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An Approach for Spectrum Allocation for Maximized Coverage in Cognitive Radio Network

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Abstract: Cognitive Radio Network (CRN) has emerged as a promising technology to exploit the unused portions of spectrum in an effective manner. The fixed spectrum allocation is used to refer the unused portions of spectrum are called as 'spectrum holes'. Cognitive Radio network detect this type of issue and also it, allowing devices to sense the spectrum for unused portions and use the most suitable ones.Cognitive radio networks is the next generation of the key enabling technology that enables dynamic spectrum access .The spectrum allocation is one of the most important issues in CRNs. The main objective is to satisfying the interference constraints, and to maximize node connectivity after spectrum allocation, which is important for packet delivery in an effective communication. The main objective is to provide spectrum resources effectively to the users in the network. To design node based selection and link based selection algorithms and an node link based algorithm are used to improve the spectrum utilization for effective transmission.
Keywords- Cognitive Radio Networks,Spectrum Allocation,Dynamic spectrum accesss,Spectral Efficiency

I. INTRODUCTION

The fundamental difference between CRNs and traditional wireless networks is that the available channel sets are dynamic, and their availabilities vary over time and space. "Primary Users" and "Secondary Users" are the terms used in CRNs. The licensed users are called the, Primary Users (PUs) that have been assigned spectrum for long-term usage, whereas unlicensed users are known as Secondary Users (SUs) , they for accessing spectrum bands and use CR technology to temporarily access the spectrum in an opportunistic manner . A radio device scanning the wireless spectrum at any specific location would observe most of the time the bands are unoccupied,some of the time the spectrum bands are partially occupied,all of the time that bands are fully occupied.The unused portions of spectrum are the definition of the term "spectrum hole" (or "white space"), which is a frequency band that is assigned to a licensed user, but at a specific place and time is not being utilized.
CR technology enables the reuse of the available spectrum resources. The basic limiting factor for spectrum reuse is interference, which is caused by the environment (noise) or by other radio transmissions. Controlling interference is essential to achieve maximum performance in wireless networks because interference directly affects the reception capabilities of clients . Actually, interference is a key factor that can lead to reduced capacity and performance because it reduces the achievable transmission rate of wireless interfaces, increases the frame loss ratio, and reduces the utilization of wireless resources. Furthermore, interference between links belonging to the same network or it originate from external sources. Some of the Features of cognitive radio networks are, Sensing the current radio frequency spectrum environment it includes measuring what type of frequencies are being used, which time they are used, estimating the location of transmitters and receivers, and determining signal modulation.Most of the results from the sensing environment can be used to determine radio settings. Policies specifying how the radio can operate and physical limitations of radio operation can be stored in the radio or made available over the network. These type of policies might specify which frequencies can be used in which locations. The Configuration databases would describe the operating characteristics of the physical radio and these databases would normally be used to constrain the operation of the radio to stay within regulatory or physical limits. This type of Self-configuration Radios may be assembled from several modules such as, a radio frequency front-end, a digital signal processor and a control processor. And each module should be self-describing and the radio should automatically configure itself for operation from the available modules. Some might call this "plug-and-play."Mission-oriented configuration Software Defined Radios (SDR) can meet a wide set of operational requirements and its Configuring a SDR to meet a given set of mission requirements is called mission oriented configuration. The typical mission requirements might include operation within the buildings, substantial capacity, the operation over long distances, and operation while moving at high speed. Mission-oriented configuration that involves selecting a set of radio software modules from a library of modules and connecting

them into an operational radio.Security,Radios will join and leave wireless networks. The mechanisms that are used to authenticate, authorize and protect information flows from the participants in radio networks. Spectrum allocation is a basic function of CRNs because it affects the normal operation of the network and is closely related to spectrum sensing, which provides information on the available spectrum. SA is responsible for allocate the most appropriate frequency bands at the interface(s) of a cognitive radio device according to some criteria such as, maximize throughput, fairness, spectral efficiency. while, at that time, avoid causing interference to primary networks operating in the same geographical area. Spectrum holes that are discovered by spectrum sensing are used as input to spectrum allocation, in order to find the optimum spectrum fragment that the SU should use according to its requirements In the Spectrum Sensing concept **,** A cognitive radio can sense spectrum and detect “spectrum holes” which are those frequency bands not used by the licensed users or having limited interference with them. Figure 1.1 represent the Spectrum hole concept.

