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Adaptation of SMAC Protocol with Adaptive Listening for Wireless Sensor Networks

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Abstract— Wireless sensor networks consist of sensor nodes which are expected to be battery-powered and hard to replace or recharge. Thus, reducing the energy consumption of sensor nodes is an important design consideration in wireless sensor networks. The purpose of this paper is to simulate the study of S-MAC protocol under dynamic spectrum access, lot of energy is wasted in wireless sensor networks (like in idle listening, retransmission etc.) to solve this problem we have implemented S-MAC protocol with periodic sleep and adaptive listening that reduces the energy consumption by (minimizing the wastage of energy) The proposed model is compared with S-MAC with periodic sleep, S-MAC without sleep and IEEE 802.11 Simulation results describes that the proposed model optimizes the energy consumption and increases the throughput network simulator 2 has been used to develop the entire model.

Keywords: WSNET, Dynamic Spectrum Access, Network Simulator 2.9

I. INTRODUCTION

WSN - an emerging technology that is a boon for coming generation have wide range of applications and could produce drastic outcomes in the field of medical systems, robotics to monitor environmental conditions such as pressure, sound, temperature etc. The basic layout of the technique is that the network consists of large number of nodes each such sensor network node has lower power radios and embedded processors [1].

Presently the allotment of WSN is strictly under government spectrum policy norms as only a slight portion of spectrum is utilize and vital portion is wasted therefore fix spectrum allocation is not a desirable procedure because of under utilization of availability of free channel [2]. Hence the ultimate solution to cope up with this issue is Dynamic Spectrum Access technology (DSA). Spectrum utilization is increasing year by year as show in Fig 1.

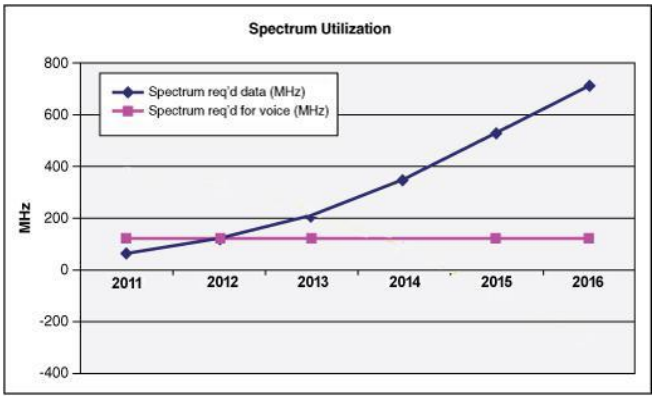

Fig. 1. Spectrum Utilization

This technique were proposed by great intellect Joseph Mitola-III [3]. Another asset of this technique is that it provide as easy demarcation of portion of the spectrum available for usage. Moreover by the virtue of this technique licensed users are also authenticated when they operate a licensed band and this feature is called spectrum sensing.

Energy consumption of node in WSN should be analyzed and devour accordingly because of finite battery available with the nodes sensor nodes in wireless network also gets activated when it needs to transmit the received data Also it became difficult to synchronized with other nodes and to acquire the needed channel therefore MAC protocol and it used for communication as requirement arises for central authority S-MAC tries to reduce energy utilization while listening to an idle channel by using technique like PAMAS, S-MAC also sets the radio of sensor nodes to sleep mode when the nodes are not involved and transmission.
In order to reduce contention latency S-MAC implements message passing for various applications. As wireless networks needs to utilize the channel efficiently and effectively, so the design of S-MAC layer should be such that it utilizes multichannel in parallel.

We need stimulate the S-MAC protocol for battery energy consumption of WSNET in dynamic spectrum access S-MAC tries to minimize the energy consumption by enabling the unused nodes to go into sleep mode by enabling multichannel utilization. We have divided the paper into five sections in the section II we discuss challenges related to WSN. Third section addresses reasons of energy waste in WSN. Section IV proposes SMAC design overview to provide dynamic spectrum access to WSNETs & its implementation. Section V discusses about the methodology used: Queueing Model and about energy consumption. Section VI addresses about the performance evaluation and results. Section VII concludes the paper.

