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DESIGN OF BANDWIDTH-BASED CHANNEL SENSING MECHANISM FOR COGNITIVE RADIO NETWORKS

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ABSTRACT

Cognitive Radio is a vast topic and has gained importance in the research community due to the increase in the number of wireless users. The spectrum availability is limited but the number of users is increasing on an exponential level. This demand for new users especially in the mobile user segment has mandated new methods to accommodate the secondary users. The first step in the cognitive radio setup is channel sensing. The primary users in the spectrum should be analyzed for the transmission parameters before the secondary users can be prepared to be accommodated. There are various approaches used in channel sense that should be carefully analyzed for a specific application before it can be implemented. This research paper reviews the channel sensing approaches and implements a simple yet efficient mechanism using bandwidth as the parameter. The design was simulated using the NS2 tool and the results of two levels using

different network configurations are described. The results are satisfactory and the simulation can be extended with other network parameters, considered the future scope.

1. Introduction

Cognitive radios have revolutionized wireless radio systems with advanced technology. The highlight of cognitive radio is the dynamically configurable channels to avoid congestion in the network. The interference from different channels can also be awarded if the design of cognitive radio is efficient [16]. The objective of the wireless channel is to increase the number of users without causing interference to the existing channels. This objective can be fulfilled only if the new channels (secondary) since the network for various parameters such as power, signal quality, interference, etc. Dynamic Spectrum management is the phenomenal used to scan the existing channels and also introduce new channels [17].

Frequency demand is one of the most but acquired resources for wireless communication. The exponential increase in the number of channels and the demand for radio channel has created scarcity in the Spectrum. Cognitive radio is a concept developed to use the unutilized areas of the frequency spectrum and to overcome the scarcity of the frequency band for new users. The existing users in the frequency band are called as primary users and the new users intending to send information are labeled as second to users. There are no fixed channels for communication in the cognitive radio setup. There are different sensors and other mechanisms used to check if the neighbors have the required frequency spectrum to a lot and assign it to the new secondary users. That displays the distribution of radius frequencies and the classification of frequencies has been made into heavy use, sparse use, and medium use. This classification is available to determine the frequency channels and classify them based on the usage. The heavy use Spectrum area is not available for the second two users easily because the band area is used extensively by the channels that transmit large data sets and information for specific applications. The medium use applications and the frequency band is used slightly lesser compared to the heavy use category. However, the focus of cognitive Radio Systems in which the secondary result can be accommodated in the area that is labeled as sparse use.

Channel sensing is the major challenge in a cognitive radio system. The existing radio channels use different values of parameters and specifications to transmit data signals. All these parameters should be considered along with the specifications of the secondary channels before the secondary channels can be accommodated. The channel sensing techniques are broadly divided into narrowband and wideband sensor mechanisms. Narrowband Spectrum sensing is a technique that allows the secondary channels to check whether the primary channels are used for data transmission or not. The presence or absence of the primary channel is the highlight of narrowband sensing. The signal transmitted by the primary channel should be checked for using the technical specifications of a wireless signal [18].

There are different ways in which narrowband sensing can be implemented. Energy production is the first method in which the energy of the primary channel is detected and used for analyzing representative the primary user. Cyclostationery detection is the second method, matched filter detection, covariance-based detection, and machine learning with sensing are the other types of approaches used in narrowband sensing. Wideband sensing is another approach used in sensing the primary users. There are certain applications of Channel sense in which the higher bandwidth and frequency of the primary users can be used to detect their presence[19]. The frequency ranges of the primary users can be used since the channels. Important types of advancing techniques - Nyquist best wideband sensing and the compressive right brain sensing. Nyquist-based method has wavelet-based detection, multi-band joint detection, and filter Bank detection as the classification whereas compressive wideband sensing has non-blind compressive sensing and the blind compressive sensing techniques.

This paper presents a novel mechanism for channel sensing using different parameters and the implementation results are discussed.

2. Related Work

Interference is the major issue when secondary users are accommodated in the Spectrum without proper channels sensing mechanisms in implementation. The channel sensing mechanism should follow certain standards such as the short duration so that the primary users are not Disturbed with indifference or the sensing mechanism. An Adaptive threshold mechanism has been proposing the research literature that uses the Spectrum holes in the frequency bands of the primary users in a channel [3]. The Spectrum holes can be used to detect the presence and the signal transmission operations of the primary users. Different parameters of the primary users can be used in the Adaptive Channel sensing mechanism to detect the presence.

A free-space path loss model has been presented that is efficient to be used in 2.4 GHz networks. The highlight of this mechanism is that it was designed for sensing the channels for mobile users in the wireless frequency spectrum [11]. There is an increasing number of mobile phone users that need to be adopted within the network that cannot be extended to accommodate any number of users. It is therefore important that mobile phone users are considered as secondary users when they're attempting to join a network. The existing WLAN channels can be considered as primary users whereas the new mobile users wishing to transmit information are the second users. The threshold range detection is the difference in the case of the mobile user because of the limited computational resources in the Mobile devices are limited when compared to other devices. The noise levels are considered the major advantage for the channel sensing in mobile devices because the advanced methods cannot be executed due to the complexity involved in the limited resources [21].

A cooperative sensing mechanism has been discussed in the literature that works on sensing the idle channels of the spectrum. It is a fact that not all the primary user's information at all times when they have been accommodated in the Spectrum. There are many instances in which the channels are idle and do not transmit any information for a long duration. The sensing policies at different players including the MAC layer has the capability to detect the idle channels [2]. This mechanism should be implemented in the shortest duration without any compromise under existing Transmissions of the primary users. The secondary user is allowed to since the technical specifications and the channel Transmissions only for a minimum duration of time. The underutilized resources of the primary users are the most important requirements of the sensing mechanism [22].

