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Energy Efficient Battery Discharge Rate Based Asynchronous Duty Cycling Protocol for WSN to improve Network Lifetime

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ABSTRACT: *In Energy Constrained Wireless Sensor Network, maximizing network lifetime is an important issue. The challenge is to find out the optimal schedule of duty cycle for nodes while maintaining the sufficient number of active nodes for network coverage. In this paper we propose the Energy Efficient Battery Discharge Rate Based (E^2BDRDC) Asynchronous Duty Cycling Protocol for WSN which consider the battery discharge rate of active node to find the duty cycle of inactive nodes. Further the E^2BDRDC protocol improves the energy consumption and network lifetime 30% and 20% as compared to DCBSP (Discharge Curve Back off Sleep Protocol).*

Keywords - *Duty cycle, Network Lifetime, SNs, WSN.*

I. INTRODUCTION

As Computing become exponentially smaller and cheaper with each passing year. Semiconductor technology can be used to build mechanical structure called Sensor Node (SN) that can sense the surrounding phenomenon including temperature, vibrations and pressure. A Wireless Sensor Network (WSN) [1, 2] consists of the small SNs having sensing, computing and communication capability. One of the features of WSN is that SNs are resource constrained having less battery power, limited storage capacity. SNs are normally deployed in unattended environment make it impossible to recharge or replace the battery. So the efforts must be employed to reduce the energy consumption of node thereby improving network lifetime.

However in WSN large number of SNs is deployed in sensing region so there is the probability of redundancy which would cause energy wastage. To maximize the network lifetime it is necessary to minimize the redundancy and number of active nodes while maintaining the optimal coverage. To eliminate the redundancy in WSN adaptively selects only minimum number of nodes to remain active for maintaining optimal coverage. For this purpose many energy efficient duty cycle protocol has been proposed. Duty cycling can be divided into different ways in WSN: Synchronous, Asynchronous and On-demand protocols [3]. Our major contribution is the design of energy efficient protocol for duty cycling based on battery discharge rate to improve network lifetime. In this paper active/sleep state of node is decided based on the remaining battery level.

As in DCBSP (Discharge Curve Back off Sleep Protocol) [4] [13] [14] protocol is also asynchronous MAC protocol uses the battery discharge rate of active node to decide the duty cycle of inactive nodes. In DCBSP inactive nodes wake up only when the current active node is close to the dead state. If more event occurs at the time of active node duration [15] [16] node may dead before its predefined time causes less reliable network and reduction in network lifetime if less event occurs. So *E^2BDRDC* protocol improves the network reliability and network lifetime by considering these [17] [18] factors.

The Rest of the paper is organized as follows: Related Work is discussed in section II. Section III elaborates the *E^2BDRDC* protocol and Simulation results are discussed in Section IV. Conclusion and future work is presented in Section V.

II. RELATED WORK

We discuss the some existing energy efficient protocol for duty cycle in this section. Many Sleep-wakes scheduling protocol is proposed in literature. Synchronized protocols, such as S-MAC [5] and T-MAC [6], decide a schedule that specifies when nodes are wake and sleep within a slot. Specifying the slot when nodes must be wake in order to communicate reduces the time and energy wasted in idle listening. In synchronous scheduling protocol [7-9] synchronization information is exchange periodically among neighbours causes message overhead. Asynchronous protocols such as B-MAC [10], and WiseMAC [11], X-MAC[12] rely on low power listening (LPL), also called preamble sampling. Idle listening is reduced in asynchronous protocols by shifting the burden of synchronization to the sender. When a sender has data, the sender transmits a preamble that is at least as long as the sleep period of the receiver. The receiver wake up, detect the preamble, and stay wake to receive the data. In asynchronous scheduling protocols node wakes up independently of its neighbours. In Random Back off Sleep Protocol (RBSP) [13], neighbouring node wakes up very frequently when the remaining energy of active node very less. DCBSP (Discharge Curve Back off Sleep Protocol) protocol uses the battery discharge rate of active node to decide the duty cycle of inactive nodes. In DCBSP inactive nodes wake up only when the current active node is close to the dead state which leads to the reduction in network lifetime. In E^2BDRDC asynchronous duty cycling protocol one of the neighbour node goes to active state when the battery discharge rate of current active node remain 50% to improve network lifetime.

