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ENHANCED MULTI-TRANSMITTER BASED CHANNEL SELECTION MATCHING SYSTEM FOR COGNITIVE RADIO AD HOC NETWORK

A. JAYA LAKSHMI[1], J. SWETHA[2] & G. N. SWAMY[3]

[1]Assistant Professor, Department of ECE, Vardhaman College of Engineering, Shamshabad, Telangana, India

[2]Research Scholar, Department of ECE, Vardhaman College of Engineering, Shamshabad, Telangana, India

[3]Professor & HOD, Department of E & IE, V. R Siddhartha Engineering College, Vijayawada, Telangana, India

ABSTRACT

Cognitive radios (CRs) are regarded as a promising solution for alleviating this spectrum underutilization problem by enabling unlicensed users. In traditional ad hoc networks, broadcasts are conducted on a common channel, which is shared by all nodes in the network. However, in cognitive radio ad-hoc networks, unlicensed users may observe heterogeneous spectrum availability, which is unknown to other unlicensed users before the control information was broadcast. In this project, a Quality-of-service (QoS)-based broadcast protocol under Blind Information for multi-hop CR ad hoc networks, i.e., QB^2IC is proposed with the aim of having a high success rate and short broadcast delay. In enhancement work a technique was proposed to provide seamless communication in most of the environment, such as communication can be done with and without infrastructure and we have enhanced our base work with the multi transmitter to get channel information in blind environment.

KEYWORDS*:* Cognitive Radio (CR), MIMO, Multi Transmitter, Channel Selection

INTRODUCTION

Wireless spectrum is currently regulated by governmental agencies and is assigned to license holders or services on a long-term basis over vast geographical regions. Exponential growth of user demands on a single convergence platform has brought researchers to explore various aspects/features of Fourth Generation (4G) Mobile Communication System. Selection of application as per the user preference based on QoS (Quality of Service) is one salient feature of 4G. The new area of research foresees the development of cognitive radio networks to further improve spectrum efficiency. Our ultimate aim is to enhance the spectrum utilization by enabling secondary users to exploit the spectrum in an opportunistic manner with budget Constraints. From the view of the CR users have addressed how the CR users optimally distribute their traffic demands over the spectrum bands to reduce the risk for monetary loss, when there is more than one unoccupied licensed band. This confronts those mechanisms with several critical problems when they are deployed in multi-hop CRNs. Nowadays more and more people, families, and companies rely on wireless services for their daily life and business, which leads to a booming growth of various wireless networks and a dramatic increase in the demand for radio spectrum. Cognitive radio technology opens the licensed spectrum bands for opportunistic usage. We investigate the path selection problem in multi-hop cognitive radio network. We introduce a new service provider, called secondary service provider, to help CR sessions to select the paths for packet delivery. Considering the price of bands and the potential returning of primary services at different CR links, the SSP purchases the licensed spectrum and jointly conducts flow routing and link scheduling under the budget constraints.

SISO and MIMO Channel Capacities

In wireless system design, the most important part to understand and design is the wireless channel. It is time varying random filter which affects the capacity and successful transmission of information. In ideal conditions, Shannon capacity of SISO channel depends upon available bandwidth (B), transmit power (P) and interference from noise (N). In order to achieve maximum SISO capacity or SISO channel, we have to increase the B or P or reduce the noise level (N). In practical systems we have limitations on B and P i.e. fixed available spectrum and power constraint.

Cognitive Radio

Cognitive Radio (CR) is one of the new long-term developments taking place and radio receiver and radio communications technology. After the Software Defined Radio (SDR), which is slowly becoming more of a reality, cognitive radio (CR) and cognitive radio technology will be the next major step forward enabling more effective radio communications systems to be developed. There are likely to be a variety of different views of what exactly what a cognitive radio may be. Accordingly a definition of a cognitive radio may be of use in a number of instances. A cognitive radio may be defined as a radio that is aware of its environment and the internal state and with knowledge of these elements and any stored pre-defined objectives can make and implement decisions about its behavior. In general the cognitive radio may be expected to look at parameters such as channel occupancy, free channels, the type of data to be transmitted and the modulation types that may be used. It must also look at the regulatory requirements. In some instances knowledge of geography and this may alter what it may be allowed to do. In some instances it may be necessary to use software defined radio, so that it can reconfigure itself to meet the optimal transmission technology for a given set of parameters. Accordingly Cognitive radio technology and software defined radio are often tightly linked.

