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Cognitive Medium Access Exploration for Home Applications

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ABSTRACT

Since cognitive radio technology can significantly boost spectrum utilization by exploiting radio spectrum unused by licensed users, it is rapidly gaining popularity and inspiring numerous applications. However, many technical issues still need to be addressed for successful deployment of CR networks, especially in the MAC layer. In cognitive radio (CR) networks, medium access control (MAC) protocols play an important role to exploit the spectrum opportunities, manage the interference to primary users (PUs), and coordinate the spectrum access amongst secondary users (SUs). we Exploited the sensing of Medium Access Control (MAC) protocol for cognitive radio (CR) networks. We consider both scenarios with single and multiple channels. For each scenario, we developed algorithm using CSMA MAC protocol for dynamic spectrum sharing among multiple secondary users (SUs), which incorporates spectrum sensing for protecting active primary users (PUs). The channel sensing algorithm is done using CSMA protocol, the algorithm made as for three scenarios are single channel- single user analysis, single channel-multi user analysis and multi user single channel analysis. These algorithms are developed for sending the data from one node to another interms of packets without loss. These scenarios exploited for home applications.

Keywords—Medium Acess Control (MAC), Cognitive Radio (CR), Cognitive Medium Access, CSMA.

I.INTRODUCTION (*HEADING 1*)

Recent developments of wireless network technology bring us to expect new various applications such as mobile applications, the advanced traffic system, the disaster prevention system, and so on. Especially, in case of Disaster Information Network, wireless network is one of the best communication means because it is easily and quickly reconstructed even if some of the communication links and nodes are down just after a disaster.

In recent years, wireless and wired systems to communicate with other devices of the same ability have been one of the fastest-growing research areas. Significant progress has been made in many domains, such as machine-to-machine (M2M) communications, wireless sensor networks (WSNs), and wireless body area networks (WBAN) [1, 2]. Typically, M2M refers to the communications among computers, embedded processors, smart sensors, smart actuators, and mobile terminal devices without or with limited human intervention [3]. The rationale behind M2M communications is based on two

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observations: 1) a networked machine is more valuable than an isolated one; and 2) when multiple machines are effectively interconnected, more autonomous and intelligent applications can be generated. Therefore, the development of M2M communications generates a lot of new opportunities for information industry.

Most wireless networks are based on the IEEE® 802.11 standards. A basic wireless network consists of multiple stations communicating with radios that broadcast in either the 2.4GHz or 5GHz band, though this varies according to the locale and is also changing to enable communication in the 2.3GHz and 4.9GHz ranges. 802.11 networks are organized in two ways. In infrastructure mode, one station acts as a master with all the other stations associating to it, the network is known as a BSS, and the master station is termed an access point (AP). In a BSS, all communication passes through the AP; even when one station wants to communicate with another wireless station, messages must go through the AP. In the second form of network, there is no master and stations communicate directly. This form of network is termed an IBSS and is commonly known as an ad-hoc network.

Wireless communications will be fundamental in future Machine-to- Machine (M2M) pervasive environments where new applications are expected to employ sensing and actuating devices that are able to autonomously communicate without human intervention. M2M devices using wireless communications are expected to represent fundamental components of a future Internet where applications will allow users to transparently interact with its physical surroundings. The heterogeneity of the characteristics envisioned for M2M devices and applications calls for new approaches regarding how devices communicate wirelessly at the various protocol layers and how security should be designed for such communications. As such devices and communications are expected to support security-critical applications, the security of M2M wireless communications is particularly important. The architecture of M2M is shown in Figure 1.

This paper is further organized as follows: Section-II gives glimpse of the related work. Section-III gives the medium access exploration for home applications, Results are discussed in section-IV followed by conclusion in section-V and references.

