"Implementation of Adaptive Channel Scheme for Multi Class Traffic in Wireless Data Communication"

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Contents

Abstract

In this paper, a new scheme has been proposed to reduce the call blocking probability together with the proper uses of channel. Here, an adaptive channel scheme is being developed to reduce call blocking probability for three classes, based on priority and non-priority schemes. For both non-priority and priority schemes, channel utilization is limited. In our proposed adaptive scheme, channel utilization is not limited when compared with the others. By using this adaptive scheme, voice call, sms, internet connectivity are able to share their channel to each other. In this scheme, higher channel utilization and lower call blocking probability for the higher priority users can be maintained. The adaptive scheme is very effective to reduce the call blocking probability of higher priority users without sacrificing the channel utilization.

Chapter 1

Introduction

1.1 Introduction

Wireless communication is that type of communication in which free air is used as a communication medium. The uses of electromagnetic waves in wireless communication transmit or receive data and voice in open space. Distance doesn't matter in wireless communication of radio waves, such as a few meters for Bluetooth, Television or as far as millions of kilometers for deep-space radio communications. It comprehends various types of fixed, portable applications and mobiles including radios, personal (PDAs),cellular telephones and wireless networking. There are several examples of applications of radio wireless technology include GPS units, garage door openers, wireless computer mice, keyboards and headsets, headphones, receivers, broadcast, satellite and cordless telephones etc. Somewhat less common methods of achieving wireless communications include the utilize of other electromagnetic wireless technologies, such as magnetic, light, or electric fields or the use of sound wireless operations give services, such as global communications, that are impractical or impossible to perform with the use of wires. The expression is normally used in the telecommunications sector to indicate those telecommunications theory (e.g. radio transmitters, remote controls and receivers etc.) which transmits information without the use of wires by some form of energy (e.g. acoustic energy). Information is transferred in this form over both long and short distances.

Wireless devices perform in the similar radio frequency as more devices. Signals from other devices can interrupt wireless transmissions, or a WLAN device can interfere with another devices. Wireless network is any type of computer network that uses wireless data connections for connecting network nodes. Homes, telecommunications networks and enterprise installations avoid the costly process of introducing cables into a building by wireless networking method, or use it as a connection between various equipment locations. The use of radio communication in wireless telecommunications networks is generally implemented and administered .This utilization takes place at the physical level of the OSI model network structure. Examples of wireless networks include cell phone networks, wireless sensor networks, satellite communication networks, Wireless local networks and terrestrial microwave networks. The communication media executes same as a communication channel for connecting various computing devices so that they may connect with each other. Contemporary communication media facilitate data exchange and communication among a large number of individuals across long-winded distances via teleconferencing, email, Internet forums, etc. Traditional mass media channels such as TV, radio and magazines, newspaper, on the other hand, promote one-to-many communication. At present mobile communication is most general and practical example of wireless communication. This paper is stands for the archetype to communicate one to another via mobile phone, internet.

1.2 Objectives of this Thesis

The main objective of this thesis is to reduce the call blocking probability together with the proper use of channel by a new scheme named adaptive channel scheme. In this scheme, channel utilization is not limited. In addition, all types of communication by voice call, sms and internet connectivity are able to share with expanding or compressing individual’s pre-defined number of channels in each class. How we can increase channel for large population density in a small area by using scheme.

Chapter 2

Wireless mobile communication scheme

There is a lot of background study is being given to prepare this paper. A brief history on background study with wireless communication is given below,

2.1 Wireless Communication

Wireless communication commonly works through electromagnetic signals that are published by an enabled device within the air, physical environment or atmosphere. The sending device can be a sender or an intermediate device with the ability to propagate wireless signals. The communication between two devices occurs when the destination or receiving intermediate device captures these signals, creating a wireless communication bridge between the sender and receiver device. Wireless communication has various forms,
Technology and delivery methods including: Mobile communication, wireless network communication, Satellite communication, infrared communication, Bluetooth communication. Although all of these communication technologies have different underlying architecture, they all lack a physical or wired connection between their respective devices to initiate and execute communication.

Figure 2.1: Wireless communication

2.2 History of Wireless Communication

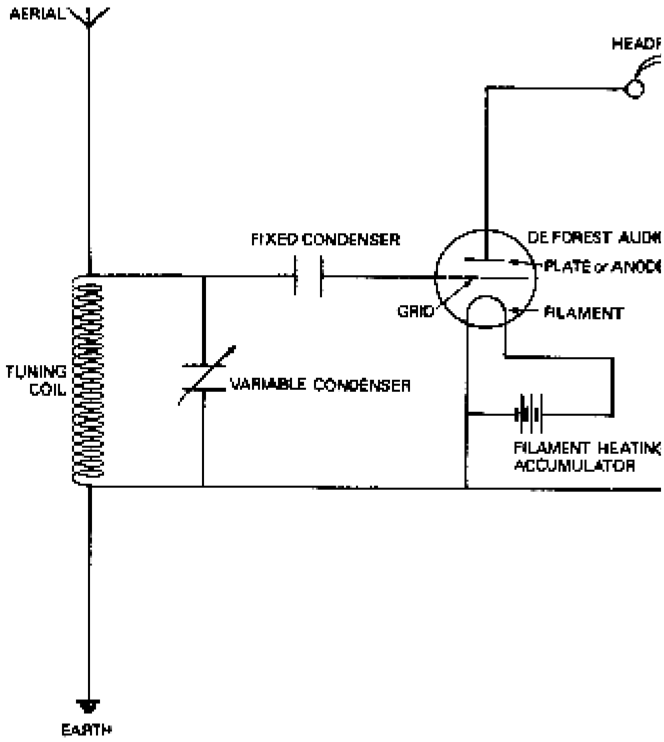
2.2.1 The pre-electromagnetic past

Communication systems using electrical and electronic technology have a significant impact on modern society. As the courier speeding from Marathon to Athens in 490 B.C. illustrates, in early history information could be exchanged only by physical transport of messages. Only a few examples exist of non-electrical communication techniques for transfer of information via other infrastructures than those for physical transport: smoke signals, signal flags in maritime operations and the semaphore are among them. Early attempts to communicate visual signals by means of the semaphore, a pole with movable arms, were made in the 1830's in France. A similar experimental system was used by the Dutch during the 'ten days campaign against the Belgian revolt in 1831 / 1832. In 1837, the House of Representatives passed a resolution requesting the Secretary of the Treasury to investigate the feasibility of setting up such a system in the United States. The market interest in enhanced communication systems was also clearly illustrated by the fact that in 1860 the Pony Express started regular physical message services over land in the U.S. But at the same time, electronic systems for communication had started to develop.

2.2.2 The wireless era

Telecommunication is defined by the ITU (International Telecommunication Union) which transmission, emission or reception of any signs, signals or messages by using electromagnetic systems. In 1832 the verification of (electrical) telegraphy by Joseph Henry and by Samuel F.B. Morse followed shortly after the discovery of electromagnetism by Hans Christian Oersted and Andre-Marie Ampere early in the 1820's. In the 1840's, the U.S. East Coast and in California built telegraph networks. In 1858 the first transatlantic cable was placed. In 1864, James Clerk Maxwell suggested for wireless propagation, which was confirmed and denoted by Heinrich Hertz in 1880 and 1887, respectively. Marconi and Popov started experiments in shortly about the radio-telegraph thereafter, and in 1897 Marconi permitted a complete wireless system.

We described the same thing by using radio and wireless for long times, but the difference being that radio was the American version of the British wireless. Because of there were no wires connecting to the transmitting station the receiver was called a wireless. The transmitting station radiated electromagnetic waves and it called radio. The British Broadcasting Company was the first who use the term of wireless, around 1923 and their program guide is "The Radio Times”. In 1876, Alexander Graham Bell permitted the telephone. Fleming formulated the diode 1904 and Lee de Forest invented triode in 1906 to make possible rapid development of long-distance (radio) telephony. Bardeen, Britain and Shockley invented the transistor, which used for integrated circuits, covered the way for miniaturization of electronic systems.



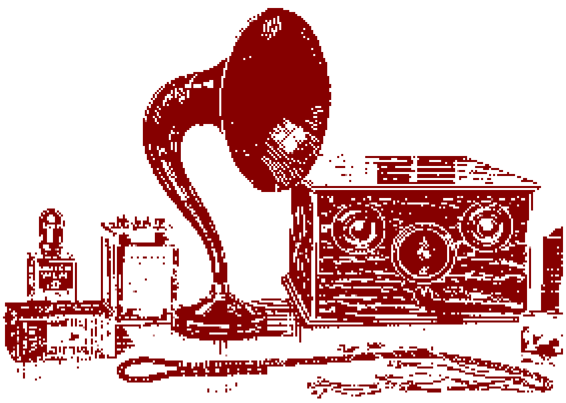


Figure 2.2:Radio times

2.2.3 Personal Communications

Micro-electronic circuits have recently made a huge rapid development of mobile and personal communication systems workable. This offer person-to-person communication, users can move freely and if desired eliminating the ineffective calls experienced with the fixed telephony service when the user is away from his or her terminal. It particularly services on employing mobile data communication become workable, such as automatic vehicle location (AVL) for fleet management, electronic mail, remote access to databases, vehicle printers or automatic repetition of the messages even if the driver has been away from the vehicle. Additionally, data communication is doing encryption and data processing possible.

In Denmark, Finland, Iceland, Norway and Sweden, the systems (earliest) providing automatic radiotelephony, the Nordic Mobile Telephone (NMT) cellular system, was based on a standard developed in close cooperation between the five different operators (PTT's) and competing manufacturers. NMT denoted the joint drive in European countries towards international cellular networks. Initially, US looked less able to develop and follow a common policy for mobile networking, even though in 1970 the Bell Laboratories had played a leading role in the novel cellular technology.

GSM is the first digital cellular telephony for European In 1992. But the GSM originated early in the 1980's as the French acronym for Group Special Mobile, the international working group tasked by most European PTT administrations to advance a common standard for cellular networks. The main advantages of a digital system are a larger user with highest capacity per unit of spectrum, ease of implementation of sophisticated encryption, authentication, and other security features, and robustness against radio channel imperfections.

