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Enhanced Performance of Proactive Spectrum Handoff Compared To Csma/Cd

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Abstract:- Cognitive Radio (CR) is the modest technology to make the unlicensed users to make use of licensed spectrum in the opportunistic manner. Collision and throughput are the main parameters to be checked while performing handoff. Proactive Spectrum is proposed to address these Concerns. Various Channel sensing methodologies were simulated and comparison was made between proactive, Reactive Spectrum. Simulation results show that our proactive spectrum handoff outperforms the reactive spectrum handoff and wireless networks approach in terms of higher throughput and fewer collisions to licensed users.

Keywords:- Congestion, CR, Handoff and proactive spectrum,CSMA/CD

I. INTRODUCTION

An adhoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any established infrastructure or centralized administration. Each node is considered to be alike here. It is needed to introduce some intelligence to the adhoc networks in order to improve their throughput efficiency. The concept of Cognitive Radio (CR) has been employed to achieve this. CR enabled devices are 'clever' and can listen to the surrounding wireless environment and can select appropriate frequency band, modulation scheme with various parameters and signal spaceor specific power level as per the requirement. COGNITIVE Radio is a technology evolved from software defined radio (SDR) for wireless communications in which a network changes its transmission or reception parameters to communicate efficiently avoiding interference with licensed or unlicensed users [1].It is generally used for military and civilian applications. Cognitive radio ad hoc networks (CRAHNs) constitute a viable solution to solve the current problems of inefficiency in the spectrum allocation, and to deploy highly reconfigurable and self-organizing wireless networks. It is needed to introduce some intelligence to the adhoc networks in order to improve their throughput efficiency.

Cognitive radio (CR) devices are envisaged to utilize the spectrum in an opportunistic way by dynamically accessing different licensed portions of the spectrum [1]. The limited available spectrum and the inadequacy in the spectrum usage necessitate a new communication standard to utilize the existing wireless spectrum opportunistically [2]. Here, we discuss the mechanisms that can be followed to provide better efficiency in utilizing an existing cognitive network. This methodology also ensures that the existing channel frequencies are not wasted and the frequencies that are in use are utilized to the maximum extent without the need for bothering about the effects of interference [3].

II. COGNITIVE RADIO

Cognitive radio is an emerging and promising technology for getting the most out of consumption of the limited radio bandwidth while accommodating the increasing amount of network services and applications in wireless network techniques. The cognitive radio networks are almost done for dynamic spectrum allocation to access the networks. [1] The key features of cognitive radio network are wideband signal processing techniques for digital radio, advanced wireless communications methods, artificial intelligence and machine learning techniques, and cognitive radio-aware adaptive wireless/mobile networking protocols.

A cognitive radio is a kind of two-way radio that automatically changes its transmission or reception parameters, in a way where the entire wireless communication network of which it is a node communicates efficiently, while avoiding interference with licensed or licensed exempt users. This alteration of parameters is based on the active monitoring of several factors in the external and internal radio environment, such as radio frequency spectrum, user behavior and network state. Fig 2.1 (17) shows the sample CR network.

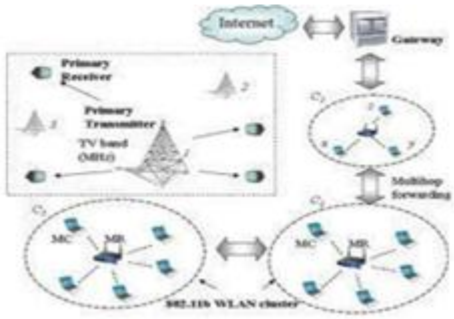

Fig 2.1: A Sample CR Network

Regulatory bodies in various countries (including the Federal Communications Commission in the United States and Ofcom in the United Kingdom) found that most of the radio frequency spectrum was inefficiently utilized. For example,

Cellular network bands are overloaded in most parts of the world, but many other frequency bands, such as military, amateur radio and paging frequencies are not. Independent studies performed in some countries confirmed that observation, and concluded that spectrum utilization depends strongly on time and place [4]. Moreover, fixed spectrum allocation prevents rarely used frequencies (those assigned to specific services) from being used by unlicensed users, even when their transmissions would not interfere at all with the assigned service. This was the reason for allowing unlicensed users to utilize licensed bands whenever it would not cause any interference (by avoiding them whenever legitimate user presence is sensed). This paradigm for wireless communication is known as cognitive radio. Since the spectrum present is limited, all users cannot be allowed to access this network (18).

