

# A Heuristic Channel Allocation Model Using Cognitive Radio

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Published online: 8 July 2015  
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**Abstract** Channels are the scarce radio resources and are to be utilized judiciously. Though efforts are being made for maximum utilization of the channels, studies indicate that still full channel utilization is often not done because of many constraints. The concept of cognitive radio suggests that opportunistic channel utilization is possible if the mobile services are classified into two classes. The usage of the channels are based on the cognition that the radio derives. This work proposes a new heuristic that makes better channel utilization using the concept of cognitive radio. Priority is given to the handoff services in comparison to the new call services. Simulation study, of the model, indicates the effective channel utilization in terms of blocked and dropped services.

**Keywords** Channel allocation · Cognitive radio · Radio spectrum · Co-channel interference · Handoff

## 1 Introduction

A report of Federal Communication Commission (FCC) highlights that more than 70 % of the allocated spectrum in USA is not utilized [1]. This leads to the invention of Cognitive Radio (CR), a technique that enables the opportunistic sharing of the licensed frequency bands [2].

Based on the spectrum licensing, two types of users are conceived; Primary Users (PU) that are the users of the licensed spectrum and Secondary Users (SU) the users of unlicensed spectrum. PUs has higher priority to use the frequency bands but often these users do not utilize the allotted spectrum fully. CR enables the SUs to utilize the spectrum

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allotted to PUs in an opportunistic manner. However, on PUs arrival SUs have to vacate the frequency band allocated to it if no free channels are available to serve the PU. Cognitive radio, imbued with the ability to sense the channel usage, uses the spectrum for opportunistically. CR has the ability to learn and to adapt to the outside environment based on their interaction with the environment [3]. The CR technology is proposed as an extension of Software Defined Radio (SDR) [4, 5]. CR also helps to improve the reliability of the wireless networks.

Cognitive radio [6] facilitates the spectrum users with the most suitable radio bands through some functionality such as spectrum sensing, spectrum management, spectrum mobility, spectrum sharing etc. This work incorporates the sharing of channels in a cellular system detected unoccupied by primary users among the existing cognitive radios which are basically the secondary users. To utilize the CR, the model considers two types of users; primary users and secondary users as per their channel utilization. Also, for a new initiated call a new service and for ongoing communication a handoff service are considered. A heuristic is being proposed in this work that gives priority to the handoff call. Initial channel distribution among the cells is done in a manner that avoids the co channel-interference. The proposed model is simulated to study how it performs for both; the blocking of new services and the dropping of ongoing services. Experimental result indicates that the model performs effectively. Also, the incorporation of the concept of CR helps to utilize the channel in a better manner.

The outline of the paper is as follows. After the introduction in Sect. 1, some related work based on the channel allocation and re-allocation along with some other issues in cellular system are discussed in Sect. 2. The channel allocation problem and the importance of Cognitive Radio for utilization of free channels are presented using in Sect. 3. The proposed model for the channel allocation problem is deliberated in Sect. 4 along with the simulation study. Finally, Sect. 5 concludes the paper.

## 2 Related Work

A channel is the scarce resource and is to be utilized judiciously. Allocation of channels, amongst the mobile users, is one of the prominent areas of the research in mobile computing. In cellular system, whole network area is divided into number of regions called cells. The mobile hosts, roaming in the cells, are assigned channels based on certain policies. Various approaches for channel allocation and re-allocation in cellular system have been suggested in [7, 8]. Two broad policies, classified for channel allocation, are centralized and distributed one.

In centralized approach, each request, for the channel, is processed by a central controller known as Mobile Switching Center (MSC) [9]. The drawback of this approach is single-point failure. In distributed approach, there is no central controller such as MSC rather each cell contains a Mobile Service Station (MSS). MSSs are responsible to allocate the channels to the mobile hosts and exchange the information when necessary. MSSs cooperate with each other for channel sharing. The MSS in the cell that wants to borrow a channel and the MSS in the cell that grants the channel work in cooperation to ensure that no co-channel interference occurs [7]. In general Distributed approach uses two techniques to update the neighbor's information; first periodic updation technique which suffers from high message complexity, due to information exchange and second, it updates the information with neighbors when it is required. But it responds to the request slower than the periodic update [7, 8].

Being an important problem, number of researchers is working in this area. Various models to address the channel allocation problem have been proposed in the literature. A GA-Based model for channel allocation, proposed by Lutfi et al. [10], aims to design a fault-tolerant cellular channel allocation. In this, number of blocked hosts and handoff failure is minimized using the policy of reserve channel. A channel allocation algorithm with channel borrowing is proposed by Mahapatra et al. [11] using improved genetic algorithm (GA). In this model, the concept of the pluck operator is introduced in GA to solve the resource allocation problem in cellular system. Also, an approach by incorporating problem specific knowledge in GA is used for the resource allocation problem. According to this model, borrowing of channels from the neighbor cells always considers those cells or channels that never lead to a worse condition and at the same time ensure a better situation for host blocking.

Recently, the concept of cognitive radio is evolved hence very few proposed channel allocation models use the concept of cognitive radio. Some channel allocation models that uses the CR are as follows.

