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Implementing an Energy Efficient MAC protocol by deducing TMAC protocol

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Abstract— The paper is oriented towards the development of a protocol based on the Tmac Protocol. This protocol is extracted and deduced from the basic Tmac protocol. The previous work involved the detailed comparison of Energy consumption, Latency and packet collisions in a network in Tmac and Smac protocol using tool Castalia for wireless sensor networks. The characteristics of T Mac and S Mac protocols were explored keeping real transmission conditions intact, like variable transmission bit rate, dynamic topology and mobile sensors in network. T Mac and S Mac protocols are contention based protocols and are designed to keep the energy consumption low using duty cycle. In both static and mobile networks it was found that Tmac performs better in comparison to Smac. Keeping Tmac protocol in mind the main motive of the new protocol developed is to reduce energy consumption. The protocol thus extracted from Tmac is named as EDMAC (Extended Deduced Mac) protocol.

Index Terms— *T Mac*, *EDMac protocol*, *S Mac*, *Castalia*, *Omnetpp*, *wsn*, activation time.

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1 Introduction

T Mac and S Mac have been studied thoroughly in the past. The study of these two protocols is important because these protocols are the parents of several newly designed Mac protocols and these two protocols are used as templates to design and implementation of such new contention based protocols. Our study of T Mac and S Mac is oriented towards the comparisons of these two protocols in some real world environments and conditions. Wireless sensor networks are applied in some very complicated conditions in actual life, so the comparisons of these two protocols demand these situations to be considered. For example a wireless sensor network applied on suspension bridge, a wireless sensor network in a battlefield where it is not possible to maintain a node or change the battery, in under water implementations of wireless sensor networks, wireless sensor networks in a metal foundry or situations like where the size of frame is very large, and several other such practical situations are possible in real world. T Mac is child protocol of S Mac and was introduced as an improvement over S Mac protocol. From the implementation perspective S Mac is much easier to implement and results are

good. T Mac is little complex in comparison to S Mac as it uses a parameter called activation time out. It provides flexible duty cycle as the sensor node goes to sleep state if it hears nothing for activation time out period. This technique reduces the duty cycle if there is nothing to listen and the energy consumption is kept low.

Energy consumption of TMac can still be reduced. This is what the main motive of my protocol is. Energy is wasted if there is no transmission or reception of data or we can say no activity during TA. So I intend to make a protocol in which a node senses the carrier during the active period and if there is no activity it immediately goes to sleep. Unlike TMac protocol the node does not needs to be active if there is no sensation in the carrier. In other words, the TA or the active period of Tmac can be varied according to the situations. So the protocol will be an extraction of the TMac protocol involving the deduction of the active period. Thus it will result in reduced energy consumption in comparison to the Tmac Protocol. EDMac is extracted from T Mac protocol. The main parameter being considered is the Activation Time.

The tool being used is Castalia. Castalia [1] uses Omnet's [2] features and is designed especially for wireless sensor networks. Omnet is a C++ based open source discrete simulation [3] tool and provides Eclipse [6] based GUI along with several promising features to simulate networking concepts. We can create different test beds for both these protocols by writing an initialization file in Castalia. Since physical layer is implemented according to the original papers for T Mac and S Mac in Castalia, we do not need to start everything from scratch. Operations, such as data rate, delay to carrier sense and physical overhead are three parameters related to physical layer and castalia have tackled these operations very well. Hence Castalia provides a perfect platform for such tests. EDMac is being developed in Castalia in a similar way like the T Mac protocol.

2 Prelimnaries

2.1 T Mac Protocol

In T MAC every node periodically wakes up to communicate with its neighbors, and then go to sleep again until the next frame. Meanwhile, new messages are queued. Nodes communicate with each other using a Request-To-Send (RTS), Clear-To-Send (CTS), Data, Acknowledgement (ACK) scheme, which provides both collision avoidance and reliable transmission. A node will keep listening and potentially transmitting, as long as it is in an active period. An active period ends when no activation event has occurred for a time TA.

In T-MAC all the messages are transmitted in a burst of variable length and there is gap between the bursts called sleep/sleep time. This is to reduce the idle listening. In this the messages are stored in a buffer and then a frame is made to

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transmit containing messages during the active time as shown in fig1. The active time ends when there is no active event for a time period TA and the node goes to sleep mode. At the time of high load nodes communicates continuously without sleeping.

