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ABSTRACT

Cognitive Radio is an promising technology which permits the secondary users(unlicensed users) to share the spectrum in frequency, space and time domains. So can access the spectrum only when primary users are not using the spectrum because of the dynamic nature of spectrum environment. Several important issues need to be addressed for the design of the MAC protocol in Cognitive Radio Network. The secondary users need to determine when and which channel access to send or receive data without interfering with the primary user. A CSMA based MAC protocol to identify and use the available frequency spectrum without interfering the primary user. The performance of the proposed MAC protocol has been analyse using MATLAB.

Index terms: ***carrier sense multiple access (CSMA), multichannel, throughput, MAC protocol.***

I. INTRODUTION

Cognitive Radio(CR) is a technology which have primary users and secondary users. Primary users are the licensed spectrum and the secondary users are unlicensed spectrum. It enhances the utilization of the radio spectrum. The spectrum scarcity problem is solved by using cognitive radio technology. The secondary users occupy the licensed spectrum if the primary user is in available condition. So the spectrum scarcity problem is resolved in this technique. Always primary users have the first priority to use the frequency of the spectrum and the secondary user is the opportunistically access the spectrum. So the relationship between the primary and the secondary users are master-slave condition.

In a broadcasting service the frequencies are not used locally which is called “white spaces or spectrum holes”. The problem was solved by using the technique dynamic spectrum access. The white spaces are identified by the wireless nodes. This nodes are uses the spectrum and sensing the white spaces. So it will be occupied by the secondary users. So the primary user is not affected by the secondary users.

There are two major challenges of multi channel MAC of collision avoidance/resolution and channel access. Collision avoidance/resolution is received from conventional MAC. in recent year the new challenging issue of wireless communication is channel access negotiation. A new location is placed transmitter and receiver to negotiate the channel for implementation, before transmission.

CR MAC protocol has two approaches. They are (i) standardization efforts leading to the formation of the IEEE 802.22 working group and (ii)application scenario specific protocols. In the formation based approach is concentrate mainly on infrastructure based networks, in which the base station manages the spectrum allocation and spectrum sharing to the CR users. The next approach (application or scenario specific protocols) is optimized for a particular environment. This approach uses distributed CR MAC protocols, that operates without central station.

The remaining topics of this paper is follows, section II exists the channel model. Section III. The conclusion is given in section V

II. COGNITIVE CSMA BASED MAC PROTOCOL FOR CRN

In a cognitive radio network, multi channel selection is presented by using different users. It is processed by different time period. The multichannel plot is characterized by {R,N,q,C}. R indicates number of multichannel and N indicates number of CRs. Some primary systems are independently occupied by some secondary users. In our proposed system is presented alternative method of markov chain model. In this model the stationary probabilities of states of the model is,

Q^Tx = 0, $\sum_{i=1}^{n} x_i = 1$, x ≥ 0, (1)

Where the unknown x = ($x_1 \ldots \ldots x_n$) is a vector probabilities of states modelled system(x_i being the probability of *i*th state) and the matrix Q =(q_{ij}) is an infinitesimal generator (transition rate matrix) of the given Markov chain model. This method is better than Markov chain model. The alternative equation (1) is changed by,

$M^{-1}Q^T$x = 0, $\sum_{i=1}^{n} x_i = 1$, x ≥ 0, (2)

Where M is the non-singular matrix M (known as a preconditioner) approximates the matrix Q^T.

For example if the secondary user is check whether the primary is available or not. The primary user spectrum is already occupied by another secondary user so the current secondary user is not occupied by the same primary user. But the secondary user is not aware of the spectrum(already occupied primary user) condition. So the secondary user go to reserve the primary user spectrum. The collision is occurred in the primary user. The solution is the CR transmitter must predefined and locate its CR receiver before transmission.

III. SYSTEM MODEL

The proposed CSMA based method is using time slotted based CRN. Time is divided into frames. In the proposed method, first the spectrum is sensed and the channel availability is checked. In this MAC protocol transmission is the initial stage and ended within one frame in avoidance of interference with primary systems.

There are three phases followed in CSMA based MAC protocol, they are *sensing phase, contention phase and data transmission phase.*

In this technique the random number generator(RNG) is used. It is check whether the channel is available or not. RNGs MAC address is S_i and time (t).

The channel selection is

K = (RNG(S_i, t)mod M)

The sensing phase is designed to avoid collision between CRs and PSs. The CR users check the primary users spectrum is available or not. Each and every channel senses the location at beginning of the frame. If the primary user appears before the channel is occupied by the secondary user. Always the primary users have first priority to occupy the spectrum, so the secondary user is leave from the used spectrum.

