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An Energy Efficient Multichannel Mac Protocols To Convey Bursty Data By Y-MAC

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Abstract-As the use of wireless sensor networks (WSNs) becomes prevalent, node density tends to increase. This poses a new analysis for Medium Access Control (MAC) protocol design. Although conventional MAC protocols achieve low-power operation, they use only a single channel which limits their performance. Several multi-channel MAC protocols for WSNs have been proposed. These protocols are less energy efficient than single-channel MAC protocols under light traffic conditions. In this work, an energy efficient multi-channel MAC protocol, Y-MAC, are used for WSNs. Our goal is to achieve both high performance and energy efficiency under varied traffic conditions. Most of the previous multi-channel MAC protocols for WSNs, Y-MAC on a real sensor node display place and conducted widespread experiments to evaluate its performance. It shows that Y-MAC is energy efficient and maintains high performance under high-traffic state.
Keywords*: *YMAC protocol; duty cycle; medium access control;multichannel; WSN

I. INTRODUCTION

Sensor nodes are naturally battery power-driven and function in unattended environments. Therefore, maximizing the energy efficiency of the nodes is important in order to extend network lifetimes. Since the radio element is a major energy consumer in a sensor node, much research has been dedicated to designing energy efficient MAC protocols. S-MAC uses several techniques to reduce energy consumption of sensor nodes. Neighbour nodes form a effective cluster to auto-synchronize their sleep schedules. Sensor nodes periodically sleep and wake up to reduce idle listening. S-MAC also implements RTS/CTS in order to reduce collisions and avoid overhear something.

Low Power Listening (LPL) combines the low-level carrier sense technique with CSMA and foreword Sampling also proposes a similar algorithm. Nodes are duty-cycled through cyclic channel sampling. By extend the foreword of a message so that it is longer than the sleep interval, Senders are able to wake up receivers. Wise-MAC and B-MAC are advanced versions of LPL. Wise-MAC avoids long preambles by learning the sampling schedule of neighbouring nodes. B-MAC supports run-time reconfiguration to reduce duty cycle and minimize idle listening. In order to save energy at non-target receiver nodes, X-MAC uses a series of short foreword packets containing target address information. To shorten the preamble length, the receiver sends an before time acknowledgement to the sender, in the short break time between foreword packets. These contention based MAC protocols can flexibly adapt to diverse traffic conditions by adjusting the duty cycle. However, they give up energy during in the contention period.

To guarantee collision-free communication, several TDMA-based MAC protocols have been proposed. PEDAMACS uses an access point to list node transmission and reception. The access point clearly schedules all the nodes, based on its knowledge of the topology of the whole network. LMAC uses a distributed time slot selection mechanism. Each node is able to send out a message collision-free since it owns an select time slot in a two-hop neighbourhood. However, all the nodes have to wake up at every time slot in order not to miss incoming messages. While LMAC list senders, Crankshaft list receivers, allocating time slots to the nodes for data reception. Because each node wakes up for data reception at a different equalize from the start of the superframe, the number of nodes overhearing unrelated messages is reduced.

Since the aforesaid MAC protocols focus on the efficient use of energy, they have difficulties in handling burst traffic. Typical sensor applications, such as habitat/environmental monitoring and infrastructure diagnostics, require low data rates and their communication model are cyclic. With the widespread use of sensor applications, however, the node density in WSNs becomes higher. Moreover, some of latest operating systems for WSNs enable sensor nodes to run multiple applications. This leads to higher packet density on the network, and thus handling burst traffic has become a major issue in MAC design. To address this issue, direct MAC and Z-MAC propose mixture approaches, combining the advantages of contention-based protocols and time-slotted protocols. SCP-MAC propose not only synchronous channel census to reduce energy wastage, but also a multi-hop streaming scheme to handle burst traffic towards base stations. Recently, several researchers have look at the possibility of using multiple channels to

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overcome the limitations of single channel MAC protocols. They propose a multi-radio MAC protocol running on a sensor node display place equipped with two radio transceivers. This approach is not an economical solution for WSNs, hence develop a multi-channel MAC protocol using a single radio transceiver would be a better solution. Most commercial radio devices, such as the CC1000 and CC2420, already provide the basic functions required to support multiple channels.

This paper proposes an energy-efficient multi-channel MAC protocol Y-MAC for wireless sensor networks. The protocol fully describes our previous exhibition. The main contributions of this paper are as follows:

We propose a light-weight channel hopping mechanism. Y-MAC avoids redundant channel assignment by not allocating fixed channels to the nodes. Initially, messages are exchanged on the base channel. When a traffic burst occurs, a receiver and potential senders hop to one of the other available channels, according to the hop sequence. Since these messages are carried over additional channels, each node is guaranteed to receive at least one message on the base channel.

