Performance Analysis of Efficient Spectrum Utilization in Cognitive Radio Networks by Dynamic Spectrum Access and Artificial Neuron Network Algorithms

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Abstract: *Efficient spectrum utilization is a prominent issue in cognitive radio networks. Owing to this, power allocation policies are proposed which underlay cognitive radio networks together among all prime nodes, secondary nodes, eavesdropper and secondary sender powered by renewable energy that is harvested from primary sender to acquire improved energy efficiency to enhance transmission rate, throughput, and Spectrum Utilization (SU). As a result, there is a need for combination of Dynamic Spectrum Access (DSA) algorithm, Artificial Neuron Network (ANN) algorithm which will make an allotment of obtainable network assets for various elements challenging for their resources. The prime objective of this paper is to intend a route control based multi-path Quality of Service (QoS) and to find substitute paths between Secondary User (SU) source and SU destination fulfilling QoS metrics, specifically providing maximal throughput and minimal delay. In order that primary substitute channels along the paths are used completely to reduce data packets loss by using Network Simulator 2 (NS2) software tool.*

Keywords: *Cognitive radio networks, DSA, ANN, SU, radio frequency, energy harvesting.*

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1. Introduction

In Cognitive Radio Networks (CRN), during certain conditions, Secondary Users (SUs) sense idle condition of licensed Primary Users (PUs) spectrum band when searched for data transmission. To minimize intrusion with PUs spectrum, sensing plays a vital role to recognize spectrum access in cognitive radio. It is observed that that the performance of a single Sensing Node (SN) is partial because it suffers from shadowing, vanishing and other fatal problems. To evade these drawbacks a recognition scheme comprising many Sensing Nodes (SNs) with a Fusion Centre (FC) that generates global decision statistics is deployed. To maintain system stability, Dynamic Spectrum Access (DSA) based channel activity is proposed in accordance with the number of vacant channels, channel energy. By this, the probability of sending data in a network is analysed and consumption of spectrum using DSA can also be achieved. High efficiency and utmost spectrum utilization can be achieved by integrating cognitive radio with DSA to avoid spectrum handoff. For example, sensor nodes can drive data to Internet of Things (IoT) [7] devices or to a data centre by DSA with a mixture of frequencies [3]. The CR nodes in the form of mobile and personal computers lead to gain hefty amount of data utilization [9, 10, 11, 15].

Spatial spectrum hole is a frequency band in an unambiguous geographic region where the PU broadcast is being occupied. A literature on Radio Frequency (RF)- Energy harvesting powered CRNs mostly focuses on investigating throughput maximization under a variety of constraints [16]. Further, based on the output data to node is assigned. The main task is to monitor the node when it is not in use in order to save energy. A route control based multipath Quality Of Service (QoS) is proposed in routing protocol to hit upon majority steady primary and other paths amid an SU's initial phase and SU's target fulfilling the QoS requirements specifically the maximal throughput and negligible delay [1, 2, 3, 4, 6, 7, 8, 9, 10, 15]. It is presupposed that due to the variations in radio environment, the parameters can differ autonomously. The sky-scraping communication time delay is also implemented since the node has to replicate the course of channel selection with healthier excellence. To minimize such potential and to perk up efficacy of a Spectrum Handoff (SH), we propose a DSA algorithm [4, 13]. The main contribution of this paper is to use RF energy harvesting with DSA and Artificial Neuron Network (ANN) which is suitable for industrial applications, the channel activity of DSA through ANN has been employed to address the spectrum utilization problem.

This paper presents performance analysis of efficient spectrum utilization in CRN. The rest of this paper is organized as follows. In section 2, problem formulations are explained, with RF energy harvesting, SU. Section 3 presents problem solution for solving networks issue has been discussed, section 4 gives proposed work. Section 5 explains result discussions. Finally, conclusions with future enhancement are given in section 6.

