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A Comparative Study of Contention-Based Mac Protocol for Wireless Sensor Network

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Abstract- Wireless sensor network has become a leading area of research because of its various applications such as environmental monitoring, target detection and tracking, health monitoring, industrial process monitoring, energy efficiency, disaster management and military security system. Energy efficiency is an important requirement in a wireless sensor network. Most of the energy is consume in the communication part of the sensor node. Medium access control protocol play an important role in energy consumption for wireless sensor network. The aim of this paper is to study energy efficient contention based mac protocol in wireless sensor network. The objective of this work is to find the best suited mac protocol for wireless sensor network in different environment.
Keywords: wireless sensor network, mac protocol suitable for wsn, energy efficiency.

I. INTRODUCTION

Wireless sensor network (WSN) is a network of sensor, microcontroller, and RF transceiver and user interface device for communications infrastructure for monitoring and recording the physical conditions of the environmental and organizing the collected data at a central location. WSNs measure environmental conditions like temperature, sound, pollution levels, humidity, wind speed and direction, pressure, etc. WSN is a collection of sensing nodes. Each node has a small energy and processing power which monitor the environment & collect the information. Each node has limited power, energy saving is a very important task in the wireless sensor network. Each node transfer information to another node & make a communication network [11]. The goal of wireless sensor network is to collect data at regular intervals and then transform data into an electrical signal. Finally, send the signals to the sink or the base node. The main features of WSN are to self – organization, energy efficiency, self-healing, low complexity, low size of nodes and low cost [16].

In all shared-medium networks, MAC is an important technique. This technique enables the successful operation of the network. Rests of paper is organized as follow: section II gives an overview on MAC Protocol for WSN and section III   Energy efficiency MAC Protocols. In section IV a related work. In section V a conclusion on basis reviews   paper and references.

A. MAC Protocol

MAC stands for **M**edia **A**ccess **C**ontrol. A MAC layer protocol is the protocol that controls access to the physical transmission medium on a LAN. The role of medium access control (MAC) is to controls, when and how each node can transmit in the wireless channel. It tries to ensure that no two nodes are interfering with each other's transmissions, and deals with the situation.

II. MAC PROTOCOLS FOR WSN

The MAC Protocols for WSN Network must achieve two goals. The first objective is the creation of the network infrastructure and the second objective is to efficiently and fairly share communication resources between sensor nodes [14]. The main task of MAC protocol is to avoid the collision from interfering nodes. In WSN many MAC protocol is developed for wireless voice & data communication network [3]. It controls the accessing of channel in a network. MAC protocol is used for improve energy efficiency by increasing sleep duration, decreasing idle listening and overhearing and eliminating hidden terminal problem or collision of packets [1] because energy efficiency is primary concern of MAC attributes. It is one of the most important attributes for sensor networks, since most nodes are battery powered and it affect the overall node lifetime.

A. Functionalities of MAC protocol

1) Framing: - It performs data encapsulation and de encapsulation in a device and also defines the frame format.
2) Medium access: - It becomes the main function of wireless MAC protocol. It controls the device to participate in communication at any time.

2288

3) Flow control: - It prevent from frame loss, overloaded recipient buffers.
4) Error control: - It use for error detection and error correction codes [1].

B. Attributes of MAC Protocol

In order to design the MAC protocol for WSN considers the following properties.

1) *Energy efficiency:* One of the most important attributes for sensor networks, the sensor node consist battery power and it is complicated to change or recharge batteries for these sensor nodes. It affect the overall node lifetime.
2) *Scalability and adaptively:* Network size, node density and topology change and a good MAC accommodates changes gracefully.
3) *Latency:* Its importance depends on application. Delay from sender to receiver.
4) *Throughput:* The amount of data transferred from sender to receiver in unit time. It affected by efficiency of collision avoidance, channel utilization, latency, control overhead… [3].

C. Energy consumption at MAC layer in WSN

The reason of energy loss in a MAC protocol for WSN is the following.

Collision, Control Packet Overhead, Ideal Listening and Overhearing are a major source of energy wastage in WSN.

