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A SPECTRUM DECISION FRAMEWORK FOR REAL TIME AND BEST EFFORT APPLICATIONS IN COGNITIVE RADIO NETWORKS

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Abstract—RF spectrum is a scarce resource. It is inefficient when no of users are increased. So cognitive radio is developed for provide to efficient use of bandwidth utilization. Licensed users are primary users and unlicensed users are secondary users. Cognitive radio enables the secondary usage of unused licensed spectrum band. In this Paper, we propose spectrum decision framework for best effort application and real time applications in cognitive radio networks. Spectrum decision framework for real time applications, it minimizes the capacity variance of decided selected band. For best effort applications, spectrum decision framework decides the spectrum band to maximize the total network capacity.

Index Terms—Spectrum decision for Cognitive radio network, spectrum decision, spectrum resource management, real time applications, best effort applications, minimum variance based spectrum decision, maximum capacity based spectrum decision.

I. Introduction

RF spectrum is a scarce resource. Cognitive radio has been developed as a solution for spectrum scarcity [1]. Licensed users are primary users and unlicensed users are secondary users. Cognitive radio enables the unused portion of the other spectrum i.e. licenced spectrum without having a license. Spectrum sensing, spectrum analysis and spectrum decision making are the main functions of the cognitive radio. These capabiliies or a function of cognitive radio is used to avoid the interference with the licenced user. However cognitive radio networks face several problems based on the fluctuating nature of the available spectrum. To solve this problem, cognitive radio networks determine the available spectrum from the spectrum band. This process is called as spectrum sensing [3]. Spectrum sensing is used for to find the available spectrum bands and that spectrum bands are selected by networks according to the application requirements. A cognitive radio network requires the capability to decide the best spectrum band among the available bands based on the application user requirements. This is called as spectrum decision [2]. There are several issues for cognitive radio networks to decide the spectrum band. First issue is for selected spectrum band, the CRN need to consider the PU activity and radio conditions. Second issue is it needs spectrum sensing and spectrum sharing functionality for reliable communication. Lastly, CRN performs spectrum decision based on PU activity and application requirement of users.

Spectrum decision framework is developed by considering all decision states and applications such as real time application and best effort applications. After getting all available spectrum bands, most appropriate spectrum band should be selected [2].

The operation types of cognitive radio network classified as licenced band operation and unlicenced band operation.

- Licenced band operation: Primary user has first priority to use licensed band. So coginitive radio networks focused on the detection of primary user. If primary user is not detected then CR user use licenced spectrum band. If primary user appear in the network or primary user is detected then CR user should move to another vacant available spectrum band.
- Unlicenced band operation: CR users have same facilities to access the licenced spectrum but must in the absence of primary user. Hence, spectrum sharing is required for cognitive radio users.

The proposed model deals with the decision making related to spectrum allocation. It uses MVSD and MCSD for the decision making. In case of poor transmission, the spectral band under consideration is skipped. To consider all issues, the cognitive radio networks needs a spectrum decision framework. For real time applications, minimum variance based spectrum decision (MVSD) scheme is used that selects spectrum bands to maintain the data loss rate at lower level. For best effort application, maximum capacity based spectrum decision (MCSD) scheme is used to maximize the total network capacity [1].

II. Proposed System Model

A spectrum decision framework can provide the efficient bandwidth utilization for different types of traffic such as best effort traffic and real time traffic. In this paper, spectrum decision is considered as an event based functionality.

When a primary user appears in the network, cognitive radio user should move to another available spectrum band. When new cognitive radio user appears in the network, it needs to be new spectrum bands for its transmission.

To consider all decision events, the cognitive radio network needs a spectrum decision framework for real time applications and best effort applications. Figure 1 shows the proposed system model for spectrum decision for different application.

