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Research on Energy Saving MAC Protocol Based on Reporting Service in Wireless Sensor Networks

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Abstract: - **The most important issue that must be solved in designing a data gathering algorithm for wireless sensor networks (WSNS) is how to save sensor node energy while meeting the needs of applications/users. In WSNs, sensors are usually equipped with capacity-irreplaceable battery sources. Therefore, optimizing an effective wireless sensor network to maximizing the lifetime of a sensor node in order to minimize energy resource and maximize overall system performance becomes important. Wireless sensor networks are widely used in various fields, but the network nodes are mostly battery-powered. Energy-saving has always been the core issue of wireless sensor networks. The existing research mainly improves MAC protocol, routing protocol and networking, reducing the energy consumption of wireless sensor network. This paper mainly studies the energy-saving of MAC protocol, analyzes the problems existing in MAC protocol, and improves the MAC protocol for its existing problems. The S-MAC Protocol, T-MAC Protocol, H-MAC Protocols are designed. The main application scenario of the wireless sensor network is that the sensor nodes periodically collect sensing data and upload them to the sink node, and the service type thereof may be a single-cycle service or a multi-cycle service. No matter single-cycle service or multi-cycle service, when nodes in the network send data at the same time, according to the MAC competition mechanism, the probability of data collision increases significantly, energy waste and transmission delay increase due to data collision. According to the MAC protocol data prediction mechanism, the node has idle snooping in the receiving slot, and idle snooping causes the waste of energy.**

Keywords: - **MAC protocol, CSMA, TDMA, QoS, hybrid scheme.**

I. INTRODUCTION

Wirelesssensor network (WSN) is collection of battery powered sensor nodes, which communicate wirelessly. Several issues are faced in wireless sensor network, in which energy consumption is the major issue, because the nodes cannot be recharged as they can be deployed in unreachable area. The communication between the WSN nodes is done using the Media access control (MAC) protocol. Various MAC protocols are proposed to reduce the energy consumption. In this paper, we have introduced some basics of wireless sensor network and then the issues of energy wastage. We have introduced the S-MAC and T-MAC protocol to reduce the problem of energy consumption. S-MAC and T-MAC protocol are compared in the paper with the main difference in their Duty cycles.Wireless sensor network is composed of a large number of sensor nodes a special Ad Hoc network, mainly for data collection and transmission, has a wide range of applications.Because sensor nodes are generally powered, and the size of the nodes is small, and the battery can carry a limited amount of energy, saving energy consumption is a research hotspot in wireless sensor networks.Many valid MAC layer protocols have been proposed, of which S-MAC is the most representative. On the one hand, it inherits the basic mechanism of IEEE802.11 MAC protocol and on the other hand, it adopts periodic sleep mode to reduce energy consumption effectively. So it becomes one of the most concerned MAC protocols in sensor networks.This article will analyze in detail the principle and performance of the Schedule class protocol represented by the S-MAC, and on this basis to explore more energy-efficient MAC protocol research and design.In addition, weproposeanewhybridMACscheme, called H-MAC (Hybrid MAC) for wireless mesh networkthatcombinesthestrengths OfTDMAandCSMA.H-MAC extends the hybrid multi-hops scheme defined in Z-MAC (Rhee, Warrier, Aia, andMin, 2005)to support channel diversity and QoS requirements for wireless mesh network. The main feature Of H-MAC is its adaptability to the level of contention in the network. In fact, under low contention, H-MAC behaves like CSMA, and under high contention, it behaves like TDMA.

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II. ENERGY MINIMIZATION TECHNIQUES IN MAC PROTOCOLS FOR WBASNs

Low power Utilization mechanisms play an important role in performance enhancement of MAC protocol. In this section, different approaches and techniques that provide energy efficiency in MAC protocols for WBASNs are discussed and compared. Energy efficiency is an important issue because the power of sensor Nodesin WBANs is limited and long duration of operation is expected. The key concept forlow power consumptionis to minimize the energy consumption in the following sources: sensing, data processingand communication. Most of the energy wastage is caused during communication process because of the collision of packets, idle listening, over hearing, over-emitting, control packet overhead and traffic fluctuations. Idle listening can be reduced through duty cycling. To reduce energy waste in order to increase network's life time and to enhance the performance of MAC protocol, different wake-up mechanisms are used.

