CLBR-Co-operative Load Balancing in Robust Duty Cycle MAC Protocol for Energy Efficient WSNs

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Abstract - ***Despite their limited resources, especially energy, wireless sensor networks (WSNs) are being accepted in many application areas. This makes them a challenging yet an appealing research area. Evidently, prolonging network's lifetime is a major focus. It leads to operate the nodes in low power mode. This duty-cycling results in increased network latency. Dynamic adjustment of duty cycle will improve the lifetime of the network. Bandwidth efficiency is another factor which plays an important role in case of high traffic of data and can be better addressed by dynamically distributing the load to other channels. This protocol CLB-RDMAC enhances the RDMAC protocol by incorporating the dynamic load balancing along with duty cycle adjustment. The simulation results show an improvement in the data delivery along with increased lifetime of the network.***

Keywords: WSN, Queue Management, CLBR, RDMAC

1. Introduction

Wireless sensor Networks (WSNs) is one of the emerging field in various networking technologies like sensing, capturing information about various sensors. This consists of various autonomous sensors which are mainly used for monitoring different condition like physical conditions like motion, vibration and temperature etc. These wireless networks have more popularity in several different fields like automation of industries, home, office and also for traffic monitoring, hospitals, robotic monitoring and agricultural surveillance.

Future era remote frameworks will require simple and complicated arrangement of remote systems. This fast system organization is impractical with the current structure of remote frameworks. Behind agenda of progression, for pattern, offered another sort remote schema known by portable specially appointed systems. "Short live" of system work without settled framework. They offer quick and simple system sending in circumstances where it is Impractical something else. Specially appointed Latin word signifies "in favor of or on behalf of this as it were." transportable Adhoc system of independent arrangement with flexible hubs associated towards remote connections; every knob works with finishing framework and a switch intended for every single node in the system.

An advertisement-hoc system is meeting of remote adaptable knobs which powerfully determining an momentary portable hubs progressively framing provisional system exclusive of the guide of several settled base or brought together organization.

Energy is a factor of outmost importance in WSN to increase network lifetime, energy must be saved in every hardware and software solution composing the network architecture. According to the radio model proposed in [1], data communication is responsible for the greatest weight in the energy budget when compared with data sensing and processing. Therefore, it is desirable to use short-range instead of long-range communication between sensor nodes because of the transmission power required. In most WSN scenarios, events can basined by many source nodes near the phenomenon of interest and far away from the sink nodes. Then, the use of short-range communication leads obligatorily to data packets being forwarded through intermediate nodes along a multi-hop path [2]. Actuators can be installed depending on the application and the type of sensors used. A WSN typically has little or no infrastructure. It consists of a number of sensor nodes (few tens to thousands) working together to monitor a region to obtain data about the environment. WSNs can be divided into two types: structured and unstructured. In an unstructured WSN, contains a dense collection of sensor nodes. Sensor nodes may be deployed into the field in an ad-hoc manner. A structured WSN contains all or some of the sensor nodes deployed in a pre-planned manner. The advantage of a structured network is that fewer nodes can be deployed with lower network maintenance and management cost. Fewer nodes can be deployed now since nodes are placed at specific locations to provide coverage.

The pre-defined location ensures the complete coverage of the entire network. While ad hoc deployment can have uncovered regions. The complexity of wireless sensor networks which generally consist of a data acquisition network and a data distribution network monitored and controlled by a management centre. The study of wireless sensor network sis challenging in that it requires an enormous breadth of knowledge from an enormous variety of disciplines. [2][3].

To design a good MAC protocol for the wireless sensor networks, we have considered the following attributes. The first is the energy efficiency. As stated above, sensor nodes are likely to be battery powered, and it is often very difficult to change or recharge batteries for these nodes. In fact, someday we expect some nodes to be cheap enough that they are discarded rather than recharged. Prolonging network lifetime for these nodes is a critical issue. Another important attribute is scalability and adaptively to changes in network size, node density and topology. Some nodes may die over time; some new nodes may join later; some nodes may move to different locations. A good MAC protocol should gracefully accommodate such network changes. Other typically important attributes including fairness, latency, throughput, and bandwidth utilization may be secondary in sensor networks.

