

# The Spectrum Sensing and Path Optimization Techniques in Cognitive Radio Networks

Chandrika Gadiparthi, Manasa Bathina, Supriya Emani, Venkata Vara Prasad Padyala

**Abstract:** Cognitive Radio (CR) is a versatile, insightful radio and system innovation that can naturally recognize accessible directs in a remote range and change transmission parameters empowering more interchanges to run simultaneously and furthermore improve radio working conduct. The primary thought of the intellectual system is to give the range band to the unlicensed clients without making any damage to the earth. By utilizing the recurrence range band, we came to utilization of these intellectual systems. Right off the bat, we have to frame the system through any methodologies .we are utilizing optimization Mechanisms for path identification in cognitive Radio.

**Key words:** Cognitive Radio, unlicensed users, packer tracer, licensed users, ant colony optimization.

## I. INTRODUCTION:

Cognitive is a word come from the Latin language which means conscious mental processes or connected with thinking. Cognitive networks are used in communicational networks used for cutting-edge technology for many research areas. Cognitive networks cover all the OSI layers. Dynamic Spectrum Access (DSA) is a solution for the problem of spectrum scarcity.

DSA have two functions:

1. Dynamic Sharing
2. Dynamic Licensing

1. Dynamic sharing: Dynamic sharing is a Dynamic Spectrum Access method utilized for the spectrum, the rights of using the spectrum range is given to an operator for specific intervals .This method is more flexible and efficient when compared to a static method.

2. Dynamic Licensing: Dynamic Licensing is a Dynamic Spectrum Access method utilized for the spectrum, the rights of use the spectrum band is given to more than one network operator at the same time.

Here the dynamic sharing of spectrum is divided into two types based on spectrum scarcity [1].

1. Horizontal sharing
2. Vertical sharing

1. Horizontal sharing: Horizontal sharing of a spectrum shared the spectrum with all equal rights.

2. Vertical sharing: Vertical sharing of a spectrum shared the spectrum based on the specific conditions, here comes the concept of cognitive radio networks where it will share the licensed spectrum with unlicensed users in cognitive radio networks (CRN'S) Based on IEEE 802.22 there was the use of TV spectrum instead of the cognitive spectrum after the research on spectrum came to know the use of the cognitive radio network present data transmission is going on.

**Revised Manuscript Received on August 09, 2019**

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The main goal of the cognitive radio networks is to provide the more efficient use of spectrum bands by giving the rights of using the licensed spectrum to unlicensed networks.

There are two types of users in cognitive radio networks primary users(PU'S) and secondary users(SU'S).PU'S are the licensed users where SU'S are the unlicensed users, here comes the use of cognitive radio networks to provide the spectrum band to the secondary users. Cognitive radio networks are two types there are used for the representation of cognitive networks underlay networks and overlay networks. Underlay networks are those where both use the spectrum bands at a time by protecting PU'S from interference by controlling the transmit power. Overlay networks are those where SU'S use the licensed spectrum bands when the absence of PU'S. Functionalities of a cognitive radio spectrum are spectrum sharing, spectrum management, spectrum mobility, spectrum sensing.

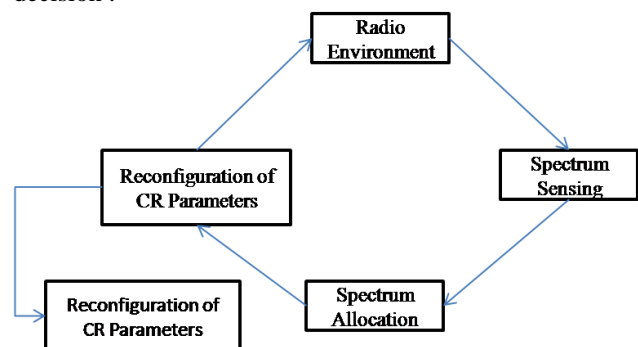
spectrum sensing: spectrum sensing is the ability to sense the gaps and to detect the PU'S, generally there are two types of spectrum sensing techniques there are 1.Frequency domain approach(direct method): This domain takes the signals directly from the frequency spectrum bands.

