The Performance of different MAC Layer Protocols in Wireless Networks: A Literature Survey

[1]Archana Mishra, [2]Shahana Qureshi, [3]Devendra Kumar
[1]M.Tech. Scholar, [2]Assistant Professor, [3]M.Tech.
[1] Department of Computer Science & Engineering,
[1]Raipur Institute of Technology (RITEE), Chhatauna, Mandir Hasaud, Raipur, Chhattisgarh, India

Abstract : ***After many years of their appearance, Wireless Sensor Networks (WSNs) remain a dynamic research point due to their wide extend applications in areas, for example, human services, military, observing and reconnaissance frameworks. In many applications, sensor networks are compelled in energy supply and correspondence data transfer capacity. Along these lines, novel strategies to decrease energy wasteful aspects and for effective utilization of the restricted transfer speed assets are fundamental. Such requirements joined with thick organize organization represent a few difficulties to the outline and administration of WSNs and require energy mindfulness at all layers of the systems administration protocol stack. For example, at the Data-Link layer, low obligation cycle Medium Access Control (MAC) protocols exchange off inactivity for energy productive activity. In this paper, we introduce an overview of cutting edge low duty cycle MAC protocols. We first blueprint the design challenges for MAC protocols in WSNs. At that point, we introduce an extensive overview of the most unmistakable and recent popular MAC protocols. These protocols are ordered into synchronous and asynchronous in light of their method of task. At last, the paper feature open research issues in MAC layer for WSNs is been discussed.***

Index Terms - Wireless Sensor Networks; Linear Sensor Networks; Duty-cycle; MAC protocols.

I. INTRODUCTION

Mac protocols get a great deal of consideration because of their effect on the life of WSN. Sensor networks are worked by batteries which have a restricted lifetime. Additionally these networks are sent in the earth where their substitution ends up troublesome.

A strengthen productive plan of MAC protocol can limit the battery utilization and increment organize lifetime to an awesome broaden. Macintosh protocol ought to likewise think about the throughput prerequisites of the application. WSN are an uncommon kind of remote information correspondence arranges which involves sensor networks scattered in condition. These sensor networks in the WSN involve a detecting unit, preparing unit, memory unit and transmitter/beneficiary circuit. These networks work on battery and cooperate to play out a shared objective which could be application particular. WSN are for the most part utilized for detecting and assembling data required by savvy situations, for example, structures, ventures, home, and so forth. Productively getting to the medium is one of the imperative necessities for consistent activity of system. The crude techniques for getting to the medium like in IEEE 802.11 are not attainable for WSN based application as it requires steady detecting and checking of the channel, which is wasteful for WSN networks as they are exceptionally subject to their battery for energy.

Association of rest of the paper is as per the following. Segment II features MAC related issues, for example, potential explanations behind energy wastage. Area III portrays some famous MAC layer protocols. Lastly Section IV closes the paper.

II. MAC RELATED ISSUES

Limiting the energy utilization in WSN is a typical sensor organize examine zone. There are a few issues that should be considered while planning a proficient MAC protocol for a WSN.

A. Reasons of Energy Wastage

There are numerous energy related issues that are impressive at MAC layer. These issues ought to be remembered previously planning any MAC protocols for WSN. These are as per the following:

• ***Collisions:*** When at least two transmissions by various network crashes at the collector then an impact is said to happen. On crash packets gets defiled and sender requirements to retransmit them. A gigantic part of energy is squandered because of retransmission caused because of crash.

• ***Protocol Overhead***: A proficient protocol configuration ought to consider the overhead of control packets i.e. the energy use on control packets ought to be dealt with. An exchange off between control packets and energy utilization for them ought to be kept up.

• ***Overhearing:*** This is of primary worry in the system where the movement is high. WSN are communicated organize where a great deal of energy squanders in type of catching, when the unintended receivers hears the packets. These energy wastage increments if the system is thick. An unintended network could turn its radio off under this condition to spare energy.

• ***Idle listening:*** This alludes to detecting the channel when no transmission is going ahead in the channel. In such circumstance on the off chance that a network continues tuning in to channel it will squander its energy this is called sit without moving tuning in. This is a noteworthy issue in the systems where the movement is low.

• ***Complexity:*** It is a measure of sum or energy spent in executing complex calculation engaged with MAC protocols.

B. Communication composed in WSN

For the most part these three correspondence patters are found in WSN [1]:(i) broadcast (ii) coverage cast (iii) nearby gossip. Base station (sink) utilizes message communicate to transmit message to rest of the networks exhibit in the system. Communicated packets may comprise of updates of specific projects for rest of the networks, control packets for the whole framework and so on.