This paper highlight a robust duty cycle adjustment MAC protocol named "***CLBR***" an energy efficient protocol for Cooperative load balancing in the robust duty cycle and which can adjust sensors duty cycle adaptively according to status buffer filled queue length, node rate of energy consumption. After the information of a sensor is obtained, the sensor adaptively adjusts the duty cycle for sending and receiving packets. Proposed approach focuses to reduce the energy spent and end to end delay. Each node adaptively varies its duty cycle if the node has data to transmit.

2. RELATED WORK

In WSN delay is the factor to some delay-sensitive applications, such as health or military applications. Many researchers have been proposed to achieve a good trade-off between power consumption and delay. Adaptive listening suggests the use of overhearing to reduce the sleep delay. Some of the existing approaches are M.I. Brownfield, K.et al. [4] proposes a traditional MAC protocols for WSN were designed to maximize bandwidth utilization, promote fair usage of the channel by all nodes. Power management of the radio transceiver unit of a WSN is crucial since the radio unit is the major consumer of the sensor's energy and the MAC protocol directly controls its operation. MAC protocols in wireless sensor networks can be classified into three general groups: scheduled, unscheduled and hybrid protocols. Scheduled based MAC protocols attempt to organize the communication between sensor nodes in an ordered way. The most common scheduling method which organizes sensor nodes in slots is Time Division Multiple Access (TDMA), where each sensor node is assigned a time slot. The most widely used MAC protocol for sensor networks is S -MAC protocol. It introduced a low duty cycle operation in multi-hop WSNs, where the nodes spend most of their time in sleep mode to reduce energy consumption. Disadvantages are it Suffers from early sleeping problem i.e. Node goes to sleep when a neighbour still has messages for it and Traffic is very high between the nodes.

P. Cheong and I. et al. [5] introduced management of wireless communication will be the key to effective deployment of large scale sensor networks that need to operate for long period of time. Collaboration between neigh boring sensor nodes overcomes the inherent limitations of their low cost, and hence limited capabilities. Ultra-wideband (UWB) technology has generated significant interest in recent times for both the very-high data rate (VHDR) as well as the low data rate (LDR) scenarios. Emerging applications of UWB are foreseen for sensor networks as well. Such networks combine low to medium rate communications with positioning capabilities. UWB signalling is especially suitable in this context, because it potentially allows centimetre accuracy in ranging, as well as low-power and low-cost implementation of communication systems. Disadvantages are UWB is the relatively short range of 10-20 m bandwidth and time consuming is very high regarding synchronization between transmitter and receiver.

S. Liu, K-W. Fan,et al. [6] proposed Duty cycling the radio is important to achieve long lifetime in wireless sensor network, but it usually causes performance degradation in throughput and latency which are critical metrics for various applications such as event tracking and surveillance. These conflicting objectives motivate our design of a new 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 any cast to wake up forwarding nodes, and then converges from route-suboptimal any cast with unsynchronized duty cycling to route-optimal unicast with synchronized scheduling. Disadvantages are Delay is very high and packet loss is high.

3. Proposed system

The Co-operative Load Balancing in Robust Duty Cycle MAC Protocol for WSNs is designed by considering the following assumptions:

i. Each node consists of the communication module and sensing module.
ii. The energy consumption during sensing is negligible compared to wireless communication.

iii. All the nodes in network synchronizes for active and sleep mode operation.
iv. In the wireless communication, the main energy consumption is used for idle listening, instead of packet transmission and reception.
v. Increase the throughput
vi. Here we utilize versatile methodology
vii. Reduce vitality utilization.