2.Time domain approach(indirect method): This domain takes the autocorrelation of the signals from the frequency spectrum bands.

spectrum sensing for spectrum opportunities: There are two types of spectrum opportunities there are primary transmitters detection and cooperative detection[2].

a. Primary transmitter detection: Transmitter detection depends on the signal received at SU'S from PU'S, for example, MF (matched filter), Energy detection, Waveform method, Cyclo stationary detection .

b. Co-operative detection: This detection depends on the co-operating of all the users. Spectrum management: spectrum management has the ability to capture the best available spectrum band, to serve the quality of service. There are two types of spectrum management used for knowing the quality of services, there are spectrum analysis and spectrum decision .



# The Spectrum Sensing and Path Optimization Techniques in Cognitive Radio Networks

**Radio Environment:** The radio of the environment provides automatically detection capacity of available channels in the wireless spectrum which is used to represent the sensing spectrums.

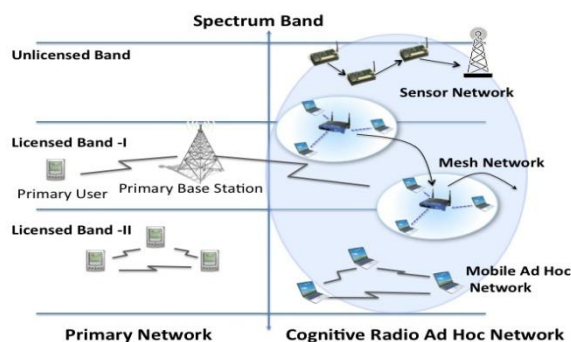
**Spectrum Sensing:** The Spectrum sensing is used to pick the transmission of the freely available channel, it is used for the strictly prohibition for allocating the channels, without permission from the publisher.

**Spectrum allocation:** The Spectrum allocation is known as frequency allocation or Spectrum management is used to allocate the channels for the regulations of the electromagnetic spectrum into the radio of the frequency bands, which is normally done by the government in many countries.

**Reconfiguration of CR parameters:** It is used for the reception or transmission of parameters, which allows the concurrent transmission of multiple additional wireless communications.

The main goal of these cognitive radio networks is used to allocate the channel for the unlicensed user without affecting the environment and the primary users.

## II. COGNITIVE RADIO NETWORK:



**Spectrum Bands:** Spectrum bands are the group of with different frequencies with different colors which are used to represent the regular frequency of spectrum. The spectrum band is to use the social benefit of the radio frequencies to promote efficient use.

**Unlicensed Band:** Unlicensed Bands are the bands used to represent the secondary users where there does not have any license for the use of the channels.

**Sensor Network:** The Network of the sensor used for the sensing the network of the available channel for the usage of unlicensed users [3].

**Mesh Network:** The Mesh Network is one of the ways of representing the networks, It is also called as the local network topology, there are different types of representing a mesh network there are switches, bridges, infrastructure devices...etc. It is used to connect directly, dynamically and nonhierarchical.

**Primary Base station:** Primary Base station is the station where all the information available in that station. It is the used to allocate the primary base channels for the primary users.

**Primary Networks:** Primary networks are the networks where the primary users are used to represent the primary channel where it has the authority to use the primary channel because it has the licensed channels provided by the government.

**Cognitive Radio Ad Hoc Network:** Cognitive Radio Ad Hoc Network(CRANET) represent the wireless sensing networks, it will allocate the channels for unavailable networks.

**Sensing Techniques:** The main problem of these cognitive networks is to sense the networks and to allocate the channel for the unlicensed users.

There are many techniques for sensing the networks there are three ways of representing a sensing spectrum.

1. Co-operative Sensing
2. Transmitter Detection
3. Interference based Detection

These are the sensing techniques used for to sense the spectrum band to allocate the channels.

**1.Co-operative Sensing:** Co-operative Sensing is used to sharing all the users within the network, the Co-operative Sensing can be classified based on the CR(cognitive radio) share the information within the network into three types there are:

- a. Centralized co-operative sensing.
- b. Distributed (Decentralized) co-operative sensing.
- c. Relay-assisted co-operative sensing.