A major challenge in this regard is that the secondary channels are also affected when they are detecting and discovering the idol channels in the primary band. The technical Energy Efficiency and liability can be severely affected by secondary users if the channel sensing mechanism is not efficient. An ad-hoc radio network has been analyzed in the research work Uses the random Channel sensing mechanism. It was found that the results were not efficient because the channels were skipped during sensing. A sequential sensing mechanism in combination with a parallel sensing scheme was proposed by the researchers that are capable of detecting the primary users in the shortest duration. The analysis was performed with many channels and the large number of primary channels that were unutilized were detected. The parameters such as throughput and efficiency were considered not to be compromised during the implementation [13]. The Contemporary schemes were compared with the results of the Adaptive scheme and the results were found to be efficient. The concept of idol channels can be efficient and when it is combined with the concentration of various parameters so that the primary users are not compromised for their efficiency, it can be an excellent solution [24].

There are different challenges to be in Concord which remain as the open-ended questions for the research community in terms of Channel sensing. The technical parameters used to detect the channels are not uniform. It is not easy to detect the values of the primary journals and since the Spectrum for accommodating the secondary Channel. Each of the channel sensing mechanisms has specific challenges to be addressed in the research. The objective of does ginseng mechanism is to increase the probability of detection of the primary users. This challenge can be overcome only when all the technical parameters are accurately detected and calculated for further analysis. Another important requirement for the channel sensing mechanism is to have a lower rate of false alarms [9]. A long list of steps is to be initiated for every accurate detection of the Channel. However, the false alarm of the new channels does not only deteriorate the quality of Channel sensing but also utilizes the resources for Unnecessary purposes. Energy detection technique liquid the determination of weak signals to realize the vacancy in the Spectrum [10]. However, the technique cannot be efficiently used if the energy value is lesser than the thermal noise of the spectrum. Another example of the challenges can

be analyzed with the autocorrelation method in which the processing power required is higher than the average channel sensing mechanisms which increase the complexity during implementation. The hardware and software implementation challenges for a majority of wideband signal sensing mechanisms should be addressed in further research [8].
The literature in the channel sensing mechanism has been open for ideas from different applications. For efficient Channel sensing, all the channels in the spectrum band should be censored in sequential order and the vacant channels should be detected [4]. The inefficiency of such mechanisms in the cognitive radio network system should be addressed using learning mechanisms and Cooperative Channel sensing Concepts. The dynamic behavior of the channel can also be used to sense its operation [20]. Among various parameters used to detect the behavior of the primary user, energy cost and availability are found to be useful for the research. The algorithm was designed to simulate the concepts of adaptability for the optimal sequence of channel sensing operations [7].
Most of the channel sensing mechanisms proposed in the literature studies are related to the technical specifications and the sensing approach used by the primary users depending on the current requirements of the secondary user [5]. In most of the cases, the quality of the secondary user is not considered as a requirement for the allocation [23]. The primary users are sensitive using various parameters and if the user can be accommodated, the process is initiated. However, A New Concept of checking the quality of the second two users before they can be accommodated despite having all the favorable conditions has been proposed that uses Channel location using matching Theory [1]. This concept reveals that the quality of the second two users and the match between the primary and secondary users is also an important parameter to be considered before implementing the entire mechanism.
The quality of service requirements should be considered from the perspective of the secondary user and both primary and secondary users must match in their requirements and the offering after the channel has been allocated [31]. The perspective of the secondary user and the channel are together considered as the requirements for channel sensing and allocation [26]. The data rate of the secondary users finds the probability value of reappearance concerning the primary results are the important parameters considered. The service process used by the secondary user is not considered in the research studies but this matching theory concept. The concept was Simulated and evaluated with the results of the Contemporary techniques. This method is a novel mechanism because the concept of the matching theory was not used for channel sensing mechanisms in the previous research studies [25].

3. Design and Implementation

The proposed mechanism in this paper has been designed based on the packet drop ratio, bandwidth traffic, and the fault levels of the primary users. The scanning of all the channels with a specific bandwidth value is the first step in the proposed mechanism. All the details of the specifications and the values of the primary users are stored in the channel sensing mechanism to be analyzed [6].