Fig.1: M2M Architecture

II.RELATED WORK AND GOAL OF THE WORK

We are in the 21st century of fast and exponentially developing technology. From the invention of wheel to the utilization of satellite services there is exponential growth in technology which is drawing the attention of huge community of people, which in turn affecting the limited resources. As in the communication world, we are facing problems due to the limitation of the frequency band, that which cannot be created artificially. So, the only solution for this problem is to utilize frequency as effectively as possible by some methods like multiplexing the data, sharing the channel, compressing the data etc. So, every user of frequency is allotted or licensed with the limited amount of frequency which he should not cross, as of TV and Cellular bands etc. Due to this limitation in the frequency band availability, people are looking forward for the techniques which can solve their problems.

This thesis describes for the cognitive medium access exploration [6]. First, the scenario in which a single cognitive user wishes to opportunistically exploit the availability of empty frequency bands in the spectrum with multiple bands is considered. In this scenario, the availability probability of each channel is unknown to the cognitive user. Hence efficient medium access strategies must strike exploring availability of other free channels. By adopting a CSMA concept for this classical bandit problem, the optimal medium access strategy is derived. Next, the multi-cognitive user scenario is considered and low complexity medium access protocols, which strike the optimal balance between exploration and exploitation in such competitive environments, are developed. Finally, this formalism is extended to the case in which each cognitive user is capable of sensing and using multiple channels simultaneously.

The spectral opportunities available to the cognitive users are expected to be time-varying on different time-scales. For example, on a small scale, multimedia data traffic of the primary users will tend to be bursty [5]. On a large scale, one would expect the activities of each user to vary throughout the day. Therefore, to avoid interfering with the primary network, the cognitive users must first probe to determine whether there are primary activities in each channel before transmission. In CSMA, nodes sense the channel before each transmission. So it is important to implement channel sensing and backing off correctly in the code. Firstly, we get the head-of-line (HoL)[6] packets of each node into the queue.

Similarly, for scenarios in which the cognitive user can access more than one channel at a time or there are multiple cognitive users, our goal is to design strategies that maximize the throughput of the cognitive users, as detailed in the following sections.

A. Main goal and contributions:

In a first scenario, we assume the existence of a single cognitive user capable of accessing only a single channel at any given time. In this setting, we derive an optimal sensing rule that maximizes the expected throughput obtained by the cognitive user. Compared with a genie-aided scheme, in which the cognitive user knows the primary network traffic information a priori, there is a throughput loss suffered by any medium access strategy.

In a second scenario, we extend our work to the case in which the cognitive user is capable of accessing more than one channel simultaneously

In a third scenario, we design distributed sensing rules by which the cognitive users take the competition from other cognitive users into consideration when making sensing decisions. We first characterize the optimal distributed sensing rule for the case in which the primary network statistics are available to the cognitive users. Under this idealistic assumption, we show that the throughput loss of the proposed distributed sensing rule, compared with a throughput-optimal centralized scheme, goes to zero exponentially as the number of cognitive users increases.

I. MEDIUM ACCESS EXPLORATION FOR HOME APPLICATIONS With the emergence of a large number of new wireless

communication systems (e.g., digital video broadcasting, wireless local area networks, and wireless metropolitan area networks) and the explosive growth of network users, the demand for radio resources increases rapidly. However, some portions of the spectrum resources allocated to licensed network users are underutilized [3]. To address this spectrum scarcity issue, cognitive radio (CR) [7,10] can be used to implement dynamic spectrum access. In CR, a CR user or secondary user (SU) is enabled to access a spectrum hole (defined as a frequency channel that has been allocated to a licensed network but is unutilized at a particular time [10]). This improves the utilization of the licensed spectrum.

The design of medium access control (MAC) protocol for CR networks is challenging because the SUs should not interfere with high-priority primary users (PUs) when they are opportunistically using the spectrum channels for secondary transmissions. The multichannel-based MAC protocols have been widely studied for CR [12], which enables SUs to hop among the available frequency channels and then determine which channels should be accessed in order to utilize the spectral opportunities and complete the secondary transmission.