The contention phase is proposed contention and collision method. The data transmission phase is proposed protocol utilizes RTSCTS/DATA/ACK four way handshake in CSMA/CA.

The proposed cognitive CSMA MAC protocol steps are given below:

Channel selection is performed by using RNG operator. Channel k is selected if

RNG(s,t) mod M = 0.

If the secondary user(S_T) is send in the packet means the receiver (S_R) side with probability p, set $s = S_R$

Else $s = S_T$

Primary user is detect using spectrum sensing on its currently locating channel (k) and update probability appearance (q).

If the primary user appears, use q_k and skip step (3) and (4)

Else update q_k.

CSMA contention phase is performed by using these steps. A backoff value is used in CR transmitter. The values occurred in between [0,N_{cw}], where N_{cw} is the contention window size. The backoff value is decremented one by one during each time slot. The CR is listening in this phase.

If the channel becomes busy before backoff value is 0, that gives transmission.

Else set S = 1.

Data transmission phase is defined by using four way handshake, before transmission.

If (S=1), sends RTS and transmit data after receiving CTS, then receiver sends ACK to transmitter after receiving CTS.

For CR_i successfully transmit its packet, the following condition is,

($x_i = 1$) CR_i decides to transmit.

The primary user is free from the selected channel(K = k)

CSMA contention (S = 1) with A = a and B = b channel transmitter.

Throughput optimization in the MAC protocol to find the optimal probability of transmission attempt p that maximizes the throughput.

$$R = \sum_{a=1}^{n} G(a) p^a (1-p)^{(N-a)}$$

Where,

$G(a)$

$$= \sum_{b=0}^{a} \sum_{k=1}^{M} \sum_{n=1}^{N_{cw}-1} \eta_k C_k (1-q_k) \left(\frac{1}{N_{cw}}\right) \left(\frac{N_{cw}-n+1}{N_{cw}}\right)^b \cdot \binom{N-1}{a-1} \binom{a-1}{b} \left(\frac{1}{M}\right)^{b+1} \left(\frac{M-1}{M}\right)^{a-b-1}$$

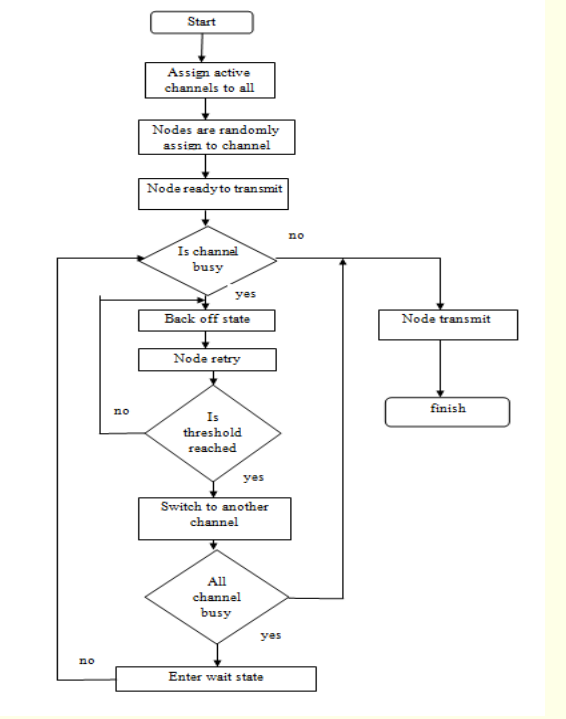
The optimization parameter p ϵ [0,1]

R is the aggregated throughput, N and q taken by the sensing function. η is defined by multichannel frame operation efficiencies η = $(\eta_k | k = 1,2 \ldots . M)$ $0 \leq \eta_k \leq 1$, a and b are the random variables, k is the channel, M is defined as number of multi channel and C is C= $\{C_k | k = 1,2, \ldots . . M\}$ capabilities over channel 1,2,....M variables.

IV. PERFORMANCE ANALYSIS

The channel assignment is assigned by using these steps in the flow chart. In order to analyze the efficiency performance of CSMA system, we make the following assumptions:

- ❖ Identify the secondary user initially.
- ❖ Initialize number of stations, simulation time, frame size, time scale for random motion.
- ❖ The user then checks whether the channel is available or not for a given simulation time.
- ❖ Then followed by distance calculation.
- ❖ If state is 0 then primary user is present else if state is 1 then secondary user is using the spectrum.
- ❖ Then it checks whether traffic is present or not.
- ❖ If traffic is not their then it formats the frame.
- ❖ Then senses the medium, if the medium is idle it transmits else if medium is busy it waits.
- ❖ If receiver received the frame successfully then sends acknowledgment to the sender.



