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# Energy Efficient Sleep Scheduling for Improvement of Critical Event Monitoring in WSN

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**Abstract**— A Wireless Sensor Network (WSN) consisting of tiny sensing devices for monitoring the event of environmental condition such as gas monitoring in coal mines, battlefield surveillance and inventory tracking etc. and allows the network real time environment. As soon as a critical event is detected at a particular node, an alarm message should be broadcast to the entire network. Therefore, broadcasting delay is an important issue for the application of the critical event monitoring. So to minimize the broadcasting delay, the need is to minimize the time wasted for waiting during the broadcasting. The existing scenario is the destination nodes wake up immediately when the source nodes obtain the broadcasting packets. As sensor nodes are mostly battery operated for event monitoring are expected to work for a long time without recharging their batteries, also it is undesirable or impossible to recharge or replace the battery power of all the sensors. Therefore, the new trend towards the energy efficient sleep scheduling design which extends system lifetime without sacrificing system reliability is one important challenge to the design of a large wireless sensor network. Obviously, sleep scheduling could cause transmission delay because sender nodes should wait until receiver nodes are active and ready to receive the message. Therefore the objective of this paper is advancement in protocols of delay-efficient sleep scheduling method needs to be designed to ensure the energy conservation and low broadcasting delay to increasing the lifetime in any node in the WSN. Therefore the proposed algorithm is compared with results of two known existing algorithm: the Low Energy Adaptive Clustering Hierarchy (LEACH) and Data Routing for In Network Aggregation (DRINA). The result of proposed algorithm provides the best results of energy conservation and minimum broadcasting delay in different nodal configuration and different performance parameters in WSN. This work has been done on the Network Simulator-2 a simulation platform for WSN.

**Keywords**—Energy Efficiency, Broadcasting Delay, Sleep Scheduling, Routing Protocol, Wireless Sensor Network

## I. INTRODUCTION

The WSNs generally is an intelligent, low power small in size and low cost solution that enables the efficiency and reliability improvement of many industrial applications such as safety and security surveillance, home and building automation, and smart grids. However, there are many challenges to bring the WSNs into real-life application. In many applications, a sensor node is powered by a finite energy source such as a battery or a super capacitor that restricts the WSNs lifetime. Therefore, energy consumption of the WSNs needs to be taken into account when planning the network operation.Also in the critical event monitoring, alarming message has to be broadcasting during most of the time. When a critical event is detected, the alarm packet should be broadcast to the entire network as soon as possible [1],[2],[3].

Unfortunately, a very little previous work on distributed systems can be applied to WSNs. Compared with traditional computer networks, WSNs have fixed or predefined infrastructure as a hierarchical structure, which resulting the difficulty to achieve routing scalability and efficiency. Therefore, innovative energy-aware, scalable, and robust algorithms for WSNs are highly required. A problem that is closely related is the energy efficient topology control, delay between the transmission packets which maintains energy efficient network connectivity by controlling the transmission power at each node, or selecting a small subset of the local links of a node. Recently, there are many sleep scheduling protocols has been implemented for the energy efficiency in the WSN. But, it gives the limitations on the network. Obviously, sleep scheduling may cause broadcasting delay because source nodes should have to wait until destination nodes are active and set to receive the broadcasting message. Hence, broadcasting delay is also an important issue for the application of the critical event monitoring [4] [5].

Therefore, the advancement in the methodology or algorithms in existing method related to the main concerns when developing the WSNs is to improvement in their parameters such as energy efficiency, transmission delay, data packet loss, network lifetime etc. contributes us to work in the research of new protocol concepts to improve or enhance the WSN in real time applications. The important factors that have major impact on performance of wireless sensor networks are discussed below.

