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An Optimized Approach for Relay Selection in Cognitive Radio Networks

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Abstract- **The cognitive radio networks benefits has been well recognized in the wireless communication application. In this paper, a decode and forward protocol is implemented in order to increase the security of the system rather than only amplifying and forwarding. The analysis of throughput is also studied with a different approach of scanning the secondary users based on their even and odd numbers. Simulations are conducted for observation steps and average reward for different number of secondary users. The analyses is also done for the increase in throughput with the modified scanning methodology using the simulation.**

Index Terms**—Relay selection, optimal stopping, amplify and forward protocol, decode and forward protocol.**

I. INTRODUCTION

A Cognitive radio (CR) is said to be an intelligent radio, which can be configured and programmed dynamically. Cognitive radio (CR) improves the utilization of spectrum resources. Cognitive radio networks classified into two groups, secondary users (SUs) and primary users (PUs). Primary users (PUs) are authorized to the licensed spectrum bands and the secondary users (SUs) can sense only the unused spectrum bands. By doing this the spectrum utilization has been improved.

The direct transmission of data from primary transmitter to primary receiver will damage the data transferred due to the unstable environment, such as shadowing and multipath fading which is present in the wireless communication. To overcome this problem we go for cooperative relaying framework. In earlier technology, separate relay nodes are used to transmit the information from primary transmitter to primary receiver. By using the cooperative relaying framework, primary user selects one of the secondary user which have the better channel condition as the cooperative relay to transmit the information.

Spectrum utilization [1] the large number of unused bands is not utilized by the secondary users (SUs), this will leads to the insufficient spectrum utilization. The effective technology has been proposed to resolve this problem, i.e. cognitive radio network (CRN). The sharing of limited spectrum between the secondary network and the primary network is effectively done by the cognitive radio network (CRN). Cognitive radio network (CRN) [2] this paper investigates the channel quality prediction problem in the cognitive radio network (CRN). Using the interfered parameters, the channel quality estimation is done. Optimal stopping theory [3] has been proposed to select cooperative relay node, scanning all the secondary users is not necessary. To avoid this we first formulate the optimal stopping problem and for the relay selection the optimal stopping rule is derived. Stopping criteria considers the expected reward and the instantaneous reward. Channel state information [4] the cooperative communication performance depends on the resource allocation such as power control and relay selection. Earlier resource allocation requires the measurement of the (CSI) channel state information. To achieve the power allocation and optimal relay selection without the knowledge of channel state information, the distributed game theoretical framework has been proposed over the multiuser cooperative communication network. Property right model and common model [5] the main advantage of cognitive radio network is the efficient utilization of spectrum bands. Cognitive radio is divided into two groups, property rights model and the common model. In common model, the aim of the secondary nodes is without interacting with the primary system, spectrum holes are detected. In the property right model, the spectrums which are owned by the primary nodes will lease some of the band to the secondary nodes. IEEE 802.11 standard [6] [7] to compute saturation throughput performance of the distributed coordination function of IEEE 802.11 the analytical model has been presented. Using IEEE standard individual station transmission probability has been derived. Wireless LANs (WLANs) [8] both unicast traffic and broadcast usually transported by the IEEE 802.11 based (WLANs) wireless LANs. Decode and forward protocol [9] cooperative communication system is technology which improves the capacity of the system. Using decode and forward protocol the possible enhancement of cooperated system has been investigated.

II. SYSTEM MODEL

In this section, first we evaluate the network model, and the cooperative relaying protocol. This network model uses the amplify forward protocol.