The efficiency is calculated by
Where B is the busy period, I is the idle period, and U is the successful transmission time of the CR users. This three are the statistical average time sensed by CR users.

$$P_{T_l} = \frac{T - t_{scan}}{T} . P_c$$

Where T is defined as the spectrum detection cycle, t_{scan} is the sensing time, P_c is the probability of correct sensing result and α is the adjustment factor, α = 5×10^4.

$$P_c(t_{scan}) = e^{-\frac{\alpha}{t_{scan}}}$$

If T_{SU} and T_{co} as the time of successful transmission and failure transmission respectively.

T_{SU}=RTS+SIFS+DATA+CTS+DIFS

T_{co}=RTS+DIFS

Where SIFS and DIFS represent the shortest and longest Inter Frame space(IFS) respectively. Assume that λ_s is the average arrival rate, U can be given as,

U=$P_s(0,\tau_{max}) = e^{-\tau_{max}\lambda_s}T_{SU}$

Transmission packet length I can be given as,

$$I = \frac{1}{\lambda_s}$$

B can be expressed as

$$B = 2\tau_{max}\frac{(1-E)^2}{\lambda_s}\tau_{max}E + ET_{SU} + (1-E)T_{co}$$

Where E=$e^{-\tau_{max}\lambda_s}$

The efficiency is

Efficiency =$\frac{successful\ transmission}{total\ transmission}$

V. SIMULATION RESULTS

Performance of the proposed MAC protocol has been analysed through simulation using MATLAB version R2013a.

The results should be given in the tabular column

Primary user is idle or busy y/ n:y

Primary user is idle or busy y/ n:n

Primary user is idle or busy y/ n:y

Primary user is idle or busy y/ n:n

Primary user is idle or busy y/ n:y

Do you want to enter a secondary user Y/N: Y

Assigned to user 2 as it was not present

AWGN noise: y

Enter the SNR in dB: 50

User 1 is present

User 2 is not present

1. Number of stations:5
2. Simulation (slot time=2): 900
3. Frame size:5
4. Time scale for random motion(0-10):8
5. Range of each station:9

Total transmission:50

Successful transmission:41

Total collision:9

Unreachable packets:0

Total acknowledgement :37

Successful acknowledgement:25

Ackowledgement collision: 12

Unreachable acknowledement:0

Efficiency :0.8200

User 3 is present

User 4 is not present

1. Number of stations:5
2. Simulation (slot time=2): 900
3. Frame size:5
4. Time scale for random motion(0-10):8
5. Range of each station:9

Total transmission:50

Successful transmission:41

Total collision:9

Unreachable packets:0

Total acknowledgement :37

Successful acknowledgement:25

Ackowledgement collision: 12

Unreachable acknowledement:0

Efficiency :0.8200

User 3 is present

User 4 is not present

1. Number of stations:5
2. Simulation (slot time=2): 900
3. Frame size:5
4. Time scale for random motion(0-10):8
5. Range of each station:9

Total transmission:50

Successful transmission:41

Total collision:9

Unreachable packets:0

Total acknowledgement :37

Successful acknowledgement:25

Ackowledgement collision: 12

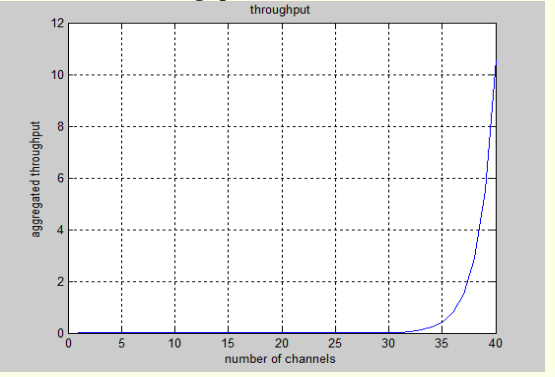
Unreachable acknowledement:0

User 5 is present

Do you want to attenuate the signals[Y/N]:y

Enter the percentage to attenuate the signal: 50

Throughput is calculated E



VII. CONCLUSION

The cognitive MAC protocol allows secondary users to identify and use the available frequency spectrum without imposing interference to the primary users. The proposed CSMA MAC protocol can sense and dynamically utilize the available frequency spectrum with better efficiency in terms of more successful transmission packets.

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