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Energy Conservation in Wireless Sensor Networks Using Top-Down Approach with Regular Sleep and Wake Periods

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***Abstract*— Wireless sensor network is nothing but collection of wireless sensor nodes these are the battery powered devices. Wireless sensor networks (WSNs) have gained a lot of attention from both the research perspective and actual users. As sensor nodes are generally battery-powered devices, the critical problem was how to reduce the energy consumption of nodes, so that network lifetime can be extended to some time. In this paper, a Top-Down approach is designed with regular sleep and wake periods. The objective of proposed network structure is to minimize delays in the data collection process of wireless sensor network. The performance of proposed network structure is analyzed using computer simulations. Simulations shows comparison with other network formation algorithm and shows that proposed network structure is able to shorten delays and increase network lifetime as compared to other.**

Keywords*— *Cluster head selection, network lifetime, schedulability, timing constraint, wireless sensor network, WSN.

I. INTRODUCTION

A WSN is a collection of wireless nodes with limited energy capabilities that may be mobile or stationary and are located randomly on a dynamically changing environment. The routing strategies selection is an important issue for the efficient delivery of the packets to their destination. Moreover, in such networks, the applied routing strategy should ensure the minimum of the energy consumption and hence maximization of the lifetime of the network [1].

The WSN was first designed by military and defense industries. WSNs were used in various wars for detection of enemies in remote jungle areas. However the implementation have several drawbacks including that the large number of sensors, the energy they consume and the limited network lifetime.

Typically, a sensor node is a tiny device that includes three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for local data processing and storage, and a wireless communication subsystem for data transmission. In addition, a power source supplies the energy needed by the device to perform the programmed task. This power source often consists of a battery with a limited energy budget. In addition, it could be impossible or inconvenient to recharge the battery, because nodes may be deployed in a hostile or unpractical environment. On the other hand, the sensor network should have a lifetime long enough to fulfill the application requirements. In many cases a lifetime in the order of several months, or even years, may be required. Therefore, the crucial question is: "how to prolong the network lifetime to such a long time?"[2]. Another way to increase network lifetime by using solar cells but working of node is non-continuous so that an energy buffer (a battery) is needed as well. WSN mainly consists of one base station (or sink node) and large number of wireless sensor node as shown in below fig.1 these nodes are deployed over large geographical area data are transformed from sensor nodes to the sink through a different communication paradigm as explained below. Then sink (or base station) communicates with internet (or user).

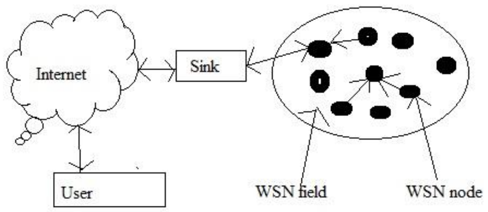

Fig. 1. Sensor network architecture

One technique to send data from sensor node to sink is by using clustering. A network with clustering is divided into several clusters. From each cluster one node is elected as cluster head and others become cluster member. Now cluster head will collect data from cluster member directly or in multihop manner. Now when use cluster there is one advantage that only cluster head involve in long distance communication therefore energy of other node reduced. The cluster also uses one more technique called data/decision fusion technique in this technique the related packets are combined during their transmission.

The main contribution of this paper is to design a network structure that will survive for long time. The proposed algorithm works between data link layer and the network layer. The main aim of proposed algorithm is that to minimize the delay during transmission and increase the lifetime of network. The rest of paper is organized as follows. Section II briefly introduces the related work. The section III briefly introduces the proposed network structure. The numerical analysis is available with section IV. The simulation result and their analysis is available with section V. Finally this paper is concluded with section VI.

II. RELATED WORK

The WSN nodes consist of several modules as shown in fig.2 Sensor Module, Processing Module, Wireless Communication Module and Power Supply Module. These components work together in order to make the sensor operational in a WSN environment. Thus, in order to evaluate the energy consumption of a WSN node, it is important to study the energy consumption of its components.

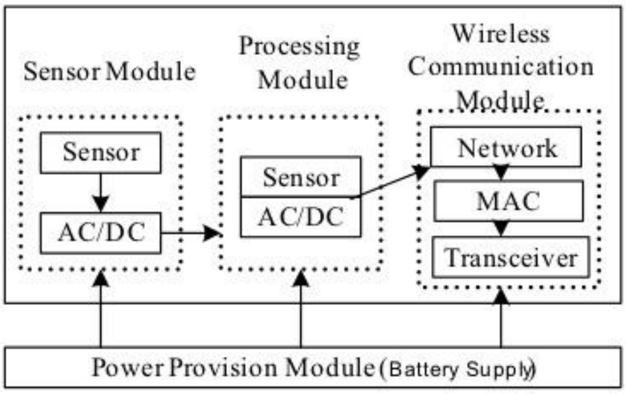

Fig. 2.Architecture of WSN node

A. *Architecture of WSN node*

- Sensor Module: The energy consumption of sensor module is due to a few numbers of operations. This includes signal sampling, AD (Analogue to Digital) signal conversion and signal modulation. Also the energy consumption of this module is related to the sense operation of the node (periodic, sleep/wake, etc.).
- Processing Module: The main aim of this module is the sensor controlling, the protocol communication and data processing. This module support three operation states (sleep, idle, run).
- Wireless communication Module: This module represent total power consumption for transmitting packet and receiving packet. It will consist the power consumption of power amplifier.
- Power supply Module: The power module of the nodes is related to the manufacturer and the model of each node. For example, a wireless sensor node LOTUS and node IRIS developed by MEMSIC, are both supplied by two AA batteries.