1) *Collision:* When two or more frames are received at the same time, damaging the resulting signal. All information is lost.
2) *Overhearing:* To receive a packet whose destination is any other node. Result is in the wasted energy.
3) *Idle listening or passive listening:* When a node has it radio on, listening to the medium while there are no transmission then result is wasting energy. Idle listening is more important because when the node has neither data to send or receive then nodes has been kept alive.
4) *Over Emitting:* Energy for sending message is wasted when the destination is no ready for receiving sending message.
5) *Control packet:* For sending and receiving control packet energy is required.[13]

D. MAC Protocols Categorization

The medium access control protocol can be broadly divided into two categories:-

1) *Schedule based:* In Scheduled Based MAC Protocol is a communication protocol, it is used for access nodes in the shared medium is divided with respect to time (Time Division Multiple Access), frequency (Frequency Division Multiple Access) and pseudo codes (Code Division Multiple Access). It allows the different nodes to access the shared channel without collision. It is energy efficient protocol hence they do not waste energy in collision and idle listening. Examples of Scheduled based MAC protocols are: Low energy adaptive clustering hierarchy (LEACH), Power efficient and delay-aware medium access protocol (PEDAMACS) Schedule bases protocol is based on strict time synchronization requirements. Schedule nodes onto different Time slots or sub-channels.
2) *Contention based:* A Contention based protocol is a communication protocol for operating wireless telecommunication equipment that allows many users to use the same radio channel without pre coordination. Contention based protocol is based on relax time synchronization requirements. In which Nodes compete in probabilistic coordination. Examples: ALOHA (pure & slotted), CSMA, S-MAC.

III. ENERGY EFFICIENT MAC PROTOCOL

A. S-MAC

S-MAC is a contention-based protocol. The goal of the S-MAC protocol is to reduces unnecessary energy consumption. While providing good scalability and collision avoidance mechanism. S-MAC adopts a duty-cycle approach. Duty cycle parameters (sleep and listen periods) are decided beforehand and may be inefficient for the actual traffic characteristics in the network. Nodes periodically transition between a listen state and a sleep state. Each node chooses its own schedule, although it is preferred when nodes synchronize their schedules such that nodes listen or sleep at the same time. Utilizes the sleep mode of wireless radios to trade energy for throughput and latency collision avoidance is based on RTS/CTS.

B. T-MAC

T-MAC introduce an active time out mechanism that depend on the dynamic sleep scheduling in which it decrease the idle listening

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by adjusting the active period of network traffic load. Nodes send messages as bursts of variable length and sleep between such bursts to conserve energy. In T-Mac, if there is no traffic program happen for a specific period of time then the sensor node drives to rest that is called Tact Time. To avoid sleeping problem T-mac introduce a full buffer priority and FRTS(future request to send).

C. B-MAC

It is advancement of S-MAC. It is intended for an Ad-hoc system of nodes with N-sender to 1-recevier transmission. In this protocol idle listening is reduced by shifting the burden of synchronization to the sender. B-MAC protocol uses rest/listen cycle. By using filter mechanism, B-MAC increase reliability and the channel assessment. It works an adaptive foreword sampling scheme which minimize idle listening and reduce duty cycle. Periodic channel sampling that are called low power listening.

