ISSN:0975-9646

Rohan Parmar et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (3) , 2014, 3421-3424

A Literature Survey on Energy Efficient MAC Protocols for WSN

Rohan Parmar, Dr. R. C. Poonia

School of Engineering & Technology
Jaipur National University

Abstract — **Developing of MAC protocol for Wireless Sensor Network (WSN) has a challenging issue of Energy efficiency because WSN has large number of sensor nodes with limited processing capability and limited power. Most of WSN uses battery for power. One of important task in developing mac protocol for WSN is increase the life time of network; it means we have to use power very efficiently. To develop MAC protocol, which is energy efficient, many flavour of MAC protocol is proposed by different researcher. This paper is a survey of active research work on Energy efficient MAC protocol.**

Keywords: Energy efficient MAC protocol, WSN, Survey.

I. INTRODUCTION

A Wireless sensor network is a wireless network consisting of distributed autonomous device using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different location. Wireless sensor network has so many sensing nodes with small energy and processing power which monitor the environment and collect the information. They also transfer information to another node and make a communication network. As we know that each node has limited power, energy saving is a very important task in wireless sensor network. In wireless sensor network, MAC protocol is used to make decision about wireless channel. How to use wireless channel for communication is decide by MAC protocol. Choosing an efficient MAC protocol is very important for a Wireless sensor network because we can save energy of node using a MAC protocol which is energy efficient.

In last few years, much research has been done by researcher in the area of MAC protocol for Wireless sensor network which are energy efficient. In this paper, part 2 is describes some reason of energy wastage in wireless sensor network. Part 3 is describing the some MAC protocol which is energy efficient and proposed for a Wireless sensor network.

II. ENERGY WASTAGE IN WSN

There are many reasons for energy wastage in wireless sensor network. Some main reason for energy wastage is as follow [1]:

2-A. Collide packet: when more than one packet received by receiver node at same time then this packet is called collided packet. All the packet which is collided is must be discarded and retransmission of this packet leads to wastage of energy.

2-B. Overhearing: When node received a packet, if it is destined to other nodes then it is called overhearing packet. While this type of packet is received, packet must be discarded and this whole process, receiving and discarding the packet, become the reason for wastage of energy

2-C. Control Packet overhead: One reason for energy wastage in Wireless sensor network is control packet overhead. If we send minimal number of control packets then we can reduce energy wastage.

2-D. Idle listening: Idle listening means listening to an idle channel to receive possible traffic.

2- E. Over mitting: receiver node is not ready for receiving message but sender send the message then over mitting occurs.

A MAC protocol which take care of above factor and prevent this reason of energy wastage can reduce the wastage of energy in wireless sensor network.

III. ENERGY EFFICIENT MAC PROTOCOLS

In this part we will describe some energy efficient MAC protocol which is proposed by researcher. We will also discuss about its advantage and disadvantage in some protocol.

3- A. Sensor MAC. (S-MAC) [1]

Basic idea behind the S-MAC is periodic listen and sleep, collision and overheating avoidance, and message passing. In most of wireless sensor network application, if sensing event didn't occurs then nodes remain ideal for a long time. In this time traffic is very low and we can make node in periodic sleep. As shown in figure 1.

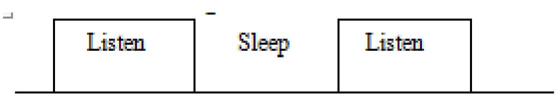

Fig. 1. Periodic listen and sleep.

Every node goes in sleep mode for some time and wakes up and sees if any node wants to communicate with it. According to application to application this time can be very. Also each node can choose different time slot for sleep and wake up. If in each second a node sleeps for half Second and listens for the other half, its duty cycle is reduced to 50%. So we can achieve close to 50% energy savings. S-MAC follow same stander as connection base protocol 802.11 to avoid collision. MAC adopts RTS/CTS exchange technique to address the hidden terminal problems. All senders perform carrier sense before initiating a transmission. If a node fails to get the medium, it goes to sleep and wakes up when the receiver is free and listening again. Broadcast packets are sent without using RTS/CTS. Unicast packets follow the sequence of RTS/CTS/DATA/ACK between the sender and the receiver. MAC uses different approach for message passing. Its approach is to fragment the long message into many small fragments, and transmit them in burst. Only one RTS packet and one CTS packet are used. They reserve the medium for transmitting all the fragments. Every time a data fragment is transmitted, the sender waits for an ACK from the receiver. If it fails to receive the ACK, it will extend the reserved transmission time for one more fragment, and re-transmit the current fragment immediately.

