



## Contention Hybrid MAC Protocol for Wireless Sensor Networks

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**Abstract**— *Wireless sensor networks (WSNs) are widely used to researchers due to their wide range of applications potential in areas such as target detection and tracking, environmental monitoring, industrial process monitoring, forest fired detection and tactical systems. As medium access control has a significant effect on the energy consumption, energy efficiency is one of the fundamental research themes in the design of MAC protocols for WSNs. Sensor networks are expected to be deployed in an ad-hoc fashion, with nodes remaining largely inactive for long time period, but it become suddenly active when something is detected. These characteristics of sensor networks and applications motivate a MAC that is different from traditional wireless MAC such as IEEE 802.11 in several ways. There are plenty of MAC protocols available for WSNs in literature but S-MAC is one of the most popular protocol designed specifically for WSN. In this paper, we described an energy-efficient S-MAC protocol, which is a well-known MAC protocol for WSN. The paper represents simulation of MAC Protocol like S-MAC and IEEE 802.11 performance with different parameters and reveals fundamental tradeoffs on energy, Control overhead, Delay, Packet Data Ratio and throughput. Network Simulator-2 is used for simulation purpose. Results show that S-MAC obtains significant energy savings compared with an 802.11-like MAC without sleeping period.*

**Keywords**— *wireless sensor networks, MAC protocols, IEEE 802.11, Sensor MAC, Energy Efficiency*

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### I.

### INTRODUCTION

This Wireless sensor networks have emerged as one of the first real applications of ubiquitous computing. It has become a hot issue in research, and it is regarded as one of the ten influencing technologies in the 21st century [3]. A WSN is defined as being composed of a large number of nodes, which are deployed densely in close proximity to the phenomenon to be monitored. WSNs communicate via a radio interface instead of being wired to a control station. Sensors themselves are normally not equipped with a radio interface.

Therefore, a simple signal processor and a radio are packaged together with one or more sensors into what is called a wireless sensor node. This is an emerging technology that has a wide range of potential applications including event tracking, environment monitoring, smart spaces, medical systems, agriculture, robotic exploration, traffic surveillance, military surveillance, fire detection, structure and earthquake monitoring, disaster relief, search and rescue, etc. Unlike other wireless networks, it is generally hard (or impractical) to charge/replace the exhausted battery, which gives way to the primary objective of maximizing node/network lifetime, leaving the other performance metrics as secondary objectives. Since the communication of sensor nodes will be more energy consuming than their computation, it is a primary concern that the communication is minimized while achieving the desired network operation. MAC is a good place to save energy. MAC layer takes charge of the distribution and management of the wireless channel. It plays a very important role in avoiding the collisions of nodes and distributing wireless channel, energy and other resources among contention nodes [1].

### II.

### BACKGROUND AND RELATED WORK

Medium Access Control is a broad research area, including work in recent area of low-power and Wireless Sensor Networks.

Recently MAC design for WSNs can be broadly divided into contention-based and TDMA protocols.

a) Contention-Based MACs: The IEEE 802.11 distributed coordination function (DCF)[4] is an example of the contention-based protocol. It is mostly used in ad hoc wireless networks because of its simplicity and robustness to the hidden terminal problem. However, work in [5] has shown that the energy consumption using this MAC is very high when nodes are in idle mode. This is mainly due to the idle listening.

b) TDMA-Based MACs: The other category MAC protocols are based on reservation and scheduling, for example TDMA-based protocols. TDMA protocols have a natural advantage of energy conservation compared to contention protocols, because the duty cycle of the radio is reduced and there is no contention-introduced overhead and collisions. However, using TDMA protocol usually requires the nodes to form real communication clusters, like Bluetooth [9], [8], and LEACH [2]. Most nodes in a real cluster are restricted to communicate within the cluster. Managing inter-cluster communication and interference is not an easy task. So its scalability is normally not as good as that of a contention-based protocol.

A. Woo et al. [5] examine how CSMA based medium access can be adapted for sensor networks. The authors outline a CSMA-based MAC and transmission control scheme to achieve fairness while being energy efficient. They categorize media access control mechanisms into listening, back-off, contention control and rate control mechanisms.

