



Introduction to T MAC Protocol with Reduction Function for Wireless Sensor Networks

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Abstract— Several mac layer protocols have been proposed in literature and implemented in real applications in wireless sensor networks. T MAC is contention based mac protocol network with high energy efficiency and easy implementation. Network lifetime, energy consumption, latency and reliable transmission of packets are some of the main issues in wireless sensor networks. Since battery, memory and processing capability are limited; there is need of very efficient mac layer transmission protocol. In this paper we propose a new mac protocol which uses inherent features of T MAC protocol and optimizes it with a simple reduction function. This simple provision cuts out the extra listen period which has higher probability of getting waste during Activation Time.

Keywords— T MAC protocol, reduction function, wsn, contention based mac protocols, energy efficiency;

I. INTRODUCTION

This Wireless sensor networks have small nodes with autonomously sensing, computing and communicating the data among them. The energy efficiency is key design issue in s wsn. Energy efficiency is directly proportional to network lifetime. Since the conditions and environments in which these networks work, it is not possible to replace batteries on regular basis. Wireless sensor networks can be utilized in a wide range of applications such as the military, battlefield, object detection, target tracking, environment monitoring and civil aviation by using *Wireless Sensor Networks (WSNs)* [1] [4-6]. S MAC[4] and T MAC(Timeout-MAC)[3] protocols are two very important contention based[3] protocols.

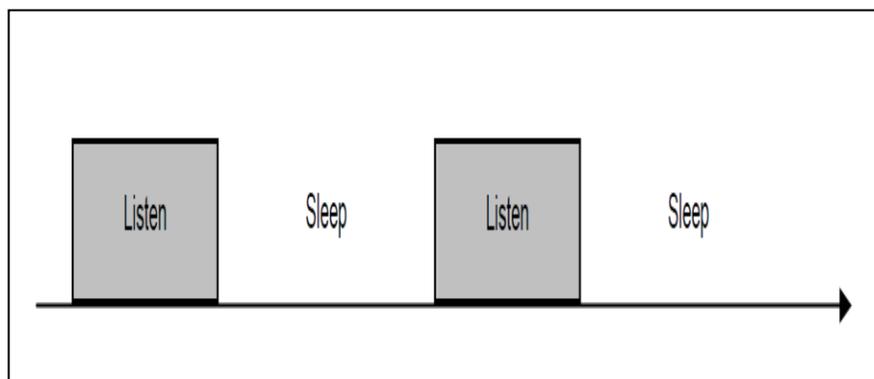


Fig 1. Listen and sleep cycle in S MAC protocol

S Mac is inherited by T MAC protocol. Both the protocols specifically designed for wireless sensor networks are contention based protocols. SMAC introduced a periodic “Listen and Sleep” method to avoid idle listening & to reduce the energy wastage. In this protocol the nodes use the RTS (Ready to send), CTS (Clear to send) and Data Acknowledgement (ACK) to communicate.

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. In T MAC node awakes periodically to communicate with neighbors and it uses RTS and CTS, Data Acknowledgement (ACK) scheme, which provides both collision avoidance and reliable trans-mission. In this the messages are stored in a buffer and then a frame is made to transmit containing messages during the active time .The active time ends when there is no active event for a time period TA and the node goes to sleep mode. T MAC automatically adapts the duty cycle to the network traffic. As with S MAC, nodes form a virtual cluster to synchronize themselves on the beginning of a frame. But instead of using a fixed-length active period, T-MAC uses a time-out mechanism to dynamically determine the end of the active period.

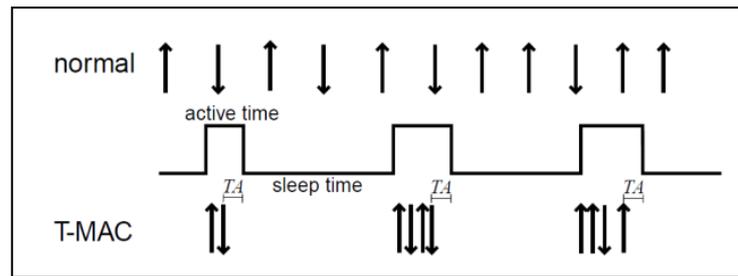


Figure 2. Listen and sleep cycle of T MAC protocol

The ratio of listen and listen + sleep is called a duty cycle. In SMAC duty cycle is constant. Generally it is kept 0.1, but in TMAC protocol the duty cycle is not constant, it varies according to a simple rule, which says if during the listen period of a duty cycle there is nothing to listen or there is no event to occur at that node for certain amount of time (which is called activation time and is generally 0.4 times of listen period), the node will go to sleep. Second important thing with TMAC protocol is that if node has lots of data to transmit then it will not follow normal duty cycle, it will transmit the data in bulk using a buffer and it may extend its activation time.

