Performance Analysis of Distributed Energy Based MAC Protocol for Wireless Sensor Networks

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Abstract—*Wireless sensor networks have been identified as one of the most important technologies in the 21st century for various applications. Recent advances in wireless sensor networks have led to many new protocols specifically designed for sensor networks, where energy awareness is an intend. The proposed method considers developing an effective cross-layer cooperative diversity-aware routing algorithm together with recently proposed DELCMAC to conserve energy while minimizing the throughput and delay degradation. A key feature in the design of DELCMAC is its independence from the underlying wireless technology used by network nodes. The proposed Distributed Energy Based MAC (DEBMAC) approach wireless sensor network for significantly prolongs the network lifetime with the IEEE 802.11 DCF and Cooperative MAC (CMAC). Extensive simulations have been performed in large-scale network scenarios.*

Keywords—Network lifetime; cooperative communication; Cooperative MAC (CMAC) protocol; Relay selection

1. INTRODUCTION

The wireless Sensor Networks (WSNs) are used in a wide range of applications to capture, gather and analyze live environmental data WSNs are an emerging technology that has become one of best growing areas in the data communication .They consist of sensor nodes that use low power consumption which are powered by small replaceable batteries that collect real-world data process it, transmit the data by radio frequencies to their destination. The uses of WSNs is increasing day by day and at the same time it faces the problems of low processing power of nodes and high energy consumption ,but reliable delivery of data in the real time also needs proper attention.

Nowadays many researchers have developed many new protocols specifically designed for different kinds of application where energy efficiency is an essential consideration. Traditional WSN application has mostly focused on passive low duty cycle sensing and monitoring in network data reduction and asynchronous operation designed to extend the sensor net lifetime. Sensor networks in both mission –critical operations and wide area surveillance like real time streaming for voice and low rate video delivery require relatively high bandwidth utilization and throughput as well as bounded end to end delay of a few milliseconds. Therefore, design of effective WSN Medium Access Control (MAC) protocols has become a more challenging task given the unique set of resource constraints in these networks which result in very different design trade offs than those in wireless sensor networks. The requirements for the Medium Access Control (MAC) Layer of a WSN are clearly different Traditional networks .The major characteristics for the MAC protocols in a WSN such as Latency, Reliability, Energy Efficiency, stability, Fairness and Decentralized.

Cooperative Communication (CC) is a essentially design for the energy consumption in MANETs networks. CC can provide gains in terms of the required transmitting power due to the spatial diversity achieved via use cooperation. Suppose if need the extra processing and receiving energy consumption required for cooperation not suitable when compare to direct transmission approach, here the losses in extra energy consumption overhead occur in transmitting power.

Nowadays CC considering design with regard to cross-layer in both physical layer and MAC layer attracts more and more attention.

Without considering the MAC layer interactions and signaling overhead due to cooperation, the performance gain through physical layer cooperation may not improve end to end performance. Researchers proposed a CMAC protocols named Coop MAC to exploit the multi-rate capability and aimed at mitigating the throughput bottleneck caused by the low data rate nodes, so that the throughput can be increased. The existing CMAC protocols mainly focus on the throughput enhancement while failing to investigate the energy efficiency or network lifetime. The proposed work focuses on the MAC layer, and is distinguished from previous protocols by considering a practical energy model (i.e., energy consumption on both transceiver circuitry and transmit amplifier), with the goal to enhance energy efficiency and extend network lifetime. In this paper, we propose a Distributed Energy based MAC protocol, namely DEBMAC, for WSNs. DEB-MAC is designed based on the IEEE 802.11 Distributed Coordination Function (DCF), which is a widely used standard protocol for most of wireless networks.

2. LITERATURE REVIEW

The researchers in ref [1], has considered Distributed Energy Adaptive Location based CMAC protocol, namely DEL-CMAC for larger scale network size and with high mobility.

It is also considered to develop an effective cross-layer cooperative diversity-aware routing algorithm together with

DELCMAC to conserve energy while minimizing the throughput and delay degradation. The researchers in ref [2], has considered the Cooperative Diversity protocol a variety of low-complexity, cooperative protocols that enable a pair of wireless terminals, each with a single antenna, to fully exploit spatial diversity in the channel.The researchers in ref [5], has considered the total energy consumption and the total delay can be reduced, even when it is taken into account the energy and delay cost associated with the local information exchange.

