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Performance Investigation on Adaptive WiseMAC Protocol for Ad Hoc and Wireless Sensor Networks

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Abstract: In present scenario the, Ad Hoc and Wireles Sensor networks render a remarkable service in case of distance or unreachable areas. The WSN are having large number of sensor nodes which are randomly spread over according to size of the area available. These sensors will function as processing of data for connecting the data to the wireless channel. The processing, transmission and reception and sensing the channel need power. Power is supplied to nodes with their batteries. The problem is in focus to reduce power consumption by these nodes according to the area usage. Thus, it is not possible in some cases to replace or change the battery. It is in need of a protocol which makes these nodes work with low battery power. Existing MAC layer protocols are not much more energy efficient and it is based on CSMA technology. To achieve low power level target, it is proposed WiseMAC protocol which is also based on CSMA but with preamble sampling. It shows very good reduction in power consumption. WiseMAC protocol is an asynchronous protocol and works very well in case of adaptive traffic conditions. To make WiseMAC energy as an efficient, it is done with reducing duty cycle and contention window of proposed protocol.

Keys words: WiseMAC, battery power, CSMA, nodes, window

INTRODUCTION

In a Wireless Sensor and Ad Hoc network, there are a number of sensor nodes which are distributed randomly over an area or a place or a location (e.g., buildings, farmer fields, valleys or hills area) in order to collect information and proceed it. These wireless sensors are connected and communicate with each other in a random and multi-hop fashion. It collects the information and passes it to the next sensor. In this way, the information is passed to the server and appropriate action took place. Ad Hoc and Wireless Sensor network may also use the satellite in a case (Li *et al.*, 2001). There are lots of applications where it can use wireless sensor network like environmental monitoring, in home and building automation to industrial control. But, the problem with sensor network is that when using them in outfields (e.g., valleys or hills area) is related to the battery. Because, whenever the battery discharges, it is not able to replace it or recharge it so to avoid or minimize this problem it is to be focus on minimizing the energy extracted from a battery. In a sensor node, there are three main functions which consume the energy most sensing, computation, radio operation. Radio operation means transmitting the collected information. The major part of energy loss comes from transmitting.

This energy consumption can be reduced at protocols level (Akyildiz *et al.*, 2002). There has been a lots of protocols implemented for this purpose. What WiseMAC does, it reduces the wakeup time of sensor nodes. Whenever, a node is not in a sending or receiving mode WiseMAC turns it in sleep mode to save energy (Fig. 1).

WiseMAC protocol: WiseMAC is predicated on the preamble sampling technique. This system consists in often sampling the medium to visualize for activity. By sampling the medium, it tend to mean taking note of the radio channel for a brief length, e.g., the length of a modulation image. All detector nodes during a network sample the medium with identical constant amount TW. Their relative sampling schedule offsets are independent. If the medium is found busy, a detector node continues to listen till an information frame is received or till the medium becomes idle once more. At the transmitter, a wake-up preamble of size up to the sampling amount is additional before of each information frame to make sure

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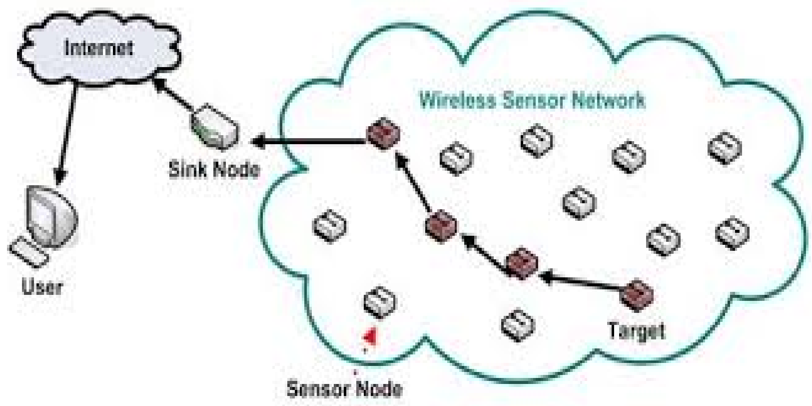

