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Enhancement of SMAC Using Clustering Approach in Wireless Sensor Networks

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Abstract: ***The Wireless Sensor Networks (WSNs) have become popular with the increasing development of the smart sensors. Since the sensors used in these networks, operate on the limited battery capacity so that energy efficiency is the main goal. Energy efficiency of MAC protocols is one the wide research area because a major energy consuming component of sensor called as radio, is controlled by MAC protocols. In this paper a protocol known as Cluster Based SMAC (CBSMAC) protocol has been proposed which is based on SMAC protocol and the results has been further analyzed by using ns2 tool to show that CBSMAC is more energy efficient in comparison to SMAC.***

Keywords: — Wireless Sensor Networks; SMAC; CBSMAC; Cluster ; Cluster nodes

1. INTRODUCTION

Wireless Sensor Networks are those networks which are formed of the large numbers of the sensors, having the sensing capability and ability to self-organize themselves with the development of the MEMS (Micro electric mechanical system) which leads the development of the smart sensors, Wireless sensor networks have become very popular. These types of the sensors are very small and have limited processing and computer resources and these are very inexpensive in the comparison of the normal sensors. This type of the sensor has the capacity of measuring and gathering of the information from the environment and also they are capable of transmitting the sensed data to the user. Smart sensor nodes can have one or more sensor, one processor and one power supply & radio along with memory. The sensor can be of thermal, mechanical, biological and optical based on the need, whose main function is of measuring of the environment property. Sensor nodes have very limited type of the memory and usually these are applied on that location which is very hard to detect. The function of the radio present in the sensor node is to transfer the data to the base station. For the power supply solar panels may be added but the main source of energy is the battery attached along with the sensor nodes. A Wireless Sensor Network normally does not have any definite. Infrastructure and has thousands of the sensor nodes which works together to control a region to take data from the neighboring environment .Wireless sensor networks are of two types structured and unstructured. A major power consuming component of the sensor is called radio which is controlled by the MAC protocol [1]. So that an efficient MAC protocol increases the lifetime of the sensor networks to a great extent. Also an efficient MAC layer protocol can help in the reduction of the collision and increasing the throughput. Now this paper proposed a Cluster Based SMAC protocol which is based on the fact that using clustering in the SMAC protocol, the listen time can be decremented which helps in better energy efficiency. The remaining paper is divided into three sections in which one describes the related work done in this field , second describes the SMAC description and in the third the results has been analyzed of the proposed work which is followed by conclusion.

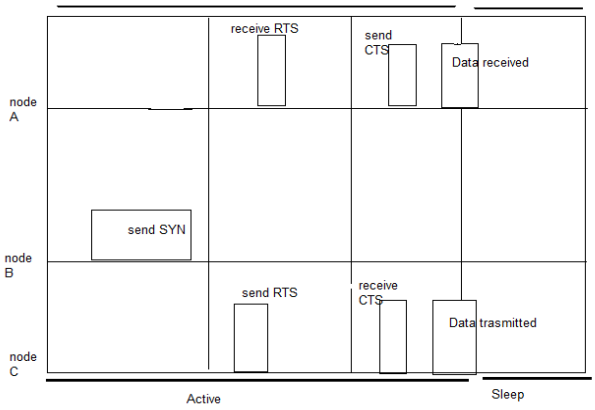
2. RELATED WORK

Base Station Controlled MAC (BSC-MAC) [2] presents an adaptive approach of the energy efficiency. It determines the nodes present on the network as the root and the source nodes and manages the sleep schedule on the basis of these structures. BSC-MAC forces the nodes to sleep adaptively and provides the continuity in the communication.[3]proposed a dynamic threshold based MAC protocol for the cooperative MIMO transmissions. [4] proposed a novel energy efficient type of traffic aware dynamic MAC protocol for wireless sensor networks .the protocol depends on the dynamic adaption of the wake up interval based on the given traffic status register bank. The technique which is used in the protocol allowed the wake up interval to converge to a a steady state for both fixed and