A channel allocation and re-allocation technique is proposed by Jiang et al. [1] for cognitive radio users to efficiently utilize available spectrum. In this model, multiple-dimension Markov analytical technique is used to evaluate the performance of the technique. This scheme is designed to facilitate the secondary users. The proposed method enhances the throughput and minimizes the blocking and dropping probability without degrading the primary user's services.

A model based on spectrum aware mobility management in cognitive radio cellular networks is proposed by Lee et al. [12]. In this work, they have proposed the spectrum pool-based network architecture, which reduces the heterogeneous spectrum availability. Based on this architecture, a unified mobility management is defined to support the diverse mobility events in cognitive radio networks. It consists of inter-cell resource allocation, spectrum and user mobility management functions.

Few better techniques for effective utilization of radio spectrum is proposed by Chen et al. [13]. It derives the condition to enable the CR users to avoid the interference to the primary users which helps the secondary users to utilize the spectrum efficiently without interrupting the primary users.

### 3 The Problem

The whole network area is divided into number of regions (cells), in a cellular system. The mobile hosts, roaming in the cells, are allocated channels for communication purposes based on certain policies. Several techniques are available for channels allocation in a cellular system. Fixed Channel Allocation (FCA) initially distributes fixed number of channels per cell and it sticks with the cell forever. In Dynamic Channel Allocation (DCA), channels are allocated to the cell by the MSC (Mobile Switching Center) as per the request/demand arising due to mobile users in the cell. Sometimes a hybrid channel allocation (HCA), that applies the techniques of both FCA and DCA, is used for the channel allocation. Using these techniques, it is possible to effectively allocate the channels. FCA has low channel utilization whereas DCA and HCA suffer from a problem known as co-channel interference. Co-channel interference is a crosstalk from two different radio transmitters using the same frequency and which any channel allocation method has to avoid. For this, co-channel cells must be separated by a minimum distance.

Azarafar et al. [4], on improving the reliability of wireless networks using cognitive radio, suggests that the concept of CR can be used to make the effective and reliable channel allocation [4]. The motivation of using the cognitive radio to enhance the utilization of the radio spectrum is derived from their work.

To use the CR, two kinds of services are classified in the cellular system: Primary Service and Secondary Service. Primary services are warranted to be completed without an interruption. These services are given the priority. But, it has been observed that most of the time channels allocated to primary services are under-utilized. This gives an opportunity for the secondary users, utilizing secondary services, to utilize these channels effectively. Secondary users, also known as cognitive users, use the cognitive radio technique to locate the un-occupied channels. These users are basically opportunistic users and utilize the primary channels when it is free. The channels designated to primary services are vacated whenever primary users seek the services. Secondary services can be interrupted on the arrival of the request for primary service by primary users which are the licensed users.

For effective channel utilization, cognitive radio technique can be used. Using this technique, utilization of the radio spectrum is enhanced. In the proposed model, a heuristic for channel allocation using cognitive radio has been proposed.

## 4 The Proposed Model

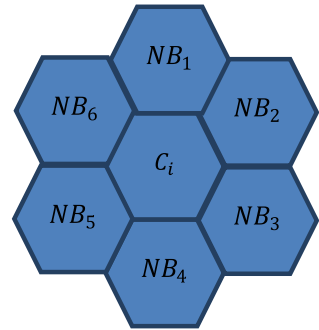
Existing channel allocation models do not differentiate between the primary services and the secondary services in a cellular system. Due to this, these services get equal priority in the channel allocation. By prioritizing these services, based on the nature of the services, it will be possible to serve them better. The priorities to handle these services basically distinguish them into primary and secondary services. Doing so results in sharp decline of blocking and dropping rate of the services. In this work, a model is being proposed in which primary services have higher priority than secondary services and utilizing the concept of CR the blocking and dropping rate of these services are reduced.

The proposed model, classifies the services into four groups. Primary New Call (PNC) and Primary Handoff Call (PHC) are the services for licensed users (PUs) whereas Secondary New Service (SNS) and Secondary Handoff Services (SHS) are the services for the opportunistic users (SUs). In case of both PHCs and PNCs in the cell, PHCs will be served first. If no free channels are available in the cell, channel borrowing is done from the neighbor cells provided it does not result in co-channel interference. In case no free channel is available in the neighbor cells, secondary service will be interrupted to vacate the channel.

Few protocols are designed to interrupt the secondary services. In the first, request which is entertained first will be interrupted first so that the services which are recently scheduled could get more time to complete. In the second, request which is entertained last will be interrupted first so that the services which are scheduled since long could get the chance to complete. Another protocol states that the secondary service which requires longer time to complete will be interrupted first so that the services which require lesser time could be completed.

While serving the request, ongoing calls will be served first i.e. PHC services have higher priority than PNC services. Similarly SHSs have higher priority than SNSs. For

**Fig. 1** A cell cluster



example, if only one channel is free in the cell, then handoff request will be served first. All primary services will be considered as higher priority services over the secondary services.

