlap at some links, causing congestion and over utilized.
Second is the longer path are underutilized. Due to congestion the data packet loss, blocking of new connection and delay in packets occurred in the network. It may slow down the network performances. There are different types of routing algorithm like Dijkstra routing algorithm, load balancing algorithm using deviation path and constraint based routing algorithm are used to reduce the blocking probability and congestion problem. It means that to manage the traffic and distribute in such a way congestion term is used.

8 Simulated Results

In this section, the proposed system is evaluated via computer simulation using MATLAB simulator. All simulation results are obtained by using Erlang method Figure 5 show the blocking probability versus Traffic Intensity (from Erlang B Formula).

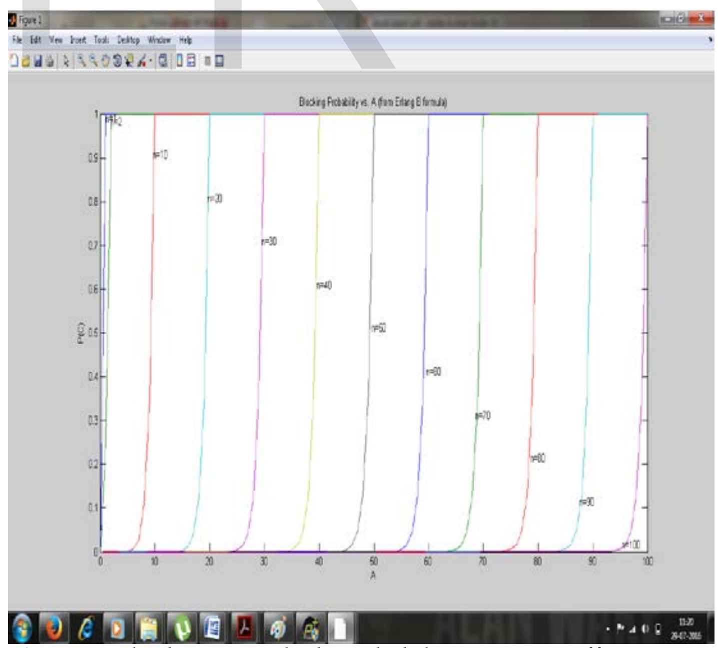

Figure 5: Plot between Block Probability versus Traffic Intensity (Erlang B Formula).

Figure 6 show the previous method of channel utilization versus system load.

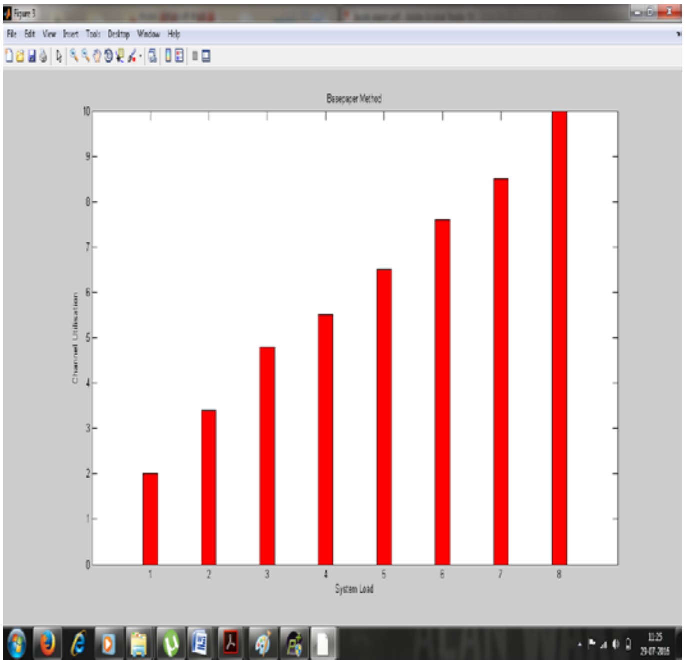

Figure 6: Channel Utilization versus System Load based previous method.

Figure 7 show the erlang method of channel utilization versus system load.