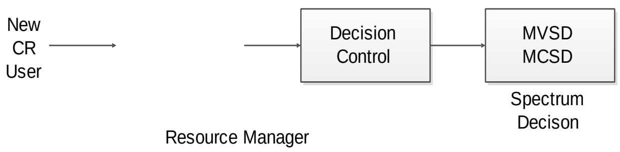

Figure 1. The Proposed System Model

It determines the spectrum bands by considering requirements of application. For real time application traffics, it reduces the data loss rate and for best effort application traffics, it increases the total capacity of the network.

A. Working of the System

Resource manager is used for to determine the incoming user is primary user or cognitive radio user. It consist admission control and decision control. If a cognitive radio user is incoming user and it is allowed to transmit then spectrum decision is used for assign the new available spectrum band. If a primary user is detected as a incoming user then the cognitive radio switches the spectrum with the help of resource manager and the spectrum decision. Based on application requirement of user spectrum decision scheme is used. For best effort applications user, maximum capacity based spectrum decision scheme is used and for real time applications user, minimum minimum variance based spectrum decision is used. Cognitive radios users are used for only perform event detection. Based on this information, the base station decides on spectrum availability and performs spectrum decision.

B. Resource Management

Cognitive radio network needs a resource management scheme to coordinate the spectrum decision methods. The objectives of resource management are it is capable to identify the new incoming secondary user, to maintain the service quality of transmitting user and balance the bandwidth between best effort application requirements and real time application requirements. Admission control io allow the transmission of CR user or reject the CR user. If cognitive radio user cannot maintain the service quality then admission control should reject the transmission of cognitive radio user. Decision control is used for both cognitive radio user and primary user. If primary user is appear then decision control is used for to vacate the licenced spectrum and if a cognitive radio user is allowed to transmit then decision control is used for to provide the available spectrum band for its transmission.

C. Spectrum Decision for Real Time Applications

Delay and jitter are more important parameters considered in a real time application. If packets are not arrived with in a specific time then it drops the packet in real time application. Even through the network can support sustainable rate on average, packets can be delayed and then discarded in the receiver due to the variation of channel capacity i.e. if capacity is lower than the average channel capacity then it discards the packets. So here we check the performance of the system in terms of number of users versus data loss rate i.e. number of packets are discarded is very less although number of users increases. Delay factors uniquely introduced by CR networks can directly lead to data losses.

Minimum Variance Based Spectrum Decision scheme for Real-Time Applications:

Minimum variance based spectrum decision (MVSD) scheme is used for real time applications. Real time applications need to satisfy strict service requirements such as delay and sustainable rates. The problem is how to maximize the total network capacity. For that it is need to guarantee the service quality of real-time applications with minimum available spectrum resources. Thus the spectrum decision problem can formulated as an optimization to minimize bandwidth utilization subjects to constraints on the sustainable rate, data loss rate and number of transceivers. So we used a three stage spectrum decision method as follows:

1. *Spectrum Selection:* In this stage, the network finds the spectrum bands with a lower primary user activity. Primary users are licensed users.
2. *Resource Allocation:* In this stage, the cognitive radio network determines the bandwidth of the selected available spectrum band.
3. *QoS Checkup:* In this stage, if target data loss rate is lower than expected data loss rate we have to perform aggressive approach or conservative approach.

- *Aggressive Approach:* In this approach it simply increases the bandwidth to meet the application requirements. If CR user cannot find proper spectrum band in this approach than it switches to the conservative approach.
- *Conservative Approach:* In this approach, it reduces the sustainable rates to a one step lower rate instead of increasing the bandwidth.

D. Spectrum Decision for Best Effort Applications

The objective of spectrum decision for best effort application is to increases the total network capacity.

Maximum Capacity Based Spectrum Decision scheme for Best-Effort Applications:

Maximum capacity based spectrum decision (MCSD) scheme is used for best effort applications. Cognitive radio network has to perform the spectrum decision over all current transmission which requires a high computational complexity for the maximum capacity. Resource reallocation leads to the spectrum switching of the multiple users at the same time results in quality degradation. So we used maximum capacity based spectrum decision for best effort applications. Decision gain can be defined as the sum of the difference between capacity gain and capacity loss caused by the addition of new user.

