Volume 4, Issue 5, May 2014 ISSN: 2277 128X

International Journal of Advanced Research in Computer Science and Software Engineering

Research Paper

Available online at: www.ijarcsse.com

Survey on MAC Layer Protocol in WSN

Neeraj Kumar*
M.tech Scholar, ECE Department
Vaish College of Engineering
India

Vaibhav Jain
Asst. Prof. ECE Department
Vaish College Of Engineering
India

Abstract— WSNs are an emerging technology that has become one of the best growing areas in the communication industry. They consist of sensor nodes that use low power consumption which are powered by small replaceable batteries that collect real-world data, process it, and transmit the data by radio frequencies to their destination. The node has limited resources, like limited processing capability, Limited memory and limited battery, energy and etc. Therefore, Energy management is a challenging problem in designing a Wireless Sensor networks protocols. Medium access protocols provide the greatest influence over communication mechanisms and provide the most direct influence over the utilization of the transceiver, the largest energy consumer in most sensor nodes. This paper presents a survey of the most recent works regarding MAC protocols for applications of wireless sensor networks. It presents two main groups of the MAC protocols, e.g. a contention-based and a TDMA-based (schedule-based).

Keywords— Wireless Sensor Network, MAC Protocol, TDMA,CSMA,S-MAC.

I. INTRODUCTION

WSN (Wireless sensor networking) is an emerging technology that has a wide range of potential applications including environment monitoring, smart spaces, medical systems and robotic exploration. Such a network normally consists of a large number of distributed nodes that organize themselves into a multi-hop wireless network. Each node has one or more sensors, embedded processors and low-power radios, and is normally battery operated. Typically, these nodes coordinate to perform a common task.

There are a lot of resource constraints for these Sensors, and energy must be conserved in order to function properly when needed. The most energy consuming task or operation in sensor networks is when they coordinate among themselves i.e communication or data transmission. Most the research is focused on the design of low power electronic devices so that the energy consumption the sensors should be minimized. In order to overcome the limitations in the hardware, further efficiency can be achieved through the design of energy efficient communication protocols. To ensure the successful operations of the network one of the most important techniques is Medium Access Control (MAC). MAC protocol tries to avoid collisions from interfering nodes, which is considered as one of the main function of these protocols. Most of the energy is wasted during the idle listening period by the classical IEEE 802.11MAC protocol for wireless local area network. One of the ways to prolong the life time of the network is to design energy efficient MAC protocols[2].

II. MAJOR SOURCES OF ENERGY WASTES

Major sources of energy waste in wireless sensor network are basically of four types [3]:

- **A.** *Collision:* The first one is the collision. When a transmitted packet is corrupted due to interference, it has to be discarded and the follow on retransmissions increase energy consumption. Collision increases latency also.
- **B.** *Overhearing:* The second is overhearing, meaning that a node picks up packets that are destined to other nodes.
- **C.** *Packet Overhead*: The third source is control packet overhead. Sending and receiving control packets consumes energy too and less useful data packets can be transmitted.
- **D.** *Idle listening:* The last major source of inefficiency is idle listening i.e., listening to receive possible traffic that is not sent. This is especially true in many sensor network applications. If nothing is sensed, the sensor node will be in idle state for most of the time. The main goal of any MAC protocol for sensor network is to minimize the energy waste due to idle listening, overhearing and collision.

III. ATTRIBUTES OF A GOOD MAC PROTOCOL

To design a good MAC protocol for the wireless sensor networks, the following attributes are to be considered [4].

- **A.** *Energy Efficiency:* The first is the energy efficiency. The sensor nodes are battery powered and it is often very difficult to change or recharge batteries for these sensor nodes. Sometimes it is beneficial to replace the sensor node rather than recharging them.

B. *Latency:* The second is latency. Latency requirement basically depends on the application. In the sensor network applications, the detected events must be reported to the sink node in real time so that the appropriate action could be taken immediately.

C. *Throughput:* Throughput requirement also varies with different applications. Some of the sensor network application requires sampling the information with fine temporal resolution. In such sensor applications it is better that sink node receives more data [4].