*A. Energy Efficiency*

As we have already known that mostly the Wireless Sensor Network is battery operated which are located at remote place. Since the sensor nodes utilizes the energy in different ways such as transmitting or receiving message packet, ideal listening, sleeping mode or any cause of hardware. To improve the energy efficiency of the network it is necessary to avoid the ideal listening of the sensor nodes in the network because it the reason to waste energy unnecessarily. For this the sleep scheduling mechanism gives efficient way to increase network lifetime [4]. Various wake-up patterns has to be implemented in WSN for energy efficiency. But it gives the broadcasting delay in WSN. The data aggregation also gives the energy efficiency in the network by collecting the redundant information at center node.

*B. Broadcasting Delay*

In WSNs, for monitoring a critical event in network a small number of messages has to be broadcast mostly. As after detection of any critical event; the overall network has to be woken up immediately. Hence it is necessary to have a minimum broadcasting delay. To extend network lifetime, the sleep scheduling methods has always implemented in the WSNs. So it causes the broadcasting delay mostly in large sensor network. Therefore, the task is to implement a protocol which gives the trade-off between energy efficiency in network with minimum broadcasting delay for any nodal configuration which completes the requirement of any applications[1], [2].

## II. COMPARATIVE STUDY

This section gives the overview of some of clustering, scheduling and data aggregation algorithms that has implemented the protocols for energy efficiency and minimum broadcasting delay WSNs.

*A.* **Low Energy Adaptive Clustering Hirarchy (LEACH)**

It gives the best suitable method for clustering in the network which ultimately reduces the energy consumption in WSNs. The LEACH utilizes a TDMA schedule-based structure, this avoids the conflicts such as collusion, hidden and exposed terminal, overhearing, ideal listening problems and allows nodes to turn themselves ON and OFF at appropriate time given by schedule. Also it allows the aggregation in the network, gives randomized, adaptive, self-configured cluster forming algorithm in the network. It is necessary to use flexible protocol that fits with the objectives of the project. Though LEACH provides energy efficiency in the network, but it gives the transmission delay [6]. Therefore, to improve these two parameters, the proposed algorithm will give the best results for these parameters of the designed network

*B.* **Data Routing for In Network Aggregation**

It has some key aspects as for energy consumption the cluster has formed based on the residual energy of sensor nodes in the network, highly correlation of data aggregation, overlapping of the data paths in the network, reliable transmission of aggregated data in the network. The proposed algorithm for the network has compared with the simulation results of these existing protocols as LEACH and DRINA [8]; which gives the better improvement in the performance parameters such as energy efficiency, broadcasting delay, packet delivery ratio, normalized routing load and average throughput.

## III. METHODOLOGY

The implementations of wireless sensor network with the sensor nodes have to be implemented in the simulation software (NS-2). Then with the help of basic idea of the DRINA protocol, determine the cluster uniformly based on the given percent count the cluster head in the network. Then determine the cluster head for the clusters based in the residual energy concept for the nodes in the network. After the formation of the clusters and cluster head, implement the sleep scheduling algorithms for the given clusters in the network. The sleep scheduling algorithm, that gives the energy efficiency in the network with the help of improvement in the network scenario.
Whereas in critical event monitoring, as the critical event occurred at any node in the network, the alarming message routed to the cluster head of respective cluster as well as the other cluster head in the network if possible based on the minimum hop of routing distance in the nodes. After the reception of the alarming message to the cluster head, the cluster head broadcasts the alarm message to the respective cluster with the dynamically routing with the advancement in the existing algorithm. Hence the improvement in the performance parameters such as the end to end transmission delay for the packet transmission between the nodes, energy efficiency by using the algorithm for sleep scheduling, packet delivery ratio i.e. number of transmitted packets at the transmitter to the number of received packets at the receiver node, average throughput for the data rate in the network.