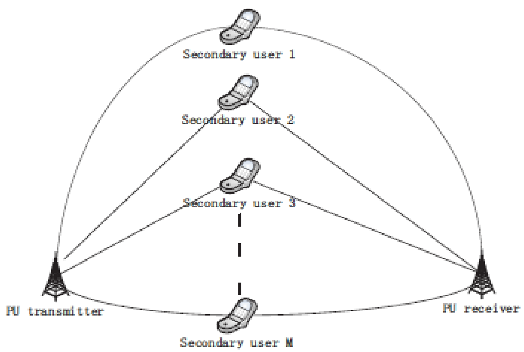

Fig.1. network model

Consider a network model, primary transmitter (Pt) transmits its data packets to the primary receiver (Pr). There are M secondary users and they are represented by Si, where i= 1,2,3,…,M. primary user scans all the secondary user sequentially to select one of the secondary user as a relay node to transmit the packets. The secondary user which has better channel condition is selected as a relay node. When primary transmitter wants to transmit data will send its data to the primary receiver through the relay node. In each time slot the cooperative relay selection is done. T is the time slot taken.

a. Cooperative relaying protocol

Time slot structure is illustrated in fig.2. and partitioned into several component. s1, s2,…..sM is the observation sequence of the secondary user. Initially according to the observation sequence the primary transmitter starts observing the secondary users. The k^{th} observation reward satisfies the criteria. At that point primary transmitter stops scanning the secondary user and selects the k^{th} secondary user as a relay node, then the primary transmitter transmits data to the primary receiver through that relay node. The time taken to select the kth node is $(1 – \alpha)(T – k\tau)$, $0 \le \alpha \le 1$. Over a time β, $0 \le \beta \le 1$, the secondary relay node transmits data

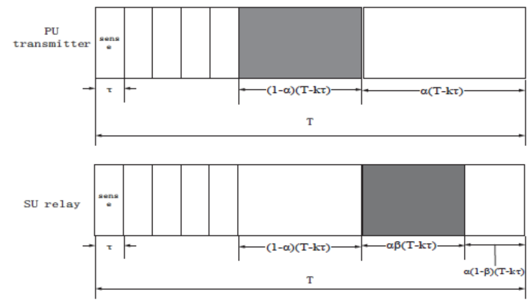

Fig.2. time slot structure

b. Optimal stopping policy

In order to maximize the reward, the primary user (PU) makes the decision based on comparing the result of expected reward and instantaneous reward. Some condition should be satisfied in order to check the data sent by primary user (PU) through the cooperative relay are safely arrived at the destination. Condition is given as follows,

$$0 < (1-\alpha)R^{r}_{ps}(t) \le \alpha\beta R^{s}_{sp}(t) \quad (1)$$

Where, *Rrps*(*t*) represents the transmission rate between primary user (PU) transmitter and secondary user (SU) relay. *Rssp*(*t*) represents the transmission rate between primary user (PU) receiver and secondary user (SU) relay. Minimum value of β can be calculated by using α.

Based on the number of the observation steps and proper transmission rate, instantaneous reward function has been derived. Instantaneous reward function is denoted by *Yk*.

$$Y_k = c_k X_k \quad (2)$$

Where, *ck* is the scaling factor given by,

$$c_k = 1 - \frac{k\tau}{T} \quad (3)$$

The number of value of *ck* is smaller then the number of value of k is larger.

$$Y_k = \frac{X_k(T-k\tau)}{k\tau + (T-k\tau)} \quad (4)$$

After k^{th} observation, primary user (PU) receives reward function *Yk*. Then the primary transmitter decides whether to stop scanning the secondary user and selects the current relay or to scan the next relay. This is done based on the reward function.

III. ALGORITHM FOR OPTIMAL STOPPING RULE

1: Construct observation sequence i.e. S = (s1, s2, s3, . . . , sM);
2: Start observing the secondary users (SUs) from s1, to select the cooperative relay;
3: for k = 1 to M – 1 do
4: after observing the kth user, compute the transmission rate rk, and reward function Yk is given by (2);
5: compute the value of expected reward and the instantaneous reward;
6: if Yk < Zm-k then
7: start to observe the next relay;
8: else
9: stop at the current step and select that kth secondary user (SU) as a cooperative relay;
10: end if
11: end for
12: select the Mth SU as a cooperative relay;

IV. DECODE AND FORWARD PROTOCOL

From the conventional max min selection, using decode and forward protocol, an optimal relay can be selected. This is done without changing the limit of the interference temperature.