**2. Transmitter Detection:** Transmitter Detection has the secondary nodes, it must have the capacity to detect the signal when a primary user is present.

There are four types of the Transmitter detection, there are:

- a. Energy detection.
- b. Waveform method.
- c. Cyclostationary method.
- d. Matched filter detection.

**3.Interference Base Detection:** Interference Base Detection utilized for detecting the centering the estimating the obstruction at the beneficiary.

There are two sorts of Interference identification, there are

- a.Interference Temperature Model.
- b. Primary Receiver Detection.

The overall detecting methods are utilized for detecting the authorized essential clients where there are not utilizing their systems, the following stage of the psychological radio systems to designate their channel to the unlicensed ice optional clients [4].

**Channel assignment:** Channel assignment is one of the issues looking in psychological radio systems. There are many direct distributions in subjective radio systems, one of the channel allotments is collector based divert designation in psychological radio systems. Collector Based Channel portion in psychological radio remote work systems: aid is one of the primary issues looking by today subjective radio systems. Chits formulates the integer program of the channel allocation problem under the proposed model, it compares the performance of other two baseline model namely the transmitter-based and all tunable channel allocations of strategies.

Advantages and Disadvantages of channel allocation anther is a channel allocation of the secondary users in a particular range of region for avoiding that receiver based channel allocation is used for allocating the channels

b. it will allocate the channels for unlicensed users by taking the permission from the authority. It will allocate the channel by taking some time but it guarantees that it will allocate the channel. And primary users, it will allocate the channel when primary users are in the absence.

Wireless sensor network formation approaches and techniques : Wireless sensor network refers to a group of dispersed sensors for recording the physical conditions and organizing the data at a location. It measures conditions like temperature, sound, pollution, humidity and wind. These are similar to wireless ad-hoc network they rely on wireless connectivity and formation of network. Nodes have communication with all the networks. Communication is in form of topology. There can be a WSN with both type of topology being the same (mesh, star etc.)

This may not be case for all the applications .Logical topology is either ad-hoc or strategy based .The strategy is defined based on network available resource [5].

Centralized formation: Centralized formation techniques are suitable for networks in which the processing power capacity depends only on unique devices .the main advantage for this approach is centralized scheme allow more efficient energy management. Roaming is allowed inside the network. Network coverage analysis is simplified Context information availability allows a better application design (application awareness, context specific design etc.)

### III. DISTRIBUTED FORMATION:

In distributed formation techniques the information is managed by each node and decisions are locally taken.

- There are autonomous devices
- Information is shared among all nodes
- Suitable for distributed applications (self organised systems)
- Information is mainly forwarded to single node
- Routers , bridges are not required
- Flexibility targets harsh environments

The complexity of the forwarding information process

Requires robust algorithms

The protocols intended for distributed wireless sensor networks must be able to provide efficient energy consumption considering nodes mobility Centralized networks take directions from a unique device.

Hierarchical network: A sensor defines priorities according to its role in the network. A network control is performed in hierarchical way and is defined based on the roles .It employs a multi-hop forwarding strategy and addresses the sensor the localization problem. They proposed a centralized technique to guarantee high mobility between sink nodes. Self-configuration is used to find the appropriate sink for the registration process.

### IV. ROUTING BASED NETWORK:

These works are focused on finding the best path to get the sink node. The route is chosen based on different metrics

evaluating the nodes with more energy, the number of hops, distance, the number of visited nodes, and so on. Ant Colony Optimization (ACO) algorithm, a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs for an optimum route discovery in a multi-hop WSN

**Cluster based formation:** Cluster-based control structures allow a more efficient use of resources. A hierarchical view of the created network through clustering decreases the computational complexity in the formation of the underlying network. This is especially true in sensor networks that are expected to consist of a large number of individual nodes. On a topological level, clustering is achieved by grouping nodes inside a certain transmission area. A designed leader node controls this group of nodes usually known as Cluster Head (CH) or a leader node

Packet tracer network simulator: Packet tracer is a powerful network simulation program and provides simulation packet traces uses ipv6 address to provide network path . ipv6 has 4.3 billion addresses Ipv6 is of 128 bit .packet tracer supports ipv6 addresses . steps to find network formation

- Assigning ipv6 addresses
- Auto-configuration
- Static ipv6
- Ipv6 static and dynamic routing
- Static routing
- Dynamic routing.

