*IRACST – International Journal of Computer Networks and Wireless Communications (IJCNWC), ISSN: 2250-3501*
*Vol.6, No 2, Mar-Apr 2016*

# Preferable channel list based channel selection in cognitive radio network

Minal S. Moon
Department of Computer Science and Engineering
G. H. Raisoni College of Engineering
Nagpur
moon_minal.ghrcemtechwcc@raisoni.net

Veena A. Gulhane
Department of Computer Science and Engineering
G. H. Raisoni College of Engineering
Nagpur
veena.gulhane@raisoni.net

**Abstract- Cognitive radio network is a wireless technology where the secondary users can borrow the channel from the primary users. It is an emerging technology to meet the radio spectrum scarcity problem. In cognitive radio network spectrum sensing and channel selection plays a major role. Various techniques are available for the same. This paper explain the various existing techniques used for channel sensing and selection. It also propose an idea for selection of appropriate channel for data communication using energy detection sensing. Here a structure called preferable channel list, PCL has been used for selection of channel where receiver is being playing the dominating role. The paper also shows the results for the proposed techniques which shows that the delay is less whereas the throughput of the system is good.**

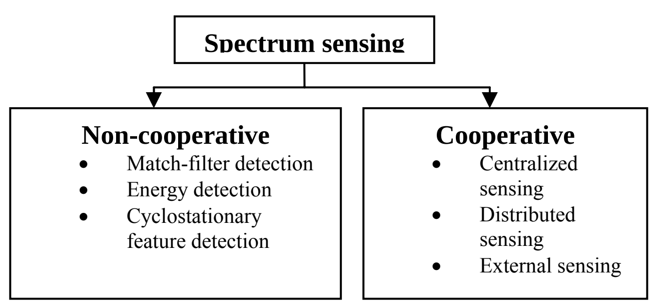
***Keywords:** Cognitive Radio, MAC, PCL, RTS, CTS*

## I. INTRODUCTION

Due to emerging wireless technology and services the demand for the radio spectrum has been increased tremendously from last two decades. Almost all the radio frequency band has been allocated for use. This traditional assignment of radio spectrum results into spectrum holes in licensed band. This spectrum holes is nothing but the unused space or white space in radio spectrum caused due to non-uniformity in spectrum usage in time, space and frequency domain. Thus the increase in wireless network deployment and inefficient spectrum assignment are the major cause leading to under-utilization of radio spectrum[12].
To overcome this problem of under-utilization and to increase efficiency of radio spectrum, in 1992 Joseph Mitola inventioned a unique method to use unused spectrum by introducing a concept of cognitive radio[6]. In cognitive radio network two types of users are considered i.e licensed users and unlicensed users. Licensed users are generally called as primary users and unlicensed users are called as secondary users. In this type of network the secondary user uses the licensed channel of primary user when not in use. Primary users do not require any special functionality to co-exist with the secondary users whereas it is the responsibility of secondary user to avoid interference with primary user when transmission is occurring.
MAC has an important role in cognitive radio network. For cognitive radio MAC protocol are classified as[1]:
DAB (Direct Access Based)
  a. contention based
  b. coordination based
DSA (Dynamic Spectrum Analysis)
  a. game
  b. stochastic
  c. genetic
  d. graph
DAB does not allow global network optimization whereas DSA provide global optimization.
Contention based protocol: Here the cognitive receiver and sender exchange its sensing outcome and then select the channel for communication after negotiation.
Coordination based protocol: Here each node shares its channel usage information with its neighbor.
The most important function in cognitive radio network are channel sensing and channel selection. Channel sensing is used for identifying the vacant primary channels and channel selection is used for selecting appropriate vacant channel from among sensed channels for data transmission by secondary user.

## II. SPECTRUM SENSING TECHNIQUES

For implementing any cognitive radio network the very first and challenging step is spectrum sensing. It is the responsibility of the secondary user to check the presence of the primary user to identify vacant channel and also to quit the channel if the corresponding primary user come back to its frequency band to avoid interference. This process is called as spectrum sensing.
Spectrum sensing techniques can be classified as:




*Match-filter Detection[10],[11]*

It is applied only when the secondary users has the prior knowledge of primary users. Here for checking the presence of primary user the signal is convolved with the filter whose impulse response is mirror and time shifted verson of reference signal.

