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Review on Channel Allocation in Cognitive Radio Network using Priority Scheduling

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ABSTRACT
Radio Spectrum is one resource that is not available in abundance. Hence it is necessary to make sure that the available spectrum is used as efficiently as possible for data transmission. Cognitive Radio is one technology that provides a solution for efficient use of the radio spectrum. A Cognitive Radio Network (CRN) can be thought of as an intelligent system that is well aware about its environment. There are two major responsibilities that can be considered for a CRN. One is sensing if there are any channels in the spectrum that are not being used by any Primary users and the other is allocation of such unused channels to the secondary users. In this paper, we present a channel selection algorithm which is based on priority queue scheduling. This algorithm helps in increasing the throughput of the network and also collision if data during transmission. The proposed algorithm results in a 20% increase in the overall throughput when implemented on a NS-2 simulator.

Keywords:- Cognitive Radio Network (CRN), Priority Queue Scheduling, Primary User (PU), Secondary User (SU), Threshold

I. INTRODUCTION

A Cognitive Radio Network is a form of wireless communication in which a node has the intelligence to determine which of the communication channels in a wireless spectrum are being used and which are not. Based on this, it performs transmission or reception, thereby enabling greater concurrent wireless communication and also reducing the delay caused, if nodes did not have the intelligence to determine if any channels were free and waited for channels that are currently being used to become free. A CRN manages the spectrum dynamically. [1][2]

In CRN, there are 2 types of users. Primary Users (PU) which are licensed users and Secondary Users (SU) which are Unlicensed Users. Both users use the RF spectrum for transmission of data. However, it's the primary users who have the priority over the secondary users. Only when the primaries are not using a channel in the spectrum, a secondary is allotted the channel. This allotment is done by the network. [1]

The network manages this type of allocation by having centralized Base Stations for both primary and secondary users. The PUs and SUs communicate through the base station. If a SU wants to make use of a channel in the spectrum, it posts a request to its base station. The base station of the SUs will have a list of requests from all the SUs under it. [1][5]

When a channel in the spectrum becomes available, the Base Station of the PUs intimates the Base Station of the SUs about the availability. The SU Base station then checks its list for the requests posted by its SUs for the channel. [7] Based on the priority, the request with the highest priority is selected. The corresponding SU is intimated about the channel availability. The SU then uses the channel for packet transmission.

The SU keeps using the channel as long as there are no PUs needing channels for transmission. In case a PU now wants to communicate, the SU that is using a channel in the spectrum must make way for the PU. This indicates that the PUs have greater priority than the SUs. [8]

The indication that a PU needs a channel for communication is determined through a Threshold value. As long as the CQI value is greater than the Threshold value, the secondary can use the channel. Once the CQI goes below the Threshold, it indicates that a primary wants to communicate and hence a SU makes way. [8]

II.LITERATURE SURVEY

Minal S. Moon et al [5] have proposed an approach for channel selection for data communication using energy detection sensing technology. A new data structure called Preferable Channel List has been introduced in the proposal. PCL has been used for selection of channel in systems where the receiver is dominant. The proposed system gives reasonable throughput while keeping the delay at a minimum.

Dibakar Das et al [6] have used Lyapunov drift techniques using which caching and scheduling is performed between the primaries and secondaries. The priority of the resource is maintained using the Variable Primary Caching Policy (VPCP) algorithm.The simulation has been carried out to compare the performances of the proposed algorithm and thenon-co-operative algorithm. The proposal also extends the analysis to a network with multiple channels.

Indika A. M. Balapuwaduge, Lei Jiao, Vicent Pla [4] have proposed a queue-based channel assembling strategy for heterogeneous channel CRNs and analytical structure for performance evaluation of such networks. They achieved significant reduction in forced terminations of ESU services. This proposal is recommended if PUs are more active in a CRN

III. PROBLEM DEFINITION

From the literature survey, it is very clear that the dynamic channel allocation routine that uses priority as its basis does not exist for a CRN. This becomes more difficult when there is a network with nodes requiring heterogeneous services. In such situations, it is possible that critical parameters like delay may be ignored. Hence, a proposal is made in this paper for providing a dynamic approach for allocating resources while keeping priority scheduling as one of the core concepts for a CRN.

As already mentioned, a CRN consists of two categories of nodes or users namely Primary and Secondary. These users have heterogeneous network and service requirements. While it is the PU that has access to the channels in the spectrum by default, it is the responsibility of the SU Base Station (SU-BS) to allocate the unused channels to the SUs. For this,the SU-BS uses a metric called Channel Quality Indicator (CQI) that helps the SU-BS make a decision on which of the secondary should get the unused channel. This metric CQI is compared with another metric called Signal-to-Interference-Noise-Ratio (SINR) to make this decision.

