A Proficient Modified Multi-Channel MAC Protocol for Wireless Networks

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***Abstract*—** Cognitive radio system is a software defined radio or an intelligent radio system which can be controlled programmatically. It's actually a webdirm system with multiple subcarriers. Whenever data needs to be communicated a transceiver pair needs to be tuned to the same sub carrier frequency. In case there is immense amount of interference or many systems are not tuned to the same subcarrier the cognitive radio can change the corresponding transmission frequency dynamically. In this phenomena, the spectrum sensing plays a major role in identifying the vacant channels. In this paper we consider a communication system in the Medium access control layer (MAC). The modified method efficiently allocates the data channels between different subsystems based on the vacant channels available. The issues of multi cannel allocation and primary and secondary user clashes is addressed through a modified routing protocol and time allocation. The simulation results show that the proposed algorithm is effective in handling the multi user system and perform well under high traffic scenario.

***Keywords*—** *Cognitive Radio, Medium Access Control (MAC), primary user, secondary user.*

I. INTRODUCTION

The presence of the omnipresent wireless utility keeps increasing, lot of various wireless paradigms increases, this ultimately burdens the demands on immobile radio spectrum. Nonetheless, reports indicate that, the utilization rate of the licensed band is less. Even when the channel is heavily used, most data traffics indicate that large amount of space still exists in the unused spectrum [1]. It clearly shows that a modification has to be done to utilize the licensed band effectively as the present system of allocating frequency for each wireless service is not efficient in utilizing the spectrum. Looking at this, the Federal Communication Committee (FCC) recommended a unique strategy for spectrum allocation in a dynamic way. The proposed cognitive radio forms a substructure to get the advantage of the open spectrum bandwidth.

Software –defined radio (SDR) is a technology which is used to develop the cognitive radio system [2]. Here, software is used to dynamically adjust the parameters obtained from the transmitter's operating parameters. The cognitive radio networks make it possible for the secondary or unlicensed users to tune their transceivers dynamically to establish communication amongst one another without interrupting the primary users [3].The designing of an efficient cognitive radio system which handles the conflicts between the licensed and unlicensed users is a challenging task. The number of primary users occupying a network, traffic variation and channel variations play a key role in governing the operation of the secondary users.

Resultantly, analyzing the differing availability of channel, it makes way to a number of non-trivial designing challenges to the medium access control (MAC) layer [4]. Challenges that arise during the design process is encountered by the secondary users, which makes them difficult to handle to transmission among the secondary users. It should be made sure that the communication between the primary users is not disturbed. This designing process makes it the most challenging part as there is no availability of centralized controllers which are generally the base stations or accessing points.

II. THE SYSTEM MODEL

The system is divided into two non-cooperating users, who are nothing but the licensed (primary) and the unlicensed (secondary) users. The primary users are those who have access to allotted licensed spectrum bands. The secondary users on the other hand do not have such an allotted spectrum [5]. But the secondary users are allotted spectrum bands on the fly when the primary users are not completely occupied. The cannel allocation block plays a major role in assigning channels without conflicts.

A. Primary Users' Bandwidth

Let us assume that the total number of channels allotted to the primary users is M. We denote the channels the occupied by the primary users as ON and the other channels are OFF. The channels labeled as OFF can be used by the secondary users [6]. Each channel can be assigned these ON/OFF tags based on the time of occupancy by the respective users. This can be done by assuming the ON and OFF periods are exclusive of each other. In this paper, on considering the x^{th} licensed channel, the ON and OFF period follows an exponential distribution by the means a_i and b_i, respectively. Denoting c_i as the probability of the x^{th} channel utilized by the licensed users, then

$$c_i = \frac{a_i}{a_i + b_i}$$

We have $1 \leq x^{th} \leq M$. Here, c_i denotes the utilization of the channel of the primary users. Generally the secondary users interfear the primary users as a practice while trying to access the licensed channel. T_{dmax} represents the maximum tolerable interference period to limit the interference caused by the secondary users. T_{dmax} acts as a protection to the primary users. Different T_{dmax} is employed by different primary users.

B. Channel Aggregating Technology

After a certain duration, the secondary users would have sensed the channel condition and would attain the information of the licensed channel [7]. The attained information makes it possible for the secondary users to utilize the multiple vacant channels synchronously. The unused channels are generally disjoint in nature.This issue can be resolved by using the concept of orthogonal frequency division multiplexing (OFDM). It can be said that, by using the cognitive radio networks with OFDM, the channel can swap between ON and OFF conditions that corresponds to the subcarriers which are based on the availability of the channel, and thus, makes it possible to access the multiple continuous or discontinuous unused channels synchronously [15].