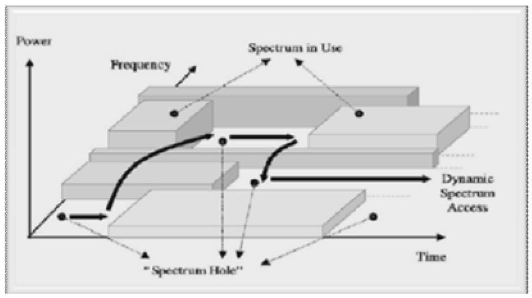

Figure 1.Spectrum Hole Concept

In the Spectrum Sharing concept **,**A cognitive radio could incorporate a mechanism that would enable sharing of spectrum under the terms of an agreement between a license and a unlicensed party. The third parties may eventually be able to negotiate for spectrum use on an ad hoc or real-time network basis, without the need for exisiting agreements between all parties. In the Location Identification shows **,** the ability to determine its location and also the location of other transmitters, and then select their appropriate operating parameters such as the power and frequency allowed at its location. In bands such as those used for satellite downlinks that are receive-only and it does not transmit a signal, location technology it is the method of avoiding interference because sensing technology would not be able to identify the locations of nearby receivers.

II. RELATED WORK

T.Shu et.al (2008) dealt with centralized approach. Centralized approximations in CRNs, formulate the problem as a mixed integer programming problem. However, centralized CA approaches suffer from many limitations, including the lack of a global common control channel to support the centralized control, and poor scalability due to the difficulty of capturing consistent global information in a dynamic environment.A.T.Hoang et.al (2006) dealt with A two-phase channel/power allocation scheme that improves the system throughput, and its defined as the total number of subscribers that can be simultaneously served. In the first phase of our scheme, spectrum and power are allocated to base stations with the aim of these machansim to maximizing their total coverage while keeping the interference caused to each primary user below a pre-defined threshold. In the second phase, in each base station allocates channels to their active subscribers based on a maximal bipartite matching algorithm. T.Shu et.al (2008) dealt with the graph color model, distributed list-edge coloring algorithms usually rely on a modified version of edge-coloring algorithms. An iterative distributed solution, based on the orientation of each link. And the end node with a larger number of channels points to another one with a smaller number of available channels.A.T.Hoang et.al (2006) dealt with spectrum-allocation/power-control schemes that maximize the spectrum utilization of the cognitive network while appropriately protecting primary users. So, the control schemes must also meet the required signal to interference plus noise ratio (SINR) of each subscriber of the cognitive network. This problem can be formulated as a linear mixed (0-1)integer programming. Due to the high complexity in obtaining optimal spectrum -allocation/power-control schemes, we propose a suboptimal scheme that can be obtained at lower complexity while still achieving good spectrum utilization. This suboptimal scheme is constructed based on the idea of a dynamic interference graph that captures the interfering effects.A.T.Kaligineedi et.al (2008),dealt with the most important challenge facing a cognitive radio system is to identify the presence of PUs over a wide range of spectrum. This process was very difficult as we need to identify various primary users employing different type of modulation schemes, data rates and transmission powers in the presence of variable propagation losses, interference generated by other secondary users, and thermal noise. Arslan et.al (2007) dealt with spectrum scarcity problems in the real world. CRNs are vulnerable to various attacks because they are usually deployed in unattended environments and use unreliable wireless communication. However, it is not simple to implement security defences in CRNs. One of the major obstacles in deploying security on CRNs is that the current CRNs have limited computation and communication capabilities. Naveed et.al (2006) dealt with the process, an unlicensed user can determine whether the radio can be used. However, if the spectrum sensing result is modified maliciously, normal network activities will be disabled; it is possible that all network traffic may collapse. Other types of threats include spectrum decision threats, spectrum sharing and spectrum mobility threats. The approaches such as centralized, distributed are proposed in the literature. These approaches do not consider spectral efficiency. In the proposed system, linear programming is used to achieve the spectral efficiency.

