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Evaluation of Energy Efficient Low Power Listening MAC Protocols in WSN

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ABSTRACT: Medium access control protocols for wireless sensor networks are designed to be energy efficient. An energy efficient MAC protocols are those which reduce idle listening and overhearing .Idle listening may have become the main source of energy waste. To reach average power consumption, most of the time trans-receiver must shut down. This phenomenon allows the nodes to use a lower duty cycle, at no cost of overhead in many cases. Simulation and implementation results show that how fail rate and delay varies in MAC protocols like X-MAC,MX-MAC and SPECK MAC.

KEYWORDS: MAC, throughput, accuracy, fail-rate and delay.

1 INTRODUCTION

Medium access control (MAC) protocols for wireless sensor networks have been proposed in the recent years. Mostly the protocols have energy efficiency as an objective. The pattern of energy use in the sensor nodes, however, depends on the nature of the application. As the range of applications which use WSNs is large and diverse, the proposed protocols display much diversity. Most of these protocols use either a contention based mechanism or a time schedule or a combination of the two for accessing the shared medium. To design a good MAC protocol for the wireless sensor networks, the following parameters are to be considered such as energy efficiency, latency, throughput and fairness [1].

Research in wireless sensor network has led to many new protocols which are energy efficient, where energy wakefulness is an essential consideration. Major sources of energy waste in wireless sensor network are basically of four types such as average delivery ratio, throughput, fail rate and idle listening [2].MAC protocols are so designed that there should be a new generation of Low-Power-Listening because idle listening cannot be neglected as it is a major source of energy consumption. B-MAC and X-MAC use the principles behind Aloha with preamble sampling [3].Sending nodes are allowed to implement transmission and wake for long interval. Receiving nodes must sleep for more time duration, and stay awake until the transmission is not completed.

MAC protocol can reduce energy consumption for unicast packets but waste energy when applied to broadcast packets. Such inefficiencies become significant as broadcast packet shake up a larger percentage of the total packets sent on a network. We use MAC schedules from pool of MAC protocols to reduce energy consumption based on parameters such as ratio of transmit to receive packet, packet size ,packet is broadcast or unicast. Comparison between two LPL MAC protocols, X-MAC and Speck MAC-D is made by showing their advantages and disadvantages for unicast and broadcast packets. We also introduce MX- MAC, a modified version of X-MAC which proves that it is efficient for both broadcast and unicast transmissions.

In this paper we will discuss about protocols MX-MAC, Speck MAC and X-MAC and comparing their results will help to analyze the best behavior among all these protocols. All these results help us

defining the MAC schedule adapted to specific conditions in network. These results help us define the MAC schedules most adapted to specific conditions in the network.

2 RELATED WORK

The basic requirement of a sensor network is energy consumption and reliable delivery of data with minimum latency. The protocol, however, fails to deliver reasonable throughput at higher rate. Tijs van dam, introduced T-MAC, a contention based Medium Access Control protocol for wireless sensor networks. Timeout-MAC enhances the performance of SMAC for higher loads, while Dynamic Sensor-MAC reduces its overall latency. B-MAC with LPL was the first MAC protocol to introduce LPL schedules. Comparison is made between B-MAC to S-MAC and T-MAC.B-MAC protocols include X-MAC and Speck MAC-D. Both protocols tried to improve the LPL scheme presented by B-MAC. In Wong and Arvind [3] also propose Speck MAC-B, which is compared, along with Speck MAC-D, to B-MAC. Speck MAC-B means Back-off and it replaces the long preamble with a sequel of wake up packets that contain the destination target which will reduce the time when the data packet will be sent. It will allow receiver to activate only at time of reception and sleep for remaining time.

Selecting a MAC protocol supposes to have suboptimal and excellent performance under certain circumstances. Various protocols perform according to the broadcast and unicast nature of the packets, frames size, and whether a node is sending or receiving the packets. We adapt the MAC schedules and create the pool of MAC schedules that are compatible with one another, while the sender will only decide which schedule to follow based on the parameters mentioned above, the receiver need not be informed of the changes in MAC schedules. We can adapt various schedules from pool of MAC protocols and implement them like X-MAC, MX-MAC [3] and Speck [MAC-D[8].

Through design choices, we allowed the three MAC protocols to be compatible. We send and receive packets using the MX-MAC, X-MAC or Speck MAC schedules. More importantly, the basic principle behind schedule compatibility is that a receiver does not need to know the ongoing schedule, and simply ACKs packets that request it. For MX-MAC and X-MAC, the acknowledgment request field must be set to one. If no ACK is requested, the receiver simply turns off after the packet has been received.