II. CHALLENGES RELATED TO WSN

A. Challenges in real time:
Wireless sensor networks mainly consists of network sensor that deal with different real world environment situations in most of the cases sensor data is required to be delivered within the specific time range in order to take actions or to make required observations till the time very less results exist that meets real time requirements in wireless sensor networks[8]

B. Challenges in power managements:
Wireless network sensor are battery operated also it is not feasible to replace the battery, replace the sensor as sensors node could be deployed in any of the geographic areas depending upon the requirements. So, it is very important to have techniques that should use the energy efficiently so that optimization to the battery utilization could be achieved.

C. Scalability
According to the application number of nodes can vary in the network form few hundreds to thousands or even more sensor nodes are highly adaptive and dynamic in nature.

D. Network Management
Depending upon the application and requirements, sensor nodes could be deployed in any region it is very difficult task to manage it directly so an indirect remote control system should be provide by the framework.

III. REASONS OF ENERGY WASTE IN WIRELESS SENSOR NETWORK

First reason if more than one node sends packet to a particular node then that packet collides at receiving end and they are known as "collides packets". Collided packets needs to be retransmitted that takes more energy utilization.

Second reason is energy waste due to overhearing, which means a node receive packets which are actually meant for some other node.

Third reason that leads to energy waste is control packets overhead like SYNC packet although control packets are required for maintenance of data transmission.

Next reason that leads to energy waste is idle listening last reason but not least in energy wastage due to over emitting i.e. receiver is not ready and transmitter has transmitted the packet.

IV. DESIGN OVERVIEW OF S-MAC

Sensor MAC protocol tends to minimize energy utilization from various source of energy squander that has been identified in the paper i.e., overhearing, collision, idle listening and control overhead firstly we summarize various assumptions that we have assumed about WSN as their implementation.

A. *Periodic Sleep and Listen*

If no event of sensing happens, then nodes remain idle for long duration. Taking the fact that during that period nodes have low data rate by keeping the nodes in periodic sleep state, S-MAC reduces the listening time of the nodes[6]. The basic strategy of periodic listen and sleep is showing Fig 2.

Every node sleeps for specific duration of time and then emerge to check if any of the node wants to communicate. When the nodes goes to sleep state, it turns off its radio and put a times to emerge itself from sleep to listen state later.

Fig. 2. Periodic listen and sleep.

Frame is considered to be a complete cycle of sleep and listen. Normally as per the physical and MAC layer parameters, listen interval is fixed. e.g. size of contention window the duty cycle is described as ratio of listen period to the length of frame. As per the requirements, sleep interval could be changed and this changes the frame length and finally the duty cycle. we consider the same values for sleep interval for all nodes because of simplicity [7].

B. *Avoiding Collision*

If at the same time more than one neighbor wants to communicate to a node they will try to send when node is in listen mode. In this case neighboring node have to undergo contention in order to get access to the medium there are various contention protocols, 802.11 does great job in avoiding collision. SMAC uses alike strategy including physical and virtual carrier sense and request to send/Clear to send interchange for hidden terminal problem. In each packet that has been transmitted there is a duration field which is specifies how long the remaining communication will be using this field node knows how long to hold if received packet which is intended to another node. Network Allocation Vector(NAV) is used to store this value and times is sets for it, nodes decrements its NAV till it reaches zero each time the timer fired. So if a node wants to start the transmission it checks its NAV value. if in case value of NAV is not zero the node assumes that medium is busy this technique is known as virtual carrier sensing[9]. At the physical layer, physical carrier sensing is performed by paying attention to the channel for feasible transference.