Advantages: The energy is saved by using sleep and wake up technique. In addition to its implementation simplicity, time synchronization overhead may be prevented with sleep schedule announcements.

Disadvantages: Broadcast data packets do not use RTS/CTS which increases collision probability. Adaptive listening incurs overhearing or idle listening if the packet is not destined to the listening node. Sleep and listen periods are predefined and constant, which decreases the efficiency of the algorithm under variable traffic load.

3-B. PW-MAC: Predictive-Wakeup MAC Protocol [3]

In PW-MAC, each nodes wake up to receive at *randomized*, *asynchronous* times. PW-MAC minimizes sensor node energy consumption by enabling senders to predict receiver wakeup times; to enable accurate predictions; PW-MAC introduces an *on-demand* prediction error correction mechanism that effectively addresses timing challenges such as unpredictable hardware and operating system delays and clock drift. PW-MAC also introduces an efficient prediction based retransmission mechanism to achieve high energy efficiency even when wireless collisions occur and packets must be retransmitted.

The main idea behind PW-MAC is for sender to wake up just before receiver is ready, means wake up. It is important for sender to predict exact wakeup time of receiver and for this problem in PW-MAC every node uses pseudo-random wakeup schedule. PW-MAC uses the receiver-initiated approach since it provides good receiver duty cycle performance and provides a transmission mechanism that can be used as the basis for transmitting the prediction state of a node when needed.

In PW-MAC, sender achieve high energy efficiency even when packets have to be retransmitted, because PW-MAC detects wireless collisions, switching to sleeping state and intelligently choosing when to wake up and retransmit the packets. PW-MAC introduces an efficient on-demand prediction error correction mechanism that can effectively control the prediction error caused by various factors. On-demand prediction error correction also is very efficient in terms of message overhead.

Advantage: An energy saving in PW-MAC is more than S-MAC because of prediction based wakeup.

Disadvantage: Accurate predication may not be possible in some application.

3-C. R-MAC: A power reduction MAC protocol for WSN [4]

The R-MAC is RTS-CTS based MAC protocol with power reduction function. The functions are adoption of duty cycle with the rhythm, synchronous method using RTS-CTS, load adaptation based on traffic estimation. In this protocol node adopts duty cycle with rhythm, rhythm is realized by changing of number of sleep per cycle. Rhythm is shown in fig 2. By using this R-MAC increase the operation time of node. This protocol uses different modes properly based on the node situation and network load.

Figure 3 Rhythm of R-MAC

R-MAC detects the synchronous gap and maintains the synchronization to reduce the power consumption. The node gets the synchronization information by the RTS and CTS control packets for making the synchronization with neighbor nodes. The RTS and CTS are always used in the case of data sending and for a CTS packet, RTS packet is returned in interactive way. Considering this, we use RTS and CTS for the synchronization. The RTS and CTS of R-MAC include also the control information called N_hop and Txts. In R-MAC traffic estimation is carried out by using regression equation based on the amount of data in the queue. The next state is determined by the estimation value and the procedure is repeated. The state transition is carried out by each sensor node based on traffic estimation result. After that, this result is notified to all neighbor nodes. By using it R-MAC can handle traffic efficiently.

Advantage: This method is better than the synchronization method of S-MAC protocol. The R-MAC can realize the communication without extension of Active time. Therefore, the R-MAC can save more power than SMAC protocol. The delay time of R-MAC is less than delay time of S-MAC. When the network load is from low to middle, the R-MAC has better behavior than S-MAC.

Disadvantage: It can be used only when all nodes has same function.

3-D EECDC-MAC: Energy Efficient Cooperative Duty Cycle MAC Protocol [5]

In Energy efficient cooperative duty cycle MAC (EECDC-MAC) protocol, sensor nodes use fixed wakeup rendezvous scheduling to exchange messages and a cooperative transmission mechanism to avoid overuse of nodes with lower residual energy. The EECDC-MAC protocol doesn't use sync period for every packet transmission by providing a fixed schedule in the beginning of network initialization

The idea behind EECDC-MAC is to wake up all nodes at the same time and using message, network synchronization is done in the first cycle in the network initialization phase in order to establish rendezvous for data exchange among them. From the second cycle onwards, nodes wake up at specific fixed time instants according synchronization message.