I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci [12] present communication architecture for sensor networks and proceed to survey the current research pertaining to all layers of the protocol stack: physical, data link, network, transport and application layers. They also propose some design factors to be taken into consideration while designing such networks. The design factors listed by the authors are fault tolerance, scalability, production costs, hardware constraints, sensor network topology, environment, transmission media and power consumption. Next, we look at some work on low-duty-cycle operation of nodes, which is closely related to S-MAC.

Finally, Ilker Demirkol et al. [13] outline the sensor network properties that are crucial for the design of MAC layer protocols. Then, it describes several MAC protocols proposed for sensor networks emphasizing their strengths and weaknesses. The authors present a comparison of MAC protocols investigated. Although there are various MAC layer protocols proposed for sensor networks, there is no protocol accepted as a standard. After going through the background work it is found that there are many existing MAC protocols for WSNs including S-MAC. S-MAC is the most popularly used MAC protocol for WSNs. Next section describes the S-MAC protocol in detail.

### III.

### SMAC PROTOCOL DESCRIPTION AND MOTIVATION

A S-MAC protocol was proposed by SCADDS project group at USC/ISI [10]. S-MAC is designed aiming at the requirement of saving energy of WSN according to 802.11 MAC. A detailed description of S-MAC protocol can be found in [11], here we summarize briefly. Three major energy wastage events occurring at a conventional MAC layer have been identified in [11]:

- (a) The Collision results in energy wastage due to their retransmissions of collision of packets.
- (b) And Overhearing occurs when a node listens to transmissions not belongs to it, unnecessary wasting power.
- (c) Idle listening occurs when nodes listen in the hope of receiving any possible data, also wasting energy. Since the power consumed by nodes in idle, receive and transmit states are on the same order of magnitude, the power wastage caused by overhearing and idle listening is no less serious than that of collisions.

The main idea of S-MAC is to put nodes to sleep from time to time to reduce energy wastage caused by the above events. A node goes to sleep periodically if it is not engaged in transmission or reception, to reduce idle listening. It also goes to sleep if its neighbours are involved in communication, of which it is not a party, to reduce collision and overhearing. A *cycle* in S-MAC consists of a listen and a sleep state. A node normally follows predetermined schedules to wake up or go to sleep with the following exceptions:

- (i) A node goes to sleep if any of its neighbours are communicating, and the node is not a party.
- (ii) A node wakes up at the end of its neighbour's transmission if it needs to relay the packet. This is done by overhearing neighbour's RTS and CTS exchanges before the node goes to sleep and serves the purpose of reducing latency caused by sleeping. This behaviour is called adaptive listening [11]. Schedules are periodically exchanged by broadcasting SYNC packets among neighbouring nodes to induce synchronized listen behaviour as much as possible and thus to reduce latency caused by sleeping. Synchronized neighbours form a *virtual cluster*, but synchronization can only be achieved to a certain extent in an ad hoc environment.

### Motivation

Nowadays, WSNs, due to the numerous benefits, support an ever growing variety of applications, including agriculture, environment and habitat monitoring, traffic control, object tracking, fire detection, surveillance and reconnaissance, biomedical applications, home automation, inventory control, machine failure diagnosis and energy management. However, despite the advantages that the utilization of a WSN offers, their use is severely limited by the energy constraints posed by the sensors. High energy consumption of the sensor nodes occurs during the wireless communication between the nodes, sensing and the data processing consume less energy as compared to communication. Therefore, most of the routing protocols in WSNs aim mainly at the achievement of power conservation.

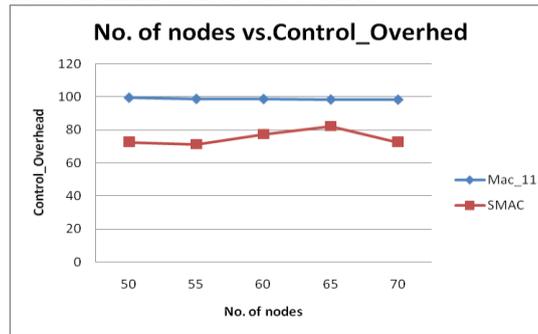
IEEE 802.11, S-MAC are contention based protocol. IEEE 802.11 contend for the entire time periods and consume more energy in compare to IEEE 802.11. S-MAC provide static sleep-listen duty cycle. Thus by adjusting the duty cycle and synchronize time schedule, the consumption of energy should be less. But still increasing the load performance of S-MAC degraded.