Physical carrier sense is performed at the physical layer by listening to the channel for possible transmissions. Randomization of carrier sense time is done in order to avoid collisions and starvations. The medium is determined as free if both virtual and physical carrier sense indicates that it is free [4].

C. *S-MAC Implementation*

Sensor MAC protocol attempts to minimize energy optimization due to collision, idle listening and over hearing. In S-MAC, all the nodes have two states, active and sleep state. S-MAC uses single channel only also data can be transmitted and received by a node only during its listen period. S-MAC uses periodic listen and wakeup scheme, listen period of neighboring nodes is synchronized using S- MAC protocol. Listen period of each node is further subdivided into three phases as described in Fig 3.

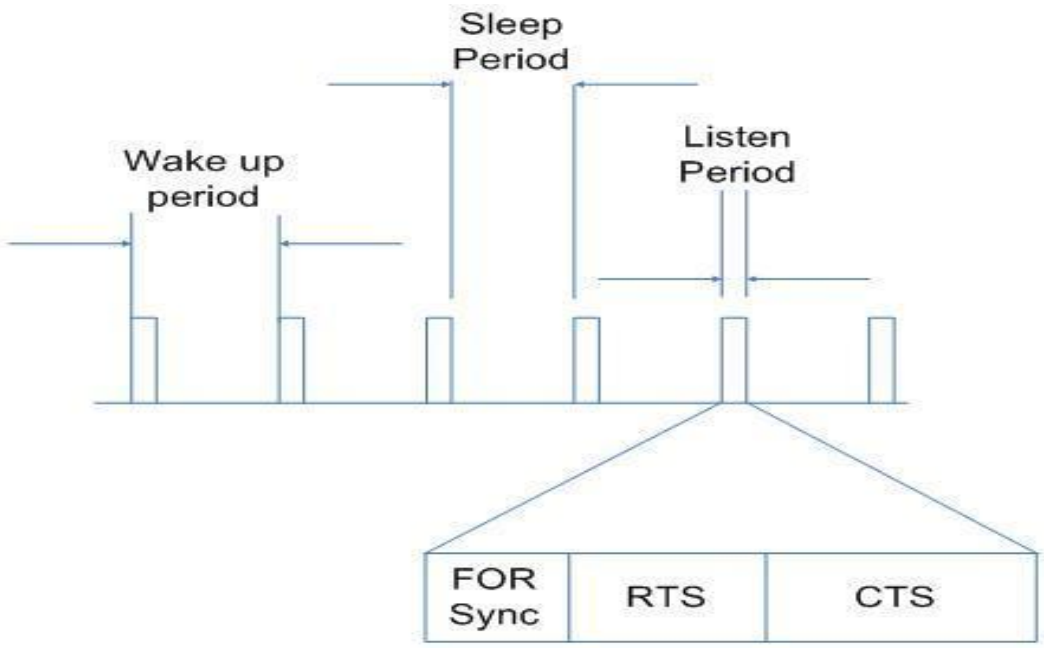

Fig. 3 Listen period phases.

The listen period is the time duration for which node is in awake mode and for rest of the time node is sleeping S- MAC uses fixed intervals for listen and sleep periods. In synchronization phase of the listen period, neighboring nodes synchronize their listen periods, neighbors is maintained using table. Nodes sends RTS packets before starting communication to a particular node, RTS stands for "Request to Send". It is used to check whether the node is free or busy in communication with some other nodes. In CSMA mode, a node send RTS, a particular RTS is acknowledged using CTS, clear to send packet once the node receives the CTS then communicate between that nodes starts. In order to synchronize the neighbor periodically, SYNC packet is used senders address and next sleep time of node is embedded in the SYNC packet. Sender decides the next sleep time and once receiver receives the SYNC packet, it adopts the neighbors schedule and adjust its time as well, In S-MAC large data message are divide into fragments and sent from transmitter to receiver.

