International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 5 Issue: 5 662 – 665

Medium Access Control Protocols for Wireless Sensor Networks: A Study

Shivali Dhaka
Department of Computer Science
Amity University,
Gurgaon, India
shivi359@gmail.com

Abstract- Wireless Sensor Networks (WSN) is an interconnection of different sensor nodes deployed over geographical areas to communicate with each other and guiding the information of target to base station via sensor and sink nodes [1]. For exploiting the prospective benefits of WSNs requires a high-level of self-organization into a multi-hop wireless network, proficiency and coordination among the sensors to accomplish the jobs required to upkeep the underlying application. For multi-hop wireless network to work requires neighboring sensor nodes to communicate with each other through air in form of electromagnetic signal. All sensor nodes must share this common transmission medium in aunbiased and rational manner. This paper discusses the overview and fundamental design issue of Medium Access Protocol used in shared medium.

Keywords: *Wireless Sensor Network; Carrier Sense Multiple Access;Medium Access Protocol; Logical Link Control; Open System Interconnection.*

*****

I. INTRODUCTION

Interaction among wireless sensor nodes is usually attained by means of a unique channel. In this unique channel only a single node can transfer a message at any given time. So to avoid collision and giving chances to all nodes for sending a message through shared common medium requires the establishment of a MAC protocol among the sensor nodes [2]. The main aim of the MAC protocol is to control access to the shared wireless medium to satisfy the performance necessities of several applications. The data link layer in OSI model is divided into two sub-layers: higher sub layer, logical link Control (LLC) and lower sub layer Medium Access Control (MAC). Lower layer of Data link layer controls MAC protocol [3].

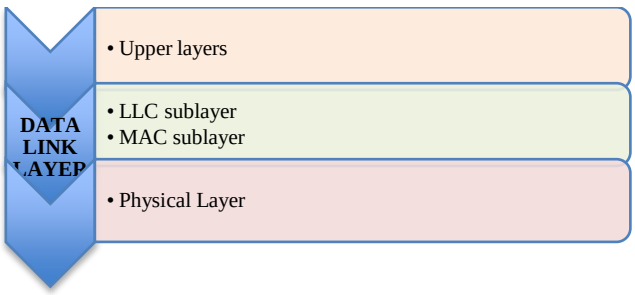

Figure 1. Sub layers of Data Link Layer in OSI model

The foremost inconvenience in planning effective MAC protocols for shared access media arises from the spatial dispersal of the communicating nodes. The nodes must coordinate with each other in some sense to decide which would access the shared channel first [5]. For maintaining coordination they need to listen to each other through use of communication channel itself. This increases the intricacy of the access control protocol and the overhead required to regulate access among the competing nodes. Two main aspects, the intelligence of the decision made by the access protocol [4] and the overhead involved show the impact on the collective behavior of a distributed multiple- access protocol.

II. PERFORMANCE PARAMETERS

The metrics like Delay, throughput, robustness and energy efficiency are some of themain issues dealt by MAC protocols as they directly affect the functioning of networks. These parameters are essential to achieve for the smooth and collision-free network[6]. Delay varies not only on the network traffic load, but also on the design selections of the MAC protocol. Two categories of delay guarantees are there, probabilistic and deterministic. Probabilistic delay guarantees are usuallyconsists of expected value, a variance and a confidence interval. Deterministic delay guarantees confirmsaexpectable number. Throughput is typically defined as the rate at which messages are overhauled by a communication system [7]. A critical objective of a MAC protocol is to amplify the channel throughput while curtailing message delay. Robustness, defined as a permutation of reliability, availability, and dependability requirements, refers to the extent to which protocol is not affected by errors, as it is a multidimensional activity. Energy efficiency is one of the most imperative concerns in the design of MAC protocol for wireless sensor nodes [8]. There are different sources of energy consumptionin Wireless Sensor Networks among which Collision, idle