Noise factor in wireless communication depends upon many factors including fading, shadowing, mobility of user and environment both. Hence we have a limited wireless capacity. Higher spectral capacity and hence efficiency can be achieved by using multiple antennas at transmitter and receiver. it was shown that capacity increases linearly with the increase of number of antennas. Using mimo system, parallel transmit streams of single user or multiple users can be sent and received. Hence using these parallel sub-channels very high capacity can be achieved. It is then mimo systems which will make giga-bit wireless systems ease of use

SISO and MIMO Channel Capacities

In wireless system design, the most important part to understand and design is the wireless channel. It is time varying random filter which affects the capacity and successful transmission of information. In this article we have studied the characteristics of SISO and MIMO wireless channels. In ideal conditions, Shannon capacity of SISO channel depends upon available bandwidth (B), transmit power (P) and interference from noise (N). In order to achieve maximum SISO capacity for SISO channel, we have to increase the B or P or reduce the noise level (N). In practical systems we have limitations on B and P i.e. fixed available spectrum and power constraint. Noise factor in wireless communication depends upon many factors including fading, shadowing, mobility of user and environment both. Hence we have a limited wireless capacity. Higher spectral capacity and hence efficiency can be achieved by using multiple antennas at transmitter and receiver. It was shown that capacity increases linearly with the increase of number of antennas. Using MIMO system, parallel transmit streams of single user or multiple users can be sent and received. Hence using these parallel sub-channels very high capacity can be achieved. It is then MIMO systems which will make giga-bit wireless systems.

Let's consider a typical communication system which consists of a transmitter, channel and receiver. The mathematical model of this communication system can be shown by using the notations: r = g *s + v where rt is the received signal. At each point in time, this is an nr-dimensional (no. of receive antennas) signal. gt is the matrix channel impulse response. This matrix has nt columns and nr rows. The notation ht is used for the normalized form of gt. st is the nt-dimensional transmitted signal. vt is the complex nr-dimensional AWGN. For the simplicity we have omitted the subscript t and in this case of SISO channel we have nt = nr = 1. The" *" here means convolution.

This is time discrete system model where noise is drawn from a Gaussian distribution of zero mean and variance N. If the noise variance is zero then the receiver receives the transmitted symbol perfectly. If the noise variance is non-zero and there is no constraint on the input, we can choose and infinite subset of inputs arbitrarily far apart, so that they are distinguishable at the output with arbitrarily small probability of error. Such a scheme has an infinite capacity as well. Thus if the noise variance is zero or the input is unconstrained, the capacity of the channel is infinite. To derive the SISO channel capacity we consider information theoretic point of view.

MIMO System Architecture

In practice, a MIMO transceiver can operate in a half-duplex manner and the transmitter and receiver in Figure 1.1. Actually stand for the MIMO transceiver in transmit and receive mode respectively. A MIMO transceiver can allow more passive antennas than RF chains and employ antenna selection techniques to determine the optimal subset of antennas, i.e., which four out of the six in Figure. Each pair of transmit antenna and receive antenna forms a sub-channel between two ends, and the MIMO link is composed of these sub-channels.

