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A REVIEW ON ENERGY EFFICIENCY IN WIRELESS SENSOR NETWORKS THROUGH MAC LAYERS

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***Abstract*--Wireless sensor networks are the devices to monitor the physical environments such as temperature, humidity, and the mobility of the objects concerned. Energy efficiency plays a vital role in the design of wireless sensor networks, as the major drawback of the sensor node is limited battery source which cannot be replaced/recharged for continuous operation. Media Access Control is one of the key areas where energy efficiency can be achieved by designing such MAC protocol that is tuned to the requirements of the sensor networks. Developing of MAC protocol for Wireless Sensor Network (WSN) has a challenging issue of Energy efficiency because WSN has large number of sensor nodes with limited processing capability and limited power. Most of WSN uses battery for power. One of important task in developing MAC protocol for WSN is increase the life time of network; it means we have to use power very efficiently. To develop MAC protocol, which is energy efficient, many flavor of MAC protocol is proposed by different researcher. This paper is a survey of active research work on Energy efficient MAC for wireless sensor networks.**

Index Terms- Wireless Sensor Network, Energy Efficient, MAC Protocol

I. INTRODUCTION

A Wireless sensor network is a wireless network consisting of distributed autonomous device using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different location. Wireless sensor network has so many sensing nodes with small energy and processing power which monitor the environment and collect the information. They also transfer information to another node and make a communication network. As we know that each node has limited power, energy saving is a very important task in wireless sensor network. In wireless sensor network, MAC protocol is used to make decision about wireless channel. How to use wireless channel for communication is decide by MAC protocol. Choosing an efficient MAC protocol is very important for a Wireless sensor network because we can save energy of node using a MAC protocol which is energy efficient. In last few years, much research has been done by researcher in the area of MAC protocol for Wireless sensor network which are energy efficient. In this paper we try to review of existing research in energy efficiency in MAC for wireless sensor networks.

II. LITERATURE REVIEW

Maria Sefuba, *et al.* [1] presents an Energy Efficient Medium Access Control (MAC) protocol for clustered wireless sensor networks that aims to improve energy efficiency and delay performance. The proposed protocol employs adaptive cross-layer intra-cluster scheduling and inter-cluster relay selection diversity. The scheduling is based on available data packets and remaining energy level of the source node (SN). This helps to minimize idle listening on nodes without data to transmit as well as reducing control packet overhead. The relay selection diversity is carried out between clusters, by the cluster head (CH), and the base station (BS). The diversity helps to improve network reliability and prolong the network lifetime. Relay selection is determined based on the communication distance, the remaining energy and the channel quality indicator (CQI) for the relay cluster head (RCH). An analytical framework for energy consumption and transmission delay for the proposed MAC protocol is presented in this work. The performance of the proposed MAC protocol is evaluated based on transmission delay, energy consumption, and network lifetime. The results obtained indicate that the proposed MAC protocol provides improved performance than traditional cluster based MAC protocols.

Senthil T, *et al.* [2] Thus proper design of the medium access control protocols will reduce the energy consumption of the sensor node per data transfer. The typical coverage area of the wireless sensor network is limited to 100 meters only so that multihop transmission is utilized with intermediate nodes for the transfer of data from source node to sink. The parameters such as throughput and latency are considered as quality factors
for the energy efficient multihop MAC protocols. An efficient shortest path algorithm are being used to reduce power consumption and increase the efficiency with regard to different MAC protocols. The approach embraces comparison of two popular MAC protocols such as RMAC (Routing Enhanced Duty Cycle Medium Access Control), and HEMAC (Hop Extended Medium Access Control) of sensor networks related to energy consumption scenarios. The network model consists of average power consumption and path length

optimization which leads to the reduction of the power consumption in the existing multihop MAC protocols of the wireless sensor networks.

Maaz M, ***et al.*** **[3]** A real time wireless media access control protocol based on earliest deadline first scheduling scheme is proposed. Unlike its predecessors, this new protocol is applicable to both event-driven and clock-driven nodes with salient features being high energy efficiency and priority based latency. Establish the improved latency performance over carrier sense multiple access protocol, through simulation of wireless sensor network in network simulator-3. Then, present a mathematical model to obtain the lower bound on the fraction of energy saved by the use of the proposed protocol as opposed to existing protocols. This improvement in latency performance facilitates an increase in cluster size and energy efficient communication ensures increased lifetime of the sensor network, which makes our protocol a promising choice for the future wireless sensor networks.

