

S-MAC Protocol for Wireless Sensor Network and Study of related work

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Abstract— Wireless Sensor Network is special class of wireless communication, consist of large number of miniature battery operated sensor nodes which are distributed and do communication wirelessly. Due to small and inexpensive sensor node, they are widely used in many areas. Sensor-MAC was designed and developed for WSN to prolong the lifetime and reduce energy consumption. Many of the work have been done on S-MAC to enhance the performance. This paper gives a insight review of such papers.

Index Terms — Energy Efficiency, Wireless sensor network, Medium Access Control Protocol, Sensor -MAC,RTS/CTS mechanism,



1 INTRODUCTION

WSN is trend of past few years. Due to availability of small sensor, efficient wireless communication, distributed computation techniques and improved small-scale energy supplies have made this technology a great successful. Wireless sensor network are made up of small battery powered sensors called as node having small amount of memory, which are specially distributed at different location capable of sense the data[8]. They can be widely used in many areas, such as environment monitoring such as forest fire detection, intelligent building systems, military application, health care application and many more[9]. Due to this wide range of application WSN got popularity in its early days.

Some of the applications are deployed in locations which are inaccessible to human and battery is not often rechargeable. In such location sensor network should work for many years without any human intervention. In such situation energy consumption of sensor node is all design consideration in wireless sensor network. . So efficient design and implementation to reduce workload on sensor so that energy consumption will be less and lifetime of network will be increased is important For the implementation of an energy-efficient MAC protocol, therefore, how to reduce the energy consumption to prolong the service lifetime of sensor nodes becomes a critical issue[10],[11]

Therefore to extend a wireless sensor network's effectiveness, the lifetime of the network must be increased by

making them as energy efficient as possible. An energy-efficient medium access control (MAC) and routing protocol can maximize the whole network lifetime. In wireless sensor networks since the communication of sensor nodes will be more energy-consuming than their computation [9]; it is a primary concern that the communication is minimized while achieving the desired network operation. The fundamental task of any MAC protocol is to regulate shared medium between nodes Thus MAC protocol is capable of successful operation on sensor network.

Different approaches of MAC for WSN are synchronous MAC protocol and asynchronous MAC protocol [9]. Synchronous MAC Protocols are also called Schedule-Based or Slotted Mac Protocol. Unnecessary power consumption takes place on synchronization message exchanges. Schedule based medium access protocols are in general require a mechanism to establish a non conflicting schedule regulating which participant may use which resource at which time. Schedule can be fixed or computed on demand. Time synchronization is needed and time is divided into slot. Asynchronous Mac Protocols are also called as Contention-Based or Random Access MAC Protocols. Here randomization is used. Nodes do not synchronize time and contend for access to the radio channel [8],[9].

There are number of MAC protocol proposed for WSN. Most of these protocols have energy conservation as an objective. The pattern of energy use in the sensor nodes, however, depends on the nature of the application. As the range of applications which use WSNs is large and diverse, the proposed protocols display much diversity. Most of these protocols use either a contention based mechanism or a time schedule or a combination of the two for accessing the shared medium. A protocol, named S-MAC[12],[7], is a robust medium access control (MAC) protocol for wireless sensor networks. Owing to its success in significant reduction in

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energy consumption and its robustness, S-MAC has been used in many wireless sensor networks (WSNs) [1].

2. CAUSES OF ENERGY CONSUMPTION

Application will have QOS like low battery consumption, efficient radio communication. The sensor node will consume energy to transmit, to receive as well as in ideal listening. [2],[9],[8],[12] had given the major cause of energy waste in WSN that is collision, overhearing, control-packet overhead and idle listening. Despite of other source of energy waste like computation, sending control and acknowledgment, here consider only the causes of energy in between the transmission. So it is observed that the main reasons of energy waste which seriously impair the energy dissipation of each sensor node is collision, overhearing, overhead and idle listening. The following section give focus on this cause of energy waste [7][12],[9].

2.1 Collisions.

They may happen when a node is within the transmission range of two or more nodes that are simultaneously transmitting so that it does not capture any frame. The energy used in transmission as well as in retransmission is totally wasted.