2. Problem Formulations

2.1. RF Energy Harvesting

In CRN it has many nodes. But, due to intrusion of many users and interference, the nodes sometimes fail to forward the information due to limited energy within it. Similarly, every node in a network will have the same limited energy as a consequence data transformation from source to destination is also limited. Moreover, energy utilized by node should be strong and energy should not be wasted when the node is not in use.

In addition, energy utilized by users in a cognitive radio can also be controlled by RF harvesting Systems. RF signals can be transformed into electricity. Usually Energy-Embarrassed Wireless Networks (EEWN), for instance Wireless Sensor Networks (WSN) [12], enclose a restricted era which principally limits the performance of network [14]. Thus, Radio Frequency (RF) energy harvesting ability allows wireless devices to reap energy from RF signals. Also, Cognitive Radio is a hopeful expertise to make the most of spectrum efficiency throughout spectrum access [10].

2.2. Efficient Spectrum Utilization

Spectrum utilization is the major problem in CRN. When the data transmission occurs between two nodes, other nodes are also engaged due to which spectrum usage by each other node is also wasted [8]. The spectrum allotment problem is at its peak that there are more than a few service providers and one customer-where several service providers fight to proffer the spectrum access opportunities to the customer [17].

The main aim of this paper is to use dissimilar steering metrics to choose the QoS paths with maximum steadiness. Distance between nodes in a cognitive radio network of the cooperative sensing system is projected. Then a design arrangement by improving distance that as the job in an optimization difficulty relating to quantization threshold is proposed [6].

3. Problem Solution

3.1. Energy Harvesting in CRN

This paper reviews the CRN energy harvesting methods with many energy harvesting sources that have been developed so far. The Radio Frequency Direct Current (RF-DC) (De radio networks direct Current) conversion can be made as shown in the below figure, which clearly explains that radio signals directly get into RF harvesting antenna and there itself the stored end harvested energy is ensured and further it is sent to RF-DC conversion. Finally, output of the system is made through power control unit which controls the power as well as the energy needed for conversion.

Figure 1 shows RF Energy harvesting System in which the input energy is sent to energy storage device where RF Energy can be stored and then only the required power can be used. Further, the stored energy can be managed and controlled by power system management and control circuitry. In this system, low power micro controller, low power RF transceiver and Antennas are used to recover energy from various sources.

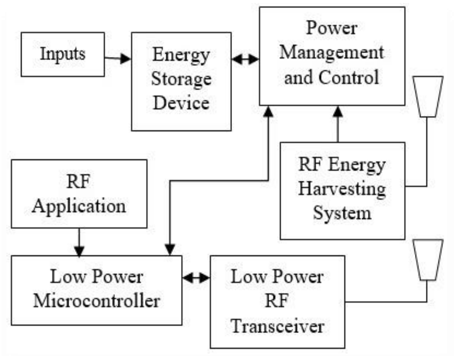

Figure 1. RF Energy harvesting system.

The parameters and the measured values are listed in Table 2 which indicates total number of primary and SU's, number of channels which we have taken into account for calculating throughput of the system, protocol used, Antenna type, Channel type, Propagation model, Maximum packet in queue, Power Spectral Density (PSD) [5].

3.2. Spectrum Utilization in CRN

To reduce wastage of spectrum usage we use DSA, ANN to identify relation among nodes in CRN, formation of affix node in a network, Packet drop due to shortage of energy and spectrum, and to improve throughput.

According to cognitive cycle First, the empty spectrum must be sensed by sending data. Once the spectrum is sensed we can utilize it for data transmission over cognitive radio networks. Adaptive methods on reducing traffic by node is shown in Figure 2.

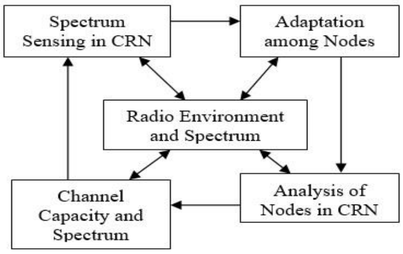

Figure 2. Effective spectrum utilization.