2.1 Categories of CR

The users are divided into two basic categories.

Primary Users: Since the spectrum present is limited, all users cannot be allowed to access this network of any other unlicensed users. Primary users do not need any modification or additional functions for coexistence (14).

Secondary Users or Unlicensed Users: They access the licensed spectrum as a visitor, by opportunistically transmitting on the spectrum holes.

2.2 Waveforms of Cognitive Radio:

The most important job of the Cognitive Radio (CR) is to efficiently use spectrum hole which is assigned to a primary user (PU) or licensed user. In order to achieve this goal, CRs have to detect the reappearance of PU frequently. They should quit the spectrum immediately as soon as a PU is detected in order to minimize their reciprocal interference. This suggests that CR has to change

it's transmitting waveform and adapt to the spectrum environment. Therefore, the adaptive waveform [10] techniques have been investigated. The term adaptive waveform stands for ―A time domain pulse in the radio frequency (RF) range that has the desired frequency response [09]. In this technique, CRs will periodically monitor the RF spectrum (spectrum sensing) and choose the best available spectrum allocation (spectrum decision). On basis of the spectrum information obtained, CRs generate an adaptive carrier waveform which fits only the free band. As soon as the waveform is generated, digital data will be modulated using this waveform and transmitted. Fig 2.2 in (1) shows the process of the adaptive waveform generation.

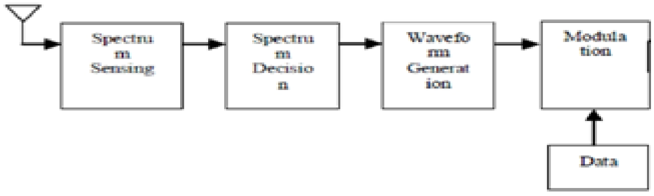

Fig 2.2: Adaptive waveform Generation

Uncertainty is also important. A prior knowledge of noise is required during sensing, but it's not available in practice. Because of such channel uncertainties, spectrum sensing must be sensitive enough to overcome such uncertainties. On the other hand, hidden terminal problem is also a threat to CR. If a secondary node is out of the range of primary transmitter and may generate false decisions, it will interfere the primary user. Cooperative spectrum sensing [2] is a possible way to solve the threats. By cooperation within secondary users, more information could be taken during spectrum sensing. This kind of sensing technique can be implemented either in a centralized or in a distributed way. [3][4]

Obviously, how to decide and select a waveform for transmitting based on environmental measures is one of the most important problems for CR. A new on adaptive carrier waveform scheme is proposed in [10] to adapt to any band without bringing about harmful interference. It is useful in accessing TV spectrum with high spectrum utilization efficiency.

III. SPECTRUM SENSING IN COGNITIVE RADIO SYSTEMS

Spectrum sensing is basically a binary hypothesis testing problem and the key performance measures for a spectrum sensing method are the probability of correct detection, probability of false alarm, and probability of miss. Cooperative spectrum sensing in CR would be challenged by some uncertainties such as channel fading or shadowing. The low received signal strength is not enough for CR to detect whether the primary user exists or not. The impact of noise