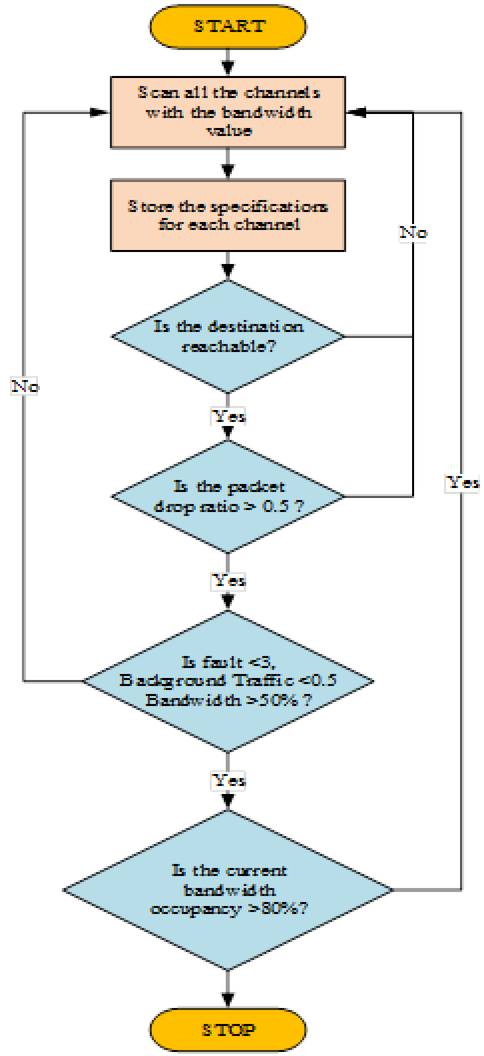


Fig. 1 *Flowchart of the proposed mechanism*

These values are separately checked for individual parameters and the proposed mechanism works on the configuration of the system. The package drop ratio is set a value of 0.5 [10]. Similarly, the values of fault, background traffic, bandwidth, and bandwidth occupancy are set. These values are compared with the current values of the primary users to decide the Channel allocation of the secondary user. The flowchart of the operation is shown in Fig. 1.
The implementation results of the proposed system were simulated on the NS2 network tool and the results are analyzed as follows. Among the various experiments conducted with the current research study [12], the results of the default network, data packets sent and received, and the new network configuration for higher accuracy of the results are analyzed. These details are simulated in the network tool and the results are shown in different stages.

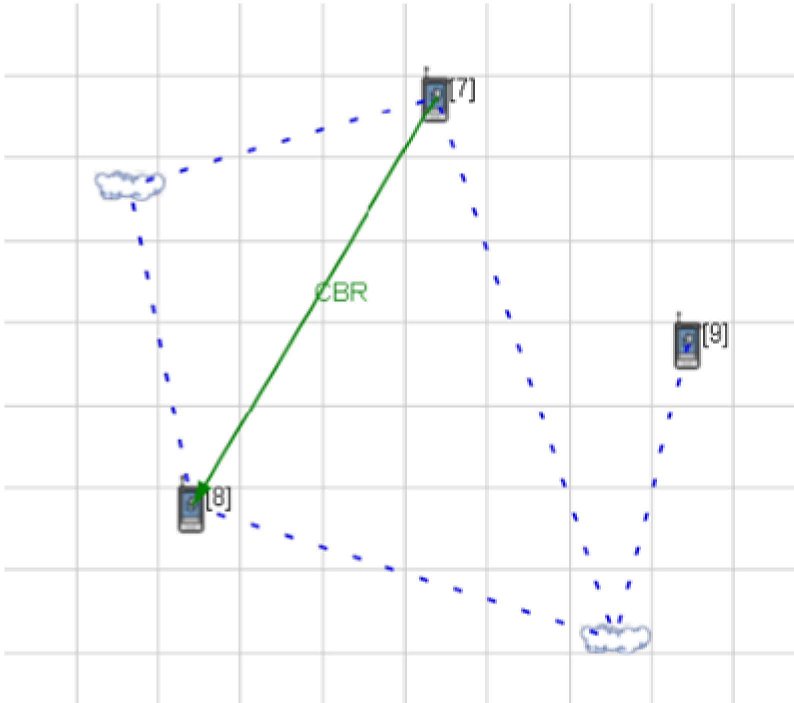


Fig. 2 *Network Design*

The configuration for the network shown in fig. 2 is listed in fig. 3. A different network with an additional node has been shown in fig. 4 and its configuration is shown in fig. 5. The difference in the frequency is evident at 2.4GHz for the first network and 8.68GHz for the second network [27]. The difference in the frequency is attributed to minimizing losses and interference. The network is challenging for simulation because it has the same receiver and the incoming data packets are from the two different nodes. Channel index is 1 and 11 for networks 1 and 2 respectively. The other parameters remain the same so that the simulation can be compared. Network results are compared using 2 stages. The first step is to design and simulate a default network in which all the parameters and configurations are set to standard values. The results of this configuration are used to compare the changes in all the proposed networks with different values.

