Advanced WiseMAC Protocol for Wireless Sensor Network

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Abstract— *From the past few years there has been progress in Wireless Sensor Networks in terms of energy efficiency, but energy efficiency in sensor networks is still a concern. WiseMAC is one of the most energy efficient protocols among various MAC layer protocols. Preamble sampling and Non-Persistent Carrier Sense Multiple Access are the major techniques made use of in fundamental WiseMAC protocol. This protocol is utilized to decrease the power spending when energy is washed out in listening to idle medium and make it energy efficient. This paper lists the WiseMAC protocol with other schemes that can be utilized in execution of WiseMAC in sensor networks. These schemes highlight on energy saving methods in WiseMAC. Different extensions are made to the original WiseMAC to make it extra energy efficient, with the similar motive of increasing energy efficiency. We focus to reduce the preamble sampling duration by dynamic duty cycle and the prediction of sampling period is proposed.*

Keywords- *Sampling Introduction, Preamble, CSMA, Adaptive Contention Window, MAC Layer Protocol, Dynamic Duty Cycle*

I.INTRODUCTION

Sensor nodes are deployed arbitrarily to collect information over a wide concerned area in Wireless Sensor Network. Communication and Sensing are the major actions performed by sensor nodes to gather and forward the information to the next sensor. Sensor nodes may be utilized in a variety of modes such as thermal, visual infrared and radar. There are lot of applications where sensor nodes are used according to the particular applications, such as to check the activities of Vehicles, to check the Lightning situation, sense the high temperature.

Wireless Sensor Network can be used in many applications and is very vast and serve in diverse fields such as healthcare, automation for industrial control, military area monitoring, environmental sensing, home and other commercial areas. MAC layer comes into existence when we need to boost the lifetime and energy efficiency of Wireless Sensor networks. There are several protocols of Mac layer proposed by other authors for healthier life time and energy reduction in sensor networks. The reasons of energy wastages in sensor nodes are collision, control packet overhead, Idle listening and over hearing. MAC protocol are divided into two basic types they are synchronous (slotted MAC) and Asynchronous (random access) protocols.

This paper presents an examination on (Wisemac) Wireless Sensor MAC which is the asynchronous MAC protocol, WiseMAC for (WSN) Wireless Sensor Networks. Significant role of Wise-MAC protocol is reviewed and some changes has been made to the basic WiseMAC to make it further energy efficient.

II. RELATED WORK

A lot of Asynchronous Protocols of MAC are done in journalism to attain the intention of energy efficiency. Due to Contention process and randomization this can be called as Random Access MAC Protocols. In Asynchronous MAC Protocol Synchronization of time is not there. A simple technique is used in Asynchronous MAC Protocols to decrease the problem of idle listening, in this technique it shifts the cost of the receiver(destination) to the sender(source) by help of extended MAC header, (which is also known as preamble). This technique helps the nodes to save energy and inspect the channel periodically and the node can stay in sleep state most of the time.

One of the type of Asynchronous MAC protocols is WiseMAC protocol , a few other protocols in that particular kind are B-MAC , C-MAC and X-MAC.

C-MAC is type of asynchronous MAC layer protocol, which improves the energy efficiency and reduces the latency. Protocol B-MAC is a mixture of CSMA and (LPL) Low power listening technique. Senders make use of the long preambles in LPL technique and to make sure that receiver is awake for upcoming genuine packet. In B-MAC unsynchronized duty cycling is made use of with the help of long preambles to waken up the receivers. In order to increase the consistency of channel estimation B-MAC make use of a low pass filter technique. Adaptive preamble sampling and (CCA) clear channel assement is used by B-MAC to minimize the trouble of idle hearing. X-MAC make use of short preamble with compared to the B-MAC, and efficiently minimizes the packet over hearing and idle listening. In X-MAC destination address information is set in the small preamble to give low power communication.

Asynchronous MAC protocols are further divided into receiver intiated or sender initiated approaches. X-MAC , B-MAC and WiseMAC are chief examples of sender initiated approach. PW-MAC and RI-MA are type of receiver initiated approach.

While in sender initiated process, a preamble is sent by the sender prior to a frames transmission begins, just to aware the receiver for upcoming frames. Whereas in receiver initiated process preambles of sending side are replaced with the receiver's wakeup beacons, bandwidth usage. So by this way collisions is further decreased by this process because beacon is significantly shorter in length than a preamble.

One of the effective process to build the MAC layer protocols more energy resourceful is by contention window adaption. The act of the MAC layer protocols depends basically on fundamental algorithm to which contention window is customized.

III. WISEMAC

Preamble sampling technique is used in WiseMAC protocol to minimize the energy consumption. In WiseMAC protocol a preamble is attached in face of every data packet to notify the receiver for not switching to sleep mode unless reception of the current frame, but it must stay in wakeup mode for the future frame transmission as well.

