DOI: http://dx.doi.org/10.26483/ijarcs.v11i4.6691

Volume 11, No. 4, July-August 2020

ISSN No. 0976-5697

International Journal of Advanced Research in Computer Science

SURVEY PAPER

Available Online at www.ijarcs.info

# SURVEY ON MAC PROTOCOLS FOR WIRELESS SENSOR NETWORKS

Putri Kevin
Department of Computer Science,
Brahijaya University, Indonesia

*Abstract:* Wireless sensor networks are alluring for analysts because of the broad scale of applications in different disciplines. Nevertheless, low sensing ranges aggregates to impenetrable networks, as a consequence it has become mandatory to attain a reliable medium access protocol. A variety of medium-access control (MAC) protocols with various intentions have been suggested for wireless sensor networks. In this survey, we will provide an overview of the sensor network characteristics that are important for the structure of MAC layer protocols. Later, we will delineate different MAC protocols suggested for sensor networks, highlighting their strengths and weaknesses. Eventually, we will explain open research challenges concerning MAC layer design.

*Keywords:* wireless sensor network, MAC protocol, sensor nodes, communication protocol, coverage.

## I. INTRODUCTION

Development in hardware technology has evolved for cheap sensor nodes, which consist of a single chip attached with a memory, a processor, and a transceiver. Low-power supplies result in restricted coverage and communication range for sensor nodes. Incompatible with other wireless networks, it is usually complicated or non-viable to restore depleted batteries. As the communication of sensor nodes is more power engrossing than their computation, it is foremost concern to lower communication while attaining the desired network operation [1-2]. Nevertheless, the medium-access decision inside a dense network consists of nodes with low duty-cycles is a huge problem that must be resolved in an energy-systematic manner [3].

Sometimes, few sensor nodes in WSN are equipped with GPS which also helps in localization process. These nodes are called beacons, anchors, locators or seeds. Based on this criterion, localization algorithms can be divided into anchor based and anchorless algorithms [4]. The above mentioned four approaches centralized, distributed, range free and range based can either be anchor based or anchor less depending upon the algorithm. The IEEE 802.5 LAN and MAN reference model also explain the MAC as a sublayer of data link explained in OSI model as shown in figure 1.

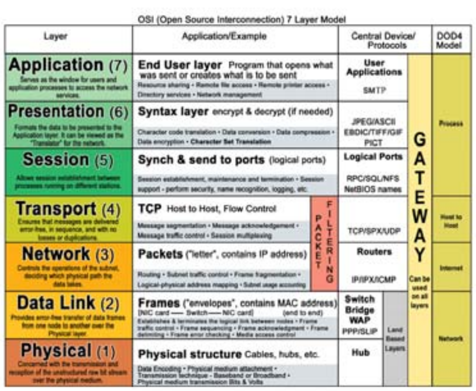


Figure 1. OSI infrastructure in WSN model

The MAC and OSI structure in given in routing scenarios will have to merged in random network deployment. For wireless communication different standard exist like cellular telephony, satellite communications, LAN, WAN and broadcast radio [5-7].

## II. PROPERTIES OF SENSOR NETWORK FOR MAC

Extending the network life period is a common purpose of sensor network research. The variety of communication patterns should be examined because these patterns control the behavior of sensor network flow. Under this situation, the suggested MAC protocol must be energy-saving. The diversion of available communication patterns is highlighted, and essential MAC-protocol characteristics worthy of a sensor network environment are proposed [8-10].

### A. *Causes of Energy loss:*

When the node receiver encounters more than one packet at the same moment, these packets collide with each other. All these packets are supposed to be repudiated and remediate, which lowers the energy efficiency. Some packets can be retransmitted through the capture effect. Another reason for energy consumption is overhearing [11-13]. The third consumption reason is encountered as control-packet overhead. The last reason for energy waste is in the form of a message when the receiver node is not ready. Innovative MAC protocols should be free of these issues as shown in figure 2.

