Enhanced Wireless Network Usage and Loading on Network Delay using Cognitive Radio Network

S. Kavitha[1*] and Dr.R. Kaniezhil[2]

[1*] Research Scholar (P.T), Department of Computer Science, Loyola College of Arts and Science, Mettala, Periyar University, Salem, Tamil Nadu, India.
kavithaloganathan1984@gmail.com, Orcid: http://orcid.org/0009-0007-8027-1183

[2] Principal, Navarasam Arts & Science College for Women, Erode, Tamil Nadu, India.
kaniezhil@yahoo.co.in, Orcid: http://orcid.org/0000-0003-1567-1088

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Abstract

Wireless communication is one of the fastest-growing fields of communication. Because the user can access and share information anywhere at any time. The communication process will suffer from an overload of traffic. If the node gets overloaded because of heavy traffic, then the performance of the whole network is degraded. So, the usage of the network will be delayed.

The proposed work uses the intellectual load balancing approach for Cognitive Radio Network to focus on automatic monitoring of network activity, and the node will continuously balance among numerous nodes. In Cognitive Radio Network the Dynamic Spectrum Access techniques are used to avoid spectrum scarcity and underutilization.

The CR base station collect the surrounding about the active primary user and waiting secondary user. To determine the principal user's on/off status of availability, the Markov chain model is employed. The waiting secondary user utilize the spectrum when the primary user is not using it. The secondary user leaves the spectrum and uses the spectrum of another primary user if the primary user is on status. It will assist with dynamic spectrum access method and it will help increase the overall performance of the network. The suggested Load balancing Cognitive Radio Network (LBCRN) sorts the nodes and uses spectrum identification before allocating the node to the secondary user. So that minimise transaction delays, prevent overcrowding of a specific node, automatically lower the level of packet drops, and enhance packet delivery radio levels. As a result, this strategy has helped to lessen the issue of spectrum shortages in the wireless communication industry.

Keywords: Load Balancing, Network Delay, Dynamic Spectrum Access, Cognitive Radio Network.

1 Introduction

Basically, Load balancing spreads a workload over numerous entities, in this instance, wireless radios, in order to ensure optimal spectrum use, optimise throughput, reduce response time, and prevent overload. Due to the rapid development of wireless technology, the demand for better and faster

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*Corresponding author: Research Scholar (P.T), Department of Computer Science, Loyola College of Arts and Science, Mettala, Periyar University, Salem, Tamil Nadu, India.

communication also arises. Increased network traffic and overloaded network resources lead to heavy utilisation of the spectrum. To overcome this problem, a cognitive radio network is applied to automatically monitor the environment and dynamically allocate the spectrum based on needs (Suliman, R.A.H., 2018).

According to the Federal Communications Commission (FCC), the licenced spectrum remains underutilised (Arora, R.E.A., 2016). In order to effectively handle the issue, cognitive radio networks have been developed, which opportunistically utilise the spectrum of many user networks. There are binary kinds of users in this network: Primary Users (PU) also called licensed user and secondary users (SU) also called unlicensed user. When the act of the PUs is not negatively impacted by the SU managing a network, PU has the historical priority to access the spectrum while SU uses it. Cognitive radio technology improves the use of the spectrum in conventional wireless networks, which expands the range of applications and services available in wireless systems (Kang, J., 2019). To improve the quality of service (QoS) for SUs, CRN understands its transmission atmosphere and modifies the constraints of its communication arrangement.

This paper is organised as follows: Segment 2 and 3 define cognitive radio technology, and related works are discussed. Segment 4 about the proposed load balancing with quick spectrum sensing proposal has been discussed. In segment 5, the focus is on performance measurement of the spectrum, and replication results are presented. In Segment 6, we finally reach our findings and conclusion.

2 Cognitive Ratio Technology

An intellectual radio is a cognitive radio that can be dynamically designed and programmed. In order to increase the quantity of wireless transmissions active at once in that band, it automatically discovers obtainable channels in the wireless spectrum and modifies their broadcast or reception properties. Selecting the available channel opportunistically is called Dynamic Spectrum Management (DSM) (Sivagurunathan, P.T., 2021) (Gowda, C.M., 2018).