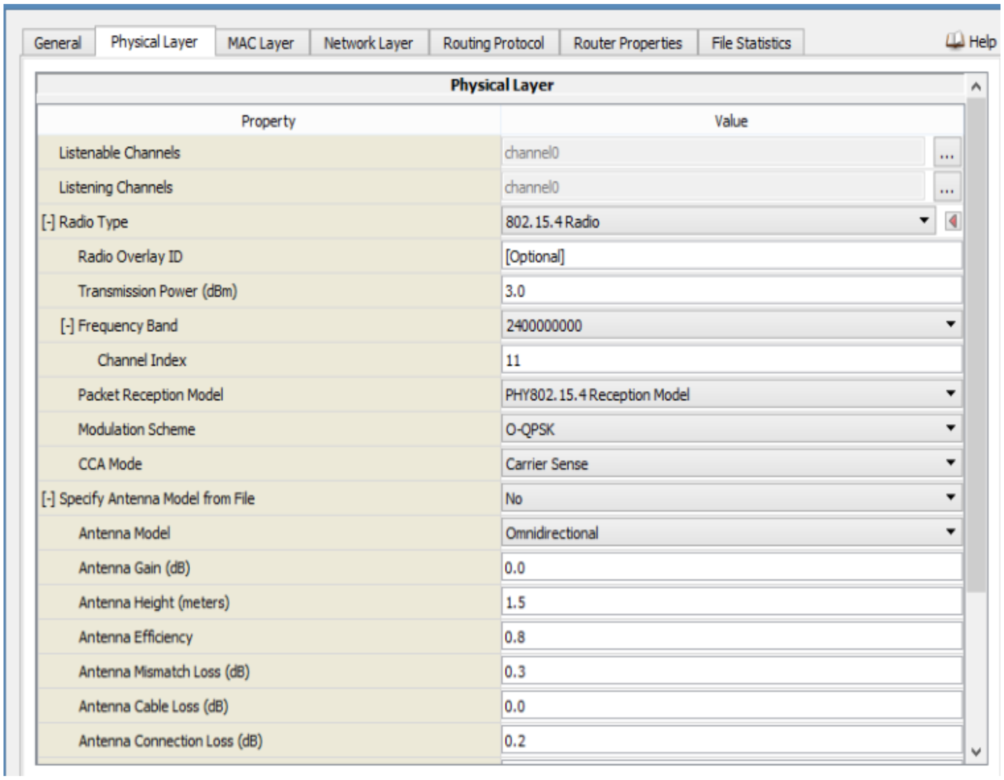


Fig. 3 *Configuration for the network*

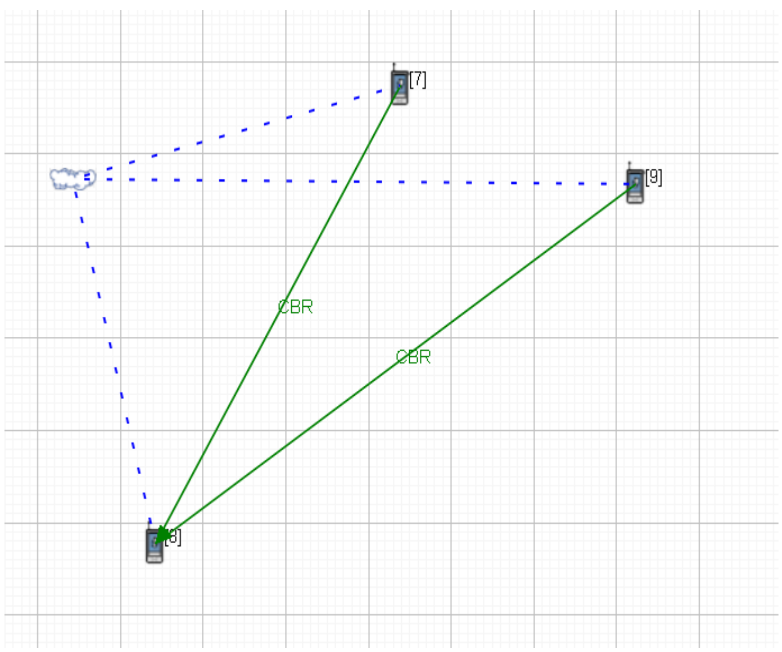
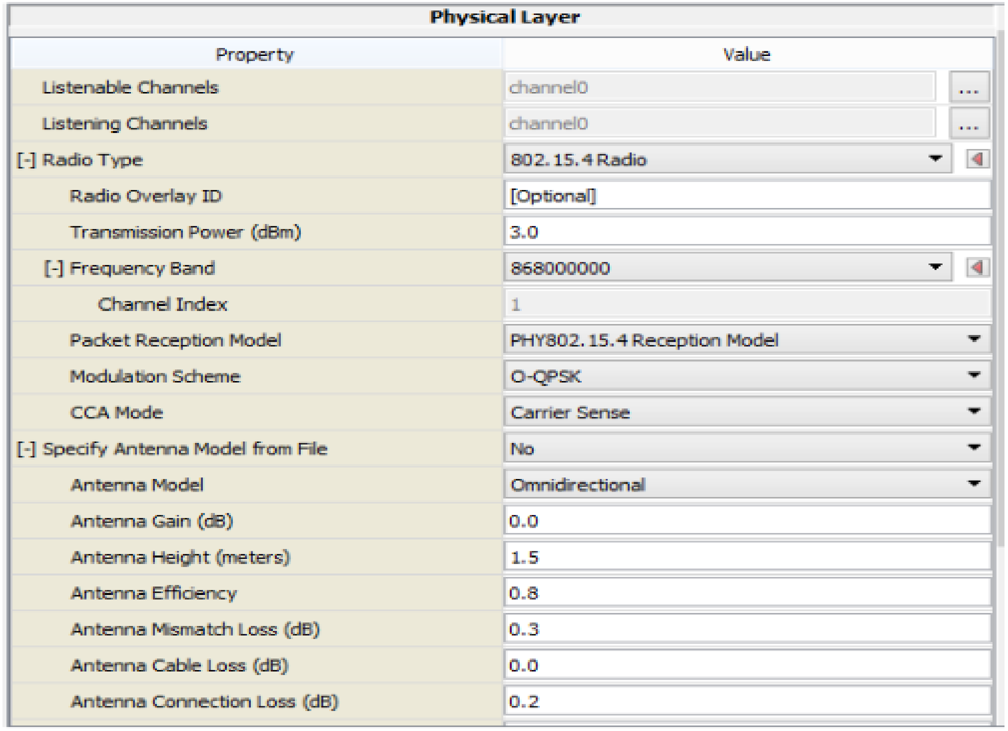


Fig. 4 *Network configuration*

Node 7 and node 9 are required to send the data packets but the difficulty in receiving both the data packets without any loss and with minimum delay and loss is the challenge.