IV. PROPOSED SYSTEM

4.1.Sensing the Spectrum

The capability of the cognitive radio to have knowledge of the spectrum and thereby detect opportunities of unused channels is mainly because of the property of spectrum sensing. This sensing is carried out by the base stations of the secondary network. Spectrum sensing can either be In-Band or Out-Band. Through Out-Band sensing, the BS tries to find out if there are any spectrum opportunities. The In-Band sensing is used to determine if there is any primary user present that needs a channel in the spectrum.

4.2 Selection of Channels

This step follows the spectrum sensing phase. Based on the result of the sensing different channels are allotted to the various SUs. The channel selection process is performed according to priority queue scheduling methodology. CQI value is used to determine if a channel can be allotted. CQI can be considered as a counting value for every spectrum opportunity. CQI also takes into account the selections of neighboring CRs, the noise and other interferences involved.

4.3 System Model

A CRN is made up of two types of nodes, namely, Primary users and Secondary Users. Out of these, it's the PUs who have more authority towards the access of radio spectrum. The SUs have low spectrum access authority. This means the SU cannot access the channels of a radio spectrum whenever they want and carry out data transmission. They will have to wait for a channel to be made available by one of the PUs. This means that the SUs must continuously keep track of the spectrum to see if any channels have become free. Once a channel is made free, the SU must make sure that it is taking over that channel and performing transmission without causing any troubles to other primaries that are using the spectrum. Also when the SU senses that a PU is approaching to access a channel, it must make way for the PU by releasing the channel that it has been utilizing for transmission.

Figure 1 represents the primary and secondary users in a CRN. The Primary Network consists of the Primary Base Station (PU-BS) and the PUs, while the secondary network is made up of the SUs and the Secondary Base Station (SU-BS). It is also clear that all the PUs are connected to the spectrum channels while the SUs are waiting for a channel to become idle.

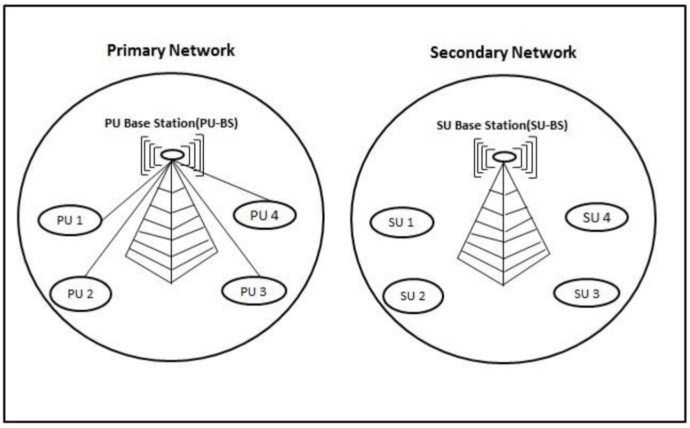


Figure 1. A CRN with PUs and SUs

When a SU wants to use a channel for transmission, it intimates this to the SU-BS. The SU-BS then keeps track of the spectrum by comparing the values of the CQI and the Threshold. If the SU-BS finds that the CQI values gets above the threshold that is an indication that a channel has become free. Thus, the SU-BS checks for its priority queue and make a decision after which it allocates the free channel to one of the SUs.

Let the spectrum be divided into Ω channels. If RC is the Radio Spectrum Channel set, then the sub channels can be represented as RC={RC1,RC2,RC3,…….RCΩ }. Also let the total bandwidth of the channel be B. Then the bandwidth of each of the individual sub channels is given by B/Ω. Thecapability of a channel in a wireless network communication is defined by the Signal-to-Interference-Noise-Ration (SINR). SINR is defined as the ratio of the power of the signal of interest to the sum of the power of interference and the power of background noise.If P is used as the power notation, then the expression for SINR is defined as,

$$SINR = \frac{Psignal}{Pinterference + Pnoise}$$

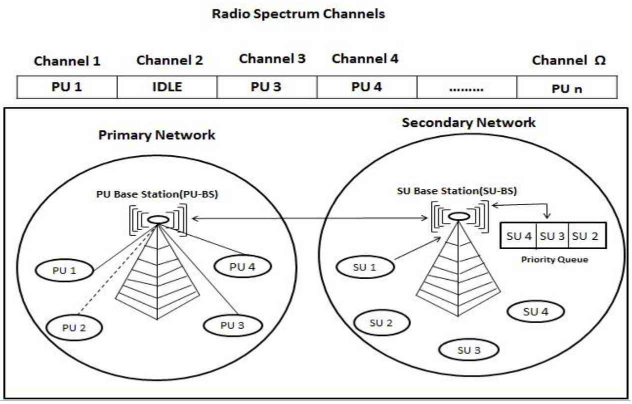
The SINR metric is used to determine the CQI, based on which the allocation decision is taken.