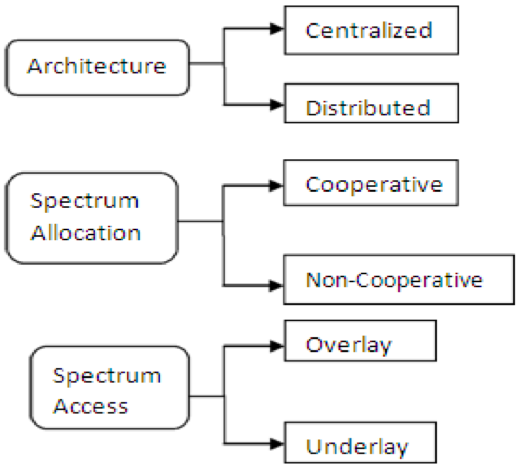

Fig 3.1: Architecture of CR Network

3.1 Centralized Cooperative Spectrum Sensing:

In the centralized approach, as illustrated in Fig 3.1, the CR base station receives all the sensing information from the secondary users and determines the state of spectrum. Then the local results are sent to a CR base station that performs data fusion and determines the final spectrum sensing result. The sensing terminals may return different results due to some reasons such as the distance between the primary user and the sensing terminals, shadowing, or fading. Each time a secondary user requests an access of a certain spectrum, a permission of the CR base station is needed. The cost of this scheme might be expensive, but it’s effective to manage to spectrums and increase the correction of sensing.

3.2 Distributed Cooperative Spectrum Sensing:

On the other hand, distributed approach requires exchange of observations among all the secondary users (12). Each secondary user plays a role of fusion center, and chooses the best channel from the available spectrum, based on the local data available to them (often from the neighbor nodes). This scheme could be easier implemented with low cost, but it is shared to manage and some collision might be happened.

Random channel selection: A SU randomly

Chooses a channel from its predicted available channels.

Greedy channel selection: In this method, only one pair of SUs is considered in the network. The SUs can obtain all the channel usage information and predict the service time on each channel. Thus, when a spectrum handoff occurs, a SU selects a pre-determined channel that leads to the minimum service time.

Local bargaining: In this method, SUs form a local group to achieve collision free channel assignment. To make an agreement among SUs, a four-way handshake are needed between the neighbors (i.e., request, acknowledgment, action, acknowledgment). Since one of the SUs is the initiating node which serves as a group header, the total number of control messages exchanged is 2NLB, where NLB is the number of SUs need to perform spectrum handoffs. Since for channel selection schemes, reducing the number of collisions among SUs is the primary goal, we consider the SU throughput, average SU service time, collisions among SUs, and average spectrum handoff delay as the performance metrics.

3.3 Advantages:

1. A distributed channel selection scheme (12) to eliminate collisions among unlicensed users in a multiuser spectrum handoff so there is no interference or collisions.
2. Due to no collisions the proactive spectrum can achieve high throughput value and higher packet delivery.
3. Due the spectrum handoff packet loss is greatly reduced.
4. Compare to reactive spectrum the quality of service is improved.

IV. PROACTIVE SPECTRUM HANDOFF PROTOCOL

In this section, we first propose the spectrum handoff criteria and policies that a CR transmitting pair is required to follow. Then, the details of the proposed spectrum handoff protocol are presented.

4.1 Proposed Spectrum Handoff Criteria and Policies:

By utilizing the sensed channel usage statistics, an SU can make predictions of the channel availability before the current transmission frame ends. Based on the prediction, the SU decides whether to stay in the present channel, or switch to a new channel, or stop the on-going transmission. We propose two criteria for determining whether a spectrum handoff should occur: 1) The predicted probability that the current and a candidate channel are busy or idle and 2) the expected length of the channel idle period. Based on these criteria, we design spectrum handoff policies.