Fig. 1: Ad Hoc/Wireless Sensor network environment

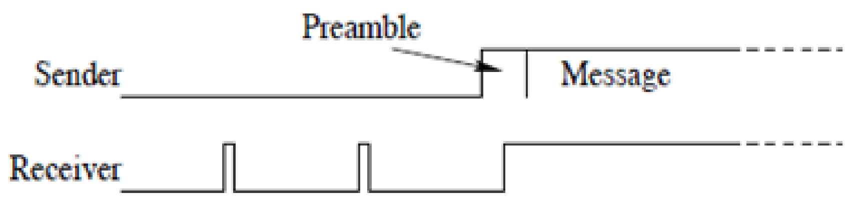

Fig. 2: Preamble sampling

that the receiver are going to be awake once the info portion of the packet arrives. The WiseMAC scheme has a very small periodic wakeup's and duty cycles which is very small in time to sense the carrier for a preamble signal (Rabaey *et al*., 2000) (Fig. 2). WiseMAC: short preamble in synchronous with receiver sampling schedule.

The receiver does not go into the sleeping mode while sensing the medium at the time when it sense that medium is busy. The medium have been sampled by all the nodes in network with a period of time T. But, they sample the medium at different time instances. If a node listen that the medium is busy while it is waking up then it continues to listen until it does not get the whole data packets or the medium becomes idle again. Every node has their own wake up pattern and it is independent of each other, in order to get the pattern knowledge of their neighbor, the node send a preamble of time duration T. After receiving the preamble the receiving nodes send back its wake up pattern details to the sender node in a acknowledge packet. Which is now used to update the table contains by node. So, in this way a node is now able to have knowledge of their neighbor's wake up pattern. This table now helps the node to know at which instances the neighbor nodes will be in their wake up mode and thus is able to minimize the preamble length of all the upcoming frames. Again the table is updated correspondingly. So, using this scheme, it is having very low power consumption in case when channel is idle. The main disadvantages of this WiseMAC protocol is that it's having very small throughput because of long wakeup preamble and also consumes very large power at the time of reception and transmission. The power consumption is not only due to the desired destination node but also by the nodes which are in listing mode and overhearing the transmission. The further approach is to reduce this preamble length.

System architecture: The architecture system is represented here in Fig. 3.

Merits of WiseMAC:

- WiseMAC have better performance rate than of S-MAC in various traffic
- Prolonged Battery life due to low power consumption
- It achieves good throughput in dynamic traffic
- Synchronization applied externally is eliminated to handle the clock drift in better way
- Different protocols can be easily combined with it if needed

Demerits of WiseMAC:

- Sleep, wake up and listing modes are not properly schedule in WiseMAC protocol results in power consumption to update the table again and again

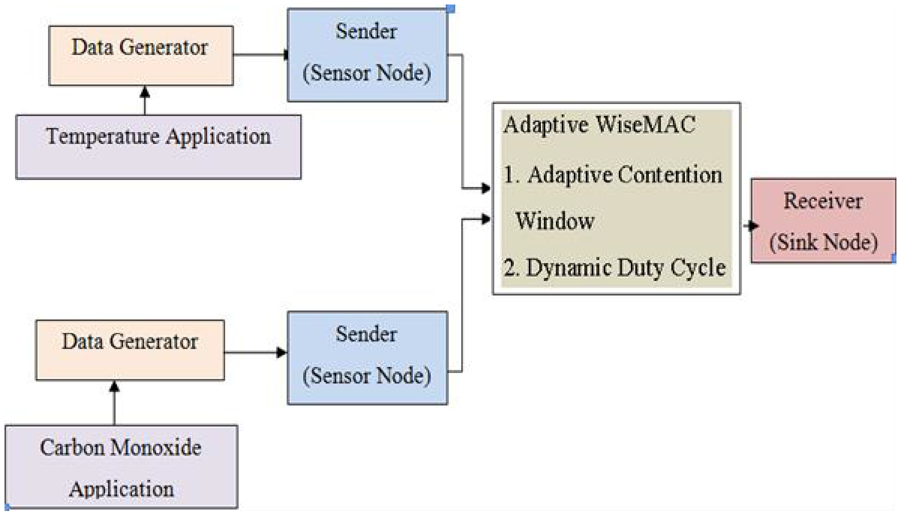

Fig. 3: AWiseMAC architecture

- Sometimes the broadcast packets are buffered for neighboring nodes and delivered many times. When they come in wake up mode, so this will consume power
- It also suffers the hidden terminal problem due to which it is facing problem of packet collision

Reason of energy waste in MAC
Collision: Once, a transmitted packet is corrupted it's to be discarded and therefore, the retransmissions of packets increase energy consumption (Melly *et al.*, 2002).