The work considers a seven cell cluster, as shown in Fig. 1. Cluster of seven cells is formed to insure minimum distance between the co-channel cells. Frequency reuse ratio is defined as the ratio of the distance between co-channel cells to the radius of the cell. This is related to the signal to interference ratio. For minimizing the co-channel interference, signal to interference ratio should be high. In the proposed model, each cell of the cluster is allotted different set of frequencies and each cluster, in the network consists of seven set of same numbered cells. This insures the acceptable separation (minimum distance) between the co-channels cells that helps to keep the acceptable signal to interference ratio i.e. co-channel interference.

One bit field is associated with busy channels to indicate if it is serving a primary request or a secondary request. If the bit value 1, it is serving a primary user otherwise a secondary user is being served. Busy channels also contain the information about how much time is required to complete the service. A hexagonal cell cluster is assumed in which central cell  $C_i$  is surrounded by the six other cells  $NB_i$ .

An example status matrix, for the center cell  $C_i$  is depicted in Table 1. The number of channels is equally distributed among the cells. In the example, each cell is assigned ten channels. Center cell contains the channels with channel-ids 1 to 10.  $NB_1$  contains the channels with channel-ids 11 to 20,  $NB_2$  with channel-ids 21 to 30,  $NB_3$  with 31 to 40,  $NB_4$  with 41 to 50,  $NB_5$  with 51 to 60 and  $NB_6$  with channel-ids 61–70.

First row of the Table 1 represents the ids of allocated channels, second row represents the required time to complete the service with that channel and third row represents if it is serving primary or secondary service. In the Table 1, channels with channel-ids 68 and 21 are borrowed channels by the central cell  $C_i$  from the neighbors  $NB_2$  and  $NB_6$ .

For experimental purposes, the arrival rate of PNCs, PHCs, SNSs and SHSs are assumed to follow the Poisson distribution with average service time. PHCs have higher priority than PNCs and PHCs and PNCs both have higher priority than SNS and SHS. Completion of service (of any type) is indicated by the service time field in the Table 1. If it is zero then the service is completed and the respective channel will be added to the free channel list.

**Table 1** Channel status matrix for central cell

Channel-id	10	1	68	2	3	4	5	7	6	8	9	21
Service time	1	1	2	1	2	1	3	3	2	3	1	3
Status PU/SU	0	1	0	1	1	0	0	0	0	1	1	0

## 4.1 Algorithm

The algorithm, of the proposed model, is as follows.

### 4.1.1 Step 1: Initialization

Initialize the number of busy channels, free channels; borrowed channels from neighbors and lending channels to the neighbors in each of the cell of the system.

Initialize the arrival rate of the primary new call (PNC), primary handoff call (PHC), secondary new service (SNS) and secondary handoff service (SHS).

Initially, interrupted service will be zero.

Time unit for the experimentation is also entered.

### 4.1.2 Step 2: Channel Allocation

Arrival of number of requests (for PHC, PNC, SHS and SNS) with their respective random service time.

Allocate the channels to PHCs and PNCs.

If number of free channels is greater than number of requests then serve all the requests. Else the requests which have higher priority will be served first and then borrow the channels from neighbors as per the requirement.

If still requests are pending then interrupt the secondary services and store their status in interrupted service.

Update the number of free channels and busy channels.

If number of free channels is greater than zero then serve the interrupted services otherwise borrow the channels from neighbors.

If number of free channels is greater than zero then allocate the channels to SNS and SHS. In case more number of channels are required than available, then borrow from the neighboring cells.

Update the number of free channels and busy channels.

### 4.1.3 Step 3: Updation

Check the status of the free channels and return them into the respective free channel list of the corresponding cells.

Update the free channel and busy channel lists.

Store the number of blocked and served services for PHC, PNC, SNS and SHS.

### 4.1.4 Step 4: Termination

Repeat the steps 2 to 4 for given number of iterations (time unit).

In Step 1 of the algorithm, initial channel allocation to the cells takes place. It also initializes the lending channels, borrowed channels, arrival rates of the request for the services and interrupted services etc. Time unit, used to iterate the algorithm, is also initialized.

Step 2 is used to assign the channels as per the request. It also takes care of the priorities of the services; the services which have higher priority will be served first. When the number of arrived requests are greater than available free channels then channel borrowing from the neighbors takes place. After assigning the channels to the services, free channels and busy channels list are updated.

Step 3 is used for the updation of the free and busy channels after every time unit. In this step, the status of the channel is checked. If it is free, it is returned to the cell from where it was borrowed with updation of the free and busy channel list in each cell. The information about the served and blocked requests is also stored for the analysis purpose.

Step 4 is for the termination of the algorithm. If time unit is over, the process terminates.

### 5 Simulation Experiments

To study the performance of the proposed model, it is simulated by writing program in MATLAB. A time instance, to test the success of services, is considered that includes the PHCs, PNCs, SHSs and SNSs. Number of experiments have been designed. Observations are taken after 90 time units so that the system stabilizes and up to 100 time units. In the graphs of the figures, it is represented on x-axis from 91 to 100 time units. Number of channels is equally distributed amongst the cells. Average service time for both primary and secondary services is assumed to be 2 time unit.