### B. *Communication overload:*

Generally, there are three different communication patterns in a wireless network; broadcast, converge-cast and local gossip. A broadcast pattern is utilized by a base station to transfer data to all sensor nodes of the network. Under some circumstances the sensor that is allowed to detect particular occasion contact with each other locally. This type of communication pattern is known as local gossip, where a sensor node is free to transmit a message to its neighboring boring nodes. After the sensors detect a particular happening, they are supposed to send what they receive to the data center. This communication pattern is known as converge-cast, in which a group of sensors contacts to a sensor [14].

In protocols that consider grouping, group heads communicate with their members and all the neighborhood might not be intended receivers. To handle such conditions, we use a fourth type of communication pattern that is called multicast [15].

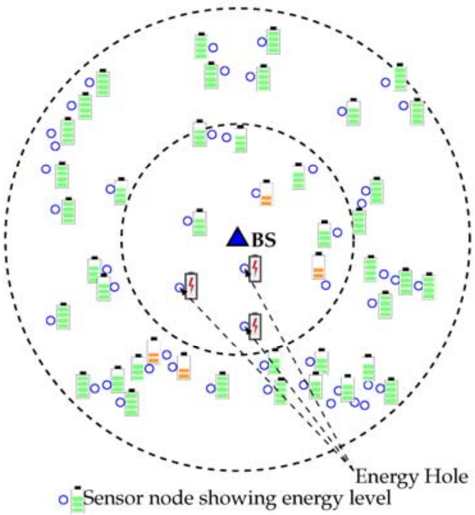


Figure 2. Energy loss factor in WSN

## III. BRIEF OF MAC LAYER PROTOCOLS

In this section, a variety of MAC protocols used for sensor networks are described by reviewing the useful behavior of available protocols. Furthermore, the advantages and disadvantages of these protocols are described. The flow of MAC protocol is shown in figure 3

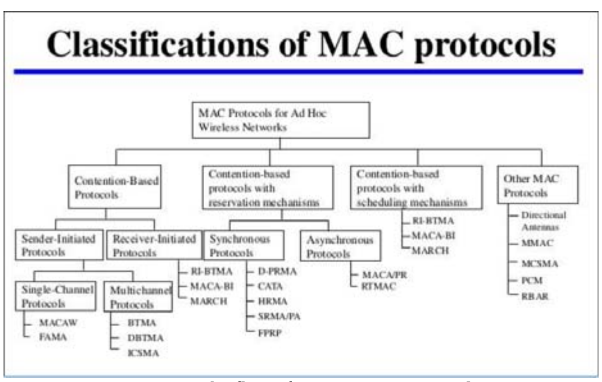


Figure 3, The flow of Sensor MAC protocols

### *A. Sensor-MAC:*

Regionally organized synchronizations and recurring sleep-listen schedules established on these synchronizations form the primary idea behind the sensor MAC protocol. Neighboring nodes form essential groups so a common sleep schedule can be set up. If two neighboring nodes inhabit two different essential groups, they get active at the listening periods of both groups. A downside of the S-MAC algorithm is the chance of attending two contrasting schedules, which results in high energy utilization.

The energy consumption due to idle listening is lowered by sleep schedules. Time synchronization might be solved by sleep schedule announcements.

Broadcast information packets do not utilize RTS/CTS, which increases collision chances. Adaptable listening sustains overhearing if the packet is not destined to the listening node. Sleep and listen periods are arranged and stable, which lowers the efficiency of the algorithm under traffic load.

### *B. Pattern matching for positioning:*

In Wise MAC the data center is reached through TDMA, however, the control center is reached through CSMA. To decrease energy consumption, Wise MAC suggests a way to effectively discover the length of the preamble. This technique requires information about the sleep schedules of the transmitter node's neighbors. The nodes determine and refresh the sleep schedule of neighboring nodes while transferring the information in the form of a message. Depending on the neighbor's sleep schedule, Wise MAC schedules transmit so that the destination node's sampling time matches the middle of the sender's preamble. To lower the collision rate, a random wake-up preamble is endorsed. Another variable affecting the selection of the wake-up preamble length is possible to clock drift between the source and destination [15].

