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Analysis of MAC protocol for Cognitive Radio Wireless Sensor Network (CR-WSN)

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Abstract - *Todays' spectrum environment faces so many challenges but the spectrum scarcity is one of the most critical problem. To solve this problem effectively, Cognitive radio is a perfect technology identifying the vacant portion of the spectrum and also ensuring that primary users are not affected at all. In sensor network it is reasonable to adopt cognitive radio capability, which ultimately yields a new sensor networking paradigm, i.e. cognitive radio wireless sensor network (CR-WSN). MAC protocols helps CR nodes to access the channel and use the white space very effectively. It also ensures that spectrum dynamics are not so high and much tighter interaction are required by MAC protocols.*
***Key Words*: Cognitive radio, wireless sensor network, MAC protocol, CR-WSN**

1. INTRODUCTION

Cognitive radio word came from the noun "Cognition". It is the mental process involving knowing, learning and understanding the things. Current researches are investing different techniques of using cognitive radio to reuse more locally unused spectrums to increase the total system capacity. Cognitive radio is the smart and intelligent wireless communication system which is aware of its surrounding environment. The main goal of cognitive radio network is to use the unallocated band very intelligently without interfering the licensed users. There are many advantages of wireless sensor network. We can combine the cognitive radio and wireless sensor network i.e.CR-WSN. Wireless sensor network has normally large deployment area to work with the tremendous nodes. That's why by combining them we can achieve more features and also very effectively. It has also the ability of self-organizing and lifetime of wireless sensor nodes which is very important.

We know there are different layers for some particular purposes for achieving tasks. First is Physical layer, second is data link layer, third is network layer, forth is transport layer and then presentation and application layers. We will work on MAC layer which comes in category of data link layer. The function of data link layer is to provide the connection between hosts on the same network. Sublayer of data link layer is LLC and MAC. And we focus on the particular mac protocol for the cognitive radio that's why we call it COGMAC protocol.

2. BRIEF OVERVIEW OF COGNITIVE RADIO TECHNOLOGY

Cognitive radio (CR) integrate radio technology and networking technology to provide efficient use of radio spectrum. CR is proposed as a mean to implement efficient reuse of licensed spectrum to overcome the problem of traffic scarcity. In cognitive radio network there are generally two types of users, primary users (PUs) and secondary users (SUs). PUs have the authority to access the channel as long as they require. Whenever there is no need of spectrum at all PUs can lease their spectrum to other users which is also called cognitive users or SUs. SUs can use the shared spectrum without any interference to PUs.

2.1 General Architecture of Cognitive Radio

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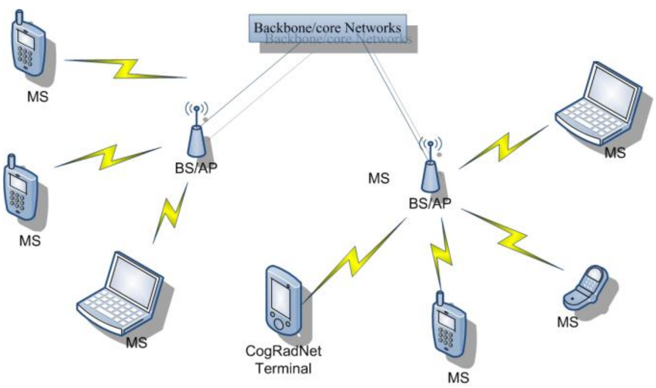

Fig -1: infrastructure architecture [4]

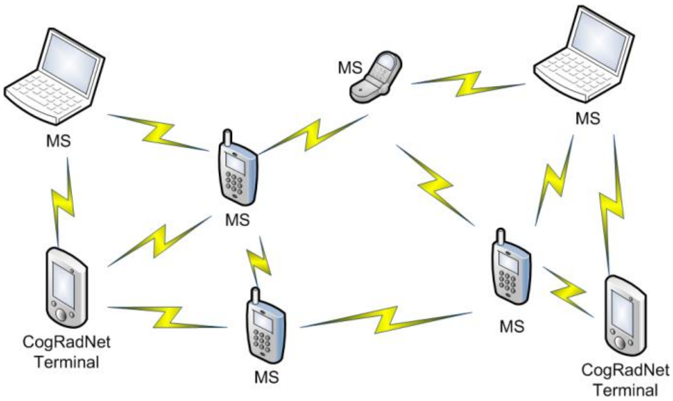

Fig -2: ad-hoc architecture [4]