Physical Layer	
Property	Value
Listenable Channels	channel0
Listening Channels	channel0
[-] Radio Type	802.15.4 Radio
Radio Overlay ID	[Optional]
Transmission Power (dBm)	3.0
[-] Frequency Band	868000000
Channel Index	1
Packet Reception Model	PHY802.15.4 Reception Model
Modulation Scheme	O-QPSK
CCA Mode	Carrier Sense
[-] Specify Antenna Model from File	No
Antenna Model	Omnidirectional
Antenna Gain (dB)	0.0
Antenna Height (meters)	1.5
Antenna Efficiency	0.8
Antenna Mismatch Loss (dB)	0.3
Antenna Cable Loss (dB)	0.0
Antenna Connection Loss (dB)	0.2

Fig. 5 *Configuration for the second network*

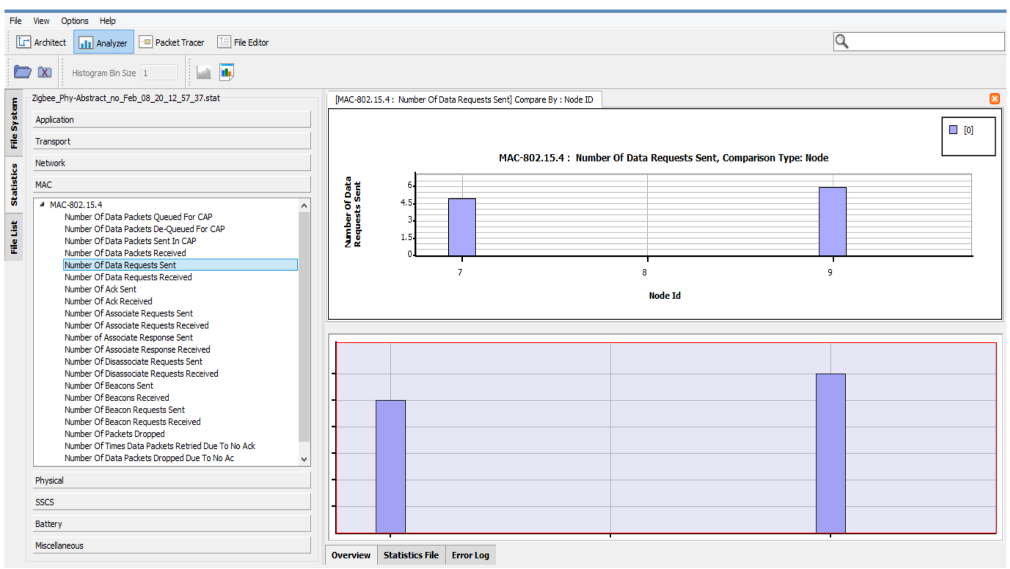


Fig. 6 *Simulation of the data packets sent*

The network configuration Showing the different nodes that have been simulated in the environment is shown in fig. 4. There are three nodes in the network and the data packets are sent to sense the channels [28]. The details of the data packets sent in the default configuration of the network before configuring it to the proposed mechanism are shown in fig. 7 [14]. A node comparison method is used to analyze the number of data requests sent. Nodes 7 and 9 are used and the data packets can be seen being transmitted.