The consequences of simulation indicate that Wise MAC works better than one of the S-MAC variables. Its wide length preamble performs incredibly under different variable conditions. Moreover, clock drifts are controlled in the protocol definition, which reduces the external time synchronization requirement.

The main disadvantage of Wise MAC is that decentralized sleep-listen scheduling results in distinct sleep and wake up schedules for every neighbor of a node. This is a critical problem for broadcast-type communication because broadcasted packets will be distorted for neighbors in sleep time and transferred as many times as the neighbor wakes up. Moreover, the invisible terminal issues accompany the Wise MAC model. The reason behind this is the basis of the Wise MAC model on non-persistent CSMA. As a consequence, one node will start colliding to transfer the preamble to another node which is already attaining another node's transmission [14].

### *C. SIFT-MAC protocol:*

SIFT is a MAC protocol suggested for event-driven sensor network environments. The main objective behind Sift is that when an event takes place, the first R of N potential reports are the most critical part of messaging. If no node starts to transfer in the first slot of the windows, then each node maximizes its transfer service for the next slot, predicting that the amount of predicting nodes is less.

Very little latency is attained for many traffic paths. Energy utilization is exchanged for latency. However, when the latency is an essential component of the system, moderately increased power consumption must be accepted. The Sift algorithm could be modulated to sustain low power consumption [16].

One of the main disadvantages is the high rate of idle listening which is a result of checking all types of listening slots before they are sent. Another disadvantage is the high level of overhearing. When there is transfer going on the nodes must listen to the end to prepare for the next transfer, which results in overheating. Moreover, the practical complexity of Sift is greater than protocols not using time synchronization.

### *D. DMAC-protocol:*

Converge-cast is the most common communication way observed during sensor networks. Unidirectional ways that extend from sources to sink could be expressed as information- gathering trees. The main objective of DMAC is to acquire very low latency for converge-cast communications but still be power efficient. DMAC could be briefly described as an advanced Slotted Aloha algorithm in which slots are marked to the sets of nodes dependent on the information-gathering tree.

DMAC attains excellent latency as compared to other sleep or listens to period assignment methods. The latency of the network is critical for some conditions in which DMAC could be a strong contender [17-18].

The drawback of DMAC includes a lack of methods to prevent collisions. When two or more nodes have the same level of schedule, they will try to transmit the same nodes and thus collisions will occur. Moreover, the data transmitting ways may not be known before which distorts the development of an information-gathering tree.

## IV. Conclusion and future work

Besides the variety of MAC layer protocols suggested for sensor networks, no network can be used as a standard. The main reason for not having a standard is because MAC protocol choice is usually application based which means that there could not be only one standard. Another disadvantage is the lack of standardization at physical layers. Common wireless networking experience also proposes that link-level performance individually may suggest wrong conclusions about system performance. A similar result can be attained for the upper layers. Moreover, layering of the network protocols invents overheads for each layer, which results in more power consumption for each packet. So, the integration of new layers is also a reliable research area that needs to be studied more broadly.

## V. References


[1] S. S. Kulkarni, “TDMA Services for Sensor Networks,”*Proc. 24th Int’l. Conf. Distrib. Comp. Sys. Wksps.*, Mar.2004, pp. 604–09.

[2] W. Ye, J. Heidemann, and D. Estrin, “Medium Access Control with Coordinated Adaptive Sleeping for Wireless Sensor Networks,” *IEEE/ACM Trans. Net.*, vol. 12, no. 3, June 2004, pp. 493–506.

[3] A. El-Hoiydi, “Spatial TDMA and CSMA with Preamble Sampling for Low Power Ad Hoc Wireless Sensor Networks,” *Proc. ISCC 2002*, July 2002, pp. 685–92.

[4] Ahmad, T., Li, X. J., & Seet, B. C. (2017). Parametric loop division for 3D localization in wireless sensor networks. *Sensors*, *17*(7), 1697.