D. *Fairness:* In many sensor network applications when bandwidth is limited, it is necessary to ensure that the sink node receives information from all sensor nodes fairly. However among all of the above aspects the energy efficiency and throughput are the major aspects. Energy efficiency can be increased by minimizing the energy wastage.

IV. MAC LAYER PROTOCOLS

A wide range of MAC protocols defined for sensor networks are described briefly by stating the essential behavior of the protocols wherever possible. The medium access control protocols for the sensor networks can be classified broadly into two categories: Contention based and Schedule based.

A. *Contention Based*

The contention based protocols on the other hand relax time synchronization requirements and can easily adjust to the topology changes as some new nodes may join and others may die few years after deployment. These protocols are based on Carrier Sense Multiple Access (CSMA) technique and have higher costs for message collisions, overhearing and idle listening [2].

1) IEEE 802.11

The IEEE 802.11 [5] is a well known contention based medium access control protocol which uses carrier sensing and randomized back-offs to avoid collisions of the data packets. The Power Save Mode (PSM) of the IEEE 802.11 protocol reduces the idle listening by periodically entering into the sleep state. This PSM mode is for the single-hop network where the time synchronization is simple and may not be suitable for multi-hop networks because of the problems in clock synchronization, neighbour discovery and network partitioning [3].

2) Sensor-MAC (S-MAC)

Locally managed synchronizations and periodic sleep listen schedules based on these synchronizations form the basic idea behind the Sensor-MAC (S-MAC) protocol [6,7]. Neighboring nodes form virtual clusters to set up a common sleep schedule. If two neighboring nodes reside in two different virtual clusters, they wake up at listen periods of both clusters. A drawback of S-MAC algorithm is this possibility of following two different schedules, which results in more energy consumption via idle listening and overhearing.

Schedule exchanges are accomplished by periodical SYNC packet broadcasts to immediate neighbors. The period for each node to send a SYNC packet is called the synchronization period. Fig 1 represents a sample sender-receiver communication. Collision avoidance is achieved by a carrier sense, which is represented as CS in the figure. Furthermore, RTS/CTS packet exchanges are used for unicast type data packets. An important feature of S-MAC is the concept of message-passing where long messages are divided into frames and sent in a burst. With this technique, one may achieve energy savings by minimizing communication overhead at the expense of unfairness in medium access. Periodic sleep may result in high latency especially for multi-hop routing algorithms, since all immediate nodes have their own sleep schedules. The latency caused by periodic sleeping is called sleep delay in [6]. Adaptive listening technique is proposed to improve the sleep delay, and thus the overall latency. In that technique, the node who overhears its neighbor's transmissions wakes up for a short time at the end of the transmission. Hence, if the node is the next-hop node, its neighbor could pass data immediately. The end of the transmissions is known by the duration field of RTS/CTS packets.

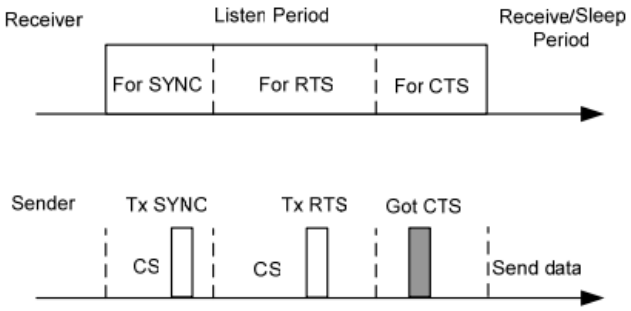

Fig 1: S-MAC Messaging Scenario[7]

3) PAMAS

Power Aware Multi-Access [8] is one of the earliest contention based MAC protocol designed with energy efficiency as the main objective. In this protocol nodes which are not transmitting or receiving are turned "OFF" in order to conserve energy. This protocol uses two separate channels for the data and control packets. It

requires the use of two radios in the different frequency bands at each sensor node leading to the increase in the sensors cost, size and design complexity. Moreover, there is significant power consumption because of excessive switching between sleep and wakeup states [2].