The carrier sensing multiple access (CSMA)-based MAC protocols have been widely used by SUs to share a common channel with PUs in a given primary network[12]. In [13], a CSMA-based MAC protocol is proposed for CR networks considering that the PUs are also operating with carrier sensing protocols. This protocol improves the CR network throughput by enabling possible secondary transmissions simultaneously during the transmissions of PUs. Another CSMA-based MAC protocol for CR networks, CR-CSMA, is proposed in [14], in which a novel two-level opportunistic spectrum access strategy is used in order to effectively schedule SUs' packet transmissions while protecting the PUs' transmissions. Moreover, the 802.11 distribution coordination function is also introduced into CR MAC protocols to support secondary transmissions.

A CR is allowed to make use of one of these channels when the channel is not occupied by a primary user. The primary users and CRs are both assumed to use a time slotted system, and each primary user is either present for the entire time slot, or absent for the entire time slot [16], [17]. Due to hardware constraints, at any given time each CR can either sense or transmit, but not both. Also, each CR can sense only one channel at a time.

A. CSMA:

Carrier sense multiple access (CSMA) is a probabilistic media access control (MAC) protocol in which a node verifies the absence of other traffic before transmitting on a shared transmission medium, such as an electrical bus, or a band of the electromagnetic spectrum. Carrier sense means that a transmitter uses feedback from a receiver to determine whether another transmission is in progress before initiating a transmission. That is, it tries to detect the presence of a carrier wave from another station before attempting to transmit. If a carrier is sensed, the station waits for the transmission in progress to finish before initiating its own transmission. In other words, CSMA is based on the principle "sense before transmit" or "listen before talk". Multiple access means that multiple stations send and receive on the medium. Transmissions by one node are generally received by all other stations connected to the medium.

In CSMA, nodes sense the channel before each transmission. So it is important to implement channel sensing and backing off correctly in the code. Firstly, we get the head- of-line (HoL) packets of each node into the queue. Then sort the queue packets by arrival time and check the interval between the first and second packets. If it is shorter than propagation delay (time sensitivity of machine node), the second node cannot sense the first packet, which means the two packets are colliding [11]. Then the colliding nodes back off a random time respectively and retransmit the packets. If the interval is longer than propagation delay but shorter than a complete transmission time (transmission delay of packet and acknowledgement plus two times of propagation delay), the posterior nodes[19] can sense the first packet and will not cause collisions. They just back off and keep sensing the channel. Finally, the first node sends the first packet and pushes the next one into the queue for next loop.

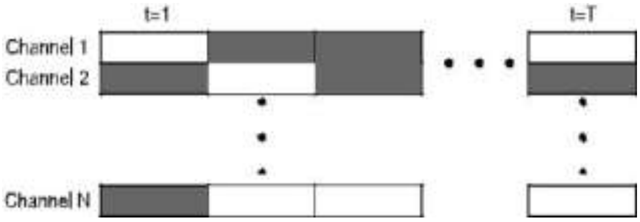

Fig.2: Channel model

A node wishing to transmit data has to first listen to the channel for a predetermined amount of time to determine whether or not another node is transmitting on the channel within the wireless range. If the channel is sensed "idle," then the node is permitted to begin the transmission process[11]. If the channel is sensed as "busy," the node defers its transmission for a random period of time. Once the transmission process begins, it is still possible for the actual transmission of application data to not occur. The channel model shown below

The basic Flow chart of CSMA [6] shown in Figure 3.

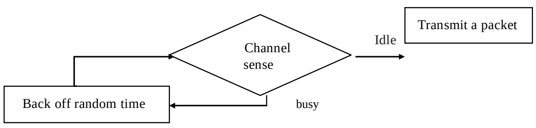

Fig. 3: Flow chart of CSMA

Initial parameters to known:

- Packet time
- Transmission time
- Propagation Delay

Packet time: It defines the time interval between two packets.

Transmission time: It is the amount of time from the beginning until the end of a message transmission. In the case of a digital message, it is the time from the first bit until the last bit of a message has left the transmitting node. The packet transmission time in seconds can be obtained from the packet size in bit and the bit rate in bits/s.

Propagation Delay: It is the amount of time it takes for the head of the signal to travel from the sender to the receiver. It can be computed as the ratio between the link length and the propagation speed over the specific medium.