There are two basic types of cognitive wireless standards: spectrum sensing and spectrum sharing. When the PU is not present, the SU must find the spectrum opportunities and then broadcast them. In the former, SUs share spectrum to prevent seriously interfering with primary receivers. A Medium Access Control Layer Protocol (MACLP) that can properly divide the spectrum among unlicensed users is necessary in such systems (Tlouyamma, J., 2021).

Cognitive Radio Cycle

Divyalakshmi, Rangaiah L. (Lakshmi, J.D., 2019) presented A cognitive radio keeps track of the spectrum bands, collects their data, and then identifies the spectrum availability in a cognitive radio cycle. The discovered features of spectrum spaces are used to estimate spectrum sensing. Then, the proper spectrum band is chosen depending on its characteristics and user needs. Communication can take place across this frequency band once the operating spectrum band has been determined. R. Kaniezhil (Chandrasekar, C., 2012) presented a spectrum of sensing, management, mobility, and sharing.

1. *Spectrum Sensing:* It means finding unutilized spectrum and sharing it with other users without detrimental intervention. Detecting primary users is the most important strategy to discover spectrum holes, which is a prime requisite of the cognitive radio network.
2. *Spectrum Decision:* The goal is to employ the best spectrum that is currently capable of fulfilling user communication needs.

3. *Spectrum Sharing:* This refers to providing an equitable spectrum scheduling approach to all customers. When using free spectrum, sharing is a major difficulty.
4. *Spectrum Mobility: This is* the procedure by which a cognitive radio modifies its operating root and frequency

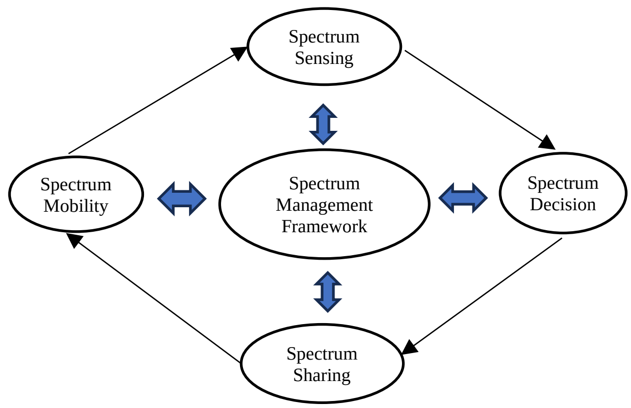

Figure 1: Spectrum Management Frame Work of Cognitive Radio

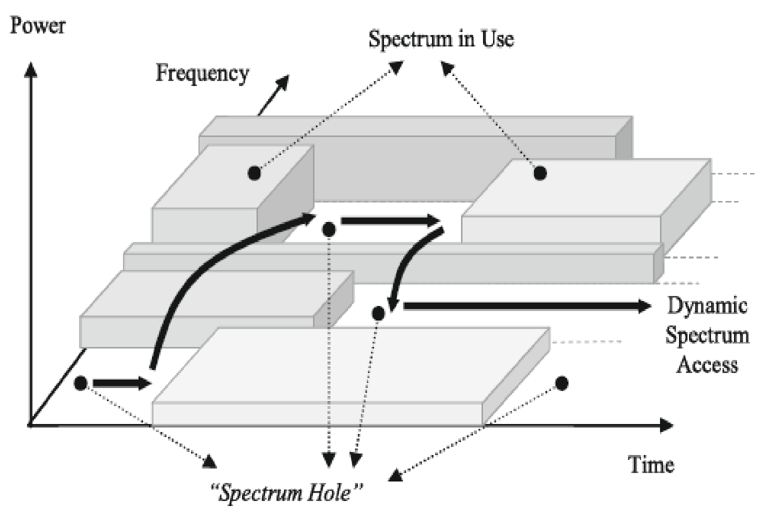

Figure 2: Spectrum Hole Concept

Cognitive Radio Process

Cognitive competence is the term used to describe the capacity of radio communication to acquire or observe information itself from the radio environment. As a result, the best spectrum and operational constraints can be chosen.