III. PROPOSED PROTOCOL

Before describing E^2BDRDC asynchronous duty cycling protocol following assumptions are considered:

1. SNs are randomly distributed within a circular field.

2. BS is located at centre of sensing area.

3. SNs and the BS are stationary after deployment.

4. SNs are location-aware. The location of the BS is known by each node.

5. All SNs are homogeneous, i.e., they have the same energy.

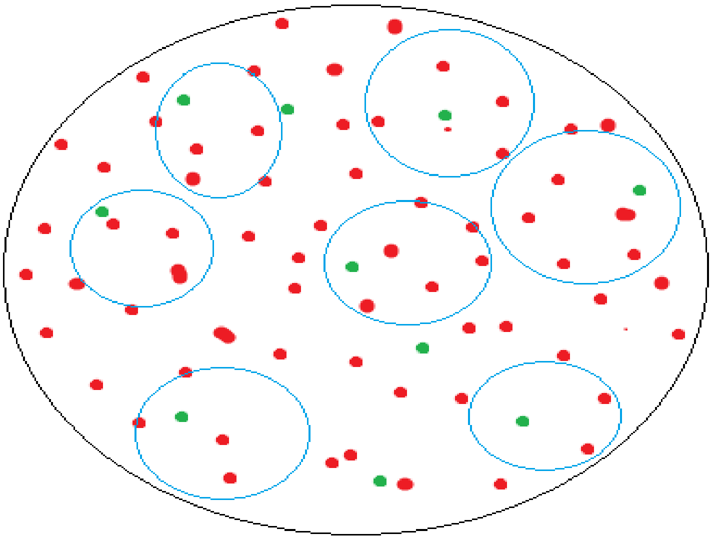

Fig. 1: WSN Topology: Active/Sleep Nodes

During set up phase some SNs are uniformly selected as active node (green colour) in the network and rest in sleep state (red colour). [19-22] Fixed duration T is associated with each active node during first round. When the duration of node expires it broadcast the packet having its remaining battery level B to its neighbours. All neighbour nodes of active node goes to sleep state till next duration and any one of the neighbour wake up only if the battery percentage of current active node is less than 50%.If more event occurs during active duration then active node can go to dead state before T sec. When the battery level of active node remains less than 50% before T sec, it broadcast the packet to its neighbour to select next active node for remaining duration. For example node 2 in Fig. 2 is in active state and its fixed duration is T=5 sec. When the duration of node expires it broadcast a packet having its current battery level i.e. 4% value to its neighbours. Node 4 will be active and node 1,2and 3 goes to sleep state for next 5 sec to uniformly distributed the active/sleep pattern among all neighbours as in Fig. 3.

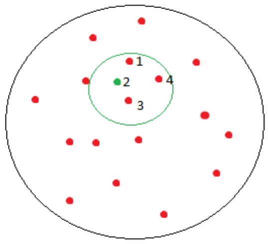

Fig. 2: Sleep/Active State during T sec

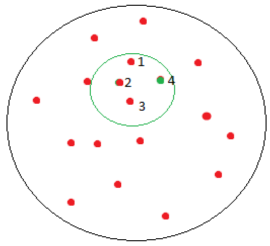

Fig. 3: Sleep/Active State after T sec

Scheduling mechanism of E^2*BDRDC* and DCBSP protocol is shown in Fig. 4 and Fig. 5. Time is divided into slots of T sec. Node A wakes up for its duration and send beacon packet to node B containing its battery status. Node B wake up only if the battery level is less than 50%. [23-25] If the battery level of node A goes less than 10% before T sec it send packet to Node B to get active for next duration increasing availability of network as in DCBSP protocol node A send packet to node B after T sec only causing network in-availability because of both nodes goes to sleep state simultaneously as in Fig. 5.

