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Spectrum Sharing Scheme Between Cellular Users

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Abstract: **In the field of communication spectrum requirement is the biggest issue. Spectrum sharing is a technique in which sharing the licensed spectrum for the Heterogeneous network like wireless in the dynamic manner will be implemented. In this, we can sense and analyze the bands which are unoccupied, allocated bands and free bands by calculating a metric of free spectrum. If spectrum is free then spectrum sharing technique assigns available channel to new user without harming existing primary users. Hence it provides the opportunistic access to the licensed spectrum for the unlicensed users and they try to access the spectrum available without causing any interference to the primary users. To design these types of schemes managing the interference is the major component.**

***Keywords*—cognitive radio, free spectrum, call blockage, spectrum sharing, system efficiency, spectrum efficiency**

I. INTRODUCTION

Nowadays, the users of wireless are increasing at the rate faster than the service providers. The technologies like 3Gpp Long Term Evolution (LTE) and IMT-Advanced these helps to satisfy the demand but many needs to be still done and a lot of applications in a wireless that shares the same medium. The infrastructure overload type may leads to the lack of spectrum in the given frequency bands. This work shows another approach of sharing the medium same by using dynamic spectrum allocation instead of using static allocation of spectrum and it is believed to cause scarcity and inefficiency of spectrum. Another technique is becoming popular to meet high demand for the service that is Dynamic spectrum access technique. It is the promising approach to reuse the unused spectrum in which that spectrum is used by both the primary users and secondary users (unlicensed) to improve the spectrum efficiency and spectrum flexibility. Cognitive radio (CR) is a new technology used to solve the issue of Spectrum underutilization in wireless communication system. CR provides a solution to this dynamic spectrum access (DSA). It is designed to provide communication in a reliable form for all the users in the network wherever they need. Cognitive radio is a device that is able to perform acquisition of spectrum, either sensing (vacant channels of geographical interleaved spectrum) or through purchasing (in cleared spectrum), a frequency bands over a wide range. This is a key enabler technology for spectrum markets in real time and sharing the licensed spectrum in dynamic manner with unlicensed devices. The overall spectral efficiency of the system can be improved with good spectrum sharing capabilities, coexistence properties, and flexibility in the usage of spectrum. Cognitive radio mainly includes these functional blocks: sensing, analysis and decision making of the spectrum. Sensing is able to determine availability of spectrum and pick a free channel for transmission. Analysis is based on sensing the spectrum in which it analyzes the situation of radio environment factors such as the radio frequency used by the neighboring devices and the state of network and its behavior. In Decision making it calls for the channel reconfiguration and required protocol for adapting to changing environments in mobile. Among these functions sensing the spectrum is believed as the most crucial task for the establishment of cognitive radio network, the basic cognitive cycle is shown in figure1.

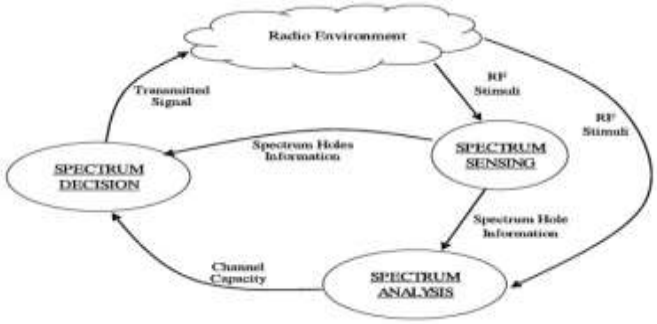

figure1. Basic Cognitive Cycle

In this the overall spectral efficiency can also be increased with the flexible usage of spectrum that adapts to the temporal variations and characteristics of environment. Then flexibility and scalability of a system is also more important to simplify the deployment of the network under the arrangements of spectrum that vary from region to region. The method of spectrum sharing efficiently among the service provider using static cognitive radio nodes, where the unused spectrum in a particular infrastructure of a service provider can be shared by the overloaded infrastructure of a service providers within the coordination between them and it also proposes the network

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of cognitive radio nodes fixed to maintain spectrum sharing among multiple service providers operating in the same geographical area. Cognitive radio nodes estimate the utilization of the spectrum in the area given and it also provides the usage of spectrum information to the service providers in which there infrastructure is overloaded.