Control packet overhead: Transmitting and receiving control packets consumes energy too and less useful information packets are often transmitted.

Idle listening: Continuously listening to the all the traffic further consumes energy of sensor nodes.

Over hearing: Node picks up packets that are destined to different nodes will unnecessarily consume energy.

Over emitting: This is often caused by the transmission of a message once the destination node isn't prepared.

MATERIALS AND METHODS

Methodology adopted for WiseMAC protocol
Medium sampling: Sampling means to sense the medium periodically for a very short time. All sensors do the same thing at different time instants or you can say that it is random. If the medium is found busy, node sense the medium continuously until it get the data frame and if the medium is idle node goes into the sleep mode. A wake up preamble is added at the front of each and every frame. The size of preamble is equal to the sampling period. In this way, it is achieved good power reduction.

Minimize wake-up preamble: Earlier the long wake up preamble has the problem of throughput and more power consumption but with the more bit and extended more bit schemes and getting extra advantages. With these schemes, it is focusing on reducing the preamble length, so that a node wake up less and consume less power from battery.

Maintain sampling table: Proposed protocol is basically targeted reduction in the preamble size in the way that now the acknowledgement packet not only contains acknowledgement to the transmitter but also contains some information about its sampling instances. So with the help of this the neighboring nodes update their relative sampling table. With help of this table nodes work intelligently and transmit only at the right instant.

Congestion avoidance: Whenever, >1 node try to send data to the same destination this preamble sampling helps to avoid the congestion which added a random time in front of data packet.

Methodology adopted for adaptive contention window: WiseMAC is basically works on non-persistent-CSMA technique which work well when we added some new ways to moderate it like preamble sampling. This will reduce power consumption, produce better throughput and provide less delay in case of moderate traffic conditions and this is because of contention window in CSMA which helps us to make a use of it in adaptive traffic conditions (Hill and Culler, 2002).

Mathematical parameters: Mathematically, it can present it as:

$$PrTf = \alpha f / (\alpha f + \alpha s)$$

αf = No. of transmission failures
αs = Total successful transmissions with one or more transmission-attempts
PrTf = Transmission failure probability due to collision

Algorithm for adaptive contention window: Every n seconds algorithm check for number of transmitted packet and step forward only when they are sufficient for condition. At any time instant, a Probability (PrTf) is calculated based on transmission of failure and Success. Less PrTf shows a node with increase contention window if all other nodes do the same and even in the second round there is an increased PrTf then it shows that it because of this common sensor node and it is the culprit. So, algorithm does one thing it allows that node not to change its contention window but allows other nodes to adjust their window. So in this way the network will be stable and adjust itself accordingly. In CSMA based WiseMAC protocol less CW leads to small PrTf and large CW leads to large PrTf. There are so many nodes in the network and each and every node try to increase its CW to a large size, so it is not possible to get this much of CW in a single step. Contention window finding can be done in the following way:

$$\Delta CW = \gamma * (CWtarget - CWcur) =$$
$$CWcur + \Delta CW$$

Where, γ is a scaling factor.