Reconfigurability: While spectrum awareness is provided by cognitive capability, reconfigurability allows the radio to be fiercely scheduleded in response to the radio environment. Through the use of dynamic spectrum access methods and heterogeneous wireless designs, CR networks are intended to offer high throughput to movable users (Chandrasekar, C., 2012). Only dynamic and efficient spectrum management approaches will be able to achieve this goal. The ultimate goal of the cognitive radio, as previously said, is to obtain the finest offered spectrum through cognitive competence and capable of being rearranged. Because the majority of the spectrum has previously been allotted, the most pressing difficulty is sharing the approved spectrum without interfering with further approved user transmissions, as shown in Figure 2.

Dynamic Spectrum Access

The use of spectrum sharing, the secondary unauthorised system (user) is able to dynamically access the primary system's licenced radio bands without requiring any changes to the primary system's equipment, workstation, services, or networks, as shown in Figure 2. Spectrum alertness, intellectual processing, and spectrum access are the three essential components of dynamic spectrum access. When spectrum access offers strategies for effectively utilising the existing options for reuse of the spectrum, spectrum awareness helps to build understanding of the radio frequency environment. The intelligence and decision-making component known as cognitive processing carries out a number of subdivisions, like understanding the radio environment and creating sensing efficiency. Spectrum access regulations that control interference are necessary for the coexistence of SU and PU networks.

3 Related Work

Telecommunication networks (Sivagurunathan, P.T., 2021) have been recognised as a necessity for survival, and as the number of users grows, so does the consumption of spectrum. Many investigations and experiments have discovered extremely inefficient spectrum usage. To address this, the cognitive radio network was introduced in order to dynamically allocate spectrum in order to increase spectrum efficiency, lower costs, and increase the amount of radiocommunication users. The cognitive radio network solved bad consumptions and improved more spectrum features in advance.

(Sharma, A., 2015) The author proposed various spectrum sensing techniques to identify the unused spectrum of the primary user in different ways. A comparison and analysis of various spectrum sensing techniques is done, and the final results show that energy detection-based spectrum sensing is extensively used because it does not need the conveyed signal. (Gowda, C.M., 2018) The author presented a first-fit method and a random assignment method that are implemented in the CR baseline and used in the cognitive radio application for selective assignment (sensing) of the node. The learning-based determination of signals employing OFDM and cyclostationary characteristics for reliable signal detection is depicted in (Xu, Z., 2020) by author Zhengjia Xu and team. For signal depiction in CR applications using unknown transmission frequencies, it uses a spectrum identification background.

The author (Chin, W.L., 2015) proposed two-step detection of spectrum sensing schemes: coarse and fine detection, which are used to expand the concert of energy detectors in the CR overlay process. In (Ravneet Kaur, 2015), the wireless communication suffers from overloading of traffic because of a lot of requests and the forcing of fast transmitting of data. Due to the above reason, the node got busy, and traffic arises. In this situation, the load-balancing approach is applied to distribute the workload and make each node balanced. But now days, usage of wireless communication has increased, and the load balancing approach is not enough to avoid traffic and delay network performance. so that the Cognitive Radio Network can intellectually detect channel availability and change the transmission parameters.

(Devi, M., 2021) As the author proposed, for multiple interfaces multi-winner allocation under heterogeneity channel characteristics, we developed a double auction mechanism. The model takes into account changes in channel availability periods as well as trends in spectrum opportunities. n essence, the reliability of the network is increased. For each channel, groups are created to help with spectrum reuse. The unlicenced user channel allocation strategy is determined by group bids from each group. (Sengottuvelan, S., 2016) The author uses a channel selection algorithm based on on-off techniques and allocates the primary user availability channel to the secondary user.

(Han, R., 2018) According to network speed and spectrum usage, the author of this study evaluates the optimal utilisation of spectrum for CR-based IoT. Because links in the network are essential components within distributing spectrum and data transmission, we provide a concurrent transmission framework that shows the limitations of reciprocal disruption and resource rivalry in linked simultaneous transmissions. We use this idea as the chromosome (outcome) in genetic algorithms (GA) to construct the spectrum allocation method for linkages. Then, we run the non-dominated arranging genetic algorithm using the many objectives spectrum allocation problem.

