Duty Cycle Scheduling Based on A-MAC Protocol for Wireless Sensor Networks

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Abstract: ***In this paper proposed duty cycle Duty cycle MAC protocol have implemented in wireless sensor network for reduce the energy consumption of sensor nodes. In this paper A-MAC, Adaptive Medium Access Control has to be taken for the energy consumption. The main objective of this paper is to reduce the sleep latency and to balance energy consumption among sensor nodes. This paper compares the proposed A-MAC with RI-MAC and provides the result and it is simulated in NS-2. Experimental result proves that the proposed method gives the better result by average energy, packet delivery ratio, duty cycle, and remaining energy.***

Keywords: Wireless Sensor Network, Medium Access Control, Energy Consumption, Packet Delivery Ratio and Duty Cycle.

1. Introduction

The emerging field of wireless sensor networks combines sensing, computation, and communication into a single tiny device. Through advanced mesh networking protocols, these devices form a sea of connectivity that extends the reach of cyberspace out into the physical world. As water flows to fill every room of a submerged ship, the mesh networking connectivity will seek out and exploit any possible communication path by hopping data from node to node in search of its destination. While the capabilities of any single device are minimal, the composition of hundreds of devices offers radical new technological possibilities.

There is extensive research in the development of new algorithms for data aggregation [1], ad hoc routing [2], and distributed signal processing in the context of wireless sensor networks [5]. As the algorithms and protocols for wireless sensor network are developed, they must be supported by a low-power, efficient and flexible hardware platform.

In present days, network protocols such as S-MAC [9], T-MAC [8], and Zigbee [7] are implemented for loosely synchronized sleep or wakeup cycle to allow nodes to operate at low duty cycles while maintaining network-level connectivity. Duty cycle is measured as the ratio of the listening period length to the wake-up period length which gives an indicator of how long a node spends in the listening period. A small duty cycle means that a node is asleep most of the time in order to avoid idle listening and overhearing. However, a balanced duty cycle size must be achieved in order to avoid higher latency and higher transient energy due to start-up costs.

Several low duty cycle protocols are proposed for WSNs which differ in aspects of synchronization, various type of channels are necessary they are transmitter or receiver initiated operation etc [11]. Divide the low duty protocols into two types they are synchronous and asynchronous schemes. Wireless sensor network data exchange concept is defined for the synchronization [12]. Two basic approaches are used for the asynchronous schemes that are transmitter-initiated and receiver-initiated. Using a transmitter-initiated approach, a node sends frequent request packets (preamble, control or even data packet themselves) until one of them "hits" the listening period of the destination node. On the other hand, the receiver-initiated approach is applicable when a node sends frequent packets (preamble, control, acknowledgment) to inform the neighboring nodes about the willingness of the node to receive packets.

2. Related Work

Wireless Sensor Network is usually regarded as being the most important systems in the current century [14]. WSN materialized because of the moves on stated in micro-electromechanical programs (MEMS) [15] which usually include communications along with signal processing capabilities [18]. As a result this specific generated the actual generation of strength limited low cost very small sensor nodes [14]. These very small sensor nodes possess functions to help perception, method along with communicate with a a remote user through a gateway called the sink. WSN facilitates everywhere calculating which another era personal computer evolution [20] is. Even so, the functions, even though great, are limited as a result of energy constrains.

Enormous research has gone into designing and reviewing energy efficient MAC protocols, reflecting the importance attached to the development of WSNs. Contention-based and schedule-based MAC protocols appear to be the most popular categorization used in the reviews [21]. Nodes in such WSN application normally having limited battery pack capacity for years [24]. As opposed to various other wireless communities [25], it's tough in order to impose or maybe substitute the particular exhausted batteries of deployed sensor nodes. Throughout WSNs, communication concerning sensor nodes is the most strength consuming procedure.