Important Dates

→1864: James Clerk Maxwell proved the existence of electromagnetic waves.
→1887: Heinrich Hertz sent and received wireless waves, using a spark transmitter and a resonator receiver.
→1895: Guglielmo Marconi sent mores radio signals over more than a mile.
→1901: Marconi received the mores message "s" (...) sent across the Atlantic.
→1904: J.A. Fleming patented the diode.
→1906: Lee Deforest patented the triode amplifier. First speech wireless transmission, by Fessenden.
→1907: Commercial Transatlantic Wireless Service, using huge ground stations: 30x100m antenna masts
Beginning of the end for cable-based telegraphy.
→WW I: Rapid development of communications intelligence, intercept technology, cryptography.
→1915: Wireless voice transmission NY to SF.
→1920: Marconi discovers short wave radio, with wavelengths between 10 and 100 meters.
→1920: First commercial radio broadcast (in Pittsburgh)
→1921: Police car dispatch radios, Detroit.
→1930: BBC began television experiments.
→1935: First telephone call around the world.
→WW II: Rapid development of radio technology.
→1968: Carte phone decision.
→1974: FCC allocates 40 MHz for cellular telephony.
→1982: European GSM and Inmarsat established.
→1984: Breakup of AT&T.
→1984: Initial deployment of AMPS cellular system.

2.3 Mobile Phone

In North America, a mobile phone known as a cell phone. It is a portable telephone. It can make and receive calls through radio frequency link while the user is moving. The radio frequency link establishes a connection to the switching systems of a mobile phone operator, which provides to access the public switched telephone network (PSTN). Around 2000 era mobile phones provides text messaging, MMS, email, Internet access, short-range wireless communications (infrared, Bluetooth), business applications, video games, and digital photography. And those capabilities are known as feature. In 1973 the first handheld mobile phone was revealed by John F. Mitchell and Martin Cooper of Motorola, which weight was 2 kilograms (4.4 lbs). And In 1983, the first commercially available handheld mobile phone was the Dynastic 8000x. From 1983 to 2014, worldwide mobile phone subscriptions increase day by day (seven billion), penetrating 100% of the global population and reaching even the bottom of the economic pyramid. Samsung is the top Smartphone manufacturer, Apple, and Huawei(and "Smartphone sales represented 78 percent of total mobile phone sales").

Figure 2.3: Evolution of the Mobile phone

2.4 Radio Network

currently there are two types of radio networks operate around the world one of them is the one-to-many broadcast network, they commonly worked for public information and mass media entertainment; and the 2nd one is the two-way radio worked more commonly for public safety, security and public services such as police, fire, taxicabs, and delivery services. The Two-way type of radio network allowance many of the same technologies and components as the Broadcast type radio network though it is set up with fixed broadcast points with co-located receivers and mobile receivers/transmitters. In this mobile radio units can communicate with each other over broad geographic regions entire states/provinces or countries. In many ways multiple fixed transmit/receive sites can be interconnected to achieve the range of coverage which required by the administration or authority implementing the system: conventional wireless links in numerous frequency bands, fiber-optic links, or microwave links. The signals are typically backhauled to a central switch of some type where the radio message is activity and repeated to all transmitter sites where it is required to be heard. In contemporary two-way radio systems a concept called trucking is commonly used to achieve better efficiency of radio spectrum use and provide very wide-ranging coverage with no switching of channels required by the mobile radio user as it roams throughout the system coverage. Trucking of two-way radio is identical to the concept used for cellular phone systems where each fixed and mobile radio is specifically identified to the system Controller and its work is switched by the controller.

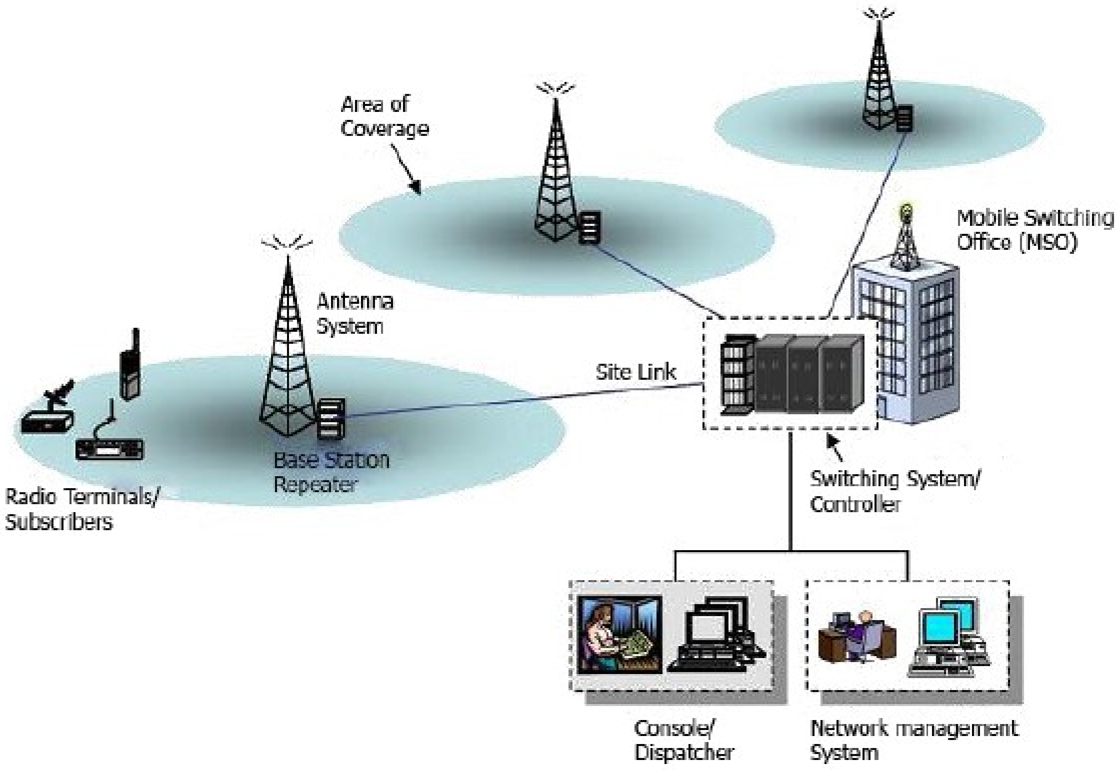


Figure 2.4: Radio network.

2.4.1 Features of Mobile Phone

The features are the set of capabilities, services and applications which offer for their users. Handsets with more approach computing ability through the use of local so try to differentiate their own products by adding additional functions to make them more attractive to customers. Now a day mobile phone is our important companion that aids us in both personal and professional. It is a tough decision when we go for a phone for ourselves. Some questions arise like do we go for the latest phone? Should we give priority to battery life or the phone's design? And the answer will depend on our own preferable. And our personal preference will take priority. In a poll on our social media channels, we asked you what the most important mobile feature was:

- Screen size or Battery

- Camera

-Design

Figure 2.5: Features of mobile phone

- Display
- Other

2.4.1.1 Voice Call

Voice call can be another way of communication among two or more person to share their opinion to each other. Voice call can be performed through different operators (e.g.Grameen Phone, Robi Axiata, Banglalink) and different mobile apps (e.g.Viber, Messenger, Tango, IMO, Whatsapp).

2.4.1.2 Text Message

When messages send from one cell phone to another cell phone by electromagnetically and communication is being performed by device that is Text Message.(e.g. Mobile phone messenger,Viber,Whatsapp,IMO).

2.4.1.3 SIM Card

The full form of SIM is subscriber identity module or subscriber identification module. SIM card contains unique information that identifies the specific mobile network, which allows the subscriber. If SIM cards cannot inserted correctly then phones aren’t working, phones cannot make calls, send messages, or connect to mobile internet services (3G, 4G, etc.).The first SIM cards size were like a credit card. But now, this time SIM cards look both Mini and Micro.

Here are the dimensions of the different types of SIM cards.

1. **Full SIM** - 85mm x 53 mm
2. **Mini SIM** - 25mm x 15 mm
3. **Micro SIM** - 15mm x 12 mm
4. **Nano SIM** - 12.3mm x 8.8 mm
5. **Embedded SIM** - 6mm x 5 mm

Figure 2.6: **SIM CARD**

2.4.1.4 Phone Operators

A mobile phone operator, wireless provider, provides wireless Internet GSM services for mobile device users. The operator gives a SIM card to the customer who inserts it into the mobile device that they can access to the service.

There are two types of mobile operators:

1. Mobile network operator (MNO)

2. Mobile virtual network operator (MVNO)

May 2016 China Mobile is the world's largest individual mobile operator and its subscribers around 835 million.50 mobile operators subscribers around 10 million each, and 150 mobile operators had at least one million subscribers by the end of 2009. By researching global penetration total mobile-cellular subscribers reached almost 6 billion by end 2011.

2.5 R-UIM

Removable User Identity Module (R-UIM) is a card developed for cdmaOne/CDMA2000 ("CDMA") handsets that increase the GSM SIM card to CDMA phones and networks. The R-

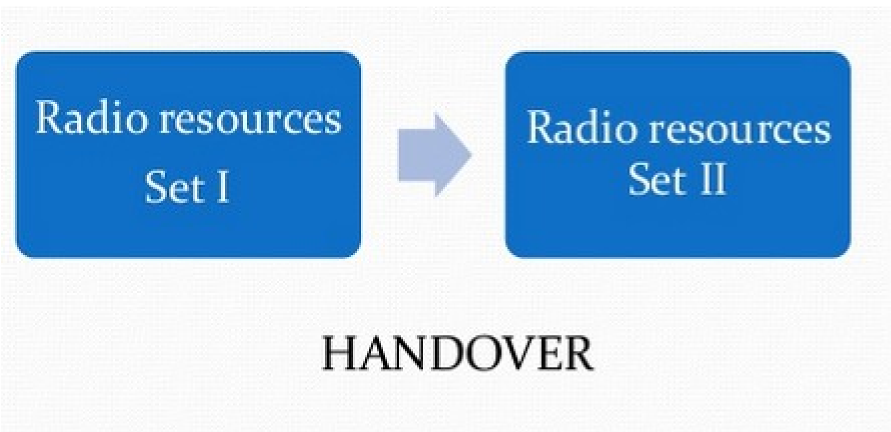
UIM carries an early version of the CSIM application. The card also contains SIM (GSM) application, so it can work for networks. It is physically suit with GSM SIMs and can fit into existing GSM phones. The R-UIM card has been replaced by CSIM on UICC. It allows three applications (SIM, CSIM, and USIM) to coexist on a single smartcard, and allowing the card to be used in virtually any phone worldwide that supports smart cards.