III. MODIFIED MAC PROTOCOL

A. Protocol outline

In a cognitive radio system, designing of the MAC protocols poses the following challenges,

i. Establishing the communication between the transmitter and receiver with importance to primary user.

ii. Since there is a difference in the availability of the channel, attaining the coordination between the transmitter and receiver has to be achieved.

The MODIFIED-MAC protocol has to be developed in such a way that the above mentioned problems have to be kept in mind and should be designed to facilitate dynamism in the operation of the secondary users.

In the MODIFIED-MAC protocol, m sensors are provided to each secondary user. Where m licensed channel can be perceived in a single time [8]. It takes a certain period of time to perceive all the licensed spectrum, once the licensed spectrums are sensed, the unlicensed users acquires the condition of the state of the channel in the spectrum band. The acquired information makes it easy for the secondary channels to utilize the empty channels. The maximum time is limited to the tolerable interference period (T_{dmax}). The key concept of the MODIFIED-MAC protocol is the use of acknowledgment signals for better data transmission. The request to send (RTS), clear to send (CTS) signals are used as acknowledge signals [9] [10].

In order to avoid the concussions amongst the secondary users, the handshakes of RTS/CTS is introduced,which prevents the adjacent secondary channels from choosing the same channel to transmit the data, which results in no collision amongst the secondary users. The synchronization of sharing the information of the empty channel between the transmitter and receptor is done by CST/CSR, this avoids the collision amongst the primary and the secondary users. The interchange of packets amongst the sender and receiver, by using the CST/CSR packets makes sure that, both the transmitter and the receiver should operate on the same channel.

B. Selection of Licensed Channels

The primary users sometimes utilize the licensed channel unevenly, simultaneously the secondary users can sense the channel limitedly. In doing so, the channel is not utilized efficiently. Efficient usage of the channels can be made by making the unlicensed users to select the channels which are used less effectively. Initially secondary users use random selections to select the channels to be sensed, i.e ≤m. Statistical information can be updated in two ways i.e either by non-cooperative way or cooperative way [11]. In the first, data of the secondary users are updated without any interchange of information. Whereas inn cooperative way the selection of the channels grants the secondary users to interchange the information which in return teaches the secondary users about the global channel rates. Cooperation based method is adopted for the MODIFIED-MAC protocol [12] [14].

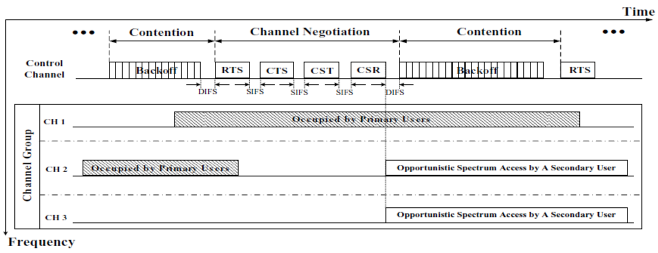

Figure 1. Illustrations of the MODIFIED-MAC protocol

In detail, information of the channel is enclosed in the control packets. By, heeding the control packets over the common control channel, the information of the channel state can be obtained by the secondary users.

C. Algorithm Working

In the proposed scenario, each user undergoes the following steps:

a) Get the communication request from the group.

b) Evaluate the availability of the destination users.

c) Establish the communication using request to send and clear to send signals.

The detailed working of the algorithm is as follows:

In the first step, the originating communication requests from each of the group are collected. In the proposed scenario, four groups have been considered for the simulation in MATLAB. Each group has the components of total users present in the group, the number of primary users and the number of secondary users and the total number of channels available. In the generation of the communication requests from the users, the steps followed are:

a) Get the channel status: check the channels available and get the occupancy count and the type of users occupying them, namely primary and secondary. In the simulation, the empty channels are marked with 0 and the occupied channels are marked with 1.

b) Get the user status: for the communication to be established, the destination user should be available. The status of the destination users are collected to which the communication requests are generated.

c) Sort the destination users into primary users and secondary users and mark the flags.

In the following step, based on the obtained data, the communication establishment process is initiated. This process is done separated for both primary and secondary users, giving importance to the primary users. For the primary user:

a) The Request to Send (RTS) is generated and sent to the corresponding destination group and the user.

b) The Clear to Send (CTS) flag is then generated based on the availability of the user.

c) The CTS flag obtains the value 1 if the destination user is free and there are vacant channels for communication.

d) The CTS flag get the value 0 if the channels are not available or the user is busy.

e) If the received CTS value is 1, the communication is good to go. If the CTS value is 0, this is counted as a miss in the record.