### *A. Proposed Protocol*

The proposed protocol uses all existing algorithms of DRINA as well as new algorithm given below for energy performance improvement [8]. The Energy aware routing plays an important role for moderately allocates the traffic load among all the participating nodes in the network. For example consider a (Figure3.1) the path A-B-C-D is the optimal path connecting from A to D. We measure hop count for shortest path routing. Thus, nodes B and C will continuously engage in forwarding the traffic, thus other nodes are free from the traffic. As a result residual energy of nodes becomes extensively varied. In Figure 3.2, the path is routed via node E and F substituting to node B with route from source to A-E-F-C-D to destination. In Figure 3.3, path is redirected via nodes E-F-G substituting node C with route A-E-F-G-D to destination node. This path routing is done by comparing the remaining energy of present nodes and the neighbouring nodes which overhear the REM message while route establishment phase. If the routing is not energy aware nodes B and C die early due to drain out of battery supply. Here we proposed the A-DRINA algorithm based on route redirection. The route will gradually meet to an option node disjoint path with this successive local redirection operation.

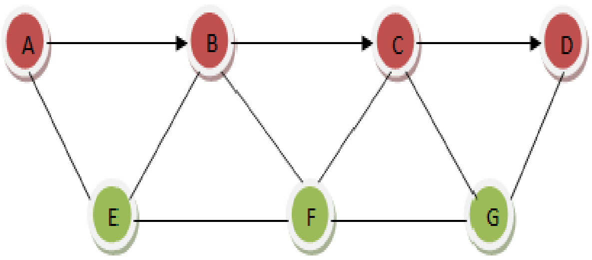


***Figure 3.1: Primary Path that drains the Residual Energy at Nodes B and C***

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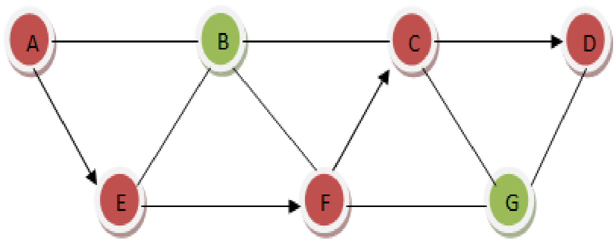


***Figure 3.2: Node B Circumvented after Route Redirection***

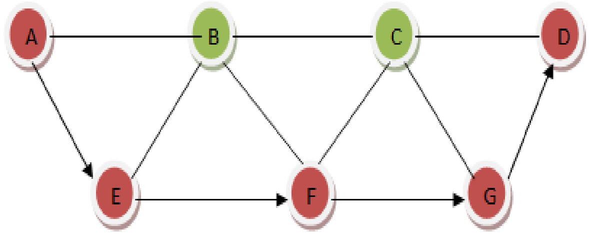


***Figure 3.3: Node C Circumvented after Route Redirection B Node Disjoint***

Figure 3.4 shows two basic redirections. In case 1, Figure 3.4 (a), we consider that three successive nodes P, Q and R on the path on A-D connection. Node S is common neighbour node of all three nodes. Sequentially transmitted data packets by three nodes (P, Q and R) can easily overhear by node S. Here node S can overhear the same packet three times. By identifying this scenario node S realize that it can replace node Q here, the sub-path P-Q-R can be redirected to P-S-R. If node S sees that power level of S is more than that of Q and the difference of energy level is significant enough, node S will do the redirection.

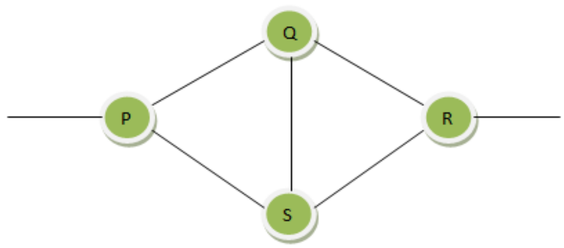


***Fig 3.4(a): 2 Step Alternate Sub-Path, P-S-R***

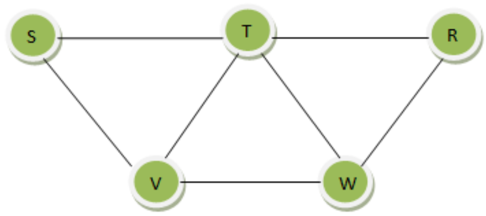


***Fig 3.4(a): 3 Step Alternate sub-Path, S-V-W-R***

As shown in Figure 3.4 (b), we consider that difference in the energy level between T and V is considerable adequate. The same is true between W and T. When the data packets travel along S, T and R nodes, node V will observe that node T desires to be circumvented.