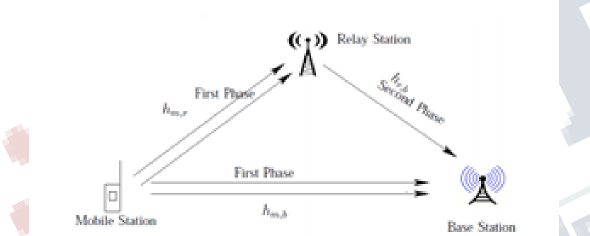

Fig.3. packets sending from MS to BS

The primary user scans the secondary users to select the relay node to send the packets to the destination. In decode and forward protocol, the primary user will first scans the even secondary users and then the odd secondary users. If one of the even secondary user satisfies the channel condition, then if will selects that secondary user as a relay node, else it will continue to scan the odd secondary users. Rayleigh fading channel is assumed between MS-BS, MS-RS and RS-BS. The relay selected is said to decode and forward incremental relay. The selected relay will decode the received signal and then forwards to the destination. After selecting the relay, the transmission takes place in two phases. In the first phase MS transmits data to both RS and BS. When the direct transmission of data to BS is successful, then BS sends ACK to MS. then MS will sends the next data to BS and RS. Then RS will not sends the data to BS. When the transmission from MS to BS fails, then BS sends NACK to MS and RS will forwards the packets to the BS, this occurs in second phase.. if first phase fails then only second phase occurs. This method has error free ACK/NACK. Signal received by BS which is sent by MS is ym , b. the signal received by the RS which is sent by MS is ym , r. nm , r denotes the additive noise in MS-RS link. Variance is given by σr 2. nm , b denotes the additive noise in MS-BS link, variance is given by σb 2. In decode and forward protocol, we get better throughput with less bit error rate (BER) when compare to amplify and forward protocol.

V. SIMULATION RESULTS

A: Results For Amplify And Forward Protocol.

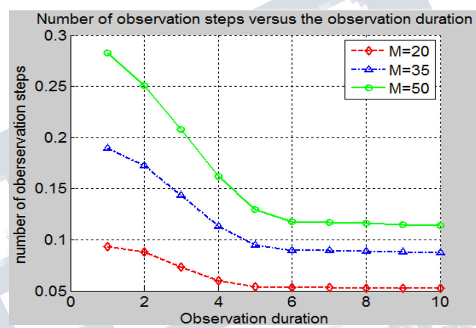

Fig.4. observation duration vs the observation steps

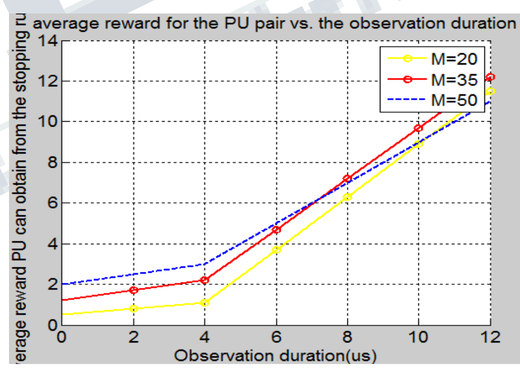

Fig.5. observation duration vs the average reward

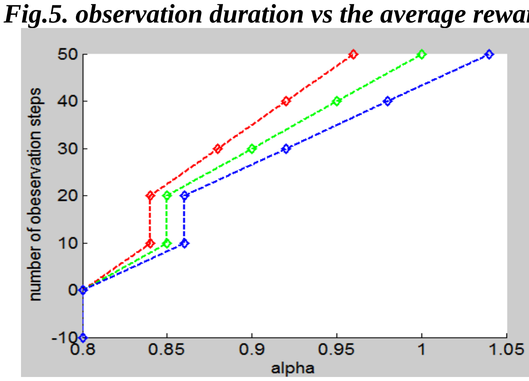

Fig.6. alpha vs observation steps.

M is the number of secondary users (SUs), assuming number of secondary users M = 20, 35, 50. In fig.5. for each observation the averarage reward result obtained by primary user pair increases, this will also leads to increase in time. The relation between observation steps and number of observation duration concludes that, less number of observation steps leads to large number of primary user pair. Fig.6. larger number of alpha indecates the larger availability of secondary users relay, and it will helps to transmit more packets.