2.6 Cellular Traffic

This article studies about the mobile cellular network. Mobile radio networks have traffic issues but in PSTN that problems do not arise. Important features of cellular traffic include: quality of service targets, traffic capacity and cell size, spectral efficiency, traffic capacity, and channel holding time analysis etc. Telegraphic engineering in telecommunications network planning secures that network costs are reduced without compromising the quality of service (QoS) delivered to the user of the network. This field of engineering is based on probability theory, as well as other telecommunications networks. A moving mobile handset will record a signal strength that differs. Signal strength is a slow fading, fast fading and interference from other signals, resulting in degradation of the carrier-to-interference ratio (C/I). A high C/I ratio provides quality communication. A good C/I ratio is reached in cellular systems by using optimum power levels. Creating excessive interference the carrier power must be too high, and reducing the C/I ratio for other traffic and also reducing the traffic capacity of the radio subsystem. When carrier power is too low, C/I is too low.

2.7 Handover

HANDOVER is said have taken place .When mobile station moves from one set to another set. It provides more reliable access continuity in network connection. Here less chances of a call ends during moving of base stations in comparison to a Hard handoff. CDMA system use it that enables the overlapping of the repeater coverage zone and every cell phone set is always well within range of at least one of the base stations. Technical execution of a Soft handoff is more expensive and complex then Hard handoff. It is used in sensitive communication services like videoconferencing.



Types of handover:

1. HARD HANDOVER
2. SOFT HANDOVER
3. HORIZONTAL HANDOVER
4. VERTICAL HANDOVER

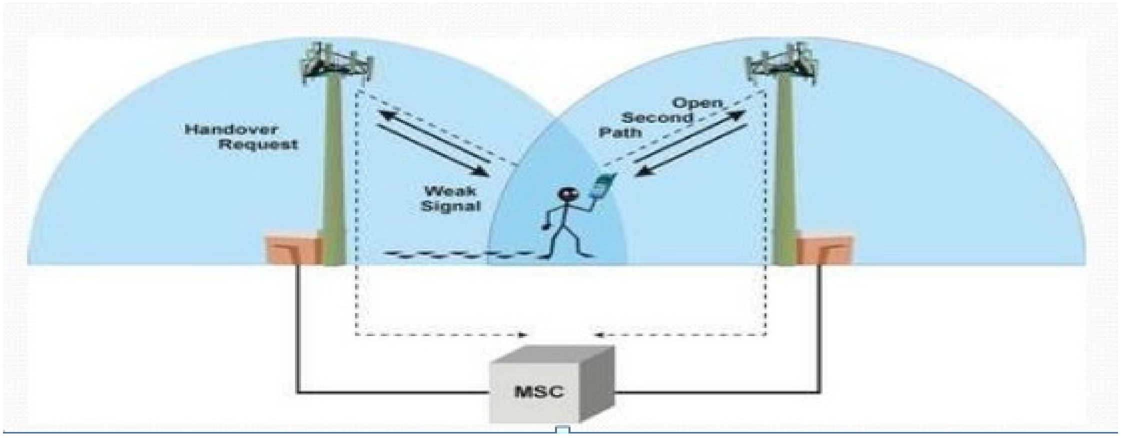


Figure 2.7: HANDOVER

Chapter 3
Various Network Schemes

3.1 Call Blocking

Call blocking, also known as call block, call rejection, or call screening allows a telephone subscriber to block incoming calls from specific telephone numbers. This article may require an extra payment to the sponsor’s telephone agency or a third-party. Call blocking is desired by individuals who wish to block unwanted phone calls. These generally include types of unsolicited calls from telemarketers and robocalls. Unwanted calls to landlines may be blocked through a number of methods. Some landline phones have built-in call blocking facilities. External call blockers are sold as telephone accessories which plug into existing phones. Such devices and services enable the user to block a call as it is in progress or alternatively block the number after the call is made. These devices rely on caller ID information and thus a phone blocker requires a caller ID service active on the line for blocking to function. It may also be possible to use computer software, in conjunction with the caller ID information from the phone company and a caller ID enabled phone modem to block an incoming call.

Treatment of blocked calls may include:

1. Sending caller to voicemail
2. Sending caller to "Number No Longer in Service"
3. Sending caller to "Keep Ringing"
4. Sending caller to busy signal

There is a multitude of third-party call blocking applications available for Smartphone’s while some manufacturers provide built-in call blocking functions as standard.

3.2 Class channel

In wireless communication system real time voice call, sms, internet connectivity etc. are the main activities. In every requested call or sms, a cell makes a connection with a user via different channels are consisting in individual classes. This individual channels are able to connect with individual users on the basis of priority. Priority plays a vital rule in the

Selection of channel and classes. The size of classes also depends on priority. For more priority size of class becomes greater and for less priority class size becomes lower. A wireless traffic system becomes single class for single request like just for voice call and multiclass for voice call, sms, internet connectivity etc. In this paper, multiclass traffic is going to be discussed

3.3 Multiclass Traffic

Cellular traffic is the internal system of a cellular system for which the overall mobile system is able to communication with different user. This traffic system is operated with the mobile operator and it deals with different predefined classes and channels. Cellular traffic is mostly used for various classes. This is known as multiclass traffic. An increasing demand of multi-class traffic has become a prime concern in wireless communication system. Quality of service is seen to be degrading to fulfill these demands. To handle multi-class traffic, already different schemes exist such as non-priority scheme, priority scheme channel reservation scheme, queuing scheme, etc. These schemes do not meet the requirements of minimizing the new call blocking probability and increasing the channel utilization at the same time. Here, we are proposing a new adaptive channel scheme for multi-class traffic system to minimize both the new call blocking probability of higher priority calls and keeping the channel utilization in a suitable range so that, both the performance metrics are optimized and thus provides good quality of service. In our adaptive channel scheme, guard channels are reserved adaptively on the basis of the arrival rates of the traffic classes and the number of channels occupied. In this paper at first we discuss different schemes for multi- class traffic system, and then discuss different problems in these schemes. Then, we introduce our proposed scheme, mathematical modeling and queuing analysis of it and at last we show the improvement in our scheme through performance analysis.

3.4 Channel Utilization

Channel utilization means the proper uses of channel in different classes. As channel utilization, two types of scheme are used called non-priority scheme and priority schemes. Both are going to be discussed for voice call and sms.

3.5 Queuing Analysis

In this section, non-priority and priority schemes has been discussed for a single traffic system such as either a voice call or a sms system. Here, it is assumed that a system has many cells, with each having S channels. The channel holding time has an exponential distribution with mean rate μ. Both originating and handover calls are generated in a cell according to Poisson processes, with mean rates and, respectively. The system is assumed to be with a homogeneous cell. We focus on a single cell (called a marked cell). Newly generated calls in the marked cell are labeled originating calls (or new calls). A handover request is generated in the marked cell when a channel holding MS approaches the marked cell from neighboring cell with a single strength below the handover threshold.

3.6 Non-Priority Scheme

Consider the number of channels is ‘□’. In this scheme, all ‘□’ channels are shared by both real time voice call and sms requests. The sms request is handled exactly in the same way or share the overall channel as like as voice call. A system model for non

-priority scheme is given below

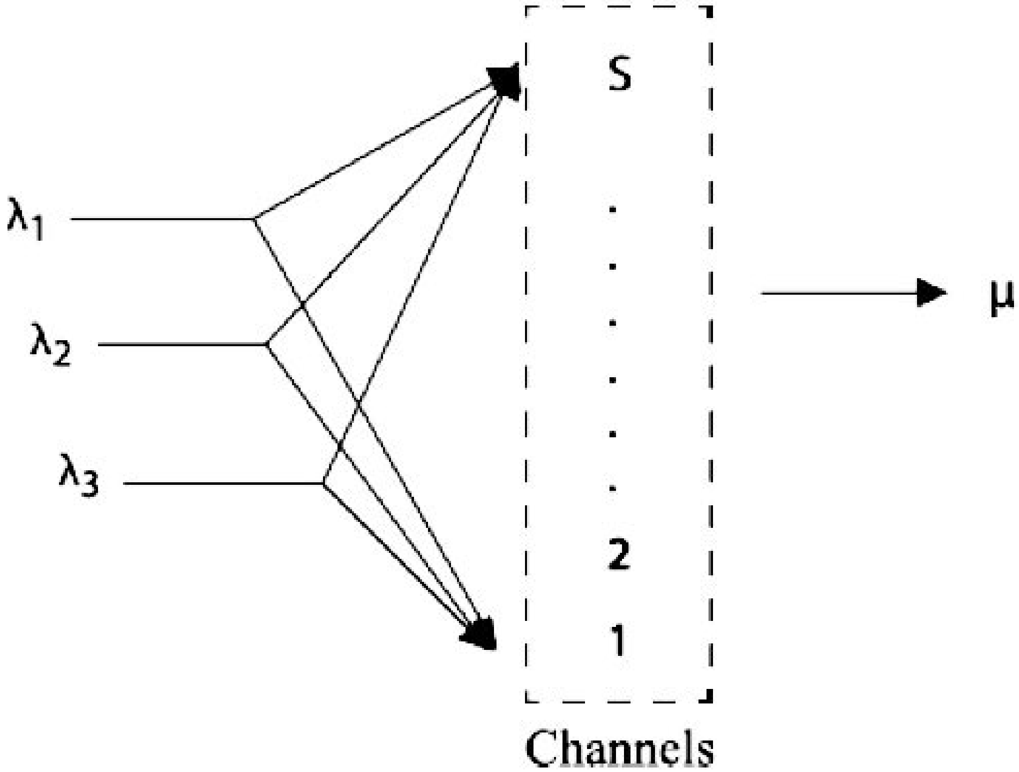


Figure 3.1: System model for non-priority scheme

Here, λ_1, λ_2, and λ_3 denote respectively the arrival rate (probability of arrival per time unit) of class 1, class 2 and class 3. Both classes can utilize total channels. The other factor here μ is the mean rate. If there is no empty channel is available, the call becomes blocked. In this scheme, priority in different class is absent. As a result forced termination probability is relatively higher.