Packet Tracer: Packet Tracer is a tool that is designed by Cisco System for designing the computer networks .Packet tracer that makes the use of just drag and drops for the users to add and remove the simulated network devices. Formation of Network through packer tracer by creating Ipv6 address on the network. It is based on 3 objectives

1. Set up the topology and configure the basic router and switch setting.
2. By configuring Ipv6 addresses manually.
3. Verification of End-to-End connectivity.

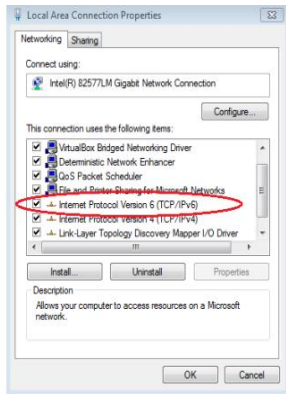
Resources Required:

a.1 Router

b.1 Switch

c)2 Pcs(Window 7 or 8) and Console cables [8].

- 1.Initializing and reload the router and switch, configure the router by assigning the device name to the router



2. Appoint the IPv6 delivers to Ethernet interfaces on R1.

a. Dole out the IPv6 worldwide unicast addresses, recorded in the Addressing Table, to both Ethernet interfaces on R1

```
R1(config)# interface g0/0
```

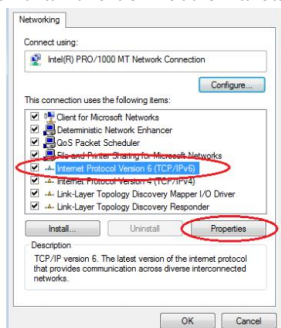
```
R1(config-if)#ipv6address2001:db8:acad:a::1/64
```

```
R1(config-if)# no shutdown
```

```
R1(config-if)# interface g0/1
```

Issue the show ipv6 interface g0/0 order. Notice that the interface is posting two Solicited Nodes multicast gatherings, in light of the fact that the IPv6 connect nearby (FE80) Interface ID was not physically arranged to coordinate the IPv6 unicast Interface ID.

3. You can likewise test network by utilizing the global unicast address, rather than the connection area.



Results of packet tracer: On the off chance that start to finish availability isn't built up, investigate your IPv6 address assignments to check that you entered the addresses effectively on all gadgets.

```
C:\>ping 2001:db8:acad:1::3

Pinging 2001:db8:acad:1::3 with 32 bytes of data:
Reply from 2001:db8:acad:1::3: time<1ms
Reply from 2001:db8:acad:1::3: time<1ms
Reply from 2001:db8:acad:1::3: time<1ms
Reply from 2001:db8:acad:1::3: time<1ms

Ping statistics for 2001:db8:acad:1::3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0%
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>
```

Ant Colony Optimization Algorithm: In an ant colony optimization algorithm, the choice of each path depends on two aspects: pheromone concentration and heuristic information. Pheromone refers to the chemical substances secreted by each ant in the process of finding a path. When the ant successfully finds the target node, pheromones will increase in a certain proportion. Heuristic information is a

priori knowledge about the link, and, in most cases, it refers to the cost of selecting the path or the connection state of the link. The ant colony optimization algorithm is mainly divided into two parts: the transition probability criterion and the parameter definition. The criterion of transition probability is how to choose the next hop according to the transition probability. The basic expression of transition probability is as follows [6]:

$$p_{ij}(t) = \begin{cases} \frac{\tau_{ij}^\alpha(t)g_{ij}^\alpha(t)}{\sum_{l \in N_i} \tau_{il}^\alpha(t)g_{il}^\alpha(t)}, & \text{if } j \in N_i, \\ 0, & \text{if } j \notin N_i, \end{cases} \quad (1)$$

