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Delay Based Scheduling For Cognitive Radio Networks

A.R.Devi[1] R.Arun kumar[2] S.Kannagi[3]

P.G Student P.S.R Engineering College, India[1]

Assistant professor at P.S.R Engineering College, India[2]

P.G Student P.S.R Engineering College, India[3]

ABSTRACT— Spectrum is generally allocated by the government for wireless networks that allotted frequencies are utilized by licensed user called primary user. Some of the frequencies are underutilized by licensed users; cognitive radio is the emerging technology to access the underutilized frequencies in available spectrum band without causing any performance degradation to the licensed users. During the switching to different frequency bands in cognitive radio networks the users experiences a delay. The proposed system addresses this delay as a scheduling problem. A scheduling problem is formulated that takes into account different delays experienced by the secondary users (SUs) in a centralized cognitive radio network (CRN) while switching to new frequency. A polynomial-time suboptimal algorithm is proposed to address the scheduling problem. Performance evaluation is done by varying switching delay, number of frequencies, and number of SUs.

KEYWORDS—cognitive radio,scheduling,spectrum switching delay

I. INTRODUCTION

Cognitive radios are wireless networks which consisits of primay users and secondary users.Frequency switching is done between primay user and secondary user.Hardware switching delay is experienced,when a cognitive radio device changes its poerating frequency.That switching delay is generally depends on wideness between two frequency bands.Switching delay from 459MHZ to 15GHZ conduces larger switching delay than changes from 450MHZ to 455MHZ.If the switching delay is narrow,it might be negligible.While switching to different frequency bands delay is occurred,so that scheduling algorithm and spectrum allocation are designed by considering switching delay.The dependence of switching delay between old and new frequency is always unique to opportunistic spectrum access.

In normal radio systems the spectrum allocation process is carried out by special control equipments, these equipments are normally parts of the core network. In cognitive radio all operations are performed by the radios themselves in an ad-hoc manner without the need for special equipments or core network. The complexity of the spectrum allocation process arises from the fact that the user demand for spectrum is highly dynamic[1]. Thus, the allocation process must also be dynamic. The dynamic spectrum allocation process can be summarized as distributing the trace demanded by the users in the spectrum holes which were found by the spectrum sensing procedure. In this operation users generally act to increase their own benefit but they should obey some general rules to keep some fairness between the users and to ensure obtaining a high overall benefit. The user behaviors along with those general rules are called user strategies. The decision making process then can be seen similar to playing a game. Each user represents a player in that game and the strategies represent the rules of the game. This concept is formulated on a mathematical theory called the game theory.
CR user in the CR netwrok has capabilities of,

- Find idle channel in avilable spectrum band.

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- Sele-ct the best channel and access that channel

The term channel switching latency refers the time taken to search for idle channel,but in some other works it gives the meaning of hardware delay in frequency synthesizer where the cognitive radio device already determined the idle channel for spectrum switching. In cognitive radio networks switching delay is considered by the area of routing.In most of the works the primary goal is to minimize the number of channel switchings.Assume that all the channel switching causes some certain delay with respect to separation between frequency bands.

II. SYSTEM MODEL

The existing work assumes that no delay occurs when an SU switches from one frequency to another frequency but in reality, some portion of the subsequent time slot is inevitably wasted to tune to the new frequency. In the existing the Greedy Maximal Scheduling (GMS) algorithm does not have any provable efficiency ratio when the switching overhead is considered. Different nodes may sense different spectrum availability, efficiently sharing the information in the dynamic spectrum environment was a challenging process. In previous work in literature, a scheduling problem is formulated that makes frequency, time slot, and data rate allocation to the SUs in a CRN cell by maximizing the total average throughput of all SUs in the CRN cell, while at the same time ensuring that reliable communication of the SUswith the centralized CBS is maintained, no collisions occur among the SUs, and the PUs are not disturbed.

III. PROBLEM FORMULATION

Sheduling is done in cognitive radio networks that makes frequency,time slot and data rate.Scheduling problem is formulated by considering above parameters in order to achieve maximum throughput of secondary users in CRN.Assume that no collision is occur between primary user and secondary user,at the same time communication of SU with cognitive base station is maintained.Secondary user should not interfere with primary user[1].