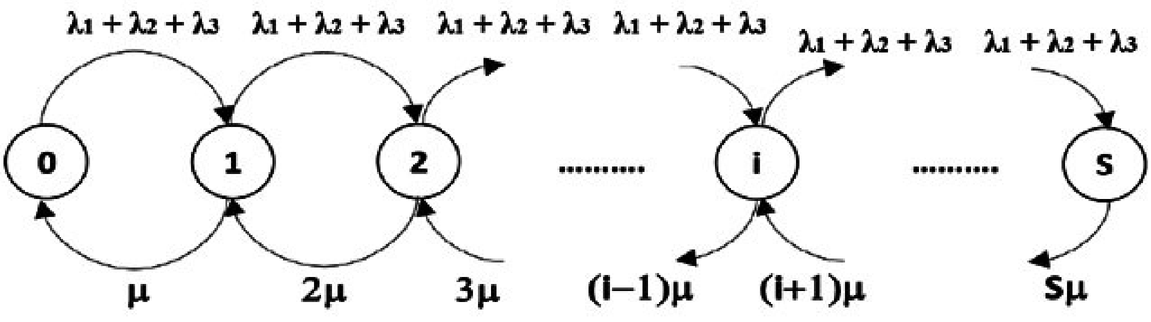


Figure 3.2: State transition diagram for Non- priority scheme

Let, $P(i)$ be the probability that the system is in state i. The probabilities $P(i)$ can be determined in the usual way for birth-death process. From figure the state equilibrium equation is,

$$P(i) = \frac{\lambda_1+\lambda_2+\lambda_3}{i\mu} p(i-1) \quad , \qquad 0 \le i \le S \qquad \ldots (1)$$

Using the above equation recursively, along with the normalization condition

$$\sum_{i=0}^{s} p(i) = 1 \qquad \ldots (2)$$

The steady-state probability $P(i)$ is easily found as follows:

$$P(i) = \frac{(\lambda_1+\lambda_2+\lambda_3)^i}{i!\mu^i} P(0), \qquad 0 \le i \le S \qquad \ldots (3)$$

Where,

$$P(0) = \frac{1}{\sum_{i=0}^{s} \frac{(\lambda_1+\lambda_2+\lambda_3)^i}{i!\mu^i}} \qquad \ldots (4)$$

The blocking probability P_B for an originating call is,

$$P_B = P(S) = \frac{\frac{(\lambda_1+\lambda_2+\lambda_3)^s}{S!\mu^s}}{\sum_{i=0}^{s} \frac{(\lambda_1+\lambda_2+\lambda_3)^i}{i!\mu^i}} \qquad \ldots (5)$$

The blocking probability P_D of a handover request is,

$$P_D = P_B \qquad \ldots (6)$$

Equation (5) is known as the Erlang-B formula.

3.7 Priority Scheme

In this scheme, priority for calls or data is divided into individuals among the ‘□’ channels. Let, λ_1 is the arrival rate for class 1, λ_2 for class 2 and λ_3 for class 3 and □ is the mean rate. Class 1, class 2 and class 3 can be used 1 □□ S_c channels. But the S_b – S_c channels are only to be used for class 2 and class 3. Finally □– S_b channels are used for only class 3. Here, the priority for class 1 is less than class 2 as well as class 3. So, class 3 has the higher priority and class 1 has the lower priority. A system model for Priority scheme is given below,

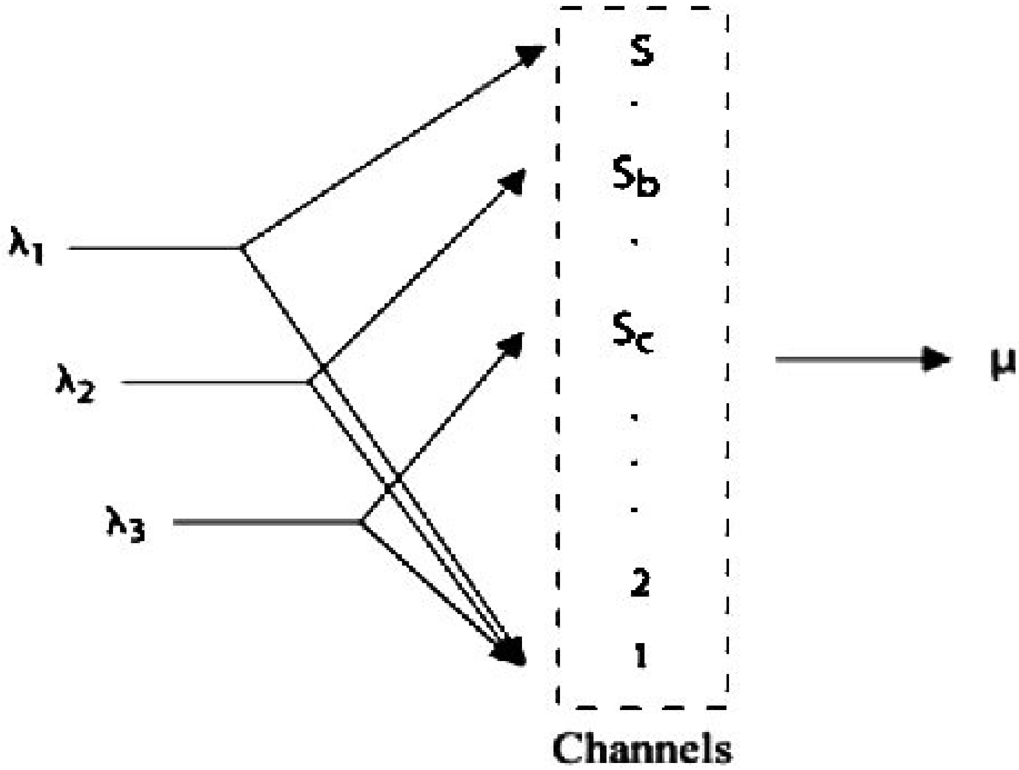


Figure 3.3: System model for Priority scheme

If the number of available channels in the cell is less or equal to □– S_b , the call will be blocked. But here, call dropping probability is less than non-priority scheme for specific prioritized channel.

But here, having higher priority in a specific class, channel utilization becomes decreased for lower prioritized class. As a result, call blocking rate of lower class increases.

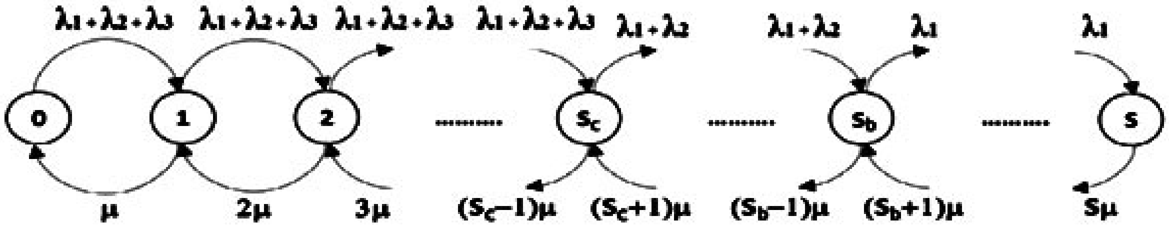


Figure 3.4: State transition diagram for priority Scheme

From the figure, the state balance equations are

$$i\mu P(i) = \begin{cases} (\lambda_1+\lambda_2+\lambda_3)P(i-1) & 0 \le i \le S_C \\ (\lambda_1+\lambda_2)P(i-1) & S_C \le i \le S_b \\ \lambda_1 P(i-1) & S_b \le i \le S \end{cases} \qquad \text{...... (7)}$$

Using this equation recursively, along with the normalization condition,

$$\sum_{i=0}^{s} P(i) = 1 \qquad \text{...(8)}$$

The steady-state probability P (i) is easily found as follows:

$$P(i) = \begin{cases} \frac{(\lambda_1+\lambda_2+\lambda_3)^i}{i!\,\mu^i} P(0) & 0 \le i \le S_c \\ \frac{(\lambda_1+\lambda_2+\lambda_3)^{S_c}(\lambda_1+\lambda_2)^{i-S_c}}{i!\,\mu^i} P(0) & S_C \le i \le S_b \\ \frac{(\lambda_1+\lambda_2+\lambda_3)^{S_c}(\lambda_1+\lambda_2)^{S_b-S_c}\lambda_1^{i-S_b}}{i!\,\mu^i} P(0) & S_b \le i \le S \end{cases} \qquad \text{... (9)}$$

Where,

$$(\lambda_1+\lambda_2+\lambda_3)^{S_c}\frac{(\lambda_1+\lambda_2)^{S_b-S_c}\text{¿}\lambda_1^{i-S_b}}{i!\,\mu^i}$$

$$P(0)=\frac{(\lambda_1+\lambda_2+\lambda_3)^i}{i!\,\mu^i}+\sum_{i=S_c+1}^{S_b}(\lambda_1+\lambda_2+\lambda_3)^{S_c}\frac{(\lambda_1+\lambda_2)^{i-S_c}\text{¿}}{i!\,\mu^i}+\sum_{i=S_b+1}^{S}\text{¿}$$

$$\sum_{i=0}^{S_c}\text{¿}$$

$$\text{¿}$$
$$\text{¿}$$
$$\text{¿}$$

….. (10)