II. SETUP AND ENVIRONMENT

For the experiment purpose we are using Castalia [7-8] simulator, which is an Omnet++[9] based open source simulator specially designed for wireless sensor networks, body area networks and other low power consumption wireless networks. Castalia have the capability to run multiple configuration simultaneously. Castalia provides facility to analyse results using CastaliaResults. It is a totally parametric based simulation environment and also provide facility to plot the results with the help of CastaliaPlot, which is based on GNU Plot. Castalia is meant to provide a generic reliable and realistic framework for the first order validation of an algorithm before moving to implementation on a specific sensor platform. This paper considers two experiments, first experiment for the energy consumption comparison and the amount of packets transmission comparison. BrideTest simulation has been used in this experiment. We can easily compare characteristics of S MAC, TMAC and TMAC with Reduction function using this realistic simulation environment. Second experiment is for considering Hidden/exposed terminal problem, Near/far terminal problem, effect of collisions, mobility of nodes and the latency.

III. TMAC PROTOCOL WITH REDUCTION FUNCTION

TMAC Protocol is an effective protocol for wsns. We are introducing a reduction function for TMAC protocol. To devise a mac protocol we need to look at the following factors too, because in practical implementation these problems are encountered very frequently by wireless sensor networks.

- Hidden/exposed terminal problem
- Near/far terminal problem
- The effect of collisions
- The mobility nodes
- latency

Along with these the energy consumption should be low for large number of nodes and complex topologies with or without routing [11] protocol available.

The flow chart [12-13] for S MAC and T MAC protocol is given in figure 3 for Castalia framework. *Reduction function* deduces activation time by 80% whenever it is used. Castalia is highly parametric; TMAC can be converted into SMAC by only setting value of couple of variables. *disableTimextension* variable is set FALSE for T MAC protocol. **conservativeTA** is a Boolean variable and if we are running T MAC protocol its value is set TRUE in Castalia. Activation Timeout is the amount of time in which radio goes to sleep if no activity is captured in active time of a duty cycle shown in figure 2 by TA. The reduction function is defined as ReduceActivePeriod().

ReduceActivePeriod()

```
{
if(conservativeTA){
    activationTimeout = activationTimeout*(0.20);
}
}
```

This function simply reduces the value of activation timeout to 20% in situations when there is low probability of any transmission or reception, due to reduced Activation Timeout the energy consumption is reduced. We can use *Reduction function* when, the time is fired for activation time and

- a. the channel is busy

- b. Waiting still for carrier sense to be valid
- c. Carrier sense is not valid
- d. There was no traffic intended for the node in the previous duty cycle.