Afraa Attiah , ***et al.*** **[4]** present EE-MAC, an Energy Efficient medium access control (MAC) protocol for distributed wireless sensor networks. EE-MAC achieves a low-duty-cycle and hence low energy consumption through optimized sleep intervals while transitioning between *sleep* and *active* states. Consider a weighted linear combination of delay and energy saving as the performance metrics and through extensive simulations, observe reduced energy consumption at the cost of increased delay. EE-MAC also improves the delay performance for fixed number of nodes compared to S-MAC.

Kyung TaeKimandHee Yong Youn, ***et al.*** **[5]** propose a new energy efficientMAC protocol called dynamic threshold MAC (DT-MAC), which employs a dynamic threshold for the buffer of each sensor node to maximize the energy efficiency regardless of specific network traffic condition. Here the packets are stored in the buffer, and then transmitted when the number of packets in the buffer exceeds the threshold dynamically decided according to the number of hops of the node from the source in the path of packet forwarding. The simulation results using OMNnet++ show that DT-MAC enables significant improvement in energy consumption compared to the existing MAC protocols. The proposed DT-MAC protocol also reduces the number of transmissions of control packets.

Swapna Kumar, ***et al.*** **[6]** proposed a Dynamic MAC (D-MAC), energy efficient and low latency MAC for data gathering in wireless sensor networks. DMAC is designed to solve the interruption problem by giving the sleep schedule of a node an offset that depends upon its depth on the novel methods. DMAC also adjusts the duty cycles adaptively according to the traffic load in the network. Previously propose paper D-MAC protocol design methodology and presently the results is projected at self-learning, traffic adaptive algorithm for the WSNs. The design incorporates contention based on CSMA/CA mechanism based timing for energy-aware sensing network to overcome this control overhead and latency. This protocol is simulated in Matlab and performance evaluated. Simulation in Matlab shows that DMAC provides significant energy savings and latency reduction while ensuring high data reliability.

Shams ur Rahman, ***et al.*** **[7]** present a TDMA-based MAC (TDMAC) protocol which is specially designed for such applications that require periodic sensing of the sensor field. TDMAC organizes nodes into clusters. Nodes send their data to their cluster head (CH) and CHs forward it to the base station. CHs away from the base station use multi-hop communication by forwarding their data to CHs nearer than themselves to the base station. Both inter-cluster and intra-cluster communication is purely TDMA-based which effectively eliminates both intercluster as well as intra-cluster interference.

Wei Ye, ***et al.*** **[8]** proposes S-MAC, a medium-access control (MAC) protocol designed for wireless sensor networks. Wireless sensor networks use battery-operated computing and sensing devices. A network of these devices will collaborate for a common application such as environmental monitoring. We expect sensor networks to be deployed in an ad hoc fashion, with individual nodes remaining largely inactive for long periods of time, but then becoming suddenly active when something is detected. These characteristics of sensor networks and applications motivate a MAC that is different from traditional wireless MACs such as IEEE 802.11 in almost every way: energy conservation and self-configuration are primary goals, while per-node fairness and latency are less important. S-MAC uses three novel techniques to reduce energy consumption and support self-configuration. To reduce energy consumption in listening to an idle channel, nodes periodically sleep. Neighboring nodes form *virtual clusters* to auto-synchronize on sleep schedules. Inspired by PAMAS, S-MAC also sets the radio to sleep during transmissions of other nodes. Unlike PAMAS, it only uses in-channel signaling. Finally, S-MAC applies *message passing* to reduce contention latency for sensor-network applications that require store-and forward processing as data move through the network. We evaluate our implementation of S-MAC over a sample sensor node, the Mote, developed at University of California, Berkeley. The experiment results show that, on a source node, an 802.11-like MAC consumes 2-6 times more energy than S-MAC for traffic load with messages sent every 1–10s.

Bhavana Narain, ***et al.*** **[9]** To work in wireless communicating sensors network, use MAC protocol which improve energy efficiency by increasing sleep duration, decreasing idle listening and overhearing, and eliminating hidden terminal problem or collision of packets. First section described the accessible energy –efficient MAC protocols for sensor networks their energy saving method. In Second section discussed the architecture of same protocols and then compare same protocols depending on their Advantages and Disadvantages.