variable traffic state which results in the better energy consumption. [5] Proposed a new approach for integration of Radio over Fiber (ROF) and WSNs and presented a new MAC protocol named as HMARS for this type of the integration. Also some results were shown to analyze better performance of HMARS in comparison with other MAC protocols. [6] Analyzed the MAC protocols on the delay efficiency basis and the protocol were divided into static schedule and the adaptive schedule. Various types of the protocols were defined after the proposed classification and the comprehensive discussion was done on the basis of the latency. [7] Proposed Advertisement based MAC protocol (ADV-MAC) is MAC type of the protocol which has eliminated the energy waste by introduction of the concept of the advertising of the data contention. ADV-MAC minimized the energy which is lost in the idle listening during maintaining of the adaptive duty cycle for handling of the variable load. Besides this ADV-MAC enabled energy efficient MAC-level multicasting. ADV-MAC performs better than the SMAC in terms of energy consumed. Scheduled Unifying Algorithm (SUA) [8] has been proposed to minimize the energy consumption of the nodes present at the border. For obtaining the goal of energy minimization, it unifies the multiple listen and the sleep schedules into a single unified schedule. The SUA performs better than the SMAC on the basis of the energy. [9] Provides a analytical framework for preamble sampling techniques in Wireless sensor networks for the MAC protocols and in addition to this transmitter behavior is also considered which controls the form and the content of the transmitted preamble. Besides this the receiver behavior was also considered. [10] Proposed a system level design method for clustered wireless sensor networks which is based on the semi random communication protocol (SERAN). A SERAN was both of routing and MAC layer protocol and on the both layer SERAN combines both the randomized and deterministic approach. This results in high reliability and major energy saving when dense types of clusters were used. .[11] proposed a scalable type of MAC protocol which works despite of the long and unknown propagation delay of the underwater acoustic type of the medium. The protocol defined can be used in the delay tolerant applications which can be underwater ecological sensor networks between the energy limited nodes. [12] Proposed MAC and efficient routing integrated with support for localization (MERLIN) is a cross layer type of protocol that can integrate both MAC and routing features. In opposite of many MAC protocols, it uses a multicast upstream and downstream approach for the relaying of the packets to and from the gateway. The transmission errors are identified by the asynchronous and negative ACK bursts messages.

3. SMAC OVERVIEW

SMAC protocol is a MAC layer protocol which has been designed for Wireless sensor networks. In this protocol the nodes form a virtual cluster with the same sleep schedule so that all the cluster wake and sleep at the same time. The node which starts synchronization is known as Synchronizer. It emits a SYNC packet which synchronizes all the nodes present inside the virtual cluster. Collision Avoidance is done by the help of the carrier sense and the data exchange is done by the help of RTS/CTS/DATA/ACK. In the Sensor MAC protocol the synchronization is managed locally and the periodic sleep and listen is present on the basis of these types of the synchronization. The neighboring nodes present in the form of a cluster to set up the common type of sleep time. If any two are present in the two different clusters then they can wake up at the listen period of the both clusters. The main objective of this protocol is reduction of the energy since Wireless sensor networks are operated on fixed battery power. Fig1 shows the intervals used in the SMAC



The features of SMAC protocol are as following-

a) Collision Avoidance: Let at a given time, multiple neighbors wants to send their data to a given node. They can send the data only when the receiver node is in listening mode. SMAC protocol uses carrier sense for this and CTS/RTS for the hidden terminal problem. All the nodes do carrier sense before sending the data and if any node does not get the medium then goes into the sleep mode and will wake when again the receiver is free and start listening again. After exchanging of RTS/CTS, in the normal sleep time, the node will finish the data transmission.

b) Periodic listening and Sleeping: In the sensor networks, the nodes are idle for most of the time to check if there is any packet for its but this causes the energy wastage, for reducing this SMAC uses periodic listening and sleeping. The basic application is that a node sleeps for a given interval of time after which it starts to listen that if any node wants to talk it. During the sleeping mode, its radio is off and a timer is set to wake it after sleep time. All the nodes can choose their sleep and listen schedule freely. Nodes broadcast a SYNC packet to exchange their schedules.

c) Message Passing: The sending of the long message in the sensor networks has some disadvantages because of the high cost of the retransmission of the message, if only a few bits have been corrupted in the sent message. And if the message is sent in the fragments then the delay and control overhead will be longer. So to avoid this SMAC sent the messages in fragments by using single RTS/CTS.

d) Overhearing Avoidance: SMAC reduces overhearing by letting of the interfering nodes to sleep after they listens the RTC/CTS . Data packets are normally longer than the control packets so that this technique prevents the overhearing of the data packets.