#### 5.1 Experiment 1

In the first experiment, the observation is taken on the number of primary requests served over the period of time by the proposed heuristic. Graph in Fig. 2 depicts the arrived primary new calls and blocked primary new calls. The simulation parameters, for the experiment, are as follows.

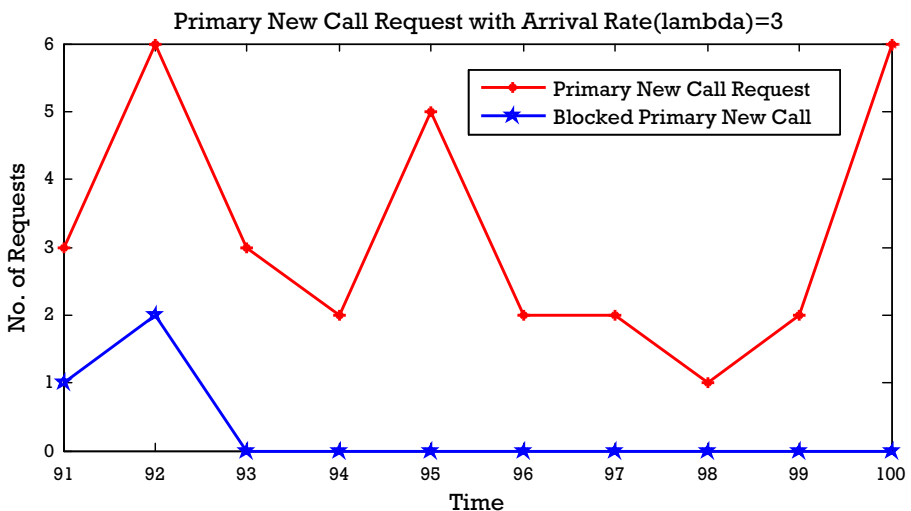


Fig. 2 Arrived and served primary new call

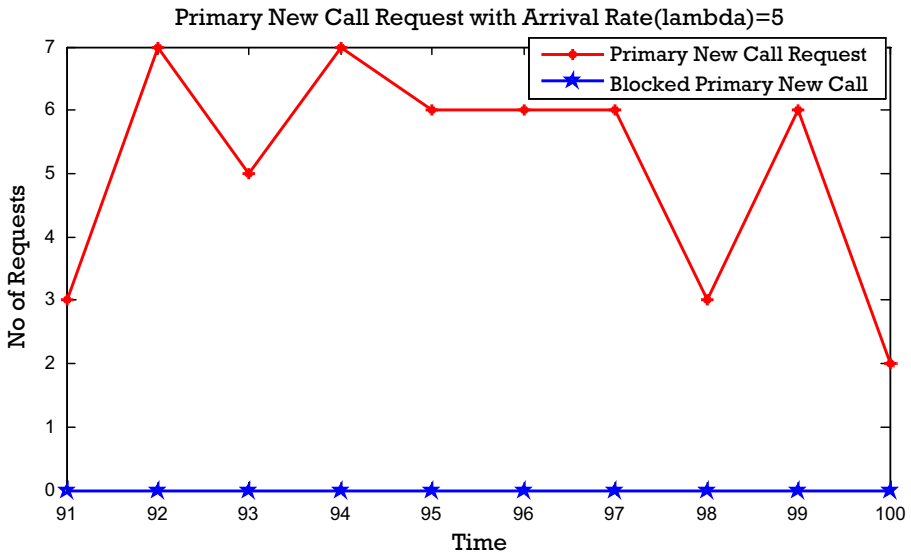
- Number of channels in each cell are 10.
- Arrival rates for the different services are as follows.
  1. Primary new call (PNC): 3
  2. Primary handoff call (PHC): 2
  3. Secondary new services: 3
  4. Secondary handoff services: 2

It is observed from Fig. 2 that the proposed heuristic is able to serve almost the entire request.

Same experiment is repeated by increasing the number of channels per cell and the arrival rates. The simulation parameters, used in the next experiment, are as follows.

- Number of channels in each cell are 20.
- Arrival rate for the services:
  1. Primary new call (PNC): 5
  2. Primary handoff call (PHC): 3
  3. Secondary new services: 5
  4. Secondary handoff services: 3

From Fig. 3 it is observed that blockage of the primary new call is zero i.e. all the requests generated is being served by the proposed heuristic. The above two experiments depict that when the number of channel per cell as well as the arrival rates of the new call are increased, the performance of the model in serving the requests improves.



**Fig. 3** Arrived and served primary new call



## 5.2 Experiment 2

The second experiment observes how the model performs in serving the primary handoff call over the period of time. Graph in Fig. 4 depicts the arrived requests and dropped primary handoff requests. The simulation parameters for the experiment are as follows.

- Number of channels in each cell are 10.
- Arrival rates for the different services
  1. Primary new call (PNC): 3
  2. Primary handoff call (PHC): 2
  3. Secondary new services: 3
  4. Secondary handoff services: 2

Figure 4 shows that the dropping rate of handoff requests is almost zero.

