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A STUDY ON SOME MAC PROTOCOLS

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Abstract:-

Wireless sensor networks (WSNs) are recently rapidly growing research in wireless communications. In WSNs, a large number of tiny sensor nodes are deployed arbitrarily over the considered area to form a network. It has various range of application potentials in areas such as environmental monitoring, military surveillance, intruder detection, industrial process monitoring, target detection and tracking, and tactical systems. However, as they are spread in areas with difficult terrain and to achieve full coverage of area there are large number of wireless sensors used, but it is difficult to replace their batteries once exhausted. Energy conservation is needed especially at MAC layer level. A large number of MAC protocols were proposed for wireless sensor networks. In this paper we first outline the sensor network properties which are required for the design of MAC layer protocols. Here we describe some MAC layer protocols with their advantages and disadvantages.

Keywords: - Wireless sensor network, MAC layer, Energy waste, Communication pattern.

1. INTRODUCTION

In wireless sensor networks, communication can be dividing it into several layers like most network communication. One of those is the Medium Access Control (MAC) layer. This layer can be described by MAC protocols.

Wireless Sensor Networks (WSN) consist of a large number of battery operated sensors. These sensors are consist of a single chip with embedded memory, processor, and transceiver. As sensor nodes are battery operated, so energy consumption is very important. In a sensor node, it always has a radio which uses most energy. Not only transmitting costs energy; receiving, or merely scanning the ether for communication, can use up to half as much, depending on the type of radio [1].

MAC protocols are designed in such a way that it can maximize packet throughput, minimize latency and provide fairness, protocol design for wireless sensor networks focuses on minimizing energy consumption [1].

Protocols for wireless sensor networks need to be extremely adaptable and scalable because of constant changes in network topology. If high energy-efficiency demands are also considered, it becomes clear that the design of MAC protocols for WSN is a difficult task [2].

2. SENSOR NETWORK PROPERTIES OF MAC LAYER

The common objective of sensor network research is to increase the network lifetime to maximum, as nodes are assumed to be discarded when there battery is exhausted. Under these situations, the

discussed MAC protocol should be energy efficient by reducing the potential energy wastes presented in section II.A. Types of communication patterns that are observed in sensor network applications should be investigated since these patterns are used to extract the behaviour of the sensor network traffic that has to be handled by a given MAC protocol which are discussed in section II.B.

A. Reasons of Energy Waste

Ilker Demirkol et al. [3] and Wei Ye et. al. [4] describes the various reasons of energy wastes. There are several reasons for the energy wastes as described here. When a receiver node receives more than one packet at the same time, these packets are called "collided packets" even when they coincide partially. To increase the energy consumption, all packets that cause the collision have to be discarded and the re-transmissions of these packets are needed. Although some packets could be recovered by a capture effect, a number of requirements have to be achieved for its success. Overhearing is an another reason of energy waste, i.e. a node receives packets which are actually for other nodes. Control packet overhead is an another reason of energy waste. Overheads are control packets which are used to maintain and manage the transmission of data .To make a proper data transmission minimum number of control packets are needed. Idle listening is a very important reason of energy waste, idle listening means listening to an idle channel to receive possible traffic.

B. Patterns of communication

Ilker Demirkol et al. [3] defines three types communication patterns in wireless sensor networks: broadcast, convergecast, and local gossip. First we discuss broadcast type of communication pattern where a base station or sink transmits some data to all sensor nodes of the network. Broadcasted information may include requests of sensor query-processing architectures, program updates for sensor nodes, control packets for the whole system [3]. The broadcast type communication pattern should not be confused with broadcast type packet [3]. In the another type of communication pattern termed as convergecast where some sensors first receive information from neighbouring nodes then transmit their findings to a specific sensor. Last communication pattern is called local gossip where a sensor communicate with its neighbouring nodes within a range. Following the above scenario, the sensors that detect intruder and different activities need to send what they perceive to the information center.

C. Required properties of a Well-defined MAC Protocol

To design a Well-defined Protocol for wireless sensor network , some parameters have to be considered . The first parameter can be considered as energy efficiency . To increase the lifetime of a network energy efficient protocols are needed.

Other important parameters are change in network size, changing dynamics of environment and node density. MAC protocol which is efficient should adapt to these characteristics. Some other properties are delay, throughput and bandwidth efficiency etc.

3. STUDY OF SOME MAC PROTOCOLS

In this section, some important MAC protocols defined for sensor networks are described briefly by stating the essential behaviour of the protocols wherever possible.

