Efficient Queue based Channel Allocation Model for User Impatience in Enterprise Networks

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ABSTRACT

The vast usage of next generation smart networks makes the researchers to concentrate more on the efficient spectrum utilization by availing channels to the secondary users without interrupting the existing primary user's data transmission. The handoff mechanism for both Secondary users (SU's) and Primary users (PU's) including new SU's arrival in a zonal coverage region was considered. A queuing model that uses two buffers are chosen namely handoff buffer and new SU's buffer have been proposed for efficient channel allocation in the 5G networks. Many next generation networks like 5G, TVWS networks, CRNs, IoT, IIoT, LTE-U etc. uses queuing mechanism of channel allocation to the secondary users as the future networks are migrating to the utilization of licensed band due to channel starvage. In this paper a new SU's buffer to accommodate starving SU's for some time has been proposed and analyzed using Markov-chain analysis. In this paper analysis work was carried out by using Markov-Chain model for different transition states from a generic state, to analyze the dropping and blocking probabilities of SU's in competitive scenario.

Keywords
Blocking probability, Channel allocation, Dropping probability, Future generation networks, Handoff buffer, Markov-chain, 5G network.

Introduction

The efficient usage of the spectrum is based upon the allocation of vacant channel, which is not in use by any primary user, at that instant to the secondary users are accommodated in order so that no SU get starved for channel and get disconnected due to impatience. A general framework has been employed proposed [1-2] for analysing the performance of admission control and Erlang capacity in CRNs with finite queuing, impatient SUs, and channel reservation. The network efficiency not only depends upon the allocation of channel to the SU's but also the success rate of data transmitted by the SU's, which can be analysed by the parameters like no.of packets lost and the dropping probability of packets in the network. The paper is mainly focused on the allocation of unused channels to the SU's without disturbing the PU's and also analysing the buffer sizes on both existing SU's and the new SU's so as to efficiently allocate the channel to both existing and new SU's. [6] The Markov chain model is used to check the occurrence of various situations by transition of the states for all the users (primary and secondary users) along with the buffers namely handoff and new buffer for the SU's [7-8]. The handoff buffer is for the starving existing SU's whereas new buffer is for the starving newly arrived SU's [9-10]. In [11] author given the detailed description for hybrid networks in 5G technology, here research efforts are made to boost the wireless connectivity for different RAN (Radio Access Network). Every network has its own physical and MAC layer specifications, so appropriate mechanisms are needed to boost the network connectivity in 5G technology. This 5G technology end to end connectivity should be low latency and effective utilization of subcarriers plays a major role. In [12] massive devices deployments in cellular technology are made for the Internet of Things. Here, 5G technology challenges are discussed namely bandwidth sharing, channel selection, and hardware device compatibility for multi-RAT technology. In [13] - [14] 3GPP standardization efforts are made to download the traffic in the cellular band to the ISM 5GHz band. i.e.., licensed cellular band facing some bandwidth issues, so to offload its traffic 3GPP Re1 13 &14 are used as LTE-U and LAA technology. By these technologies also wireless connectivity can be boosted in 5G technology. Every mechanism has its pros and cons, so research efforts are made to increase the wireless connectivity with minimum latency by utilizing the efficient channel for its communication. In [15] - [16] Ericsson company efforts are described in terms of time scheduling networks for 5G technology. In [17] - [18] road map to 5G networks and Listen Before Talk (LBT) are described. The paper is organised in the following sections as section-1 deals with the problem formulation and section-2 provides the description of proposed system model. Section -3 depicts the Markovian analysis of the proposed queuing model. Section- 4 gives the analysis of results and discussions on it and finally section-5 concludes the paper.

Preliminaries and Problem Formulation

World is racing behind digital transformation day by day. This causes the migration of communication networks from one generation to other abruptly. Data and data rate are the key factors in the future generation networks as huge the data is growing that much speed the data is transferred. We can see higher data rates of 10Gbps to hundreds of Gbps in the present generation networks. These stats can even more increase in future with reduced coverage. The networking scenario is changing day by day from long distance communications to shorter and shorter distances. By the huge deployment of users, the need for the channel is even more increasing which led to the sharing of licensed spectrum by the unlicensed users in a cognitive mode. This efficient utilization of spectrum led to the new concept of sharing the common channel by primary users (licences users) as well as secondary users (unlicensed users). In the proposed model the users of any wireless network are assumed to be operated by splitting the total area into different cells or zones to provide service to each user in that network service area. Basically, the spectrum license is generally provided to one who owns it, that are considered as primary system and the other network in the same service area is taken as secondary system. The secondary system shares the primary system based on its unoccupancy rate. The primary users are assumed to be unaware of the existence of activities of SU's in their leased spectrum. The SU's can identify the existence or occupancy of the PU's by spectrum-sensing techniques.