Intuitively, the cognitive user would like to select that channel with the highest probability of being free in order to obtain more transmission opportunities. The cognitive user should choose the channel to sense. by accessing the channel with the highest estimated availability probability based on currently available information. Similarly, for scenarios in which the cognitive user can access more than one channel at a time or there are multiple cognitive users[13], our goal is to design strategies that maximize the throughput of the cognitive users, as detailed in the following sections.

For that consideration of data loss the algorithms written for without losing the data in terms of packets, there are mainly 2 scenarios.

a) Single user analysis

b) Multi user analysis

B. Single User analysis

1) Single channel cognitive user: A spectrum sensing scheme uses received signals to detect channel states, and it virtually predicts channel states in the near future simply using previous detected channel states. Intensive work on prediction for cognitive radio has been reported. Here data will sending in terms packets, so we are considering the packet times. Based on packet time the CSMA will works. The Flow chart for single user-single channel scenario shown in Figure 4.

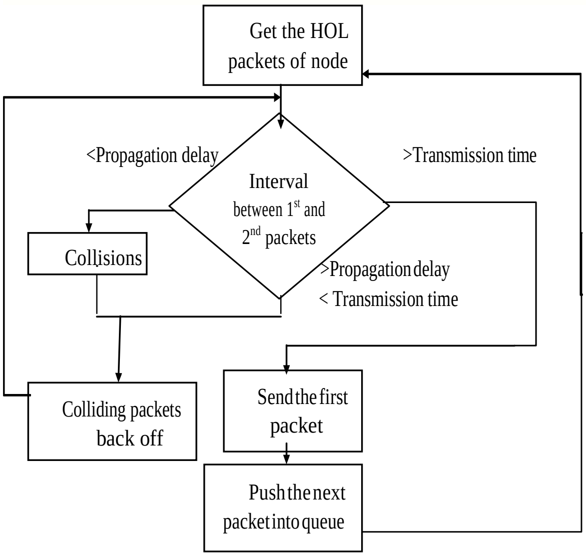

Fig. 4: Flow chart of single user

We start by developing the optimal solution to the single user-single channel scenario. In CSMA, nodes sense the channel before each transmission. So it is important to implement channel sensing and backing off correctly in the code. Firstly, we get the head-of-line (HoL) packets of each node into the queue. Then sort the queue packets by arrival time and check the interval between the first and second packets. If it is shorter than propagation delay (time sensitivity of machine node), the second node cannot sense the first packet, which means the two packets are colliding. Then the colliding nodes back off a random time respectively and retransmit the packets [6]. If the interval is longer than propagation delay but shorter than a complete transmission time (transmission delay of packet and acknowledgement plus two times of propagation delay), the posterior node can sense the first packet and will not cause collisions [6]. They just back off and keep sensing the channel. Finally, the node sends the first packet and pushes the next one into the queue for next loop. The result of single user-single channel analysis is in Section-IV.

Single channel Multipleuser: Intuitively, the cognitive user would like to select that channel with the highest probability of being free in order to obtain more transmission opportunities[18].In this scenario consider two conditions those are transmission time and propagation delay. Scan for the channels in order of higher probability of the channel availability. If the channel is not available scan for the next higher probability of channel[5], the channel is free send the packet through the free channel. After that calculate the time difference between the channel, if the time interval between two packets is less than transmission time and less than propagation delay then collision will occur[6],so packet will wait and goes to scan for the channel availability. If time interval between two packets is greater than transmission time, then packet send trough the same channel. The result of single user-multiple channels analysis is in section-IV. The Flow chart for single user-multiple channel scenario shown in Figure 5.