Sensors imparting locally are said to convey by means of nearby gossip, here a sensor makes an impression on its neighboring networks inside its region. At the point when a gathering of sensors convey to a particular sensor network then it is called meet cast.

This goal sensor network might be a group head, information combination focus or a base station and so on. Multicast kind of correspondence is determined by correspondence design where a sensor network imparts to a particular subset of networks.

C. Qualities of MAC Protocol

A proficient MAC protocol configuration considers certain critical characteristics [2]. The first is the energy effectiveness, the protocol ought to be energy moderating with the goal that the lifetime of system increments. Other than this other noteworthy qualities are versatility and flexibility. Network topology and size changes quickly in WSN in light of regular and surprising expansion. One fundamental property of a MAC protocol ought to be adaptability to these progressions. Also, other characteristics like idleness, throughput and data transfer capacity use are application subordinate and have less need. Reasonableness among networks isn't that critical as networks are committed to the same objective which is detecting.

III. LITERATURE SURVEY

In this paper, we arrange WSNs obligation cycle MAC protocols into synchronous and asynchronous. Synchronous protocols make a schedule for networks to indicate their rest and wake up times. Asynchronous or unscheduled plans are additionally sorted into transmitter-started and recipient started. When utilizing a transmitter-started approach, a network sends visit transmission ask for parcels, a short introduction or the information packets themselves, until one of them "hits" the listening time of the goal network. In the receiver started approach, networks send visit packets demands, short preface or affirmation, to educate the neighboring networks about the preparation of the network to get packets. In the accompanying two sub-segments we talk about the most conspicuous and popular recent protocols in these two classifications.

3.1. A Synchronous Low Duty Cycle MAC protocols

Every network has two modes, in particular wake and rest. In wake cycle, networks will tune in to the medium for synchronization solicitations and information packets. While in rest mode, nodes kill their packets until the point that the following scheduled wake up time.

In 2001, Pei and Chien presented Power Aware Clustered Time Division Multiple Access (PACT) to use latent grouping, where networks execute as the foundation of the correspondence ***[11].*** Networks are named, Ordinary network, Cluster Head, and Inter-group Gateways. Group Head networks and Inter-bunch Gateways pivot their obligation to maintain a strategic distance from control consumption. Energy utilization caused by synchronization overhead increments as the system develops in estimate. This is because of networks tuning in to the medium to gain power packets from different networks. What's more, any network with information prepared to be transmitted will make its way to the sink before transmitting, which expands the information conveyance inactivity.

One early energy effective and most referred to obligation cycle MAC protocol is Sensor-MAC or S-MAC ***[21].*** S-MAC is a complex protocol that applies intermittent rest wake cycle to IEEE 802.11 for WSNs to lessen energy utilizations furthermore, bolster self-arrangement ***[12].*** The method of S-MAC accepts that applications will have long sit out of gear periods and can endure some inertness. This makes S-MAC inadmissible for the class of utilizations requiring brief revealing. It accept that networks don't should be in wake/standby mode untouched. Rather, its gathering all networks in level way and mastermind them by synchronizing the rest/wake timetables of neighboring networks. Networks likewise keep up their rest/listen cycles plan by making a calendar table for every network to refresh its neighbors plan. Accordingly, neighboring networks may have same schedule vacancies for transmissions. Sit without moving networks will rest amid transmissions of different networks. The listening time frame contains SYNC and DATA messages. Matchup is a packets to synchronize one network with its neighbors. While DATA message is for information transmission utilizing the handshake techniques for Request-To-Send (RTS)/Clear-To-Send (CTS). S-MAC uses a consolidated dispute plan and booking for crash shirking. What's more, meddling networks will rest when they got control message to abstain from catching. In S-MAC, long messages will be partitioned into little sections keeping in mind the end goal to be sent as burst ***[21].*** This strategy makes more messages to send, which requires longer access to the medium. S-MAC was outlined primarily to lessen energy utilization, yet it overlooks other vital execution factors, such as decency, throughput, data transfer capacity usage, and inactivity ***[13].*** Decency will corrupt (MAC level point of view) as a few networks with little date should hold up MAC with versatile tuning in, messages move two jump in every obligation cycle ***[13].*** Therefore, idleness gets higher as more messages are holding up to be sent.