In the proposed model we assumed **S** number of spectrum channels from **O** number of occupied channels which can be exclusively used by SU's. When an unused spectrum channel is sensed it can be allocated temporarily to SU. If any PU returns to the spectrum channel all the SU's using that channel must suspend the ongoing transmission and depart from the channel instantly. The suspended transmission of SU can be resumed after sensing any spectrum channel unused by any PU's and complete its transaction. This process is referred to as spectrum handoff mechanism. If SU's are already under transmission occupying the maximum number of O channels and there is no vacant spectrum channel, then its packet is queued into the buffer of the base station which is termed as Hand-off buffer. The SU's in buffer are allocated in first in first out (FIFO) discipline. The arrival of new SU's also effect the spectrum allocation, in case a new SU is also starving of vacant channel (i.e., both spectrum and occupied channels are busy) they are queued into another buffer which is termed as New buffer. The total buffer size is assumed to be **B** in packets which is a non-negative real number. The hand-off and new SU buffers sizes are considered as $\boldsymbol{B_{h0}}$ & $\boldsymbol{B_n}$ respectively. The session based analysis can be referred to as ON-OFF source model by assuming a transaction from single source, with an ON(active) period corresponding to a period of talk spurt $(\boldsymbol{t_{Sp}})$ and an OFF (inactive) period corresponds to silence period $(\boldsymbol{t_{Si}})$ [4-5]. The probability of state transition of SU from ON to OFF is given as $\mathbf{t_{Sp}(t_{Si})}$ and probability of state transition of SU from OFF to ON is given as $\mathbf{t_{Si}(t_{Sp})}$.

The voice samples are assumed to be generated with a constant bit rate with constant packet size **z** and interval $\Delta \boldsymbol{t}$ generated equally for all the users. The typical value used for Δt is assumed to be [3] 10 ms and 20 ms [4]. The arrival rate of primary (PU's) and secondary users (SU's) are taken as independent Poisson processes $\boldsymbol{\lambda^P}, \boldsymbol{\lambda^S}$ and their corresponding means are taken as $\boldsymbol{\mu^{(Pt)}}, \boldsymbol{\mu^{(St)}}$ respectively. The network service area is split into number of coverage zones represented by **L** and the data rate in each zone is high data rate. For ith zone is considered, the in-zone data rate is given as $\boldsymbol{r_z^{(i)}}$.

For each zone, the number of secondary users under the coverage area is given as $\boldsymbol{e_i}$ for ith zone. Similarly, the number of primary users under ith zone coverage area is considered as $\boldsymbol{e_0}$. The total number of active sessions of SU's and PU's in z 2 i is taken as $\boldsymbol{S_{Si}}, \boldsymbol{S_{Pi}}$ respectively.

$$S = [S_{Si}, S_{Pi}, b_{h0}, b_n, T_{Cr}^V]$$

Let the talk spurt and silence periods are sufficiently greater than that of frame interval, the probability of one Secondary User in region $\mathbf{S_i}$ **($\mathbf{S_i}$=1,2,…..,L)** goes from OFF state to the ON state or vice versa during a given frame interval can be represented as

$$\xi_{Si} = \binom{S_{Si}}{1} t_{Sp}(t_{Si})^{i} \left(1 - t_{Sp}(t_{Si})^{i}\right)^{S_{Si}-1}$$
$$\eta_{Si} = \binom{e_i - S_{Si}}{1} t_{Si}(t_{Sp})^{i} \left(1 - t_{Si}(t_{Sp})^{i}\right)^{e_i - S_{Si}-1}$$
$$\xi_{Pi} = \binom{S_{Pi}}{1} t_{Sp}(t_{Si})^{i} \left(1 - t_{Sp}(t_{Si})^{i}\right)^{S_{Pi}-1}$$
$$\eta_{Pi} = \binom{e_0 - S_{Pi}}{1} t_{Si}(t_{Sp})^{i} \left(1 - t_{Si}(t_{Sp})^{i}\right)^{e_0 - S_{Pi}-1}$$

In each frame transmission, the number of packets depends up on the detection of number of idle or busy channels as well as active amount of Sus in each region. We assume a maximum allowable number O of simultaneously occupied channels for the exclusive use of VoIP Sus. Then the number of channels that can be used for transmission is given by

$$(O+S-(e_0+i_{fa})).$$

The proposed system is to queue the secondary users in an ordered manner so as to reduce the congestion and interference among the users.