[5] V. Rajendran, K. Obraczka, and J. J. Garcia-Luna-Aceves, “Energy-Efficient, Collision-Free Medium Access Control for Wireless Sensor Networks,” *Proc. ACM SenSys ‘03*, Los Angeles, CA, Nov. 2003, pp. 181–92.

[6] L. Bao and J. J. Garcia-Luna-Aceves, “A New Approach to Channel Access Scheduling for Ad Hoc Networks,” *7th Ann. Int’l. Conf. Mobile Comp. and Net.*, 2001, pp. 210–21.

[7] Ahmad, Tanveer, Xue Jun Li, and Boon-Chong Seet. "A self-calibrated centroid localization algorithm for indoor ZigBee WSNs." In *2016 8th IEEE International Conference on Communication Software and Networks (ICCSN)*, pp. 455-461. IEEE, 2016.

[8] Dawadi, B. R., Rawat, D. B., Joshi, S. R., & Keitsch, M. M. (2020). Towards energy efficiency and green network infrastructure deployment in Nepal using software defined IPv6 network paradigm. *The Electronic Journal of Information Systems in Developing Countries*, *86*(1), e12114.

[9] Ahmad, Tanveer, Xue Jun Li, and Boon-Chong Seet. "3D localization based on parametric loop division and subdivision surfaces for wireless sensor networks." In *2016 25th Wireless and Optical Communication Conference (WOCC)*, pp. 1-6. IEEE, 2016.

[10] K. Jamieson, H. Balakrishnan, and Y. C. Tay, “Sift: A MAC Protocol for Event-Driven Wireless Sensor Networks,” MIT Lab. Comp. Sci., Tech. rep. 894, May 2003, available at http://www.lcs.mit.edu/publications/pubs/pdf/MIT-LCS-TR-894.pdf

[11] Y. C. Tay, K. Jamieson, and H. Balakrishnan, “Collision-Minimizing CSMA and Its Applications to Wireless Sensor Networks,” *IEEE JSAC*, vol. 22, no. 6, Aug. 2004, pp. 1048–57.

[12] Ahmad, Tanveer, Xue Jun Li, and Boon-Chong Seet. "3D localization using social network analysis for wireless sensor networks." In *2018 IEEE 3rd international conference on communication and information systems (ICCIS)*, pp. 88-92. IEEE, 2018.

[13] Ahmad, Tanveer, Xue Jun Li, and Boon-Chong Seet. "Noise Reduction Scheme for Parametric Loop Division 3D Wireless Localization Algorithm Based on Extended Kalman Filtering." *Journal of Sensor and Actuator Networks* 8, no. 2 (2019): 24.

[14] Ahmad, Tanveer, Xue Jun Li, and Boon-Chong Seet. "Fuzzy-Logic Based Localization for Mobile Sensor Networks." In *2019 2nd International Conference on Communication, Computing and Digital systems (C-CODE)*, pp. 43-47. IEEE, 2019.

[15] G. Lu, B. Krishnamachari, and C. S. Raghavendra, “An Adaptive Energy-Efficient and Low-Latency MAC for Data Gathering in Wireless Sensor Networks,” *Proc. 18th Int’l. Parallel and Distrib. Processing Symp.*, Apr. 2004, p. 224.

[16] Ahmad, Tanveer, Xue Jun Li, Boon-Chong Seet, and Juan-Carlos Cano. "Social Network Analysis Based Localization Technique with Clustered Closeness Centrality for 3D Wireless Sensor Networks." *Electronics* 9, no. 5 (2020): 738.

[17] hakila, R., and B. Paramasivan. "An improved range based localization using Whale Optimization Algorithm in underwater wireless sensor network." *Journal of Ambient Intelligence and Humanized Computing* (2020): 1-11.

[18] Ahmad, T. (2019). *3D Localization Techniques for Wireless Sensor Networks* (Doctoral dissertation, Auckland University of Technology).