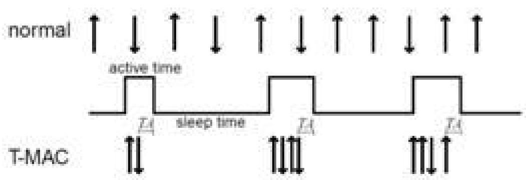

Fig 1. Nodes with active time TA

2.2 Major Issues of Energy Wastage

a. *Idle listening*

When nodes have nothing to send or receive, the nodes still remain in active state and do idle listening to the network. This process consumes equal amount of energy as during transmitting or receiving process. Thus resulting into energy wastage.

b. *Collision or Corruption*

Normally collision may occur when neighbouring nodes contend for free medium and lossy channel will result in corruption of transmitted packets. When either of two cases happens corrupted packets should be retransmitted, which increases energy consumption.

c. *Overhearing*

This happens when a node receives some packets that are destined to other nodes.

d. *Control Packet Overhead*

Exchanging control packets between sender and receiver also consumes some energy.

2.3 EDMac

As we have seen in T Mac the activation time is less so there may be a possibility that after knowing that the data is about to come but due to short activation time it may happen that the activation time ends and the data packet arrives so in ED-Mac the activation time is extended as soon as there is an indication that a data packet is about to arrive. Also the activation time can be deduced if there is no information of data arrival. So we have Extended Deduced Mac Protocol.

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3 Configuration File

According to Omnet's nomenclature these files are named as omnet.ini generally. Castalia have a modular structure and all the modules are interconnected and communicate with each other. The behaviour of these modules can be controlled by modifying the value of parameters according the requirement. This is a property of omnet to write initialization file and keep the value of most general parameters free from implementation, Castalia enhances this property by enabling users to pass parameter values at run time and user do not need to rewrite configuration file each and every time. Castalia enables to run more than one configuration at simultaneously or even the combination of more than one configuration simultaneously. Every configuration file in a Castalia implementation imports Castalia.ini.

4 Parameters

Table 1. Common parameters for both protocols

General Parameters	Value
Simulation Time	100 s
Radio used	Telos CC2420
Threshold RSSI(neighbour)	-89.3 Db
Transmission Power	-5 Db

Telos CC2420 is very commonly used radio in sensor devices. We can vary transmission power and RSSI threshold if required in any simulation.

Table 2 . Various parameters used for both protocols

	TMac	ED Mac
Listen Timeout	15	15
Time Out Extension	Rrequired	Required
Collision resolution	Immediate retry	Immediate retry
Activation Timeout	15ms	15 ms
Use FRTS	Required	Required
Ack Packet size	11bytes	11bytes
Sync Packet size	11bytes	11bytes
CTS/RTS Packet size	13bytes	13bytes
Frame time	610 ms	610 ms
Contention Period	10 ms	10 ms
Sync time	6 ms	6 ms
Frame size(case II)	2 KB	No Limit

Conservative activation timeout will always stay awake for at least 15 ms after any activity on the radio. Listen Timeout is generally 10% of Frame time.

5 Analysis and Results

In our consideration there are 100 sensor nodes those are arranged in uniform fashion in a square field which is 200 m×200 m size. Sensor density is high in wireless sensor network. Parameters are detailed in table 1 and table 2.The study of these two protocols gets more significant because almost all the parameters of both these protocols are same except few, so we can get even clearer picture independent of variable parameters. The configuration shows how communication link between two static nodes is disrupted when a third node passes between them.

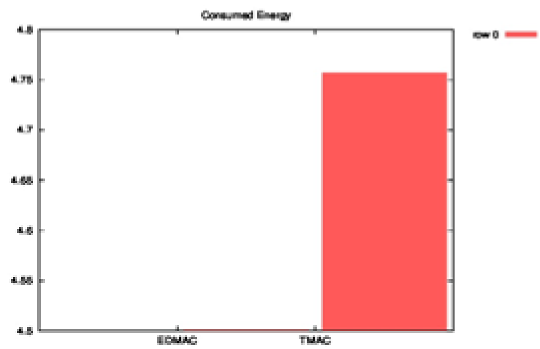

Fig 2. Energy Consumption

The default configuration sets one node to be mobile while the other two sending nodes are static. The receiving node will move in a diagonal pattern, allowing it to receive packets from the sending nodes one by one. The energy consumption in T Mac is higher as shown in figure 2. Energy consumption patterns are same for all the nodes respectively which actually depends on the position of sensor node in the experiment field. The nodes on the boundary consume comparatively less energy. This experiment shows better energy Efficiency of EDMac protocol. The figure shows that the energy consumption of EDMac is around 4.5 and that of Tmac is 4.75.

The difference in these two protocols with average number of packets sent by each node, average number of packets during transmission and average number of packets during reception can be illustrated with figure 3, 4, and 5 respectively.