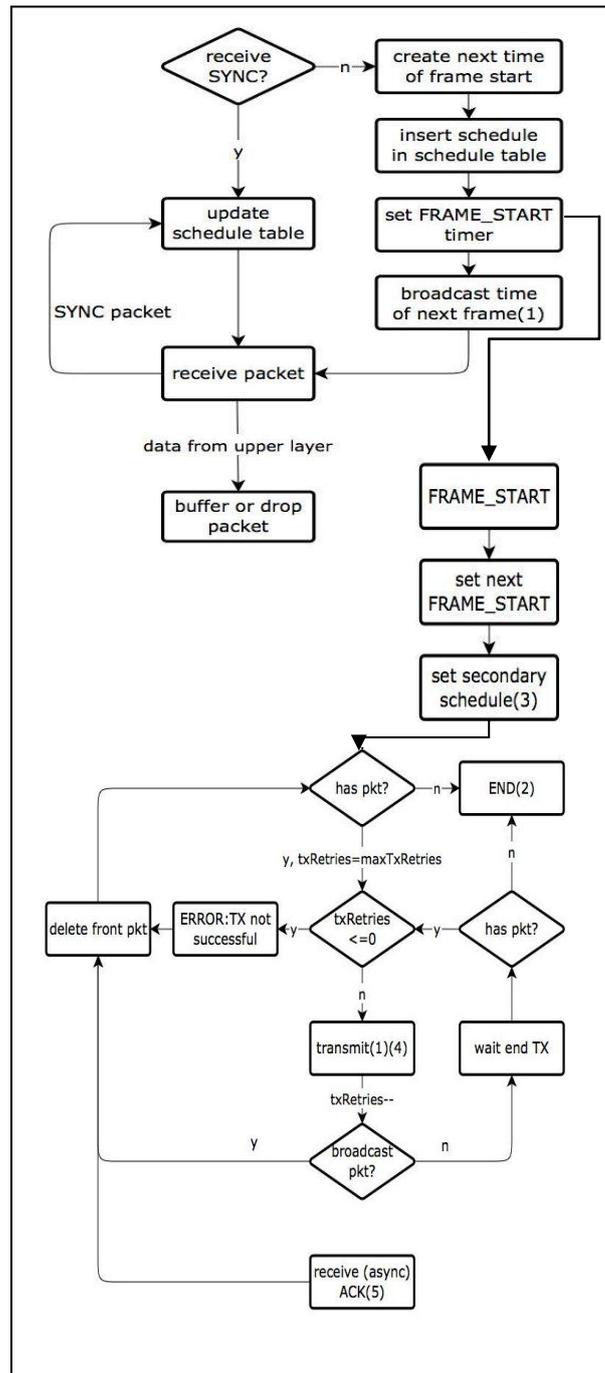


Figure 3. Flow Chart for SMAC-TMAC Protocol

When channel is busy there is not much benefit of keeping radio of node active since transmission will not be healthy. Same situation will occur when Carrier Sense is not valid or node is still waiting for Carrier Sense to be valid. Another case is possible in which reduction function is applied on activation time as a penalty, in case when no traffic occurred on this node in previous duty cycle and the channel was clear.

IV. RESULTS AND ANALYSIS

For the first experiment, the figure 3 shows the energy comparison of all the three protocols for first experiment. The energy consumed by T MAC with Reduction function is very low in comparison to other to mac protocols. The energy consumption is low because reduction function peels off extra active listen time of radio which is mainly responsible for the energy consumption.

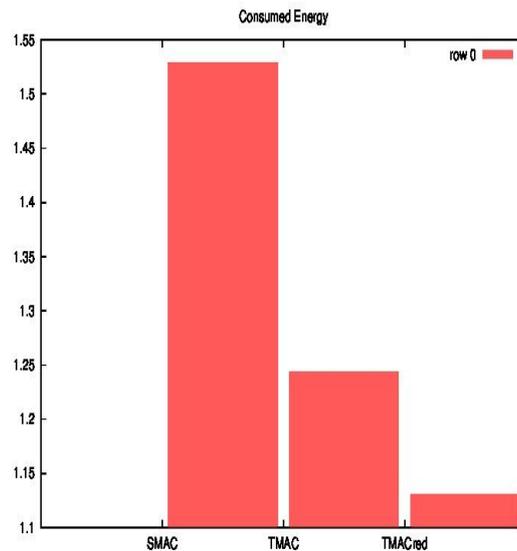


Fig 4. Energy consumption comparison

Figure 5 shows that although the report reception is little lower in T MAC with Reduction Function but it does not cause that much concern because it reduces a lot of energy and increases network lifetime to great extent. In condition where loss of little data is manageable T MAC with reduction function can prove very useful.

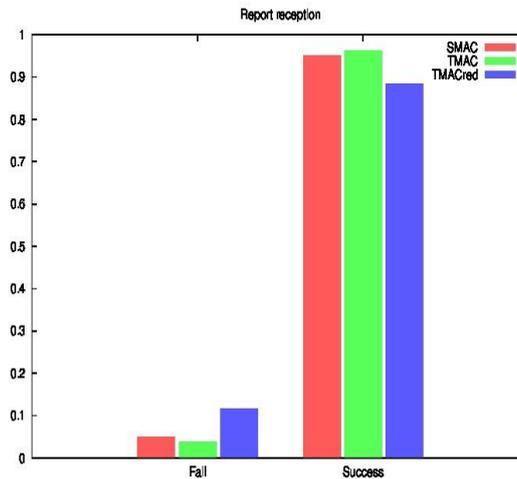


Figure 5. Report Reception

For the second experiment we can create a scenario in which there is field of wireless sensors network containing five nodes arranged in a fashion like figure 6. As we discussed earlier about Hidden/exposed terminal problem, Near/far terminal problem, effect of collisions, mobility nodes and latency we need an special arrangement.