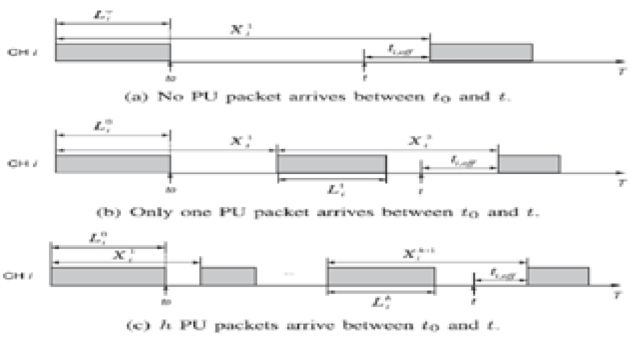

Fig 4.1: The PU activity of channel 1

Fig 4.1 in (12) shows the PU traffic activity on channel i, where X_{ki} represents the inter arrival time of the k_{th} packet. We denote Y(t) as the number of PU packets that arrive between t_0 and t. As shown in Fig 4.1a, the probability that channel i is idle and no PU packet arrives between t_0 and t is given by

$$\Pr(N_i(t)=0, Y(t)=0) = \Pr(X^1_i > t - t_0 + L^0_i)$$

Where L_{ki} denotes the length of the k^{th} PU data packet on channel i. As shown in Fig 4.1b, the probability that channel i is idle and only one PU packet arrives between t_0 and t is given by

$$\Pr(N_i(t)=0, Y(t)=1)$$
$$= \Pr(X^1_i + L^1_i < t - to + L^O_i)\ \Pr(X^1_i + X^2_i > t - to + L^O_i)$$

Similarly, in Fig 4.1c, the probability that channel i is idle and h (h 2 ½1; U) PU packets arrive, where U is the maximum number of PU packets that could arrive between t_0 and t, is

$\Pr(N_i(t) = 0, Y(t)=h)$

$$= Pr(\sum_{k=1}^{h} X^k + L^h < t - t_0 + L^0)$$
$$Pr(\sum_{k=1}^{h+1} X^k < t - t_0 + L^0$$

Thus, if the PU traffic model is known and the channel statistics (e.g., PU packet arrival rate, PU packet length) are obtained from the scanning radio, the predicted probabilities can be calculated. Hence, based on the above prediction, the policy that an SU should switch to a new channel is

$$\Pr(N_i(t)) \geq T_L$$

Where T_L is the probability threshold below which a channel is considered to be busy and the SU needs to carry out a spectrum handoff, that is, the current channel is no longer considered to be idle at the end of the frame transmission. In addition, the policies that a channel j becomes a candidate channel at time t are

$$\{\Pr((N_j(t) = 0 \geq T_H \Pr(t_{j,off} > N_j(t) = 0))\} \geq \Theta$$

where T_H is the probability threshold for a channel to be considered idle at the end of the current frame, Θ is the probability threshold for a channel to be considered idle for the next frame transmission. The second criterion in (14) means that, in order to support at least one SU frame, the probability that the duration of the idleness of channel j to be longer than a frame size.

4.2 Proposed Spectrum Handoff Protocol:

In proposed Spectrum handoff the secondary user is made to vacate the channel before the primary user arrives .Spectrum handoff frame can be designed by using multiple channel multi access protocol whereas the single access scheme is used in Bluetooth and multiple access scheme using pseudorandom sequence made our protocol highly reliable and highly securable. The goal of our proposed protocol is to determine whether the SU transmitting pair needs to carry out a spectrum handoff and then switch to a new channel by the time a frame transmission ends by introducing the hopping pattern.

The proposed spectrum handoff protocol is based on the above proposed spectrum handoff policies. It consists of two parts. The first part, namely Protocol 1 describes how a Secondary user pair initiates a new transmission. Regardless of the coordination schemes used during channel hopping, if a data packet arrives at an SU, the SU predicts the availability of the next hopping channel (in the single rendezvous coordination scheme case) or the hopping channel of the receiver (in the multiple rendezvous coordination scheme case) at the beginning of the next slot. Based on the prediction results, if the channel satisfies the policies in (14) for data transmissions, the channel is considered available. Then, if the CTS packet is successfully received by the SU transmitter, the two SUs pause the channel hopping and start the data transmission on the same channel in the next time slot. Note that if more than one pair of SUs contends the same hopping channel for new data transmissions, only the SU pair who exchanges the RTS/CTS packets first claims the channel. Hence, no RTS collision will occur. The second part, namely, Protocol 2 is on the proactive spectrum handoff during an SU transmission. Fig4.2 in (4) illustrates the operations of Protocol 2.