Sampling of the medium can be defined as hearing to wireless channel for a short period of time . T_W denotes the regular interval at which all sensor nodes exam the medium in sensor network. The sensor nodes from time to time sense the medium in the sampling process to check the accessibility of channel in order to transmit data. If the sampled medium is found to be busy, then the sensor node once more listens to the channel till the medium becomes idle or a data frame is received. A wake-up preamble of size equivalent to the sampling period is attached at the transmitting side in face of each data frame to confirm that the receiver will be in awake state when the packet arrives.

WiseMAC protocol exploits the sample schedule of its direct neighbors by which it can be used to lessen the wake-up preamble size. If the node doesn't have any information of its neighbors sampling schedule, then it can transmit a preamble of duration T, in intention to know the sampling period of the adjacent node. After the receiving of data-frame effectively, the receiver node's sampling schedule piggybacked in its acknowledgement packet. To keep the neighboring nodes relative schedule apart from the nodes own wake pattern a sampling table has to be maintained. By referring to this table, a node can decide the next (sampling period) wake-up of all its adjacent nodes, and shorten the preamble length for all forthcoming future data-frames. By use of this scheme we provide a noticable development for basic preamble sampling protocols.

In WiseMAC protocol, random interval preamble denoted as (T_{MR}) Medium Reservation preamble is attached in face of preamble wake-up which is utilized to avoid the collisions between two nodes, which is in the state of sending a data frame to the same destined node. After the process of wake-up preamble, the data frame of WiseMac includes (SYNC) which is a bit synchronization preamble and also (SFD) known as Start Frame Delimiter . T_P can be denoted as duration of wake-up preamble in WiseMAC. The wake-up preamble consist of two parts: the clock drift compensation preamble of interval T_{CDC} and the medium reservation preamble of length T_{MR}. So the wake-up preamble can be calculated as,

$$T_P = T_{MR} + T_{CDC}$$

In basic preamble sampling technique due to use of long wake-up preambles causes a restriction on throughput and increase the overhead and extra power utilization in transmission and reception. WiseMac protocol reduces its length of long preamble with compared to the basic preamble sampling technique, so that it decreases the cost and energy consumption of the node. By referring other different reviewed papers here are few advantages and limitations of WiseMAC as listed below.

A. Advantages of WiseMAC

- Performance of WiseMAC is much superior than SMAC in changeable traffic rates.
- WiseMAC gives increased life time of battery due to its low power utilization
- WiseMAC provides good throughput in inconsistent traffic rates relative to other MAC layer protocols.
- WiseMAC is flexible enough to be combined with other MAC protocols if required for enhanced results in diverse applications.

B. Limitations of WiseMAC

- Due to decentralized sleep-listen scheduling scheme in WiseMAC results in dissimilar wake-up and sleep times for each adjacent of a node.
- Unnecessary power consumption and higher latency occurs when different packets are buffered for adjacent node in broadcast kind communication in sleep state and delivered many times as each adjacent node wakes up.
- Collsion occurs at the start of transmission of preamble to node due to hidden terminal problem.

IV. DIFFERENT SCHEMES USED IN IMPLEMENTATION OF WISEMAC

A. Minimized Wake-Up Preamble

In Basic Medium Access Control of WiseMAC the nodes present in network trial the medium with a general cycle interval T, however their wake-up schedule methods are at all times independent. By the moment of communication of a frame, a preamble of uneven length can be used to aware the receiving node in its wake-up period informing it not to go to sleep status. Preamble is a plain bit sequence informing an forthcoming transmission to nodes vicinity. In WiseMAC Protocol, after receiving the packets the acknowledgement packets carry acknowledgement for the same, simultaneously used to notify other nodes of the left over time until next sampling period(sampling time).

Here each node maintains a table of sampling time offsets of all the frequent destinations up-to-date. Node has a limited figure of direct destinations, the table is easy to manage and is very easy even with restricted memory resources. By referring the information contained in the table, node transmits a packet right at the correct time, with wake-up preamble of small length as shown in Fig.1.

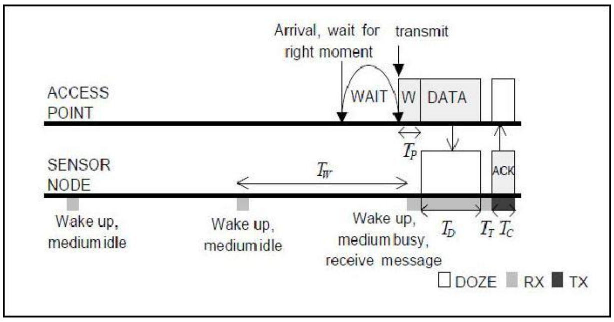

Figure 1. WiseMAC

In Fig.1, T_P is used to denote the duration of the wake-up preamble. Preamble of WiseMAC Protocol is minimized and calculates the period as shown below :

$$T_{Preamble} = \min(4\theta L, T)$$

Here L represents the time from the time when the last revise of the neighbor node wake pattern, T represents the general basic cycle duration and θ represents the clock drift of quartz oscillator.