In the process of establishing communication, the primary user is given importance and can use the channel as long as one pleases. Coming to the secondary user, there is an upper time limit in the duration which one can communicate. In case the number of channels are occupied and the primary user is experiencing call misses, the channels occupied by the secondary user are forcefully vacated to reduce the miss count of the primary user. In the simulation, the primary user can have a random time duration generated by the randi function in MATLAB and the secondary user has a maximum duration of 50 iteration. The proposed algorithm is iterated multiple time to check the miss ratio of the primary and secondary users. The findings are discussed in the following section.

IV. RESULTS AND DISCUSSION

In this simulation, 4 groups have been chosen with different number of primary and secondary users. The details have been depicted in table below.

Total number of groups under consideration: 4

TABLE I. PROPOSED GROUP INFORMATION

GROUP 1	
TOTAL CHANNELS : 8	8
TOTAL USERS : 20	20
PRIMARY : 10	10
SECONDARY : 10	10
GROUP 2	
TOTAL CHANNELS : 10	10
TOTAL USERS : 15	15
PRIMARY : 10	10
SECONDARY : 5	5
GROUP 3	
TOTAL CHANNELS : 12	12
TOTAL USERS : 12	12
PRIMARY : 8	8
SECONDARY : 4	4
GROUP 4	
TOTAL CHANNELS : 10	10
TOTAL USERS : 18	18
PRIMARY : 8	8
SECONDARY : 10	10

The working scenario proposed in the paper is run through several iterations. In each iteration, first each subnet generates the communication requests with other groups. Then, an assigning algorithm first searches if the destined users are free. If the users are free, the available channels are allotted with primary users having the highest priority. The channels allotted to the secondary users are freed after a stipulated time interval which can be customised. This process is repeated over several iterations and the miss plot of primary and secondary users is depicted in the images below.