The blocking probability P_B for an originating call is given by,

$$P_B = \sum_{i=S_c}^{S} P(i) \qquad \text{…(11)}$$

Here again, a blocked handover request call can still maintain the communication via current BS until the received signal goes below the receiver threshold or the conversation is completed before the received signal strength goes below the receiver threshold. The equations of channel utilization for non-priority and priority scheme are respectively,

$$\frac{(1-P_B)\lambda_1+(1-P_B)\lambda_2+(1-P_B)\lambda_3}{\mu\times N}\times 100 \qquad \text{…(12)}$$

And

$$\frac{(1-P_{B1})\lambda_1+(1-P_{B2})\lambda_2+(1-P_{B3})\lambda_3}{\mu\times N}\times 100 \qquad \text{……(13)}$$

The equation (3) and (9) are simulated in MATLAB and the following figure is found,

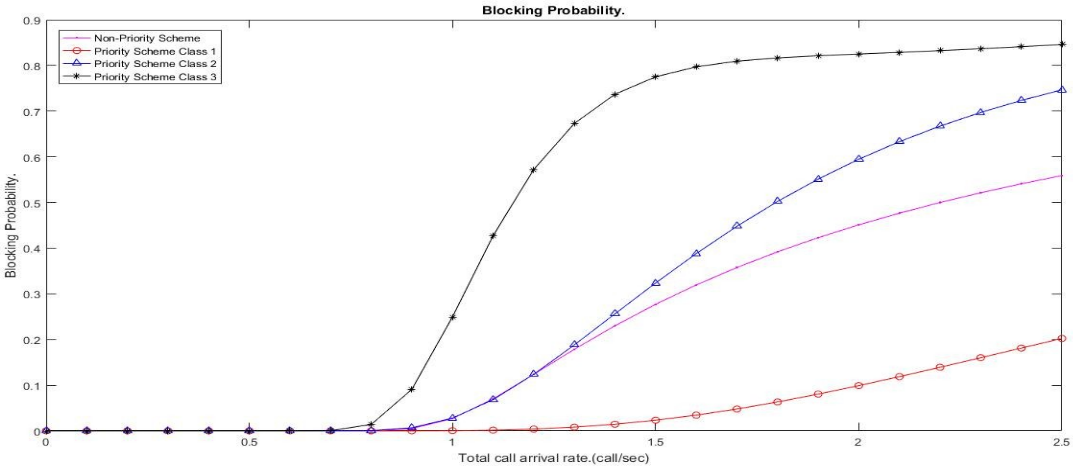


Figure 3.5: Comparison of new call blocking probability

The equation (12) and (13) are simulated in MATLAB and the following figure is found,

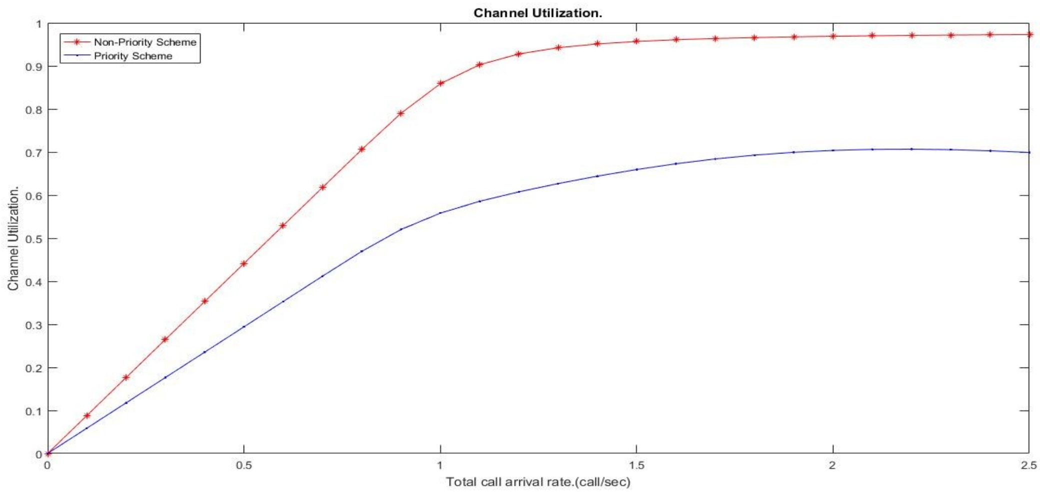


Figure 3.6: Comparison of channel utilization

Chapter 4
Proposed Idea and Methodology

4.1 Proposed Idea

For both non- priority and priority schemes, channel utilization scope is limited. In this paper, a new scheme is being proposed to reduce call blocking probability together with increase channel utilization named adaptive channel scheme. In this scheme, channel utilization is not limited. In addition, all types of communication by voice call, sms and internet connectivity are able to share with expanding or compressing individual's pre-defined number of channels in each class. A brief of adaptive method is being discussed in methodology.

4.2 Methodology

To describe the adaptive channel scheme, consider total number of channels are 'S'.

Total 'S' channels are consisting in three classes are respectively class 1, class 2 and class 3. Here, priority of class 1 is less than class 2 as well as class 3. Here, μ is mean rate. A system model for adaptive scheme with three different classes are given below,

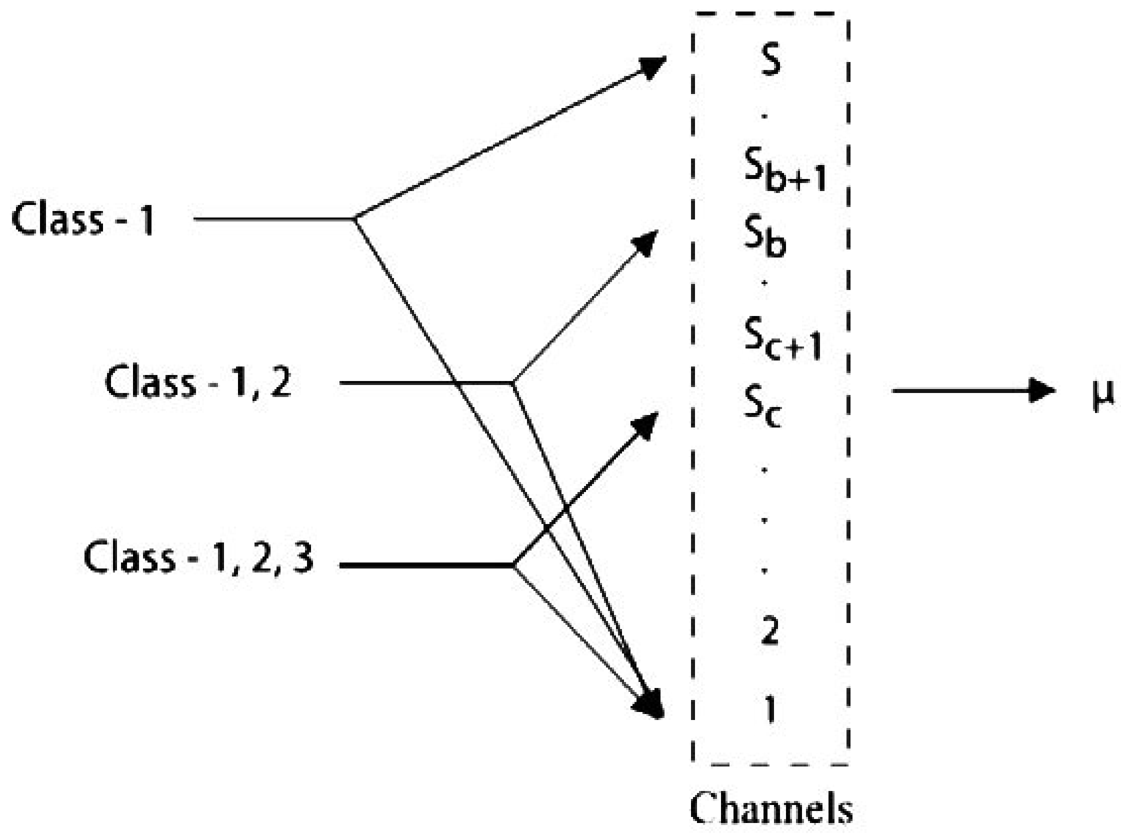


Figure 4.1: System model for adaptive channel scheme

This scheme is similar with the priority scheme. But, little difference changes the overall concept. In priority scheme length of classes are fixed like for class 1 is 1 to S_c , length of class 2 is 1 to S_b etc. But, in adaptive scheme the length of classes are variable. That means for class 1, S_c can be expanded to S_c+1 or more and compressed to S_c-1 or less etc. This method becomes a proper utilization for the overall channel.

4.3 Adaptive Channel Scheme

There are many types of schemes to handle multi-class traffic in wireless network. We propose an adaptive channel reservation scheme in which we only deals with three classes- class 1, class 2, class 3. Class 1 has the highest priority and class 3 has the lowest priority. Here no priority channel is reserved for priority class1 and priority class 2.We use some factors on the basis of which the number of reserved channels for class 1 and class 2 traffics have been made adaptive. Thus the channel utilization is high and the blocking probability of the classes reduces with respect to the other schemes.

4.4 Mathematical Modeling

The mathematical modeling of our proposed adaptive scheme has been done on the almost same way as the non-priority and priority schemes. But here we introduce some factors on the basis of which the reservation of channels for the different classes will be determined.
Let,

The total number of channels = N_1

Number of classes = 3

Call arrival rate for class 1 = λ_1

Call arrival rate for class 2 = λ_2

Call arrival rate for class 3 = λ_3

Fixed number of minimum common channels for class 1 & class 2 = M_1

Fixed number of minimum common channels for all classes = M_2

Blocking probability for class 1 = B_{P_1}

Blocking probability for class 2 = B_{P_2}

Blocking probability for class 3 = B_{P_3}

Average call life time = $\frac{1}{\mu_c}$

Dwell time = $\frac{1}{\eta}$

Channel holding time becomes,

$$\frac{1}{\mu} = \frac{1}{\eta+\mu_c}$$

.... (1)

Proposed factor for priority 1: $f_1 = \frac{\left[\left(1-B_{P_1}\right)\lambda_1\right]\frac{1}{\mu}}{N_1}$; $\alpha_1 = \frac{\lambda_1}{\lambda_1+\lambda_2+\lambda_3}$

…(2)

Proposed factor for priority 2: $f_2 = \frac{\left[\left(1-B_{P_2}\right)\lambda_2\right]\frac{1}{\mu}}{N_2}$; $\alpha_2 = \frac{\lambda_2}{\lambda_1+\lambda_2+\lambda_3}$ ….