2.1 XMAC: Short preamble sampling with target address information

XMAC protocol improves the problems of low power listening, overhearing, and excessive preambling. Asynchronous protocols like BMAC and Wise-MAC, rely on LPL (low power listening) also called preamble sampling. XMAC makes use of a preamble, strobed in nature, which allows interruption and instantly works upon the incoming packet. XMAC also implements short preamble which consists of the address information of the destination and thus, retains the benefits of low power listening such as simplicity, decoupling of the sleep schedules of the transmitter and receiver and low power communication.

X-MAC Protocol Design

The design goals of X-MAC protocol for WSNs are:

- Energy-efficient
- Simple and low-overhead
- Low latency
- High throughput
- Applicable to all packet size

2.2 MX-MAC:A Modified X-MAC for Broadcast Transmissions

X-MAC is efficient for unicast packets, but not suitable for broadcast transmissions [5]. One additional drawback of X-MAC is that it is highly affected by the problem of hidden nodes and false acknowledgements of packet reception. So, we propose to modify the MAC schedule of X-MAC by repeating the data packet and waiting for acknowledgement frames between the transmissions. A received acknowledgement signifies the correct reception of the data packet and stops their further transmission. Thus, solves the problem of false positive acknowledgement of X-MAC.

2.3 SpeckMAC-D:Repeating the Data Packet

Another LPL protocol is SpeckMAC-D [8],in whichbefore transmitting a packet, sender performs a clear channel assignment (CCA),and if its

response is positive, it will start repeating the packet for the time(ti) seconds. At the receiver side, on the reception of the data packet, receiver generally checks the medium. If the medium is found to be busy, it listens to it until the time it has received the full data packet or it has realized that it is not the correct destination for the data packet.

3 SIMULATION METHODOLOGIES

In order to prepare the performance of MAC protocols that are X-MAC, MX-MAC AND SPECK MAC, the important quality of services and parameters have been identified accuracy, fail rate, packet delivery ratio and throughput for the simulative investigation. The proposed design flow for each parameter has been illustrated.

3.1 SIMULATION PARAMETERS

The main goal of this paper is to compare MAC schedules of MAC protocols without biasing we need optimized behavior of all three MAC protocols.Because all MAC schedules are meant to be compatible with each other and implemented by the MATLAB code. Consequently, all three protocols have the some essential parameters such as inter-frame time, sending rate their fail rate and throughput.

4 RESULTS AND DISCUSSIONS

4.1ACCURACY OF MODEL

We have confirmed by the CC2420 datasheet that it takes 32 µs to send one byte. Time for each protocol is for Speck-MAC based schedules, the time for TX mode is 772 µs and 1.351 ms for MX-MAC and X-MAC protocol as ACK frames between packet size is done by them.We are sending and receiving the packets at different sending and receiving rate andpacket size, where ‘m’ signifies the sending rate and ‘n’ signifies the receiving rate.

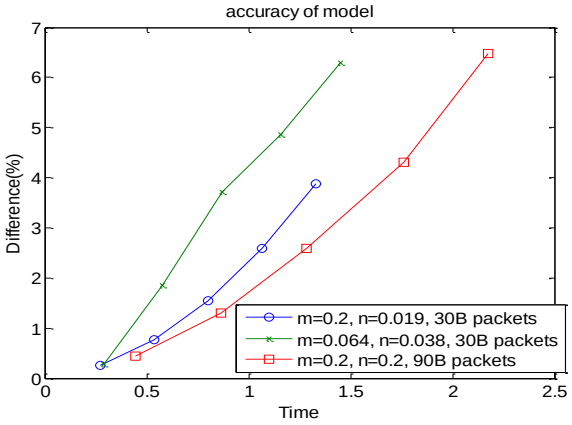

Fig.1.Accuracy of Model

4.2 DESIGN AND CHOICE OF ADVERTISEMENTS OF PACKETS

To make compatibility with other protocols, weconsidered long packets to be advertisements. The receiver, upon reading a 40B packet stays on to receive the data packet. When a MAC protocol needs to send a 40B long packet, it has to use the X-MAC schedule,and the acceptable value is between 320 µs and 512 µs for SpeckMAC, and 512 µs for MX-MAC and X-MAC, represent the best compromise between energy use in very low traffic networks and fairness to all protocols. We must have compatible parameters for Mix-MACand set for all MAC schedules and set the values to 512 µs and 320us for all protocols. With the increase in packet size, receiver can hear the transmission easily.Hence we can have packet delivery ratio for MX-MAC and SpeckMAC sending them at different time and schedule.