With the above assumptions, the proposed algorithm can be put into the following modules.

a) Duty Cycle Controller
b) Query Management
c) Collision Avoidance
d) Medium access for MH-TRACE Clustering
e) Collaborative Load Balancing

"RD-MAC" that can adjust duty cycle adaptively according to status of sensor's sending/receiving buffer, rate of energy consumption and traffic loading. The proposed robust duty cycle MAC protocol fairly updates the duty cycle to the maximum level which has the enough battery capacity and its rate of energy consumption is lower than the threshold rate of energy consumption and taking number of packets in the buffer into account. This mechanism increases the network lifetime by spending the node energy uniformly among the nodes which may participate in the routing.

3.1 Duty cycle controller

Based on the network model, the distributed duty cycle controller which control the duty cycle of each node by dynamically adjusting the sleep interval time under network condition changes. In each control period, the controller determines a node's sleep time using the local information available at the node. In a sensor network where the packets converge towards a sink, the excessive packets received by a node eventually result in an excessively large queue length.

This phenomenon may be incurred by a combination of several reasons, such as congestion, contention, collision, and high traffic. Based on the queue length and its variations, we propose a dynamic duty cycle control scheme to meet time-varying or spatially non uniform traffic loads by constraining the queue length at a predetermined threshold. Meanwhile, the sleep interval time decreases as the forward difference of queue length becomes larger than zero because the increased forward difference of queue length induces a longer latency. The duty cycle control model for queue management.

The traffic load of a node increases as the route depth increases, or as the number of descendants increases, which automatically leads to a higher duty cycle. Sensor nodes are deployed in an ad hoc fashion, with individual nodes remaining largely inactive for long periods of time. In order to minimize power consumed during idle listening, some nodes, which can be considered redundant, can be put to sleep. Therefore the energy of the nodes and the energy of the network are conserved. The idea is sensor nodes dynamically create on-off schedules such that the nodes will be awake only when they are needed. This also limits the collisions, therefore the energy consumed during retransmissions. Although, it seems best way to limit consumed energy and the main consideration should be energy efficiency, the other QoS issues have to be considered. The key design considerations for duty cycle control protocol design are scheduling and routing.

3.2 Queue Management

Congestion is an important issue which researchers focus on in the Transmission Control Protocol (TCP) network environment. To keep the stability of the whole network, congestion control algorithms have been extensively studied. Queue management method employed by the routers is one of the important issues in the congestion control study. Active queue management (AQM) has been proposed as a router-based mechanism for early detection of congestion inside the network. In this paper we analysed several active queue management algorithms with respect to their abilities of maintaining high resource utilization, identifying and restricting disproportionate bandwidth usage, and their deployment complexity. We compare the performance of FRED, BLUE, SFB, and CHOKE based on simulation results, using RED and Drop Tail as the evaluation baseline. The characteristics of different algorithms are also discussed and compared. Simulation is done by using Network Simulator (NS2) and the graphs are drawn using X- graph.

3.3 Collision Avoidance

If multiple neighbors want to talk to a node at the same time, they will try to send when the node starts listening. In this case, they need to contend for the medium. Among contention protocols, the 802.11 does a very good job on collision avoidance. S-MAC follows similar procedures, including virtual and physical carrier sense, and the RTS/CTS exchange for the hidden terminal problem [8]. There is a duration field in each transmitted packet that indicates how long the remaining transmission will be. If a node receives a packet destined to another node, it knows how long to keep silent from this field. The node records this value in a variable called the network allocation vector (NAV) [9] and sets a timer for it. Every time when the timer fires, the node decrements its NAV until it reaches zero. Before initiating a transmission, a node first looks at its NAV. If its value is not zero, the node determines that the medium is busy. This is called virtual carrier sense.

Physical carrier sense is performed at the physical layer by listening to the channel for possible transmissions. Carrier sense time is randomized within a contention window to avoid collisions and starvations. The medium is determined as free if both virtual and physical carrier sense indicates that it is free.

3.4 Medium access for MH-TRACE Clustering

In MH-TRACE, time is confined into super casings of proportional length, where the super casing is reiterated in time and further separated into edges. Every group head works using one of the housings as a part of the super edge structure additionally, gives channel access to the center points in its correspondence range.