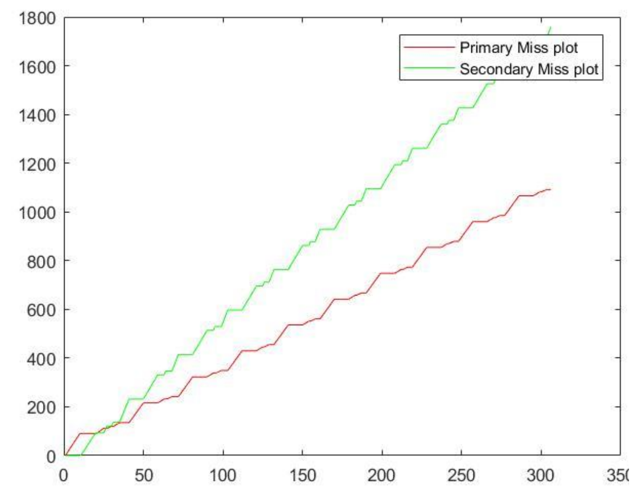

Figure 2: Primary and secondary miss over 10 iterations

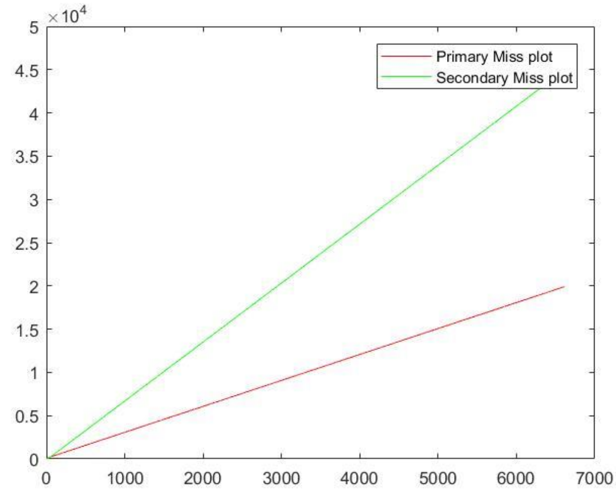

Figure 5: Primary and secondary miss over 200 iterations

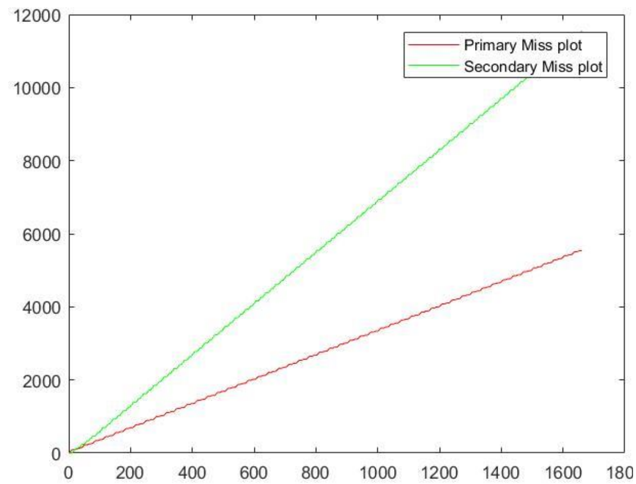

Figure 3: Primary and secondary miss over 50 iterations

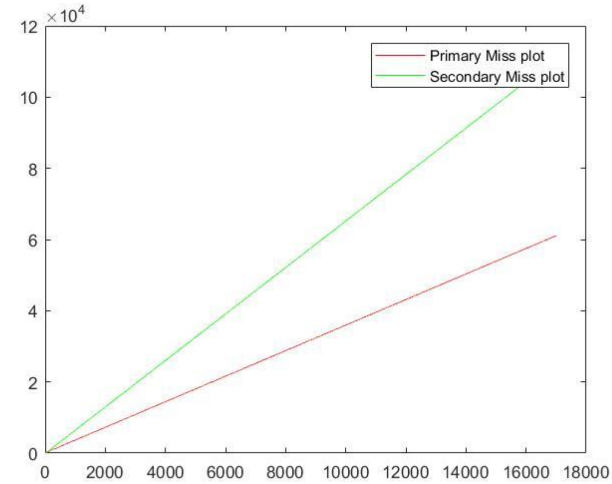

Figure 6: Primary and secondary miss over 500 iterations

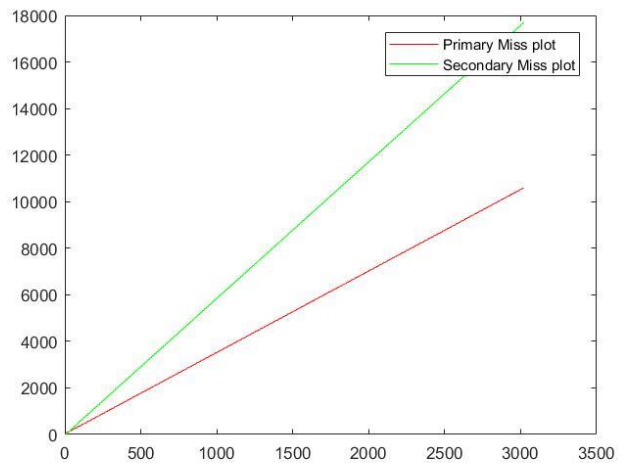

Figure 4: Primary and secondary miss over 100 iterations

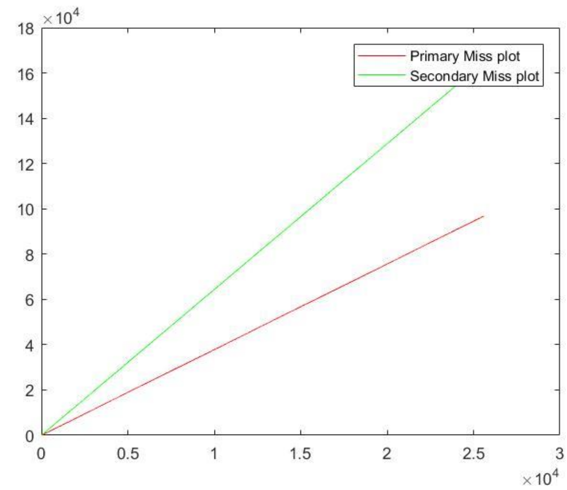

Figure 7: Primary and secondary miss over 800 iterations

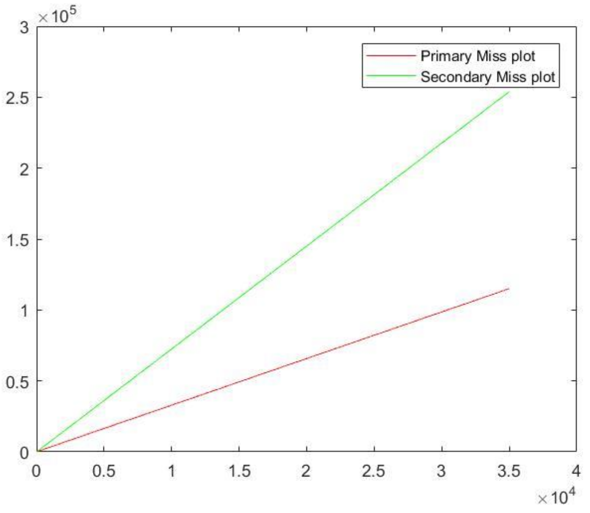

Figure 8: Primary and secondary miss over 1000 iterations

V. CONCLUSION

In this paper, a modified MAC protocol is presented with the insistence of reducing the miss count of the primary users. The proposed algorithm is run over various iteration and the results substantiate our hypothesis that the proposed algorithm can reduce the miss count substantially

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