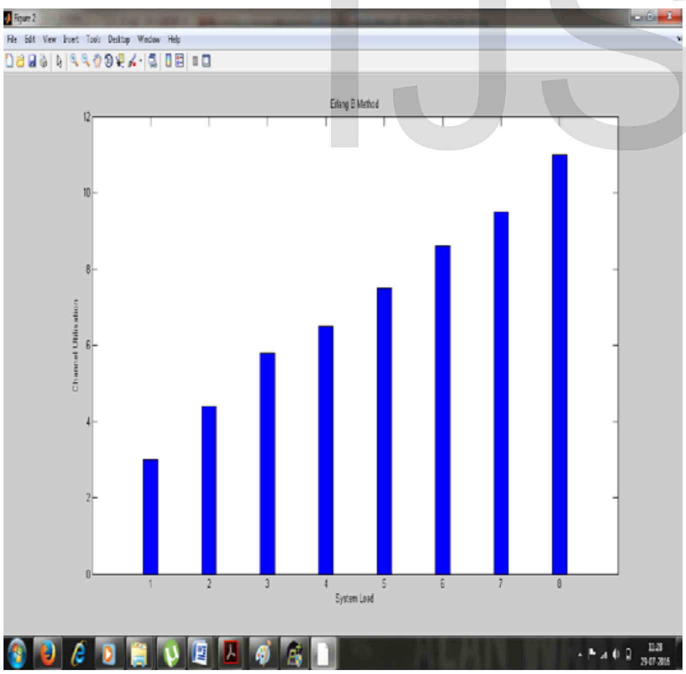

Figure 7: Channel Utilization versus System Load based Erlang Method.

Figure 8 show comparative analysis of channel utilization versus system load based on previous method and proposed erlang-B method.

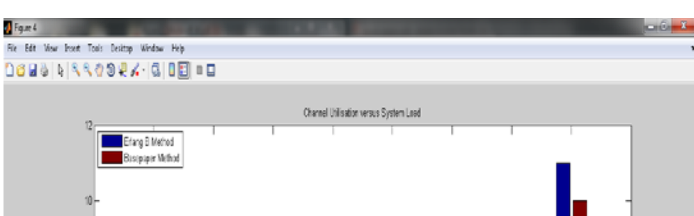

Figure 8: Comparison of Channel Utilization versus System Load based Previous Method and Erlang Method.

7 Conclusion

The variations of the new call blocking probabilities for the central main cell with the increasing offered load and the variations of the handoff call dropping probabilities for the central main cell with the increasing offered load is reduced to zero. As user uses static guard channels, numbers of available channels for new calls are less than previous approach. The proposed approach performs better in reducing handoff blocks at the cost of increased new call blocks. This is due to the fact that the Erlang B scheme scheduled the channel in the inner tier of all the cells. As a result it utilizes channels effectively to decrease the call blocks in inner tier. Further, the unused channels of the least congested neighbour cells are also utilized to serve the call requests originated in main cell, if needed. Hence, it can serve more call requests than the total number of available channels. At the same time, during congestion most of the unused channels from neighbour cells are also utilized in serving the call requests from the main cell. Further, since dynamic numbers of guard channels are used, channel utilization is efficient. Due to this, observe more channel utilization in case of the proposed scheme. For further extent of work, an efficient Artificial Intelligence (AI) can be utilized for channel utilization and call blocking probability in cellular network. Even more parameter can be used for new algorithm to improve handoff probability.

References

[1] Abhijit Sharma, Suvendu Konai and Uma Bhattacharya, "New Call and Handoff Call Management Scheme for Reuse Partitioning Based Cellular Systems," IEEE International Conference on Recent Advances and Innovations in Engineering (ICRAIE-2014), May 09-11, 2014, Jaipur, India.

[2] Er.Sukhdeep Kaur Sohal & Sehajpal Kaur "Blocking Probability of Dijkstra Shortest and Least Congestion Routing Algorithm in Wavelength-Routed WDM Network." International Journal on Recent and Innovation Trends in Computing and Communication. Volume: 2, Issue: 6, December 2014.

[3] Shalini Tripathi "A Survey on Blocking Probability in MPLS" International Journal of Advanced Research in Computer Science and Software Engineering. Volume: 4 Issue: 11, November 2014.

[4] Mrs.Mahalungkar Seema "Improved Call Blocking Probability Reducing Technique Using Auxiliary Stations" International Journal of Scientific & Engineering Research Volume: 4, Issue: 3, March 2013.

[5] Mrs.Mahalungkar Seema "A survey on call block probability reducing techniques" International Journal of Scientific and Research Publications, Volume: 2, Issue: 12, December 2012.

[6] Fenglin Li, Jianxun Chen "MPLS Traffic Engineering Load Balance Algorithm Using Deviation Path". International Conference on Computer Science and Service System, 2012.