Proposed System Model

The queue-based channel allocation methods are the mostly used interference mitigation model now-a-days. Due to the huge penetration of users into the network service area and the migration of future generation networks into licensed spectrum due to channel starvation there is a need of more optimized queueing model so as to mitigate the interference among the SU's at the same time to reduce dropping probability of the users due to impatience. Figure 1 shows the proposed model of allocating channel to the randomly arriving PU's and SU's. Here an assumption has been made that SU's are aware of the presence of PU's so as to avoid the service interruption to the intended primary users of the spectrum.

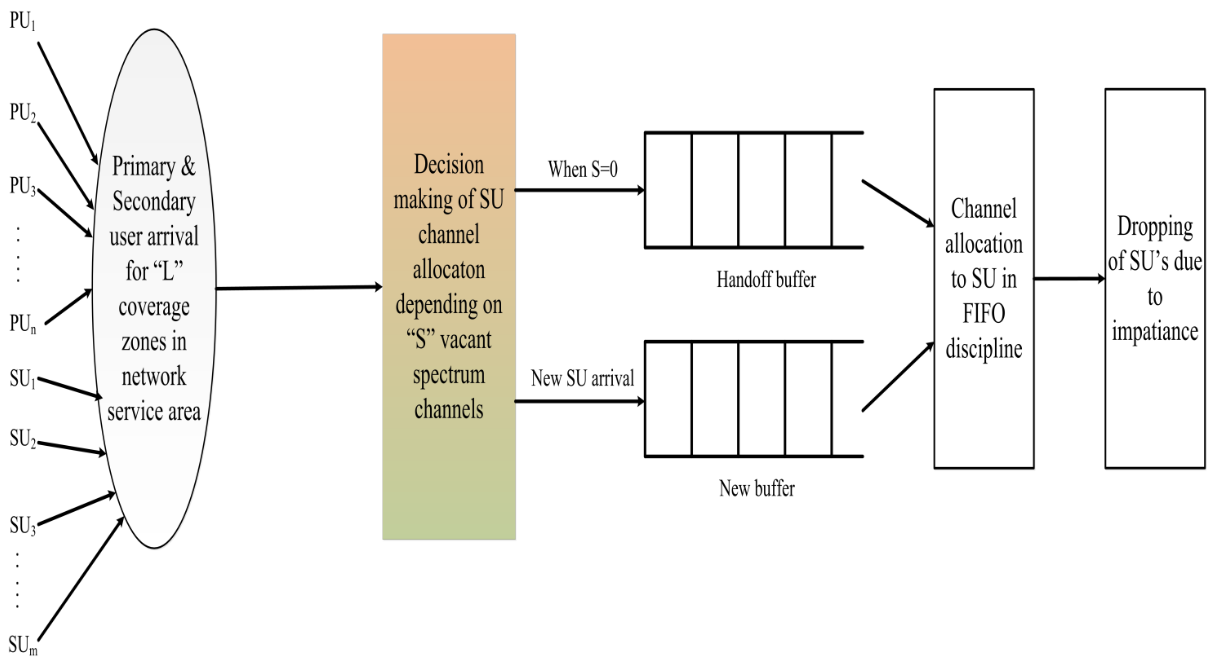

Figure 1. Proposed queue-based channel allocation system model

Depending on the occurrence of PU's and SU's the total network service area is divided into L coverage zones to differentiate in-zone and out-zone users among them. The decision-making box decides the allocation of S channels among arriving SU's by splitting them into two buffers depending on the conditions that when S completely drained to zero (i.e., no vacant channel for SU when PU suddenly arrives) these SU's must be stacked into Hand-off buffer. When there is any new SU arrived and the Hand-off buffer is fully stacked those SU's must be stacked into a New buffer. The cha[...]l allocation to the buffer stacked SU's is done [...] FIFO (First-In-First-Out) manner. In the least and worst case even after some waiting time stacked in the New buffer those SU's will be dropped due to impatience.