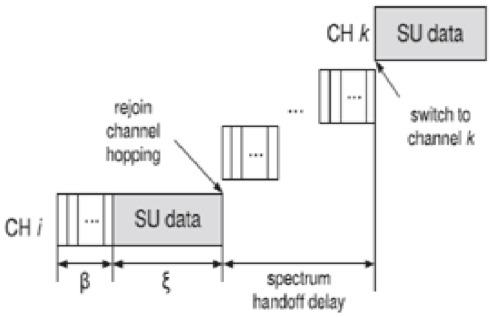

Fig 4.2: Operation of protocol

Using the proposed protocol, the SU transmitting pair can avoid disruptions with PUs when PUs appears. Based on the sensed channel usage information, an SU transmitter checks the spectrum handoff policy in (6) for the current channel by predicting the channel availability at the end of the frame.

V. CONGESTION DETECTION

The dual buffer thresholds (13) and weighted buffer difference are used to detect the congestion. The Fig.5.1 shows the details of buffer state such as “accept state (0 -Q_{min})”, “filter state (Q_{min} - Q_{max})” and “reject state (Q_{max}- Q)”. The different buffer states are reflected different channel loading which is used to accept or reject packets in different states.

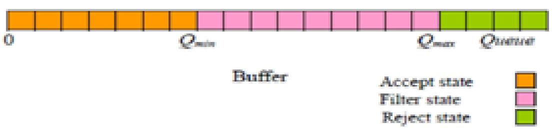

Fig. 5.1 Buffer state

The packet at each node has to send for buffer monitoring and piggybacks its weighted buffer changing rate (*WR)* and weighted queue length (*WQ)* with outgoing packets. The corresponding congestion level bit in the outgoing packet header is set if a node’s buffer occupancy exceeds a certain threshold and its packets has higher priority among neighborhood. The weighted buffer with length WQ (t) after Δt and the weighted buffer difference at time $t + \Delta t$ are calculated as,

$$WQ\,(t + \Delta t) = WQ\,(t) + WR * \quad t \quad (1)$$

$$WQD_{nodei}\,(t + \Delta t) = \qquad\qquad - \text{Max}\,(WQ_k(t + \Delta t)) \qquad (2)$$

Where $k_\in$ neighbor (node$_i$) and N is the total number of packets in the buffer. If $WQD_{nodei}(t+\Delta\ t) \geq 0$, the data of node i is the most important among its neighbors. If congestion happens, other nodes should lower down their data sending rate to mitigate node's congestion.

VI. SIMULATION RESULTS

The current simulation is carried out in the network simulator (Ns-2). This is very helpful in the networking concepts. By using this, the parameters like throughput, delay, collision rate, packet drop can be measured.

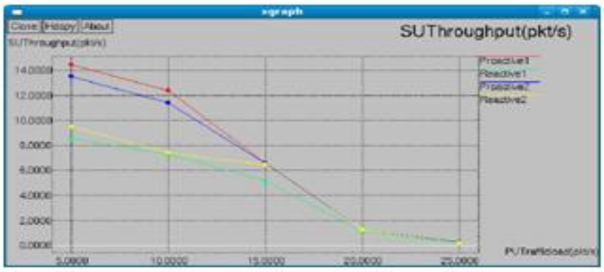

Fig 6.1 Comparison of proactive Vs Reactive

From the graph, the throughput offered in the proactive will be better than the reactive spectrum is shown in fig 6.1. It clearly shows that 30% increase in throughput in proactive when compared with the reactive spectrum. The collision rate in proactive is less than the reactive spectrum is shown in fig 6.2. From graph, its shown that 27% of the collision rate gets decreased in proactive spectrum.