T-MAC ***[14]*** was acquainted with enhance the execution of S-MAC by utilizing a dynamic obligation cycle rather than a settled one. The thought is to transmit all messages starting with one network then onto the next in blasts of variable length, and to rest between blasts for assist energy sparing. It additionally decides the length of variable load by keeping up an ideal time. T-MAC applies RTS and CTS strategy. At the point when RTS did not get CTS reaction it would attempt again before giving up. As in S-MAC, T-MAC can just send the message to one expectation each obligation cycle, which result in high dormancy. In expansion, T-MAC has an early rest issue, as a network change to rest notwithstanding when a neighbor has some message holding up to be sent. Thus, the throughput is diminished in networks to sink transmission.

RMAC ***[15]*** is like S-MAC as sensor networks have three states of mind in each cycle (SYNC, DATA, and SLEEP). It contrasts from S-MAC by sending a pioneer outline (PION) amid the DATA mode to save the divert in the Rest cycle to send the message through numerous networks in a single obligation cycle. PION is doing RTC and CTS separately, what's more, proceeds through the system until the point when the finish of DATA cycle, or the PION achieved its objective.

Expanding on RMAC, P-MAC ***[16]*** proposed to send numerous messages per obligation cycle. That has given better movement taking care of favorable position over RMAC. P-MAC partitions the system around the sink network by utilizing Grade Division what's more, Scheduling Assignment (GDSA). Every network sets up its calendar as per the review it has a place with. Networks that are situated in a similar review will keep up a similar planning time. This timetable is stumbled with lower and upper evaluations. P-MAC utilizes pipelining to advances packets from upper to bring down review to decrease the system inactivity. RTS in P-MAC contain review information, thus just networks from bring down review can react with CTS. Furthermore, Dispute Window (CW) used to dodge conflict when more networks answer with CTS. Basic examination for this protocol required. Table 1 abridges the highlights of the inspected synchronous obligation cycle MAC protocols.

Table 1: Synchronous duty cycle protocols Advantages & Disadvantages.

MAC Protocol	Advantages	Dis-Advantages
S-MAC	Low duty cycle to save energy;- Virtual clusters to support scalability and self-configuration;Overhearing avoidance to save energy;- Message passing to reduce contention latency	High latency due to periodic sleep ;Fixed duty cycle not adaptive to dynamic traffic loads
T-MAC	Save more energy by the adaptation to dynamic traffic	ADC increase latency and reduce throughput ;Difficult to distinguish the communication pattern of a live WS
R-MAC	Energy-efficiently in high traffic loads ; Data collision rate is low regardless the traffic loads	Proposed GTS packets cause sleep latency in the neighbouring nodes
P-MAC	Cross-layer Energy-efficiently in high traffic loads ;Data collision rate is low regardless the traffic loads	Does not exploit linear topology in the network.

3.2. Asynchronous Low Duty Cycle MAC protocols

Berkeley MAC or B-MAC ***[17]*** is a non concurrent obligation cycle MAC protocol. In B-MAC, every network has its autonomous obligation cycle booking. Network can transmit by sending a prelude alongside the information parcel, which must be longer than the collector's resting time, to ensure that the beneficiary will be in wake up mode. On the off chance that a network is in a wake cycle, it tests the medium just when a preface has been recognized. Power utilization, throughput what's more, dormancy are enhanced in B-MAC, in any case, catching and the long preface are significant downsides.

X-MAC ***[20, 18]*** was proposed to beat the disadvantages of B-MAC. It utilizes short introductions to keep away from the catching issue. The introduction contains the objective deliver to encourage untargeted networks to rest and permit the directed network to send early ACK. This abstains from catching as well as lessens the idleness significantly. The absence of adaptability is the fundamental disadvantage of this protocol as it is difficult to reconfigure it after organization. Another issue with this approach is that it neglects to consider the movement caused by the preface transmissions. The control proficiency is impact when the movement developed, as the remote medium will be occupied by the prelude transmissions.

Table 2: Asynchronous duty cycle protocols Advantages & disadvantages

MAC Protocol	Advantages	Dis-Advantages
S-MAC	Low duty cycle to save energy;- Virtual clusters to support scalability and self-configuration;Overhearing avoidance to save energy;- Message passing to reduce contention latency	High latency due to periodic sleep ;Fixed duty cycle not adaptive to dynamic traffic loads
T-MAC	Save more energy by the adaptation to dynamic traffic	ADC increase latency and reduce throughput ;Difficult to distinguish the communication pattern of a live WS
R-MAC	Energy-efficiently in high traffic loads ; Data collision rate is low regardless the traffic loads	Proposed GTS packets cause sleep latency in the neighbouring nodes
P-MAC	Cross-layer Energy-efficiently in high traffic loads ;Data collision rate is low regardless the traffic loads	Does not exploit linear topology in the network.