2.2 Overhearing

It happens when a node energy is wasted in receiving irrelevant packets or signals. Irrelevant packets may be for example unicast packets destined to other nodes or redundant broadcast packets. Irrelevant signals include the preambles used in some low power MAC protocols to occupy the communication channel

2.3 Overhead

Protocol overhead may result in energy waste when transmitting and receiving control packets. For example, RTS and CTS control packets used in some protocols do not carry any useful data to applications although their transmission consumes energy.

2.4 Idle Listening.

The node keeps on listening to the channel waiting for potential data frames. The amount of energy wasted whilst the radio is on is considerable even when it is neither receiving nor transmitting frames.

From the above discussion, we can figure out that S-MAC, which is specially designed for wireless sensor networks, will differ from other traditional wireless MAC protocols in the following aspects: energy efficiency and self-configuration ability are the primary goals, while others attributes, like latency and fairness, are secondary.

3. WORKING OF S-MAC

Because of limited power supply, the main objective to design MAC protocol for WSN is energy efficiency. S-MAC[12][7] is specially designed for WSN to reduce energy consumption which caused due to reasons mentioned in Section 2. The following section gives the working of basic S-MAC given by [12],[8] and how to preserve power which causes due to reasons mentioned above.

3.1 Periodic sleep and listen:-

The basic technique that S-MAC uses for to reduce energy consumption, that each node should follow listen and sleep schedule. The cycle of listen and sleep called as frame (Fig 1). In light traffic load, the node should go to sleep when rather than in Ideal state, because when node is in ideal state it will consume the same energy as they used for transmission. The energy consumption caused due to ideal listening is reducing due to such frame. The node will go to sleep after some predefined time during sleep period. And in listen period they send or receive data if necessary. This period is fixed by some MAC layer parameter. The ratio of listen period to frame length is called as duty cycle.

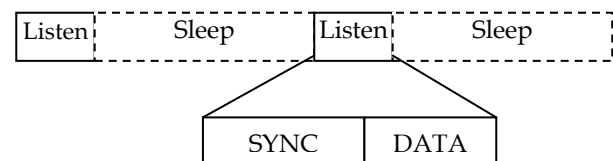


Fig 1. Frame structure for S-MAC[ye]

The data period is further divided into SYNC and DATA period. In SYNC periods the node will broadcast the SYNC packet to resolve synchronization problem between communicating node. The node exchange the schedule by periodically broadcasting SYNC packet. The most important part from SYNC packet is sleep time, which tells the receivers next listen time of sending node. Each node will store its own schedule and schedule of its entire neighbouring node. The node which follows same schedule are said to be in one clusters. It may be case that the node belonging to more than one schedule. In this case, the node should follow schedule of cluster in which it belongs.

Suppose B receives a data packet destined to C from the upper layer, it first searches in its schedule table to find out the schedule that C is following, and it sets the txData (one of the field in schedule table) flag on that schedule to 1. When C's

next DATA period comes, the corresponding schedule timer on B will inform B that its data buffer has a data packet destined to C and now it is time to send it out.

Another important component in S-MAC is neighbour list. Each S-MAC node has to set up such a table to records the information of all its known neighbours

3.2 RTS/CTS mechanism

The communication between nodes is done by first carrier sense and followed by actual data transmission .Prior to actual data transmission , Ready to Send and Clear to Send (RTS/CTS) packets which are unicasted to win the communication media nodes start transmission of the desired data .

Consider one example, say node A want to send some data to say node B. Then node A initiates the process by sending a Request to Send frame (RTS) to node B. The destination node (node B) replies with a Clear To Send frame (CTS). After receiving CTS, node A sends data. After successful reception, node B replies with an acknowledgement frame (ACK)..

3.3 Overhearing Avoidance

Overhearing takes place on a node when it receives some packets that are destined for other nodes. To achieve better performance in a shared-medium network, carrier sense, especially virtual carrier sense should be performed more efficiently. The best way to achieve it is to let each node keep listening to all its neighbours' transmissions

For S-MAC, saving energy is its primary goal. To avoid overhearing, S-MAC forces interfering nodes to go to sleep after they receive an RTS or a CTS packet that is not destined for them. In this way, nodes that interfere their neighbours' transmissions will not hear DATA packets, which normally take much longer transmission time than control packets, and following ACK packets. We take an example in Fig 2 to illustrate this algorithm.