This experiment is repeated by increasing the number of channels per cell and the arrival rates. The simulation parameters, used in the next experiment, are as follows.

- Number of channels in each cell are 20.
- Arrival rate for the services:
  1. Primary new call (PNC): 5
  2. Primary handoff call (PHC): 3
  3. Secondary new services: 5
  4. Secondary handoff services: 3

Figure 5 shows the arrived and dropped requests for primary handoff requests. It is observed that after increasing the number of channel per cell and respective arrival rates of the services, dropping is negligible. Thus, Figs. 4 and 5 indicate that The model serves the handoff requests in a better manner in comparison to the new generated calls as obvious from Figs. 2, 3 and 4, 5.

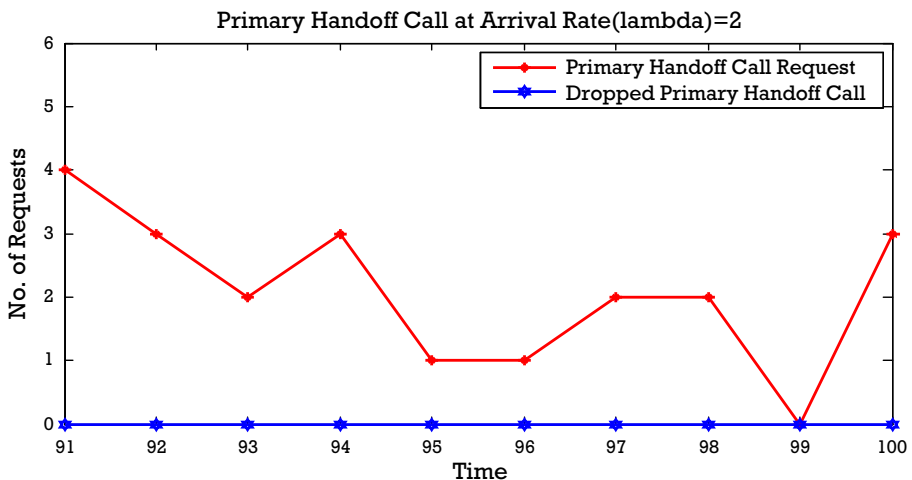


Fig. 4 Arrived and served primary handoff call

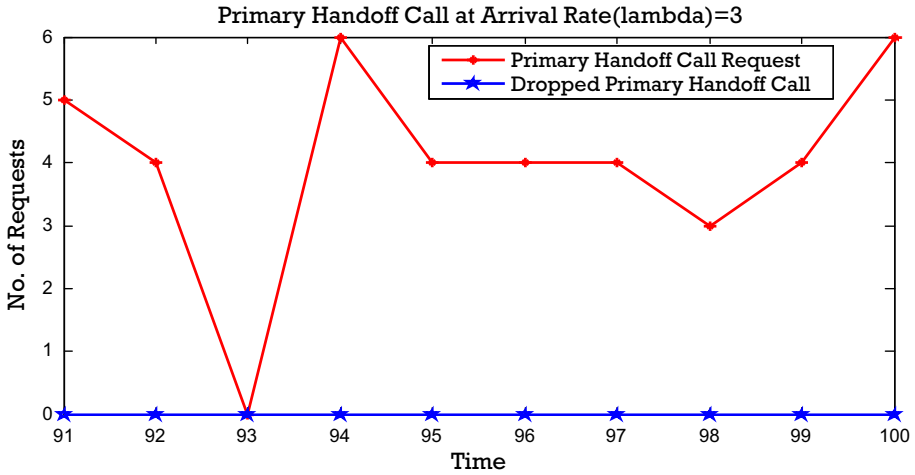


Fig. 5 Arrived and served primary handoff call

### 5.3 Experiment 3

The experiments are designed to study how the proposed heuristic performs for the secondary services. This experimentation also considers secondary new calls and secondary handoff requests. Experiment 3 studies the service for the secondary new call. Graph in Fig. 6 depicts the blocked secondary services. The simulation parameters, for the experiment, are as follows.

- Number of channels in each cell:10
- Arrival rates for the different services
  1. Primary new call (PNC): 3
  2. Primary handoff call (PHC): 2