RI-MAC ***[19]*** utilizes the beneficiary started instrument to accomplish bring down power utilization, higher throughput and parcel conveyance proportion. Like B-MAC, every network has its autonomous obligation cycle booking. The key distinction contrasted with B-MAC and X-MAC is that the sender in RI-MAC remains in dynamic mode until the focused on recipient is prepared and the message begin to be conveyed. Collector will advise the sender by sending signal casing. Table 2 compresses the highlights of the investigated offbeat obligation cycle MAC protocols.

3.3 Other Research Work on MAC Protocols

Numerous different systems for diminishing energy have been put forward as of late at MAC layer to lessen the energy utilization. For instance in ***[3]*** where a philosophy of making a unique ring is utilized and each network has its turn in correspondence which is requested like a ring to maintains a strategic distance from impacts. Utilizing a ring structure has leverage that as it were one network sends at once and just a single network gets in an opening and every other network will rest. This expands the rest time of every other network. The ring is made versatile by refreshing the opening task of all sensors if there should be an occurrence of new networks joining or on the other hand old networks leaving the system. This requires three stages: to start with is the set-up advance in which a pioneer is chosen which allocates every sensor network an opening for sending and getting the information (opening R and S) all networks are conscious amid this progression.

The second step is correspondence venture in which all networks get information in their particular spaces and total got information which is send to the following network in the sending opening of the network. The third step is adaption advance in which when a sensor leaves or joins the system, the structure is refreshed ***[4]*** proposes the initial two stages. In ***[3]*** the adaption step also, the protocol parcel structure is presented.

There are numerous token based protocol like the one presented in ***[5]*** which is single token based protocol. Here sink network is the root network, which has a token and any source network which need to send any information send a demand message to the sink network for the token. At the sink network a demand line is kept up as per the timestamp of the solicitations which are prepared in FIFO arrange. The answer for the demand is then sent alongside the token. This technique diminishes the danger of crashes yet builds inactivity. In this way a rest booking component is presented ***[5]*** in which sink is the root network and is at level zero. Every network should have two parents keeping in mind the end goal to build up various way from source to sink. Guardians are chosen at the purpose of development of tree as indicated by the criteria specified in ***[5].*** After this progression the networks set their level one not as much as that of their particular parent. At the point when this methodology closes every network has a settled level.

Since tree development is an occasional occasion, every network's level (other than the sink network) changes occasionally. A multi-token based protocol ***[6]*** utilizes this tree booking and different token way to deal with enhances it further. In this approach each moderate network has a token which it goes to the sensor networks who are available at the clears out.

Another protocol is characterized in ***[7]*** which is a cross breed protocol furthermore, consolidates the benefit of both TDMA and FDMA in request to give constant correspondence in WSN. Recipient started protocols are getting up to speed a considerable measure of consideration on the grounds that they offer numerous advantages over sender started protocols. They are productive in dealing with shrouded networks issue effectively.

They bolster offbeat correspondence however does not utilize introduction of sender-started low power tuning in. These protocols utilize recipient started probe**,*[9]*** displays such a protocol. In [***10]*** a similar investigation of four MAC protocols is given on test bed of Telos B bits to look at them in different correspondence situation like communicate, converge cast, nearby talk and so forth.

Body region networks (BAN) are a use of WSN in which an arrangement of sensor networks are put in human body associated by remote connects to screen the body. The working of MAC protocols in such a situation is very unique due to changes caused by body developments. One of such works is said in [8] known as BAN-MAC. It effectively handles the contention free getting to in Body territory systems which is a progressive field in human services area.

IV. CONCLUSION

Assessing the looks into display till date there are hundreds of MAC protocols for different utilizations of WSN, however none of them could be considered as a standard protocol for all applications. By and large all protocols are application-subordinate this is because of the way that in WSN situation the essential nature of activity, networks and so forth changes as indicated by the application. The changing nature of these traits causes this heterogeneity in MAC protocols. In addition there is an absence of institutionalization in the lower layers. Likewise sensor equipment are additionally application subordinate. Consequently we can state that there is no standard MAC protocol for each WSN based application however a portion of the best protocols could be found in the past examines agreeing to the idea of the application.

REFERENCES

[1] S.S., Kulkarni,"TDMA services for Sensor Networks", 24th International Conference on Distributed Computing Systems Workshops, 23-24, pp.604 609, March 2004.

[2] W. Ye, J. Heidemann, D. Estrin, "Medium Access Control With Coordinated Adaptive Sleeping for Wireless Sensor Networks", IEEE/ACM Transactions on Networking, Volume: 12, Issue: 3, , pp.493 -506, June 2004.