B. More bit Scheme

WiseMAC consist an optional fragmentation scheme, to boost the throughput in the circumstance of packet bursts and upper traffic loads, this scheme can be said as more bit scheme. This method provides similar functionality as used in SMAC i.e. fragmentation scheme. Here in more bit scheme each time a node has additional data packets to send, it raises a flag bit in MAC frame. Flag bit set in frame header indicate the receiver node that it must not go to sleep state and turn off its transceiver after frame is received and change to receive mode yet again in order to receive the next data-frame. The sender doesn't need to wait for the next wakeup preamble of receiver to send their next frame so the throughput is increased. The more bit scheme is very efficient with unpredictable traffic load and in situation of packet bursts created by a single node.

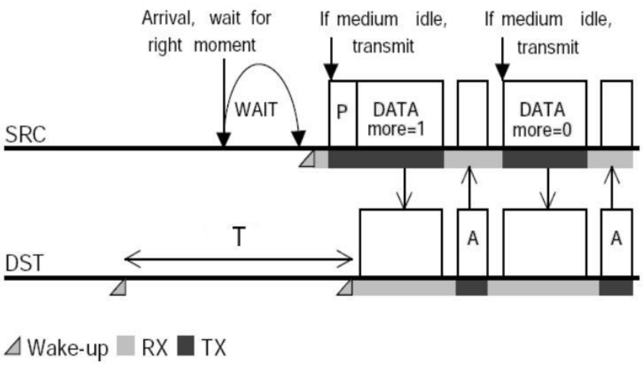

Figure 2. WiseMac MoreBit

C. Extended More Bit Scheme

Previous method More bit scheme is efficient and serves to develop the traffic adaptively between one receiver and one sender and so it possess limitations. Extended More bit scheme is used to overcome the limitations of More bit schemes.

Consider a scenario, where 2 sources, Source1 and Source2 at the same time trying to broadcast a quantity of frames to the similar destination node and hence Source1 and Souece2 both attempt to contact the destination in the same wake-up interval, then there is verdict of which node is first given the preference by the medium reservation preamble. If Source1 is selected for contention then it has to set the More bit and send with its first two frames. Acknowledgement packet with the More bit in it is acknowledged by the end node and the end node stays awake for a minimum of basic wake-up period T. However Source2 has to overhear the broadcasting to the destination and wait as it has lost contention. As the guarantee of keep on awake in the ACK packet, Source2 finds that it can start transmitting its own data frames as soon as Source1 has finished with its transmissions. By using this method we can put away the waiting time, as the transmission of Source2 is started without any stoppage after the transmission of source1 node. Whenever there is a node buffering for more than one frame only then the extended more bit method is activated. It informs the destination to be in awake state for the next frame, which is indication of more load. It will lead pointless energy consumption if extended more bit is applied to every unicast transmission so it is not applied to that case.

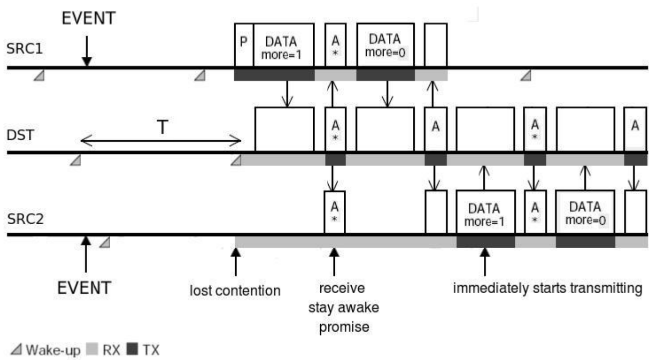

Figure3. WiseMac Extended MoreBit

D. Medium Reservation

In WiseMAC systematic collision can occur due to synchronization mechanism. In Wireless Sensor Network, nodes send data in a multiple hop network to a sink. In such case, many nodes work as relays (repeater) along the pathway towards the sink. There will be higher probability of collision if a no of sensor nodes attempt to transmit the data packet to the same relay node, with same size of wake-up preambles at the same scheduled sampling time.

Medium reservation preamble of random length T_{MR} is added in front of the wake-up preamble in order to avoid such type of collisions. The sensor node which has selected the longest medium reservation preamble, reserve the same and will start its transmission.