[7] Partha Goswami, S.K. Ghosh2 and Debasish Datta "Dimensioning and Resource Provisioning for IP/MPLS-over WDM Network". IEEE Department of Electronics & Electrical Communication Engineering, Indian Institute of Technology, Kharagpur, 2011.

[8] Olabisi E.Falowo "Joint Call Admission Control Algorithm for Reducing Call Blocking/dropping Probability in Heterogeneous Wireless Networks Supporting Multihoming", Department of Electrical Engineering, University of Cape Town, South Africa, IEEE International Workshop on Management of Emerging Networks and Services, 2010.

[9] Eric W. M. Wong, Senior Member, IEEE, Jayant Baliga, Moshe Zukerman, Fellow, IEEE, Andrew Zalesky, and Garvesh Raskutti, "A New Method for Blocking Probability Evaluation in OBS/OPS Networks With Deflection Routing." Journal Of Lightwave Technology, Vol: 27, Issue no: 23, December, 2009.

[10] Fang Ya Quin , Wang Lin-Zhu, "An Algorithm of Static Load Balance based on Topology for MPLS Traffic Engineering". WASE International Conference on Information Engineering, 2009.

[11] Antonio Capone, Fabio Martignon, "Analysis of Dynamic QoS Routing Algorithms for MPLS Networks" IEEE Communications Society, 2004.

[12] Abhijit Sharma, Deepak Kumar, "Call Blocking Performance of New Reservation based Channel Assignment Scheme in Cellular" IJCA Special Issue on "2nd National Conference- Computing, Communication and Sensor Network" CCSN, 2011.

[13] Saravanan Kandasamy, Prihandoko, Borhanuddin Mohd.Ali, "New Call Blocking Probability (NCBP) in Improved Adaptive Quality of Service (AdQoS) for Wireless Multimedia Communications using Hierarchical Cellular Approach" 2003.

[14] Rana Ejaz Ahmed, "A Channel Allocation Algorithm for Hot-Spot Cells in Wireless Networks" journal of advances in information technology, vol. 1, no. 3, August 2010.

[15] Poonam B Bhilare, "Seamless handoff in Next Generation Wireless System" (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 2 (6), 2011.

[16] M.L.S.N.S. Lakshmi1 "An insight to call blocking probabilities of Channel assignment schemes" International Journal of Advances in Engineering & Technology, May 2012.

[17] Moshe Sidi and David Starobinski "New call blocking versus handoff blocking in cellular networks" Wireless Networks 3, 1997.

[18] Jon M. Peha and Arak Sutivong "Admission Control Algorithms for Cellular Systems" ACM/Baltzer Wireless Networks, 1999.

[19] Sridharan and K. N. Sivarajan, "Blocking in All-Op-tical Networks," IEEE/ACM Transactions on Networking, Vol. 12, No. 2, 2004, pp. 384-397.

[20] M. K. Dutta and V. K. Chaubey, "Priority Based Wave- length Routed WDM Networks: A Queuing Theory Ap-proach," International Journal of Recent Trends in Engineering (Electrical & Electronics), Vol. 1, No. 3, 2009, pp. 253-256.

[21] R. Guerin, "Queueing-blocking system with two arrival streams and guard channels," IEEE Transactions on Communications 36 (2) (1998) 153-163.

[22] F. M. Zhao, L. G. Jiang and C. He, "A Pre-emptive Horizontal Channel Borrowing and Vertical Traflic Overflowing Channel Allocation Scheme for Overlay Networks", IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences, Volume E91.A, Issue 6, pp. 1516-1528, Jun. 2008.

[23] S. Papavassiliou, L. Tassiulas and P. Tandon, "Meeting QoS Requirements in a Cellular Network with Reuse Partitioning", IEEE Journal on Selected Areas in Communications, vol. 12, no.8, pp. 1389-1400, Oct 1994.

[24] Joshi and G. Mundada, "A hybrid channel allocation algorithm to reduce call blocking probability using hot-spot notification," 5th International Conference on Information and Automation for Sustainability (ICIAFs), 2010 , vol., no., pp.404,410, 17-19 Dec. 2010.

[25] H. Jiang, "Simulation of Capacity and Performance of a Tiered Wireless System", IEEE Wireless Communications and Networking Conference. pp. 408 - 412, vol.1, 1999.