 ISSN: 2321-8169
662 – 665

listening, overhearing and frequently switching are some of the main causes. To avoid affecting these factors on the network require generations of energy efficient algorithms and different schemes that will help in increasing lifetime of network and will help in avoiding wastage of energy sources. Besides these main parameters scalability and stability also affect the whole network in some extent. Scalability is the capability of network to handle growing amount of work and achieving scalability is very difficult in case there is millions of sensor nodes spread over larger geographical areas. But by localizing interactions among sensor nodes and aggregating information strategies scalability can be achieved. Stability is achieved by handling fluctuations of traffic load over sustained period of times[9]. For this MAC protocols have to adapt to high fluctuations in traffic load through cautious planning of bursty traffic. Below is table showing different parameters affecting Wireless sensor networks and the solution offered by MAC protocols to achieve their 100 percent.

TABLE I. PERFORMANCE PARAMETERS OF WSN

Parameters	Definition	Problem	Solution
DELAY	Time spent by data packets in MAC layer before Transmission	Essential to meet QoS requirements.	MAC protocols support delay-bound guarantees
THROUGHPUT	Rate of servicing messages measured in msgs/sec or bits/sec	As load increases, throughput decreases	Maximize the fraction of channel capacity used for data transmission.
ROBUSTNESS	Refers to the extent to which protocol is not affected by errors.	Achieving robustness is difficult as it depends on failure models of communication modes.	Redundancy should be there in all connecting links between communicating nodes.
ENERGY EFFICIENCY	To increase efficiency of network by increasing its lifetime	Direct impact on lifetime of sensor node.	To increase efficiency of network by increasing its lifetime.

III. MAC METHODS AND PROTOCOLS

The essential criterion for determining the performance of a WSN is selection of best Method and Protocols used by MAC that helps in solving the shared medium access problem [10]. These approaches can be categorized in three main classes: fixed assignment, demand assignment, and random assignment.

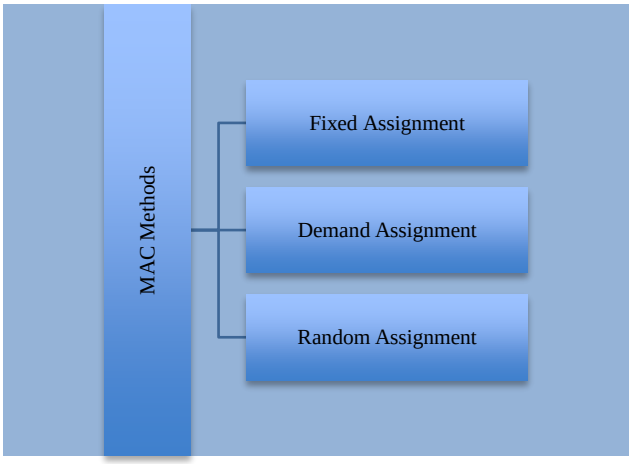

Figure 2. Different methods of MAC

A. Fixed-Assignment Protocols

In fixed-assignment schemes, each node is assigned a predestined fixed quantity of the channel resources. Each node uses its assigned resources exclusively and there is no competition with other nodes. Protocols that come under this protocols include frequency-division multiple access (FDMA), time-division multiple access (TDMA), and code-division multiple access (CDMA).

B. Demand Assignment Protocols

It assigns the capacity of the channel to contending nodes in an optimum or near-optimum way to exploit the channel in efficient way. Unlike fixed-assignment schemes, where channel capacity is allocated exclusively to the network nodes in a predetermined way regardless of their current communication requirements, demand assignment protocols ignore idle nodes and take into consideration only nodes that are ready to transmit. The channel is allocated to the node for a time that may vary from fixed-time slot to the time it takes to transmit a data packet. Polling and reservations are two techniques used in Demand assignment protocols.

C. Random Assignment Protocols

For the bursty traffics the above schemes does not do well and also lead to the wastage of allocated bandwidth when node remains idle. Random assignment method tries to address this shortcoming by excluding pre-allocation of bandwidth to communicating nodes. Random assignment methods neither practice any control to determine the elective communicating node that can access the medium next nor assign any predictable time for any node to transmit [11]. To prevent collisions, the protocol uses different mechanisms for channel access.Random assignment method

 ISSN: 2321-8169
662 – 665

uses three types of protocols- ALOHA (Pure ALOHA and Slotted ALOHA), CSMA/CA (Carrier sensing multiple access/ collision avoidance), CSMA/CD (Carrier sensing multiple access/ collision detection).