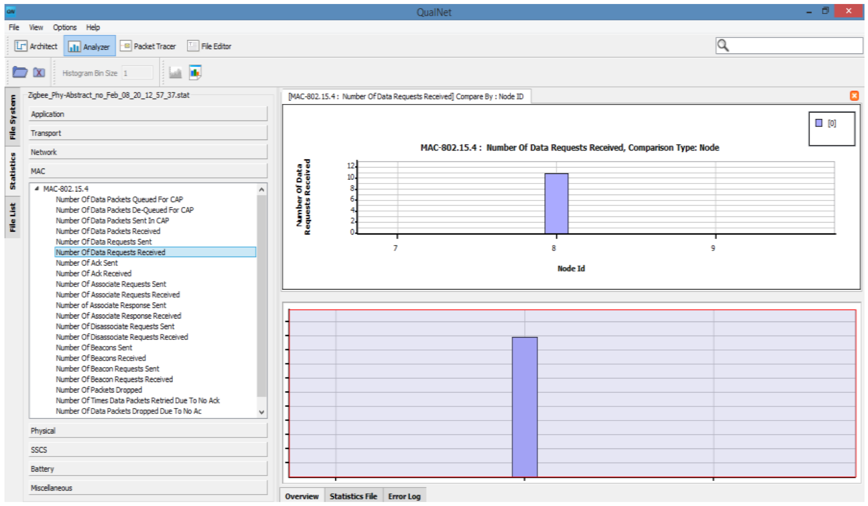


Fig. 7 *Simulation of the data packets received.*

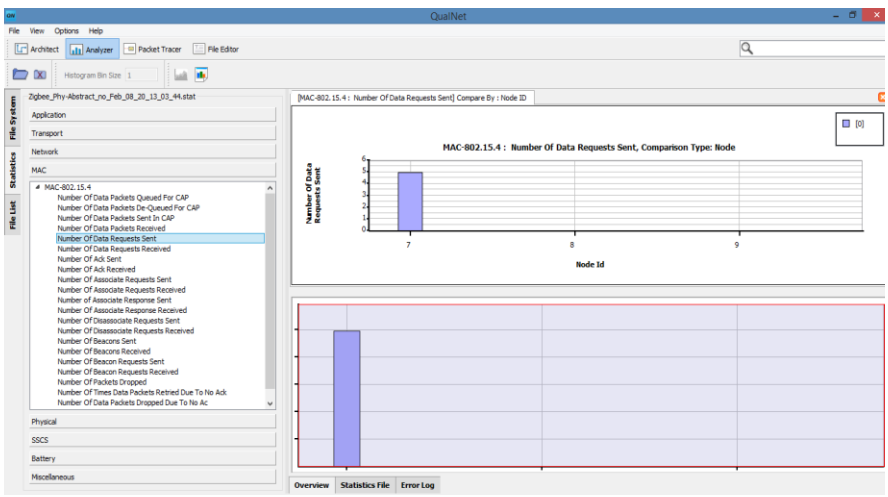


Fig. 8 *Data packets sent using node 7.*

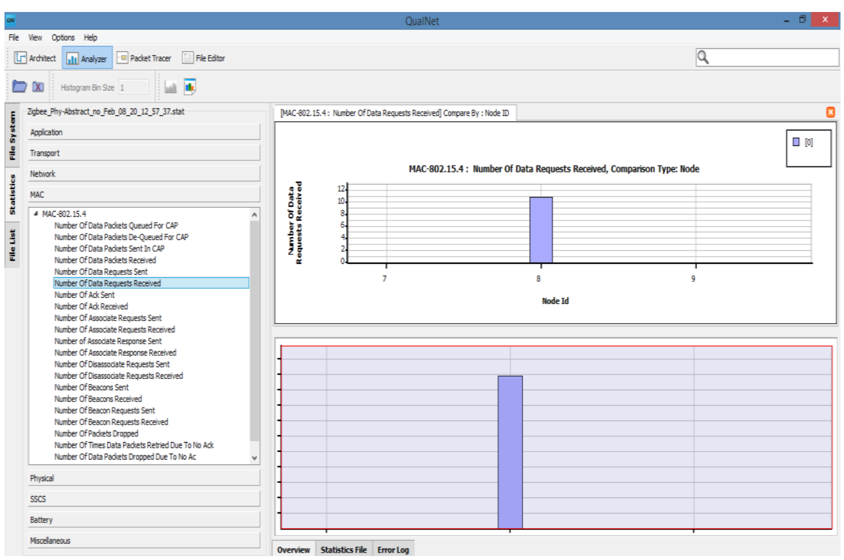


Fig. 9 *Data packets received on node 8.*

The data packets received are to be analyzed in the next stage and fig. 7 shows the details of the node 8 that received the data packets. Fig. 4 shows the presence of data packets received as designed [15].
In a different sequence of data transmission the data packets were sent and received using node 7 and received on node 8 as shown in fig. 8 and fig. 9 respectively.
An intermediate node 6 is introduced and the network design is shown in fig. 10. This node can be used to improve the results [9]. Node 7 and node 6 are used to transmit the information to node 9 and it can be used as an additional setup that can be connected to the network for minimizing the error.
There are three nodes and CBR is a transmission type node. The data packets are sent from node 6 to node 7. The average path loss and transmission delay for this network is considered and the results are obtained for the same. The data packets can take any path irrespective of the distance because the path is not the primary concern of the network design [29]. The factor of cost is considered primarily in this design because all the network parameters such as distance and complexity are collectively called as a cost factor. Losses in the data packet transmission will be prioritized.

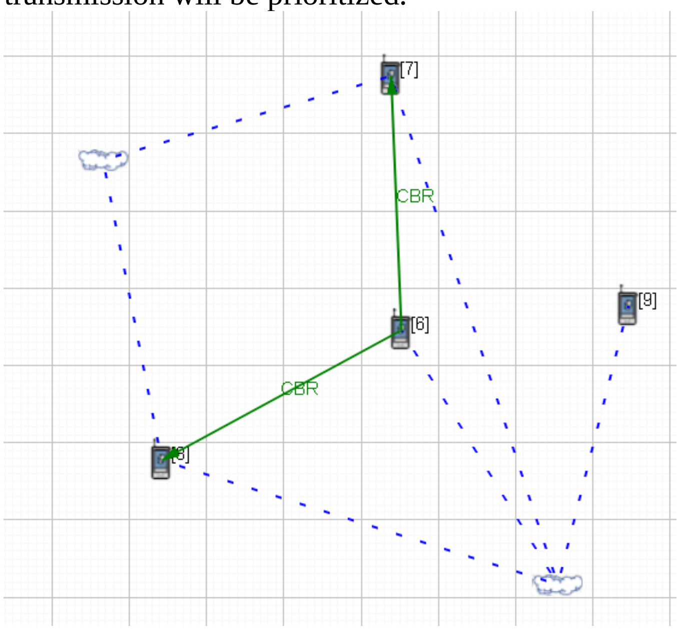


Fig. 10 *New network configuration.*

The average path loss for node 7 has been displayed as 80dB as shown in fig. 11. The data packet sent for node 8 for which the path loss is more than that for node 7. The path losses are considered for the receiver node because the paths are not labeled. The delay in transmission is the next parameter that should be considered to analyze the efficiency, also shown in fig. 11.
The time spent on transmitting is another parameter considered that displays the total number of packets sent. The transmission time is determined as 1.6ms for node 7 and 1.3ms for node 6. The time spent in the node to receive the data packet is evident. Packets are labeled so that the destination node can recognize the packets. The exact time and the packet number at the destination will not be

known during transmission to the sender or the receiver because of many parameters that contribute to the losses and delay [31]. Reordering the packets, checking the header, and working with the node parameters will cause the delay in the transmission and reception. Time spent on receiving is determined as 3.2ms for node 7 and 2.4ms for node 8, shown in fig. 12. The exact time cannot be compared for different simulation configurations because there are many other parameters that vary, contributing to different time delays of the packets each time. The type of packet and the data content also influences the time taken. For example, the time taken to process a data packet of multimedia type is different compared to the text file or binary data.