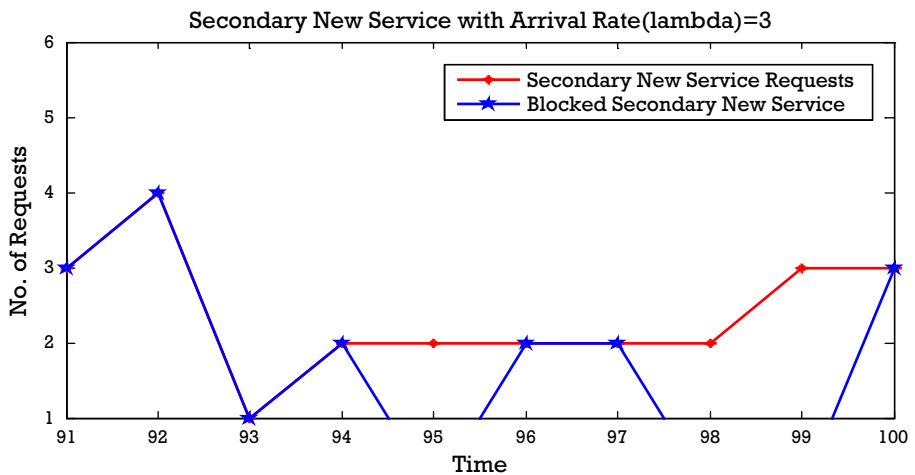
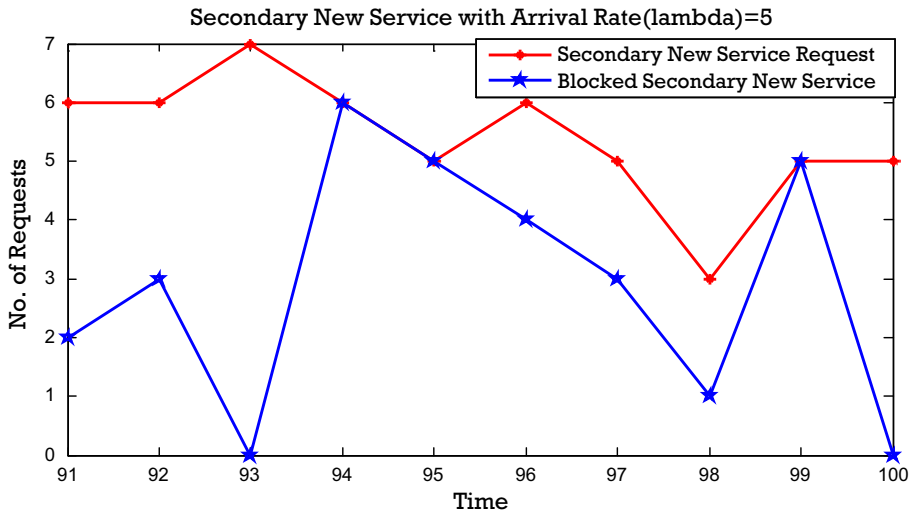


Fig. 6 Arrived and served secondary new services



**Fig. 7** Arrived and served secondary new services

3. Secondary new services: 3
4. Secondary handoff services: 2

Figure 6 shows the arrived and blocked requests for the secondary new calls. It is observed that the proposed method serves significantly even the secondary new services. In Fig. 6, up to 94 time units from 91, though all new arrived secondary calls are being blocked, but after 94 time units, many of the requests are being served.

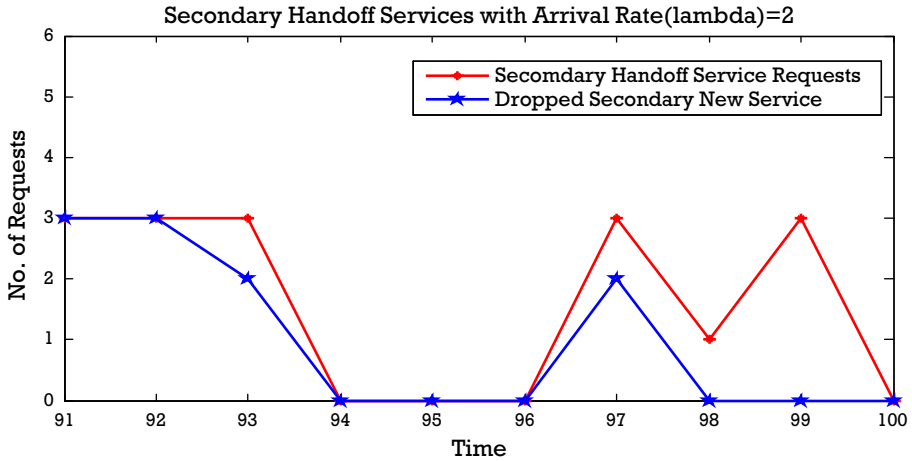
Same experiment is repeated by increasing the number of channels per cell and the arrival rates for the various requests. The simulation parameters, used in the next experiment, are as follows.

- Number of channels in each cell are 20.
- Arrival rates for the different services:
  1. Primary new call (PNC): 5
  2. Primary handoff call (PHC):3
  3. Secondary new services: 5
  4. Secondary handoff services: 3

Figure 7 shows, the arrived and blocked requests for secondary new services and observed that after increasing the number of channels per cell and respective arrival rates of the services, model performs much better and is able to serve significantly the secondary new services.

## 5.4 Experiment 4

Next experiment is to study how the proposed method performs for the secondary handoff services. Graph in Fig. 8 depicts the arrived and blocked secondary handoff services. The simulation parameters for the experiment are as follows.



**Fig. 8** Arrived and served secondary handoff service

- Number of channels in each cell are 10.
- Arrival rates for the different services
  1. Primary new call (PNC): 3
  2. Primary handoff call (PHC): 2
  3. Secondary new services: 3
  4. Secondary handoff services: 2

Figure 8 shows the arrived and blocked requests for the secondary handoff services. It is observed that the proposed method significantly serves the secondary handoff services.

Experiment is done by increasing the number of channels per cell and the arrival rates. The simulation parameters, used in the next experiment, are as follows.