This paper is arranged as follows; section II to define cognitive radio. Section III is used to define how spectrum sharing process is done in Cognitive radio networks. Section IV is used to discuss the techniques of spectrum sharing. In Section V it shows the performance metrics of the system. In section VI it is used to present the results of simulation and implementation issues. Finally, section VII is used to present conclusion.

II. COGNITIVE RADIO

Cognitive radio (CR) is defined as a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, and instantly move into vacant channels while avoiding occupied ones. This optimizes the use of available radio-frequency (RF) spectrum while minimizing interference to other users.

Cognitive radio is a radio that can be configured and programmed dynamically to use the best wireless channels in its surroundings. It detects automatically the available channels in the wireless spectrum, then it changes the transmission or reception parameters accordingly to allow wireless communications more concurrently in one location of a given spectrum band. This process is in the form of dynamic management of spectrum.

A. CR nodes Sensing method Proposed

It has the capability to sense the environment and identify the spectrum availability dynamically. Cognitive radio technique helps to improve the efficiency of the spectrum utilization and for implementation of spectrum sharing. In this work, Cognitive Radio Nodes here helps to provide the available channels list and it checks for availability of the channels and mobile nodes gets the information of available channels and it sends to base station (BS) via cognitive radio nodes as it is shown in the figure2.

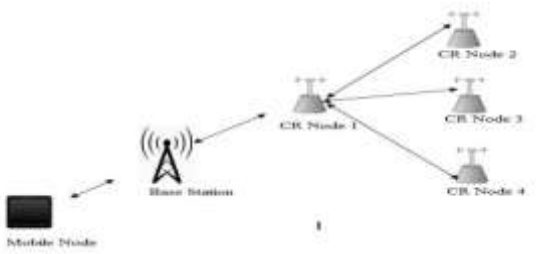

Figure2. Cognitive radio nodes sensing the available channels

The nodes of cognitive radio monitor the channels in a given area and number of cognitive radio nodes should be minimum and these cognitive radio nodes can cover the given area fully and it estimates the utilization of channel properly.

III. PROCESS OF SHARING THE SPECTRUM IN COGNITIVE RADIO NETWORKS

Based on the various factors the techniques of sharing the spectrum have been classified into architectures, access technology and access behavior. The classification of sharing the spectrum in cognitive radio network is firstly described on the architecture and it is defined below:

- Distributed Spectrum Sharing: The spectrum access and spectrum allocation are based on the global policies or local policies in which each nodes performs in the distributive form. This type of solutions used between different networks such that the base station (BS) has to compete with its interferer base stations according to the quality of service requirements of users of it and a portion of spectrum is allocated.

- Centralized Spectrum Sharing: The central entity can control the procedures of spectrum access and allocation of spectrum. For the specific amount of time the spectrum for the users in the limited geographical area can be leased by the central entity.

- The second type of classification is based on strategy for the allocation of the spectrum and the access of the spectrum can be either non-cooperative or cooperative.

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- Cooperative spectrum sharing: In this type of spectrum sharing all the users of the cognitive are cooperate with each other either through the centralized base station or through the distributed or common control channel in the centralized cognitive radio networks.

- Non-cooperative spectrum sharing: In this type of spectrum sharing any kind of information was not exchanged between cognitive users with each other. It is helpful for less number of cognitive users in the network and communication overhead is less.

- Third type of spectrum sharing classification is based on the access technology. Spectrum underlay and overlay are the two methods.

- Spectrum overlay: It is a spectrum management principle where the secondary users use a portion of spectrum from a primary user only when it has not been used by primary users. This type of techniques are based on detect and avoid mechanism.

- Spectrum underlay: It is the principle in which spectrum management is done with a very low power signals of spectral density can co-exist as a secondary user with the frequency band of primary users.

- Finally, there are two types of solutions are generally focused on spectrum sharing techniques: sharing the spectrum among multiple coexisting cognitive radio networks (internetwork spectrum sharing) and inside the cognitive radio network (intranet spectrum sharing), as explained below:

- Internetwork Spectrum Sharing: In this the cognitive radio architecture enables multiple systems to be deployed in overlapping locations and spectrum, as shown in figure2. This type of solution provides the concept of spectrum sharing by certain operator policies.

- Intranet Spectrum Sharing: This is used for allocating the spectrum between the cognitive radio network entities, as shown in the figure3. Here, the users of cognitive radio network try to access the available spectrum without causing any interference to the primary users.