In synchronous multi-channel MAC protocols, single hop broadcast can be easily implemented due to synchronization. Nodes in MC-LMAC [27], MuChMAC [29] and Y-MAC [28] simply broadcast the packet to their neighbor node. MC-

LMAC supports single-hop broad cast without the requirement of some broadcast channel. According to energy saving, the Medium Access Control protocol (MAC) plays an important role to help sensor node. A MAC protocol mediates use of the radio channel among several nodes; it says who is allowed to transmit when. In addition to energy conservation, MAC protocols usually have several other goals. The protocol should be fair: each node should have equal opportunity to communicate with other nodes. The protocol should allow for high bandwidth utilization: the radio channel's time should not be wasted [30].

3. A-Mac Design

In A-MAC, the node with relatively higher remaining energy wakes up more frequently and serves more for the network. This way, data traffic load over the network lifetime will be distributed almost equally to each node, resulting in the fairness of each node's energy consumption rate. This also leads to better sensing coverage or QoSv, which mainly relies on the number of remaining active sensor nodes. In designing A-MAC protocol, we assume the network is densely deployed and the sensing events occur in a low frequency.

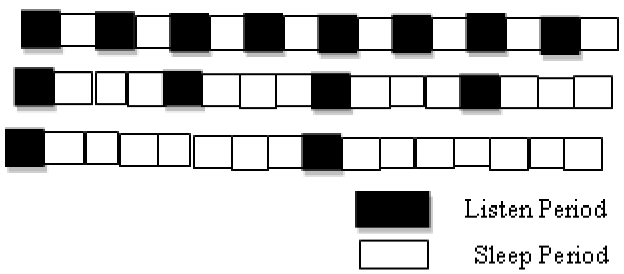

Figure 1: Duty cycle distribution

3.1 Protocol Overview

A-MAC uses the periodic listen/sleep device. An illustration of this duty cycle submission associated with three nodes is actually shown in figure 1. One cycle of sleeping along with a listen period is called the Super frame. This consists of the listen along with a sleeping period, and the listen period is composed of SYNC and also RTS/CTS time slots are generally shown in figure 2. The size of listen period is actually repaired within A-MAC, so your work cycle simply depends on the length of your sleeping period. Through the listen period, your SYNC information and also RTS/CTS packets are generally exchanged. When the RTS/CTS communication is actually successfully exchanged, both the sender and the receiver really should wake up for the sleep period and also send/receive data.

The node to begin with establishes a unique listen/sleep schedule as well as routinely broadcasts the idea within the SYNC communication. One other node listens closely due to this synchronization information. In the event the node hears a new schedule through a different node, the idea adopts this obtained schedule while a unique, similar to within S-MAC. Realize that each node practices this followed schedule merely at the start. This kind of self-organization process will be completed within the first synchronization period.

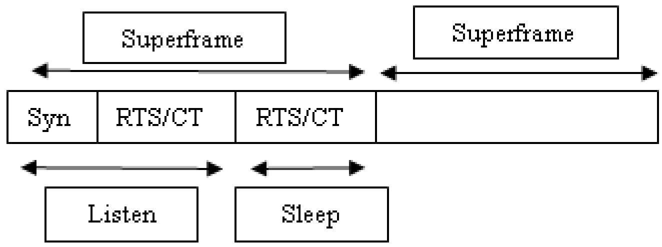

Figure 2: A-MAC Superframe structure

After the self-organization phase, your system function phase begins. In this phase, a new node adjustment the duty period with regards to the left over power. SYNC message information consists of three main fields: the source address, the next wake-up time and the listen/sleep schedule. The source address would be the address on the node delivering the SYNC frame. Next wake-up time and the listen/sleep schedule are reported to tell in the event the node is going to be energetic all over active as well as the way usually the active time is going to be, respectively. This way, each node keeps track of all of the one-hop neighbor schedules. Each node wakes up during the neighbor schedule if packets should be transmitted to that node. In SMAC, sensor nodes with the same schedule form a virtual cluster and the nodes in the border follow both clusters schedules. On the other hand, in A-MAC, nodes hardly form virtual clusters because each node dynamically changes its own schedule depending on its energy consumption rate. As a consequence, the schedules of one-hop neighbors should be maintained.