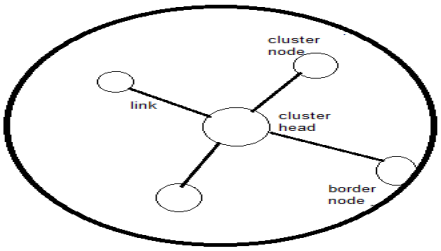
e) Adaptive listening: The technique of periodic sleep and listen can reduce the time for the idle listening when the traffic is normal but it is desirable that when sensing happens then the sensing data must be transferred without any type of the delay. SMAC adopts adaptive listening to reduce the latency caused by the periodic listen. The basic technique for this is to let the given node, hearing its neighbor transmission, to listen for a short period of the time. In this process, if the node is immediate neighbor will able to pass data immediately and will not wait for its scheduled listen time.

4. PROPOSED WORK

In this section Cluster Based SMAC (CBSMAC) protocol is proposed whose main goal is to reduce the energy consumption in the Sensor Networks. It is proposed to overcome the energy which has been wasted in the SMAC protocol. It has been observed that the idle listening wastes around 50-80% energy of the sensors in the listen mode. One way to overcome this problem is to switch ON nodes when data is present and switch OFF when data is not present but due to randomness in coming of the given data the nodes cannot adaptively switch between the sleep and the listen states. So for reducing the energy consumption the listen time should be reduced. The new protocol CBSMAC will reduce the energy wastage in the SMAC protocol. CBSMAC uses the available features in the SMAC protocols and besides this it uses some of the additional features.

a) Periodic Sleep and Listen: The listen time present in SMAC protocol is further reduced which helps in the reduction of the energy consumption.

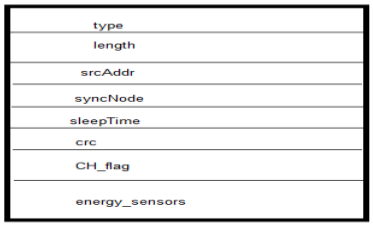
b) Synchronization: In CBSMAC the synchronization is different from SMAC. The nodes which are present in the SMAC exchanges the SYNC packets but the nodes in CBSMAC will exchange the SYNC packets which has cluster along with them. Besides this the periodic time present between two SYNC packets is further decreased which helps in decreasing the overhead in the given network.



CBSMAC follows a mechanism in which the cluster head node controls the remaining nodes present in the given network while the SMAC follows the adhoc fashion for the communication and exchanging of the data. Fig2 is showing a cluster which is having a cluster head, border node and the cluster nodes. Energy saving present in CBSMAC is due to the increased sleep time at the cluster nodes which are present in the cluster. In the starting, the listen time is same for all the nodes of the cluster, but when a node sends data, it sends this to cluster head and after that it goes to sleep state. After this the cluster head increases the listen time of itself and then forward the data to the destination. So that the overall listen time has been decreased on the cluster nodes and it has been increased on the cluster head which enables the cluster head in handling of the data packets. Now the node will save their energy because they are spending more time in sleeping state. The synchronization is done by cluster head who make its node to go in sleep state at the same time. The schedule synchronization is achieved by the sending the SYNC packets among the all node and after this once a cluster head is elected, all the remaining nodes are synchronized by the selected cluster head. In the fig the comparison of the sleep and listen time of the both CBSMAC and SMAC has been done. The frame time present in the both of SMAC and CBSMAC is same while the listen time in the CBSMAC has been decreased which has been added to the sleep time of the CBSMAC. When a cluster node receives the data from more than one cluster then it follows the schedule of all the cluster head from which it has received the SYNC packets and after this bridges between the two given cluster and bridges them and helps the exchanging of the information or the data packets. Border nodes can be said as the backbone of the inter cluster communication because when the border node battery is low then communication between the two cluster is lost so in this case a new border is needed. The cluster node which has maximum number of the neighbors can become a cluster head. The selection procedure of the cluster head can be further described.