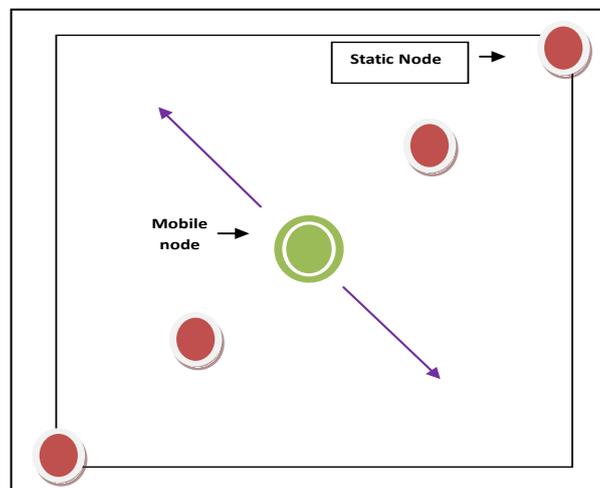


Fig 7. 200×200 m² Field with sensors

To comprise all the above problems 4 nodes are arranged diagonally in this field (node 0,1 ,3 and 4) and one node (node 2) is situated at the bisection of this diagonal. Node 2 is mobile and it can move linearly in perpendicular direction and bisecting the diagonal of this field. To induce the problems of collisions more we kept the size packets large (2kb). As the packet is lengthier in size there is very high probability of a collision with other packets.

The energy consumption comparison is shown in following figure. TMACred refers to T MAC with reduction function. Here s MAC performs better in terms of energy because of large frame size only.

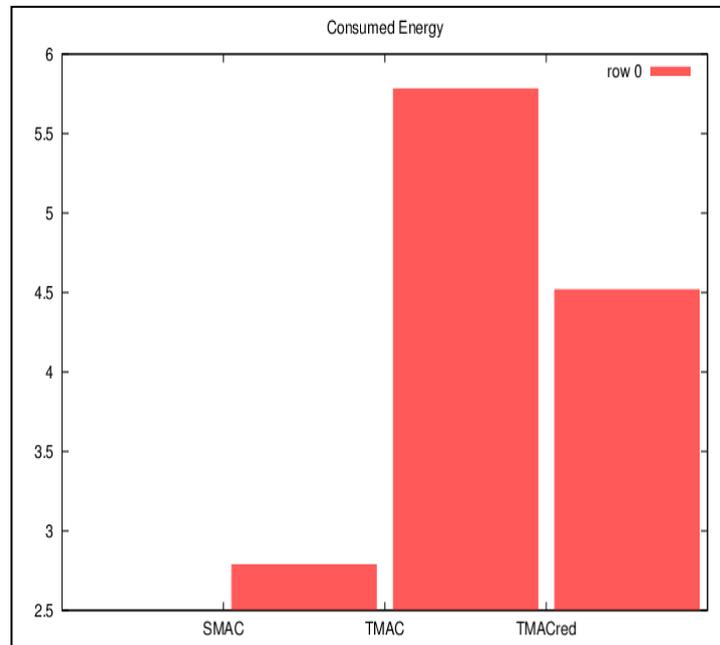


Fig 8. Energy Consumption

Other important term is latency. The main drawback of T MAC in comparison to SMAC is latency, which means that amount of time to transmit data the node have to wait is higher in TMAC because of short activation time. T MAC with Reduction function has lower latency in comparison to T MAC. Latency makes nodes less available for any kind of activity data transmission or reception. In this particular experiment S MAC performs better than T MAC with reduction function because of the large size of data packet only.

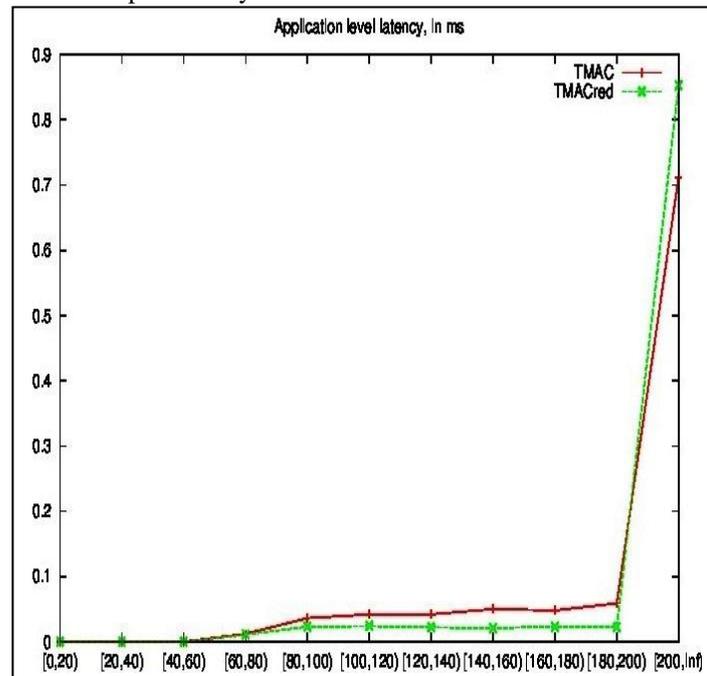


Figure 9. Latency

Number of packets transmitted by both the TMAC protocols with and without reduction function remains same and better in comparison to SMAC protocol. Fig 10 shows the results.