Lei Tang, ***et al.*** **[10]** presented the design and evaluation of the *EM-MAC* (*Efficient Multichannel MAC*) protocol, which addresses these challenges through the introduction of novel mechanisms for adaptive receiver-initiated multichannel rendezvous and predictive wake-up scheduling. EM-MAC substantially enhances wireless channel utilization and transmission efficiency while resisting wireless interference and jamming by enabling every node to dynamically optimize the selection of wireless channels it utilizes based on the channel conditions it senses, without use of any reserved control channel. EM-MAC achieves high energy efficiency by enabling a sender to predict the receiver's wake-up channel and wake-up time Implemented in TinyOS on MICAz motes, EM-MAC substantially outperformed other MAC protocols studied. EM-MAC maintained the lowest sender and receiver duty cycles, the lowest packet delivery latency, and 100% packet delivery ratio across all experiments. Evaluation includes single-hop and multihop flows, as well as experiments with heavy ZigBee interference, constant ZigBee jamming, and Wi-Fi interference.

Simarpreet Kaur, *et al.* [11] introduces different types of MAC protocols used for WSNs and proposes S‐MAC, a Medium‐Access Control protocol designed for Wireless Sensor Networks. S‐MAC uses a few innovative techniques to reduce energy consumption and support self configuration. A new protocol is suggested to improve the energy efficiency, latency and throughput of existing MAC protocol for WSNs. A modification of the protocol is then proposed to eliminate the need for some nodes to stay awake longer than the other nodes which improves the energy efficiency, latency and throughput and hence increases the life span of a wireless sensor network.

Sha Liu, *et al.* [12] present the design of a new low duty-cycle MAC layer protocol called Convergent MAC (CMAC). CMAC avoids synchronization overhead while supporting low latency. By using zero communication when there is no traffic, CMAC allows operation at very low duty cycles. When carrying traffic, CMAC first uses anycast to wake up forwarding nodes, and then converges from route-suboptimal anycast with unsynchronized duty cycling to route-optimal unicast with synchronized scheduling. To validate our design and provide a usable module for the community, we implement CMAC in TinyOS and evaluate it on the Kansei testbed consisting of 105 XSM nodes. The results show that CMAC at 1% duty cycle significantly outperforms BMAC at 1%in terms of latency, throughput and energy efficiency. Also compare CMAC with other protocols using simulations. The results show for 1%duty cycle, CMAC exhibits similar throughput and latency as CSMA/CA using much less energy, and outperforms SMAC and GeRaF in all aspects.

Gaurav Jolly, *et al.* [13] present an energy efficient, scalable and collision free MAC layer protocol for sensor networks. The approach promotes time-based arbitration of medium access to limit signal interference among the transmission of sensors. Transmission and reception time slots are prescheduled to allow sensors to turn their radio circuitry off when not engaged. In addition, energy consumption due to active to sleep mode transitions is minimized through the assignment of contiguous transmission/reception slots to each sensor. Scalability of the approach is supported through grouping of sensors into clusters. Described an optimization algorithm for energy conscious scheduling of time slots that prevents intra-cluster collisions and eliminates packet drop due to buffer size limitations. In addition, also propose an arbitration scheme that prevents collisions among the transmission of sensors in different clusters. The impact of our approach on the network performance is qualified through simulation.

Brian Bates, *et al.* [14] investigates energy usage in three such protocols AS-MAC, SCP-MAC, and Crankshaft–on physical sensor hardware. It additionally presents BAS-MAC, an energy-efficient protocol of our own design. We evaluate our implementation of these four protocols on TelosB motes over multiple sensor network topologies. Our evaluations show that in single-hop networks with large send intervals and staggered sending, AS-MAC is best in the local gossip and convergecast scenarios, while SCP-MAC is best overall in the broadcast scenario. We conjecture that Crankshaft would perform best in extremely dense hybrid (unicast and broadcast) network topologies, especially those which broadcast frequently. Finally, BAS-MAC would be optimal in networks which utilize hybrid traffic with infrequent broadcasts, and where broadcasting is performed by motes that do not have an unlimited power source.

Li Deliang, *et al.* [15] present a survey of the recent typical MAC protocols regarding energy efficiency for WSN. According to channel access policies, classify these protocols into four categories: contention-based, TDMA-based, hybrid, and cross layer protocols, in which the advantages and disadvantages in each class of MAC protocols are discussed. Finally, point out open research issues that need to carry on achieving high energy efficiency for the design of MAC protocols in WSN.