2.1 Sensor-MAC

Sensor-MAC(S-MAC) Sensor-MAC [2] regulates sleep periods in a sensor network to conserve energy and improve network lifetime. This protocol based upon sleep and active time for achieving energy efficiency in wireless sensor network. SMAC uses static sleep scheduling for reduce the energy consumption and divides the time into frames. Every frame is divided into an active and a sleep period as shown in Figure 1. In active period, the transmitter-receiver is switched on and it is switched off during sleep period. A complete cycle of listenand sleep period is called a frame.

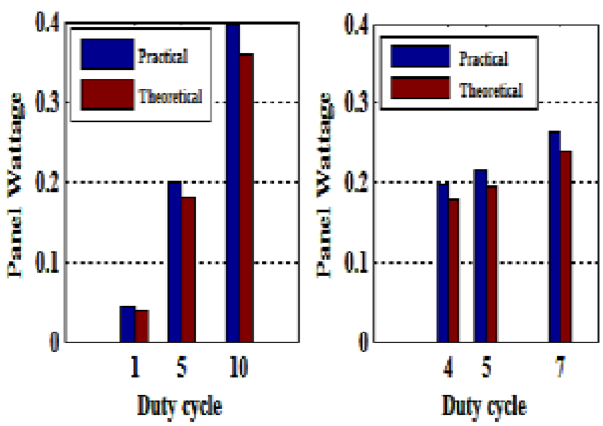

Figure 1: Duty cycle of S-MAC

Frame = Listentime +Sleeptime

S-MAC reduces idle listening time by letting nodes go into periodic sleep mode. Each node goes to sleep for some time, and then wakes up and listens to see if any other node wants to talk to it.

All nodes are free to choose their own listen/sleep schedules. However, to reduce control overhead, neighboring nodes synchronize together.Nodes exchange their schedules by periodically broadcasting a SYNC packet to their immediate neighbors. This ensures that all neighboring nodes can talk to each other even if they have different schedules. The period for each node to send a SYNC packet is called the synchronization period.The S-MAC protocol follows similar procedures to the 802.11 protocol for collision avoidance,request-to-sent/clear-to-send (RTS/CTS) exchange.But the problem with the S-MAC is that even if data exchange finishes within active period, the node will still remain awake until its sleep timethus wasting energy. So, the static duty cycle of the S-MAC protocol causes energy waste.

2.2 T-MAC

A solution with a fixed duty cycle like the S-MAC is not optimal. The nodes must be deployed with an active time that can handle the highest expected load. And wheneverthe load is lower than that, the active time is not optimally used and energy will be wasted on idle listening. The idea of the T-MAC protocol is to reduce idle listening by transmitting all messages in bursts of variable length, and sleeping between bursts. To maintain an optimal active time under variable load, we dynamically determine its length. T-MAC end the active time in an intuitive way.

T-MAC Protocol design

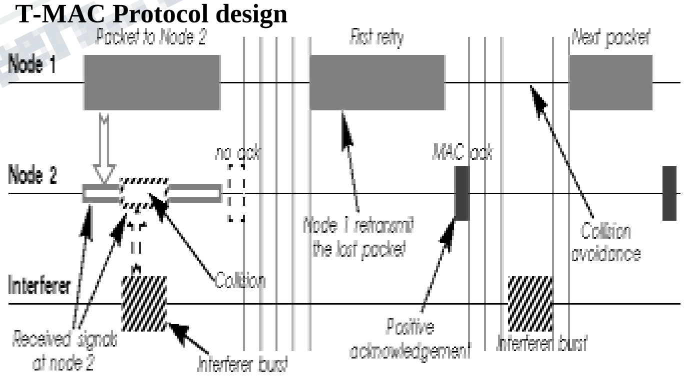

Fig. 2 shows the basic scheme of the T-MAC protocol.