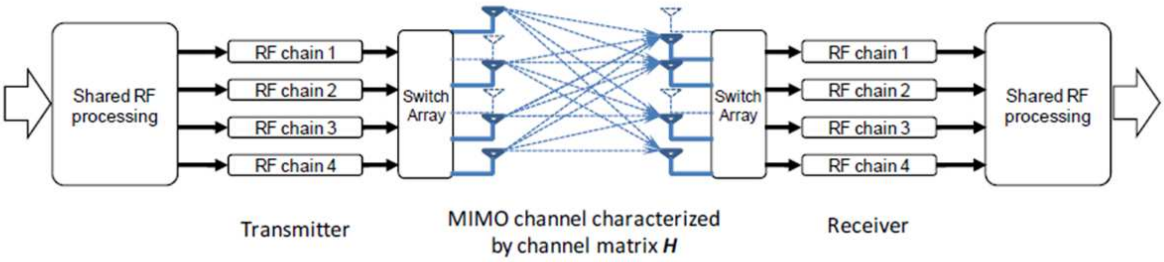


Figure 2.1: MIMO Channel Model

The MIMO channel can be characterized by an Nr X Nt complex matrix H, as illustrated in Fig. 1. The number of active antennas in the receiver and transmitter are denoted as Nr and Nt respectively. jØ

$$\boldsymbol{H}(t) = \sqrt{\frac{K(t)}{K(t)+1}}\boldsymbol{H}_{LOS}(t) + \sqrt{\frac{1}{K(t)+1}}\boldsymbol{H}_{NLOS}(t). \tag{1.1}$$

In the model H_LOS (t) and H_NLOS (t) denote the line-of sight (LOS) component and non-line-of-sight (NLOS) component of the channel, respectively. The elements in H_NLOS (t) are independent normalized complex circularly symmetric Gaussian random variables. The elements in H_NLOS are all one multiplied by a phase shift ^{ejØ} where Ø is a random variable uniformly distributed within [0,2π]. In addition K (t) is the Rican factor that indicates the propagation condition of the channel, i.e., how dominant is the LOS component compared to the NLOS component. By varying K (t), the model can fit channels with various fading distributions.

For example, K= 0 models ideal Rayleigh fading and K= ∞ models ideal Rican fading. The change of both H_LOS (t) and H_NLOS (t) and K (t) can yield channel variation.

It is important to highlight that the above model has been normalized to the path loss of each sub-channel. In other words, given a fixed distance between the transmitter and receiver, the channel fluctuation due to small-scale node movement can be modelled as above. To eliminate ambiguity, we refer the change of H_LOS (t) and H_NLOS (t) and K (t) as small-scale fading, and the change of path loss as large-scale fading.

In a Random Matrix, two Dimensional points are 4-connected (or 4-neighbors) if the difference in one of their coordinates (x or y) is 0 while in the other. The connectivity can be defined in a recursive way: for edge point p, q, and r, p is connected to q if p is 4-connected to q, or p is 4-connected to r and r is connected to q. 16-connectivity and m-connectivity are similarly defined.

The algorithm can be regarded as a simulation of “flooding of connected canal systems (connected users)”, hence the name of our algorithm. The assumptions include:

- We have unlimited water supply at the starting point (Base Station);
- Water flows at a constant speed in all directions;
- Water front will stop only at a dead-end, or at a point where all possible directions have been filled.

As water fills the Users of Corner Place (edges), important statistics are recorded such as maximum filling time; the number of points where the water front forks; and the maximum accumulated fork numbers, and various histograms etc.

The WF algorithm for 4-connectivity can be described as follows (for simplicity, when we say “4-neighbors” we mean the edge pixels (Users of Corner Place) that are 4-neighbors of the current pixel, since we only deal with edges):

- Initialization: mark all edge pixels as “unfilled”, Water Fronts={ }, Max Filling Time= 1, Max Fork Count =1, Max Water Amount=0
- for every “unfilled” edge pixel (Users of Corner Place) *p* in the edge map:
  - Mark it as “filled”, Filling Time=1, Fork Count=1, Water Amount=1, Water Fronts = {*p*}, and
  - For every pixel (Users of Corner Place) *q* not marked as “dead-end” in the set Water Fronts: If *q* has *m* “unfilled” *4-neighbors (m>0)*, put them into Water Fronts and mark them as “filled”, Filling Time++, Fork Count += *m* – 1, Water Amount += *m*; and remove *q* from Water Fronts; Else, mark *q* as “dead-end”.
  - According to the current values in Filling Time, Fork Count, and Water Amount: Update Max Filling Time, Max Fork Count, and Max Water Amount. Update Filling Time Histogram, Fork Count Histogram, and Water Amount Histogram.