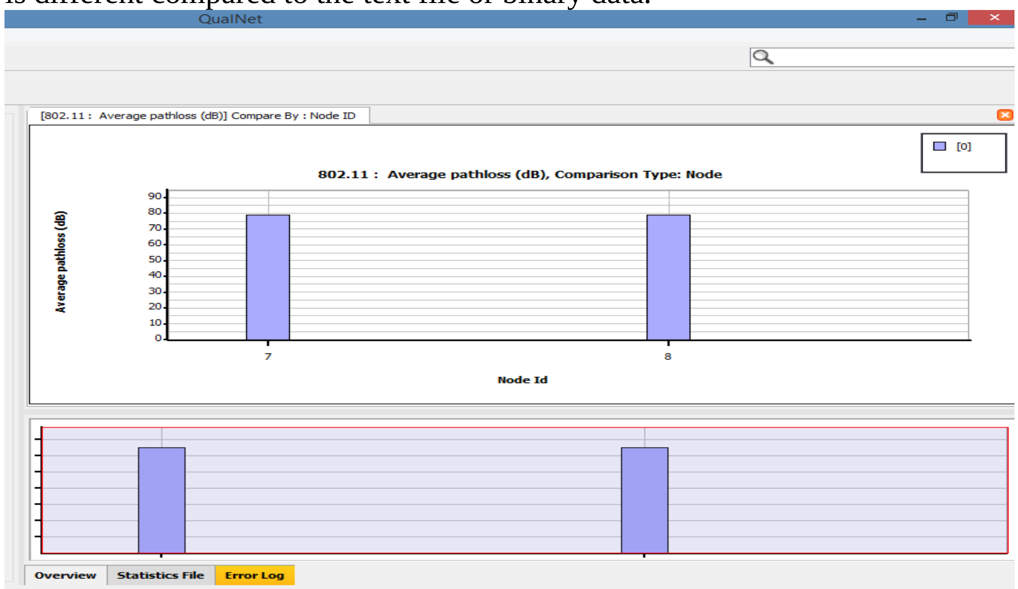


Fig. 11 *Average Path loss*

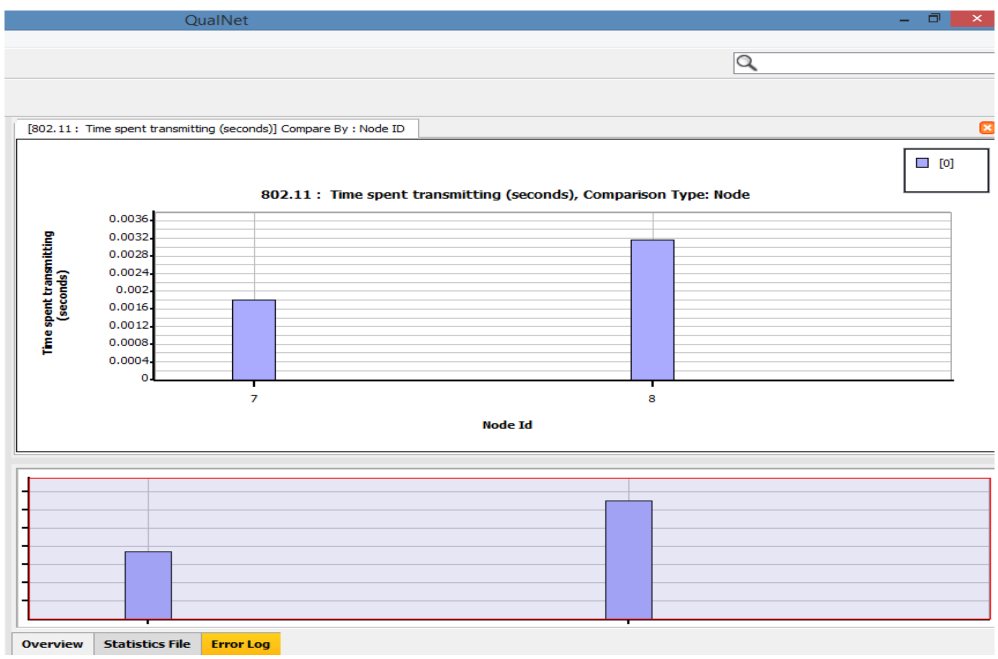


Fig. 12 *Time spent transmitting the packets.*

The new network configuration was simulated for the value of packets received and it was found that the improvement of the packets received was significant as shown in fig. 13.