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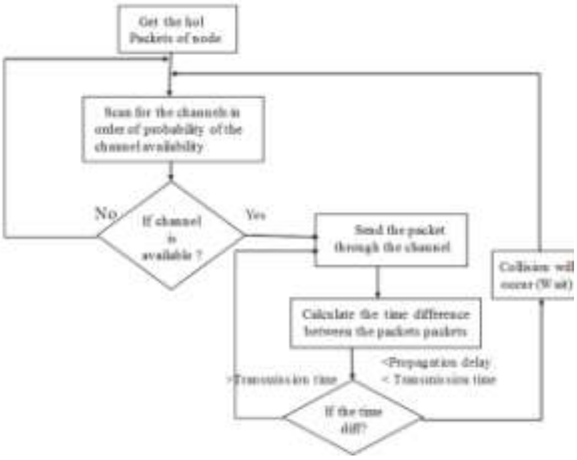

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive.”
- Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, cle
- arly state the units for each quantity that you use in anH.”
- Use a zero before decimal points: “0.25,” not “.25.” Use “cm3,” not “cc.” (*bullet list*)

Fig. 5: Flow chart of single channel single-user

C. Multi User User analysis

Here, we assume the presence of a set K= (1, ... k) of cognitive users and consider the distributed medium access decision processes of the multiple users with no prior coordination. The presence of multiple cognitive users[15] adds an element of competition to the problem. In order for a cognitive user to make use of a channel now, it must be free of the primary traffic and traffic from the other competing cognitive users. We start with a simpler situation in which each cognitive user can sense one channel[17] at a time We assume that the users follow a generalized version of the Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) protocol to access the channel after sensing the main channel to be free. The flow chart of Multi user-Single channel analysis shown in Figure 6 below. In this scenario all packet times of the all nodes arranged in ascending order, and calculate the time difference between the packet times. If the time difference between the packets is less than propagation delay and less than the transmission time collision will occur, the packet waits and goes to the up. If the time difference between the packets is greater than the transmission time then scan for the channel availability, if the channel is free send the packet through the

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channel. If channel is not available wait and scan for channel availability.

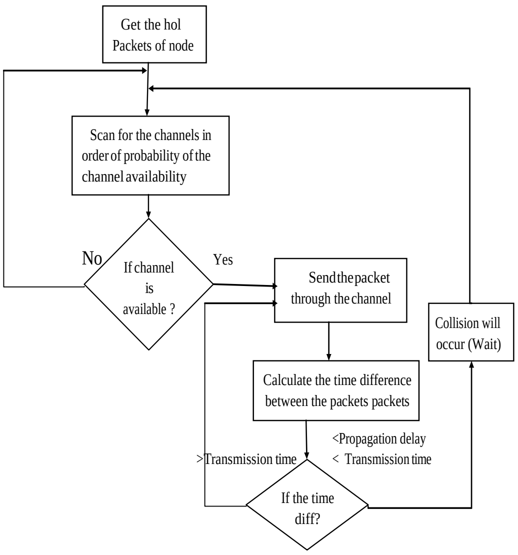

Fig. 6: Flow chart of multi channel-single user

III.RESULTS AND COMPARISONS

A. Single user-Single Channel Analysis:

In this analysis the data sends in terms of packets. Here we are considered packet times as [0.7,0.9,0.95,1.12,1.19]. The data was transferred without losing the packets, here we are sending five packets and received packets are also five. So from this scenario we are sending the data without losing the packets. The program for Single user-Single Channel Analysis is in chapter 3.5.1. The single user-single channel analysis for five packets shown below.

Sensing Channel Packet sent is 2
Collision occurred at packet 3 Sensing Channel
Sensing Channel Sensing Channel Sensing Channel Sensing Channel Packet sent is 3 Sensing Channel Packet sent is 4 Sensing Channel
Number of packets in sent : 5

B. Single user-Multi Channel Analysis:

The result of the Single user-Multi channel Analysis as shown below. The algorithm was developed sending the packets without losing. Here sending 50 packets and the channels are 20, the busy channels are taken as 4, The total packets have been sent through the different channels. The tabular form shows the which packet sending through which channel. The program of Single user-Multi channel Analysis is in chapter 3.5.2. The below shown Graph is for packet vs channel, i.e which packet sending data through the which channel.