1) Sensor-MAC (S-MAC)

S-MAC protocol basically follow synchronizations and periodic sleep listen schedules which are controlled locally by the sensor network. In S-MAC, generally

nearby nodes form virtual clusters to set up a common sleep schedule. This means that if two nodes are adjacent to each other and if two neighbouring nodes reside in two different virtual clusters, they wake up at listen periods of both clusters. This also results in more energy consumption as nodes wake up to two different schedules. The schedules are also needed to be communicated to different nodes of virtual cluster which is accomplished by SYNC packets and time in which it is sent is known as synchronization period. Figure 1 represents a sample sender receiver communication. CS stands for carrier sense method of collision avoidance. After that, RTS/CTS can perform unicast data packets transmission.

An innovative feature of S-MAC is the idea of message-passing where long messages are sent in burst by dividing it into small messages. With this method, energy consumption can be reduced by minimizing communication overhead. In case of multi-hop routing algorithms periodic sleep may cause high latency, since all neighbouring nodes have their own sleep schedules. This is known as sleep delay. This disadvantage can be overcome by using adaptive listening technique. In that technique, the overhearing adjacent nodes wake up for a small period of time at the end of the transmission. So, if this node is the next-hop node, it can take the data immediately from the transmitting/passing node.

Advantages: Sleep schedule has the capability of reducing energy waste, which is caused by idle listening and it can prevent time synchronization overhead.

Disadvantages: Collision can occur because broadcast data packets do not use RTS/CTS. Adaptive listening incurs overhearing or idle listening if the packet is not destined to the listening node [3]. Under variable traffic load, efficiency of the algorithm will decrease because of predefined and constant Sleep and listen periods.

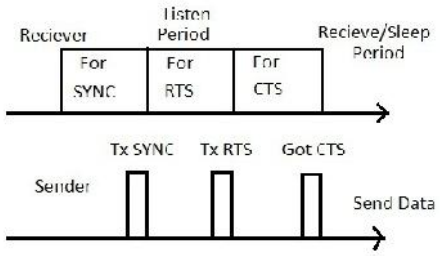

Figure 1: Sensor MAC Protocol

2) Berkeley-MAC(B-MAC)

Berkeley Media Access Control for Low-Power Sensor networks. B-MAC reduces idle listening by an adaptive preamble. When a node has a packet to send, it waits during a back- off time before checking the channel. If the channel is idle, the node transmits otherwise it begins a second back-off.

Each node much check the channel periodically with the help of Low power listening. A node returns to sleep mode if it finds a channel idle but it has no data to send. Figure 2 illustrates one example transmission using B-MAC.

The B-MAC preamble sampling scheme adjusts the interval in which the channel is checked to equal the frame preamble size [5]. As an example, if the medium is checked every 100 ms, the preamble of the packet must last 100 ms as a minimum, in order for the receiver to detect the packet. Upper layers may change the preamble duration, according to the application requirements [5].

Advantages: B-MAC does not use RTS, CTS, ACK, or any other control frame by default, but they can be added. B-MAC can be tested in hardware. Higher layers can tuned the protocol performance to meet the needs of various applications and it requires no synchronization.

Disadvantages: The preamble creates large overhead.

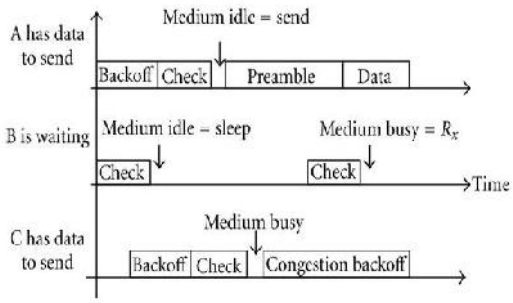

Figure 2: Berkeley MAC Protocol

3) Predictive Wake-UP MAC (PW-MAC)

PW-MAC [6] improves on protocols like S-MAC and B-MAC because it uses pseudo random schedules. To avoid collision, not all nodes will wake up and transmit at the same time. When nodes wake up, it sends a short beacon to all the nodes so that other nodes know it is up. After doing this a sender can transmit a data packet and request more information from the receiver such as current time and current seed for the pseudo random schedule used by receiver. By using the seed in a linear congruential generator (LCG), sender in PW-MAC can predict when a receiver will wake up; hence sender sleeps a little bit before the receiver is awake[6]. PW-MAC uses a compensating value called "sender wake-up advance time"[6],which is particular to clock drift, operating system delay, and hardware latency. The value helps correcting errors which occur during prediction of receiver's wake up time by a sender.

Advantages: The duty cycle of the sender will decrease because it continues it's sleeping mode until the receiver will up effectively. This protocol has been tested on hardware, using MicaZ motes, and memory footprint is small.

Disadvantages: PW-MAC include overhead created by beacons and idle listening.

CONCLUSIONS

For sensor network, there are many MAC layer protocol proposed, but no protocol is accepted as standard. One of the reasons behind this is the MAC protocol choice will be application-specific, which means that there will not be single standard MAC for sensor networks. Major area which needs attention is the extension of network life which is dependent on utilization of battery with as much efficiency as possible. So more efficient MAC protocols have to be developed.

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