The researchers in ref [7], has considered Studied the basic categories of MAC protocol, Contention based collision, free, scheduling based and hybrid in terms of reliability, latency, QoS and energy efficiency. The researchers in ref [9], has considered HyMAC is designed to provide high throughput and small bounded end to end delay for the packets exchanged between each node and the base station.

3. Related Work

The basic operations of the existing DEL-CMAC are based on the IEEE 802.11 DCF [1] (Distributed Coordination Function). In DCF, after a transmitting terminal senses an idle channel for a duration of Distributed InterFrame Space (DIFS), it backs off for a time period that chosen from 0 to its Contention Window (CW). After the backoff timer expires, the well-known RTS-CTS-DATA-ACK procedure is carried out .Any terminal overhearing either the RTS or the CTS extracts the information contained in the MAC frame header, and sets its NAV to imply the time period during which the channel is busy.

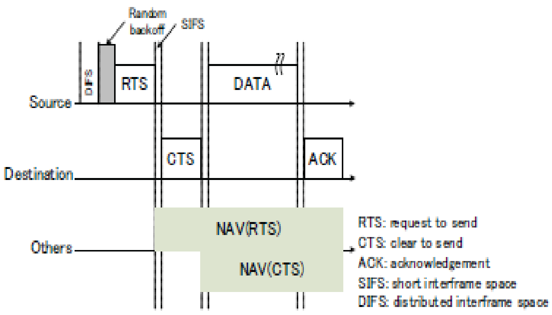

Fig 1:IEEE802.11 DCF

DEL-CMAC Protocol

The main objective of recently proposed DEL-CMAC protocol is increasing the network lifetime and increasing the energy efficiency, DEL-CMAC mainly focused in multi hop Mobile Adhoc Networks (MANETs). DEL-CMAC Deal with the relay and transmitting power (dynamic) based on the Request to send (RTS), Clear to Send (CTS), and Acknowledgement (ACK) additionally DEL CMAC introduces two new control frames such as Eager-To-Help (ETH) and Interference- Indicator (II).

Eager-To-Help (ETH) and Interference- Indicator (II)

ETH mainly used to identify the winning relay to inform the source, destination and lost relays. DEL-CMAC select the winning relay that has the maximum energy and the minimum transmitting power among the capable relay candidates. The Interference Indicator (II) frame is used to reconfirm the interference range of allocated transmitting power at the winning relay, in order to enhance the spatial reuse, here the transmitting power for the II frame and data packet are dynamically allocated.

Protocol Description

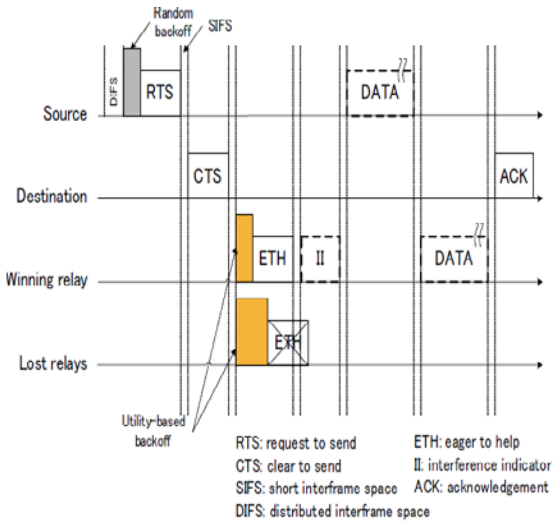

Fig 2: Frame exchanging process of DEL_CMAC

The frame exchanging process of DEL-CMAC is shown in Fig. 2. Similar to the IEEE 802.11 DCF protocol, the RTS/CTS handshake is used to reserve the channel at first.

As we know, the cooperative transmission is not necessary in the case that the transmitting power is small [6], because the additional overhead for coordinating the relaying overtakes the energy saving from diversity gain. Those inefficient cases are avoided by introducing a transmitting power threshold Λp. In DEL-CMAC, upon receiving the RTS frame, the destination computes the required transmitting power for the direct transmission PDs.There are two cases depending on the calculated PDs.

4. Proposed Work

Contention-based MAC protocols are mainly based on the Carrier Sense Multiple Access (CSMA) or Carrier Sense Multiple Access/ Collision Avoidance (CSMA/CA). The main idea is listening before transmitting. The purpose of listening is to detect if the medium is busy, also known as carrier sense. The typical contention based MAC protocols are Sensor MAC(S-MAC).