We consider a frequency-flat MIMO channel to calculate its capacity. The capacity is the upper bound on the error-free data rate allowed by the MIMO channel. The model clearly indicates that capacity C depends on both the channel and the communication parameters. That is, P_TX, N_t and N_r are dependent on the configuration of the transmitter and receiver is dependent on the receiver, while is determined by the channel. Higher transmit power P_TX or more active antennas, i.e. larger N_t and N_r, can increase the channel capacity C, regardless of H. However, both ways will meanwhile increase power consumption of the transceiver. A key observation that motivated this work is that under some particular circumstances more antennas can yield little improvement to the channel capacity, e.g., when the channel has a large Rican factor K so that the sub-channels are highly correlated. Under these circumstances it may not be energy efficient to employ a large number of active antennas.

EQUATIONS

		Optimizing both ends	Optimizing one end	
			Transmitter optimization	Receiver optimization
Energy per bit of both ends		*Case 1* $E_b = P_{MIMO}/R = E_b(P_{TX}, N_T, N_R)$	*Case 2* $E_b = P_{MIMO}/R = E_b(P_{TX}, N_T)$	*Case 3* $E_b = P_{MIMO}/R = E_b(N_R)$
Energy per bit of one end	Transmit energy per bit	*Case 4* $E_b = P_{Transmit}/R = E_b(P_{TX}, N_T, N_R)$	*Case 5* $E_b = P_{Transmit}/R = E_b(P_{TX}, N_T)$	*Case 6* $E_b = P_{Transmit}/R = E_b(N_R)$
	Receive energy per bit	*Case 7* $E_b = P_{Receive}/R = E_b(P_{TX}, N_T, N_R)$	*Case 8* $E_b = P_{Receive}/R = E_b(P_{TX}, N_T)$	*Case 9* $E_b = P_{Receive}/R = E_b(N_R)$

Figure 2.2: MIMO Channel Capacity

Modules

We have divided our proposed system into small modules. There are the modules given below.

- Network Design
- Timer setting
- Channel info message generation
- Design listening state
- Design transmission state

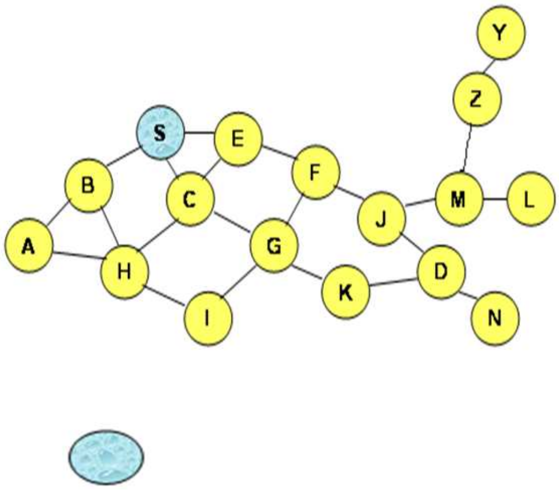
Network Design

We have designed a cognitive radio network with the secondary user model. And we made the assumption with PU availability. In real time the secondary users can scan the PU availability and as well as channel usage. We have considered the SU already collected the neighbor PU availability and neighbor channel occupancy. The secondary user has the channel table in that it can store the details about channel sets. Secondary users can make communication to other device like Ad hoc network. From the introduction of new technologies such as IEEE 802.11the commercial implementation of ad hoc network becomes possible. One of the good features of such networks is the flexibility and can be deployed very easily. Thus it is suitable for the emergency situation. But on the other side it is also very difficult to handle the operation of ad hoc networks. Each node is responsible to handle its operation independently. Topology changes are very frequent and thus there will be need of an efficient routing protocol, whose construction is a complex task. TCP performances are also very poor in mobile ad hoc network. In coming sections we are discussing the TCP working mechanism and challenges for TCP in ad hoc networks in more detail. A wireless mesh network can be seen as a special type of wireless ad-hoc network. A wireless mesh network often has a more planned configuration, and may be deployed to provide dynamic and cost effective connectivity over a certain geographic area. An ad-hoc network, on the other hand, is formed ad hoc when wireless devices come within communication range of each other. The mesh routers may be mobile, and be moved according to specific demands arising in the network. Often the mesh routers are not limited in terms of resources compared to other nodes in the network and thus can be exploited to perform more resource intensive functions. In this way, the wireless mesh network differs from an ad-hoc network, since these nodes are often constrained by resources.