- Number of channels in each cell are 20.
- Arrival rate for the services
  1. Primary new call (PNC): 5
  2. Primary handoff call (PHC): 3
  3. Secondary new services: 5
  4. Secondary handoff services: 3

Figure 9 also shows the arrived and blocked requests for secondary handoff services. It is observed from Fig. 9 that after increasing the number of channels per cell and respective arrival rates of the services, the model serves significantly for the secondary handoff services. Here also, secondary handoff services are being served comparatively better than secondary new services as obvious from the Figs. 6, 7, 8 and 9.

### 5.5 Experiment 5 (Set 1)

This experiment is designed to observe how the model works on arrived requests, blocked requests and dropped requests for both primary and secondary services for last 10 time units. Arrival rates are same for all the services. The input parameters are as follows.

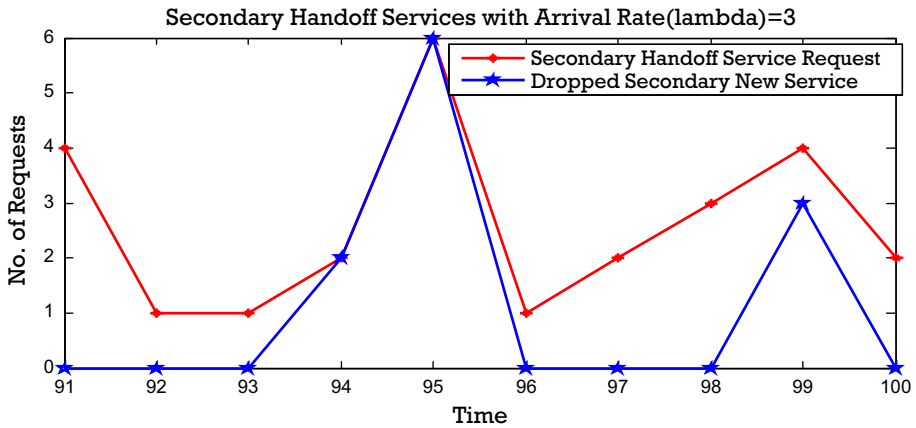


Fig. 9 Arrived and served secondary handoff service

- Number of channels in each cell are 15.
- Arrival rate for the services are:
  1. Primary new call (PNC): 3
  2. Primary handoff call (PHC):3
  3. Secondary new services: 3
  4. Secondary handoff services: 3

Table 2 shows, the arrived and blocked primary and secondary services. It is observed from Table 2 that blockage of PNC and PHC is almost negligible. Also, it is able to serve the secondary services such as SNS and SHS significantly.

### 5.6 Experiment 5 (Set 2)

Experiment is repeated by increasing the number of channel per cell and the respective arrival rates of the services. Table 3 represents the arrived request for the services, blocked services and dropped services for primary and secondary services. The input data are as below.

- Number of channels in each cell are 30.
- Arrival rate for the following services:

Table 2 New, blocked and dropped services for Set 1

PNC arrived	1	1	2	2	1	4	4	3	2	1
PNC blocked	0	0	1	0	0	0	1	3	0	0
PHC arrived	2	5	6	2	4	3	5	3	3	4
PHC dropped	0	0	0	0	0	0	0	0	0	0
SNS arrived	2	2	4	4	3	2	4	3	1	5
SNS blocked	2	2	4	4	3	2	4	3	1	3
SHS arrived	3	1	4	3	2	1	1	3	3	5
SHS dropped	1	0	0	0	1	1	1	1	3	2

**Table 3** New, blocked and dropped services for Set 2

PNC arrived	3	5	5	10	7	5	6	5	3	3
PNC blocked	3	1	2	6	1	5	2	1	2	0
PHC arrived	6	3	4	2	3	7	3	1	3	5
PHC dropped	2	0	0	0	0	3	0	0	0	0
SNS arrived	8	5	6	9	6	5	6	9	3	5
SNS blocked	7	5	6	8	6	5	6	9	3	5
SHS arrived	6	1	8	5	4	10	7	2	9	8
SHS dropped	6	1	7	5	3	8	7	2	9	7

1. Primary new call (PNC): 5
2. Primary handoff call (PHC):5
3. Secondary new services: 6
4. Secondary handoff services: 6

Table 3 shows the arrived requests for primary, secondary services and their respective blockages. The Table 3 infers that blockage of PNC and PHC is very less. Also, secondary services are being better served. Tables 2 and 3 indicates that after increasing the arrival rate, heuristic model is able to serve the requests.