Most of the aforesaid multi-channel MAC protocols for WSNs have only been evaluated through simulation experiments. To authorize the practicality of the proposed algorithm, we implemented Y-MAC in the RETOS operating system, and compared it with other published MAC protocols using a set of TmoteSky sensor nodes.

II. EXISTING SYSTEM

A dynamic-duty-cycled multiple rendezvous multichannel MAC protocol is used, DMM-MAC.The proposed a multichannel energy-efficient MAC protocol, DMM-MAC, that is suitable for transmitting burst traffic in a duty-cycled UWSN. DMM-MAC can operate in a more realistic multi-hop environment, instead of a simplified single-hop network, without the information of propagation delays to other nodes.

The DMM-MAC protocol combines the dynamic duty cycling scheme and the MM-MAC protocol. In each wake up frame, the MM-MAC protocol is used to handle channel negotiation and data transmission such that collisions can be reduced. The dynamic duty cycling scheme is applied to determine if a node should have additional wake up frames.

DMM-MAC has several attractive features. Utilizing the dynamic duty cycling scheme, DMM-MAC effectively conserves energy and efficiently delivers burst traffic. Energy conservation is achieved by applying duty-cycling while efficient burst traffic delivery results from DMM MAC’s ability of dynamic active section addition. DMM-MAC reduces collision probability by distributing contending nodes to multiple channels. Assume the concept of cyclic quorum systems, DMM-MAC also guarantees a convention between a node and its proposed receiver. It should be noted that DMM-MAC is a contention-based solution and thus, it is a good candidate in scenarios when a contention-based MAC scheme is preferred. Also note that DMM-MAC is a MAC protocol that is transparent to routing protocols. Similar to other UWSN MAC protocols, DMM-MAC can be used by any MAC-independent UWSN routing protocol.

III. PROPOSED SYSTEM

An energy efficient multi channel MAC protocol, Y-MAC, for WSNs. Our goal is to achieve both high performance and energy efficiency under varied traffic conditions. Y-MAC is a TDMA-based multi-channel MAC protocol.Y-MAC is energy efficient and maintains high performance under high-traffic conditions. Y-MAC avoids redundant channel assignment by not allocating fixed channels to the nodes. Initially, messages are exchanged on the base channel**.** On occurrence of a traffic burst, a receiver and potential senders hop to one of the other available channels in accordance to the hopping sequence. This is done as long as there are potential senders for that node and in the meantime the remaining nodes continue to exchange messages according to slot schedules. All nodes are awake at the beginning of the broadcast period. If there are no incoming broadcast messages, each node turns off its radio until its own receive time slot to save energy.

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IV. ARCHITECTURE

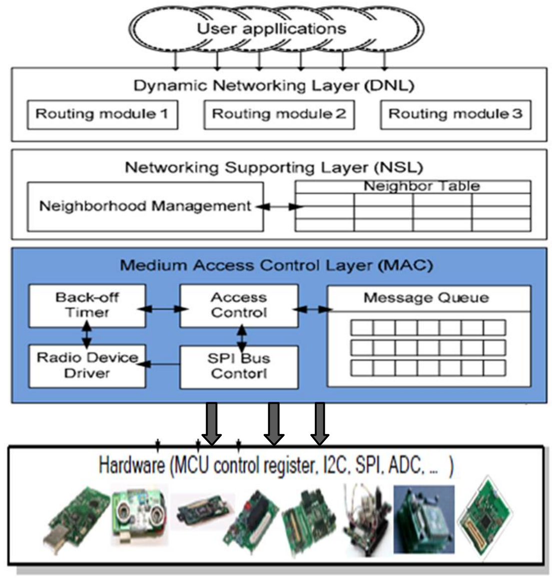

Fig 1: Network Architecture

V. ALGORITHM

Y-MAC is implemented in the RETOS (Resilient, Expandable, and Threaded operating system) operating system on the TmoteSky motes. It consists of three layers: the dynamic networking layer (DNL), the networking supporting layer (NSL), and the medium access control (MAC) layer. User applications need only to interact with the DNL to deliver messages, and different routing modules can be selected taking into account the characteristics of user applications. The NSL is responsible for neighbourhood management, and maintains neighbourhood information in the neighbour table. New nodes are added to the neighbour table, and nodes are removed from the table if their periodic control messages have not arrived for a predefined period of time.

The bottom layer is the MAC layer. We break the MAC layer into five components: back-off timer, access control, radio device driver, SPI bus control, and message queue. To handle burst messages effectively, Y-MAC exploits multiple channels. A light-weight channel hopping mechanism is proposed that enables multiple node pairs to communicate simultaneously on multiple channels. Y-MAC achieves effective transmission of burst messages, under high traffic conditions, while maintaining low energy consumption.