The sender receives acknowledgment for each fragment as receiver sends acknowledgment. If sender does not receive the acknowledgement correspond to fragment then it needs to be retransmitted. Using one RTS and CTS message a series of fragments are sent. This method is known as message passing. MAC protocol with variable listen and sleep periods is known as T-MAC. T-MAC allows variable listen and sleep periods to use as per the load in the network the main concept in S-MAC is to synchronize the listen and sleep periods of neighboring nodes by forming virtual clusters. During listen period nodes communicate and for rest of the time they sleep. The immediate neighbor of the nodes, which are participating in communication, sleep till the time communication is completed.

S-MAC contributes in energy optimization by reducing idle listening (as in idle state, nodes sleep) using CTS and RTS, it avoids collision and overhearing by sending long message as a series of fragments together, it saves time and energy. Rather than going for contention after sending each fragment.

V. SIMULATION RESULTS

In this section, results of the simulation are implemented of the proposed model. It explains about the performance environment used for simulation and the simulation results are compared with S-MAC with periodic sleep.

A. *Network Simulator 2*

We have used network simulator version 2.9 in order to evaluate the performance of S-MAC protocol with periodic sleep and adaptive listening [5] NS2 shares various advantage because of which it is widely used for simulating the model it isolates the nodes and network design from operations implemented in AWK[10]

B. *Performance Evaluation*

Gnu plot Fig.4 shows the relationship between the message inter arrival period and energy consumption It is very clear from the graph the energy consumption for IEEE 802.11 is split very high as compare to S-MAC for a given flow.