Youngmin Kim, *et al.* [16] proposed an energy efficient multichannel MAC protocol, Y MAC, for WSNs. Our goal is to achieve both high performance and energy efficiency under diverse traffic conditions. In contrast to most of previous multi-channel MAC protocols for WSNs, we implemented Y-MAC on a real sensor node platform and conducted extensive experiments to evaluate its performance. Experimental results show that Y-MAC is energy efficient and maintains high performance under high-traffic conditions.

Eleazar Chukwuka, *et al.* [17] among others, one of the main sources of energy depletion in WSN is communications controlled by the Medium Access Control (MAC) protocols. An extensive survey of energy efficient MAC protocols is presented in this reference. Categorise WSN MAC protocols in the following categories: controlled access (CA), random access (RA), slotted protocols (SP) and hybrid protocols (HP). Further discussed, how energy efficient MAC protocols have developed from fixed sleep/wake cycles through adaptive to dynamic cycles, thus becoming more responsive to traffic load variations. Finally present open research questions on MAC layer design for WSNs in terms of energy efficiency.

Tijs van Dam, *et al.* [18] described T-MAC, a contention-based Medium Access Control protocol for wireless sensor networks. Applications for these networks have some characteristics (low message rate, insensitivity to latency) that can be exploited to reduce energy consumption by introducing an active/sleep duty cycle. To handle load variations in time and location T-MAC introduces an adaptive duty cycle in a novel way: by dynamically ending the active part of it. This reduces the amount of energy wasted on idle listening, in which nodes wait for potentially incoming messages, while still maintaining a reasonable throughput. Discussed the design of T-MAC, and provide a head-to-head comparison with classic CSMA (no duty cycle) and S-MAC (fixed duty cycle) through extensive simulations. Under homogeneous load, T-MAC and S-MAC achieve similar reductions in energy consumption (up to 98 %) compared to CSMA. In a sample scenario with variable load, however, T-MAC outperforms S-MAC by a factor of 5. Preliminary energy-consumption measurements provide insight into the internal workings of the T-MAC protocol.

Kaushik R , *et al*. [19] presents CMAC, a fully desynchronized MAC protocol that is designed to exploit the existing multi-channel support in sensor nodes. The hardware requirements of our protocol are minimal, requiring a single half-duplex transceiver and a low power wake-up radio. CMAC takes into account the fundamental energy constraint in sensor nodes by placing them in a default sleep mode and waking them up only when necessary. As a contrast to other dual radio wake-up schemes, our protocol focuses on how communication and its preceding control message exchange mechanism can be undertaken in a multi-channel scenario without assuming a separate control channel. CMAC enables spatial channel re-use, nearly collision free communication, and addresses the deafness problem without incurring a tradeoff in fairness or latency. When compared with a recent MAC protocol SMAC, results show that CMAC obtains nearly 200% reduction in energy consumption, significantly improved throughput, and end-to-end delay values that are 50-150% better than SMAC for our simulated topologies.

Rajesh Mathew, *et al*. [20] describes a bootstrapping protocol for a class of sensor networks consisting of a mix of low-energy sensor nodes and a small number of high-energy entities called gateways. We propose a new approach, namely the slotted sensor bootstrapping (SSB) protocol, which focuses on avoiding collisions in the bootstrapping phase and emphasizes turning off node radio circuits whenever possible to save energy. Our mechanism synchronizes the sensor nodes to the gateway's clock so that time-based communication can be used. The proposed SSB protocol tackles the issue of node coverage in scenarios, when physical device limitations and security precautions prevent some sensor nodes from communicating with the gateways. Additionally, we present an extension of the bootstrapping protocol, which leverages possible gateway mobility.

III. CONCLUSION

All application of sensor network has different characteristic and different environment. Some application has busty traffic and some application has small data transmission. So many MAC protocol is proposed for a WSN, but we cannot specify any one protocol as stander for MAC protocol. Choice of MAC protocol depends on application. We have no stander sensor hardware for sensor network, due to this, according hardware, different MAC protocol is applicable as per hardware. For better performance, all protocol has different different technique for collision, overhearing, collision overhead and idle listening. For researcher, Solution to this all problem in a MAC protocol is challenge.

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