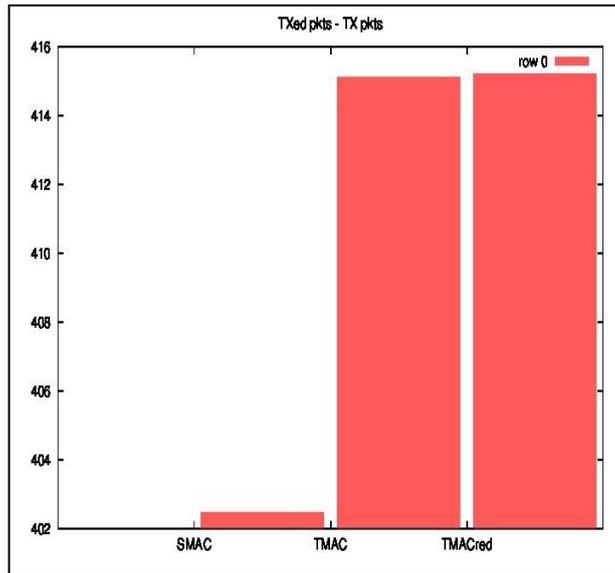


Fig 10. Transmitted packets during simulation

The packet breakdown during reception state is shown by figure 11. There can be various states possible for packet breakdown as shown in figure. In most cases T MAC with Reduction function performs better than other two.

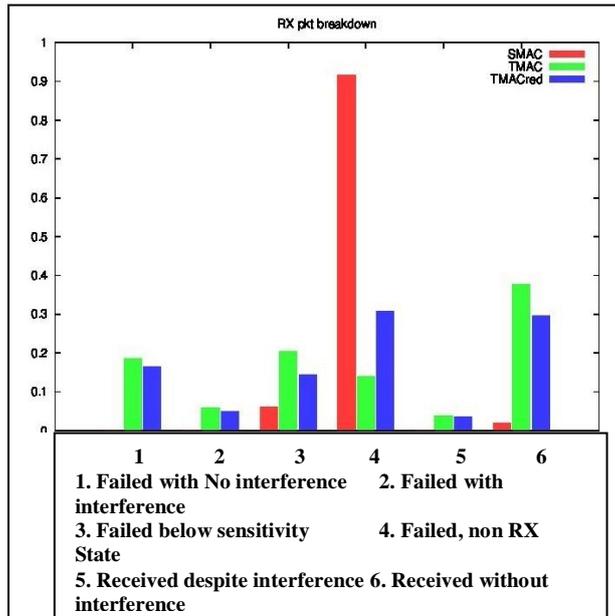


Figure 12. Packet breakdown during reception mode

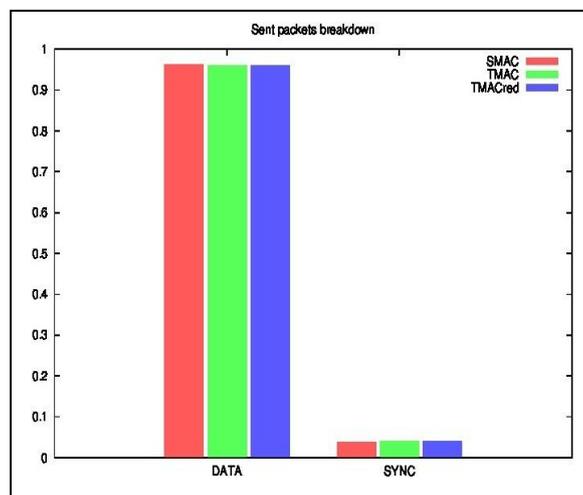


Fig 12. Sent Packets Breakdown

Sent packet breakdown is almost same in all three protocols as shown in figure 12. The results of both the experiments shows that although the amount of successful packets transmission may go down slightly low occasionally in T MAC with reduction function, but the energy efficiency, network lifetime and latency are improved significantly.

V. CONCLUSION

The results show the effectiveness of T MAC protocol with reduction function. Low energy consumption, low latency and decent data transmission make it promising mac layer protocol for wireless sensor networks. Since there are no major modifications in T MAC protocol for the implementation of this protocol, only a simple function reduces the activation when it is required, so it does not need any extra hardware or software requirements. Although further optimization of this protocol is possible as this reduction function can still be optimized.

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