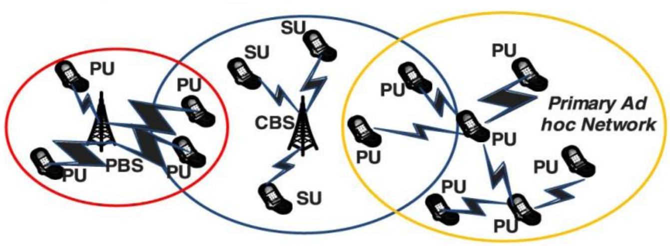

Figure 1-CRN Architecture[1]

Figure 1 shows the centralized CRN architecture,in this type of architecture scheduling is done in the cognitive base station.All the secondary user sends their sensing results to the CBS and spectrum decision is made CBS.In this work consider that all the secondary user has the packets for its transmission. The packets transmitted by secondary user is calculated for its every interface by the following equation[1].The size of the packet size is calculated as S=B×T,B is bandwidth and T is length of the timeslot.The number of packets transmitted by cognitive user is calculated in every T seconds.

$$U_{if} = \left[ln\left(1 + P_{IFmax} X \left(\frac{|Gi0|}{|G_{if} * \sigma|} \right)^2 \right) \right]$$

Where P_{IFmax} is PU tolerable interference power,Gio is channel gain between SU and CBS, Gif is channel gain between PU and SU.□ is noise variance.

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Network conditions are assumed,that means PU and SU location.The channel co-efficients should not affect the value of Uif.The length of the scheduling time period is generally depends on spectrum environment.In some network secondary user have to vacate the presence of primary user witin 2 seconds.Scheduling period can be denoted as T and it will be T=1,2……T..

$$\sum_{F=1}^{F}\sum_{t=1}^{T} Xift \geq 1$$

$$\sum_{F=1}^{F}\sum_{t=1}^{T} Xift \leq 1$$

Xift is a binary decision variable.If Xift=1 SU i transmit packets in time slot t with frequency time t and zero for otherwise.Atleast one time slot is assigned to every secondary user for this formulation and then provide some spectrum environment.The secondary user may endup with bad channel conditions and with unable to send their packets.Transport layer protocol is used to close he connection if no packets are recieved for sometime period.

The formulation of the work assumes that no delay occurs when an SU switches from a frequency to another frequency. However, in reality, some portion of the subsequent time slot is predictably wasted to tune to the new frequency; therefore, only the remaining portion of the next time slot can be used for actual data transmission. It may be the case that the time it takes to switch to the new frequency is greater than or equal to the time slot length, which means that no packets can actually be sent using the new frequency. Since the scheduling decisions are known in progress by SUs, they should not waste time and energy in vain to switch to the new frequency; they should instead stay in the same frequency. On the other hand, the new frequency band might be more gainful in terms of throughput by having a higher Uif value. The problem is whether the delay incurred while switching to the new frequency band offsets this throughput advantage or not. If the throughput advantage of the new frequency band outweighs the disadvantage of throughput losses due to switching delay, then the SU may favor switching to the new frequency. Therefore, there is a tradeoff here; i.e., switching to the new frequency band may or may not be gainful depending on the circumstances (switching delay and the channel conditions (Uif values) of the old and new frequencies). Furthermore there is also need to keep track of the information about which interface is assigned to which frequency since each interface experiences different switching delays depending on the frequency that it was assigned to in the previous time slot. Spectrum switching delay, which depends on the distance between the used frequencies. Moreover, as in [1], we assume in the simulations part of this work that the buffers of the SUs are continuously backlogged; i.e., there are always enough number of packets to transmit with the data rate dogged by the scheduling algorithm. This statement enables us to efficiently evaluate the performance of the scheduling algorithms by avoiding the possible influence of the traffic arrival process. In practice, channel gains can be expected by the SUs for instance by employing sensors near all receiving points and can be made available at the central controller, which is the CBS.

IV. SIMULATION RESULTS

If a frequency f is not the first used frequency for interface a of SU i and there are silent time slots previous time slot t, i.e., 0 < miat < t _ 1, then interface a uses these silent time slots to switch to the new frequency f. Scheduling decisions are made by the CBS for the duration of a scheduling period, which consists of T time slots. Scheduling decisions for all T number of time slots are made by the scheduling algorithm but it is not the case that the scheduling algorithm is executed in each time slot. The decisions for all time slots of that particular scheduling period are made once and this is before the actual scheduling period for data transmission of that scheduling period starts. In other words, ours is a "frame based" scheduling discipline rather than a "slot-based" scheduling discipline. These scheduling decisions (Xiaft values) are then sent by the CBS to the SUs through the CCC. Therefore, SUs know the scheduling decisions (which frequencies are assigned to them

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in which time slots) before the beginning of the first time slot of the scheduling period. Because the scheduling decisions are known by SUs in advance, they can use these silent time slots to switch to the new frequency. If the number of silent time slots are enough to reach the total frequency switching, SU becomes ready to use the new frequency in the upcoming busy time slot. In this case, SU does not misuse any portion of the busy time slot for frequency switching and hence it can use the full busy time slot for data transmission. Otherwise, SU utilizes the silent time slots to achieve some portion of the frequency switching. The enduring switching is completed at the beginning of the next busy time slot. If the silent time slots and portions of the busy time slot are still not enough to achieve the frequency switching and no available time ruins in the busy time slot for data transmission, then it means that no packets can be sent by the SU using the new frequency in the busy time slot.