In EECDC-MAC they assumed that all node have same energy initially, cooperative transmission is initiated in first cycle and from second cycle it is done based on energy information provided by the receiver. EECDC-MAC follows following steps:

a. Receiver and other sending nodes wake up at same time. Receiver sends synchronization message to all potential senders. Other senders also get message and complete the channel access and decide whether cooperative transmission should be enable or not.

b. For a cooperative transmission, a message along with data is broadcasted by a node which got the channel access.

c. In second cycle receiving node sends a ready to receive message that contains residual energy and distance information to sending node. By comparing with own residual energy with receiving node's energy, sender decide whether cooperative transmission have to do or not.

If the remaining energy of the receiving node is greater than sending node's remaining energy then non cooperative transmission will e performed; otherwise cooperative transmission will be used.

Advantage: The EECDC-MAC protocol can prolong the entire network longevity efficiently in comparison with an existing cooperative duty cycle MAC protocol, prediction wakeup MAC (PW-MAC) protocol**.**

3-E. X-MAC/CA protocol **[6]**

X-MAC protocol with CA (Collision Avoidance) algorithm is introduced to randomize transmissions in sensor network. X-MAC/CA is to reduce collisions when so many nodes simultaneously transmit data in WSN network when they have to report some events. In X-MAC, they also introduce collision avoidance algorithm to increase the network throughput. It spreads out the transmission time by delivering data frames after waiting a random amount of time once the channel is free.

Unlike IEEE 802.22, sensor node performs preamble back off and randomly draws and integer I from a range (1,W_{max}) without polling the channel When sensor node wakes up and have to some data transfer in queue. Until the early acknowledgement comes back, it begins its short preambles in sequence, if channel is idle. It immediately delivers one data frame and goes to sleep when early acknowledgement arrives. Sender waits for ongoing transmission without going to sleep if channel is already busy in some transmission. When ongoing transmission is ends, it runs data back off whose operation is same as preamble back off.

Advantage: It prevents the collisions which occurs in X-MAC and reduce the power consumption.

3-F. *Timeout-MAC (T-MAC)* [7]

We know that S-MAC performance is not good under variable traffic load due to static sleep-listen periods. Timeout- MAC (T-MAC) is introduces to overcome this problem. 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. 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.

3-G. Dynamic Sensor-MAC (DSMAC) [8]

DSMAC adds dynamic duty cycle feature to S-MAC. The idea behind it is to decrease the latency for delay-sensitive applications. All nodes share their one-hop latency values (time between the reception of a packet into the queue and its transmission) Within the SYNC period. All nodes start with the same duty cycle. 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. The duty cycle is doubled so that the schedules of the neighbors will not be affected. The latency observed with DSMAC is better than the one observed with S-MAC. Moreover, it is also shown to have better average power consumption per packet.

IV**. CONCLUSION**

All application of sensor network has different characteristic and different environment. Some application has busty traffic and some application has small data transmission. So many MAC protocol is proposed for a WSN, but we cannot specify any one protocol as stander for MAC protocol. Choice of MAC protocol depends on application. We have no stander sensor hardware for sensor network, due to this, according hardware, different MAC protocol is applicable as per hardware.

For better performance, all protocol has different different technique for collision, overhearing, collision overhead and idle listening. For researcher, Solution to this all problem in a MAC protocol is challenge.

REFERENCES:

[1] An Energy-Efficient MAC Protocol for Wireless Sensor Networks Wei Ye, John Heidemann, Deborah Estrin.

[2] Energy Consumptlon Analysls of S-MAC Protocol in Single-Hop W'ireless Sensor Networks Seokjin Sung, Hyunduk Kang, Eunchan Kim, and Kiseon Kim , I1-4244-0574-2/06/$20.OO (0)2006 IEEE

[3] PW-MAC: An Energy-Efficient Predictive-Wakeup MAC Protocol for Wireless Sensor Networks Lei Tang , Yanjun Sun, Omer Gurewitz, David B. Johnson , technical program at IEEE INFOCOM 2011

[4] R-MAC: A MAC Protocol for Power Reduction in Wireless Sensor Networks Based on Load Estimation and Its Performance Evaluation Akio Koyama Ryoma Watanabe Leonard Barolli Makoto Takizawa , 2011 Third International Conference on Intelligent Networking and Collaborative Systems

[5] EECDC-MAC: Energy Efficient Cooperative Duty Cycle MAC Protocol Lakshmikanth Guntupalli1 , Frank Y. Li and Xiaohu Ge , 978-1-4673-4404-3/12/$31.00 ©2012 IEEE

[6] X-MAC Protocol with Collision Avoidance Algorithm Ayaz Ullah, Jong-Suk Ahn, and Gayoung Kim , 978-1-4673-5990-0/13/$31.00 ©2013 IEEE

[7] 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.

[8] 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.