Delay Minimization using Cognitive Radio from Spectrum Management Perspective

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ABSTRACT
Cognitive radio (CR) technology is accepted as the most efficient method to improve the spectrum efficiency, which utilizes the available spectrum opportunistically in wireless communication networks. CR acts as a secondary (unlicensed) user to access the primary (licensed) user frequency bands when they are not being used, and release the frequency bands when the primary users are detected. In this paper we propose the system for efficient and flexible spectrum access and utilization amongst the secondary users. The proposed system is implemented by developing fast and efficient algorithm using CR concept. The experimental results have addressed the issues discussed in the proposed system. We optimized the switch delay between the nodes and improved the packet transmission amongst the nodes.

General Terms

Wireless communication, licensed user, unlicensed user, switch delay, packet transmission.

Keywords

Cognitive radio, Dynamic spectrum access, spectrum allocation.

1. INTRODUCTION
Traditional spectrum management techniques, as defined by the Federal Communications Commission (FCC), are based static spectrum allocation policy where the radio frequency bands are licensed to the authorized users by the government.. on a long term basis for the specified region. However this can cause inefficient spectrum usage [1],[2]. Where a large portion of the assigned spectrum is used sporadically, leading to an under utilization of the allocated spectrum. And this under utilization is due to the fact that an authorized user may not fully utilize the spectrum at all times in all locations. Hence efficient spectrum management is necessary and critical for satisfying the increasing spectrum demands in wireless communication applications. However numerous reports indicate that the spectrum usage experiences significant fluctuations [3],[4].The FCC has been investing new ways for efficient and flexible utilization of the available spectrum and proposed dynamic access techniques, to solve the spectrum inefficiency problem, for improving the flexibility of the spectrum usage by considering all dimensions and issues of spectrum usage. Cognitive Radio technology is acknowledged as the key enabling technology of dynamic spectrum access [5],[6].

Cognitive radio systems offer the opportunity to improve spectrum utilization by detecting unoccupied spectrum bands and adapting the transmission to those bands while avoiding the interference to primary users. The cognitive radio can dynamically adjust the operating points over a wide range depending on availability of the spectrum. The CR provides the capability to share the wireless channels in an opportunistic manner. However the basic requirement is to ensure that the existing licensed users are not affected by such transmissions. The CR networks, however, impose unique challenges due to the high fluctuation in the available spectrum, as well as the diverse quality of service (QoS) requirements of various applications. For addressing these challenges, each CR user in the CR network must.

• Determine the availability of the spectrum.

• Select the best available channel.

• Coordinate access to this channel with licensed users.

• Vacate the channel when a licensed user is detected. [7]

Above mentioned challenges can be realized through spectrum *management* functions that address four issues: spectrum sensing, spectrum decision, spectrum sharing, and spectrum mobility. For addressing the above issues we focus on development efficient and fast algorithms for minimizing the switch delay between the nodes using the CR concept.[8]

The rest of the paper is organized as follows. We give an overview of the CR system in section 2, and describe the proposed system using the concept of reconfigurable radio in section 3.Section 4 presents the implementation techniques used for development with performance analysis. The paper is concluded with summary.

2. COGNITIVE RADIO CONCEPT
The term” Cognitive Radio” was coined by Joseph Mitola III. In an article published in 1999 [3]. A Cognitive Radio (CR), as its name readily implies, is a radio that is capable of cognitive behavior. CR’s cognitive abilities form six-phase cognition cycle “Observe, Orient, Plan, Learn, Decide, and Act” Cognitive radio is a goal-driven framework in which the radio autonomously observes the radio environment, infers context, assesses alternatives, generates plans, and supervises multimedia services, and learns from its mistakes. The cognitive radio should have the following characteristics:

• Aware of its environment;
• Capable of altering its physical behavior to adapt to its current environment;
• **L**earns from previous experiences; and
• Deals with situations unknown at the time of the radio’s design

Based on the above, the term cognitive radio can be defined [9] an intelligent wireless communication system that is aware of its surrounding environment (i.e., outside world), and uses the methodology of understanding-by-building to learn from the environment and adapt its internal states to statistical variations in the incoming RF stimuli by making corresponding changes in certain operating parameters (e.g. transmit-power, carrier-frequency, and modulation strategy) in real-time, with two primary objectives like highly reliable communications whenever and wherever needed and efficient utilization of the radio spectrum. Two main characteristics of the cognitive radio are [10-12].