*Energy based detection[10],[11]*
Detection of primary signal is based on the sensed energy. It does not require the prior knowledge of the primary user signal. It is also known as blind detecton as it does not consider the structure of the signal. Here the presence of the primary user is estimated by comparing the energy of the received primary signal with predefined threshold derived from statistic of noise.

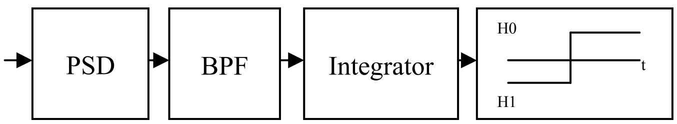



*Fig1 : Block diagram of energy detection*

Figure above shows the block diagram of energy based detection method. It consist of primary signal detector, band pass filter, integrator and comparator. The signal of primary user is passed through band pass signal to select the channel and then given to integrator. The integrator, integrates the signal over the time interval. The output from integrator is then compared with the pre-defined threshold. This comparator is used to know the presence or absence of the primary user. If the compared value is greater then the threshold(i.e H0) primary user is present and if value is smaller than threshold (i.e H1) channel is vacant.

*Cyclostationary feature detection[10],[11]*
For identifying the presence of primary user, the periodicity of the received primary signal is being exploited. The periodicity is present in sinusoidal carrier, pulse train, hopping sequence spreading code or cyclic prefix of primary signal. It requires the prior knowledge of signal characteristic.

*Centralized sensing[9]*
In this technique a cognitive radio controller is present. This central controller receives the sensing information from cognitive users, identify the available spectrum and send send this information to other cognitive radios.

*Distributed sensing[9]*
No need of central controller. Cognitive radio shares its sensing outcomes with its neighbours but makes its own decision of channel usage. More advantageous as it does not require backbone infrastructure and thus reduce cost.

*External sensing[9]*
An external agent is used in this type of sensing. This agent performs the sensing operatio and broadcast the information of channel status to the cognitive radio users. The external agent notifies to the cognitive radio through the control channel. It overcomes the hidden primary problem but the cost of implementation is increased tremendously.

## III. Channel Selection techniques

After channel sensing the next step is selection of appropriate and proper chnnel from among the sensed channels.

*Multichannel contention based MAC[2]*
This technique make use of external sensing where stationary sensors are deployed for spectrum sensing. Common control channel has been used for beacon broadcast as well as for channel contention. During contention period all secondary contending nodes randomly picks one of the mini-slot in RTS window and send intention for transmission. When more than one secondary user try for same mini-slot, to avoid collision the colliding node transmit in next RTS window. Then receiver sends CTS on same mini-slot which is acknowledge by transmitter. And then that mini-slot is being used by the transmitter for further communication.

*Statistic channel allocation[3]*
It make use of statistics of channel usage for channel access decision making. A CR device must pass the threshold of the successful transmission rate through negotiation before it can begin a valid transmission on data channels. The negotiation between the sender and receiver on transmission parameters is necessary for each transmission.

*Channel aggregation diversity[4]*
In channel aggregation diversity, by using only single data radio the secondary user can utilize multiple channels simultaneously and efficiently allocate upperbound resources.

*Dynamic slot allocation[5]*
This technique is based on TDMA mechanisn. Here the channels are divided into time slots and secondary users send its data and control information an designated slot. Here the real time data is transmitted with least delay. It garuntee full use of available spectrum.

## IV. Proposed Plan

The proposed algorithm is basically based on the Preferable channel list (PCL). In the transmission range of particular node the usages of channels are maintain in the PCL. Based on this usage pattern the PCL divides the channels in three classes namely high preference class, medium preference class and low preference class.

*High preference class*: The channels which are free and having the integrated value less than the threshold value

*Medium preference channel*: The channels which are free and having both intregrated value and threshold value equal.