Markovian Analysis

Based on the system model a Markov-chain analysis has been done and the state transition diagrams has been formulated. Table 1 shows the state transition table depending on various conditions like in-zone and out-zone arrival and departure of SU's or PU's in New and Hand-off buffers.

Table 1. Transitions from a generic state S = ($S_{S1}, S_{P1}, b_{h0}, b_n, T_{Cr}^{V}$)

Activity	Destination state	Rate	Conditions
There are no changes in number of SU's.	($S_{S1}, S_{P1}, b_{h0}, b_n, T_{Cr}^{V}$)	$(1-t_{Sp}^{S1})^{Ss1}, (1-t_{Sp}^{P1})^{Sp1}$, b_{h0}, b_n	-
Upon one PU arrival and a SU leaves which is queued in handoff SU	(S_{S1}-1, S_{P1}+1, b_{h0}+1, b_n, T_{Cr}^{V})	$\xi_{S1}(1-t_{Si}^{S1})^{e1-Ss1}, \eta_{P1}(1-t_{Sp}^{P1})^{Sp1}$, b_{h0}+1, b_n	$S_S = 0, b_{h0} < B_{h0}, S_{P1} < e_0$
If $n_s > 0$	(S_{S1}-1, S_{P1}+1, b_{h0}, b_n, T_{Cr}^{V})	$\xi_{S1}(1-t_{Si}^{S1})^{e1-Ss1}, \eta_{P1}(1-t_{Sp}^{P1})^{Sp1}$, b_{h0}, b_n	$b_{h0} = B_{h0}$
Upon new SU arrival in zone i	($S_{S1}, S_{P1}, b_{h0}, b_n$ +1, T_{Cr}^{V})	$(1-t_{Si}^{S1})^{e1-Ss1}, (1-t_{Sp}^{P1})^{Sp1}$, b_{h0}, b_n +1	$b_n < B_n$
A PU goes to OFF state, leaves from zone i	(S_{S1}+1, S_{P1}-1, b_{h0}-1, b_n, T_{Cr}^{V})	$\xi_{P1}(1-t_{Si}^{P1})^{e0-Sp1}, \eta_{S1}(1-t_{Sp}^{S1})^{Ss1}$, b_{h0} -1, b_n	$b_{h0} > 0$
When Q_h= 0 ,a PU goes to OFF state	(S_{S1}, S_{P1} -1, b_{h0}, b_n, T_{Cr}^{V})	$\xi_{P1}(1-t_{Si}^{P1})^{e0-Sp1}, \eta_{S1}(1-t_{Sp}^{S1})^{Ss1}$, b_{h0}, b_n	$b_{h0} = 0$
When SU goes to OFF state $q_h > 0$	(S_{S1}-1, S_{P1}, b_{h0}-1, b_n, T_{Cr}^{V})	$\xi_{S1}(1-t_{Si}^{S1})^{e1-Ss1}, (1-t_{Sp}^{P1})^{Sp1}$, b_{h0} -1, b_n	$b_{h0} > 0$
$B_{ho = 0}$	(S_{S1}-1, S_{P1}, b_{h0}, b_n, T_{Cr}^{V})	$\xi_{S1}(1-t_{Si}^{S1})^{e1-Ss1}, (1-t_{Sp}^{P1})^{Sp1}$, b_{h0} , b_n	$b_{h0} = 0$

When a queued new SU departs from buffer due to IMPATIENCE	$(S_{S1},S_{P1},b_{h0},b_n-1, T_{Cr}^{V})$	$(1-t_{Si}^{S1})^{Ss1},\left(1-t_{Sp}^{P1}\right)^{Sp1}$, b_{h0} ,b_n -1	Due to impatience
When a queued handoff SU departs from buffer due to IMPATIENCE	$(S_{S1},S_{P1},b_{h0}-1,b_n, T_{Cr}^{V})$	$(1-t_{Si}^{S1})^{Ss1},\left(1-t_{Sp}^{P1}\right)^{Sp1}$, b_{h0} -1,b_n	Due to impatience

Figure below shows the state transition diagram from a generic state which is formulated as $S = (S_{S1},S_{P1},b_{h0},b_n, T_{Cr}^{V})$