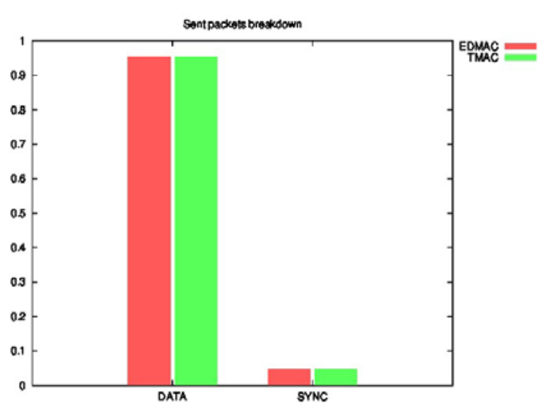

Fig 3. Sent Packets Breakdown

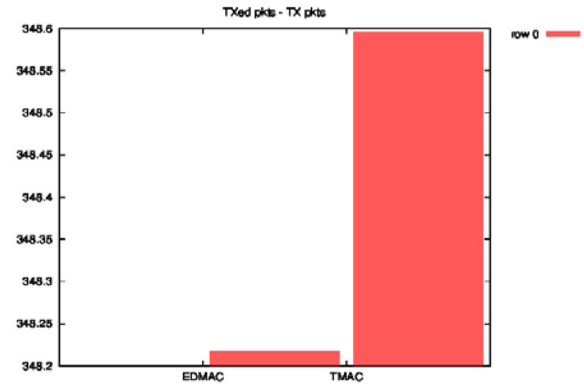

Fig 4. Packets during Transmission

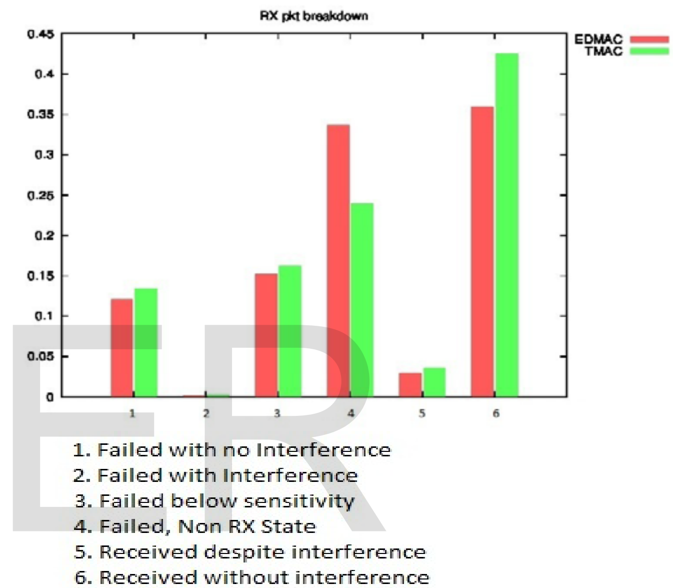

Fig 5 Sent Packets failure and Reception

EDMac Protocol is more energy efficient due to the introduction of a new parameter that is deduce active time along with the activation time out. This parameter extends the activation time if it gets a message that data is arriving. Also it deduces the activation time if it finds that no data is about to arrive. In TMac the activation time is very less whereas if we talk about the SMac the listen time out is rigid. Figure 3 illustrates that EDMac and TMac have almost equal data and sync packets respectively. Figure 4 shows the number of packets during transmission mode in EDMac and T Mac Protocols. Figure 5 is more self explanatory and tells about the sent packets failure and reception.

Figure 6 shows the application level latency for all the nodes in wireless sensor network. The effect of interference is minor in both the protocols because the sensor nodes in this arrangement are kept far from each other.

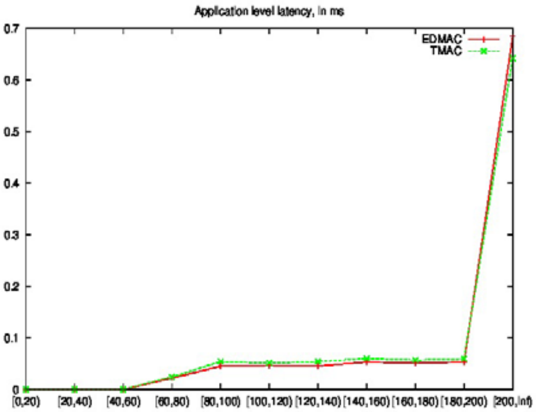

Fig 6. Application Level Latency

6 CONCLUSION

Previous studies have shown that T Mac is better mac protocol than S Mac protocol because the major criteria of performance in wireless sensor networks is energy consumption and network lifetime. [13] This study gives a more energy efficient protocol EDMac whose energy consumption is less in comparison to TMac protocol.The simulation gives a detailed comparison of these two protocols. The EDMac protocol performs better than TMac protocol as it has an additional extended activation time function which is extracted and deduced from the original activation time function in TMac. Interference and varying data rate affect both of these but the effects are quite similar. The most important thing about these protocols that can be concluded with this study is that, as we can see clearly by making very few amendments in T Mac, a better protocol is devised; hence these protocols provide perfect templates to design new high performance, contention based wireless sensor network mac layer protocols. By introducing some simple but well thought out mechanisms these protocols can produce tremendous results.

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