III. PROPOSED METHOD

A. Effective Spectrum Allocation

Spectrum allocation is a basic function of Cognitive Radio Networks (CRNs) because it affects the normal operation of the network and is closely related to spectrum sensing, which provides information on the available spectrum. Spectrum Allocation (SA) is responsible for assigning the most appropriate frequency bands at the interface of a cognitive radio device according to maximize throughput, fairness, spectral efficiency, etc, while, at the same time, avoid causing interference to primary networks operating in the same geographical area. Spectrum holes that are discovered by spectrum sensing are used as input to spectrum allocation, in order to find the optimum spectrum fragment that the Secondary User (SU) should use according to its requirements.The effective spectrum allocation method contains the following modules ,(1) Multi-channel selection (2) Primary user not considered (3) Primary user considered.

1) *Multi-Channel Selection:* The use of multi-radio devices (i.e. in a cognitive mesh network) capable of accessing simultaneously multiple spectrum fragments, can dramatically increase the network capacity, giving users the capability of much higher data rates.Although the use of spectrum aggregation seems promising for achieving better spectrum utilization and higher data rates, there are also some limitations.
2) *Primary User Not Considered:* These approaches almost disregard the existence of PUs, because only use them to limit the number of channels that the SUs are allowed to use, without directly considering the PU in the system model.
3) *Primary User Considered:* The module contains the information about the PUs and also it requires either the cooperation of the primary network or that the SUs know the location of PU nodes so that they can calculate the interference they cause to them.

B. Node-Based Algorithm

The node-based algorithm, which uses only local channel information at each node to select channels for adjacent links, is given in Algorithm . It randomly assigns channels for each link, based on the information of each node. There is no coordination between two end nodes of one link. Obviously, its efficiency is low. The probability of selecting the same channel at both end nodes of a link is medium, which results it will take many rounds being needed to complete the algorithm.

C. Link- Based Selection

There is coordination between two end nodes during channel selection. The coordination here is achieved by two end nodes exchanging their available channel information through the common control channel. However link-based selection does not take priorities of different links into consideration;this would still result in a relatively low efficiency.

D. Node-Link-Based Algorithm

The node-link-based selection algorithm the host of link uv is u. That link u needs to collect Cu Cv, and Cw for all w ∈ Nv SNu to calculate channel weight for uv. Therefore, two-hop information is needed. This process can be done through two rounds of exchanges, using a common control channel.Node based selection of Algorithm Node-Link based selection requires one round of exchanges, and is calculated only once. It needs to be re-calculated at each round, as G changes at steps.

E. Maximize Spectral Efficiency

A key objective for the deployment of cognitive radio networks is to achieve better utilization of the available spectrum bands. Thus, maximizing spectrum utilization is another common criterion for designing an efficient cognitive SA algorithm The goal is to maximize either the number of channels assigned to SUs or the number of SUs that are being served in the CRN.

The spectral efficiency is calculated as follows,

$$\eta = \frac{R}{W} = \log_2 M \qquad (4.5.1)$$

where,R = Transmission of data rate,W= Weight of each link,M = M-ary Quadrature Amplitude Modulation,

$$\max = \frac{1}{L}\sum_{j=1}^{L} \log_2 M^{(j)} \qquad (4.5.2)$$

Where,L = The number of possible simultaneous transmission This function converts the problem of maximizing the spectral efficiency into maximizing the transmission power of each cognitive radio node.