One way to reduce energy consumption in sensor network is to adopt a clustering algorithm.[1] A clustering algorithm tries to arrange nodes in clustering within each cluster one node is elected as cluster head responsible for 1) collecting data from cluster member. 2) fusing the data by means of data decision fusion technique. 3) report the fused data to remote sink. In clustering the cluster head is the only node involved in long distance communication. Therefore the energy of whole network is reduced.

The another technique proposed by Heinzelman is clustering algorithm called Low-Energy Adaptive Clustering Hierarchy (LEACH). The operation of LEACH consists of two phases the setup phase and the steady state phase.

The setup phase: In the Setup Phase, the clusters are organized and the cluster heads are selected. The cluster heads aggregate, compress and forward the data to the base station. Each node determines whether it will become a cluster head, in this round, by using a stochastic algorithm at each round. If a node becomes a cluster head for one time, it cannot become cluster head again for P rounds, where P is the desired percentage of cluster heads. Thereafter, the probability of a node to become a cluster head in each round is 1/P. This rotation of cluster heads leads to a balanced energy consumption to all the nodes and hence to a longer lifetime of the network.[2]

The steady state phase: In the Steady State Phase, the data is sent to the base station. The duration of the steady state phase is longer than the duration of the setup phase in order to minimize overhead. Moreover, each node that is not a cluster head selects the closest cluster head and joins that cluster. After that the cluster head creates a schedule for each node in its cluster to transmit its data.[2]

Another technique is Power-Efficient Gathering in Sensor Information Systems (PEGASIS). The PEGASIS protocol is a chain-based protocol and an improvement of the LEACH. In PEGASIS each node communicates only with a nearby neighbor in order to send and receive data. It takes turns transmitting to the base station, thus reducing the amount of energy spent per round. The nodes are organized in such a way as to form a chain, which can either be accomplished by the sensor nodes themselves, using a greedy algorithm starting from some node, or the BS can compute this chain and broadcast it to all the sensor nodes.[2] Another important approach is Top-Down approach. In Top-Down approach all nodes participate in transmission by using this delay can be minimized. The overall approach is going to execute at base station. Base station is responsible for all the activities. Another approach is Bottom-Up approach. In Bottom-Up approach joins the cluster of the same size together. It is scalable than Top-Down approach. In Bottom-Up approach the base station is selected from among nodes depending on energy of node.

III. PROPOSED NETWORK STRUCTURE

Wireless Sensor network contain large number of wireless sensor nodes to collect information from other nodes. Wireless sensor nodes are battery powered devices energy saving is always important to the lifetime of wireless sensor network. Here we are going to organize the wireless nodes in such way that the delay is minimum and energy of node is consumed less by using different algorithm to organize the nodes. The algorithm we are going to use Top-Down approach using regular sleep and wake periods. The algorithm can have following step

1) The algorithm starts with network structure in that all nodes are connected with each other. The connection degree of a wireless sensor node is telling the number of data links associated with each node. The available nodes form a set H and set b=N/2

2) Select b nodes from set H to form set H1 in such way that geographical distance between two nodes i & j is maximize. The algorithm will then remove all connection among nodes within set H1. Set iteration s=s+1 and b=b/2.

3) Repeat step 2 until b<2 set r=2.

4) Nodes within degree N-r form set L and Nodes with degree greater than N-r form set U.

5) During first time set L will go in sleep state when there is trigger then it will activate at that time nodes in set U go in sleep state.

IV. NUMERICAL ANALYSIS

A wireless sensor node can be considered as a device built up of three major units, namely the microcontroller unit (MCU), the transceiver unit (TCR), and the sensor board (SB). Each of these units will consume a certain amount of energy while operating. The energy consumed by a wireless sensor node can be expressed as

$$E_{i\_SN} = E_{i\_MCU} + E_{i\_TCR} + E_{i\_SB} \qquad (1)$$

Where E_{i_MCU} represents the energy consumed by the MCU, E_{i_TCR} represents the energy consumed by the TCR, and E_{i_SB} represents the energy consumed by the SB. Here E_{i_TCR}, can be further expressed as

$$E_{i\_TCR} = E_{i\_TCR\_RX} + E_{i\_TCR\_TX}(d_i) \qquad (2)$$

Where $E_{i\_TCR\_RX}$ denotes the energy consumed by the TCR in receiving mode, while $E_{i\_TCR\_TX}(d_i)$ denotes the energy consumed by the TCR to transmit for a distance of d_i. The total energy consumed by a network of sensor nodes is expressed as

$$E_{TOT}(N) = \sum_{i=1}^{N}(E_{i\_MCU} + E_{i\_TCR\_RX} + E_{i\_TXR\_TX}(d_i) + E_{i\_SB} \qquad (3)$$