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 using a RTS, CTS and ACK. 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. An activation event is "the periodic frame timer, "the reception of any data on the radio", "the end-of-transmission of a node's own data packet or acknowledgement", "the overhearing prior RTS and CTS packets". A node will sleep if it is not in an active period. Consequently, TA determines that minimal amount of idle listening per frame. The described timeout scheme moves all communication to a burst at the beginning of the frame. Since messages between active times must be buffered, the buffer capacity determines an upper bound on the maximum frame time.

2.3 P-MAC

In the Pattern-MAC (PMAC) protocol, instead of having fixed sleep- wakeups, the sleep-wake up schedules of the sensor nodes are adaptively determined. The schedules are decided based on a node's own traffic and that of its neighbors. Our analytical results show that in comparison to SMAC, PMAC achieves more power savings under light loads, and higher throughput under heavier traffic loads. Furthermore, unlike SMAC, only the sensor nodes involved in communication wake up frequently in PMAC and hence energy is conserved in other sensor nodes.Pattern-MAC (PMAC) protocol for sensor networks that adaptively determines the sleep-wake up schedules for a node based on its own traffic and the traffic patterns of its neighbors. Power efficiency, which is the throughput achieved per unit of energy consumed, is given as

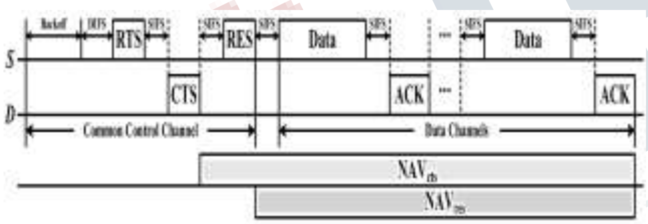

Fig. 3 shows the basic scheme of the P-MAC protocol.

However, when the traffic is heavy, PMAC has asignificant improvement on the throughput. Periodic sleepingblocks the traffic flowing through in SMAC.
ss

2.4 H-MAC

H-MAC uses the two contention modes LCLand HCLsimilar to that of Z- MAC. It also implements two allocation algorithms. The first one is a Receiver Based Channel AssignmentAlgorithm (RBCA). In this algorithm, each node is assigned a unique channel in which it will receive all its packets. The second is the Sender Based Slot Assignmentalgorithm (SBSA) where each node is assigned a set of slots of which it will become the owner. These algorithms are an extension of NCR (Neighbor-aware Contention Resolution) algorithm defined in (BaoAnd Garcia-Luna-Aceves, 2003), which does not require any control message exchange. H-MAC uses a medium access function similar to the IEEE 802.11e EDCA techniques that support the QoSrequirements (IEEE Std 802.11e, 2004).H-MAC operates in two phases: initialization phase and communication phase. In the initialization phase, the following operations run in sequence: neighbor discovery, channel assignment, slot assignment, and finally global time synchronization. These operations run only once during the setup phase and does not run again until a significant change in the network topology (such as HELLO joining, or QUIT message) occurs. In the communication phase, each node performs channel negotiation and runs the LCL or HCL mode according to the contention level.

III. CONCLUSION

In this paper, we compared CSMA based MAC protocols with respect to their energy consumption and found that in general, H-MAC performs better than all other protocols which were considered. Protocols based on preamble sampling consume lesser energy than protocols based on static or dynamic sleep schedule. The paper also presented the advantages and disadvantages of these protocols when traffic is high and when it is low. Such analysis may be used to configure the network as per user requirements. In future, we aim to present a system with which users would be able to do such configurations using SQL like queries. We aim to integrate the implemented protocols with TinyDB2 [14], a query driven data extraction system for WSNs. The system would be integrated with Power Tossim-Z to enable users see the energy Consumed by their application using SQL like queries without exposing them to internal details of sensor network platforms

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