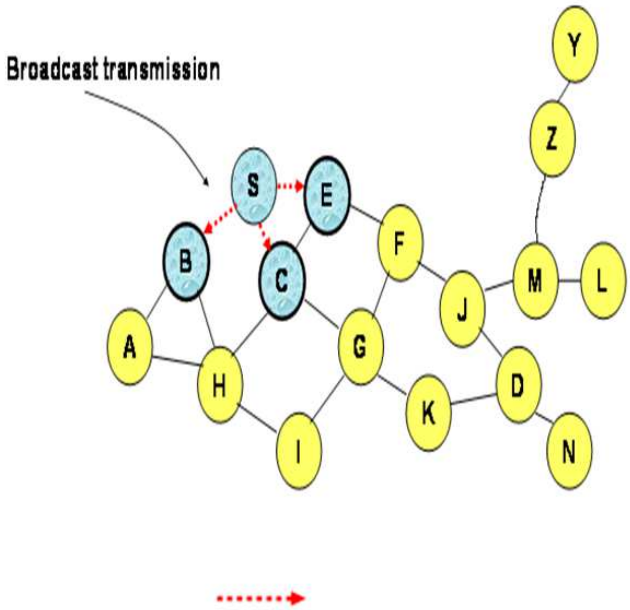
Routing Protocols

DSR includes source routes in packet headers. Resulting large headers can sometimes degrade performance-particularly when data contents of a packet are small, AODV attempts to improve on DSR by maintaining routing tables at the nodes, so that data packets do not have to contain routes. AODV retains the desirable feature of DSR that routes are maintained only between nodes which need to communicate. Route Requests (RREQ) are forwarded in a manner similar to DSR. When a node re-broadcasts a Route Request, it sets up a reverse path pointing towards the source-AODV assumes symmetric (bi-directional) links. When the intended destination receives a Route Request, it replies by sending a Route Reply (RREP).Route Reply travels along the reverse path set-up when Route Request is forwarded. Route Request (RREQ) includes the last known sequence number for the destination. An intermediate node may also send a Route Reply (RREP) provided that it knows a more recent path than the one previously known to sender. Intermediate nodes that forward the RREP, also record the next hop to destination. A routing table entry maintaining a reverse path is purged after a timeout interval. A routing table entry maintaining a forward path is purged if not used for an active_route_timeout interval. A neighbor of node X is considered active for a routing table entry if the neighbor sent a packet within active_route_timeout interval which was forwarded using that entry. Neighboring nodes periodically exchange hello message. When the next hop link in a routing table entry breaks, all active neighbors are informed. Link failures are propagated by means of Route Error (RERR) messages, which also update destination sequence numbers. When node X is unable to forward packet P (from node S to node D) on link (X,Y), it generates a RERR message. Node X increments the destination sequence number for D cached at node X. The incremented sequence number *N* is included in the RERR. When node S receives the RERR, it initiates a new route discovery for D using destination sequence number at least as large as N .When node D receives the route request with destination sequence number N, node D will set its sequence number to N, unless it is already larger than N. Routes need not be included in packet headers. Nodes maintain routing tables containing entries only for routes that are in active use. At most one next-hop per destination maintained at each node-DSR may maintain several routes for a single destination. Sequence numbers are used to avoid old/broken routes. Sequence numbers prevent formation of routing loops. Unused routes expire even if topology does not change.