For multiple selections the cognitive radio network first determines the order of the spectrum decision, and then chooses a spectrum band for each user as follows:

- If CR user losses its spectrum band then each cognitive radio user finds another spectrum band with highest decision gain.
- CR user who has highest decision gain is assigned to the spectrum.
- Then cognitive radio network updates its current bandwidth allocation and repeats the MCSD for the remaining user.

III. Simulation Setup

In the simulation, no of CR user is set to 100, transceiver is set to 10, spectrum band is set to 20, switching delay is set to 0.5, target data loss rate is set to 0.5, total bandwidth is set to 500 kHz, expected bandwidth is set to 200 kHz, minimum bandwidth is set to 150 kHz and overload threshold is set to 0.5. Simulation is done by using MATLAB software tool.

To evaluate the performance of our spectrum decision framework, we introduce three different cases:

- Case 1: CR user use entire spectrum decision framework with all functionalities.
- Case 2: Capacity based decision: CR user select the spectrum with the highest channel capacity.
- Case 3: Primary user activity based decision: CR user select the spectrum band with the lowest PU activity.

A. Real time applications

First we consider the scenario with only real time users. Figure shows the simulation results for real time applications. Figure 2 shows how average number of users affects the data loss rate. When small number of users are transmitting, each case maintain data loss rate at lower level. However as the number of users increases, case 2 and case 3 increase the data loss rate. From figure we conclude that case 1 still maintain the data loss rate at certain level. In figure 3, we investigate the performance of spectrum decision framework based on primary user activity. In all cases, case 1 shows better performance in data loss rate as compared to other methods. In figure 4, we show the relationship between data loss rate and switching delay. Case 1 shows lower data loss rate than other methods. In all cases, higher switching delay results in higher data loss rate.