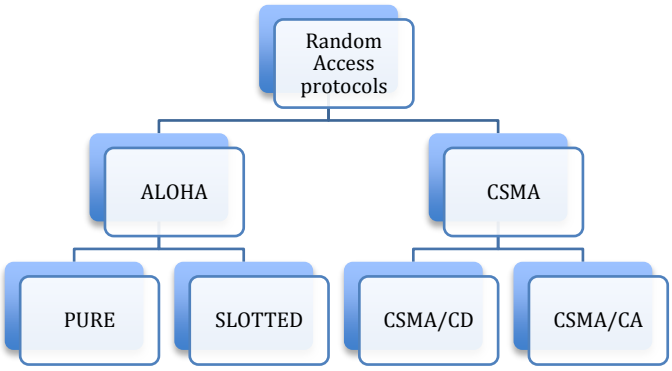

Figure 3. Sub-techniques of Random Access Protocols

a) *ALOHA*

It is a simple random assignment protocol developed to control access to a shared transmission medium among uncoordinated contending users. Channel access in pure ALOHA is completely asynchronous and independent of the other nodes on the transmission medium. A node is just permitted to send data whenever it is ready to do so. Upon finalizing the data transmission, the node under communication process listens for a period of time equal to the lengthiestfeasible round-trip propagation time on the network. To increase performance and efficiency of pure ALOHA, slotted ALOHA was proposed. In Slotted ALOHA method, all communication nodes are synchronized and all data packets to be transmitted have the same length [12]. Besides, the communication channel is separated into uniform time slots whose duration is equal to the transmission time of a data packet and transmission can happen only at a slot boundary. Subsequently, collision can happen only in the beginning of a slot.

b) *Carrier Sensing Multiple Access (CSMA)*

In this technique, station which is ready to transmit first ‘‘listens’’ to the channel to determine if it is idle or not.The CSMA method can result in less average delays and more throughput than with the ALOHA protocols [13]. This betterment in performance is basically due to the point that carrier sensing lessons the frequency of collisions and critically the duration of the collision interval. CSMA is further categorized into two sub-techniques- Carrier Sensing Multiple Access CSMA with collision detection (CSMA/CD) and Carrier Sensing Multiple Access with collision avoidance (CSMA/CA).

- *CSMA/CD:* Allthe networks using CSMA/CD allow the communicating nodes to listen while transmitting. This permits the node to observe the signal on the channel and find a collision when it occurs. Particularly, if a node wants to send the data, it first listens to conclude if there is any other transmission going over the communication channel. In case it found the channel idle, the node starts transmitting its data and continues to observe the signal on the channel while transmitting. When a collision occurs, every station involved in collision waits for a random period of time before retransmission of packet.An algorithm called binary exponential back off determines that random period of time. CSMA/CD lacks in the need to provide sensor nodes with collision detection capabilities as they have a very restricted amount of space, processing power, and source of energy.
- CSMA/CA: Another form of CSMA is CSMA/CA that acts to prevent collisions before they occur. Itproliferates the network traffic as it necessitates sending out a signal to the network even before transmitting any data packet. This is to listen for any collision happening in the network and simultaneously informing other devices not to transmit.