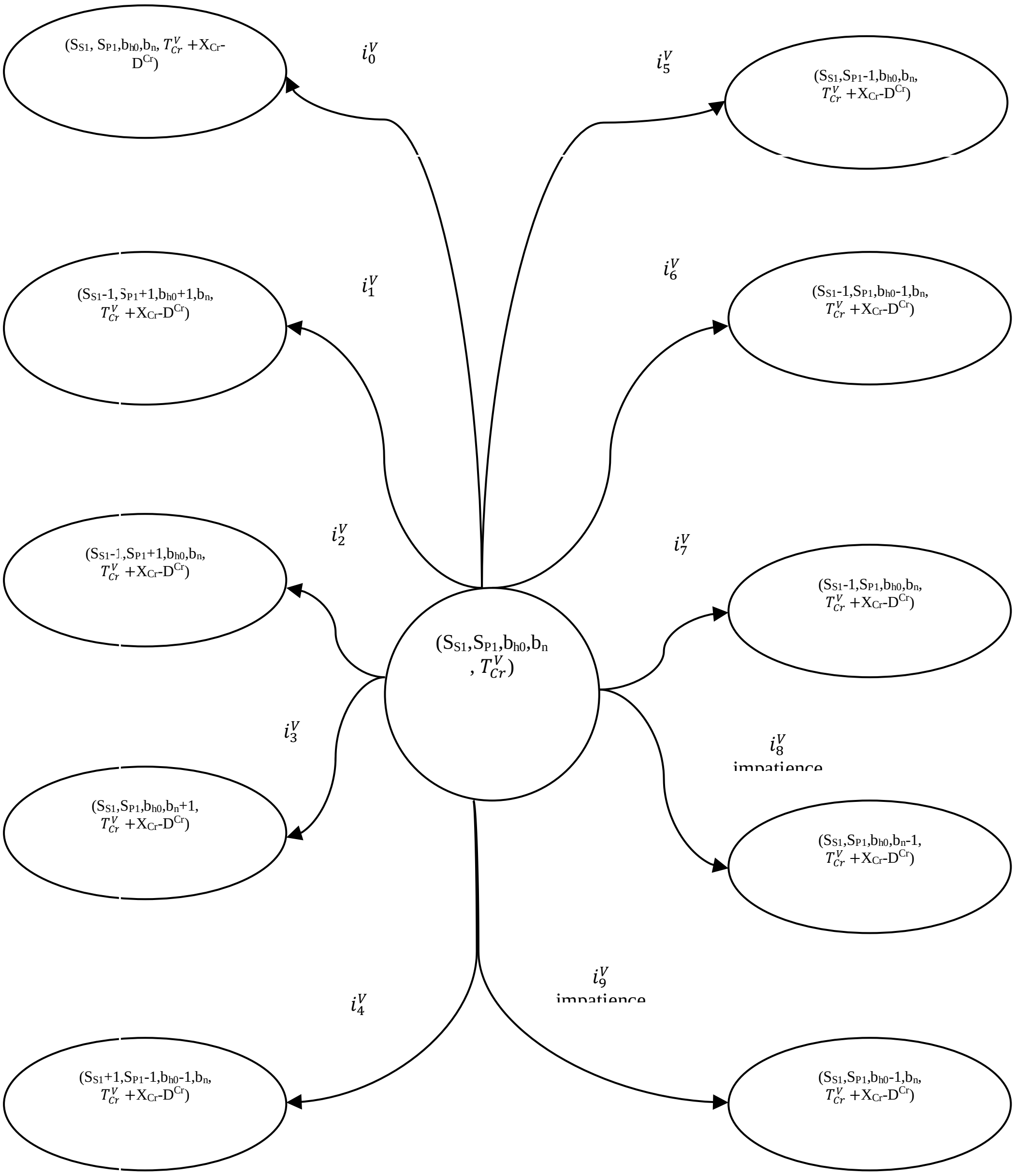

Figure 2. State transition diagrams for the Markov chain model.

Subsequently current frame capacity when there are e_0 PUs can be computed as follows

$$V= \left\{\left[\left(\frac{\sum_{i=1}^{L} r_z^{(i)} S_{Si}}{\sum_{i=1}^{L} S_{Si}}\right)\Delta t(O + S - (e_0 + i_{fa}))/z\right]\right\}$$

Number of packets transmitted during current frame interval.