Each packaging in the super edge is further isolated into sub outlines. The control sub-packaging is used for motioning amongst center points and the CH, and the data sub-packaging is used to transmit the data payload. In the Beacon space, CHs proclaim their nearness and the amount of open data spaces in the present packaging.

3.5 Trace for Collaborative Load Balancing

In this module we depicted DCA-TRACE, which handles non-uniform weight course by allowing the CHs to get to more than one casing in the super edge. The same issue can moreover be taken care of from the part centers' perspective. In our past work [1], we found that the lion's offer of the center points in a TRACE framework are in the district of something past than one CH The center points that are in the locale of more than one CH can ask for channel access from any of these CHs.

4. Performance Analysis

Performance of the proposed robust duty cycle MAC for WSNs is simulated by using ns-2 simulator. There is 20 nodes are organized in grid fashion and transmission range of the sensor node is set to be 20 meters. The bandwidth is fixed to 100kbps. Each data packet size is 100 bytes and 4 bytes for control packets including RTS, CTS, and SYNC. Table 1 shows the different parameters set during the simulation, it is set as similar TA-MAC.

End to end delay is the cumulative average delay by all the packets to reach the destination or sink node. Fig 2 shows that end to end delay comparison between SMAC and proposed RDMAC. The delay is analysed by varying the number of nodes between 10 to 50 nodes.

It is observed that end to end delay is keep on increasing as the number of number of nodes are increased. It is due to as the number of nodes increases the number of hops between source and destination also increases and results in delay. There is a reduction of 29.49 % of delay in RDMAC compared with SMAC. It is because of the complete path to the destination is sent along with sync packets and It also synchronizes the next hop node active mode before sending the data packet.

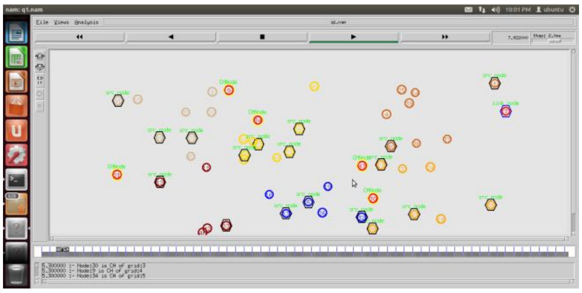

Fig 1. Cluster Formation

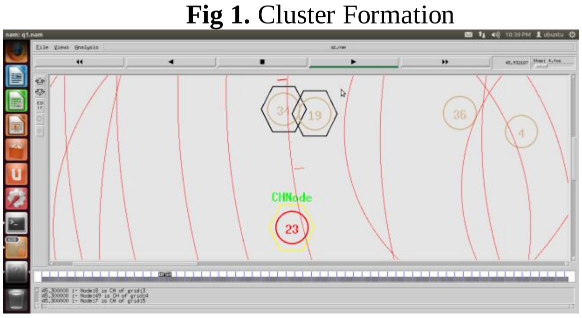

Fig 2. Data transmission to CH node

Fig 2 shows that aggregate energy consumption in SMAC and RDMAC when the number of hops between source node and destination is taken into account. Energy spent is the average cumulative expenditure of energy among all the nodes in the network. It shows that energy spent in the network is compared with SMAC and RDMAC. When the number of nodes is increasing energy spent in SMAC grows in steep compared to RDMAC.It is observed from the fig that the energy is increasing when the number of hops is increasing. SMAC shows a delay reduction of 25 %. The reduction of energy when the number of nodes between source and destination is considered it is 29%. Since the SAMC does not follow the data aggregation process and hence reduces the energy spent during redundant data transmission. As the number of hops are increasing, the transmission length will be and hence increase in energy consumption.