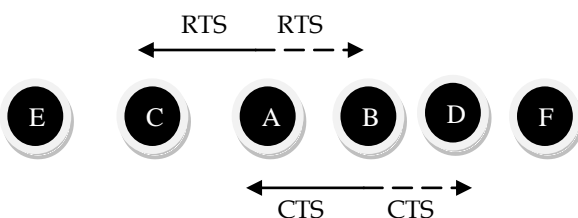


Fig 2: C and D overhear the transmission between A and B

Suppose node A wants to send data to node B . The node A will send RTS message to its entire neighbouring node, which is replied by node B by sending CTS message. When node B sends CTS message which in turns received by node D. So node C and D will go to sleep, because the node will overhear the transmission between A and B.

3.4 Message Passing

Transmitting long message is risk. Because when any single bit gets corrupted whole message has to be retransmitted. In fragmentation, long message is divided into small fragments. All fragments are sent in a burst, and using one pair of RTS/CTS, if none of them is corrupted. If one of the fragments is corrupted, another pair of RTS/CTS is needed. When the receiver has gotten all fragments, its MAC is responsible for

assembling all the fragments into a whole and passing it upwards. In S-MAC, each fragment should be acknowledged by receiver.

In S-MAC, the duration field of all packets carries the remaining length of the whole transaction, including all fragments and their acknowledgments. Therefore, the whole message shall be passed at once. If one fragment needs to be retransmitted, the remaining duration is incremented by the length of a data plus ack packet, and the medium is reserved for this prolonged time

4 RELATED WORK

Reducing energy consumption and reduce latency to increase the battery life of sensor nodes and throughput of network is basically main objective of many of the researchers.

4.1 Performance of WSN MAC Protocol with Global Sleep Schedule[1]

Problem with multiple schedules: The node which belong to more than one virtual clusters, has to synchronize with all the schedule they follow, resulting in higher duty cycle and consume more energy.

Proposed Modification: Proposed modification suggests that when connectivity between more than one isolated clusters, then all nodes from merged clusters will follow same schedule. When node receives any schedule after it has chosen its own ,then depending of schedule identifier of received schedule node changes its own schedule. If received schedule identifier is higher than current schedule then it advertises its new schedule as its own during sync periods of both the schedule, otherwise received schedule is ignored and follow its own schedule.

4.2 Investigation and Implementation of border nodes in S-MAC[2]

Problem of S-MAC : All nodes in the network will adopt the same schedule which results into latency intolerable and the node which follow same schedule never find each other

Proposed Design : Normally Border nodes follow more than two schedule ,which they receive from neighboring clusters. In the implementation, they have allowed nodes that are located between different virtual clusters to adopt two or more than two schedules and become border nodes by merging

different schedules it received. The schedule of border node depends on time difference between received schedules. If received schedule falls behind then we keep sync period as it is and add extra DATA period at the end of schedule (Fig 3a). If received schedule is ahead, then we still keep SYNC period of original schedule and add extra DATA in front of original schedule (Fig 3b).