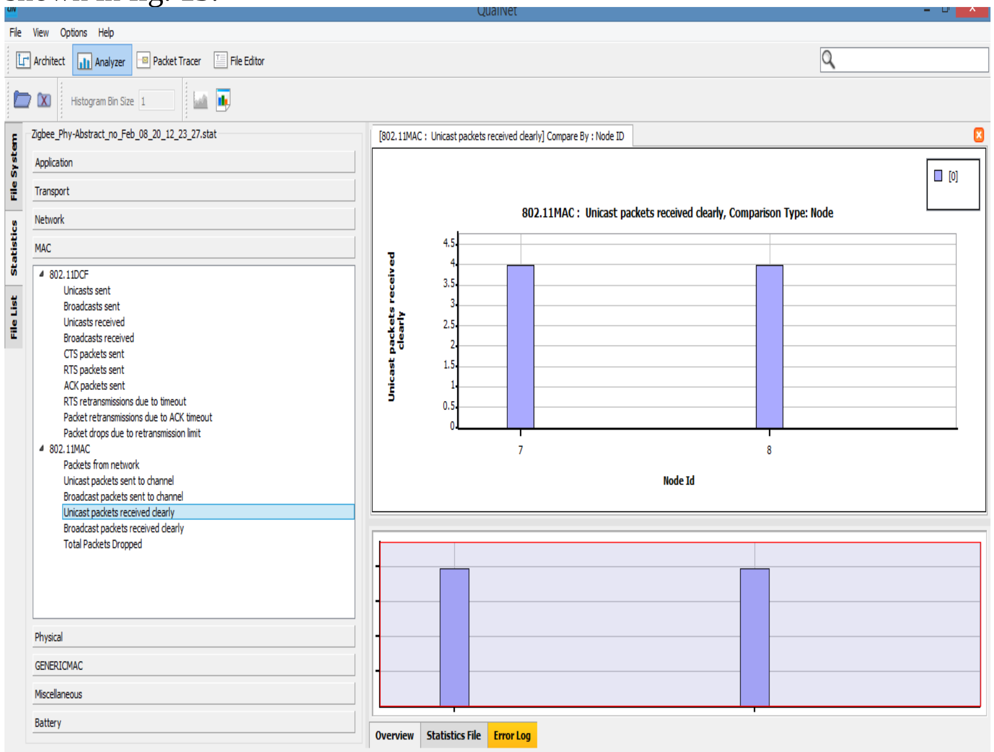


Fig. 13 *Simulation of data packets received using a new network configuration.*

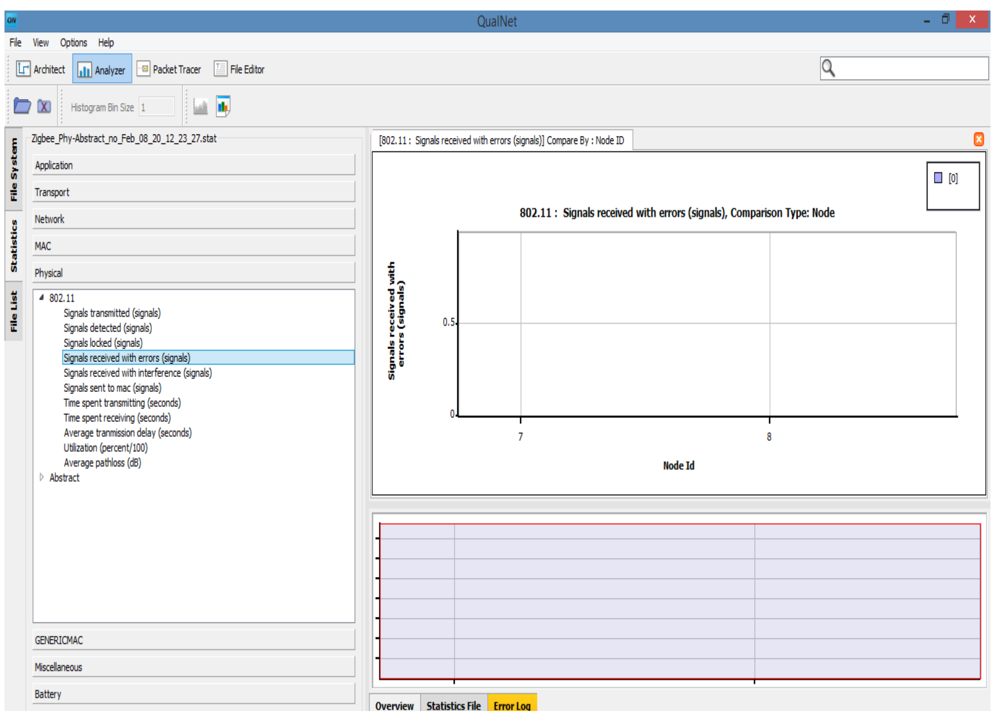


Fig. 14 *No error rate on the network.*

The results are also checked for the error rate as this parameter is considered important. The proposed improvement had no error which signifies the importance of the newly added node in the network. The proposed channel sensing mechanism can be used for detecting the primary users.
Antenna gain is the relative increase in radiation at the maximum point expressed as a value in decibels (dB) above a reference—in this case, the basic antenna, a half-wavelength dipole by which all other antennas are measured. The reference is known as 0 dBD (zero decibels referenced to a dipole):
Antenna gain in dBD = 10*log (Power output/Power input)
An antenna with the effective radiated power of twice the input power would therefore have a gain of 10*log (2/1) = 3dBD. Therefore, if you know the power output and input, you can find out the gain or "efficiency" of an antenna.
Effective Isotropically Radiated Power (EIRP)
The effective isotropically radiated power is the arithmetic product of the power supplied to an antenna and its gain relative to an isotropic source:
EIRP (dBm) = Power of transmitter (dBm) – loss in transmission line (dB) + antenna gain in dBi
dBm = 10 *log(power out / 1mW)

4. Discussion

The bandwidth and the data traffic values are set and this research study. It is important to understand that there are various combinations of values that should be tested in real-time to determine the exact values. The values of these parameters can also be extended to include other specifications such as Energy Efficiency [3][9]. This research is limited availability of resources it considers only the bandwidth values and the traffic as important variations to be considered before transmitting the data packet to the primary user. Bandwidth can be a significant parameter that contributes to the overall efficiency and performance of the channel sensing mechanism. The further implementation of this proposed research method can be extended by integrating other parameters such as time taken for sensing, proactive and reactive approaches, and machine learning algorithms.

5. Conclusion

Channel sensing is a vast topic with many Approaches and techniques. This research study is related to the review of the existing channel sensing mechanisms for various parameters and the design of a simple bandwidth-based mechanism to analyze the results of the mechanism. It considers the importance of bandwidth and uses the values based on the review of research studies. The proposed mechanism is simulated using NS2 and the results are discussed. Extension of the proposed study with different parameters and a comprehensive approach using an appropriate mechanism is the future scope of the study.

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