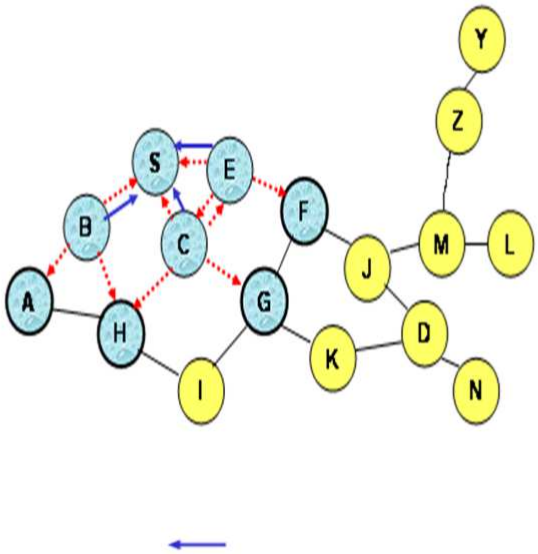
Route Discovery in AODV



A. Represents a node that has received RREQ for D from S.

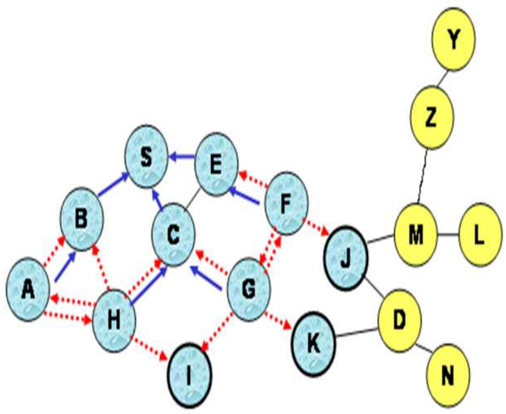


B. Represents Transmission of RREQ.

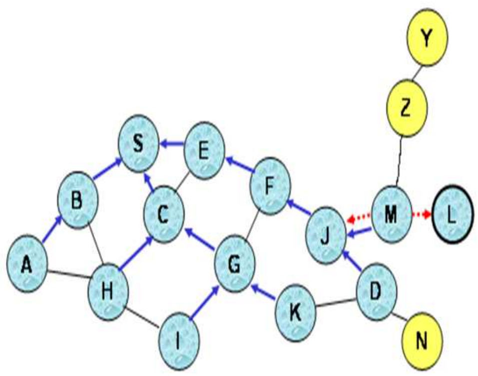


C. Represents links on reverse path.

Figure 3.1: Route Discovery in AODV

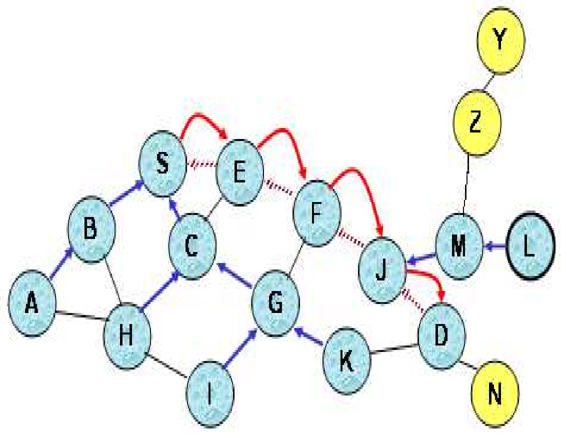


- Node C receives RREQ from G and H, but does not forward it again, because node C has already forwarded RREQ once.



Node D does not forward RREQ, because Node D is the intended target of RREQ.

Figure 3.2: Reverse Path Set-Up in AODV



Forward links are Set-Up when RREP travels along the reverse path.

D. Represents a link broken on the forward path.

Figure 3.3: Forward Path Set-Up in AODV

The Timer

The enhancement solution which helps to find the channel availability. In that, node has the timer, which generate the time period. Once the timer is got expired then the device will trigger the channel availability message sharing.