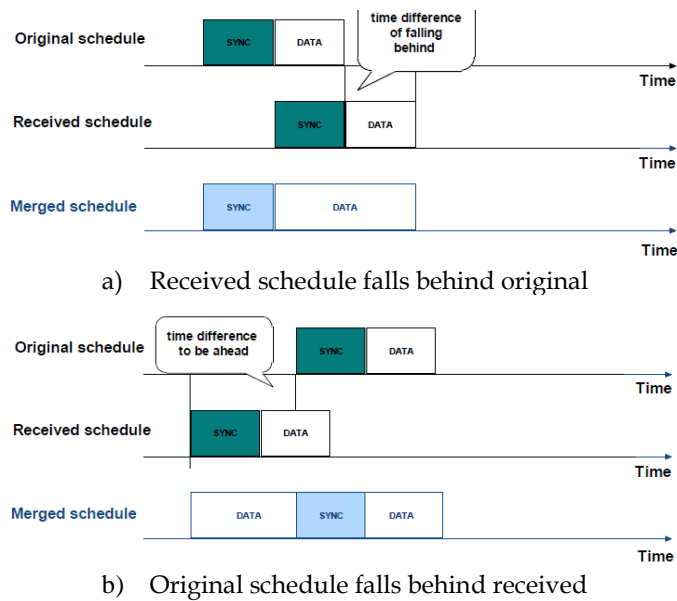


Fig 3. Schedule of border node

So that the connectivity of WSN is maintained even though nodes in WSN follow different periodic listen schedules.

Disadvantage: More energy is consumed by border node. When Border node die, different virtual cluster do not communicate with each other

4.3 An Improved S-MAC Based on Parallel Transmission for Wireless Sensor Network[3]

Motivation for parallel transmission: referring Fig 2. the transmission of C and E does not interfere with ongoing communication between A and B, as the transmission is blocked because of communication between A and B.

Parallel transmission concept: Rather than blocking whole transmission block half the transmission. The node A and E can be able to receive though they are in same transmission range, as long as destination node viz. E and B is not in same transmission range

4.4 A MAC Protocol Based on S-MAC for Power Asymmetric WSN Network[4]

Hidden terminal problem in S-MAC: Possible link asymmetry wherein the transmission of a high power node is received (or is sensed) by a lower power node whereas the high power node cannot sense the transmissions by the low power node. As shown in Figure 4 Control packet exchange between node 0 and 1 does not overheard by 3, thus communication between 0 and 1 collide with communication between 3 and 4. Thus, the low power nodes are hidden from high power nodes. This

increases the number of collisions that are experienced by low power communications

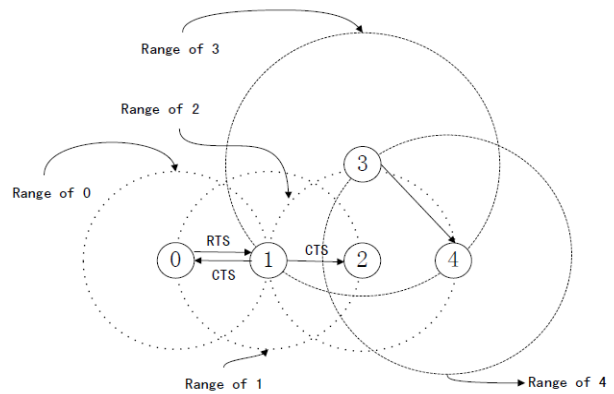


Figure 4: Hidden terminal problem due to power asymmetric node

Proposed modification - RTS/CTS mechanism does not eliminate problems which arise due to power asymmetric node. Improved protocol broadcast new control packet called as BRES (Bandwidth reservation) whose message structure is same as RTS with one additional field ,originator address (sender of RTS) to avoid duplicate BRES message . CTS message structure contains one extra field B. The nodes which receive CTS message check the B field. If B=1 broadcast BRES (Bandwidth Reservation) Control packet. The BRES message format is similar to the RTS message format except that that the frame control field has an additional attributes: the originator address field which contains the MAC address of the node that initiated the communication (RTS sender). These fields are used for the detection of duplicate BRES messages that may be received. The improved protocol adds an attribute B in CTS message

4.5 Dynamic S-MAC Protocol for WSN Based on Network traffic state[5]

Basic perspective from S-MAC-fixed duty cycle: the latency is increased due to message generation. Event may occur between sleep period, so the message is queued until next active period comes.

Proposed algorithm: Dynamically change the frame size. Dynamic S-MAC uses flag variable to determine active and sleep interval. When no message is generated in prior active interval flag is set to 0 and next active interval has sleep schedule, otherwise flag is set to 1 and next active has same active schedule. In other words when no message is generated schedule toggle between active and sleep.