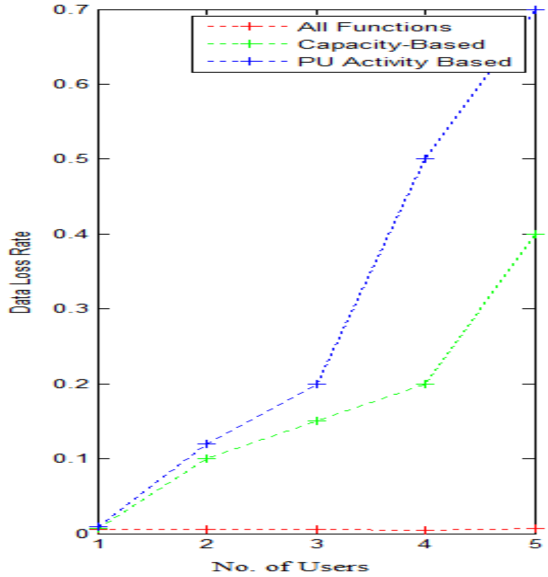

Figure 2. Data loss rate v/s No. of users

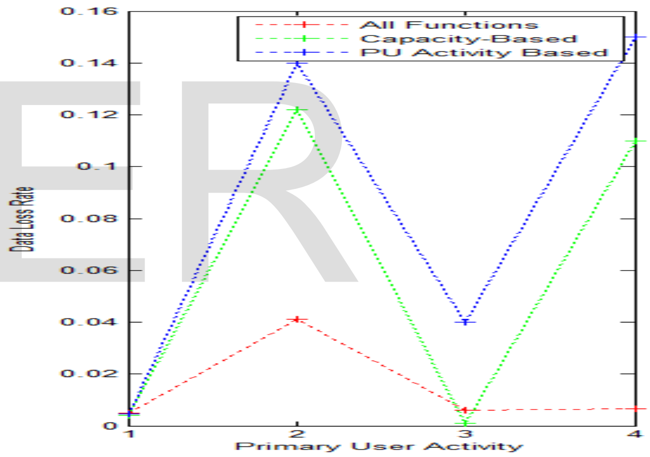

Figure 3. Data loss rate v/s Primary user activity

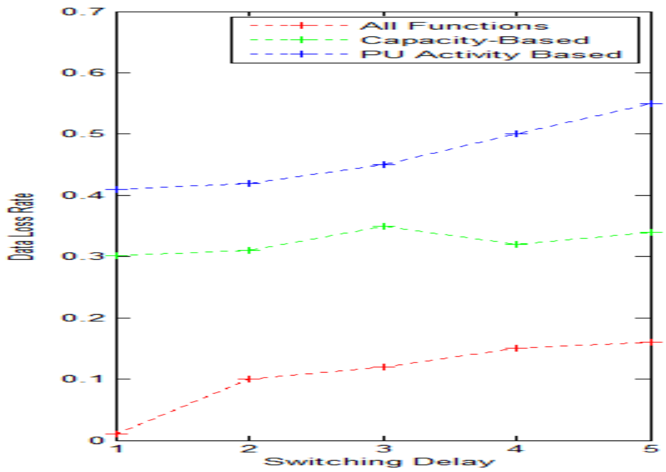

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Figure 4. Data loss rate v/s Switching delay

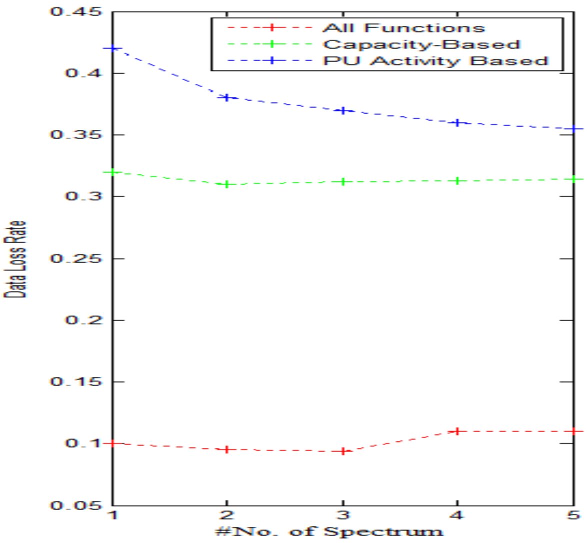

Figure 5. Data loss rate v/s No. of spectrum band

In figure 5, as the number of spectrum bands increases, the total amount of primary user activity on multiple spectrum bands increases which may cause effect on data loss rate. Case 1 shows better performance than other methods.

B. Real time applications

In this simulation, we also show how the number of users, PU activity, switching delay and number of spectrum bands influence the total network capacity. In figure 6, it indicates the relationship between the number of users and total capacity where case 1 shows better performance over other cases. In figure 7, we investigate the performance of spectrum decision framework based on primary user activity and total capacity. In all cases, case 1 shows more improvement in total capacity due to less frequent switching delay. Figure 8 shows the simulation result on the total network capacity. We observed that increasing switching delay decreases the total capacity. Case 1 shows better performance than other methods. In figure 9, we observed that up to 2 bands case 1 increases the total capacity and for more than 2 bands it is decreases. Still case 1 gives better performance than other cases.