Node V also knows that it is a neighbour of both node T and node S which is its up-stream route neighbour. Similarly, node W will observe that node T needs to be circumvented and node W is neighbor node with node T which is its down-stream root neighbour and node R. Even from locally overheard information, nodes V and W can differentiate their different role. It is up to node W to find out continuation of node V. To make easy this process, W broadcast the message saying that “Node T needs help, and I am its down-stream helper, who is its up-stream helper?” If node V replies this message with acknowledgement here wireless link between V and Q is identified. The two helper nodes will do the redirection to replace S-T-R sub-path by the new S-V-W-R- path.

Consider an example shown in figure 3.1, nodes B and C both have low energy level. After one redirection as shown in fig. 3.2 path A-B-C-D becomes A-E-F-C-D here node B is circumvented. Then node C is circumvented and path becomes A-E-F-G-D shown in fig. 3.3.

### B. *Algorithm for the proposed protocol*

Two more fields we need to add to the conventional IP-header of each packet. They are “Residual Energy level “and “Hop Counter”. We use REL (P) and HC(P) respectively to represent these two additional fields on the packet. The other fields in the packet needs to access in this algorithm such as sender, sequence number, source and destination, they are represented by SEN(P), SEQ(P), SRC(P) and DEST(P) respectively. We use SRC-DEST(P) to symbolize the source-destination pair of the flow that the packet belongs to. Each node maintain an “overhear table”. The table contains the following three fields in each entry: sequence number, source-destination pair and “overhear list”.

**When packet P is overhear by node i,**

BEGIN
**Step 1:** Find SRC-DEST (P) in overhear table;
**Step 2:** Add entry e’, if no match: SRC-DEST(e’)=SRC-DEST(P), SEQ(e’)=SEQ(P), O-list(e’) initialized with first entry <HC(P),REL(P),SEN(P)>. GOTO END;
**Step 3:** (Suppose a match is found at entry e.) Ignore P, if SEQ(P)<SEQ(e). GOTO END;
**Step 4:** If SEQ(P)>SEQ(e), update e as the following:
SEQ(e)=SEQ(P), O-list(e) reset as having only one entry<HC(P),REL(P),SEN(P)>. GOTO END;
**Step 5:** If SEQ(P)==SEQ(e), do the following:
Step 5.1: Add entry <HC(P),REL(P),SEN(P)> into O-list(e);
Step 5.2: If O-list(e) has three entries P, Q, R fulfilling the following conditions, a better sub-path is found.
1)HC(R)==HC(Q)+1==HC(P)+2;
2)REL(node i)≥MAX(REL(P),REL(R));
3) (REL(node i)-REL(Q))≥2. Stimulate this new sub-path. Drop entry e from overhear table. GOTO END;
Step 5.3: If O-list(e) has two entries P and Q, such that HC(Q)==HC(P)+1 and REL(node i) ≥ MAX(REL(P),REL(Q)+2), add this indicator I in the Waiting Indicator list: candidate(I)=Q, SEQ(I)=SEQ(e), SRC-DEST(I)=SRC-DEST(e). GOTO END;
Step 5.4: If O-list(e) has two entries Q and R, such that HC(R)==HC(Q)+1 and REL(node i) ≤ MAX(REL(Q)+2,REL(R)), node i broadcast one DRINA informing packet P’ as follows: candidate(P’)=Q,SEQ(P’)=SEQ(e) SRC-DEST(P’)=SRC-DEST(e);

## IV. PERFORMANCE EVALUATION

The performance evaluation of routing protocols is evaluated with the NS-2 simulator. Then our proposed protocol is compared with the LEACH and DRINA algorithm in terms of energy efficiency, broadcasting delay and other performance parameters.