## 5.7 Experiment 6

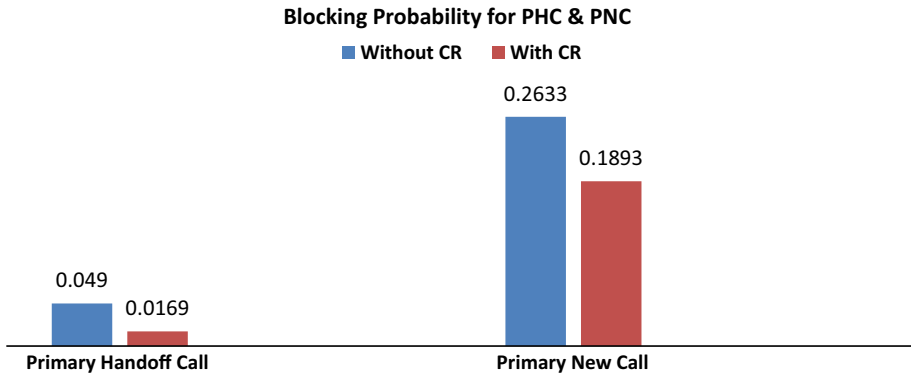
Experiment has been designed to make a comparative study for the channel utilization when the concept of CR is used with that of non-CR. Simulation parameters for the comparison between primary new call and primary handoff call using cognitive radio and without cognitive radio are as follows.

- Number of channels in each cell are 10.
- Arrival rate for the various services:
  1. Primary new call (PNC): 3
  2. Primary handoff call (PHC):3
  3. Secondary new services: 2
  4. Secondary handoff services: 2

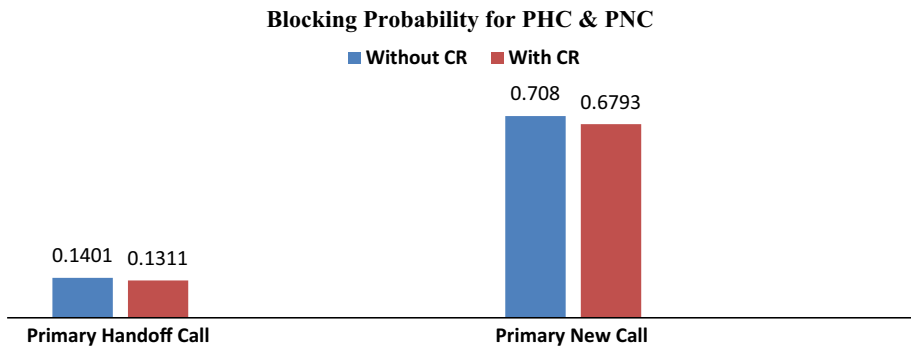
From Fig. 10, it is observed that using CR technique dropping probability of primary handoff call and blocking probability of primary new call is significantly minimized in comparison to a channel allocation technique which does not use cognitive radio technique. Also obvious from the Fig. 10 is the fact that handoff drops are quite lesser than new call blocks as the proposed model gives priority to the handoff requests to service.

Same experiment is repeated by increasing the number of channels and other input parameters. The input values are as follows.

- Number of channels in each cell are 20.
- Arrival rate for the following services:
  1. Primary new call (PNC): 6
  2. Primary handoff call (PHC): 6
  3. Secondary new services: 4
  4. Secondary handoff services: 4



**Fig. 10** Comparison of blockage probability for PNC and PHC



**Fig. 11** Comparison of blockage probability for PNC and PHC

From Fig. 11, it is observed that after 100 time units dropping probability of primary handoff call and blocking probability of primary new call is minimized significantly even on increased set of values. Figures 10 and 11 show that even for increased set of values, CR system is performing better than non-CR system for primary services.

Thus, almost all the experiments performed, suggests that the blockage of primary services is negligible. The blockage of PNC can as clearly observed from Fig. 2 and Fig. 3. Similarly, for PHC that has higher priority than PNC, dropping is almost negligible as can be observed from Fig. 4 and Fig. 5. In this process, secondary services are also getting served in a better manner as observed from Figs. 6 and 7 for SNS and Figs. 8 and 9 for SHC. Comparative study in Figs. 10 and 11 indicate that using the CR technique blocking of primary services are significant minimized, whereas secondary services are being served in a better manner.

## 6 Conclusion

This paper introduces a heuristic that uses the concept of cognitive radio in channel allocation in a cellular system. For this, services have been categorized in two groups: primary services and secondary services. Primary services are used by the primary users

and secondary services are used by the secondary users. Secondary users are opportunistic users that uses the channels meant for the primary services when these are free. A heuristic model uses the cognitive radio concept to minimize the blocking and dropping rate of the primary services. Meanwhile, when the channels are free it is possible to serve the secondary users as well. Thus, secondary users are also getting better response. Experimental evaluation is done which indicate the better channel utilization.

Besides primary services, secondary services are also getting served better using the cognitive radio concept. Though in comparison to the primary services, blocking and dropping in the secondary services are more. It is because primary services have higher priority. Also, in comparison to the new call, the drop in the handoff call is significant as these are being given more priority.

A comparative study is done on the frequency band utilization with and without using cognitive radio concept. It is observed that using CR it is possible to minimize the probability of primary new call blocking. Also, the probability of primary handoff dropping is minimized. In the meantime, using the concept of cognitive radio, it is possible to facilitate the secondary users to use the services opportunistically when the channels are not being utilized by the primary users and thus enhance the usability of the radio spectrum.

**Acknowledgments** The authors would like to accord their sincere thanks to the anonymous reviewers for their useful suggestions resulting in the quality improvement of this work.

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