IV. RELATED WORK

A large number of studies have been carried out that define energy efficient   MAC Protocol for Wireless Sensor Network. Bhavana Narain(1) carried out such comparisons. this article describe the accessible energy efficient MAC protocol for sensor network their energy saving method and architecture of same protocols and compare the protocol on the basis of their advantage and disadvantage.it use both contention based and scheduled based protocols for wireless sensor network. Meghan (2) this article proposes some MAC protocol for Wireless sensor network and compared their design tradeoffs. It describes how energy consumption reduces and enhances the network life time .the goal is to identify the important design issues that improve the overall performances. Awatef Balobaid (4) This article describe the performance of the MAC protocol in the term of energy efficiency in the different situation and the result of this paper is comparing the protocol on the basic of energy efficiency , throughput, latency and energy efficiency is given higher priority than latency and throughput for comparison. Moshaddique (5) This article describes the various energy saving mechanism that are proposed for MAC protocol in wireless sensor network and discuss the detail mechanism and their strength and weakness and also discuss MAC protocol that use existing energy saving mechanism. MACs use a variety of approaches to save energy and give optimal performance. Hence energy efficiency, though a primary requirement in a MAC protocol, depends on a particular network and application area. Wei ye (6) this article describes S-MAC, a medium-access control (MAC) protocol designed for wireless sensor networks. Wireless sensor networks use battery-operated computing and sensing devices. . S-MAC uses three novel techniques to reduce energy consumption and support self-configuration. To reduce energy consumption in listening to an idle channel, nodes periodically sleep and to reduce contention latency for sensor-network applications.(7)This article describes an energy efficient MAC protocol. This study present a MAC protocol adapted to a class of wireless sensor network. It is used for nodes located in the same radio range. In this case, a node executes a code during a small period and in the rest of the time it moves to a sleeping mode.it maintains an abstract ring which ensures the ordered communication and avoids collisions. (8)This paper carried a multi token based MAC protocol with sleep scheduling for wireless sensor network. The MAC protocol is to improve the energy efficiency along with faster data transmission, data aggregation, data accuracy and minimize the latency delay in hop to hop delivery compared the performance of the proposed protocol with SMAC and RMAC.(9) This paper describe energy efficient dual layer MAC protocol with adaptive layer duration of wireless sensor network. The aim of MAC protocol is to minimize the energy consumption for low power nodes. Performance evaluation is used to compare the proposed MAC protocol with both sensor –MAC and multi-layer MAC using computer simulation. The result shows that the proposed MAC protocol saves energy more than both S-MAC and ML-MAC.(10) This paper proposed and energy efficient analysis of S-MAC and H-MAC protocols for wireless sensor network with special correlation concept. Two MAC protocols such as sensor MAC and hybrid MAC protocol and used to analysis the performance of wireless sensor network using for Energy Consumption. (11) This paper proposed the active research work on energy efficient MAC protocol. Wireless sensor network use battery for power. Developing the MAC protocol for wireless sensor network is an important task to increase the life time of the network. It means power is use very efficiently and the solution of this problem in a MAC protocol has different technique for collision, overhearing, collision overhead and idle listening. (12) This paper proposed the active research work on energy efficient MAC protocol. Wireless sensor network use battery for power. Developing the MAC protocol for wireless sensor network is an important task to increase the life time of the network. It means power is use very efficiently and the solution of this problem in a MAC protocol has different technique for collision, overhearing, collision overhead and idle listening. (15)This paper present the functions of synchronization medium access protocol .It consider passive listening as a source of energy wastage. Passive listening can be an effective method to save the energy.(17) This paper explains the comparative study of contention based and scheduled based MAC

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

protocol on the basic of performance analysis ,its benefits and limitation. (18) This paper presents the energy consumption simulation process of MAC protocol which is used by sensor node. The result of this paper is to get best or effective protocol of energy consumption in wireless sensor network. (19) This paper focused on the theoretical delay lower limit and throughput upper limit exits for IEEE802.11 protocol. It reduces overhead for good performance and to achieve higher throughput. (20) This paper presents the performance of different MAC protocol in WSN. Its performance likes to evaluate mean latency, packet delivery ratio.(21)This paper present TDMA MAC protocol which is used an effective algorithm for nodes to make decision between active and passive sates of medium access protocol. in this paper EMAC and SMAC protocols are compared to each other and the result of simulation process is the EMAC protocol is better than SMAC according to prolong the lifetime of network.

A. *The Comparative Table Based on Related Work*

The following table show the different MAC protocol proposed for WSN, according to four criteria energy saving, MAC techniques, benefits and drawbacks.

Table-1:- Comparative study of some MAC protocols in WSN.

PROTOCOLS	ENERGY SAVING	MAC Techniques	BENEFITS	DRAWBACKS
S-MAC	Power saving over CSMA/CSMAC	CSMA/Scheduling	Time synchronization overhead is prevented due to sleep schedules, Energy consumption is low when traffic is low.	Low throughput, sleep latency.
T-MAC	Less than half of energy use of S-MAC	CSMA/Scheduling	Give better result under variable load, Adaptive active time	Sleep mode issue.
B-MAC	Battery power saving	CSMA/Scheduling	Consume less power, low overhead, high throughput.	Long transmission latency, overhearing.
D-MAC	Low latency	CSMA/Scheduling	Energy-efficient, low latency.	Aggregate rate is large
WISE –MAC	Low power listening	CSMA/Scheduling	Energy saving.	Low power for low traffic.
TRAMA-MAC	Utilization of classical TDMA.	TDMA	Higher throughput and energy saving.	Time is divided into random-access period

V.   CONCLUSION

After study of many research papers we conclude that energy efficiency is one of the major goals in the design of WSN. All paper discusses the different MAC protocol for WSN with their advantage and disadvantage and also compares them to each other. So from overall observation we can conclude that performance of MAC protocol in WSN with aim to improving energy efficient can be improved by using new techniques.

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