4) Timeout-MAC (T-MAC) / Dynamic Sensor-MAC (DSMAC)

Static sleep-listen periods of S-MAC result in high latency and lower throughput as indicated earlier [7]. Timeout MAC (T-MAC) [9] is proposed to enhance the poor results of S-MAC protocol under variable traffic load. In T-MAC, listen period ends when no activation event has occurred for a time threshold TA. The decision for TA is presented along with some solutions to the early sleeping problem defined in
[9]. Variable load in sensor networks are expected, since the nodes that are closer to the sink must relay more traffic. Although T-MAC gives better results under these variable loads, the synchronization of the listen periods within virtual clusters is broken. This is one of the reasons for the early sleeping problem.

Dynamic Sensor-MAC (DSMAC) [10] adds dynamic duty cycle feature to S-MAC. The aim is to decrease the latency for delay-sensitive applications. Within the SYNC period, all nodes share their one-hop latency values (time between the reception of a packet into the queue and its transmission). All nodes start with the same duty cycle.

Fig 2 conceptually depicts DSMAC duty cycle doubling. When a receiver node notices that average one-hop latency value is high, it decides to shorten its sleep time and announces it within SYNC period. Accordingly, after a sender node receives this sleep period decrement signal, it checks its queue for packets destined to that receiver node. If there is one, it decides to double its duty cycle when its battery level is above a specified threshold.

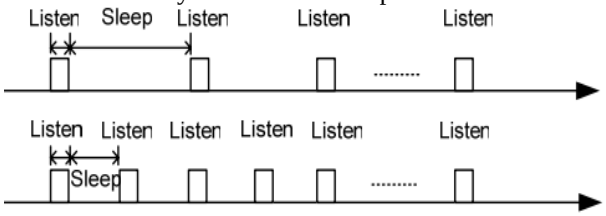

Figure 2:DSMAC duty cycle doubling

B. *Scheduled Based*

The schedule based protocol can avoid collisions, overhearing and idle listening by scheduling transmit & listen periods but have strict time synchronization requirements.

1) Traffic Adaptive Medium Access Protocol (TRAMA)

The traffic adaptive medium access (TRAMA) [11] is a Contention based protocol that has been designed for energy efficient collision free channel in WSNs. In this protocol the power consumption has been reduced by ensuring collision free transmission and by switching the nodes to low power idle state when they are not transmitting or receiving. This protocol consists of three main parts [2]:

- **i.** The Neighbor Protocol is for collecting the information about the neighboring nodes.
- **ii.** The Schedule Exchange Protocol is for exchanging the two – hop neighbor information and their schedule .
- **iii.** The Adaptive Election Algorithm decides the transmitting and receiving nodes for the current time slot using the neighborhood and schedule information. The other nodes in the same time slot are switched to low power mode.

The TRAMA is shown to be more energy efficient and has higher throughput than Sensor S-MAC protocol. However, the latency of TRAMA is more as compared to the other contention based MAC protocol such as SMAC and IEEE 802.11. This protocol may be suitable for applications which are not delay sensitive but require higher energy efficiency and throughput [2].

2) *Wise MAC*

The Wise MAC [3] medium access control protocol was developed for the "Wise NET" wireless sensor network. This protocol is similar to Spatial TDMA and CSMA with Preamble Sampling protocol [12] where all the sensor nodes have two communication channels. TDMA is used for accessing data channel and CSMA is used for accessing control channel. However, Wise MAC needs only one channel and uses non-persistent CSMA with preamble sampling technique to reduce power consumption during idle listening. This protocol uses the preamble of minimum size based on the information of the sampling schedule of its direct neighbors. The sleep schedules of the neighboring nodes are updated by the acknowledgement message (ACK) during every data transfer. Wise MAC is adaptive to the traffic loads
and provides low power consumption during low traffic and high energy efficiency during high traffic.
The simulation results show that Wise MAC performs better than S-MAC protocol[3].

3) Berkeley a Access Control (B-MAC)

The Berkeley Media Access Control (B-MAC) [13] is a contention based MAC protocol for WSNs. B-MAC is similar to Aloha with Preamble Sampling [14], which duty cycles the radio transceiver i.e. the sensor node turns ON/OFF

repeatedly without missing the data packets. However in B-MAC, the preamble length is provided as parameter to the upper layer. This provides optimal trade-off between energy savings and latency or throughput.