A. *Synchronization phase of the CBSMAC*

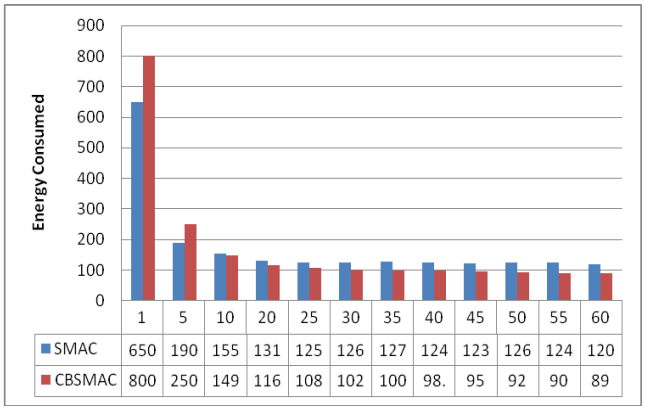
The nodes which are operating in CBSMAC listen to a channel in the initial time and if the SYNC packet is received in this time period the node will check the CH _flag value. If the value is 1 then it will starts to follow the schedule defined in the SYNC packet otherwise in the num Neigh field updation is done and the packet will be dropped. The SYNC packet format used in the CBSMAC is shown in the given fig. The type field to check that received packet is SYNC packet. Length field is used to indicate the size of the packet whose value is 9 bytes by default and the srcAddr keeps the sender ID of the node. Besides this sync Node is present which specifies whose schedule is followed by the given node. The sleep Time specifies the time period when the node goes to the sleep. CH-flag is very important which lets the node to investigate that if the SYNC packet received is from the cluster head. If any node received the two SYNC packets having the CH-flag set to 1 then the node is synchronized and become the border node. Energy sensor specifies the remaining energy in the sender node. The node does not received the SYNC packet with CH_flag set to 1 then it will follow its own schedule which will be broadcasted in the next SYNC cycle.



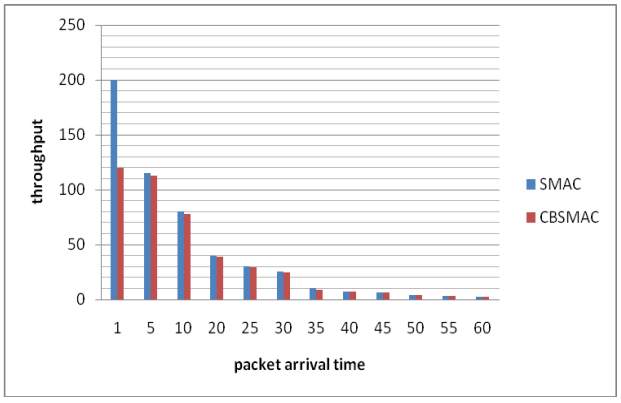
5. RESULTS AND ANALYSIS

The both of the SMAC and CBSMAC has been simulated in NS2 tool and the approach used here is inter cluster scenario. The performance of both of these protocols is compared on the basis of the parameters such as energy consumption and the throughput. Network topology is taken such that source and destination are 6 hops apart from each other. The initial energy value is taken 1000 and the cbr traffic is taken for the 1000 seconds and the packet arrival time is changed from 0 to 60 seconds. Two nodes 1 and 5 sends traffic to the nodes 14 and 13 respectively and the data packet is taken 80 bytes long. After that the following results has been received

a) Energy consumption: The following graph has been plotted on the basis of the energy consumption with the packet arrival time which varies from 0 to 60. From the graph it can be shown that initially the SMAC performs better than the CBSMAC but as the packet arrival time increases the CBSMAC starts to perform better than the SMAC and the energy consumption of the CBSMAC protocol becomes lower in comparison of the SMAC protocol.



b) Throughput: The second metric used is throughput. From the given graph it is shown that when the arrival time is less than 10 the SMAC gives more throughputs then the CBSMAC and after that the throughput of the CBSMAC is almost same as of SMAC. The reason for the low throughput in starting is that as the difference between the sender and receiver distance increases the difference of sent time and the received time of packet also increases. It is due to the increased sleep time of the cluster node and also because of the collision on the cluster head. The last ACK packet that will be received is of higher order so that drop in the throughput happens. But after 10 the throughput increases, it is because of the decrement of the control overhead



6. CONCLUSION AND FUTURE WORK

In the given work the a new protocol named as CBSMAC has been proposed and using simulation it has been shown that this protocol is more energy efficient in comparison to SMAC protocol. In future the results will be analyzed on the other parameters apart from throughput and energy efficiency. And efforts will be done to make this protocol efficient on the other parameters also.

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