B: Comparision Between Amplify Forward And Decode Forward Protocol.

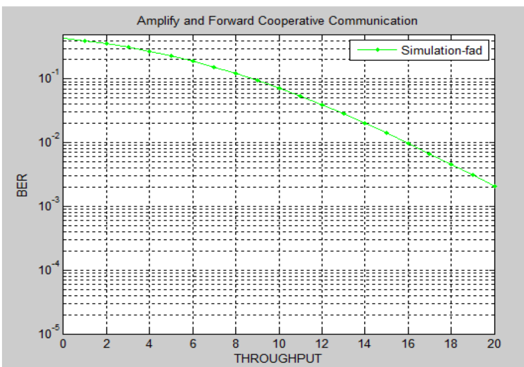

Fig.7. BER vs Throughput of amplify forward protocol.

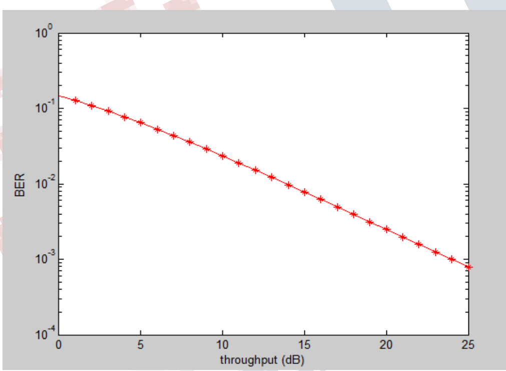

Fig.8. BER vs throughput of decode and forward protocol.

Simulations are carried out for throughput analysis with respect to the Bit error rate using decode and forward protocol and the results are compared with the amplify protocol.In Fig.7. we observe that at the for BER 10^{-3} the throughput obtained is 20dB. Where as in the Fig.8 for BER 10^{-3} the throughtput obtained is 25dB. It is hence studied that there is approximately an increase of 5dB in throughput using decode and forward protocol.

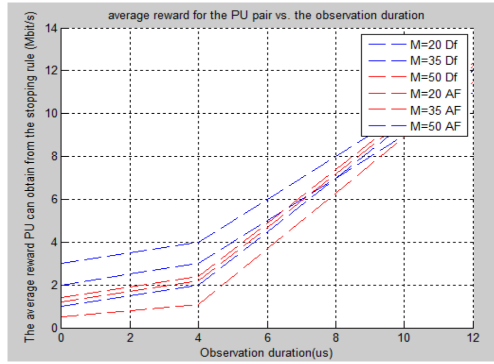

Fig.9 comparing amplify forward and decode forward protocol through observation duration and average reward.

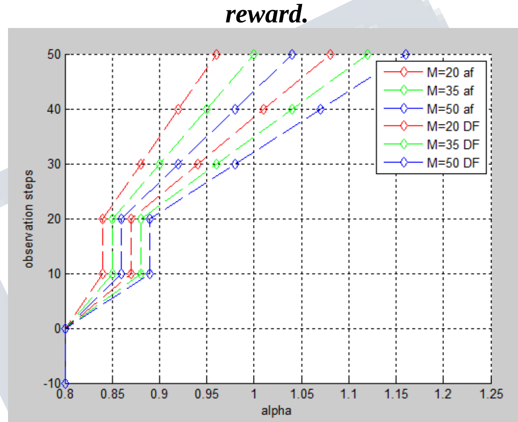

Fig.10.comparing amplify forward and decode forward through alpha vs observation.

VI. CONCLUSION

In this paper, the problem of relay selection in a cognitive radio network is studied, and solved using an existing optimal stopping policy. The work is enhanced using a decode and forward protocol to improve the system security. In the proposed system the scanning methodology is in complement to the sequential scanning, The enhance decode and forward protocol, primary user first scans enhancement in the throughput is achieved using the successive even and odd scanning of the secondary users to find the best relay node which increases the probability of finding the secondary node earlier. we also observed an increase of 5dB in the throughput.

In future research, work can be carried out to enhance the dynamic spectrum access efficiency consider channel assignment and relay selection.

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