E. Overhearing Mitigation

High overhearing traffic is commonly avoided in WiseMAC protocol due to use of the minimum wake-up preamble length in mixed form and preamble sampling method. In WiseMAC, their relative sampling period offsets are independent but sensor nodes are not synchronized among themselves. Let T_P and T_D and be length of wake-up preamble and period of data packet respectively. The duration of the wake-up preamble T_P

becomes small when traffic rates are high. Assuming that total length is T_P+T_D of data packet is very small than sampling interval T_W.The short transmissions hypothetical come in between sampling periods of possible over-hearers as the nodes have independent sampling offsets. Suppose if the wake-up preamble is bigger than the data message, an overhearing prevention method prevents in repeating the data message in the wake-up preamble. If there seem to be repetitions of data messages in wake-up preamble then the over-hearers go to sleep state after reception of only one duplicate of data message.

F. Random backoff

A slotted random backoff method is applied when the medium is found to be busy after sampling. In this method choosing a random backoff which is consistently circulated and decrementing the counter of backoff by one for each slot is Detected idle. This method can also be triggered after a transmission to give even chance for other nodes to snatch the channel.If the communication was successful, then backoff window will be reset to its min size. If the communication was not successful, then backoff window is doubled up to its maximum size. The exponential raise of the backoff window is done to minimize or avoid congestion. In Wise MAC this method is invoked prior to every unsynchronized communication and it is not nedded to call upon the backoff after all communication. The nodes might be coordinated by an external event, so it's better to use slotted random backoff method..

G. Inter-frame spaces

SIFS (Short Inter-Frame Space) is a type of delay, There is an inactive interval between data message end and start of the acknowledgement, which is caused by the time required to turn about transceiver. This delay can be called SIFS (Short Inter-Frame Space) . Short Inter-Frame Space is computed as the sum of turn around time, the baseband processing delay and the propagation delay. If any another nodes attempts a communication during the interval between the acknowledgement and the data, the medium will be idle and which in-turn initiate the transmission. This will led to ACK message to collide. The problem of accident can be avoided by presenting mandatory waiting time at the end of busy interval, prior to which any communication is forbidden. The waiting period is called (Distributed Inter-Frame Space) DIFS. A node doesn't monitor the medium to check the end of a busy interval in Wise-Mac. To make sure that a data-ACK operation is not broken up, a node which is trying for a communication and finds the medium inactive waits for time of DIFS and senses the medium yet again. If the medium is found active, the broadcast attempt is postponed.

I .Predictive wakeup mechanism for WiseMac

In this scheme the nodes wake up to receive at asynchronous and randomized times. This method decreases sensor node energy utilization by making the senders to predict receiver's wakeup times, to make precise predictions. It also inputs an error rectification method that efficiently points our timing difficulties such as irregular operating system and hardware delays and clock drift. This method also introduces an competent prediction-based retransmission method to gain high energy efficiency even when wireless collisions occur and packets are to be retransmitted

PERFORMANCE OF WISEMAC WITH AND WITHOUT USING THE SENDER WAKEUP ADVANCE TIME

WiseMAC with Wakeup Advance		WiseMAC without Wakeup Advance	
Sender Duty Cycle	Delivery Latency	Sender Duty Cycle	Delivery Latency
9.4 %	538 ms	39.7%	930 ms

H. Our Contribution

In this paper we have proposed predictive wakeup mechanism for Wise Mac for variable traffic. We calculate the exact time of sender wakeup time ,right before the receiver comes to the wakeup state. WiseMac performance can be increased by adding the sender wakeup advance time. WiseMAC without this parameter has a high delivery latency and sender duty cycle, as the error of prediction caused by operating system latency and hardware takes us to the sender missing some wakeups of the receiver. We take in the sender wakeup advance time parameter (20 ms) when doing experiments in order to improve the performance of WiseMac.

Better result is obtained by Predictive mechanism of WiseMAC protocol. For Practical implementation purpose it was simulated and checked for authentic results, Network Simulator 2 (NS2) was made use of for simulation purpose. In simulation results the proposed change increase packet delivery ratio, throughput and energy efficiency for changeable traffic.

V. CONCLUSION

This paper has presented the different schemes of WiseMac, an energy-efficient asynchronous duty-cycling MAC protocol for sensor networks. It is intended to decrease energy consumption by making the senders to predict receiver wakeup times even given the difficulties of unpredictable operating system delay, hardware and clock drift.

Better Lifetime for node and low power consumption are the main necessities in Wireless Sensor Network. Basic WiseMAC is also an energy efficient protocol in Wireless Sensor Network. Wise-Mac protocol is an development of CSMA with preamble sampling. Now Preamble sampling can be used with a variety of other ideas that can be defined formerly to decrease the power consumption. Present protocol results in high energy efficiency but with restricted throughput. Our proposed alteration further increases performance for variable traffic.

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BIOGRAPHIES

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