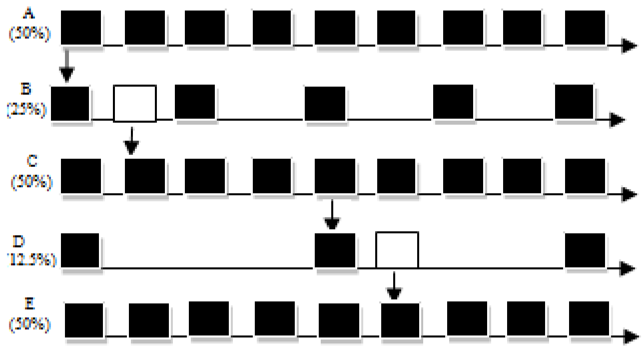

Figure 3: Example of data transmission in A-MAC

Fig. 3 illustrates a data transmission from the source node (A) to the sink (E). The percent next to the node id is the duty cycle; for example, 25% node will have the sleep period three times as long as the listen period. Each node basically follows its own listen/sleep schedule, and if a node has a packet to send, it wakes up on the next hop's listen period, and after RTS/CTS exchange, it transmits data to the next-hop node. In this manner, data is relayed to the sink. On the other hand, if the node does not have packets to send, it does not wake up on the neighbor's listen period.

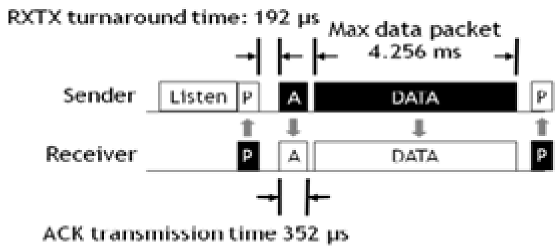

Figure 4: A-MAC: An 802.15.4 initiated link layer

The above figure shows the A-MAC communications timing and flow. A sender listens (L) for a receiver's probe (P) which it auto-acks (A) precisely 192 µs later. The sender subsequently transmits a data frame (DATA) after a short but random interval, perhaps on a different channel, which the receiver acknowledges with a second probe and then listens briefly for an auto-ack before returning to sleep.

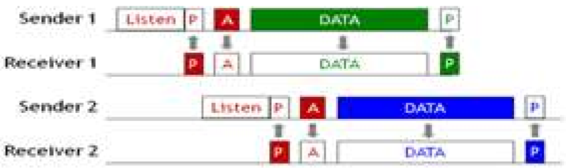

Figure 5: A-MAC parallel multichannel data transfers use control, data (1) and data (2) channels

The above figure shows a sender (Node 1) with traffic pending for the receiver (Node 2). The sender turns on its radio, sets its hardware address to 0x8002, enables hardware auto- acks, and begins to listen. At some later time, the receiver wakes up and sends a probe with a source address of 0x0002 and a destination address of 0x8002, and requests an acknowledgment. When the sender receives the probe frame, its radio generates an auto-ack. Upon detecting the beginning of the auto-ack, the receiver decides that an auto-ack frame may be incoming, so it continues to listen for at least 352 µs (or possibly less if the data appear garbled) before turning off the radio. If a valid auto-ack is received, the receiver concludes there is pending traffic for it, and it remains awake to receive this data.