We implemented Y-MAC in the RETOS operating system on the TmoteSky mote RETOS is an operating system for WSNs. The network architecture of RETOS is layered. It consists of three layers: the dynamic networking layer (DNL), the networking supporting layer (NSL), and the medium access control (MAC) layer. User applications need only to interact with the DNL to deliver messages, and different routing modules can be selected taking into account the characteristics of user applications. The NSL is responsible for neighbourhood management, and maintains neighbourhood information in the neighbour table. New nodes are added to the neighbour table, and nodes are removed from the table if their periodic control messages have not arrived for a predefined period of time.

The bottom layer is the MAC layer. We break the MAC layer into five components: back-off timer, access control, radio device driver, SPI bus control, and message queue. For our implementation of Y-MAC in RETOS, we also separate the broadcast message queue and the unicast message queue. All of the Y-MAC parameters, including the queue size, are determined at compile-time. The most important of these four components is the access control component which coordinates medium access by nodes. MAC designers can easily implement new MAC protocols by rewriting this component. General TDMA-based MAC protocols maintain neighbour information that includes assigned time slots. Since the NSL is in charge of neighbourhood management, MAC implementers can concentrate on the access control component, keeping the source code simple and concise.

The main difficulty in implementing any TDMA-based MAC protocol is time synchronization. Every node in the network periodically communicates with other nodes to compensate for synchronization errors caused by clock drift. To timestamp the time remaining in the current frame period in the control message, we used a technique proposed in ETA. Besides errors from clock drift,

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another problem is caused by the timer queue. TDMA-based MAC protocols should maintain an accurate time interval between two consecutive frame periods. Like other operating systems, RETOS provides a common timer queue. Since RETOS implements a common timer queue as a variable timer, the kernel has to reprogram the timer tick rate for every timer request. We initially implemented Y-MAC using this variable timer.When a new frame period is invoked, Y-MAC registers the next frame period as a timer event, but delays in the registration and deletion of timer events caused jitters. Moreover, activated timer requests should wait in the bottom half to be executed for a while. For these reasons, we added a new timer queue dedicated to Y-MAC. This saves the starting time of the previous frame period. By adding this value and the event interval, Y-MAC maintains a constant time interval between timer events.

VI. EXPERIMENTAL RESULTS

For comparison purposes, we also implemented LPL and Crankshaft in RETOS. Our version of LPL was based on the technique proposed, and Crankshaft was implemented by modifying some features of Y-MAC. By using MATLAB version 2012 the result is shown as

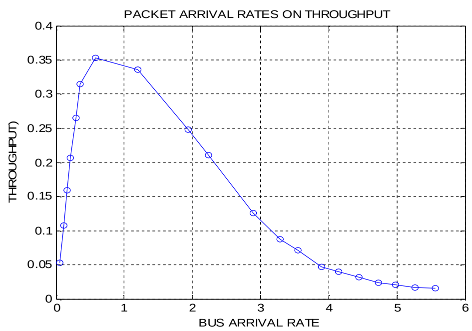

Fig 2: Packet arrival rate in throughput

We evaluated performance in terms of three metrics: energy efficiency, delivery latency and reception rate. We used duty cycle as an indicator of energy efficiency, because accurately measuring the energy consumption of sensor nodes is difficult.

To compare the three MAC protocols fairly, we set the sleep interval for LPL to equal the frame length of Crankshaft and Y-MAC. RETOS is a multi-threaded operating system, so when a node receives a message it wakes up a blocked thread.

Taking into account this wake-up delay, and the time to handle a message, we set the message exchange window to 15ms.

VII. CONCLUSION

In this paper, we proposed a multi-channel MAC protocol for wireless sensor networks. Although existing energy efficient MAC protocols achieve low energy consumption, they sacrifice network throughput. When an important event occurs, sensor nodes around the occurrence have to report their data to the base station as quickly as possible. To handle bursty messages effectively, Y-MAC exploits multiple channels. Unlike most of the other multi-channel MAC protocols for WSNs, we implemented Y-MAC in the RETOS operating system running on TMoteSky motes.