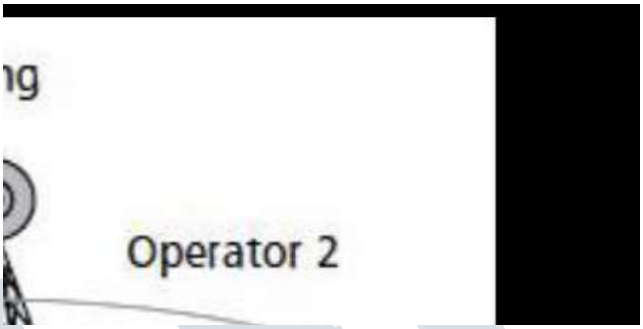

figure3. Cognitive radio network Intranet and Inter network spectrum sharing

In our work we consider the architecture of distributed form of spectrum sharing and for the behavior of spectrum allocation we consider cooperative spectrum sharing. For the access technology we consider spectrum overlay and also spectrum sharing techniques like Internetwork and intra network spectrum sharing are also considered here.

IV. SPECTRUM SHARING TECHNIQUES PROPOSED

A. Spectrum sharing process

At the busy hours like peak hours, the active users are more than the maximal users. The infrastructure at this time will be in the situation of over-loaded because scarcities of the channel and at same time the nearby different service provider's infrastructure may be in the under-loaded condition. Available channels from under-loaded infrastructure can be used by the over-loaded infrastructure. Both the service providers here operate in cell-based wireless networks. Here we implement the method of sharing the spectrum among the service providers through cognitive radio nodes to reduce the Co-Channel interference. Periodically the cognitive radio nodes sense the surrounding environment and estimate the usage of channel within their sensing range. From the infrastructure, once it gets the available channel

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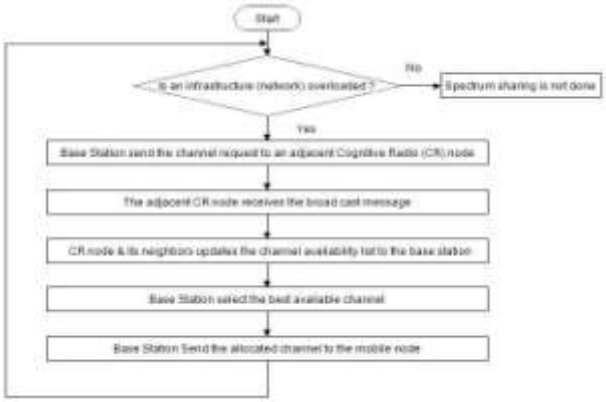
information the Cognitive radio nodes response to these infrastructures with a set of channels available.

The process of sharing the spectrum among service providers is as shown in the following flowchart.



flowchart for the spectrum sharing process among service providers

B. Simulation Results

If one of the service provider infrastructures (base station) is found to be in the state of over-loaded then it sends the service request to their adjacent cognitive radio nodes regarding availability of the channel. The base station receives the service request from the mobile nodes and then it will send request for the channel to the cognitive radio node.figure4 shows request sending from the base station to the cognitive radio node.

figure4. Before request sending to Cognitive radio node

Cognitive radio node receives the request for the channel and broadcast message is sent to their adjacent cognitive radio nodes. The broadcast message was received by the neighboring cognitive radio nodes and they also send the list of channel availability to the base station. The list of available channel was updated to the base station by the cognitive radio node and its neighbor's and for the base station it sends the response. The request sending and receiving the response from cognitive radio nodes is shown in the figure5.

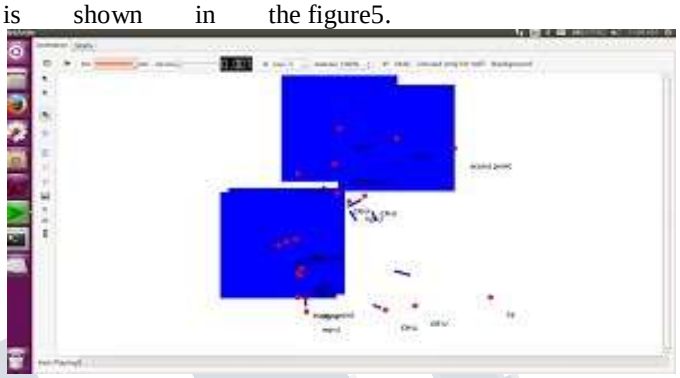


Figure5. Request sending to cognitive radio nodes and response from the cognitive radio nodes

If the base station receives the cognitive radio nodes response and then it select the channel available and service reply was sent with the channel allocated to the mobile nodes. This shows the maximum channel utilization and it offers services like multimedia, internet, calls and so on to the mobile nodes. Maximum utilization of the channel by sending response to the base station regarding the availability of the channel is shown in figure6.