Algorithm for dynamic duty cycle:

- The above algorithm, its check for enough number of transmitted packets and this happens after every T seconds
- Now, it's turn to segregate, the different traffics depending on which kind of traffic it is like audio, video, non-real time and temperature (real time)
- This segregation is called type of service (ToS) and it is used to determine which kind of traffic has more number of packets
- So according to this segregation, it is now able to find which kind of tariff has more number of packets and it is called dominating traffic. Now, the duty cycle is adjusted according to this traffic

Table 1: Simulation environment

Environment	Parameters
Number of nodes	100
Topology size/area	400×400 m
Energy	1000 J
Simulation time	1000 Sec
Communication range	50 m
Carrier sensing range	100 m
Data rate	20 kbps
Carrier frequency	900 MHz
Packet queue length	20
Transmitting power	11 mW
Receiving power	4 mW
Sleeping power	5 micro W

RESULTS AND DISCUSSION

Simulation environment: Simulation environment will decides the performance evaluation of the WiseMAC protocol to achieve low power level target based on CSMA but with preamble sampling and reduction in power consumption. To make WiseMAC energy as an efficient, it is done with reducing duty cycle and contention window of proposed protocol environment as follows in Table 1.

Throughput: It defines the maximum rate at which each node can send packets to each other in the WSN network. it is measured in bits/sec or bps or may be data packets per timeslot or per second. It is depend on number on nodes as the number of nodes increase the hop count decrease and hop progress increase. A large number of nodes will definitely decreases the throughput, Fig. 4 explains the throughput-dynamics for different traffic classes. In proposed MAC protocol, it first classifies the traffic into different classes depending on the Type of Service (ToS). Subsequently, it adjust it's the contention windows depending on the traffic classes.

Packet delivery ratio: It defines as the number of data packets delivered to the destination node to the number of data packets transmit from the source node. Figure 5 shows the packet delivery ratio. Figure 5 contains the comparison between SMAC, WiseMAC and AWiseMAC (Adaptive WiseMAC) (Fig. 5).

End to end delay: It is defined as the time difference between transmission and reception of the accurate data packets. The different protocols further compared here but here, AWiseMAC has some limitation and it is not showing comparably good end to end delay (Fig. 6).

Energy efficiency: It is defined the Energy efficiency difference between transmission and reception of the accurate data packets. The different protocols further compared here but here AWiseMAC has some limitation on energy constraints (Fig. 7).