IV. PERFORMANCE ANALYSIS

The performance of spectrum utilization is analyzed by taking parameter into account. From the obtained results it is inferred that the performance of spectral utilization is improved by node-link based selection. The following are the parameters which taken into account for comparison:

1. Spectral Efficiency
2. Energy Efficiency

Formula to calculate spectral efficiency

$$\text{Spectralefficiency} = \frac{\text{Assigned link rate}}{\text{No of channel}} \qquad (3)$$

Assigned link rate is refers to the transmission of packet at link level.

Formula to calculate the Energy efficiency for allocating spectrum

$$EE = \frac{\text{Data rate}}{\text{Total power}} \qquad (4)$$

Data rate is consider to be transmission of packets through the network based on transmission time and transmission power.

Table 1.Parameter settings

Total number of node	[10,40]
Communication range of each node	[50,70]
Total number of channels	[4,10]
Total number of primary users	10
Interference range of primary users	40

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A. Number of Nodes Vs Assigned Link Rate

Assigned link rate is usually measured in bits/second. In the graph 6.2assigned link rate is minimized by applying node based selection mechanism which is comparatively low if link based selection schemes are implemented in node level.

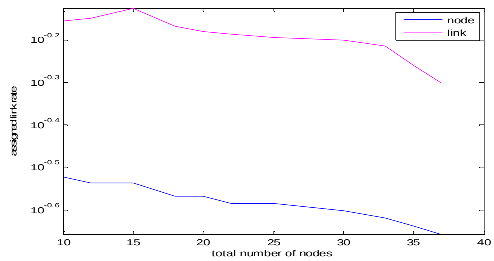

Figure .2 Nodes Vs Assigned link rate

The above graph shows the assigned link rate increase due to assigned links over possible links. By using link based selection.

B. Nodes Vs Number Of Rounds

The number of rounds needed by spectrum allocation . In the graph 6.3 number of rounds is decreased by applying link based selection which is comparatively high if node based selection are implemented in node level.

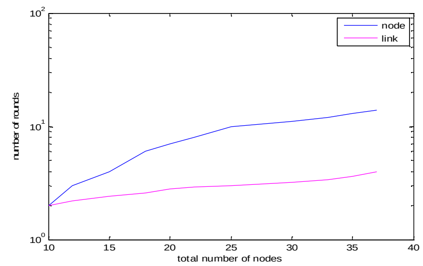

Figure 3. Nodes Vs Number of rounds

A small number of rounds indicates higher efficiency. Because the number of rounds needed by spectrum allocation.

C. Power Vs Energy Efficiency

Energy efficiency refers to time taken for the spectrum allocated for group of node. In the graph 6.4 Energy efficiency is increased by applying link based selection which is comparatively low if node based selection.

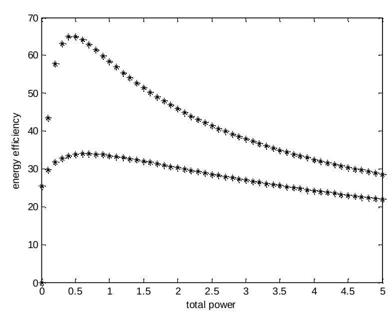

Figure 4. Power Vs Energy Efficiency

Transmission rate is increase the energy efficiency is reduced due to interference between the primary user as well as secondary user.Transmission of each data rate is increased means spectral efficiency is also decreased when the primary is considered through the spectrum allocation .

Table 2.Comparsion of rate and spectral efficiency

RATE	SPECTRALEFFICIENCY
20.67	59.06
34.14	75.88
53.51	81.29
61.11	82.33
67.8	81.48
73.81	81.48
79.25	77.69
84.24	75.48

V. CONCLUSION

The spectrum allocation (SA) problem is solved by using node based algorithm, link based algorithm, node-link based algorithm. In the node based algorithm assigned link rate is less when compare to link based algorithm. Interference between the primary user and secondary user are reduced. Spectral efficiency and energy efficiency are maximized through the multi channel selection.Spectrum utilization is improved by using node-link based algorithm. In future cluster-based and segment based approaches can be used to overcome the user behavior priorities and spectrum fragments by using evolutionary algorithm.