*Low preference channel*: Such a channel is already being used in the transmission range of the node by other neighbouring nodes. They are having integrated value greater than threshold value.

According to the algorithm appropriate channel selection is carried out in following manners: spectrum sensing, creating PCL, channel selection and then data transmission.

At every beacon interval the sensing of channel is being done by the secondary users. The sensing is energy detection where the secondary user detect the signal of primary user then passed it through band pass filter and finally then integrate this filtered signal and compares that integrated value with the threshold value. And accordingly identifies weather the primary channel is vacant or not and also generates the PCL for that particular secondary user. Similarly each secondary user will maintain its own preferable channel list. Now, the source secondary user who intended to send the data had to first send the indicator packet message to destination secondary user along with its PCL on common control channel. On the reception of the indicator packet message the destination secondary user compares its PCL with the source secondary user's PCL. If there is high preference channel in both the PCL then that channel is selected. Else if there exist a common middle preference channel in PCL of both sender and receiver then that channel is selected. Else if all channels are in low state the channel with least count is selected.

After selecting the channel the destination secondary user sends the acknowledgement to the source secondary user along with the selected channel ID. Source secondary user on reception of acknowledgement conforms weather it can send data on selected channel. If yes, sends reservation packet message to the destination secondary user. If source secondary user does not want to send or receive data on selected channel it can go in power saving mode.

The proposed algorithm requires single transceiver. It does not have any dedicated control channel. Channel selection is totally depends on preferable channel list. The computational requirement will also be less in proposed algorithm. The only thing important is that the secondary nodes need to update their PCL at every beacon interval.

***Pseudocode:***

*Begin*

*The signals of primary user is first detected by the secondary users*

*This signal is passed through band pass filter for selection of particular channel*

*This channel is integrated over time*

*This time integrated signal is compared with the threshold value*

*If*

*Integrated value > threshold*

*Primary user is present*

*Else*

*Primary user is absent*

*SUs update its PCL*

*For data transmission secondary senders send indication message along with its PCL to secondary receiver*

*Receiver compare its PCL with senders PCL*

*If*

*Either sender or receiver has high preference channel*

*Then*

*Channel is selected*

*Else*

*If*

*There is common middle preference channel or any middle preference channel in receiver and sender*