where  $p_{ij}(t)$  is the probability that the ant moves from node  $i$  to node  $j$  at time  $t$ ;  $N_i$  is the set of optional next hop nodes of node  $i$ ;  $\tau_{ij}(t)$  represents the pheromone concentration on the link at time  $t$ ;  $g_{ij}(t)$  denotes the heuristic information on the link at time  $t$ , which usually refers to the connection status of the link or the cost of selecting the path.  $\alpha$  is the pheromone heuristic factor, indicating the role played by the pheromone released by the ant in the path selection. The greater its value is, the stronger the indirect effect between ants will be. In other words, the path taken by the forwarded data packet has a greater influence on the selection of the current path, then eventually all ants select the same path. If  $\alpha=0$ , it degrades into the greedy algorithm (local optimum selection), and the ant selects only the path which is currently considered best.  $\beta$  is the expected heuristic factor, indicating the relative importance of heuristic information. The higher its value is, the greater the influence of link quality on the packet selection path will be. In the transfer probability formula, the emphasis is on pheromone and heuristic information. Other weight factors can be set according to different scenarios by using empirical values or simulation analysis. When an ant completes a routing or selects the next hop, or the update cycle set by the routing protocol comes, the pheromone of the selected path is updated according to Formula :

$$\tau_{ij}(t+1) = (1-\rho)\tau_{ij}(t) + \rho\Delta\tau_{ij}(t),$$

where  $\Delta\tau_{i,j}(t)$  is the amount of pheromone that the ant deposits this time on the link  $(i,j)$ ;  $\rho$  is the pheromone evaporation rate, indicating the rate that the pheromone decays over time, and the value range of  $\rho$  is  $\rho \in [0,1]$ , so  $1-\rho$  indicates the residual level of the pheromone. In different algorithms, the expressions of  $\Delta\tau_{i,j}(t)$  or  $p_{i,j}(t)$  are distinct depending on specific problems .

### Energy Optimization of Ant Colony Algorithm:

In the ant colony algorithm, the current node finds the next node according to the pheromone concentration of the path and the node's energy. The pheromone concentration of a certain path increases significantly with more ants passing this path. However, when the pheromone is at a high level, the energy of the node in the path will decrease rapidly.



Suppose that there are two paths, one with high pheromone concentration and low residual energy of node, while the second one with low pheromone concentration and high residual energy, according to the traditional ant colony algorithm, ants will continue choosing the path with high pheromone concentration, and the energy of the node on the path will become very low. However, in the IACAEO algorithm, the ants will choose the path with high node residual energy even if the pheromone concentration of that path is relatively low [7]. Therefore, this is not only conducive to ensure the stability of the WSN but also guarantees the energy consumption equilibrium of the node in the WSN. The author proposes that when the node energy decreases to a certain value, the pheromone volatilization rate of the current path should be increased. When other ants pass this path, the pheromone concentration will increase. Additionally, the node notifies its neighbor node of its residual energy when it is lower than a threshold. So, this node has no chance to be selected by its neighbor nodes as the next hop node [8].

**Pheromone Impact Factor:** Improvement of Pheromone Impact Factor for ACA the impact factor alpha is used to measure the proportion of pheromones. The value is unchanged, which affects the convergence of the algorithm. In order to speed up the convergence rate at the initial stage and avoid a fast local convergence, the impact factor alpha is modified as follow.  

$$\alpha(k) = \lambda(1 + e^{-\gamma k}), 0 \leq k \leq K$$
 [9].

Through this way a large proportion of pheromones at the beginning can be expected. With the increase of the searching times we hope a smaller proportion of pheromones gradually. In this way, the searching speed will change with the searching times. At the beginning a relatively faster searching speed is taken. With the progression of the algorithm the searching speed will slow down gradually.