(Vignesh Kumar et al., 2016) An interference metric for spectrum sharing between licenced and unlicenced users is interference. The works that are being offered use a novel channel allocation technique that uses a non-dominated set of solutions in order to achieve the following goals: optimum SINR, chance for maximal SINR, and maximum channel free time. Using a naive and slow approach, the non-dominated solution set has been calculated. The simulation analysis demonstrates that the future method works better than the current method. In a centralised system (Maurya, D.K., 2020) (Chandrasekar, C., 2012), a service provider's share of the available spectrum is essentially determined by the number of customers it serves and the amount of spectrum needed for each customer's application. The authors developed a novel spectrum sharing technique in a CRN based on the throughput model, where maximal theoretical throughput is taken into account. The author of (Bany Salameh, H., 2020) created a multi-channel cognitive radio network with a combined channel estimation and adaptive Multi-Input-Multi-Output (MIMO) mode selection protocol. In order to increase the throughput of the network and communication consistency, the proposed protocol makes use of the multiplexing and dynamic access features of cognitive radio devices. The proposed protocol aims to improve system performance by choosing the appropriate MIMO operating modes for each idle channel in accordance with the neighbouring RF environment. It then chooses the channel that offers the highest throughput. The authors developed a novel multi-channel connection graph technique for equitable spectrum sharing, as presented in (Awoyemi, B.S., 2016). In (El Azaly, N.M., 2021), it is necessary to consider route selection and spectrum management while evaluating spectrum efficiency in multi-hop broadcasts. In (Chandrasekar, C., 2015), the author presented a traffic pattern prediction that, as the author recommended, offers a superior method of enhancing spectrum utilisation and avoiding spectrum scarcity. By making it simpler to identify the finest users to use the spectrum with maximum spectrum coverage, this supports increase the more count of active users. The author used the NS2 simulator to empirically assess the efficiency of our method, demonstrating that we can handle more users while minimising interference once the traffic has been predicted.

However, in most past publications on spectrum distribution and sharing (Chin, W.L., 2015), allocations were allocated in the unlicensed band. Spectrum sensing using a cognitive radio network is explored in this paper for load balancing and effective spectrum usage in a heterogeneous wireless network.

4 Proposed Work

The existing system fails to avoid overloading traffic using the load balancing approach. We need to focus on the self-regulating monitoring of the network, and the load will continuously stay balanced among numerous nodes. This will increase the overall performance of the network. We need to use a load balancing approach with a cognitive radio network to avoid traffic and delay the network process for better utilisation of the spectrum. Then, using LBCRN for better spectrum utilisation, LBCRN determines node availability by sorting the distance the available node sends to the SU.

Stage 1 Check the Primary User Channel Availability Using Markov Chain Model

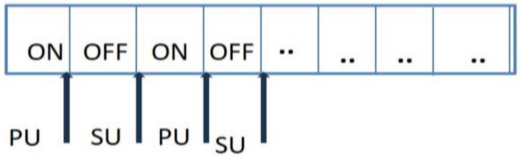

Figure 3a: ON/OFF Slots Diagram

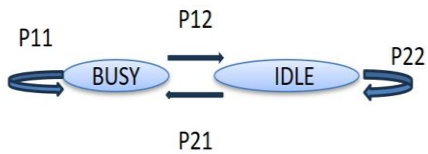

Figure 3b: ON/OFF Slots Diagram Showing SU Sensing

Figure 3a ON/OFF slots diagram represents the channel availability of the PU. The primary user (PU) is also called the licenced user, and if the PU is ON, it indicates that the spectrum is in use. The OFF slot indicates that PU is not in use. So, the unlicenced user is now eligible to use the spectrum. Figure 3b is a diagram of ON/OFF slots that shows spectrum sensing by the SU. In the Markov Chain Model, two states are characterised by business and idleness. The busy state represents ON, and the idle state represents OFF. Now, deliberate a CRN with unlicenced user, where the state space vector is assumed as follows:

x = *O*, *S1*,...*Sn*, *P*, and the state transition, the primary channel is modelled as an blinking between ON (busy) and OFF (idle) periods, as shown in Fig. 3(b). To describe the identical constraint and the portion of time in which the primary channel is in on states and OFF states, appropriately:

Different SU approaches are considering $O \rightarrow ON \quad P \rightarrow OFF$
O to P transaction represents λ_P
P to O transaction represents μ_P
Therefore $x = (O, P)$

$$\pi = (\pi_0, \pi_P) \quad (1)$$

$$\pi_0 = \frac{\mu_P}{\mu_P + \lambda_P} \quad (2)$$

$$\pi_P = \frac{\lambda_P}{\mu_P + \lambda_P} \quad (3)$$

$$\pi = \frac{\mu_P}{(\mu_P + \lambda_P)\left(1 + \frac{\lambda_1}{\mu_1 + \lambda_P} + \cdots + \frac{\lambda_n}{\mu_n + \lambda_P}\right)} \quad (4)$$

From this representation, (2) and (3) indicate the transaction, and (4) represents the overall transaction.