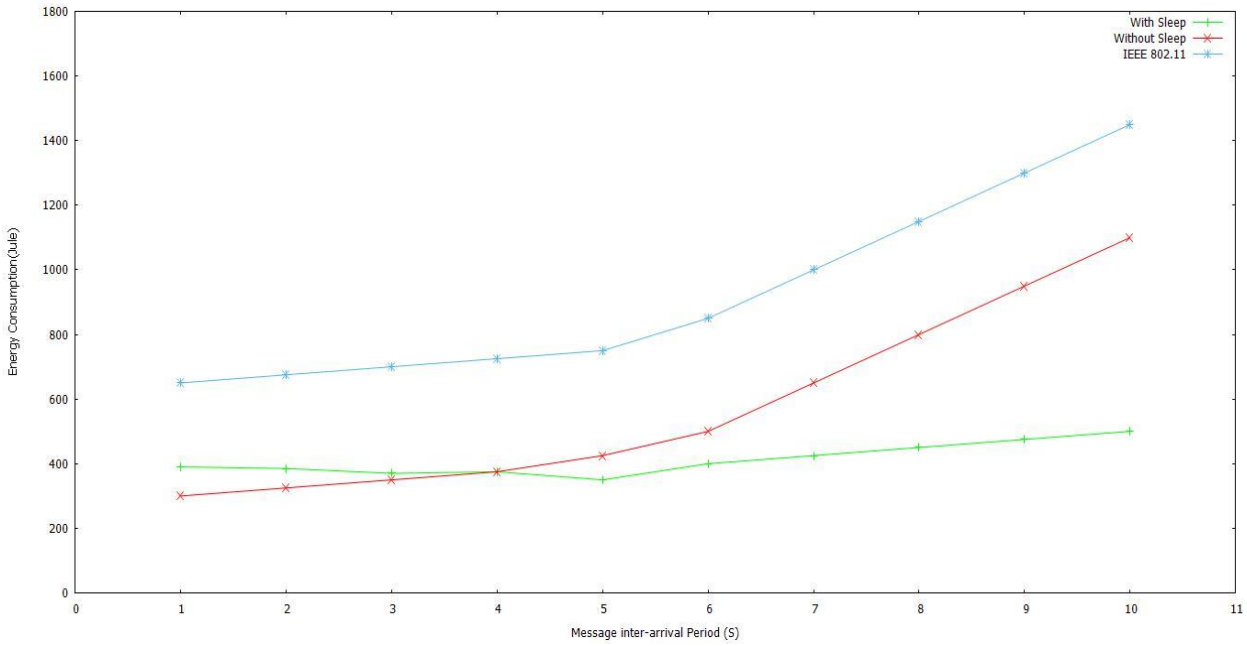

Fig.4 Energy consumption vs Message inter arrival period

Energy consumption reduces with SMAC periodic sleep for the same flow. From Fig. 5, the energy consumption was almost same in the start but drops considerably between 375mJ to 500mJ for SMAC with periodic sleep and adaptive listening in the given range of flows. This is because with increase in message flow adaptive listening dominates the energy consumption. Finally, S-MAC protocol with periodic sleep and adaptive listening is much more energy efficient protocol than SMAC with periodic sleep protocol [11].

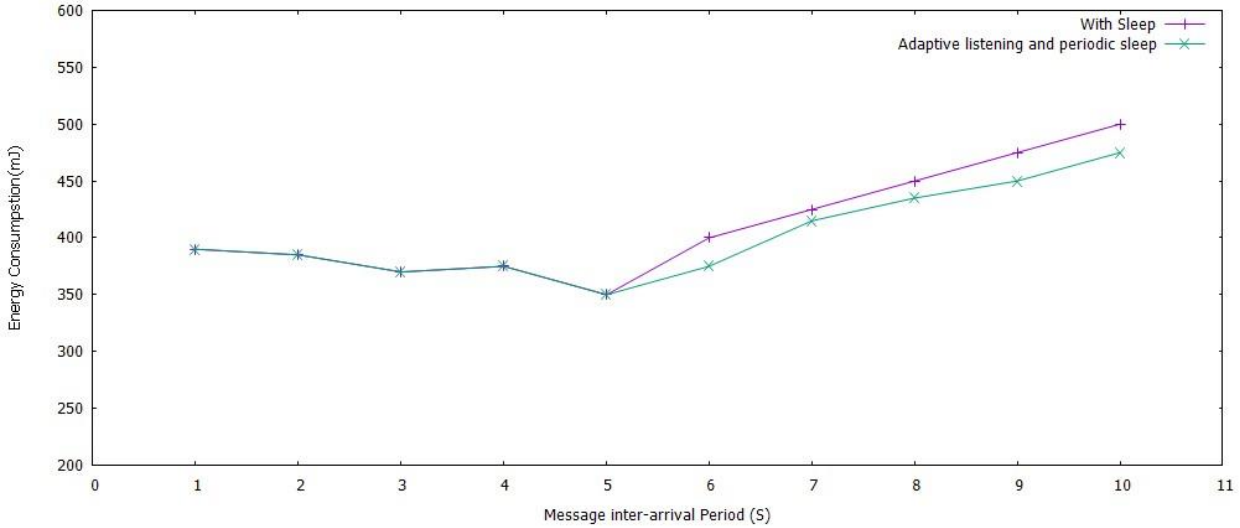

Fig. 5 Energy consumption vs Message inter arrival period

VI. CONCLUSION

This paper presents energy optimization technique for WSN using SMAC protocol with periodic sleep and adaptive listening. Battery optimization and efficiency of energy are the primary goals in the implementation of sensors using periodic sleep and adaptive listening, we achieve the low duty cycle operation of each node with adaptive listening, S-MAC achieves comparable energy saving as compared to S- MAC without sleep and 802.11. This enhances the lifetime of the network which is very important for real world network sensor implementations Adaptive listening enables each node to switch its mode as per the traffic in the network, which in turn reduces the energy waste. Periodic sleep mitigates throughput and elevates latency although curtails the battery consumption we combine the two, periodic sleep and adaptive listening in order to get better results for future work, we have planned to study over hearing and collision avoidance techniques that will further help in optimization of battery for sensors.

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