Design Listening State

The secondary users are not having any specific channel to make communication; the secondary users can make communication based on the free channel which is not used by the primary users. So the SU has to listen in the different channels to get the primary user availability and as well the neighbor secondary user availability. The listening stage is based on the timer. The secondary users are using the timer to keep the channel usage time period. The secondary users has to listen the all the channels, so the SU will use the each channel for small duration. And each time period the SU will switch to next channel. Spectrum sensing is an exceptionally important task in a cognitive radio system. The transmissions of licensed users have to be reliably detected: Thus, spectrum sensing is the first step towards adaptive transmission in free spectral bands. Without causing any interference to the primary user, the secondary system has to be spectrum aware to exploit the available spectrum efficiently. There are certainly a number of approaches that can be used to check whether the primary user signal is present or not, but the only autonomous and flexible approach is based on measurements of the actual occupancy in given location and time. Spectrum sensing could add robustness and responsiveness to changes in the environment because it provides real-time feedback. Therefore, we argue that spectrum sensing should be considered as an important part of any cognitive radios system. Wireless systems today are characterized by wasteful static spectrum allocations, fixed radio functions, and limited network coordination. Some systems in unlicensed bands have achieved great spectrum efficiency but are faced with an increasing interference that limits network capacity and scalability. When the ultimate cognitive radio is considered, it is a more general term that involves obtaining the spectrum usage characteristics across multiple dimensions such as time, space, frequency, and code. However, this requires more powerful signal analysis technique because of the additional computational complexity. Even though there are many kinds of primary user systems, the cognitive radio's knowledge of their characteristics and requirements for interference protection can be abstracted by a few generally applicable parameters. Three critical requirements for sensing radio are the detection time and the detection probability and the minimum detectable signal level. The required detection time and probability of detection are set by the primary user tolerances to QoS degradation. While these are two conflicting requirements, the cognitive radio system goal is to minimize detection time in order to increase the time available to use the channel. In spectrum sensing many techniques exist to detect the primary user, two of the most practical techniques being energy detection and match filter detection. Spectrum sensing is still in its early stages of development. A number of different methods are proposed for identifying the presence of the signal transmission. In some approaches, characteristics of identified transmissions are detected in order to decide the signal transmission and identify the signal type. In this paper we propose new approaches for spectrum sensing. The first approach is investigated by using real code values to detect the primary user in match filter status when the code value is known to the secondary user. For the second approach, we propose a new scheme for energy detection depending on a fixed number of verifications. We can see after using this scheme that we improve the probability of detection and improve the detection time. Then we explain the performance for each approach.

The remainder of this paper is divided as follows:

- We provide an overview of spectrum sensing.
- We formulate the new approach for spectrum sensing by using code values in the match filter.
- We describe the conventional energy detection.

The new structure for energy detection by using a number of verifications to improve spectrum sensing. We plot all the simulations and describe the performance of each scheme. We conclude with our main results. Consider two (active) secondary user pairs who are non-mobile and are 1-hop neighbors (i.e., no hidden terminal). Due to the random nature of multi-path propagation, the channel gains of the available channels for secondary user pair 1 are plausibly different from that for secondary user pair 2. As such, it is very unlikely for the two secondary user pairs to have the same channel sensing sequence if the channels are sensed according to the descending order of their achievable rates. Here, it is proposed that each secondary user pair senses and accesses the channels based on its own channel sensing order. Without any coordination between the secondary user pairs, however, it is still possible that a particular channel is sensed free by these two secondary user pairs simultaneously, thereby leading to packet collisions. To avoid collisions, one approach is to exhaust all the possible combinations of their sensing sequences and find the combination that can maximize the total reward/throughput performance. This approach is undoubtedly computationally expensive, and the computational cost increases exponentially with the number of secondary user pairs. Such an exhaustive search also requires the knowledge of θ sk's. Therefore, instead of devising optimal sensing sequences, we study the probability of transmission collision with respect to and investigate the reward performance of our proposed simple channel exploitation approach for two or more secondary user pairs. To derive this probability of collision, for simplicity, we assume that the channel sensing sequences are independent and equally likely, and the channels are randomly placed in a channel sensing sequence.