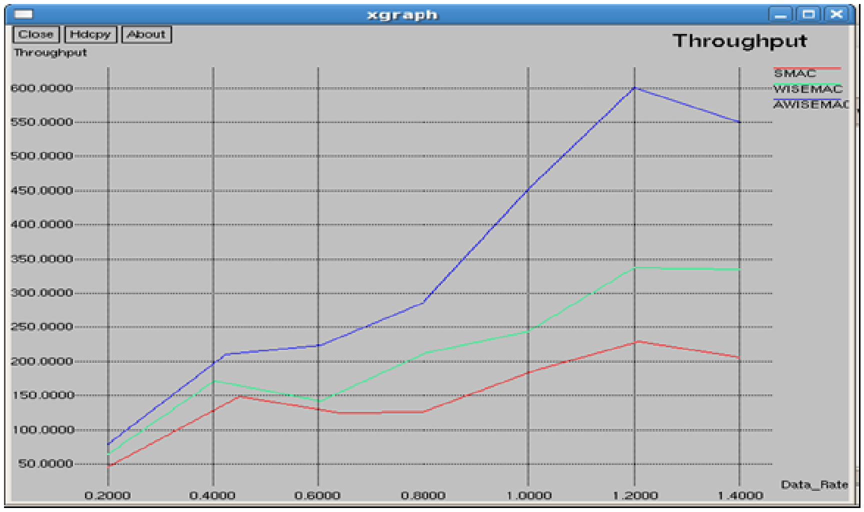

Fig. 4: Throughput

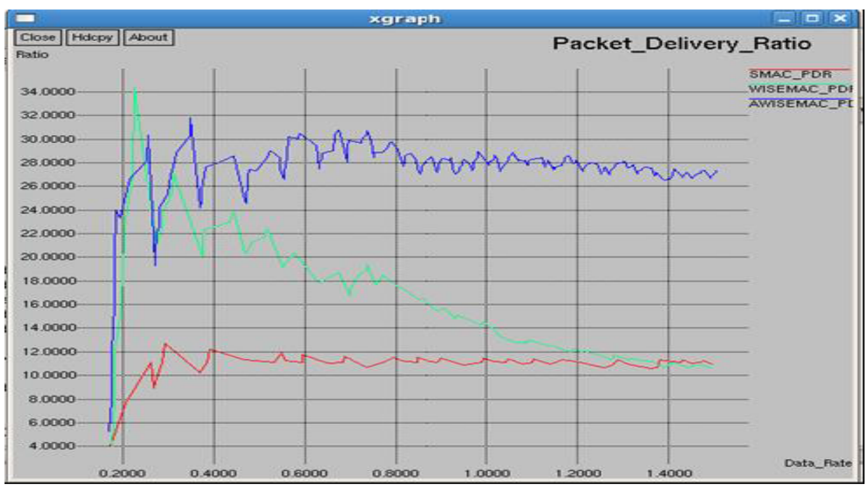

Fig. 5: Packet delivery ratio

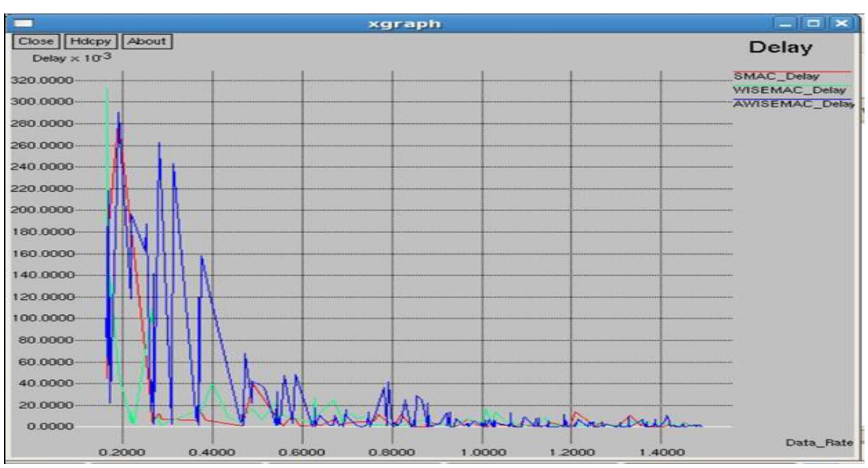

Fig. 6: End to end delay

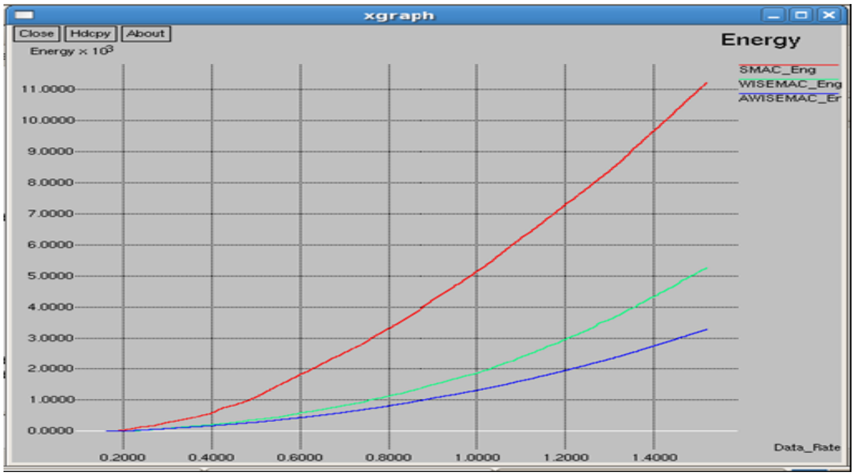

Fig. 7: Energy efficiency

CONCLUSION

Ad Hoc and Wireless Sensor network, the main key aspect is reduction in energy consumption throughput and end to end delay are the main target. WiseMAC protocol is an extension to the basic CSMA with preamble sampling and this technique helps to reduce the power consumption but it has limitation to the throughput.

Recent year's different MAC protocol is widely used in health monitoring. WiseMAC is one of them; this is the main reason of frequent enhancement in existing WiseMAC protocol. Adaptive WiseMAC will consider and compare three main parameters of energy efficiency that are delay, power consumption and throughput in wireless sensor network. It is proposed some alterations to the original WiseMAC to enhance the performance especially in terms of energy efficiency and power consumption in Wireless Sensor networks.

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