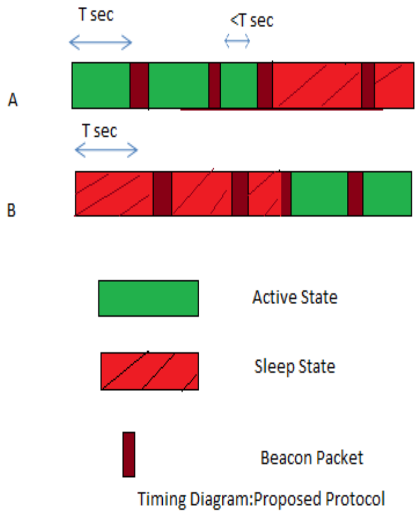

Fig. 4: Scheduling Mechanism: E^2*BDRDC* Protocol

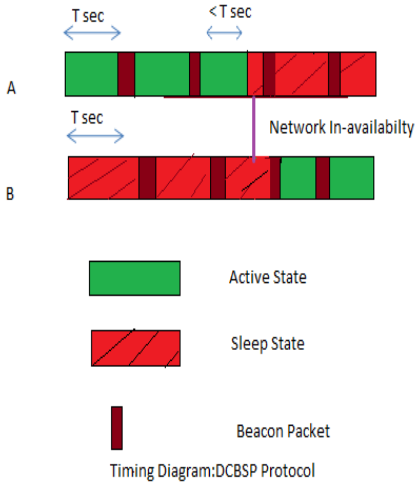

Fig. 5: Scheduling Mechanism: DCBSP Protocol

3.1 Energy Model

E^2*BDRDC* asynchronous duty cycling protocol uses energy model discussed in [15].To transmit an L-bit data to a distance d, the radio expands energy.

$$E_{TX}(L,d) = L * E_{elec} + L* \in_{fs} *d^4 \ if \ \ d \geq d_0 \qquad (1)$$

$$L * E_{elec} + L* \in_{fs} *d^2 \ if \ d \prec d_0 \qquad (2)$$

where $E_{TX}(L,d)$ is energy consumed by a node to transmit L bit packet at distance D, E_{elec} is the electronic energy that depends on factors such as the digital coding, coding, modulation or, is the amplifier energy that depends on the transmission distance and the acceptable bit-error rate.

While receiving, the radio expands energy:

$$E_{RX} = L * E_{elec} \tag{3}$$

$E_{RX}(L)$ is energy dissipated by a node to received L bit packet .

IV. SIMULATION AND RESULTS

In this section we evaluate the performance of E^2*BDRDC* asynchronous duty cycling protocol. Simulation model is designed using MALTAB. We assume network of 200*200 meters^2 and number of nodes varies from 100-500.Intial energy of node is 0.5 Joules. Performance metrics considered are network lifetime, average number of active nodes and average energy consumption E^2*BDRDC* protocol is compared with DCBSP protocol and simulation results shows that proposed protocol improves the network lifetime and overall energy consumption of network 10-20% as compared to DCBSP protocol. Network lifetime of E^2*BDRDC* and DCBSP protocol is shown in Fig. 6.We Compare the network lifetime in terms of number of dead nodes. As shown in Fig. 8 E^2*BDRDC* asynchronous duty cycling protocol extends the network lifetime by decreasing the number of dead nodes as compared to DCBSP protocol. Fig. 6 shows the average energy comparison of the approaches. Average energy consumption per simulation is less in E^2*BDRDC* protocol due to availability of active node all times in E^2*BDRDC* protocol. Total number of active nodes in each simulation for both approaches is shown in Fig. 7.