In this paper, we demonstrate the LBCRN algorithm using the Markov chain model to avoid network delay and traffic. As a result, an increase in network resources improves the utilisation of the spectrum.

Stage 2 CR Node Sensing the Available Channels

Under this topic, each station of the network checks the availability node to see whether, at present, the channel is used. If so, then it is PU.

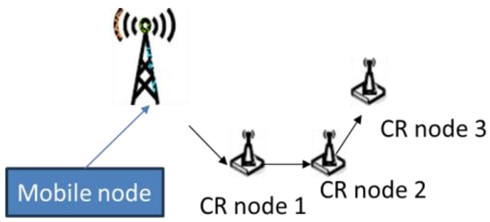

Figure 4: Primary and Secondary User

Otherwise, it is considered SU. If the SU is utilising the channel and the PU approaches the channel for utilisation, then the SU should leave the channel without any interference. Once the SU leaves the channel, it checks for the nearest availability of the channel and insists on the CR node automatically detecting the channel that is not in use. CR helps to sort and compute the available channels in descending order and balances the node to avoid traffic.

Algorithm For LBCRN

Input	Use the Primary Users (PU) and Secondary Users (SU).
Output	Balanced Load for each Node in process
Assumption	No user is spiteful and provides Information about its load

Step 1: Start the process

Step 2: For each station denoted as ‘x’(use Markov transition diagram) and Sense spectrum usage for x

Step 3: if (spectrum usage >= dawn) then Identify another free available Channel’s

Step 4: Compute the available channel strength and measure then find availability

Step 5: Sort all the availability of node capacities in descending order format. Store the sorted channels in a list (LI) else

Check obtainability and capacity for next station

Step 6: For assuming each node in LI assign free capacity to x, if assignment practicable execute load balancing.

Step 7: Stop the process

5 Simulation and Result Discussion

In this segment, the presentation of the total system efficiency has been assessed using the NS2 simulator. In NS2, the imitation for the suggested task has been completed. Table 1 displays the imitation constraints that were used.

Table 1: Simulation Constraints& Boundary

Constraints For Simulations Process	**Values**
Simulation Period	60 second
Channel name	Wireless Chaneel
Propagation Model in work	Two Ray Ground Model
Number of Nodes to Use	150
Quantity of CRI (Cognitive Radio Interfaces)	3
Number of Primary User	10
Number of Secondary User	40
Speed in Use	20 m/s
X - value	1000 m
Y - value	1000 m
Packet Size	1024 bytes

Figure 5 describes the normal load-balancing approach to transactions and spectrum usage. Figure 6 describes When a new user requests a spectrum allocation, the CR node accepts the request and participates in the decision-making process. This necessitates making a choice while taking into account a number of variables, including the secondary user's requirements as well as constraints such as channel coding, data transfer rate, etc. The user sends its QoS necessities to the cognitive radio, which also receives information about the radio frequency surroundings from a sensing module in order to conduct its communications.