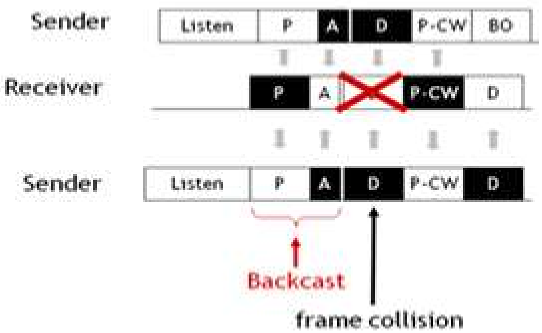

Figure 6: A-MAC Contention mechanism

The figure 6 shows the first approach. In this figure, all nodes cease periodic communications like routing beacons and instead operate at a very low duty cycle. The nodes wake up infrequently, perhaps once every ten seconds or each minute, to check if any of their neighbors requires them to stay awake, by sending a probe to the broadcast address. Node 1 initiates an asynchronous network wakeup by configuring its radio to acknowledge all frames. After some time, Node 2 sends a probe. Node 1 auto-acks this probe and Node 2 stays awake.

4. Experimental Result

In order to evaluate the performance of proposed scheme, in this paper perform simulations, varying network conditions, and compare the results with those of RI-MAC. In this section therefore, consider several metrics that are;

- Average energy
- Delay
- Balance factor
- Remaining energy.

In this paper compare these four factors for proposed A-MAC and existing RI-MAC. The simulations are conducted using NS-2 [13].

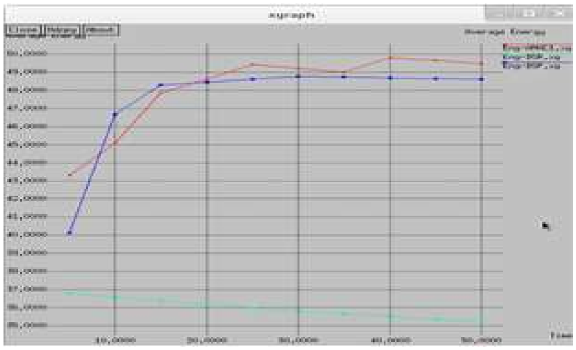

Figure 7: Average energy comparison

The figure illustrates the average energy comparison between proposed A-MAC and existing RI-MAC. From the simulation result clearly observed that the proposed method gives the better average energy.

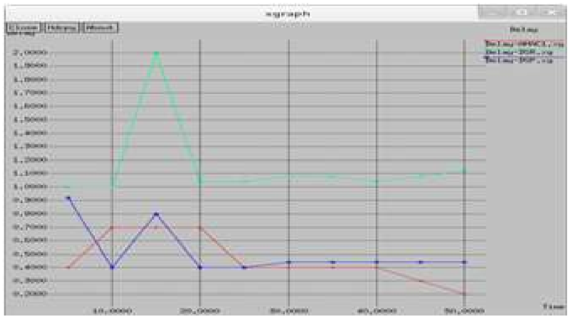

Figure 8: Delay Comparison

The figure 8 illustrates the delay comparison between proposed A-MAC and existing RI-MAC. From the simulation result clearly observed that the proposed method gives the better than the existing RI-MAC, it provides more delay in their process.