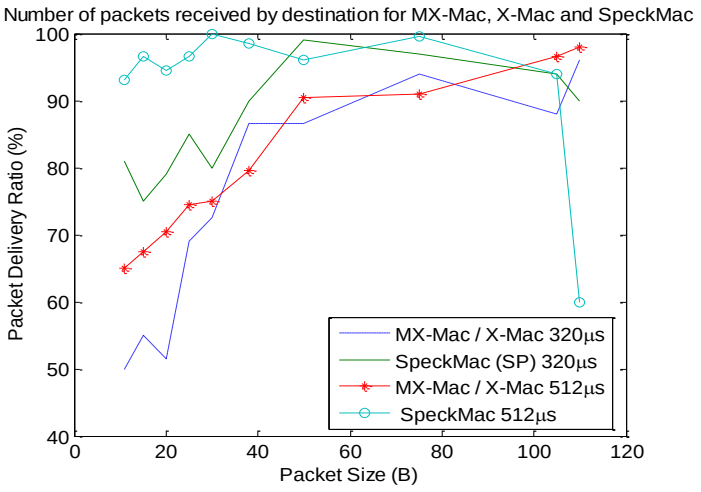

Fig.2.PDR v/s Packet Size

4.3 RELIABLE THROUGHPUT

To evaluate the throughput of the MAC protocols, we send 100 packets to three different neighbors. For smaller values of time X-MAC has the highest throughput as shown in Fig. 3.,Fig. 4.and Fig. 5. With larger values of time and for large packet size, MX-MAC performs best. This is because MX-MAC is capable of staggering packet transmissions, which compensates for retransmissions.When time is small, MX-MAC cannot fit for more transmissions. Whereas X-MAC schedule yields the best throughput for small packets (less than 40B), while the MX-MAC schedule has the best performance for larger packets.MX-MAC also performs best with increase in time as shown in table 1.With increase in time and packet size MX-Mac increases the throughput by 50% and fewer retransmission will occur.