$$Y_{Cr} = \min(V, T_{Cr}^{V})$$

During the frame period, packets can be lost when the available resources identified in the next frame interval is less than the number of packets waiting for transmission. Hence, the total number of packets lost from current frame to next frame

$$D^{Cr}= \max\left(0,\sum_{i=1}^{L+1} S_{Si} - T_{Cr} - \bar{V} - B\right)$$

Where B is the buffer size (given in packets). From this, it can be seen that the Number of packets of SU's to be transmitted at next frame period is given by

$$T_{Cr}^{V}= T_{Cr} + x_{Cr} - D^{Cr}$$

here, $x_{Cr} = \sum_{i=1} \overline{S_{Si}} - Y_{Cr}$

The blocking probability of SU's is the probability that there is no vacant channel for the newly arrival SU, is given by

$$P^{(b)} = \left[\sum_{\{Q^n=B_n\}} \lambda^s \pi(S_p,S_s,Q^h,Q^n) + \sum_{\{Q^n\leq B_n\}} Q^n \mu_n \pi(S_p,S_s,Q^h,Q^n)\right] / \lambda^s$$

The dropping probability of SU's is the probability that when no vacant channels are found when SU handoff, is given by

$$P^{(d)} = \left[\sum_{\{Q^h=B_h\}} \lambda^p \pi(S_p,S_s,Q^h,Q^n) + \sum_{\{Q^h\leq B_h\}} Q^h \mu_h \pi(S_p,S_s,Q^h,Q^n)\right] / \lambda^{success}$$

Where $\lambda^{success} = \lambda^s(1 - p^{(b)})$ is a total arrival rate of the successfully accessed SU's.

3

Numerical Results and Analysis

A Markovian chain analysis has been done to analyze the proposed queuing models based on the formulations stated above. An analysis has been done to observe the blocking and dropping rates for the proposed model of differentiating the buffers for efficient channel allocation among the starving SUs. The results obtained shows that when the SUs arrival rate is increased from 10 to 90% gradually, we can see an abrupt change in the impact on blocking probability depending on the SU and PU arrival rates. Figure 3 shows the comparison among the various conditions depending on the SUs arrival rate. When there is no PU presence, we can see that the blocking probability is zero. Since the available spectral channels S=O (total number of channels).

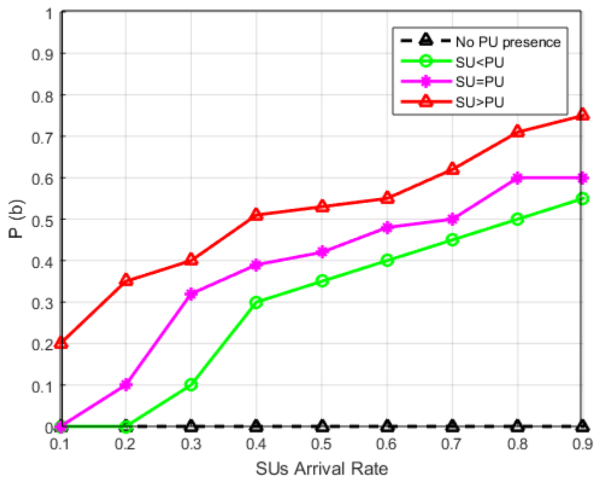

Figure 3. Comparison of blocking probability wrt Sus arrival rate for various conditions

Figure 4 shows the dropping probability of SUs depending on the arrival rate from 10 to 90% based on the PU and SU count. The dropping probability is observed to be very less compared to the blocking probability (i.e., from 1% to 7%).

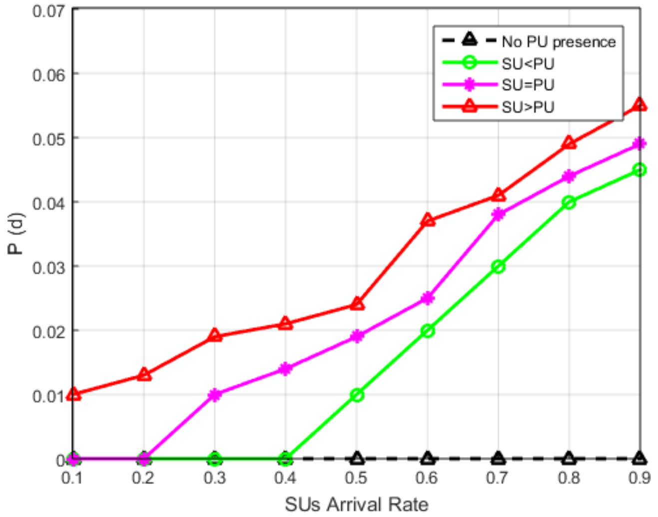

Figure 4. Comparison of dropping probability wrt SUs arrival rate for various conditions.