*Then*

*Channel is selected*

*Else*

*Low preference channel is selected*

*Receiver gives indication reply along with selected channel*

*Sender gives indication reservation message*

*Data transmission is done on selected channel.*

*Finish*

## V. RESULTS

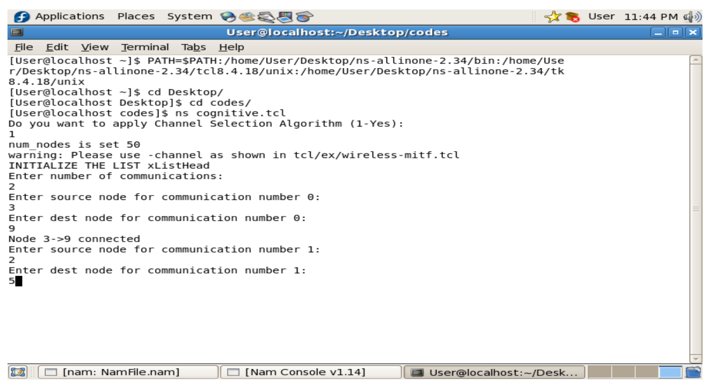



*Fig 2: Application of proposed algorithm*

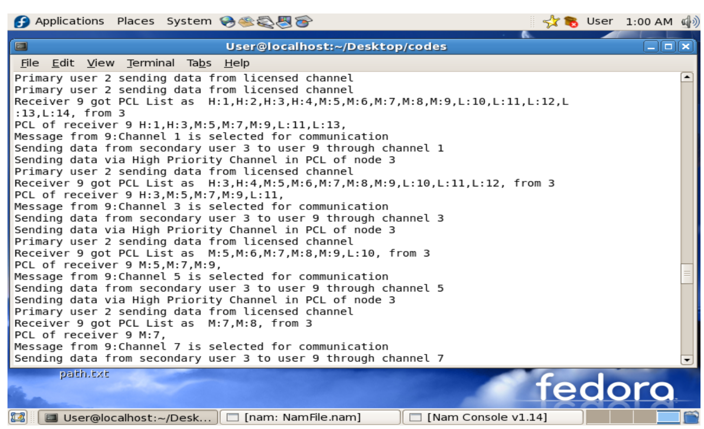



*Fig 3: Preferable channel list*

First wheather we want to apply channel selection algorithm or not will be consider. Then we have to decide the number of communications to be initiated. Then finally the source and destination nodes will be selected as shown in Fig 2.

Fig 3 shows the preferable channel lists for all source and destination nodes and selection of proper channel for further communication. If the source node is primary node there is no need for channel selection. Data will be communicated directly through licensed channel.

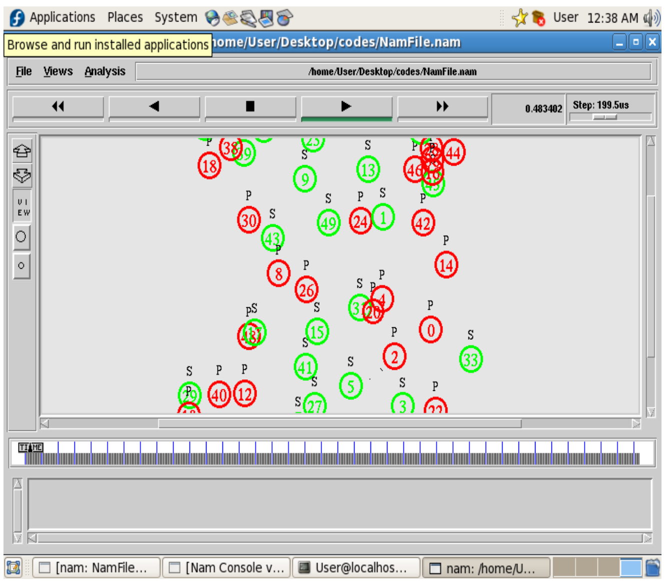



*Fig 4: communication between nodes using selected channel*

Communication between the nodes 2→5 and 3→9 using selected channel has been shown in Fig 4

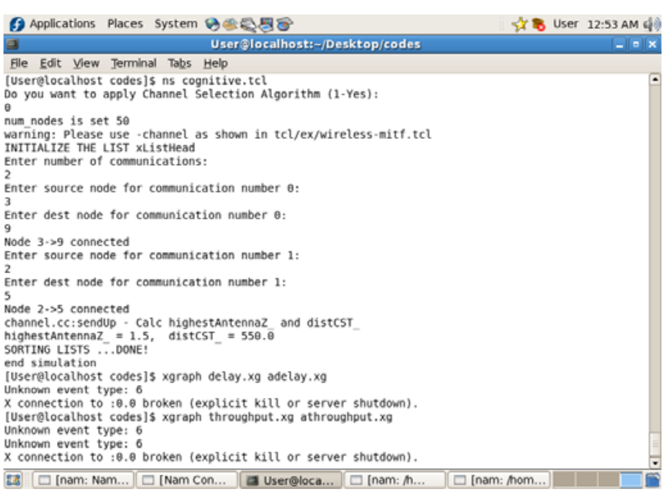



*Fig 5:Initiating communication without proposed algorithm*

Fig 5 shows the initiation of communication without the application of proposed channel selection algorithm and selection of source and destination nodes.