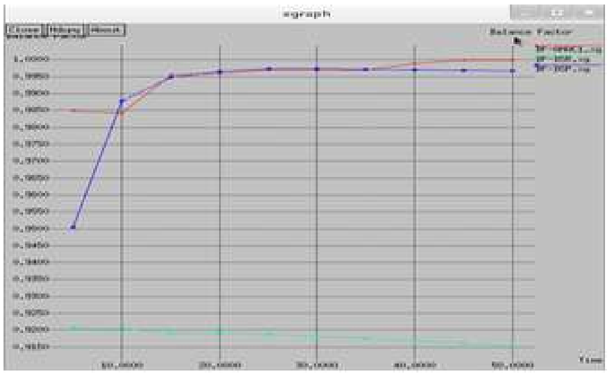

Figure 9: Balance Factor Comparison

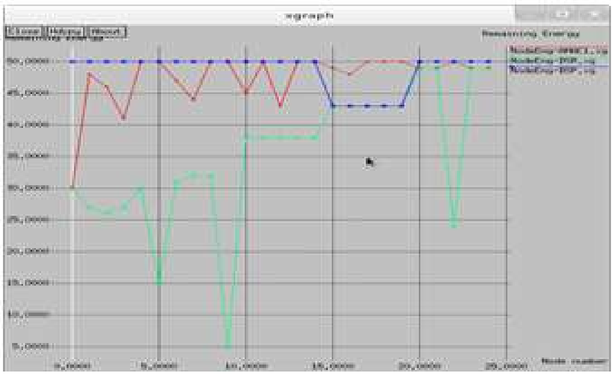

Figure 10: Remaining energy Comparison

From the figure 9, 10 it is observed that the proposed method of A-MAC gives the better result.

Table 1: Existing RI-MAC Packet Delivery Ratio

MAC	*Number of senders*	*Packet Delivery Ratio*		
		Average	*Minimum*	*Maximum*
RI-MAC	1	99.9%	-	-
	2	97.5%	97.3%	97.7%
	3	95.6%	95.0%	96.8%
	4	90.7%	90.3%	90.9%

Table 2: Proposed A-MAC Packet Delivery Ratio

MAC	*Number of senders*	*Packet Delivery Ratio*		
		Average	*Minimum*	*Maximum*
A-MAC	1	99.9%	-	-
	2	99.3%	98.2%	100%
	3	99.3%	98.3%	99.5%
	4	98.5%	96.7%	99.5%

Table 1, 2 gives the packet delivery ratio for existing RI-MAC and proposed A-MAC. The table gives the packet delivery ratio for four senders. The adaptive medium access control has offered some advantages when it compared to the receiver initiated medium access control protocol. In the RI-MAC the number of senders is 4, the average packet delivery ratio is 90.7%. By using adaptive medium access control protocol the average packet delivery ratio is 98.5% achieved.

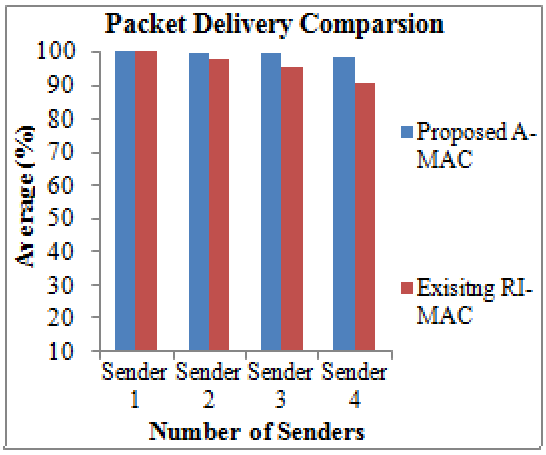

Figure 11: Average Comparison

From the above figure it is clearly observed that the proposed-MAC gives better result than the existing RI-MAC.

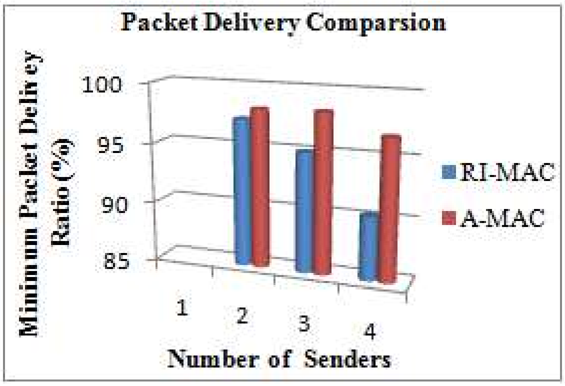

Figure 12: Minimum Packet Delivery Ratio Comparison

From the above figure, it is clearly observed that the proposed method of A-MAC gives the better minimum packet delivery ratio.