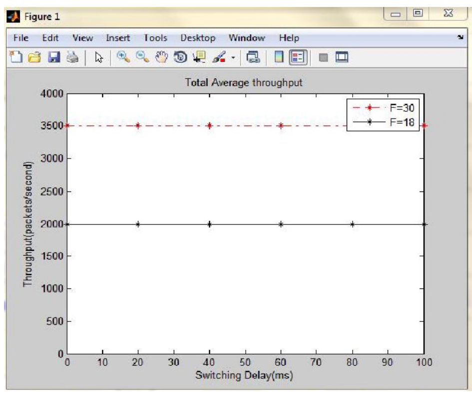

Figure 2-Delay Vs Throughput

Three set of experiments were evaluated. In the first case the values of β is varied and plot the graph for F=18 and F=30.Set the value as N=30 and compare switching delay inure result this system achieves maximum throughput. In this case for F=30 throughput that the upper bound yields is3376 packets per timeslot. If F=30 we can get maximum throughput at the same time it increases with increases in switching delay this implies that higher throughput savings is achieved form throughput as frequency and switching delay increases. It gets more difficult to assign each SU at least one time slot as the number of SUs increases and the scheduler mostly uses more than one interface. It occurs most of the time that an SU is assigned a frequency for a particular time slot but not assigned any frequency in the subsequent time slot because the other SUs need to be assigned some frequency to satisfy the constraint that each SU is assigned at least one time slot. Observe here that the scheduler does not mandate each SU to be assigned a frequency in each time slot, but only permission that each SU is assigned at least one time slot during the course of the entire scheduling period.

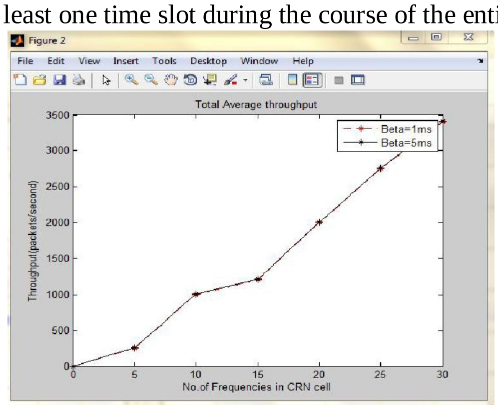

Figure 3-Throughput Vs No. of Frequencies

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In the second set the value of N=30 and vary the value of F,then plot the results for β=1 ms, β=5ms.Throughput increases linearly with the number of frequencies in all cases. From this result id demonstrates that switching delay becomes an even more important factor in CRN. When an SU is not assigned a frequency in a particular time slot but assigned a frequency in the subsequent time slot, the hardware switching delay has less impact on the throughput performance since there is more time available to achieve the frequency switching

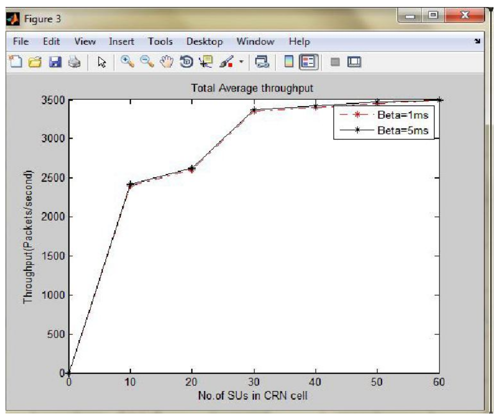

Figure 4-Throughput Vs No. of SUs

V. CONCLUSION

The scheduling problem is formulated which considers switching delay that occurs while switching to different frequency band. The simulation results show that the throughput of the system yields is very close to its upper bound. Moreover system is robust to changes in the hardware spectrum switching delay. Also throughput savings it achieves increase as the number of frequencies in the CRN cell (F) and the hardware switching delay for a unit frequency difference increases. Moreover, the throughput savings of our algorithm are important even when there are a small number of SUs, and the savings remain significant as the number of SUs increases.

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