Cognitive capability: It is the ability of the radio technology to capture or sense the information from its radio environment and to adjust and reconfigure its radio parameters and adapt to the dynamic radio environment. The tasks required for adaptive operation in open spectrum is referred to as the cognitive cycle. Through this capability, the portions of the spectrum that are unused at a specific time or location can be identified, referred as spectrum holes. Therefore, the best spectrum and appropriate operating parameters can be selected.

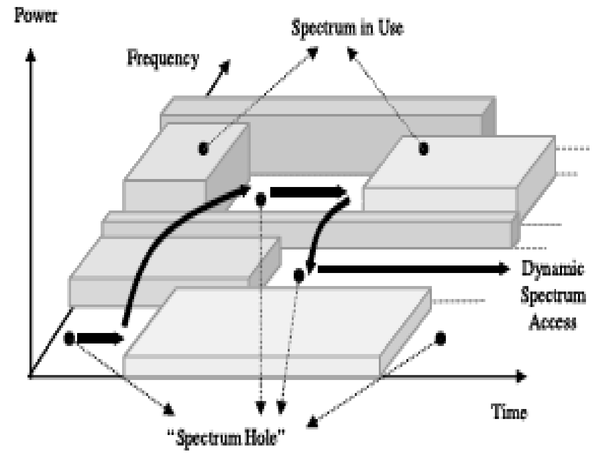

Fig 1.Concept of spectrum hole

Reconfigurability: This enables the radio to be dynamically programmed according to the radio environment means thereby device able to change its operating parameters like center frequency, power, bandwidth, frame length, modulation, spatial transmission pattern etc. according to information gathered from its radio environment.

The cognitive radio technology is used to satisfy increasing requirements for spectral efficiency, effective etiquette, and resistance to interference. It is noteworthy that the cognitive radio network concept has the potential to explicitly protect the spectrum rights of incumbent license holders. The cognitive cycle is different from today's handsets that either blast out on the frequency set by the user, or blindly take instructions from the network. Cognitive radio technology thus empowers radios to observe more flexible radio etiquettes that were not possible in the past [9]. Cognitive radio is used to meet increasing demand of spectrum with a system that is compatible with existing deployed wireless systems, stimulates new innovation, reduces regulatory burden, encourages market competition, preserves the rights of incumbent spectrum license holders, and benefits the populace overall [13].
The two characteristics mentioned above are very important form spectrum management point of view. And it can be addressed from spectrum management perspective by reducing the switching delay amongst the users.[14],[15].

3. PROPOSED SYSTEM FOR DSM USING COGNITIVE RADIO

For addressing various issues from dynamic spectrum management Point of view, we have developed the high level communication model of the system [16]**.** Fig.2 shows proposed system model.

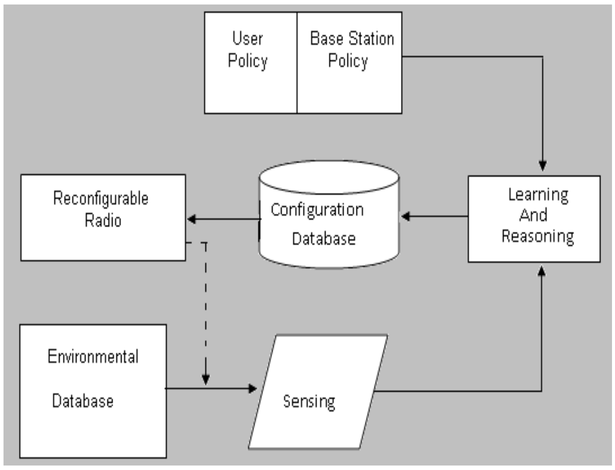

Fig 2: Proposed System Model

The proposed system model consist of major components like a reconfigurable radio with configurable parameters like center frequency, power, bandwidth, frame length, modulation, spatial transmission pattern etc.