(3)

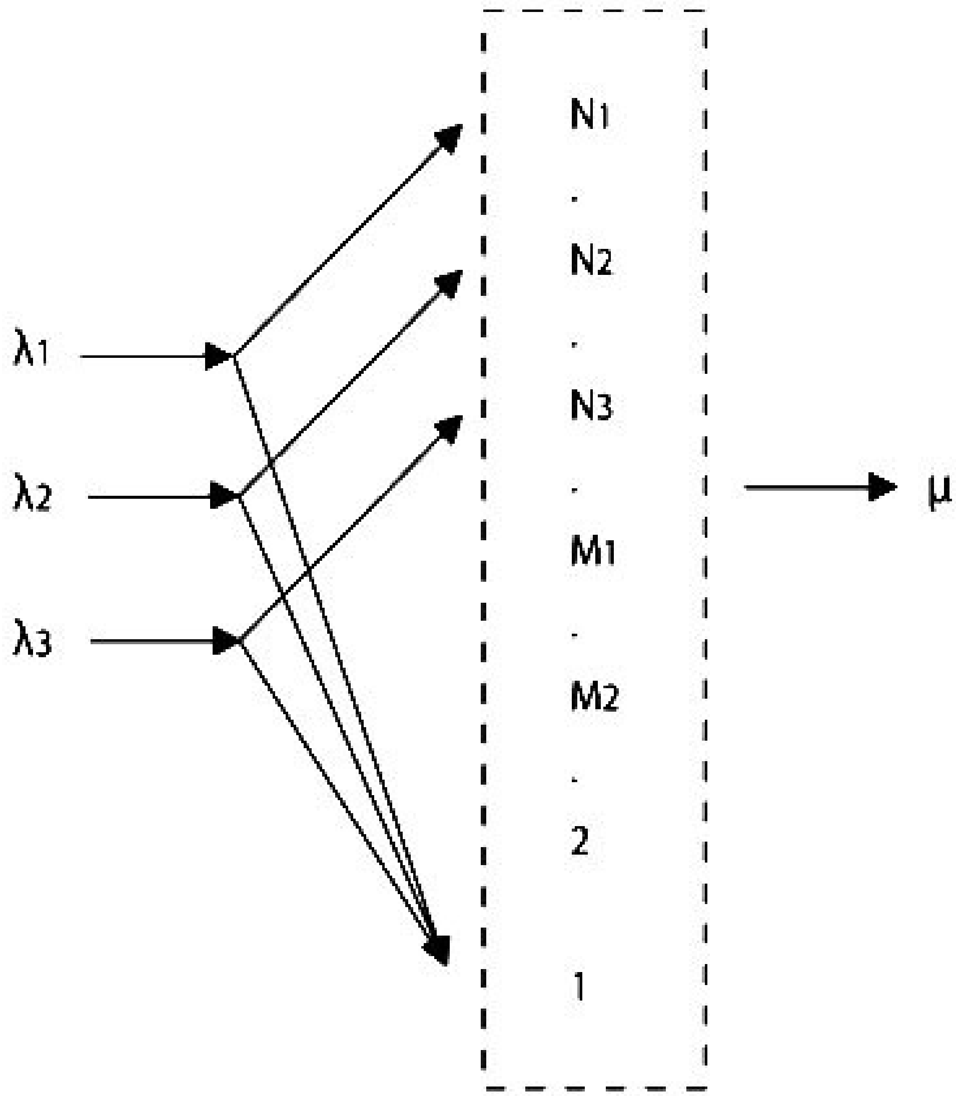


Figure 4.2: A generic system model for Proposed Adaptive Channel Reservation Scheme.

Number of channels reserved only for class 1 traffic, $X_1 = f_1\alpha_1 (N_1 - M_1)$ …(4)

Number of channels reserved only for class-1 and class 2 traffic, $X_2 = f_2\alpha_2 (N_1 - M_2)$ ….(5)

The number of channels available for the traffic class 2, $N_2 = N_1 - X_1$ . ...(6)

The number of channels available for the traffic class 3, $N_3 = N_2 - (X_1 + X_2)$ …(7)

A generic model of the proposed scheme has been shown in Fig. 4.2.

We define the state i ($i=0, 1,\ldots N_1$) of a cell as the number of calls in progress for the BS of that cell.
Let, $P(i)$ represent the steady-state probability that the BS in the state i. The probabilities $P(i)$ can be determined in the usual way for birth-death processes. The relevant state transition diagram is shown in Fig. 4.3.

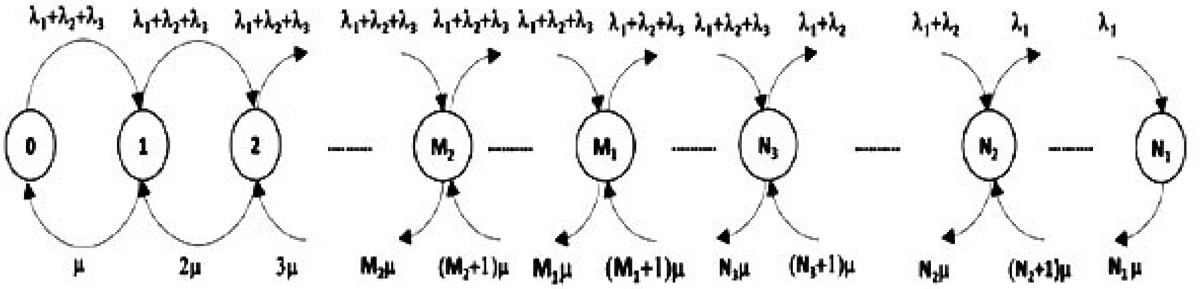


Figure 4.3: State transition diagram for proposed adaptive scheme

A system in statistical equilibrium will possess the average rates of entering a state equal. So, at state 0, we find

$$\mu P(i) = (\lambda_1+\lambda_2+\lambda_3)P(0) \qquad \ldots..(8)$$

So, solving for $P(i)$, we have,

$$P(i) = \frac{(\lambda_1+\lambda_2+\lambda_3)}{\mu} P(0) \qquad \ldots.(9)$$

Now consider state 1. The average rate of entering state 1, $2\mu P(2)+(\lambda_1+\lambda_2+\lambda_3)P(0)$. Proceeding in the same manner, the average rate of leaving state 1 is found to be given by $(\lambda_1+\lambda_2+\lambda_3+\mu)P(1)$. Equating these two transition rates to provide a balance of arrivals and departures from state 1, we get

$$(\lambda_1+\lambda_2+\lambda_3+\mu)P(1)=)(\lambda_1+\lambda_2+\lambda_3)P(0)+ 2\mu P(2) \qquad \ldots.(10)$$

This given equation,

$$P(2) = \frac{(\lambda_1+\lambda_2+\lambda_3)^2}{2\mu.\mu} \text{ P}(0)$$

...(11)

Continuing in this manner by setting up a balance equation at each state $i \leq (N_3 - 1)$, equating average arrivals and departures at a state to maintain statistical equilibrium, we find, for the state probability at state i, $1 \leq i \leq N_3$

$$P(i) = \frac{(\lambda_1+\lambda_2+\lambda_3)^i}{i!\mu^i} \text{ P}(0) \qquad 1 \leq i \leq N_3$$

......................(12)

Now, we can consider the states $i = N_3$ to N_2. This is the acting reserved channel region for class-1 and class-2. The state probability at state i,

$$\text{P(i)} = \frac{(\lambda_1+\lambda_2+\lambda_3)^{N_3} ¿ (\lambda_1+\lambda_2)^{i-N_3} ¿}{i!\mu^i} \text{ P(0)} \qquad N_3 \leq i \leq N_2 \qquad \text{….(13)}$$

Now, we can consider the states $i = N_2$ to N_1. This is the acting reserved channel region for class-1 only. The state probability at state i,

$$\text{P(i)} = \frac{(\lambda_1+\lambda_2+\lambda_3)^{N_3} ¿ (\lambda_1+\lambda_2)^{N_2-N_3} ¿ \lambda_1^{i-N_2}}{i!\mu^i} \text{ P(0)} \qquad N_3 \leq i \leq N_2 \qquad \text{…..(14)}$$

Using this equation recursively, along with the normalization condition,

$$\sum_{i=0}^{S} P(i) = 1 \qquad \text{… (15)}$$

The steady-state probability $P(i)$ is easily found as follows,

$$\frac{(\lambda_1+\lambda_2+\lambda_3)^i}{i!\mu^i}P(0)1\le i\le N_3$$
¿

P(i) = $$(\lambda_1+\lambda_2+\lambda_3)^{N_3}\frac{(\lambda_1+\lambda_2)^{i-N_3}}{i!\mu^i}P(0)N_3\le i\le N_2$$ ..(16)

$$¿(\lambda_1+\lambda_2+\lambda_3)^{N_3}\frac{(\lambda_1+\lambda_2)^{N_2-N_3}\lambda_1^{i-N_2}}{i!\mu^i}P(0)N_2\le i\le N_1$$
¿

Where,

P(0)= $$\frac{(\lambda_1+\lambda_2+\lambda_3)^{N_3}\frac{(\lambda_1+\lambda_2)^{N_2-N_3}\lambda_1^{i-N_2}}{i!\mu^i}}{\frac{(\lambda_1+\lambda_2+\lambda_3)^i}{i!\mu^i}+\sum_{i=N_3+1}^{N_2}(\lambda_1+\lambda_2+\lambda_3)^{N_3}\frac{(\lambda_1+\lambda_2)^{i-N_3}}{i!\mu^i}+\sum_{i=N_2+1}^{N_1}¿\;\sum_{i=0}^{N_3}¿}$$ ......