Normally E_{i_MCU}, $E_{i\_TCR\_RX}$, E_{i_SB}, and are constants. On the other hand, $E_{i\_TXR\_TX}(d_i)$ is a function of (d_i) which is heavily depending on the network structure.

$$E_{TOT}(N) = C_1 + \sum_{i=1}^{N} E_{i\_TCR\_TX}(d_i) \qquad (4)$$

Where is C1 a constant. Assume that the path loss exponent is equal to 2, $E_{i\_TCR\_TX}(d_i)$ can be further expressed as where $E_{i\_TCR\_EC}$ is the energy consumed by the TCR's electronic circuitry, while $E_{i\_TCR\_PA}$ denotes the energy consumed by the power amplifier of the TCR. Both and are constants and, therefore,

$$E_{TOT}(N) = C_1 + C_2 + C_3 \sum_{i=1}^{N} d_i \wedge 2 \qquad (5)$$

where c1,c2 and are constants. Here shows that the total energy consumption of the network can be minimized by reducing $\sum_{i=1}^{N} d_i \wedge 2$. Thus, the objective of the proposed network formation algorithms is to construct the proposed network structure, while keeping $\sum_{i=1}^{N} d_i \wedge 2$ at low value. In this section, two network formation algorithms, namely the top-down and the bottom-up approaches, are proposed to achieve the objective mentioned above.

V. SIMULATION RESULT

The comparison of energy between proposed algorithm and available algorithm is as follow. In this graph blue line indicate the energy require for all node available in network is minimum. The following fig.3 shows that

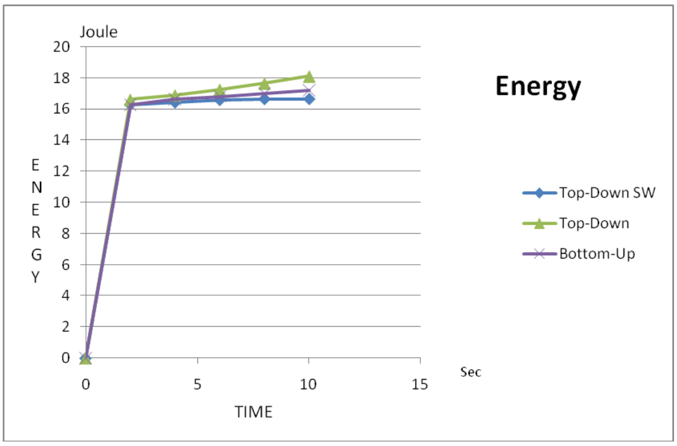

Fig.3. Energy spend by different technique

The comparison of average delay between proposed algorithm and available algorithm is as follow. In this graph blue line indicate the average delay require for all node available in network is minimum. The following fig.4 shows that

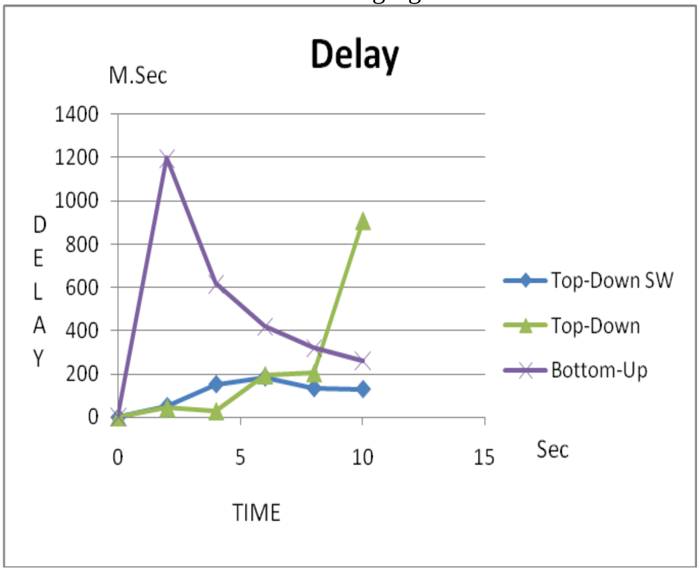

Fig.4. Delay by different technique

VI. CONCLUSION

In this paper the energy conservation by using top-down approach with regular sleep and wake periods is implemented. The results have been checked by using simulation. The proposed network structure minimized delay in communication and increase lifetime of network. The proposed network structure can highly reduce the data collection time while keeping the total communication distance and the network lifetime at minimum values.

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