Sensor-MAC: As a slotted energy-efficient MAC protocol, S-MAC is a low-power RTS-CTS protocol for WSNs inspired by 802.11. S-MAC includes four major components: periodic listening and sleeping, collision avoidance, overhearing avoidance, and message passing.

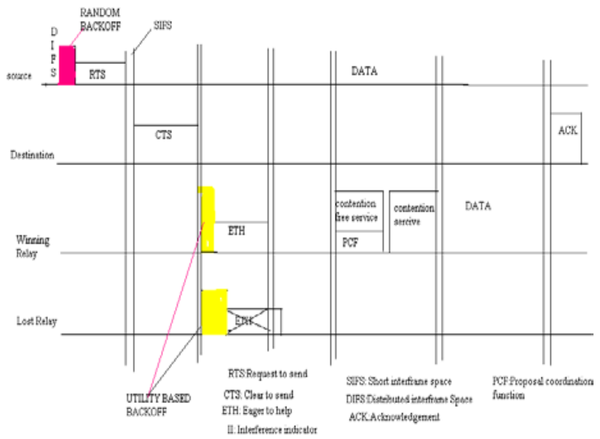

Fig 3 Flow Diagram

After the sleep period, the nodes wake-up and listen whether communication is addressed to them, or they initiate communication themselves. This implies that the sleep and listen periods should be (locally) synchronized between nodes. Each active period is of fixed size, 115 ms, with a variable sleep period.

The length of the sleep period dictates the duty cycle of S-MAC. At the beginning of each active period, nodes exchange synchronization information. Following the SYNC period, data may be transferred for the remainder of the active period using RTS-CTS. The advantages of S-MAC are energy waste caused by idle listening is reduced by sleep schedules and time synchronization overhead may be prevented by sleep schedule announcements.

Although S-MAC achieves low power operation, it doesn't meet simple implementation, scalability, and tolerance to changing network conditions. As the size of the network increases, SMAC must maintain an increasing number of neighbours' schedules or incur additional overhead through repeated rounds of resynchronization. In S-MAC, a node that has more data to send can monopolize the wireless radio channel. This is unfair for other nodes that have short packets to send but need to wait for the completion of the transmission of the long packet.

5. Assumptions

DEBMAC to minimize collisions during contention between multiple stations. Following assumptions are being made for the DEBMAC.

1. There are collisions because of busy medium.
2. Whenever collision takes place for the resolution of the collision the back off time to be selected from [0, CW-1] randomly.
3. The size of contention window is between (CWmin ,CWmax).
4. Initial value of CW is set as min CW .
5. Initially the contention window is modified in the form of (2CW) then after four collisions at the 5th collision the size of contention window will be doubled in consecutive collisions.
6. The value of contention window (CW) will be set again after each successful transmission or CW reaches the maximum limit of transmission i.e. retry limit. This is the DEBMAC algorithm.

6. Simulation and Result Analysis

In this section we provide an evaluation of the performance of DEBMAC and give a comparison of it with the already proposed DCF and DELCMAC protocols. The figure3 shows the packet loss ratio with increase in numbers of nodes in DCF, DEL-CMAC and DEBMAC. From the results it has been observed that the packet loss ratio percentage reduced with the usage of DEBMAC.

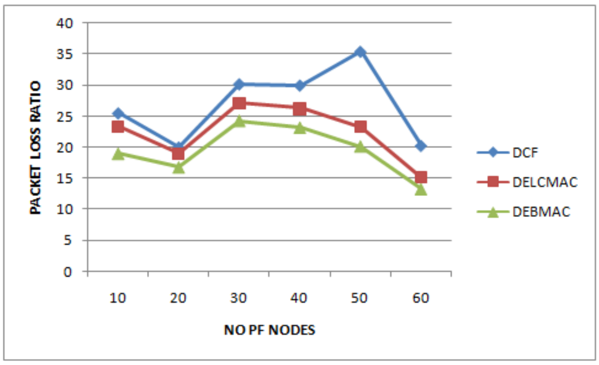

Fig 4 Packet Loss Ratio

The figure4 shows the energy consumed with increase in number of nodes in DCF, DEL-CMAC and DEBMAC. From the results, energy consumption reduced with the usage of DEBMAC.