4. Proposed Work

License users in a network share data with each other without any interference and with a help of Cognitive Radio (CR) base station. Zone A, Zone B, Zone C are separated in such a way that license users execute their data sharing in a right way. Frequency spectrum hole is a neighbouring frequency band in which manners of the SU does not cause harmful interference to the PUs. Temporal spectrum hole is a frequency band that is not occupied by a PU for a period of time. By spectrum sensing system, a SU can spot spectrum holes and opportunistically access it without mortifying QoS of PU.

The main motivation in this paper is to combine spectrum energy saving and maximize RF energy harvesting. Spectrum sensing is the input task of CR as it involves shaping the spectrum individuality such as time, depending on frequency and the variety of PU signals present. DSA method for cognitive radio is used to moderate additional spectrum utilization in fixed spectrum and channel assignment policies. Obviously, CRNs vary from usual wireless communication networks. The Optimization crisis of DSA is

$$\sum_{i=1}^{m}\sum_{j=1}^{n}\mu_{i,j}(t)y_{i,j}(t) \tag{1}$$

The threshold value of $y_{i,j}(t)$ is mentioned below as

$$\sum_{j=1}^{n} y_{i,j}(t) \le 2 \tag{2}$$

The probability of occurring interference due to SU's (N-numbers)

$$PA_j(t) + \sum_{i=1}^{M} x_{i.j}(t) + (1+\lambda_{SU})^{i+c} \ge 1t \in \beta\psi \tag{3}$$

The interrelated shading chart is

$$\sum_{i=1}^{M} x_{i,j}(t) G_0^j exp\left(\frac{1}{4}\left(\frac{log\,10}{10}\right)\left(\frac{log\,10}{10}\right)^2 \sigma_{i,j}^2\right) P_{SU}^i \tag{4}$$

The Q-function is defined as

$$Q(x) = \frac{1}{\sqrt{2}}\int_x^{\infty} exp\left(-\frac{u^2}{2}\right) du \tag{5}$$

The Q(x) is validated and it is applied for energy saving in spectrum management through cognitive radio in view of the fact that they have cognitive capabilities to sense, to examine, and to become accustomed to the uncertainty of the communication surroundings where the spectra have been owed to the PU.

$$\sum_{i=1}^{M} x_{i,j}(t) G_\alpha^j S(i,j)^{-\eta} exp\left(\frac{1}{4}\left(\sigma_{i,j}\frac{log\,10}{10}\right)^3\right) P_{SU}^i, \forall j \in Y \tag{6}$$

Based on the Q-function, the performance of the entire system is analysed

$x_{i,j}(t)$ –Input Function of System

$G_\alpha^j S(i,j)^{-\eta}$ –Gaussian Noise

The blocking among a SU can be defined as a node process containing subsequent arrival instants in the form of binomial distribution.

$$P\{b_i = c\} = \binom{i}{c}\lambda_{SU}^{c}(1-\lambda_{SU})^{i-c} + (1+\lambda_{SU})^{i+c} \tag{7}$$

Where c-Number of Nodes in Network

λ_{SU}-Wavelength of Secondary User

The numeral of timeslot involving two arrivals at concurrent time period is

$$P\{B_n = 0\} = \lambda_{SU}(1-\lambda_{SU})^{0}(1+\lambda_{SU})^{i+c}, 0\epsilon N_0 \tag{8}$$

The conditional probability and Euclidian distance are

$$P(¥(c,d)/T(c,d))(1+\lambda_{SU})^{i+c} = P\left(\beta(c,d) \le \beta_{thr} \setminus (c,d)\right) \tag{9}$$

In this model, total energy can be harvested based on power transmission, wavelength, and distance between RF source and harvesting lump. Table 1 shows amount of energy or power harvested in watts. The energy harvested by RF and power transmitter are 5.4 µW and 191 µW respectively. The harvested energy can be used for data transmission.