### IV.

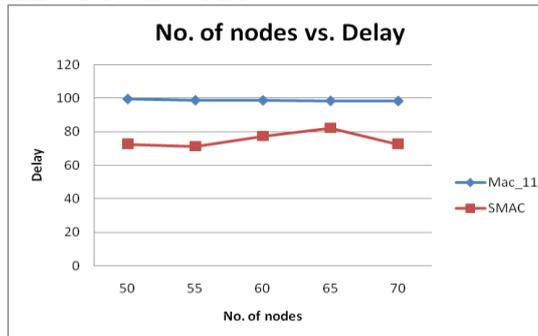
### RESULTS AND DISCUSSION

This section presents the work which has been carried out using NS-2 simulator. We compare the performance of IEEE 802.11 MAC protocol with S-MAC protocol on different parameters like energy consumption, delay, control overhead, throughput, packet data ratio by varying message-inter arrival period and number of nodes. Then this paper analyses the performance of S-MAC protocol in different modes like without periodic sleep and with adaptive listening on different parameters like energy consumption, average end-to-end latency and throughput by varying message-inter arrival period and number of hops. Then this work would reveal the fundamental tradeoffs on energy, latency and throughput on a sample sensor node.

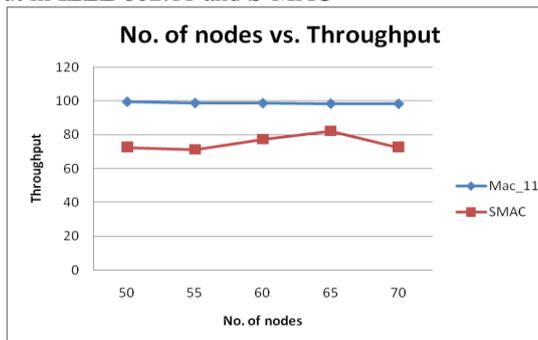
- Comparison of control overhead in IEEE 802.11 and S-MAC



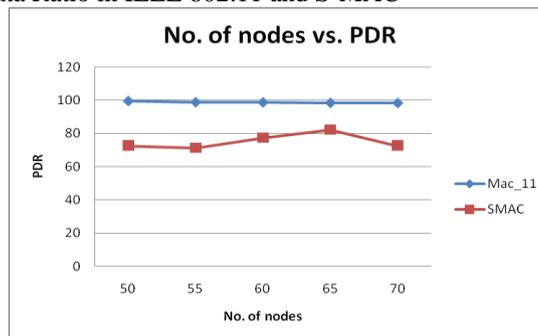
- Comparison of Delay in IEEE 802.11 and S-MAC



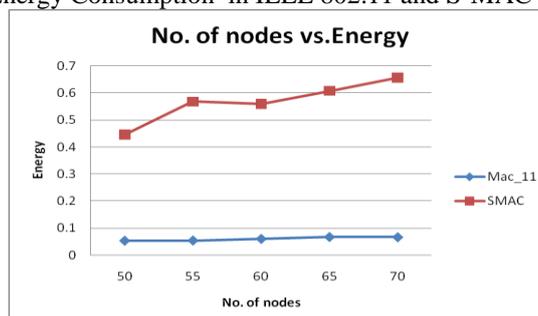
- Comparison of Throughput in IEEE 802.11 and S-MAC



- Comparison of Packet Data Ratio in IEEE 802.11 and S-MAC



- Comparison of average Energy Consumption in IEEE 802.11 and S-MAC



## V. CONCLUSIONS

By Surveying all Papers here we can conclude that IEEE 802.11 is contention based protocol . So in IEEE 802.11 all nodes in the sensor networks always do idle listening for communication between nodes, So lots of energy wasted in that all time hearing. But due to limitations of IEEE 802.11 the new basic protocol introduced that is known as Sensor MAC(S-MAC). S-MAC having the concept of sleep and listen phases in duty cycles. So whenever according to time synchronization the node get requested , will become activated then after go to sleep mode and waits for the next frame starts. But again S-MAC having limitation of static duty cycle, so sometimes energy wastage due to listening. Also performance of S-MAC will be degraded because they are not suitable under load variance. So, in wireless sensor networks to conserve energy of nodes and increase the network lifetime here we propose a new Hybrid Mac protocol that having the concept of TDMA approach. In that protocol the nodes only remain in active mode who have reserved slots in reservation period rather than all time idle listing, otherwise send them to sleep modules. So that energy can be consumed and it will help to increase the network life time.

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