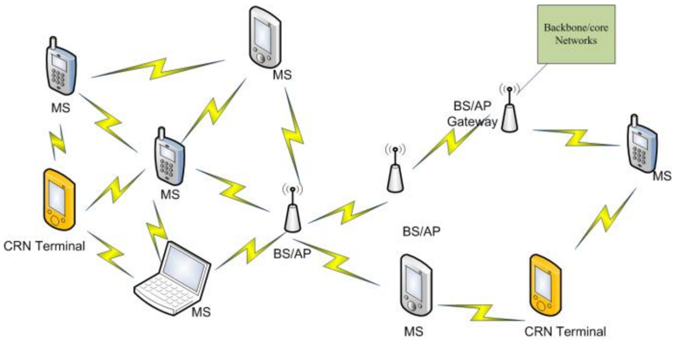

Fig -3: mesh architecture [4]

3. WIRELESS SENSOR NETWORK

Wireless Sensor Network (WSN) is made up of a set of spatially distributed autonomous sensors aiming to monitor physical as well as environmental condition. The autonomous sensors are equipped with radio transceiver to enable wireless communication among different wireless sensor nodes. The architecture of WSN is look like as shown in fig.4. WSN consists of hundreds of WS nodes deployed throughout the sensor field. The distance among the nodes are generally a few meters. Sink node / base station is responsible for the collecting the data from the WS nodes in single hop or multi hop manner. Sink node then sends the collected data to users via a gate-way, internet , routers and any other way.

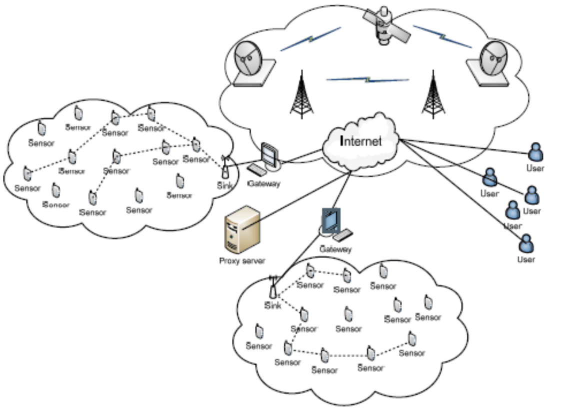

Fig -4: conventional wireless sensor network [6]

4. COGNITIVE RADIO WIRELESS SENSOR NETWORK

Cognitive Radio Wireless Sensor Network (CR-WSN) is defined as distributed network of wireless sensor nodes, which sense an event signal and collaboratively communicate dynamically over the available spectrum bands in multi hop manner. In CR-WSN nodes selects the most appropriate channel once an idle channel is detected, identify it and vacate the channel when the licensed users arrives. CR-WSN increase the spectrum utilization, also look after fulfillment after end-to-end connection also increase the efficiency of the system.

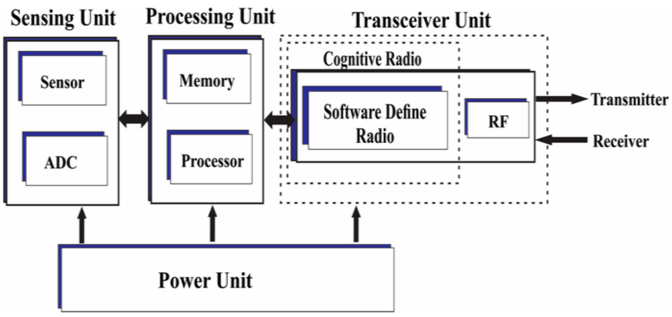

Fig -5: hardware structure of CR-WSN [6]