The table below shows the comparison between the main characteristics of all three-sub techniques of Random Access Protocols depicting their role in preventing collision during transmission of data

TABLE I. PERFORMANCE PARAMETERS OF MAC PROTOCOLS

Random Protocols / Parameters	Pure ALOHA	Slotted ALOHA	CSMA	CSMA/CD	CSMA/CA
Coordination among users	NO	YES	YES	YES	YES
Asynchronous Channel Access	YES	YES	NO	NO	NO
Central Control	NO	NO	YES	YES	YES
Collision frequency	HIGH	HIGH	MED	LOW	LOW
Sensing the channel	NO	NO	YES	YES	YES
Short collision interval	NO	NO	NO	YES	YES
Wastage of bandwidth	YES	YES	YES	NO	NO
Transfer of data after collision	HIGH	HIGH	MED	LOW	LOW
RTS/CTS handshake to remove collision	NO	NO	NO	NO	YES

IV. CONCLUSION

As Wireless Sensor Network is a large network consisting of millions of sensor nodes communicating with each other, sending data to base stations via sink nodes. But for these nodes to communicate with each other, they require a common shared medium that is controlled by MAC protocols. Among these protocols, while ALOHA is just useful in only transmitting data without detecting collision, CSMA helps in both transmitting as well as detecting the collision of nodes under communication. With help of these MAC protocols, the devices under Wireless sensor networks are able to communicate efficiently and with increased performance.

REFERENCES

[1] H. Li, P. Shenoy and K. Ramamritham, "Scheduling Messages with Deadlines in Multi-Hop Real-Time Sensor Networks," *Proceedings of IEEE Real Time and Embed- ded Technology and Applications Symposium*, 7-10 March 2005, pp. 415-425.

[2] R. Rugin, G. Mazzini, "A simple and efficient MAC-routing integrated algorithm for sensor network", IEEE International Conference on Communications, Volume: 6, Pages: 3499 - 3503, 20- 24 June 2004

[3] C. C. Enz, A. El-Hoiydi, J-D.Decotignie, V. Peiris, "WiseNET: An Ultralow-Power Wireless Sensor Network Solution", IEEE Computer, Volume: 37, Issue: 8, August 2004.

[4] V. Rajendran, K. Obraczka, J.J. Garcia-Luna-Aceves, "Energy- Efficient, Collision-Free Medium Access Control for Wireless Sensor Networks", Proc. ACM SenSys 03, Pages:181 - 192, Los Angeles, California, 5-7 November 2003.

[5] L. Bao and J.J. Garcia-Luna-Aceves, "A New Approach To Channel Access Scheduling For Ad Hoc Networks", Seventh Annual International Conference on Mobile Computing and Networking, pp. 210–221, 2001.

[6] K. Jamieson, H. Balakrishnan, and Y. C. Tay, "Sift: A MAC Protocol for Event-Driven Wireless Sensor Networks," MIT Laboratory for Computer Science, Tech. Rep. 894, May 2003, http://www.lcs.mit.edu/publications/pubs/pdf/MIT-LCS-TR-894.pdf.

[7] Y.C. Tay, K.Jamieson, H. Balakrishnan, "Collision-minimizing CSMA and Its Applications to Wireless Sensor Networks", IEEE Journal on Selected Areas in Communications, Volume: 22, Issue: 6, Pages: 1048 – 1057, Aug. 2004.

[8] G. Lu, B. Krishnamachari, C.S. Raghavendra, "An adaptive energy- efficient and low-latency MAC for data gathering in wireless sensor networks", Proceedings of 18th International Parallel and Distributed Processing Symposium, Pages: 224, 26-30 April 2004.

[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] A. Safwat, H. Hassanein, H. Mouftah, "ECPS and E2LA: new paradigms for energy efficiency in wireless ad hoc and sensor networks", IEEE Global Telecommunications Conference, GLOBECOM'03, Volume: 6, Pages: 3547 - 3552, 1-5 December 2003.

[12] S. Cui, R. Madan, A. J. Goldsmith, and S. Lall, "Joint Routing, MAC, and Link Layer Optimization in Sensor Networks with Energy Constraints", to appear at ICC'05, Korea, May, 2005.

[13] J. Ding, K. Sivalingam, R. Kashyapa, L. J. Chuan, "A multi-layered architecture and protocols for large-scale wireless sensor networks", IEEE 58th Vehicular Technology Conference, 2003, VTC 2003-Fall 2003, Volume: 3, Pages:1443 - 1447, 6-9 Oct. 2003.