Figure 5 shows that comparision of blocking probability wrt S spectral available channels from 10% to 90% for different queuing methods(i.e., no buffer, queue buffer and proposed buffer). No buffer is the conventional or ancient queuing model in which the cahnnelk allocation is done by the arrival of the users. Queue buffer model is the FIFO based channel allocation queuing model and the proposed queuing model is the di-buffer model of channel allocation queuing model. The results obtained shows that the proposed model has reduced blocking probability comapred to the last two conventional models.

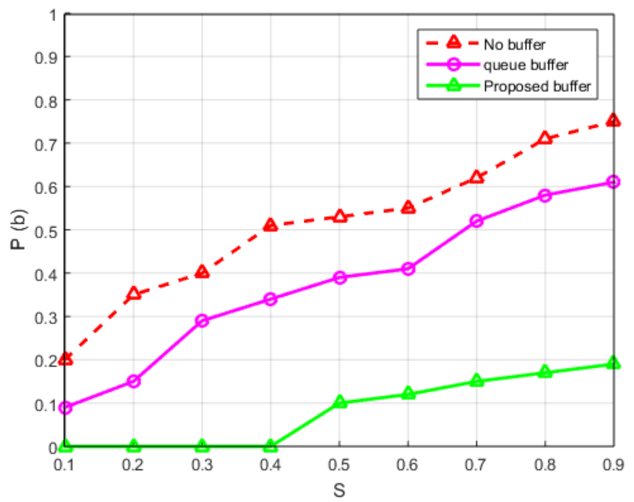

Figure 5. comparison of blocking probability wrt 'S' available spectral channels depending on various queuing methods.

Figure 6. shows the comparison of dropping probability wrt S available spectral channels depending on the queuing models like figure 5. The results obtained shows that there is an abrupt change in the proposed buffer model wrt dropping probability. There is huge difference for blocking and dropping probabilities. The results obtained shows that dropping probability is between 1% to 7%. The proposed buffer shows better results compared to the conventional queuing models.

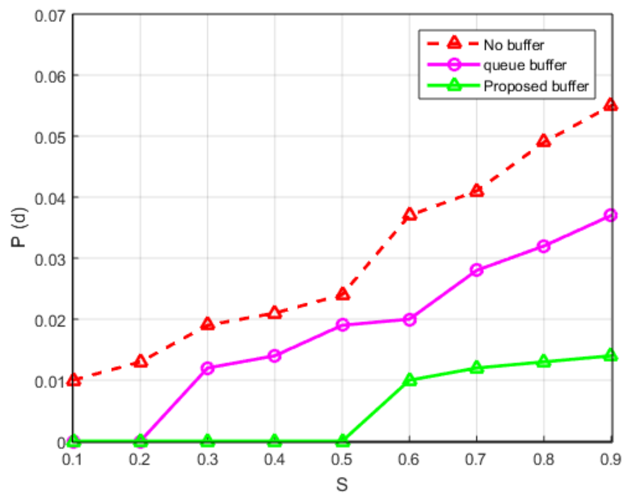

Figure 6. Comparison of dropping probability wrt 'S' available spectral channels depending on various queuing methods.

The above analysis for random SUs arrival rate and the S spectral channels has showed better results for the proposed model of queuing for the channel optimization in the future generation networks like 5G, IoT, IIoT, industry 4.0 etc.

Conclusion and Discussions

A generic state framework was analyzed by using Markov chain model with different state transitions to improve the efficiency of SU's. Many future generation networks are looking forward to utilizing the licensed spectrum such as LTE-U, CRNs, TVWS networks, IoT, IIoT etc. The Dropping and blocking probabilities of Su's in competitive scenario was analysed by using two buffers for both new SU's and existing SU's. The optimization of channel allocation has been done more efficiently when compared to many conventional networks. The results obtained proves that the channel allocation optimization based on proposed buffering mechanism provides less blocking and dropping probabilities compared to the conventional networks. Markov chain analysis has been done and used to analyse the proposed mechanism. The proposed buffering mechanism not only reduces the congestion and interference communication networks, there is more and more requirement for this queuing mechanism to reduce congestion and starvage of channels for Sus.

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among the SUs but also reduce the dropping of users due to impatience. As the network capacity is increasing more and more wider and the next generation networks are moving to short to very short-range

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