SIMULATION RESULTS

We run the tcl program by using the base network simulator version 2. We have called the basic network simulator version 2 inside the MATLAB. And we have stored the output in some temporary files. Then we have read the file in MATLAB to generate the graph.

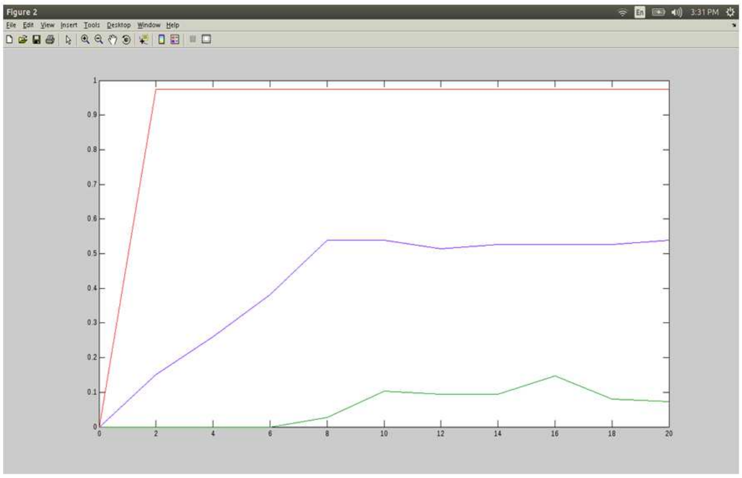


Figure 4.1: Success Rate at Different Samples by Using MIMO

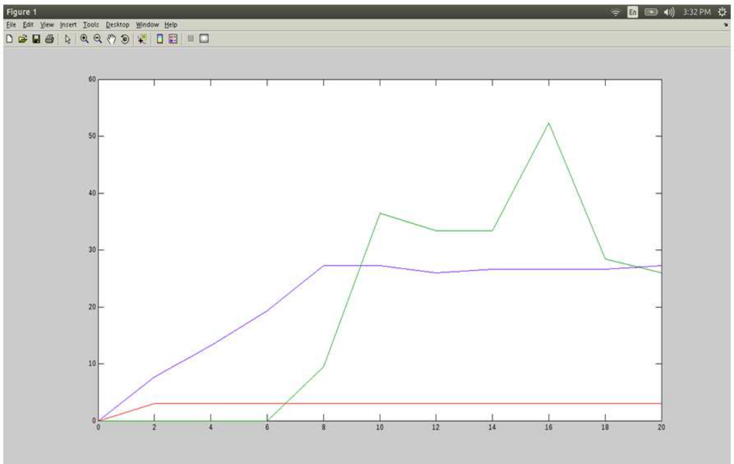


Figure 4.2: Average Delay Time at Different Samples in MIMO

CONCLUSIONS

Cognitive radios (CRs) are regarded as a promising solution for alleviating this spectrum underutilization problem by enabling unlicensed users. In traditional ad hoc networks, broadcasts are conducted on a common channel, which is shared by all nodes in the network. However, in cognitive radio ad hoc networks, unlicensed users may observe heterogeneous spectrum availability, which is unknown to other unlicensed users before the control information was broadcast. In this paper, multi transmitter based broadcast protocol under Blind Information for multi-hop CR ad hoc networks proposed and we have achieved a high success rate and short broadcast delay compare than existing work. And in our enhancement work we proposed a technique to provide seamless communication in most of the environment, such as 1) communication can't be done without infrastructure, 2) communication can be done without infrastructure. And we have enhanced our base work with the multi transmitter to get channel information in blind environment. So we have got a good results such as stable success rate and less delay.

In our enhancement work we have proposed multi transmitter technique to check the channel availability and data transmission. Due the periodic update, little overhead is increased. So in our future work we will concentrate on the overhead reduction.

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