A sensing engine will accept inputs from the external environmental such as the radio frequency (RF), but possibly other sources such as data sources on the internet or other networked nodes. Our learning and reasoning engine will accepts inputs from the sensing engine and policy data base where user policy and base station policies are already defined. The learning and reasoning engine will also determines an appropriate configuration for the radio components. Reasoning engine may be capable of learning based on experience.

A configuration database is required to maintain the current configuration of the radio components. A simple CR system might have single reconfigurable radio component with a reasoning engine accepting sensing information from local node but not from external data sources. Finally, a policy data base may exist that determines what behavior is acceptable in what circumstances. This data base may be dynamically configurable allowing policies to be changed when required.

For implementation of the system discussed above, we have considered a group of primary and secondary users with a base station. In which a group of secondary users monitor a set C of primary channels. The state of each primary channel switches between 'used' and 'unused' frequency band. The secondary users can cooperatively sense any one out of the channels in C in each slot, and can access any one of the L = |C| channels in the same slot. In each slot, the secondary users must satisfy a strict constraint on the probability of interfering with primary transmissions on any channel. The objective of the secondary users is to select the channels for sensing and accesses in each slot .We assume that all channels in C have equal bandwidth B, and are statistically identical and independent in terms of primary usage. The state of channel as in any time slot k is represented by variable Sa(k) and could be either 1 or 0, where state 0 corresponds to the channel is free for secondary access and 1 corresponds to the channel is occupied by some primary user. The secondary system must be capable of taking decisions about which channels to sense and access in each slot. Whenever the secondary users access a free channel in some time slot k, they get a reward B equal to the bandwidth of each channel in C[17].

The secondary system includes a decision center that has access to all the observations made by the cooperating secondary users. The observations are transmitted to the decision center over a dedicated control channel. The same dedicated channel can also be used to maintain synchronization between the secondary transmitter and secondary receiver so that the receiver can tune to the correct channel to receive transmissions from the transmitter. The sensing and access decisions in each slot are made at this decision center.

For this purpose we develop an algorithm which will sense the primary channel and based on that information sharing policy is decided. Once decided, another algorithm for deciding the priority will be developed base on the results of this algorithm, the priority of the secondary channel will be decided by minimizing the switch delay between the node to node transmissions**.**

4. IMPLEMENTATION

4.1 Infrastructure

For implementation of the proposed algorithms, we considered a system with single base station with n number of primary and secondary users for different services. Each primary user will have their own licensed spectrum band, and secondary users can access that spectrum band when not used by primary user.

4.2 Scenario

The scenario for implementing the algorithm and obtaining the results is shown in Fig.3 The wireless network is developed for three different services like call, internet and multimedia. The size of the simulation area is 1000*1000 .We created network of n=50 nodes where primary users and secondary users are assigned. Three channels and one base station is placed. Also we declared the base station policies and user policies in the policy database tables. The track of all the users is kept. We may think of primary and secondary users as arriving to the system by initiating service request and terminating the same. For above scenario TCL scripting is done. Each node is assigned with the node id and timing specifications are also declared.