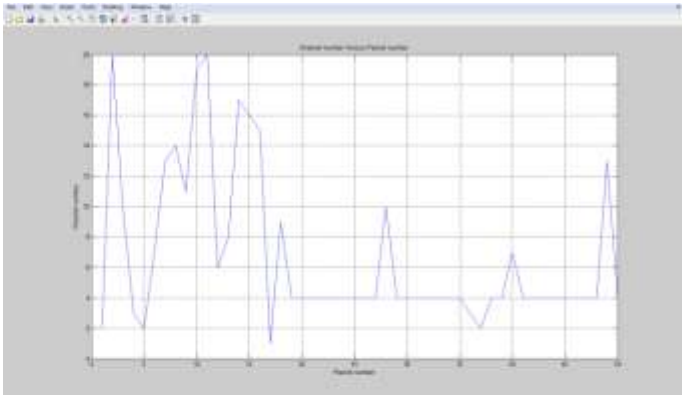

Fig.7: Result of Multi user-single channel analysis(packets vs channel)

C. Single user-Multi Channel Analysis:

The result of Multi User-Single Channel Analysis is shown below. Here we are considered for three users, each user of five packets, so total packets are 15. The five packets contains five packet times. Here the packet times are randomly considered. The total packets are send through the channel without losing any packet. Below shown as packet times arranged in ascending order and which packet belongs to which node.

Packet sent is 1 of node 2 Packet sent is 2 of node 1 Packet sent is 3 of node 3 Packet sent is 4 of node 3 Packet sent is 5 of node 1
Collision occurred at packet 6 of node 2 Packet sent is 6 of node 2
Packet sent is 7 of node 2 Packet sent is 8 of node 3 Packet sent is 9 of node 3 Packet sent is 10 of node 1
Collision occurred at packet 11 of node 2 Packet sent is 11 of node 2
Packet sent is 12 of node 1 Packet sent is 13 of node 1 Packet sent is 14 of node 3 Packet sent is 15 of node 2
Congratulations.............!!!!!!!!!!!!!!!!!!! ur message has been sent.......... Number of packets in ur message is : 15

D. Comparison:

The result of 3 scenarios shown above, from that we observed the data loss is not there. Here exacta scenario is created of multi user analysis in exacta is shown below. In this scenario data loss (packet loss) is occur. Here five nodes considered each node sending 1920 bytes data so total data is 9600 bytes and the received data is 6720 bytes , the data loss will occurred due to the interference of the channel.

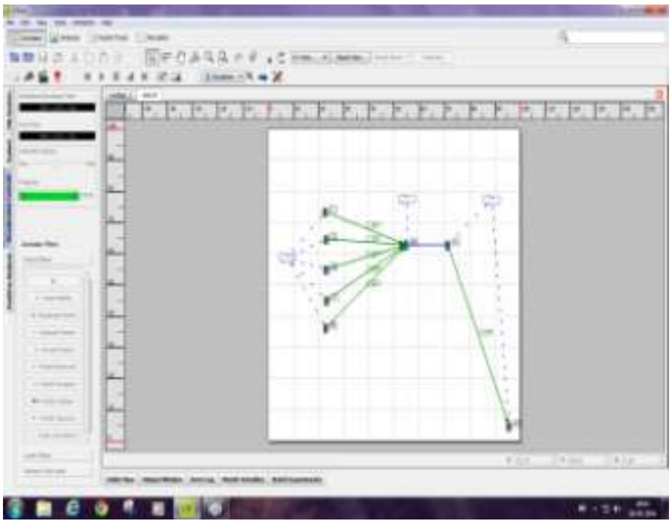

Fig.8: Exacta scenario for multi user case

IV.CONCLUSION

In this paper, channel sensing algorithms are developed for single user and multi user analysis. The main aim of the project is to send the data without losing the packets. The algorithms developed sending the data from one node another is M2M communication using CSMA protocol of MAC layer.

This work has taken a first step in the design and analysis of cognitive medium access operating in uncertain environments, based on the classical bandit problem. In the single user scenario, our formulation is inspired by the equivalence with the multi armed bandit problem. This equivalence is used to highlight the trade-off between explorations in cognitive channel selection. The multiuser analysis has also been formulated, as a competitive bandit problem enabling the design of efficient and game theoretically fair medium access protocols. These ideas have also been extended to the multichannel scenario in which the cognitive user is capable of sensing and utilizing several channels simultaneously.

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