$$CQI = \log_2(SINR + 1)$$

Now that there are Ω channels in the spectrum and assuming that one of the SU has intimated to its SU-BS about its need to perform transmission, the SU-BS first calculates a referral threshold. Then the SU-BS compares the values of CQI and the Threshold. If CQI > Threshold, it indicates that a channel is idle. The SU-BS immediately refers its priority queue. It then selects the SU with the highest priority. The SU with the highest priority is the one having the least Spriority value. The Sprioritynof the selected SU is then incremented by one. This is to make sure that the same SU does not get access to the channel everytime.

For the data transmission to take place, the power required to transfer the data is compared with the total power currently available. Only if Ptransmitted < PTotal, thetransmission happens. The SU-BS repeats this process till CQI > Threshold. Once CQI falls below the threshold, it indicates arrival of a primary and hence the channel is taken from the SU and relinquished to be used by the PU. The entire process is represented in figure 2.

Figure 2. SU-BS allocating idle channels to SUs



Based on Dynamic Spectrum Allocation for cognitive radio, when a primary user (PU) returns to the band area which cognitive users are using, cognitive radio have to pause the work and transit to another frequency band, this is called spectrum handoff. The switching needs to be done as smooth as possible because the unexpected transition of working spectrum may lead to decreased transmission reliability or even transmission failure. The proposed algorithm for the system is presented next.

4.4 Algorithm

Step 1: let the spectrum be divided into **Ω** channels.
Step 2: One of the **SU**s requests Base Station for a channel.
Step 3: Calculate the Threshold value
Step 4:**SU-BS** does the following check
If *CQI < Threshold*
Then **SU** request declined
Else Goto **Step 5**
Step 5:**SU-BS** selects the **SU** wit (2) t priority (minimum$S_{priority}$ value)
Step 6:$S_{priority}$of the selectedSU is incremented.
Step 7: Check the queue size of selected **SU**
If *queue size > Threshold value*
ThenGoto **Step 5**
Step 8:**SU-BS** allocates the idle channel to the **SU** with highest priority and small queue size.
Step 9: check if $P_{transmitted} < P_{Total}$
Then data transfer takes place
Step 10:**SU-BS** does the following check again
If *CQI < Threshold*
Then **SU** request declined
Channel handed over to the **PU**
Else Goto **Step 5**

V.SIMULATION RESULTS

The proposed algorithm is implemented using the NS-2 simulator. The simulation is run for a time period of 100 seconds. The transmission range for all the hubs has been defined at 200 meters. The size of the data being transmitted is 256 B. The standard used at the MAC sub layer is IEEE 802.11. The area size considered for the simulation is 500m X 500m. The X-axis represents the number of nodes while the Y- axis represents the throughput. The simulation was run for different number of nodes ranging from 20, 40, 60, 80 and 100. Out of the all nodes 5 nodes we considered to be the source. The data recorded as a result of this simulation is graphically presented next.

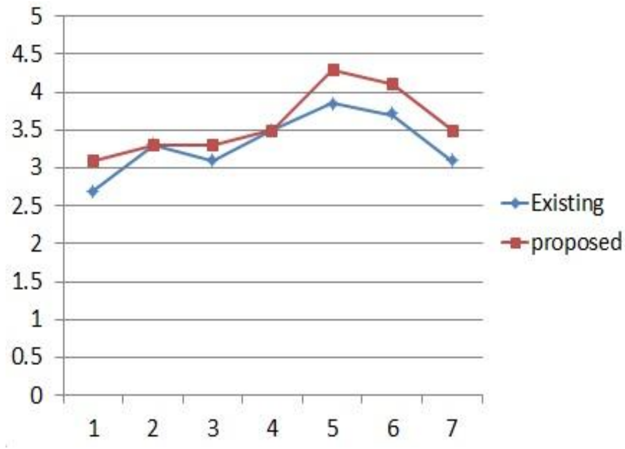


Figure 3. Throughput

VI. CONCLUSION

In this paper, we have presented a novel approach to minimize the wastage of spectrum by using two important methodologies, namely Spectrum Sensing and Channel Selection based on priority. Although several techniques existed for selecting the users to whom channels would be allotted, the priority based scheduling approach made sure that there is impartial allocation of channels for all the SUs. From the graph it is very evident that the proposed algorithm has made significant improvement in the throughput of the system with minimization of delay and collision avoidance. Statistically, an improvement of 20% is achieved by the proposed algorithm using NS-2 simulator.

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