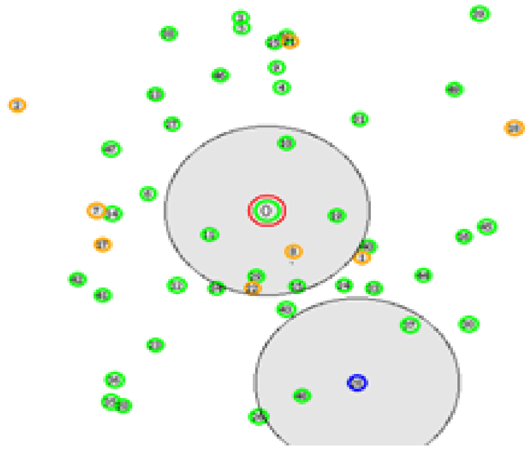

Fig 3: Simulation scenario

4.3 Performance Analysis

In this section we show the relation between number of nodes and the switch delay as shown in Fig.4. In order to evaluate the performance for validation of our algorithm we have simulated the wireless network developed using CR concept and following results are obtained.

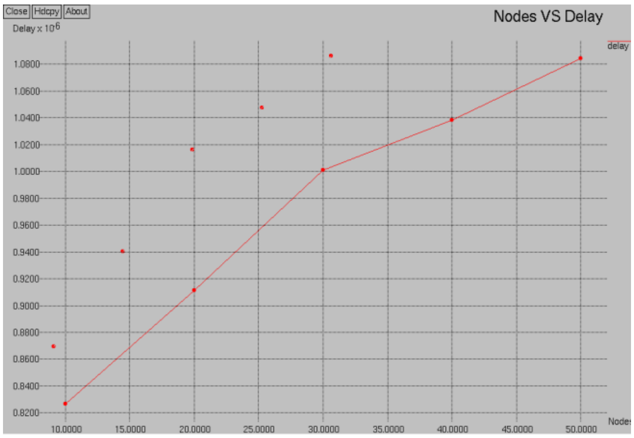

Fig 4: Reduction in switch delay versus number of nodes

In Fig 4. , We show the effect on switch delay even if the number of users is increased. The delay represented here is the traveling time between the nodes for the packet. From the result it is observed that the switch delay is decreased significantly even if the number of users increased which is essential for effective channel allocation and utilization from spectrum management point of view. Following results show the improvement in packet transmission because of reduction in switch delay.

Fig.5 shows the relationship between transmissions of packets from node to node versus number of nodes. From the results we can see that the packet transmission is increased even with the increasing number of users.

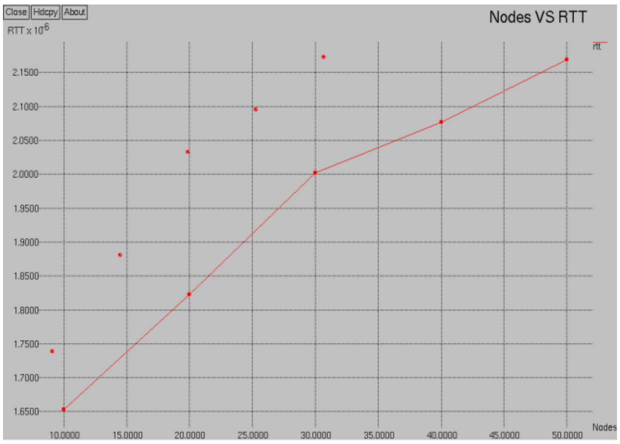

Fig 5: Transmission of packets versus number of nodes

5. CONCLUSION

In this paper we consider the problem of spectrum management for wireless communication. We mainly focus on utilization of the available spectrum effectively. We addressed the issue of switch delay minimization and improvement in packet transmission rate between the nodes using the CR concept. With reference to the proposed system we have developed an fast and efficient algorithm and implemented the same using .Results have shown the improvement in the system performance by reducing the traveling time required between the nodes for increasing number of users,also the packet transmission is increased amongst the nodes .For the next step, existing algorithms can be modified and efficient channel allocation model can be developed and we will study routing protocols in CR networks ,which can be used for the dynamic channel allocation and routing using the CR concept for improvement of spectrum usage.

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