**Pheromone Update Strategy:**

In order to avoid too large pheromone concentration on each route, which may results in a relatively faster local convergence, the pheromone is limited by a threshold.

$$\tau_{ij}(t+1) = \begin{cases} \Gamma, & \tau_{ij}(t+1) > \Gamma \\ (1 - \rho)\tau_{ij}(t) + \sum_{m=1}^n \Delta\tau_{ij}^m, & \text{else} \end{cases}$$

$$\Delta\tau_{ij}^m = \begin{cases} Q/L_m, & \text{if } m\text{th ant uses the edge}(i, j) \\ 0, & \text{otherwise} \end{cases}$$

Where T represents the threshold value, Q is the pheromone strength, n is the total number of ants. the path length of the mth ant,  $\rho$  represents the coefficient of the Pheromone volatilization[10].

volatilization,  $\rho \in (0; 1)$ .

In the traditional ant colony optimization algorithm, it is often used to find the shortest path, the current node energy is not considered, which will lead to premature death of some nodes, and then affect the lifetime of the entire network. In this paper both the node energy and the route path will be considered simultaneously. After all ants reach the destination node, each individual ant corresponds to a route. Here we give a fitness function for optimal route selection. The fitness value of each route can be calculated by the following formula.

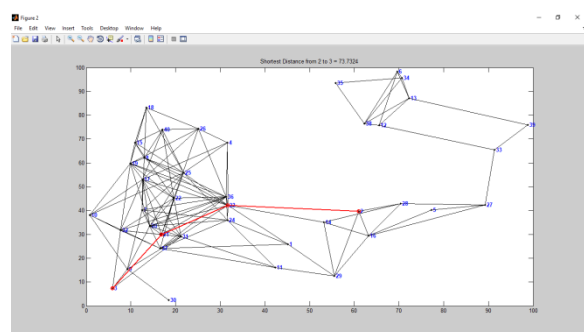
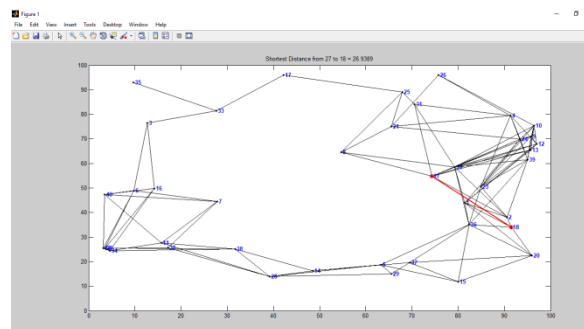
$$fit_m^k = \frac{E_{aver} \times E_{min}}{L_m^k}$$

Where it refers to the average node residual energy. It denotes the node minimal energy of ants passing through the route.  $L_m^k$  represents the route length for mth ant and kth iteration. The larger the fitness value is, the more optimal route will be. By comparison, the route with the largest fitness value is regarded as the optimal route. Then pheromone concentration on this route is updated. Through this way only the route with high fitness value will be chosen after several times of iteration, and finally the balance of the energy consumption of the network will be improved. **Heuristic Information:** The transfer distance to the next node j but don't take into account the distance from the node j to the Sink. However, this distance affects the network energy consumption. Within the communication range choosing the node closer to the sink node the smaller total energy consumption of the network will be reached [10]. Thus the heuristic information should not only consider the distance to the next node but also the distance to the sink.

$$\eta_{ij}(t) = \frac{1}{w_0 d_{ij} + (1 - w_0) d_{jS}}, w_0 \in (0, 1)$$

Where  $w_0$  is parameter that control the relative weight of  $d_{ij}$  and  $d_{jS}$ ,  $d_{jS}$  indicates the distance from the next candidate node j to the Sink node.

**V. RESULTS:**



## VI. CONCLUSION:

The utilization of a sensing spectrum techniques and the usage of the spectrum band for the unlicensed users, and by the allocation of the channel through the received based channel allocation, the cognitive radio succeed in providing the spectrum band for unlicensed by taking the permission from the authority of primary users, is able to allocate the channel and not causing any harm to the environment. The network energy consumption is reduced and the network lifetime is prolonged Simulation results shows that new ant algorithm can effectively save the energy of nodes and prolong the network lifetime.

### Acknowledgment:

We thank our parents and VenkataVara Prasad Padyala for their support and motivation, without their blessings and God's grace this review paper would not be possible.

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