### A. Simulation Enviornment

In this simulation, our experimental model performed Network Simulator .v2 (NS-2) on different nodal density which were randomly deployed and distributed in a 100m×100m square meter simulator area. We assume that all nodes have no mobility as the nodes are fixed in applications of most of the wireless sensor networks. The simulation model required for experiment uses the same parameters as shown in table 1.

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*TABLE I. SIMULATION PARAMETERS*

| Simulation Parameters | |
|---|---|
| ***Parameters*** | ***Values*** |
| Simulation tool | NS-2 |
| Channel used | Wireless |
| Initial energy | 100 Joules for each node |
| Network area | 100m*100m |
| Number of nodes | 100,150,200,250,300 |
| Number of clusters | 2 |
| Antenna type | Omni-Directional |
| Routing MAC protocol | AODV |
| Data packet length in queue | 50 |

### *B. Simulation Result Analysis*

In the designed network for given protocols as above, the implemented network for the different nodal scenario for 100, 150, 200, 250& 300 nodes with comparison of results of different performance parameters as given below:

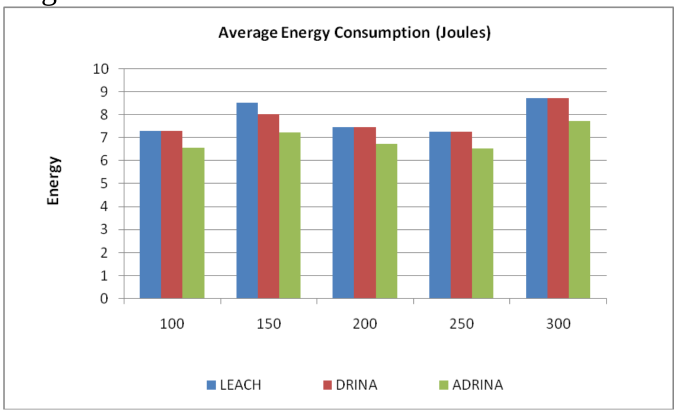


***Fig. 4.1 Average energy consumption for different algorithms***

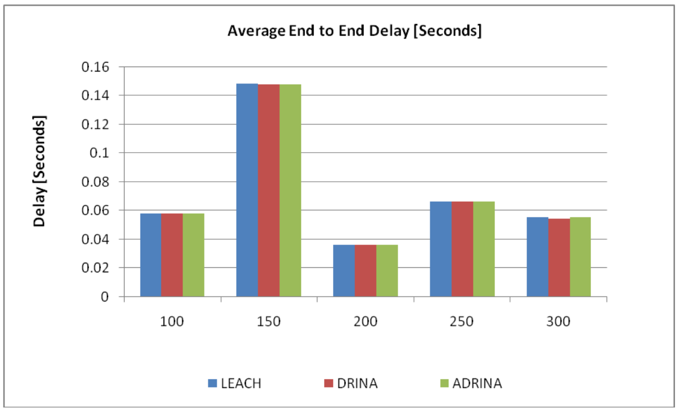


***Fig.4.2 Broadcasting delay for different algorithms***

## V. CONCLUSION

In this work, we proposed the efficient sleep scheduling algorithm for the energy efficiency and improvement in routing path through the network which ultimately gives the minimum broadcasting delay. The simulation results of proposed algorithm compared with two other known algorithms, the LEACH and DRINA regarding the energy efficiency, broadcasting delay, normalized routing load and average throughput. By implementing the dynamically routing in the network and improvement of sleep scheduling in proposed algorithm which ultimately obtains the results clearly shows that the proposed algorithm gives best network performance results over the LEACH and DRINA for the different nodal scenario.

Therefore, with the reference of result of the performance parameters of conducted simulation the energy consumption and broadcasting delay of proposed algorithm is effectively lower than that of the other existing compared algorithms.

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