¿
¿
¿

(17)

The blocking probability B_{P_1} for class-1 is given by,

$$B_{P_1} = (\lambda_1+\lambda_2+\lambda_3)^{N_3}\frac{(\lambda_1+\lambda_2)^{N_2-N_3}\lambda_1^{N_1-N_2}}{N_1!\mu^{N_1}}\;P(0)$$ ...... (18)

¿

The blocking probability B_{P_2} for class-2 is given by

$$B_{P_2} = \frac{(\lambda_1+\lambda_2+\lambda_3)^{N_3}\frac{(\lambda_1+\lambda_2)^{N_2-N_3}\lambda_1^{i-N_2}}{i!\mu^i}P(0)}{\sum_{i=N_2}^{N_1}¿}$$ ... (19)

The blocking probability B_{P_3} for class-3 is given by

$$B_{P_3} = \sum_{i=N_3}^{N_1} P(i) = B_{P_2} + \frac{(\lambda_1+\lambda_2+\lambda_3)^{N_3} \frac{(\lambda_1+\lambda_2)^{i-N_3} \text{¿}}{i!\mu^{i}}}{\sum_{i=N_3}^{N_2-1} \text{¿}} \quad P(0) \qquad \ldots.$$

(20)

The equation for channel utilization is,

$$\% \text{ Channel utilization} = \frac{\left[\left(1-B_{P_1}\right)\lambda_1\right]+\left[\left(1-B_{P_2}\right)\lambda_2\right]+\left[\left(1-B_{P_3}\right)\lambda_3\right]}{\mu N_1} \times 100$$

… (21)

The flow diagram for proposed adaptive channel scheme is given below,

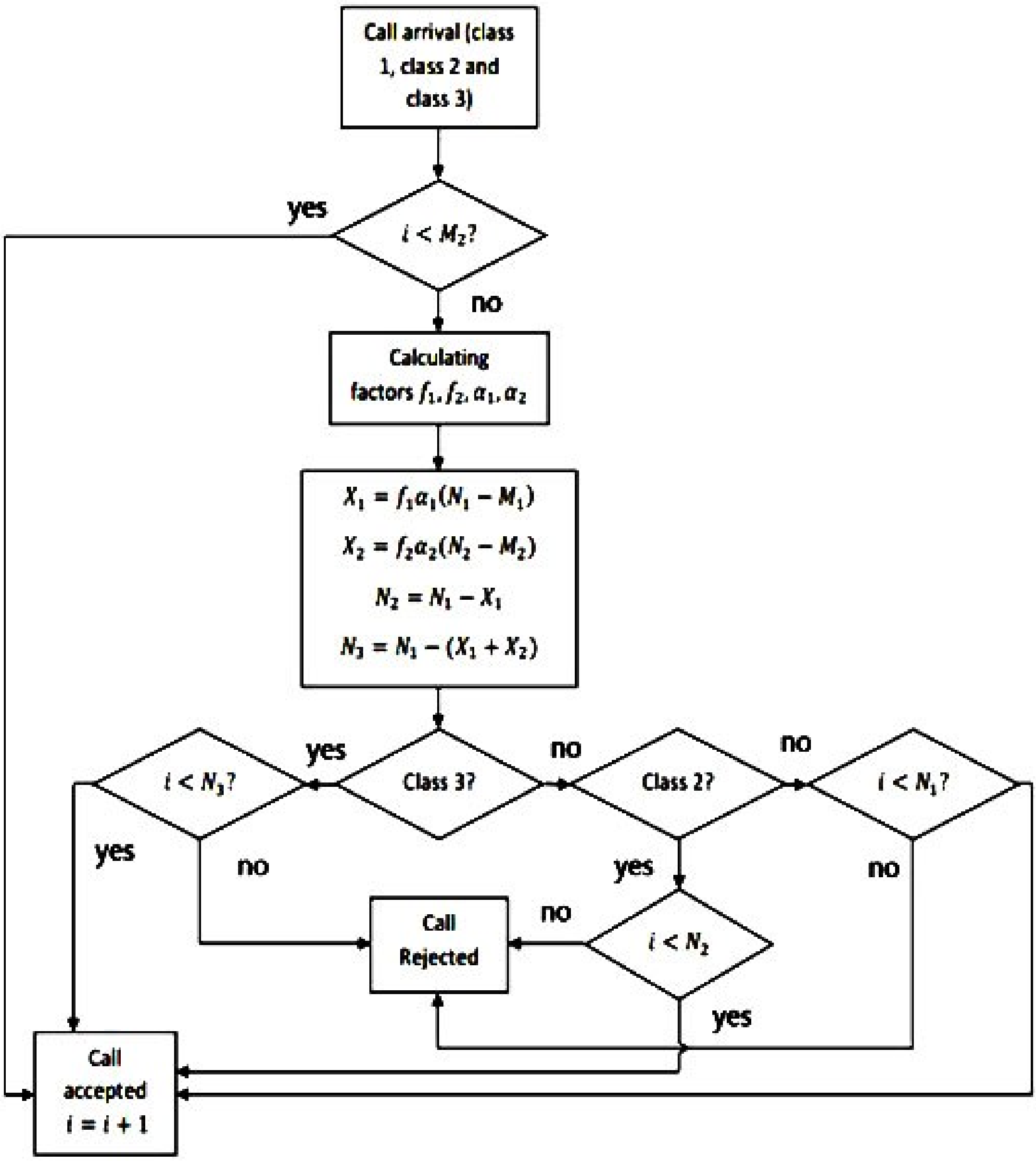


Figure 4.4: The flow diagram of the proposed Adaptive Channel Scheme

The guard channel reservation strategy of the proposed adaptive scheme is shown in Fig 5.4. For any traffic arrived in the cell at first it searches the minimum number of fixed channels for all the classes are empty or not and if it finds free channels in the minimum fixed channels range M_3 the call will be accepted. If no channel is empty in this range, then by calculating the factors α_1 , α_2 , f_1 and f_2 on the basis of the channels occupied and the arrival rate of the traffics, the range N_3 and N_2 are determined is the variable channels range available for the priority 3 and priority 2 traffic classes. If the call arrived is of traffic class-3 and no channel is empty in the range N_3 then the call will be rejected. When class-2 call arrives then if in the range N_2 any channel is empty, the call will be assigned and if no channel is empty then the call is rejected. Now when the call is of class-1 then in the range N_1 if no channel is empty, the call will be rejected but if any channel is empty then the call will be assigned.

4.5 Analysis of Proposed Scheme

In this state, we have established the act of the proposed scheme. We compared the act of the proposed scheme with priority scheme and non-priority channel reservation scheme for multi-class traffic system. The major performance metrics considered here are: new call blocking probability and channel utilization.

Here we are assigning with three classes: class 1, class 2 and class 3 and we assume themselves as voice call, sms and internet connectivity respectively. Voice call has been given more priority than sms and internet connectivity, while sms has been given more priority than internet connectivity. So voice call, sms and internet connectivity are priority 1, priority 2 and priority 3 traffic classes for our analysis.

In non-priority scheme no priority is given to any class of traffic. So the overall new call blocking probability of all classes remains same. But in this case because of giving no priority to the upper class traffic so that there will be more blocking of these traffics which is totally unexpected and not desirable.

In priority channel scheme there are some priority channels for the upper class traffics and they have been given more priority. So that the blocking probability of the highest priority traffics are lowered by giving some increase in the blocking of the lowest priority traffic classes. But due to the reservation of the channel for the highest priority traffics gives poor channel utilization.

In the proposed adaptive channel scheme the guard channels have been made adaptive so that they can be used most efficiently by all the classes on the basis of their priority and on the basis of their arrival rate and number of channels used. So in this case the channel utilization can be found very high than the priority channel scheme and slightly lower than the non-priority scheme. This scheme also minimizes the blocking probability of the highest priority traffics which the main advantage of this scheme.

The input parameters for the analysis are total number of channels (N_1), number of guard channels, average call life time $\left(\frac{1}{\mu_c}\right)$, average dwell time $\left(\frac{1}{\eta}\right)$ and new call arrival rate (calls/sec). Table.1 shows the assumptions of the parameters, which were used to perform the analysis. The parameters were same for all the schemes which have been stated here

Table. 1: The Basic assumptions of the parameters for performance analysis.

Average call life time ($\frac{1}{\mu_C}$)	120 sec
Average dwell time $\left(\frac{1}{\eta}\right)$	360sec
Total number of channels in a cell (N)	100
Call arrival rate: $\lambda_1 : \lambda_2 : \lambda_3$	1:2:3

Fig. 4.5 presents the performance of the multi-class traffic system in the case of new call blocking probability. Here we can see that our proposed scheme shows a better performance than the priority and non-priority channel schemes. For non-priority scheme, the blocking probability of all three classes are same and so that the blocking probability of class-1 and class-2 traffic are very high with respect to our proposed scheme. In case of priority channel scheme the blocking probability of the class 1 and class 2 are lower than the non-priority scheme but for class 3 it is higher than the non-priority scheme because the class 1 and class 2 have been given more priority than the class 3 traffic and the blocking probability of the class 1 and class 2 are improved by sacrificing for class 3. But in our proposed scheme the blocking probability for class 2 and class 3 have been more improved than the priority channel scheme. The blocking probability of the class 1 traffic is slightly greater than the priority channel scheme but the amount is negligible and we can take these two quantities equal. So our proposed scheme shows an overall better performance than the non-priority and the priority channel schemes.