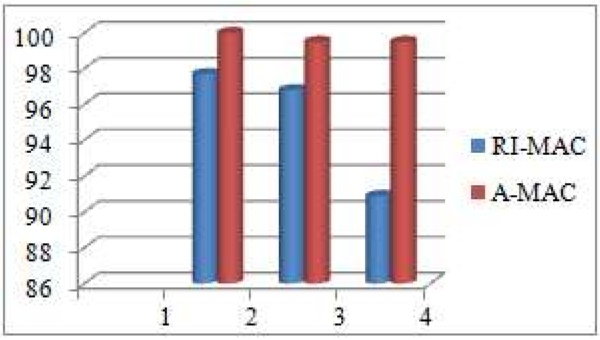

Figure 12: Minimum Packet Delivery Ratio Comparison

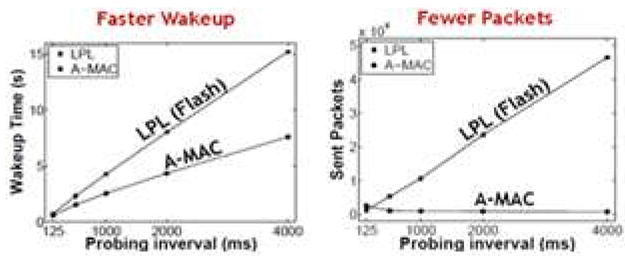

Figure 12: A-MAC wakes up the network faster and more efficiently than LPL (flash) flooding

The figure 12 shows the wakeup times of 59 nodes in a multihop testbed across a range of sampling/probing intervals. In this waster wakeup shows that A-MAC wakes up the network about 38% faster than the default Tiny OS LPL. Fewer packets shows A-MAC transmits far fewer packets to do so, hence exhibiting dramatically better channel efficiency.

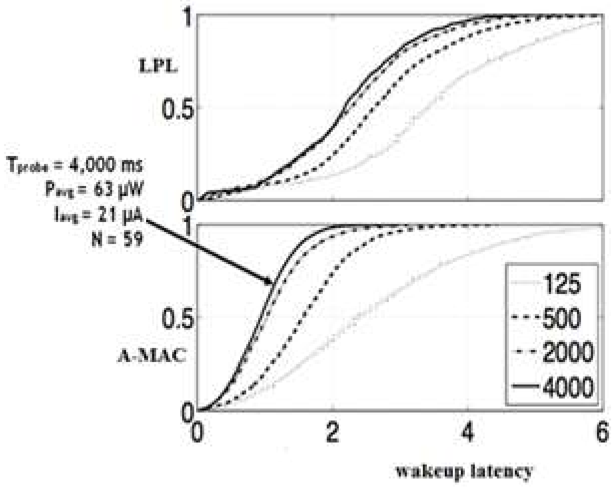

Figure 13: A-MAC wakeup at low duty cycle

The figure 13 shows the CDF of wakeup latencies. The better relative performance of longer probe intervals seems counter-intuitive, but it occurs because there is a lower probability of a node transmitting a probe when a neighbor is otherwise occupied as the probe interval length is increased.

5. Conclusion

For the purpose of reducing the sleep latency and balancing energy consumption among nodes, the proposed schemes allow sensor nodes to adjust their duty-cycle according to their residual energy. Through NS-2 simulations, both of DSR and DSP have lower end-to-end delay and higher packet delivery ratio than the static duty-cycle scheduling scheme of RI-MAC. At the same time, they can contribute to balancing energy consumption among sensor nodes. The adaptive medium access control protocol has the better performance when compared to the receiver initiated medium access control protocol. The A-MAC has several advantages when compared to the receiver initiated medium access control protocol. A-MAC wakes up the network faster and more efficiently than RI-MAC. Faster wake-up means baseline power consumption is low. A-MAC offers modest incast (with in a area) performance of high packet delivery. A-MAC wakeup works well at low duty cycles. In Ns 2 simulation it uses A-MAC 802.15.4 protocol standard. It consumes low energy, So the Remaining energy is high. From the experimental proved that the proposed A-MAC provides better result than existing RI-MAC. In the current version adjust duty cycle based on linear decision graph. An exponential decision graph can be developed in future.

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