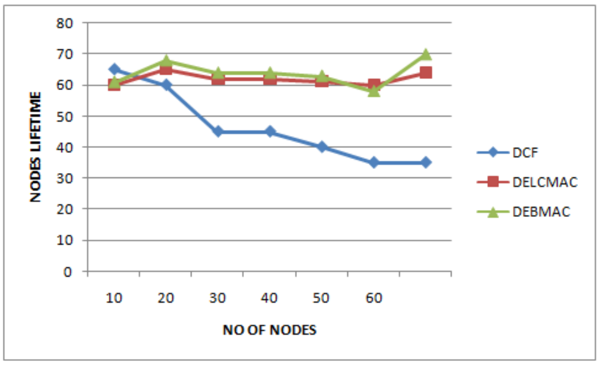

Fig 5 Nodes Lifetime

The figure5 shows the Node life time with increase in number of nodes in DCF, DEL-CMAC and DEBMAC. From the results, Node life increases with the usage of DEBMAC.

The figure 6 shows the Average delay caused with increase in number of nodes in DCF, DEL-CMAC and DEBMAC. It is clear from the graph that there is considerable reduction in the average delay with maximum increase in the node.

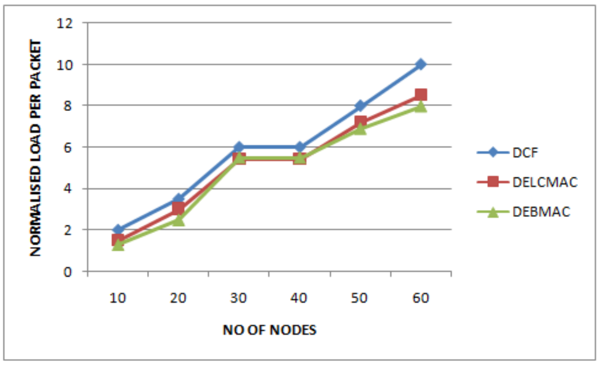

Fig 6 Average Delay

The figure7 shows the Normalized Routing Load packet caused with increase in number of nodes in DCF, DEL-CMAC and DEBMAC.

It is clear from the graph that there is considerable reduction in the Normalized Routing Load packet with maximum increase in the node.Concludes your research work.

7. Conclusion and Future Work

DEBMAC significantly prolong the network lifetime compared with the IEEE 802.11 DCF and DELCMAC, at relatively low throughput and delay degradation cost. The existing method only consider two threshold levels analysis , As a future work, Multiple Threshold levels are to implemented and analysis for getting improved performances in WSNs.

References

[1] Xiaoyan Wang, "Improving the Network Lifetime of MANETs Through Cooperative MAC Protocol Design "IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS, VOL. XX, NO. XX, MONTH 2013.

[2] J. Nicholas Laneman," Cooperative Diversity in Wireless Networks: Efficient Protocols and Outage 2004.

[3] J. Nicholas Laneman," Distributed Space–Time-Coded Protocols for Exploiting Cooperative Diversity in Wireless Networks", IEEE TRANSACTIONS ON INFORMATION THEORY, VOL. 49, NO. 10, OCTOBER 2003

[4] Andrew Sendonaris," User Cooperation Diversity—Part I: System Description ",IEEE TRANSACTIONS ON COMMUNICATIONS, VOL. 51, NO. 11, NOVEMBER 2003

[5] Shuguang Cui," Energy-efficiency of MIMO and Cooperative MIMO Techniques in Sensor Networks ",IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, 2004

[6] Parveen Thakur, " Improved Energy Efficient MAC Protocol for Wireless Sensor Networks", International journal of Advanced Research in computer Science and Software engineering, Vol 3, March,2013.

[7] Umesh kumar Singh, " Study and Analysis of MAC Protocols Design Approach for Wireless Sensor Network", International journal of Advanced Research in computer Science and Software engineering, Vol 2, April,2012.

[8] Madan Mohan Nagar," Design of Energy Efficient MAC Protocol with Increased throughput in MANETs", International Journal of Engineering and Innovative Technology, Vol 2, Nov 2012.

[9] Mastooreh Salajegheh, "Hybrid TDMA/FDMA MAC Protocol for Wireless Sensor Netrworks", 2007

Bibliography

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