Table 1. Power management.

Device/Parameter	Power Used	Amount of Energy Harvested
RF Transmitter	1.78-4W	5.4µW
Power Transmitter	3W	191µW

In CRN network though nodes will be in a mobilized manner, there will be a robust connectivity. Also, the required transmission and reception parameters are automatically configured dynamically and get tuned according to the environment. The radio network automatically finds empty channels in wireless spectrum.

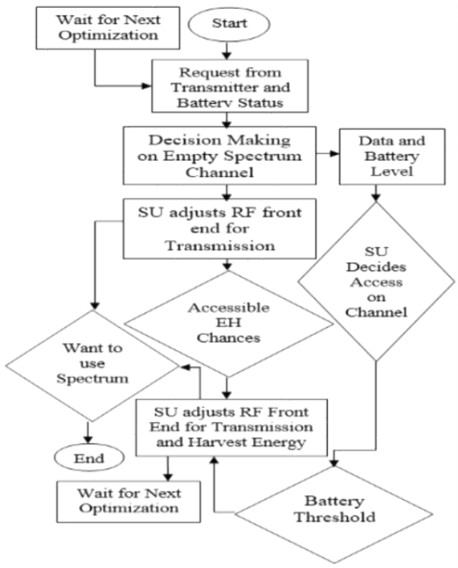

Figure 3. Flow chart of RF energy harvesting system.

Figure 3 represents the operation done by integrating RF energy harvested with DSA in cognitive radio networks. In this paper we have created rectangular node using 50 sensor nodes and one anchor node. The ANN algorithm is used for finding shortest pathway connecting source and destination. Figure 4 shows relations among a variety of node paths available among all nodes and from this figure shortest distance have also been calculated. Figure 5 shows affix node formation between source node and anchor node.

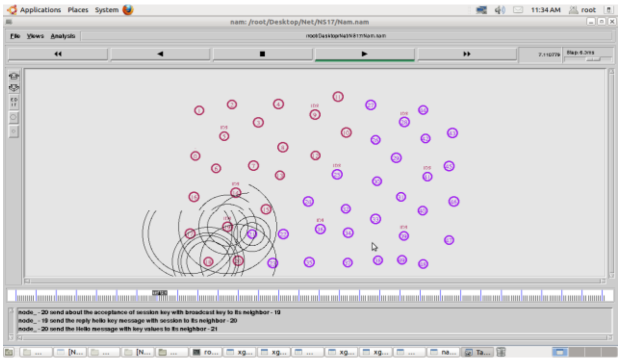

Figure 4. Relations among a variety of nodes.

Figure 5. Affix node pattern.

Table 2. Comparison parameters Vs measured values.

Parameters	**Measured Values**
No. of SUs	14–485
No. of PUs	2–7
No. of channels	1–7
Aloha-type protocol	802.11
Packet size	1000 bytes
Antenna type	RF Harvesting Omni Directional
Channel type	Wireless Channel
Propagation model	Two ray Ground
Max packet in queue	50
Power Spectral Density	0–3
bandwidth	2.4-4.44 GHz
Operating Frequency	2.4 GHz

Table 3. Comparison table.

Parameter/Method	**Neural Networks**	**DSA Method**	**DSA and ANN Method**
Bandwidth (%)	63.07	82.5%	85.01
Operating Frequency	2 GHz	1.96-3.05 GHz	**2.4** GHz
Efficiency (%)	86.7	87.5%	93.5

The nearby node is identified whether it is engaged or not. If the node is engaged, we could estimate time duration about to transmit/receive information. In Figure 6 packet drop due to interference has been calculated in every level of communication, the packet of information should not loss as an alternative, rather, it must reach the destination with no interference.

In this paper ANN is used for decision making on empty spectrum channel as shown in flowchart. By doing so timeliness is achieved which results effective usage of spectrum without delay.