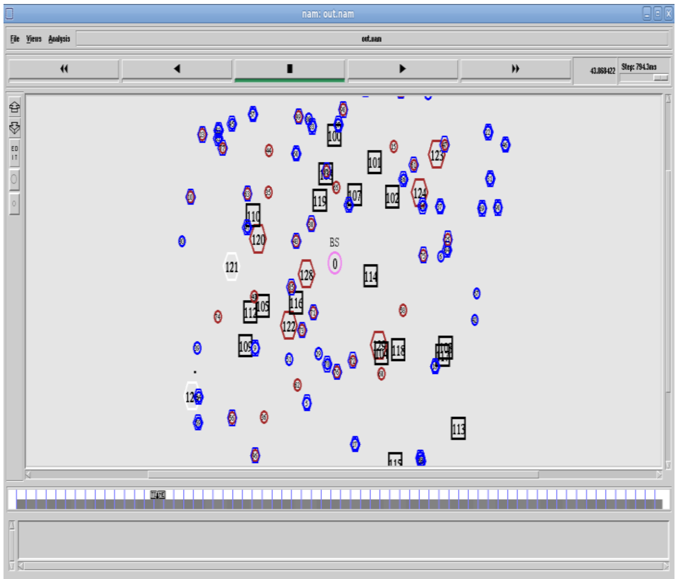

Figure 5: Normal Load Balancing

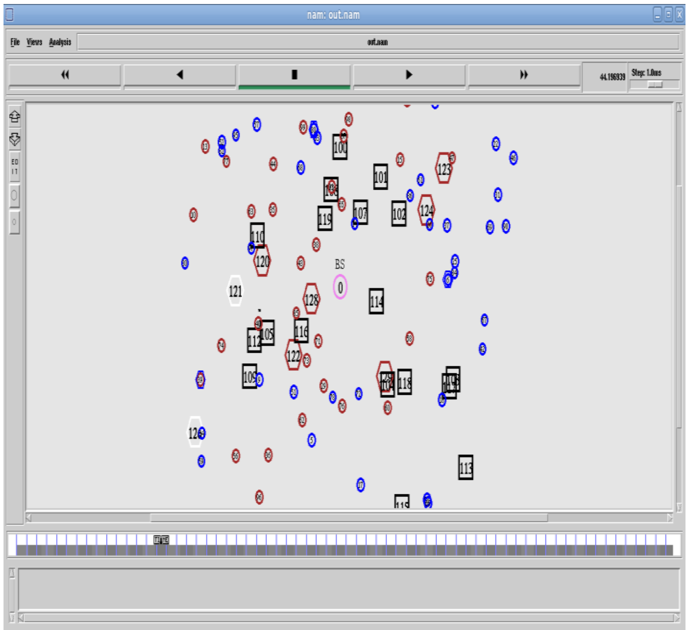

Figure 6: Load Balancing with CR

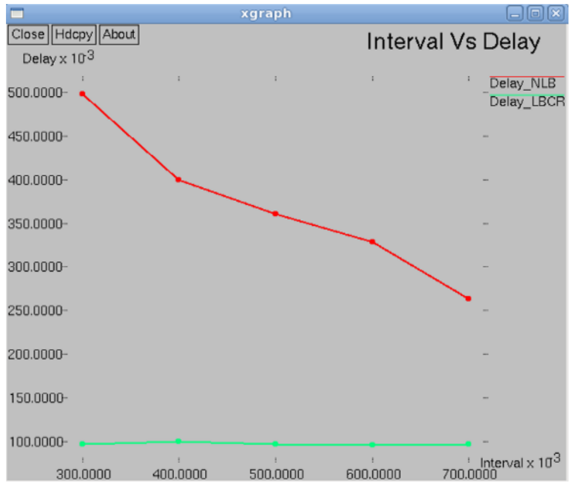

Figure 7: Interval Vs Delay

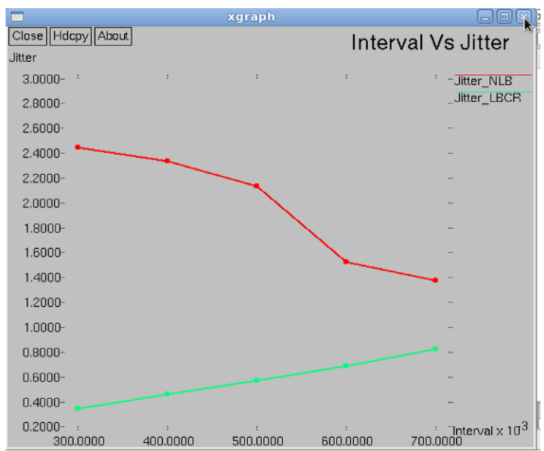

Figure 8: Interval Vs Jitter

Figure 7, The data transmission chart displays the Normal Load Balancing (NLB) delay and Load Balancing Cognitive Radio (LBCR). The interval time is symbolised by the X-axis, and the transmission delay by the Y-axis. It describes the typical time at which a data packet will be transmitted via a network from source to destination. The latency in data packet broadcasts and the delay brought on by the route detection procedure are also taken into account. Only data packets that reached their estimated and determined destinations successfully were taken into account.