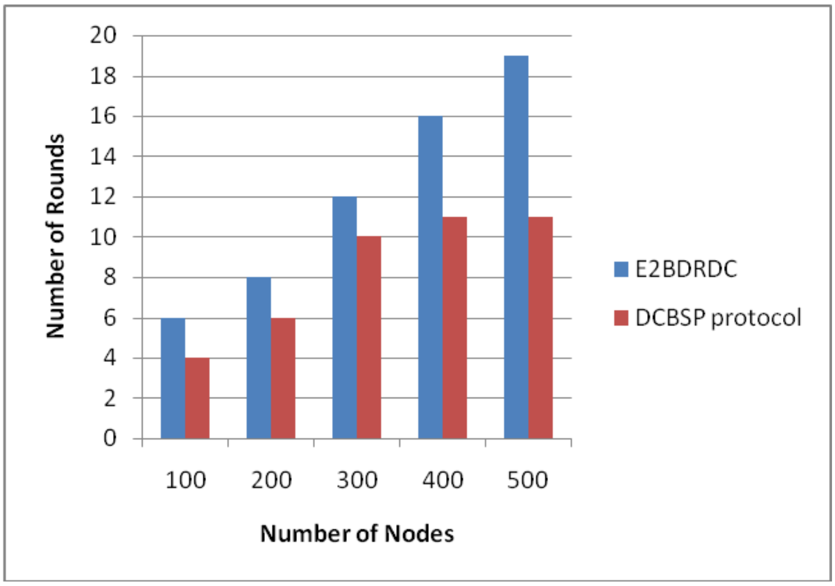

Fig. 6: Network Lifetime

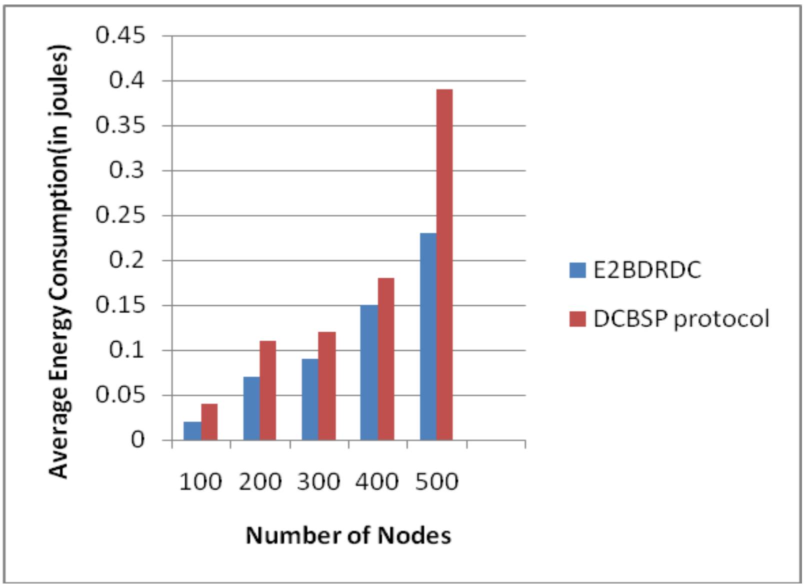

Fig. 7: Average Energy Consumption

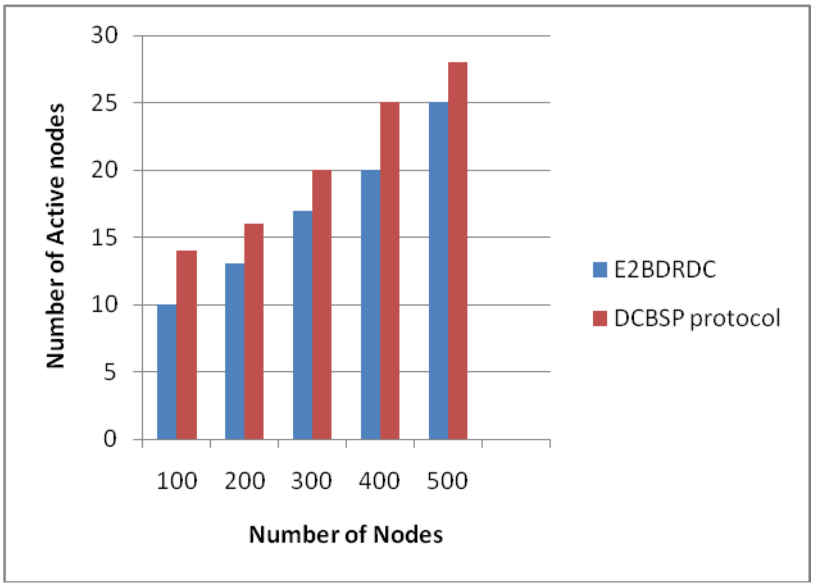

Fig. 8: Number of Active Nodes

V. CONCLUSION AND FUTURE WORK

We have proposed the Energy Efficient Battery Discharge Rate Based Asynchronous Duty Cycling Protocol (*E^2BDRDC)* in which sleep nodes goes to active state after predefine time slot to improve Network Lifetime. Proposed protocol also avoid unnecessary frequent wake up of sleeping nodes as in existing protocols. In proposed protocol sleep node goes to active state immediately if any active node dead before its active duration to improve the network reliability. Further we extend our proposed protocol to increase the network connectivity.

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