# A Multi-Channel MAC Protocol for Cognitive Radio

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## ABSTRACT

Opportunistic spectrum access (OSA) allows unlicensed users to share licensed spectrum in space and time with no or little interference to primary users, with bring new research challenges in MAC design. We propose a cognitive MAC protocol using statistical channel utilization information and selecting appropriate spectrum hole for multi-channel data transmission. The protocol based on the CSMA/CA, exploits statistics of spectrum usage for decision making on channel access.

## KEYWORD

MAC protocol, spectrum hole prediction, utilization function, multi-channel data transmission

## Ⅰ. INTRODUCTION

Currently, the concept of cognitive radio has been proposed to make use of the unused spectrum at a given time and place. In cognitive radio networks, unlicensed (secondary) users can make use of licensed frequency bands without violating the licensed (primary) users. Also in cognitive radio wireless ad-hoc networks, secondary users do not have pre-assigned frequency bands but they opportunistically search, find and operate in an available and without constraining the primary users [1].

In a appropriate cognitive radio MAC protocol, one of important issue is according to the sensing and channel statistical information, find the appropriate spectrum hole for second user.

Some proposed papers have given us some ways to design the cognitive MAC protocol. But they have less focus on the channel utilization statistical information [2]. We proposed a new cognitive radio MAC protocol for finding appropriate spectrum hole, and using it for second user multi-channel data transmission. The channel selecting algorithm will base on the series channel utilization statistical information exchanged in control channel. And we will make sure that the interference that is induced by second user transmission below an acceptable level.

The remainder of the paper is organized as follows. Section 2 presents our proposed protocol, section 3 provides throughput analysis, and in section 4, we will give the conclusion of our paper.

## Ⅱ. MULTI-CHANNEL MAC PROTOCOL

When the node A has packets that the length is $L$ intended to node B. node A listens to the control channel and waits until it becomes idle. Then, it waits for the channel to remain idle for DIFS duration before it begins the countdown of the contention window. If the channel is still idle after the contention window. A sends the RTS that includes the length of packet $L$ in the control channel.

When the node B receives the RTS packet, it begins to sense the data channels and find spectrum hole. For getting the spectrum hole time duration, we need use utilization in formation of primary user. Utilization of primary user can be got from environment sensing and learning. If we use the spectrum hole for transmission, the collision probability with the primary user must be below desired threshold $C_{th}$. The predicted time duration of spectrum hole is:

$$1-(1-utilizep(i))^{timep(i)} \leq C_{th} \quad (1)$$

Where, $utilizep(i)$ is the utilization of legacy user in the unit time. The $timep(i)$ is the predicted idle time according to the collision with legacy user.

The receiver calculates the predicted data length that the spectrum hole can transmit during the idle duration.

$$length(i)=time(i)*rate(i), i=0,1,...,m \quad (2)$$

Where, $time(i)$ is the predicted time duration of spectrum holes of each available channel. The $m$ is the number of available channels.

After calculating, we can get a sequence where from max to min. the receiver stop choosing the channel until

$$\sum_{0}^{K} length(i) > L, K < m \quad (3)$$

Where, $K$ is the number of channels that is used for data transmission.

After the receiver makes the decision, B sends CTS to A with selected channels information. Then the A receivers the CTS, and A switches from control channel to the selected data channel and transmit the data immediately.

If a collision happens on some selected channels, the data transmission will be stopped. After all selected channel's idle time duration expire, if all messages which length is L has been transmitted, the whole transmission is over. Otherwise, the algorithm go back to calculate the predicted idle time duration of spectrum hole, and continue to select other channel and renegotiate with destination.

## Ⅲ. THROUGHPUT ANALYSIS

In this paper, we use collision probability and system throughput to analysis performance of system. If there is an appearance of primary user when the unlicensed user transmitting the data, thus causing the collision. We use passion distribution to analysis the collision probability. Passion distribution is a discrete probability that express the probability of a number of events occurring in a fixed period of time, if these events occur with known average rate

$$f(k;\lambda) = \frac{\lambda^k e^{-\lambda}}{k!} \quad (4)$$

Where, $e$ is the base of the natural logarithm (usually $e=2.718$), $k$ is the number of occurrences, and $\lambda$ is the average rate in the unit time.

the collision probability can be calculated by

$$p_{ci} = \prod_{i=0}^{h} (1-f(0;\lambda_i)) \quad (5)$$

Where, $h$ is the number of selected channel that has the random traffic, and $\lambda_i$ is the utilization of the legacy user in the unit time.

So, the system throughput can be described as,

$$syth = \frac{\sum_{i=0}^{g} (t_i * (1-p_{ci}))}{\tau} \quad (6)$$

Where, $g$ is the number of channel that selected for data transmission, $\tau$ is the duration of whole data transmission, and $t_i$ is the duration of data transmission of each selected channel.

## Ⅳ. CONCLUSION

In this paper, we proposed a new MAC protocol in cognitive radio wireless network. By using channel utilization statistical function, we show the protocol model and algorithm. By collecting the channel statistical information, the appropriate spectrum hole can be selected for second user transmission. Through the throughput analysis, a better closed throughput result can be showed.

## REFERENCE

[1] DARPA ATO the next generation programs.

[2] H, Su and X, Zhang, "Cross-layer based opportunistic MAC protocols for QoS provisionings over cognitive radio wireless networks," IEEE Journal on Selected Areas in Communications, January,2008