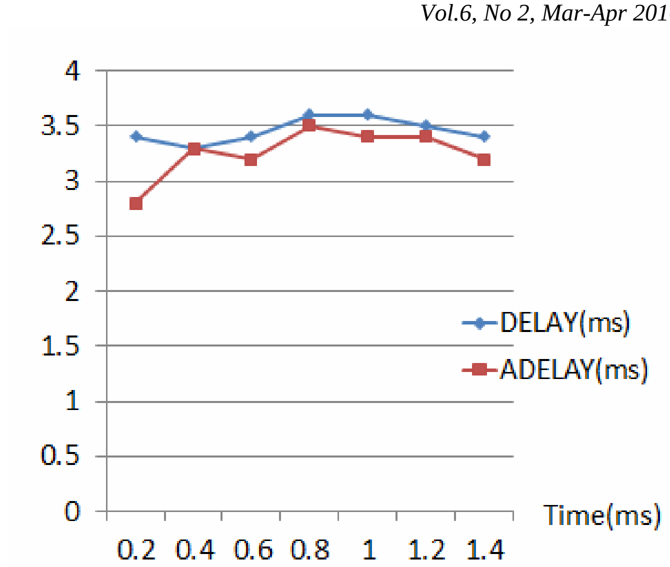



*Fig 6: Delay graph(msec)*

Fig 6 shows the graph for delay where we can see that the maximum delay with the application of algorithm is 3.4 msec and without applying algorithm is 3.6msec.

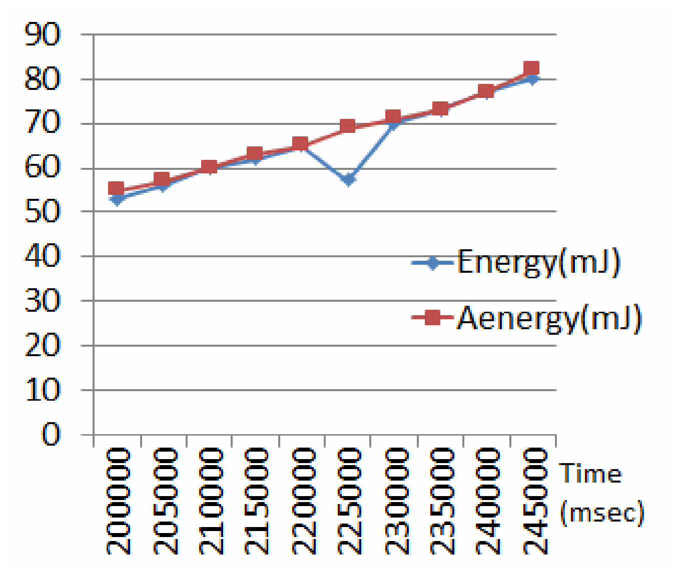



*Fig 7: Energy graph(milijoules)*

Fig 7 shows the graph for the path energy, the maximum energy of path using channel selection algorithm is 83mJ and without channel selection akgorithm is 80mJ

Signal to Noise ratio is defined as power ratio between the signal and noise. SNR ratio is given by:

$SNR=P_{signal}/P_{noise}$

The SNR ratio of the system by applying algorithm is 50.009dB and without algorithm is 49.917dB.

Path-loss is defined as ratio of power of transmitted signal to the power of same signal received by the receiver.

$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi d}\right)^2$

Where,
$G_t G_r$ are transmitter and receiver gain
λ wavelength
d is distance between transmitter and receiver

Pathloss by applying algorithm is 0.42dB and without applying algorithm is 0.53dB

The basic formula for spectral efficiency ( $\eta$ ) is defined as

$$\eta = P R_{av} G / BW,$$

where $\eta$ is spectral efficiency (bps/Hz/Cell), *P* is the peak data rate (bps), $R_{av}$ is the modulation and coding scheme (MCS) average factor, *G* is other gain from advanced.

Spectrum efficiency of system with algorithm is 0.017 and without algorithm is 0.0005

## VI. CONCLUSION

Using cognitive radio the under-utilization of the radio spectrum can be minimized. Channel sensing and channel selection are the two important tasks in cognitive radio. Various techniques are available for the same. In the proposed technique for data transmission, appropriate channel can be selected by the receiver using PCL in co-operation with the transmitter. From the graph we can say that the delay with application of the channel selection algorithm is less compared to the delay without application of proposed algorithm. Similarly the energy of the path is more in communication where channel selection algorithm is applied. The value for SNR ratio is 50.009 dB, path-loss is 0.42 dB and spectral efficiency is 0.017 bps/Hz

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