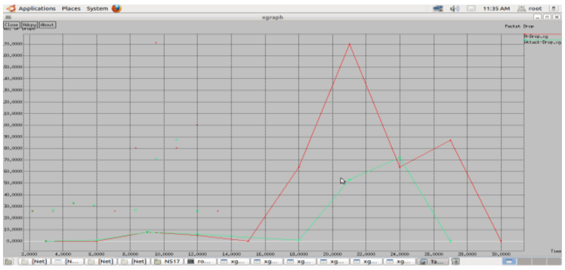

Figure 6. Packet drop chart.

5. Results

We identified places where we usually have many losses and after identification, we recover problem by reducing interferences. At certain level we may have losses at peak level during that time minimization of interferences takes place at the rate of less than 1 micro second (μs).

According to this relation, nodes are identified and transceiver in a network is directed to send/request data by their own. The red color nodes have alike features, the blue color nodes designate the opponent nodes. As said by this relative, nodes are recognized and the transceiver in a system is focussed to send/request data by their individual. Once the nodes have been known, the node pattern will be fashioned as shown above to deliver maximal throughput and minimum delay.

Once the nodes are identified, the node pattern will be formed as shown above to provide maximal throughput and minimum delay.

The throughput of the system is indicated by the red line. The white designates the reference. From this, it has been experiential that there is an upgrading in energy harvesting and spectrum utilization in CRN by NS-2 tool and it is indicated in Figure 7.

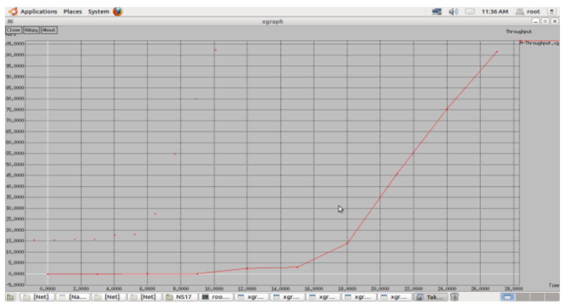

Figure 7. Throughput chart.

Figure 8 shows the throughput comparison chart. Next if the transceiver wants to use spectrum SU will be provided and when not in use it will be discontinued and corresponding energy will be harvested.

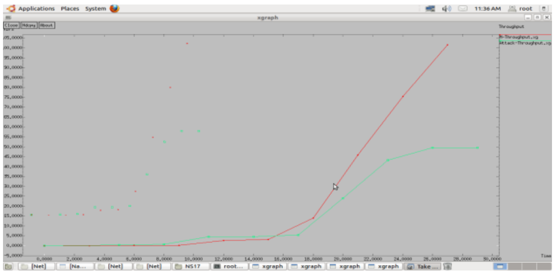

Figure 8. Throughput comparison chart.

The bandwidth utilization of every node is calculated which is shown in Figures 9 and f 8 we have been observed the improvement by Network Simulator 2 tool. Table 3 shows production of our work in comparison with previous work.

Figure 9. Bandwidth utilization.

NS2 is merely a simulation tool that has proved functional in studying about communication networks. Simulation of wired, wireless network parameter and protocols (e.g., routing algorithms, Transmission Control Protocol (TCP), User Defined Protocol (UDP)) can be done using NS2. In general, NS2 provides users with a way of specifying network protocols and simulating their analogous behaviours.

6. Conclusions

The DSA is implemented to reinforce SU in CRN. spectrum utilization in CRN have been expanded by ANN algorithms. Moreover, the experimental results show the improvement compared with the previous results. The proposed system performance has been inspected by various constraints. In this paper we have compared packet loss, node formation, and throughput calculation which is simulated by NS-2 and Relations among a spread of Nodes are studied under different measured values and therefore the result is traced within the sort of charts. For future work we plan to use a relatively comparable method for SU in CRN.

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