End to End Delay = ∑i (Arrive at – Send period) / ∑i Number of Connection (5)

This graph shows the delay performance of Normal Load Balancing (NLB) and Load Balancing with Cognitive Radio (LBCR). From that LBCR gives a better result than NLB. Finally, Figure 7 shows that using the proposed algorithm, LBCRN, the delay has been reduced.

Figure 8 denotes the jitter as the time it takes for received packets to arrive, commonly measured in milliseconds (ms). The time difference between each packet sequence is averaged. To compare the jitter performance of Normal Load Balancing (NLB) and Load Balancing with Cognitive Radio (LBCR) shows that LBCR gives a better result than NLB. The presentation of the proposed work and the time delay will be reduced in LBCR.

(Jitter = The sequence's average packet-to-packet timing difference)

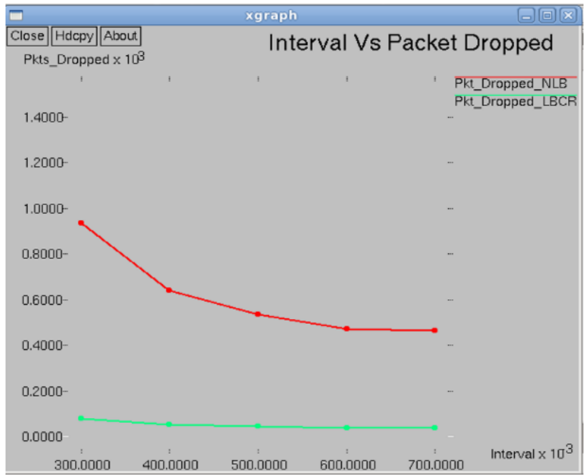

Figure 9: Interval Vs Packet Dropped

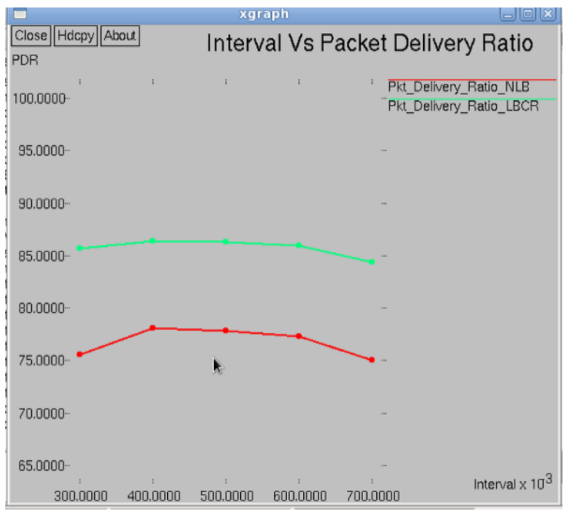

Figure 10: Interval Vs Packet Delivery Radio

Figure 9 represents that whenever one or perhaps more data packets moving over a computer network are dropped, their destination is considered a packet loss. The ratio of lost packets to all packets sent is denoted by the packet loss ratio. Each packet does have a deadline before it must be processed, and the dispatcher works to decrease the number of missed packets as a result of the deadline expiration if this is not achievable.

$$\text{Packet Loss Radio} = \frac{\text{count of lost packets in process}}{\text{Total count of packets send in process}} \tag{6}$$

Comparing NLB and LBCR in packet dropped analysis, the proposed LBCR minimizes packet loss while maximizing the utilization of the spectrum.

The Packet Delivery Ratio(PDR), shown in Figure 10, is computed by dividing the whole amount of data packets that were sent from bases by the whole amount of data packets that were delivered to destinations. In other words, The ratio of packets sent from the point of origin to those delivered at the point of destination is known as the packet delivery ratio.

$$\text{PDR} = \frac{\text{Total number of packed received in process}}{\text{Total number of packet sent in process}} \tag{7}$$