Fig 6.2: Collision Rate Vs Load

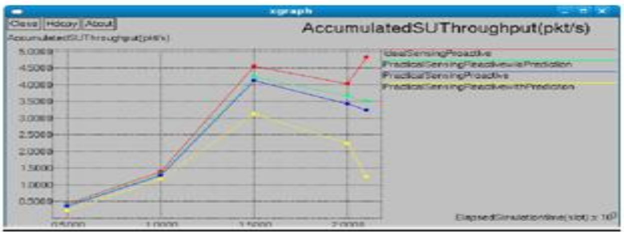

Fig6.3: Accumulated throughput Vs Elapsed time

From the graph, it is clearly shown that the ideal sensing proactive gets higher throughput than practical sensing throughput is shown in fig 6.3. The average delay on the channel is also maintaining the initial delay on greedy channel selection on comparing with the secondary user channel which is shown in fig 6.4.Among all the channel sensing methods, ideal channel sensing performs well, but it cannot be practically implemented, next to ideal sensing is that proactive sensing with prediction which outperforms better than other channel sensing techniques.

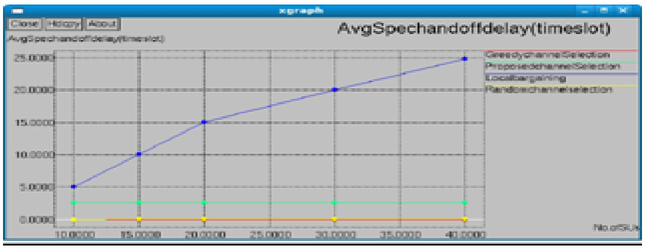

Fig 6.4: Avg delay Vs Secondary user

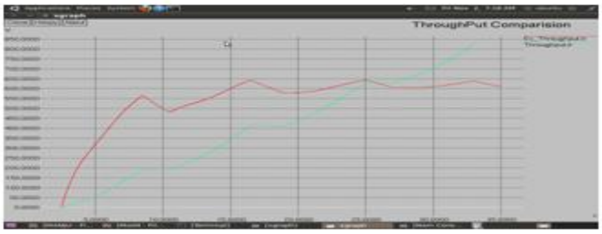

Fig 6.5: Throughput analyses in Wireless network

The throughput analyses for the same number of nodes in wireless network in Fig 6.5 shows that our proposed proactive method outperforms normal wireless network methodologies especially carrier sense multiple access/collision detection in terms of higher throughput.

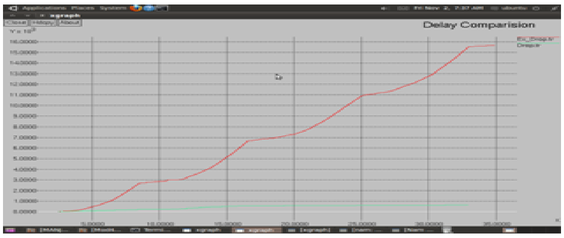

Fig 6.6: Delay analyses in Wireless network

From the Fig 6.6, it is clearly shown that the Proactive spectrum produces lesser delay, when compared to Wireless network with Collision detection technique.

Table 6.1: Comparison Chart for WN & CR

Parameter	**Wireless etwork Technology**	**CR Technology**
Throughput	Low (78.76%)	High (85%)
Delay	High (5.41%)	Low (3.5%)

From the Table 6.1, it is clear that Proactive spectrum cognitive radio outperforms the wireless networks in terms of throughput and average delay to primary user by letting primary users predicting the future spectrum availability in advance and perform spectrum handoffs before it occupies the current spectrum.

VII. Conclusion

In this paper, Collision avoidance is shown by using proactive spectrum handoff, proactive spectrum outperforms the reactive spectrum in terms of higher throughput and shorter Handoff delay. Compared to other channel sensing method and Collision detection in wireless networks, our method achieves fewer disruptions to primary users.

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