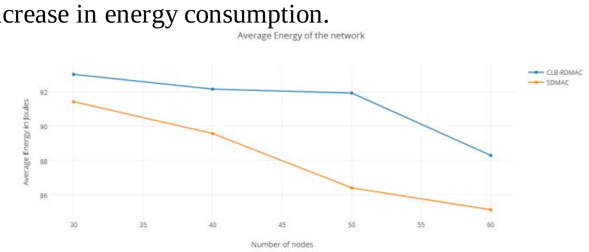

Fig 3. Average Energy of the Network

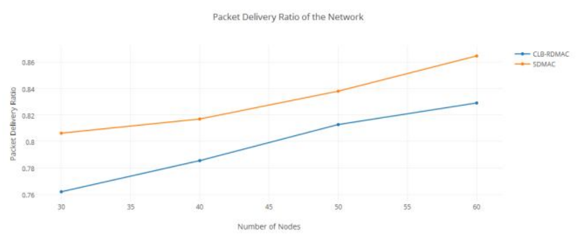

Fig 4. Packet Delivery Ratio

Fig 3 shows the latency of the nodes in transmitting the data. Latency is defined as the time interval between when the source node sends the data and the destination node receives it. The latency is because of various factors like the channel availability, number of hops, data collision. Virtual clustering decreases the latency as the neighbour nodes will be in sync and hence will be turn on mode at same interval of time. Thus transmission will be faster.

5. Conclusion

The proposed protocol increases the data delivery ratio by balancing the load dynamically. It also takes the duty cycle into consideration through the queue management to achieve high performance under network condition changes. The cluster head nodes will monitor the traffic in the network periodically. Under increased traffic load, the network will adjust the channels allocated for each cluster head to route the data without much latency. Also the energy efficiency is achieved by setting the sleep time dynamically using the predetermined queue length values. This results in lower power consumption and faster adaptation to traffic changes. Thus the protocol shows improved performance in data delivery as well as energy efficiency. This protocol can be extended further by introducing non uniformed energy distribution to further increase the delivery ration of the network.

REFERENCES

[1] A. Bachir, M. Dohler, T. Watteyne, and K.K. Leung, “MAC Essentials for Wireless Sensor Networks” *IEEE Comm. Surveys and Tutorials*, vol. 12, no. 2, pp. 222-248, Apr.-June 2010.

[2] S.C. Ergen and P. Varaiya, “PEDAMACS: Power Efficient and Delay Aware Medium Access Protocol for Sensor Networks,” *IEEE Trans. Mobile Computing*, vol. 5, no. 7, pp. 920-930, July 2006.

[3] M. Ringwald and K. Romer, “BitMAC: A Deterministic, Collision- Free, and Robust MAC Protocol for Sensor Networks,” *Proc. IEEE. Second European Workshop Wireless Sensor Networks (EWSN)*, pp. 57- 69, 2005.

[4] M.I. Brownfield, K. Mehrjoo, A.S. Fayes, and N.J. Davis, “Wireless Sensor Network Energy-Adaptive MAC Protocol,” *Proc. IEEE Third Consumer Comm. and Networking Conf. (CCNC)*, vol. 2, pp. 778-782, 2006.

[5] V. Rajendran, J.J. Garcia-Luna-Aceves, and K. Obraczka, “Energy- Efficient, Application-Aware Medium Access for Sensor Networks,” *Proc. IEEE Int’l Mobile Adhoc and Sensor Systems Conf. (MASS)*, pp. 623-630, 2005.

[6] A. Barroso, U. Roedig, and C. Sreenan, “uMAC: An Energy- Efficient Medium Access Control for Wireless Sensor Networks,” *Proc. IEEE European Workshop Wireless Sensor Networks (EWSN)*, 2005.

[7] P. Cheong and I. Oppermann, “An Energy-Efficient Positioning- Enabled MAC Protocol (PMAC) for UWB Sensor Net0works,” *Proc. IST Mobile and Wireless Comm. Conf., pp*. 95-107, 2005.

[8] T. Zheng, S. Radhakrishnan, and V. Sarangan, “PMAC: An Adaptive Energy-Efficient MAC Protocol for Wireless Sensor Networks,” *Proc. IEEE 19th Int’l Parallel and Distributed Processing Symp*. (IPDPS), 2005.