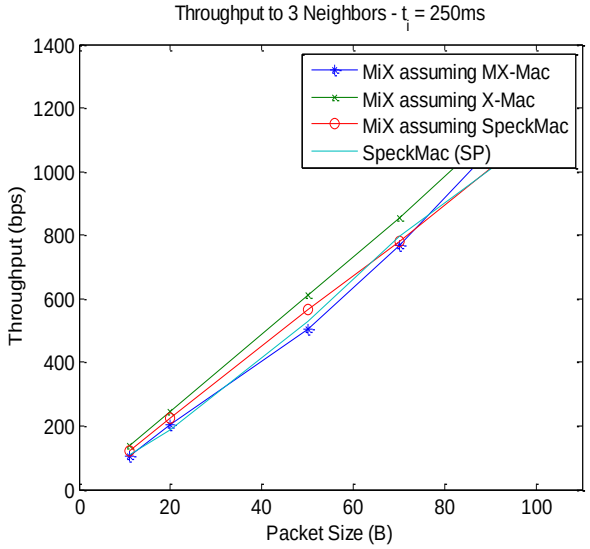

Fig.3.Throughput v/s Packet Size

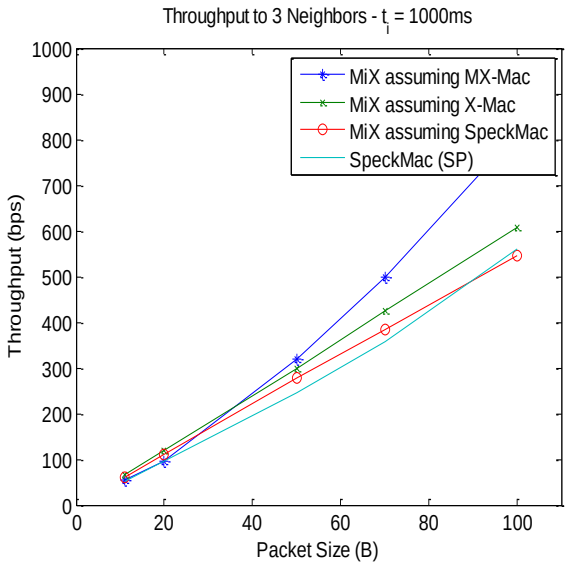

Fig .4.Throughputv/s Packet Size

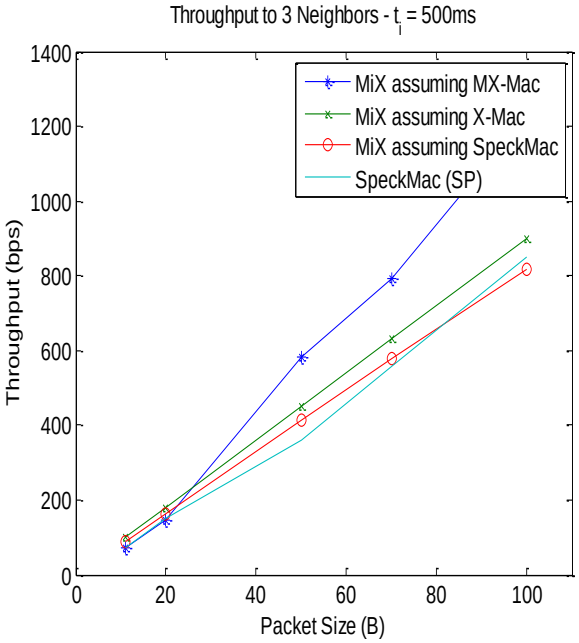

Fig. 5 ***Throughput v/s Packet Size***

Table 1.Comparison of Throughput for Different Time

PROTOCOLS	t_i=250ms		t_i=500ms		t_i=1000ms	
	THROUGHPUT FOR PS		THROUGHPUT FOR PS		THROUGHPUT FOR PS	
	20B	90B	20B	90B	20B	90B
X-MAC	100	1100	180	800	100	550
MX-MAC	200	1200	100	1100	100	750
SPECKMAC	180	1100	170	700	100	550

4.4 FAIL RATE

It is the rate that the packet transmission will not be heared by destination from the fig. 6. we can observe that the fail rate for MX-mac is less that means it perform best. Which means X-MAC schedule yields the best for small packets (less than 40B), while the MX-MAC schedule has the best performance for larger packets.The advantages of X-MAC are reduced further when the data packet

size reaches that of the advertisement size because the advertisement packet is no longer easier to hear than the data packet.

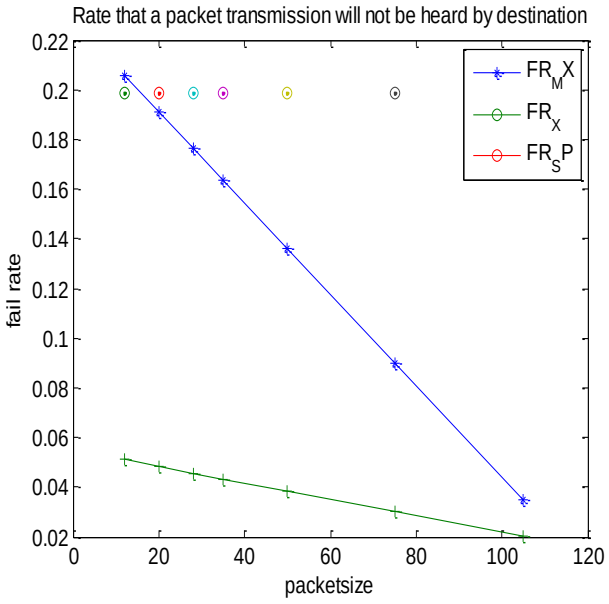

Fig. 6.Fail Rate v/s Packet Size

From the fig.6. it is clear that for small packet size X-MAC and SPECK MAC performs well but as the packet size increased fail rate also increase. For 20B X-MAC and SPECK-MAC fail rate is 0.2. MX-MAC for 20B packet size has fail rate 0.05.With the increase in packet size X-MAC reception rate is very less that is packet transmission will not be heared by destination.MX-MAC performs best with larger packet size.

5 CONCLUSION AND FUTURE WORK

Function of MAC protocols is mainly concerned with reliable channel access between the communicating peer entities. Within the increasing trends of portable handheld devices and infrastructure less ad-hoc mode operation. There is great need of energy efficient MAC protocols. Considering energy efficient as a major channel, present work has been carried out using extensive simulations. X-MAC, MX-MAC and SPECK MAC have been identified for comparative merits and demerits in terms of standard quality of service.We adapt the MAC schedule to improve performance under the conditions for both unicast and broadcast packets their throughput, fail rate and advertisements of packets. Implementations in MATLAB show how MAC schedule can be performed.

The MAC schedule should be chosen to maximize the lifetime of the network, which includes reducing contention.Future work includes researching how to best implement MX-MAC and X-MAC schedules inincompetent fashion.

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