



SURVEY ON MAC PROTOCOLS FOR WIRELESS SENSOR NETWORKS

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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.

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].

Layer	Application/Example	Central Device/Protocols	DOD4 Model
Application (7) Serves as the window for users and application processes to access the network services.	End User layer Program that opens what was sent or creates what is to be sent. Resource sharing • Remote file access • Remote printer access • Directory services • Network management	User Applications SMTP	GATEWAY Host to Host Interned Can be used on all layers Network
Presentation (6) Formats the data to be presented to the destination user. It can be viewed as the "translator" for the network.	Syntax layer encrypt & decrypt (if needed) Character code translation • Data compression • Data compression • Data encryption • Character set translation	JPEG/GSIC EBCDIC/ASCII PICT	
Session (5) Allows session establishment between processes running on different devices.	Synch & send to ports (logical ports) Session establishment, maintenance and termination • Session support • perform security, name negotiation, logging, etc.	Logical Ports RPC/SQ/LNFS NetBIOS names	
Transport (4) Ensures that messages are delivered across the network, in sequence, and with no losses or duplications.	TCP Host to Host, Flow Control Message segmentation • Message acknowledgement • Message retransmission • Session multiplexing	TCP/IP/SQ/LNFS	
Network (3) Controls the operation of the network, deciding which physical path the data takes.	Packets ("letter", contains IP address) Routing • Subnet traffic control • Frame fragmentation • Logical-physical address mapping • Subnet usage accounting	Routers RIP/RIPX/ICMP	
Data Link (2) Provides error-free transfer of data frames. Both one side to another and the physical layer.	Frames ("envelopes", contains MAC address) NIC card —> Switch —> NIC card Establishes & terminates the logical link between nodes • Frame traffic control • Frame sequencing • Frame acknowledgement • Frame delimiting • Frame error checking • Media access control	Switch Bridge WAP PPP/SLIP	
Physical (1) Concerned with the transmission and reception of the unformatted raw bit stream over the physical medium.	Physical structure Cables, hubs, etc. Data Encoding • Physical medium attachment • Transmission techniques • Synchronous or Asynchronous • Physical medium transmission Bits & bytes	Hub Layer Based Layers	

Figure 1. OSI infrastructure in WSN model

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].

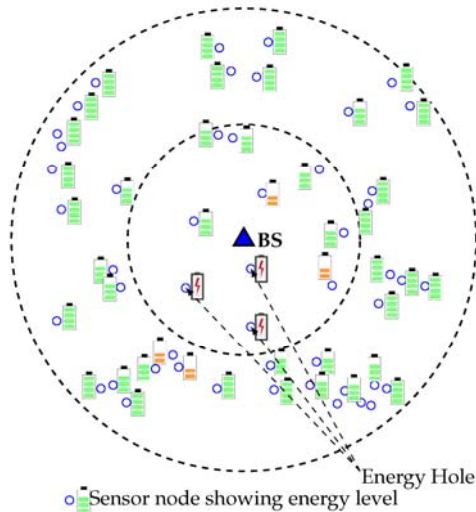


Figure 2. Energy loss factor in WSN

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

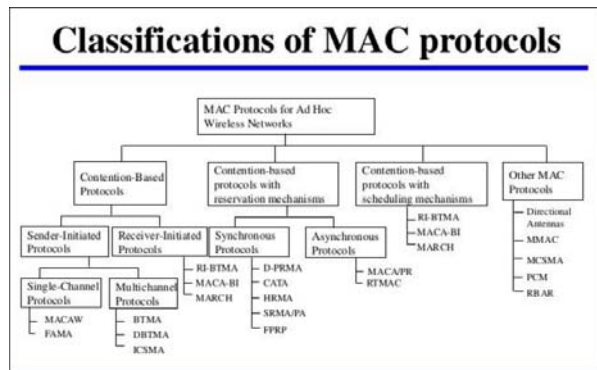


Figure 3. The flow of Sensor MAC protocols

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.

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