5. CLASSIFICATION OF CR MAC PROTOCOL

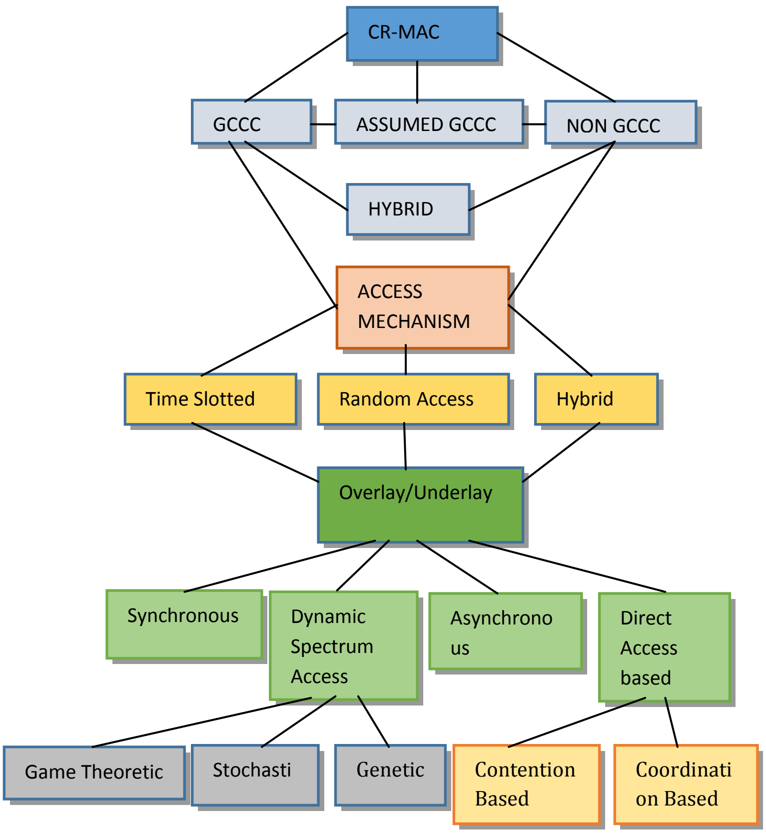

Fig -6: classification of CR-MAC protocol

6. INTRODUCTION of COGMAC PROTOCOL

COGMAC is a decentralized cognitive mac protocol, which is based on MPR scheme. It is designed to efficiently utilize the performance characteristics of PU. Conventional mac protocols require common control channels but the noticeable advantage of COGMAC is that it does not require any MAC protocol. COGMAC is suitable for both licensed as well as unlicensed band.In situation where accurate spectrum opportunities are hard to predict and cooperation from PU is unlikely, decentralize MAC protocols are desirable. The goal of our MAC solution is to provide a simple learning based distributed MAC protocol that is able to choose a new channel in weighted manner if vacating an existing channel for a PU is required.

6.1multichannel preamble reservation (MPR)

Basically MPR scheme is adopted to solve the rendezvous problem and guarantee seamless transmission. For that it requires the receiving node continuously sense all available channels to detect potential transmissions. The set of available channels as a channel is called as pool of a node. That's why the operation of sequentially sensing these channels is called as a pool sensing. The transmitting node is supposed to send multiple copies of the same frame back-to-back so that we can occupy the channel. Therefore that nodes are able to detect its transmission during the pool sensing. Transmitting the same frame repetitively is termed as a repetitive frame transmission. As shown in the figure, both RX1 and RX2 detect the transmission and successfully receive at least one complete frame. But the problem is that it takes too long time to complete the process. This problem can be solved by another protocol which is called COGMAC+ protocol.