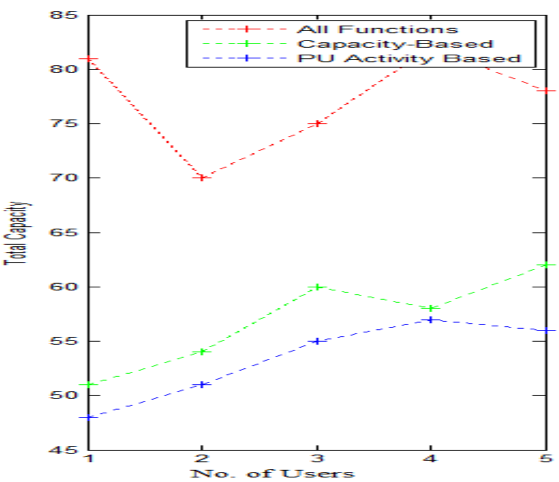

Figure 6. Total capacity v/s No. of users

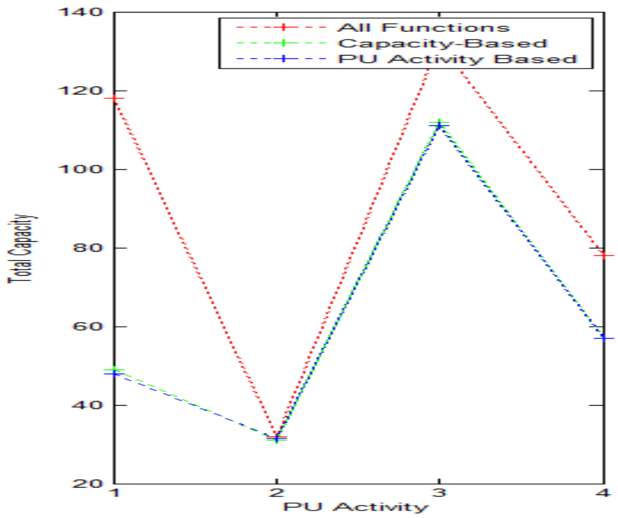

Figure 7. Total capacity v/s Primary user acticity

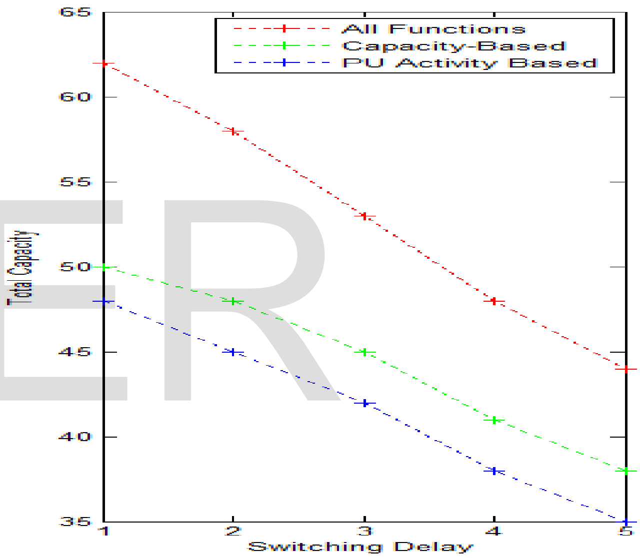

Figure 8. Total capacity v/s Switching delay

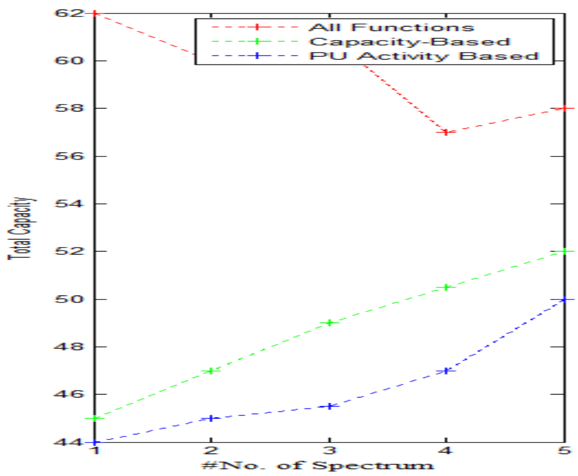

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Figure 9. Total capacity v/s No. of spectrum band

IV. Conclusion

Spectrum decision framework for real time applications and best effort applications is used for to determine a set of spectrum bands by considering the channel and application requirements in the cognitive radio networks. MVSD scheme is developed for determines the spectrum bands to minimize the capacity variance for real time applications and MCSD scheme is developed for select the spectrum bands to maximize the total capacity for best effort applications. Simulation result shows proposed framework provide efficient bandwidth utilization while satisfying service requirements.

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