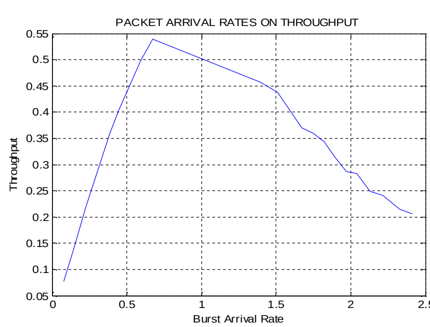

Fig 3: packet arrival rate in bursty throughput

A serious challenge in implementing any TDMA-based MAC protocol is achieving accurate time synchronization. In our implementation, sensor nodes exchange the time remaining in the current frame period to synchronize their starting points for the next frame period. Our initial experiments show that the average time synchronization error among sensor nodes is acceptable for

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MAC designers to implement TDMA-based MAC protocols. We also proposed a light-weight channel hopping mechanism that enables multiple node pairs to communicate simultaneously on multiple channels. Sensor nodes hop to the next radio channel if they have additional awaiting messages for the receiver. This mechanism increases network throughput and reduces message delivery latency at the same time. Throughout this paper, we have conducted widespread experiments to confirm the practicality of the proposed Y-MAC protocol. Experimental results show that Y-MAC achieves low duty cycle under light traffic conditions, similar to other existing low power MAC protocols. We have proven that Y-MAC achieves effective transmission of burst messages, under high traffic conditions, while maintaining low energy consumption.

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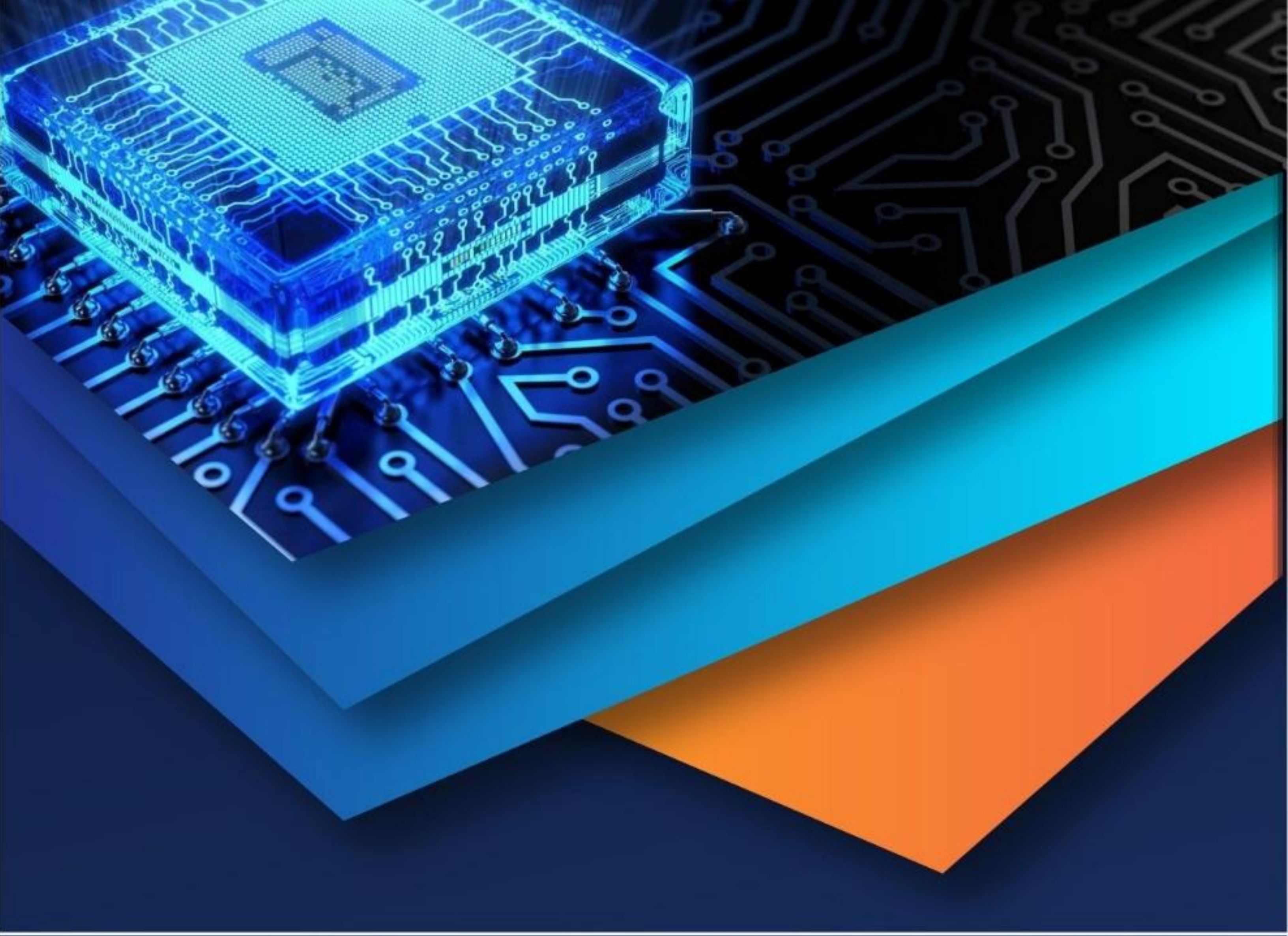

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