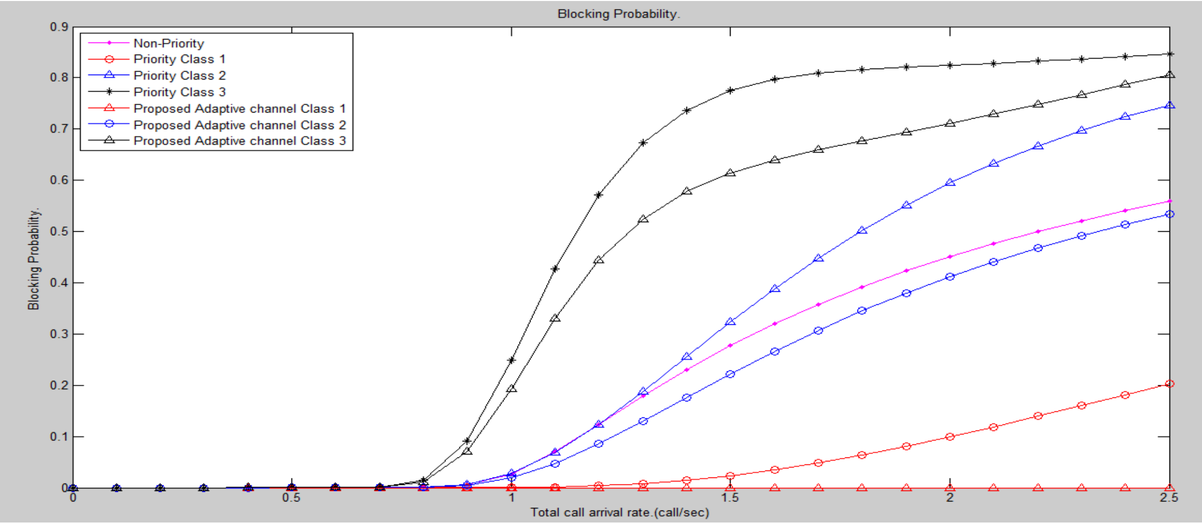


Figure 4.5: Comparison of new call blocking probability.

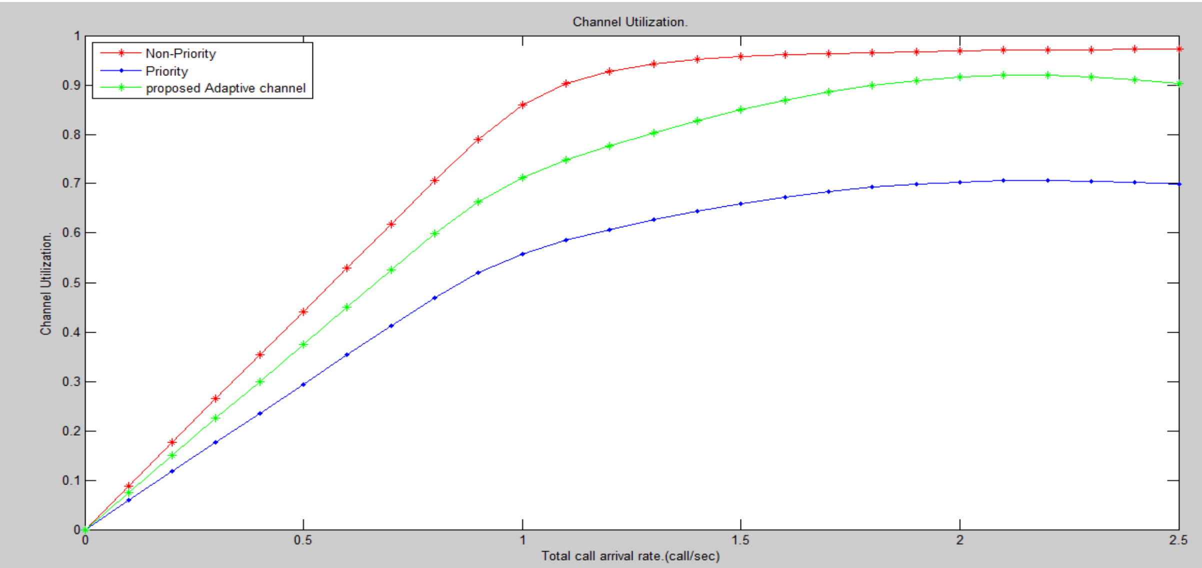


Figure 4.6: Comparison of channel utilization.

Fig. 4.6 shows the comparison of the channel utilization of the proposed adaptive scheme with the non-priority and the priority channel schemes. From this figure we can see that our proposed adaptive scheme has a very good utilization than the priority channel scheme and a slightly less than the non-priority scheme. Non- priority scheme always shows a better utilization because here no reserved channels for any classes and so that channels are always more utilized. But in case of priority channel scheme because of reservation of the channels for the higher priority traffics sometimes all channels are not utilized and remain empty if number of traffic arrival for the higher priorities are less. But by making the guard channels adaptive it has been made possible to use all the channels more perfectly and the maximum channel utilization for our proposed scheme has been found 91.5%.

Chapter 5

Conclusion and Future Research

5.1 Conclusion

In this paper, we proposed an adaptive channel scheme for multi-class services in wireless network system. The proposed scheme can also be successfully applied to other communication systems, where multiple traffic classes are provided and resources are allocated based on the priority of the traffic classes. The idea behind the proposed scheme is to reserve an adaptive number of channels for the higher priority users. Reserving channels is equivalent to the guard channels; however the numbers of reserved channels are not fixed in our proposed scheme to maintain higher channel utilization and to provide always lower call blocking probability for the higher priority users. More channels are reserved for the higher priority traffic class when the call arrival rate of higher priority traffic class is higher compared to the lower priority users to support large number of higher priority users. Thus, the scheme gives higher priority for higher priority calls over the lower priority calls without sacrificing the channel utilization.

It has shown that the proposed adaptive scheme is quite effective in reducing the call blocking probability of higher priority users without sacrificing the channel utilization. While the proposed scheme blocks some more calls of lower priority calls instead of blocking of higher priority calls during heavy traffic condition.

5.2 Future Research

Cellular system is the most common wireless network communication system in the present era of communication. In this cellular system, non-priority and priority schemes are common method for cellular priority. But, the major limitation of the both Non-priority and priority schemes method channel utilization rate is limited. Adaptive channel scheme that is established in this paper is more advanced than non-priority and priority schemes. The new method is able to improve the rate of proper channel utilization. Here, it has discussed about three classes. But, on the rate of progress of technology is that it does it make sense, it’s likely possible to use more than three classes that depends on the number of the type of call requests.

APPENDIX (1)

```
clc;
clear all;

N = 100;
N2 = 95;
N3 = 90;

dMuc = 1/120;
dEta = 1/360;
mu = dMuc + dEta;

%h = call arrival rate (lambda)
h = 0:0.1:2.5;
%h = h1: h2: h3 = 1: 2: 3 = 6

h3 = h/6;
h2 = h/3;
h1 = h/2;

pZ1 = 0;
pZ2 = 0;
pZ3 = 0;

% --------------------- Non-Priority Scheme
--------------------------------

ppZ = 0;

for j = 0:N
    ppZ = ppZ + (((h1 + h2 + h3).^j)/ (factorial(j)*mu.^j));
end
pZ = 1./ppZ;

for i = 0 : N
    pEye = (((h1 + h2 + h3).^i).*pZ)/(factorial(i)*mu.^i);
end

% --------------------- Priority Scheme
------------------------------------

for i  = 0 : N3
    pZ1 = pZ1 + ((h1 + h2 + h3).^i)/(factorial(i)*(mu.^i));
end

for i  = (N3 + 1) : N2
    pZ2 = pZ2 + (((h1 + h2 + h3).^N3).*((h1 + h2).^(i - N3)))/
(factorial(i)*(mu.^i));
end
```

```
for i  = (N2 + 1) : N
    pZ3 = pZ3 + (((h1 + h2 + h3).^N3).*((h1 + h2).^(N2 -
N3)).*(h1.^(i - N2)))/ (factorial(i)*(mu.^i));
end

pZ = 1./(pZ1 + pZ2 + pZ3);

B1 = (((h1 + h2 + h3). ^N3).*((h1 + h2).^ (N2 - N3)).*(h1.^(N
- N2)).*pZ)/((mu^N)*factorial(N));

B2 = 0;
for i = N2 : N
   B2 = B2 + (((h1 + h2 + h3).^N3).*((h1 + h2).^(N2 -
N3)).*(h1.^(i - N2)).*pZ)/(factorial(N)*mu.^N);
end

B3 = 0;
for i = N3 : N2 - 1
   B3 = B3 + (((h1 + h2 + h3).^N3).*((h1 + h2).^(i -
N3)).*pZ)/(factorial(i)*mu.^i);
end

% -------------------- Proposed Adaptive Scheme
-----------------------

B4 = (((h1 + h2 + h3).^N3).*((h1 + h2).^(N2 - N3)).*(h1.^(N -
N2)).*pZ)/((mu^(N3))*factorial(N));

B5 = 0;
for i = N2 : N
   B5 = B5 + (((h1 + h2 + h3).^N3).*((h1 + h2).^(N2 -
N3)).*(h1.^(i - N2)).*pZ)/(factorial(i)*mu.^i);
end

B6 = 0;
for i = N2 : N
   B6 = B3 + (((h1 + h2 + h3).^N3).*((h1 + h2).^(N2 -
N3)).*(h1.^(i - N2)).*pZ)/(factorial(i)*mu.^i);
end


figure(1)
plot(h, pEye, 'm.-', h, B1, 'ro-', h, B2, 'b^-',h, (B2 + B3),
'k*-',h, B4, 'r^-',  h, (B5 - B1)/2.1 + B1, 'bo-', h, (B2 +
B6)/1.3, 'k^-');
legend('Non-Priority', 'Priority Class 1','Priority Class 2',
'Priority Class 3', 'Proposed Adaptive channel Class
1','Proposed Adaptive channel Class 2', 'Proposed Adaptive
channel Class 3', 'Location’, ‘northwest')
title('Blocking Probability.');
```

```
xlabel('Total call arrival rate.(call/sec)');
ylabel('Blocking Probability.');


cU = ((3*(1 - pEye).*h1))/(mu*N);
cUP = (((1 - B1).*h1) + ((1 - B2).*h2) + ((1 - (B1 + B2 +
B3)).*h3))/(mu*N);

% Proposed scheme
cA = (((1 - B4).*h1) + ((1 - B5).*h2) + ((1 - B6 -
5*B1).*h3))/(mu*N);

figure(2)
plot(h, cU/1.53, 'r*-', h, cUP/1.53, 'b.-', h, cA/1.2, 'g*-');
legend('Non-Priority', 'Priority', 'proposed Adaptive
channel', 'Location’,’ northwest')
title('Channel Utilization.');
xlabel('Total call arrival rate.(call/sec)');
ylabel('Channel Utilization.');
```

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