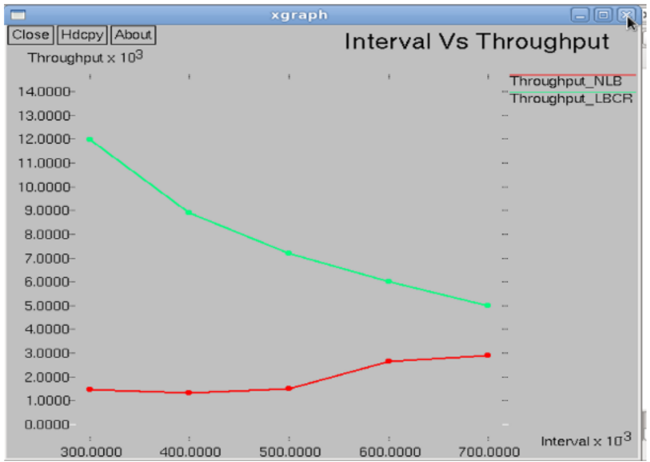

Figure 11: Interval Vs Throughput

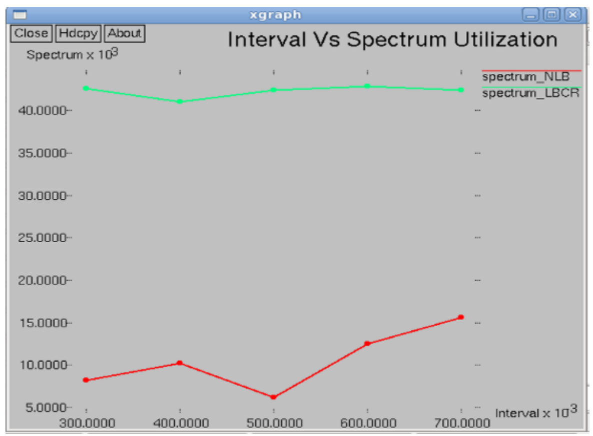

Figure 12: Interval Vs Spectrum Utilization

As shown in Figure 11, throughput is the most crucial quality-of-service characteristic in wireless connections. It is the typical data connection transfer speed. It is derived by dividing the typical bit rate per data request by the typical data transmission duration. The comparison between NLB and LBCR shows the proposed work (LBCR) gives a better throughput result. Figure 12 illustrates the consumption of the spectrum in the proposed work, which is upgraded from underutilization of the spectrum using CR. so that performance and usage of network processes will increase.

Table 2: Value for Interference

S.NO	No. of possible transaction	Communication range values (in dB)		
		CRI 1	CRI 2	CRI 3
1	20	1.1880	1.1855	1.1805
2	40	1.1705	1.1680	1.1655
3	60	1.1630	1.1580	1.1505

The communication value ranges for various CRI are displayed in Table 2. Here, when the CRI count rises, the inference also falls.

6 Conclusion

The proposed algorithm easily predicts the unused spectrum of the licenced user while at the same time sorting the availability of nodes at the nearest allow to use the spectrum by the secondary user. The

LBCRN algorithm, which promotes sensing efficiency while adhering to primary networks' rigorous interference constraints, provides the best transmission and observation times. At the sophisticated traffic volume, recovering the network is impossible, but with the help of the CR node, it is easy and quick to recover the network structure. It is also easy to maintain the node's balance, which helps to avoid overloading and delay. This forecast improves primary user channel usage and primary user contact with secondary users. Hence, CR nodes make it possible to keep track of how each service provider is using their channels while avoiding using up precious spectrum.

Future research will focus on how the CR can pick the fittest node for a transaction in order to avoid unwanted interference and facilitate a quick transaction.

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Authors Biography

S. Kavitha received her MCA and M. Phil degrees from Periyar University and Vinayaka Mission University in 2007 and 2009, respectively. She is currently pursuing a Ph.D. degree with the Department of Computer Science, Periyar University, Salem, India. Her research interests include wireless networking, spectrum management, and mobile computing.
Email: kavithaloganathan1984@gmail.com , Orcid: http://orcid.org/0009-0007-8027-1183

Dr.R. Kaniezhil received his Ph.D. degree from Periyar University. She is working as a principal at Navarasam Arts &Science College for Women, Erode, Tamil Nadu. Her areas of interest include wireless networking, mobile computing, computer communications, and networks. She is a research guide at various universities in India. She has published more than 39 technical papers at various national and international conferences and in 27 journals. She received the Outstanding Scientist Award and the Women Researcher Award. Email: kaniezhil@yahoo.co.in , Orcid: http://orcid.org/0000-0003-1567-1088