V. CONCLUSIONS

WSNs have emerged as one of the dominant technology trends of this decade that has potential usage in defense and scientific applications. These WSNs can be used for different purposes such as target tracking, intrusion detection, wildlife habitat monitoring, and climate control and disaster management. A typical node in the WSN consists of a sensor, embedded processor, moderate amount of memory and transmitter/receiver circuitry. Medium access control (MAC) is an important technique that ensures the successful operation of the network. One of the main functions of the MAC protocol is to avoid collisions from interfering nodes. There are several medium access control protocols for the wireless sensor network have been proposed by the researchers. However, no protocol is accepted as standard. This is because the MAC protocol in general will be application specific. Therefore, there will not be one standard MAC protocol for the WSNs. We describe several MAC protocols for the WSNs emphasizing their strength and weakness wherever possible.

REFERENCES

[1] Ye, Wei, John Heidemann, and Deborah Estrin. "An energy-efficient MAC protocol for wireless sensor networks." INFOCOM 2002. Twenty-First Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings. IEEE. Vol. 3. IEEE, 2002.

[2] Salman Faiz Solehria, Sultanullah Jadoon, "Medium Access Control Protocol for Wireless Sensor Network – a Survey", IJVIPNS-IJENS Vol: 11 No: 03, June 2011.

[3] Rajesh Yadav, "ASURVEY OF MAC PROTOCOLS FOR WIRELESS SENSOR NETWORKS", UbiCC Journal, Volume 4, Number 3, August 2009.

[4] Neha Trivedi, G. Kuamr, Teena Raikwar, "Survey on MAC Protocol for Wireless Sensor Network", Volume 3, Issue 2, February 2013.

[5] IEEE Standard 802.11. Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications (1999).

[6] W. Ye, J. Heidemann, D. Estrin, "Medium Access Control With Coordinated Adaptive Sleeping for Wireless Sensor Networks", IEEE/ACM Transactions on Networking, Volume: 12, Issue: 3, Pages:493 - 506, June 2004

[7] Demirkol, Ilker, Cem Ersoy, and Fatih Alagoz. "MAC protocols for wireless sensor networks: a survey." Communications Magazine, IEEE 44.4 (2006): 115-121.

[8] Singh and C. Raghavendra: PAMAS: Power Aware MultiAccess Protocol with Signaling for Ad-hoc Network, ACM SIGCOMM Computer Communication Review (July 1998).

[9] T.V. Dam and K. Langendoen, "An Adaptive Energy-Efficient MAC Protocol for Wireless Sensor Networks", The First ACM Conference on Embedded Networked Sensor Systems (Sensys'03), Los Angeles, CA, USA, November, 2003.

[10] P. Lin, C. Qiao, and X. Wang, "Medium access control with a dynamic duty cycle for sensor networks", IEEE Wireless Communications and Networking Conference, Volume: 3, Pages: 1534 - 1539, 21-25 March 2004.

[11] V. Rajendran, K. Obraczka and J.J. Gracia- Luna-Aceves: Energy Efficient, Collision Free Medium Access Control for Wireless Sensor Networks, in ACM International Conference on Embedded Networked Sensor Systems (SenSys), pp. 181-192 (November 2003).

[12] A. El-Hoiydi: Spatial TDMA and CSMA with Preamble Sampling for Low Power Ad-hoc Wireless Sensor Network, Proceedings of ISCC '02, Seventh International Symposium on Computers and Communications, pp. 685-692 (July 2002).

[13] J. Polastre, J. Hill, D. Culler: Versatile low Power Media Access for Wireless Sensor Networks, Proceedings of the 2nd ACM Conference on Embedded Networked Sensor Systems (SenSys'04), Baltimore, MD, (November 2004).

[14] A. El-Hoiydi: Aloha with Preamble Sampling for Sporadic Traffic in Ad-hoc Wireless Sensor Networks", in Proceedings of IEEE International Conference on Communications (April 2002).