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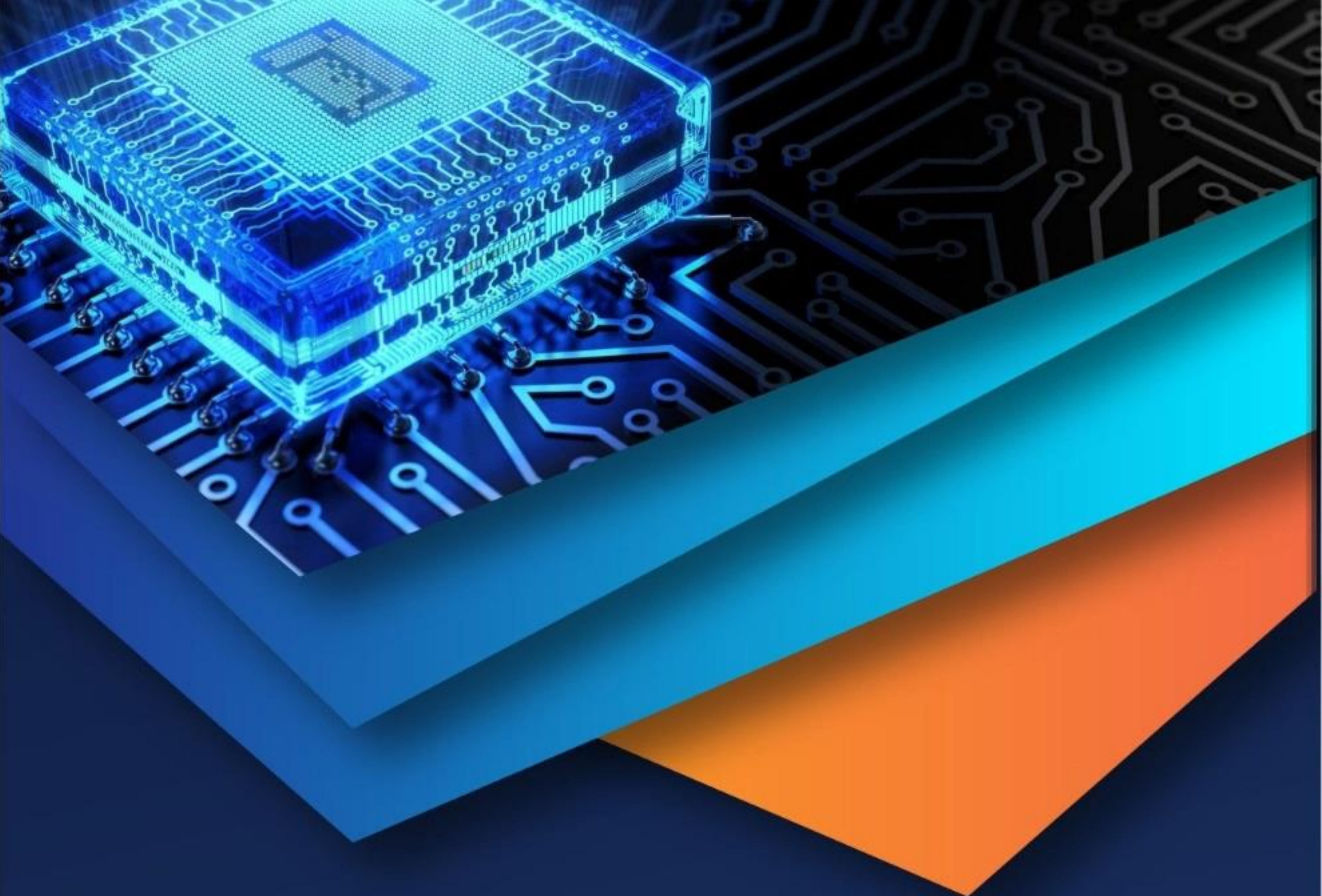

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