[3] Thibault Bernard, Hac'ene Fouchal, "A Low Energy Consumption MAC Protocol for WSN", IEEE ICC Ad-hoc and Sensor Networking Symposium 2012.

[4] T. Bernard and H. Fouchal, "Efficient communications over wireless sensor networks", IEEE Global Communications Conference (Globecom-2010), Miami, USA, December 2010

[5] Amulya Ratna Swain, R. C. Hansdah,Vinod Kumar Chouhan "An Energy Aware Routing Protocol with Sleep Scheduling for Wireless Sensor Networks", 24th IEEE International Conference on Advanced Information Networking and Applications 2010.

[6] Subhasis Dash, Amulya Ratna Swain, Anuja Ajay, "Reliable Energy Aware Multi-Token Based MAC Protocol for WSN", 26th IEEE International Conference on Advanced Information Networking and Applications 2012.

[7] Djalel ABDELI, Saoussan ZELIT, Samira MOUSSAOUI, "RTH-MAC:A Real Time Hybrid MAC protocol for WSN", 978-1-4799-1153-0/13/, , pp. 153-162, 2013 IEEE.

[8] K.Shashi Prabh, Fernando Royoy, Stefano Tennina, Teresa Olivaresy,"BANMAC:An Opportunistic MAC Protocol for Reliable Communications in Body Area Networks", 8th IEEE International Conference on Distributed Computing in Sensor Systems, pp.166-175, 2012.

[9] P. Dutta, S. Dawson-Haggerty, Y. Chen, C.J. Liang, and A. Terzis,"Design and Evaluation of a Versatile and Efficient Receiver-Initiated Link Layer for Low-Power Wireless", 8th International Conference on Embedded Networked Sensor Systems(SenSys10) Zurich, Switzerland, pp.1-14, 2010.

[10] A. Keating, B. Bates, and R. Kinicki."Energy Analysis of Four Wirelesss Sensor Network MAC Protocols", 6th International Symposium on Wireless and Pervasive Computing (ISWPC11), Hong Kong, China, February, pp. 1-6, 2011.

[11] Pei, G. and C. Chien, Low power TDMA in large wireless sensor networks, in Military Communications Conference, 2001. MILCOM Communications for Network-Centric Operations: Creating the Information Force.. p. 347-351 vol.1, IEEE. 2001.

[12] Sung, S., et al., Energy Consumptlon Analysls of S-MAC Protocol in Single-Hop Wireless Sensor Networks, in Communications, APCC '06. p. 1-5, Asia-Pacific Conference on 2006.

[13] Ye, W., J. Heidemann, and D. Estrin, Medium access control with coordinated adaptive sleeping for wireless sensor networks. IEEE/ACM Trans. Netw. 12(3): p. 493-506, 2004.

[14] Van Dam, T. and K. Langendoen,An adaptive energy-efficient MAC protocol for wireless sensor networks,in Proceedings of the 1st international conference on Embedded networked sensor systems., ACM: New York, NY, USA. p. 171—180, 2003.

[15] Akl, A., T. Gayraud, and P. Berthou. A metric for evaluating density level of wireless sensor networks. in Wireless Days (WD), IFIP. 2011.

[16] Fei Tong; Wan Tang; Rong Xie; Lei Shu; Young-Chon Kim, "P-MAC: A Cross-Layer Duty Cycle MAC Protocol Towards Pipelining for Wireless Sensor Networks," Communications (ICC), 2011 IEEE International Conference on , vol., no., pp.1,5, 5-9 June 2011.

[17] Polastre, J., J. Hill, and D. Culler, Versatile low power media access for wireless sensor networks, in Proceedings of the 2nd international conference on Embedded networked sensor systems., ACM: Baltimore, MD, USA. p. 95-107, 2004.

[18] Beaudaux, J., et al., Thorough Empirical Analysis of X-MAC over a Large Scale Internet of Things Testbed. Sensors Journal,. PP(99): p. 1-1, IEEE, 2013.

[19] Vigneshwar, G. and T. Senthil. Life time maximization analysis with application to LL MAC & RI-MAC protocol in wireless sensor networks. in Information & Communication Technologies (ICT), 2013 IEEE Conference 2013.

[20] Buettner, M., et al., X-MAC: a short preamble MAC protocol for duty-cycled wireless sensor networks, in Proceedings of the 4th international conference on Embedded networked sensor systems., ACM: New York, NY, USA. p. 307—320, 2006.

[21] Ye, W., J. Heidemann, and D. Estrin, "An energy-efficient MAC protocol for wireless sensor networks" in INFOCOM 2002. Twenty-First Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings.. p. 1567-1576 vol.3, IEEE. 2002.