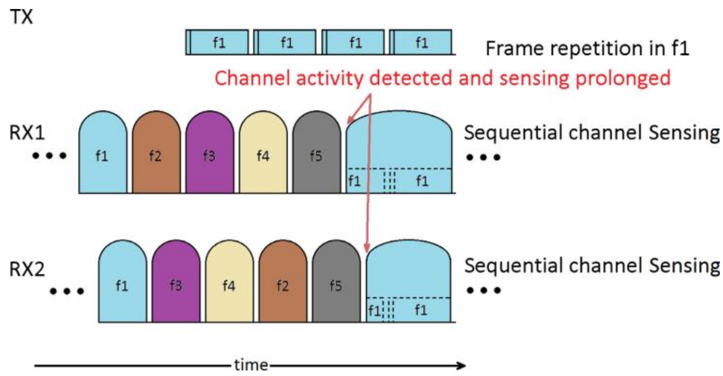

Fig -7: MPR scheme [(7)]

7.COGMAC+ PROTOCOL

COGMAC+ uses an adaptive energy detection scheme to dynamically set the energy detection threshold according to the carrier sensing status, the false positive ratio and the estimated noise level. Efficiently support high data traffic we have to minimize the frame repetition. COGMAC+ continuously transmits frames without any repletion after the reserving channel, it is called aggregation transmission.

7.1multichannel multi-frame transmission (MMT)

We can overcome the challenge of high data traffic by MMT scheme. In that we give some bound to the parameter then try to procced further. In this protocol we use frame based analysis which gives better performance. We derive several bounds to optimize the protocol performance and achieve better protection to Pus protection. MMT scheme is just upgraded version of MPR scheme.

Considering the minimal duration between two successive frames inter_Fr, we have,

$$N_{PU} = \frac{t_{PU-}\ t_{RX\_mode} - t_{TX\_mode} + t_{inter\_FR}}{t_{Fr} + t_{inter\_FR}} \quad (1)\ [7]$$

Where NPU denotes the upper bound of the number of frames that are allowed to be transmitted in one PU allowance interval. To avoid missing repetitive frame transmission, the duration of CCA1 operation has to be lower bounded as below,

$$t_{CCA1} > t_{TX\_mode} + t_{RX_{mode}} + t_{CCA2} \quad (2)\ [7]$$

7.2 CCA based random back-off scheme

Channel Collision Avoidance (CCA) is generally used to avoid the collision which is one of the very serious problem. In that nodes have to wait for a random time. COGMAC+ choose the duration of (CCA1 + channel switching duration) as the unit time of random back off scheme. This scheme improves portability of the protocol.

7.3 noise floor estimation

Whenever carrier sensing is performed, Noise Floor Estimation (NFE) is carried out. Generally it is used to compare the power level of received carrier with the predefined threshold.

When a low detection threshold, there is large detection range which can enables devices to cooperate which has low transmit power or long distance.so that it causes high false positive frame detection ratio and ultimately it causes unnecessary delay. Unnecessary delay also create problem.

When a high detection threshold, there is lower communication range, which is also one category of disadvantage. Therefore appropriate threshold should be applied to every devices. Fix detection threshold is also ineffective and unmovable.

For that we have one solution is false positive detection ratio and detecting range, while keeping protocol stable at run-time. This requires no priory-knowledge of noise and external transmission. It allows node to dynamically adjust the threshold based on parameters.

There are two methods, first is real time Noise Floor Estimation (NFE) and second is Adaptive Energy Detection Threshold Adjustment (AEDTA). In NFE method, NFE updates noise level during carrier sensing operation if channel is determined idle. In AEDTA, it continuously reduces the threshold to increase detection range. The principle of both performs when the channel is idle.

8.SUMMARY

In this paper, we present an overview of the medium access protocols in cognitive radio networks. Cognitive radio increase spectrum utilization and communication quality with opportunistic spectrum access capability and adaptability to the channel conditions. These silent features can also be exploited in resource-constrained sensor networks. Moreover, multiple channel availability provided by cognitive radio capabilities can be used to overcome the problems caused by the dense deployment and busty communication nature of sensor network.

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