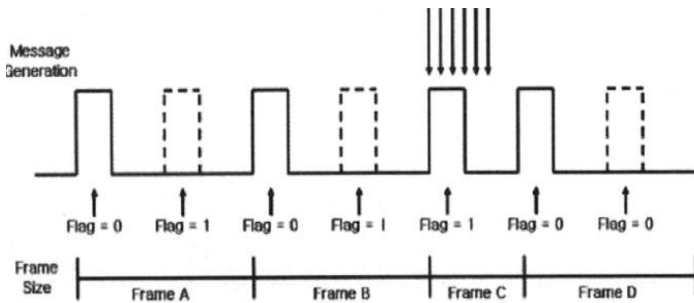


Fig 5 : Dynamic S-MAC : change in frame size

As shown in Fig 5, burst traffic is generated in a special interval, the entire frame is reduced, as show for Frame C. For the purpose of reducing message latency. the case where message is generated, as the case of Frames A, B and D, the entire frame length is , whereas in the case where a message is generated, as in the case of Frame C, the frame interval is reduced. In this manner, dynamic S-MAC can dynamically control the entire frame length according to the network traffic state.

4.6 Energy Consumption Improvement of S-MAC in WSN [6]

Competition windows are fixed and cannot automatically adapt to the changes of the flow capacity of wireless sensor network. In the changing of flow capacity, much energy will be wasted if there is not correspondent adaptive contention window.

Proposed algorithm:-adaptive adjustment of contention window size according to current traffic state and queue size and varying, by considering flow prediction, queue size, queue length

5 CONCLUSION

Wireless sensor network has different design consideration and requirement than other wireless network like energy conservation, scalable network, state of sensor node, effective radio communication. Thus we have survey different MAC protocol to enhance the performance of S-MAC protocol for WSN. Most researchers had tried to solve drawbacks of S-MAC to prolong the life time of network by preserving the battery life as well as living lots of room for future research.

6 REFERENCES

[1] Somnath Ghosh, Prakash Veeraraghavan, Samar Singh, and Lei Zhang ,”Performance of WSN MAC Protocol with Global Sleep Schedule”,International Journal of Multimedia and Ubiquitous Engineering Vol. 4, No. 2, April, 2009

[2] Elhadi Shakshuki, T.R.Sheltami, H.Malik , C.Yang, “Investigation and Implementation of border nodes in S-MAC”, 2009 International Conference on Network-Based Information System, 350-357

[3] Librahim Ammer, Irfan Awan and Geyong Min ,An Improved S-MAC Based on Parallel Transmission for Wireless Sensor Network, 2010 13th International Conference on Network-Based Information Systems,48-54

[4] Yun Li,Hao Jia,Zhan-Jun Liu,Zhi Ren,Guo-Jun Li, “ A MAC Protocol Based on S-MAC for Power Asymmetric WSN Network”, 2008 International Symposium on Computer Science and Computational Technology ,299-302

[5] Dae-Suk Yoo,Su-Sung park,Seung sik choi and Se Hwa Park , “Dynamic S-MAC Protocol for WSN Based on Network traffic state ”, IEICE 2008

[6] Li-li Gao, “ Energy Consumption Improvement of S-MAC in WSN”, Internet Technology And Application(iTAP) 2011,Pages 1-3

[7] Ilker Demirkol, Cem Ersoy, and Fatih Alagöz ,“MAC Protocols for Wireless Sensor Networks a Survey”,Communication Manazine ,IEEE 2006

[8] Zahra Rezaei 1 , Shima Mobininejad,“ Energy Saving in Wireless Sensor Networks International Journal of Computer Science & Engineering Survey (IJCSSES) Vol.3, No.1, February 2012

[9] A Roy and N Sarma “Energy Saving in MAC Layer of Wireless Sensor Networks: a Survey “, National Workshop in Design and Analysis of Algorithm (NWDAA)”, Tezpur University, India, 2010”.

[10] Mark A. Perillo and Wendi B. Heinzelman Wireless Sensor Network Protocols Department of Electrical and Computer Engineering University of Rochester Rochester, NY, USA

[11] John A. Stankovic “Wireless Sensor Networks”, IEEE 2008 pages 92-95

[12] Wei Ye, John Heidemann, and Deborah Estrin. An energy-efficient mac protocol for wireless sensor networks. Proceedings of the IEEE Infocom, June 2002.