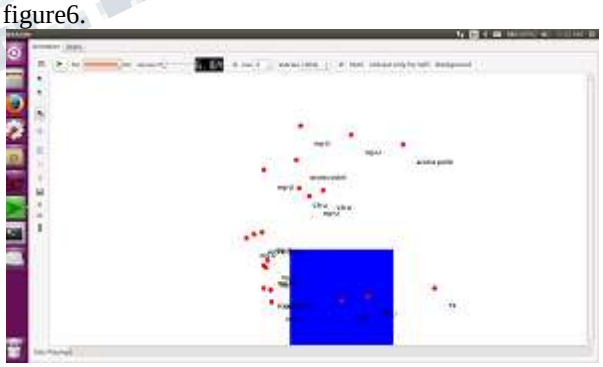


Figure6. Response from the CR Nodes

V. PERFORMANCE METRICS

The performance metrics was discussed in this section and study about spectrum sharing impact on the service provider that includes the system efficiency, call blocking rate, etc

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A. Call Blocking Rate

The rate of call blocking R_{BL} is defined as the ratio of total calls blocked over total processed calls by all the service providers and it corresponds to

$$R_{BL} = \lim \frac{n_{BL}^{(total)}(t)}{n_{processed}^{(total)}(t)}$$

Where the total calls blocked at a time t by all service providers is given by

$$n_{BL}^{(total)}(t) = \sum_{i=1}^{n_{sp}} n_{BL}^{(i)}(t)$$

and total calls processed are:

$$n_{processed}^{(total)}(t) = \sum_{i-1}^{n_{sp}} n_{processed}^{(i)}(t)$$

Where the number of service provider is n_{sp}. If all the service providers are over-loaded then the call would be blocked.

B. System Efficiency

The efficiency of the system η_{sys} can be defined as the Probability efficiency metric for service provider is determined by the processed traffic intensity and the total traffic loaded to the service provider within the observation time. Thus, $\eta_{sys}^{(i)}$ is calculated by $\eta_{sys}^{(i)} = \frac{E_p^{(i)}}{E_{in}^{(i)}}$

Where $E_p^{(i)}$ is processed traffic intensity for service provider i and $E_{in}^{(i)}$ is the total traffic loaded to the service provider i within the observation time t.

C. *Spectrum Utilization Efficiency*

The Efficiency of spectrum $\eta_S^{n_{(sp)}}$ is defined as the ratio of average busy channels over the total owned channels by service providers and it corresponds to

$$\eta_S^{n_{(sp)}} = \lim \frac{1}{t} \int_0^t \frac{n_{busy}^{n_{(sp)}}(t)}{N_{ch-total}^{n_{(sp)}}(t)} dt$$

Where $n_{busy}^{n_{(sp)}}(t)$ is the number of channels used at time t for service provider $n_{(sp)}$ and $N_{ch-total}^{n_{(sp)}}(t)$ is the total number total channels owned by service provider $n_{(sp)}$. Here

VI. SIMULATON RESULTS

Using NS3 Simulation the overall performance of system efficiency has been evaluated. The main parameters used in this simulation work are shown in TABLE 1.

TABLE 1. SIMULATION PARAMETERS

PARAMETERS	VALUES
Number of base stations	4
Number of Mobile Nodes	12
Number of Cognitive Radio units	4
Pause Time	8.2sec
Types of services	Internet, Multimedia , Call
Channel	CSMA

VII. CONCLUSION

In this paper the efficient utilization of the unused spectrum of the licensed users is shown. The spectrum assigned to one service provider is not utilized efficiently, and then the underutilized spectrum of licensed user can be shared by the other service providers when that unused spectrum needs for the other service providers in a licensed manner and the operations of Cognitive radio nodes sensing and sharing the infrastructure of service providers. We can sense the cognitive radio node range and decide the optimal channel for sharing the spectrum is done in this work.

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