Chain Clustered Communication Protocol for WSN

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***Abstract*—A Wireless Sensor Network (WSN) is composed of a collection of sensor nodes. Sensor nodes being small energy constrained devices; hence the main focus is that these have to be as energy efficient as possible. The focus should also be on minimizing the transmitting and receiving of data, as these are expensive operations.**

Sensor webs consisting of nodes with limited battery power and wireless communications are deployed to collect useful information from the Region of Interest (ROI). If each node transmits its sensed data directly to the base station then it will deplete its power quickly and reduces network lifetime. The LEACH (Low Energy Adaptive Clustering Hierarchy) protocol is a technique where clusters are formed to fuse data before transmitting to the base station. By randomizing the cluster heads chosen to transmit to the base station, LEACH achieves a factor of 8 improvement compared to direct transmissions, as measured in terms of when nodes die. PEGASIS (Power-Efficient Gathering in Sensor Information Systems), a near optimal chain-based protocol is an improvement over LEACH. In PEGASIS, each node communicates only with a close neighbour and takes turns transmitting to the base station, thus reducing the amount of energy spent per round. The limitations of LEACH and PEGASIS are explained below:

The proposed method is highly energy efficient. This protocol outperforms LEACH by eliminating the overhead of dynamic cluster formation, minimizing the distance non leader-nodes must transmit and using only one transmission to the base station in each round. In PEGASIS the clustering overhead is avoided but it still requires dynamic topology adjustment since a sensor node needs to know about position of its neighbours in order to know where to route its data. Such topology adjustment introduces significant overhead. Here the nodes also require global knowledge of the network. The proposed method, a hybrid approach, an improvement over LEACH & PEGASIS is based on the concept of clustering and chaining. The proposed method is named as CCCP. The proposed method gives 200% and 60% improved performance over LEACH and PEGASIS respectively. So this protocol is better than these two protocols. It eliminates most of the limitations of LEACH and PEGASIS.

KEYWORDS—LEACH- Low Energy Adaptive Clustering Hierarchy, PEGASIS- Power Efficient Gathering in Sensor Information Systems, CCCP- chain Clustered Communication Protocol, ROI- Region of Interest.

I. INTRODUCTION

wireless sensor network (WSN) consists of spatially distributed autonomous sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants [7].

The wireless sensor network (WSN) is composed of a collection of sensor nodes, which are small energy constrained devices. Wireless sensor network has been widely used in the field of environment monitoring, military and smart home. WSN can be deployed in a wide geographical space to monitor physical phenomenon with acceptable accuracy and reliability [8,10]. The sensors can monitor various entities such as: temperature, pressure, humidity, salinity, metallic objects, level and mobility. The problems associated with sensor network are deployment, network lifetime, communication bandwidth, scalability, and power management. Sensor nodes are likely to be battery powered, and it is often very difficult to change or recharge batteries for these nodes. Prolonging network lifetime for these nodes is a critical issue and it is defined in terms of number of rounds.

In this paper, it is proposed a method of gathering the data between the sensor nodes and communicating to base station in energy efficient manner. Here the main objective is to improve the lifetime of the network and to maintain a balanced energy consumption of nodes. In this localized information is used and data fusion is incorporated to reduce the amount of data sent to the base station.

The rest of the paper is organized in the following sections: Section 2 contains Assumptions. The proposed technique is given in Section 3, The Method is discussed in Section 4, Section 5 contains. The Algorithm. Simulations and discussion are presented in Section 5. Section 6 concludes the paper.

II. ASSUMPTIONS

The following assumptions have been considered initially:

1 .Each node periodically senses its nearby environment and would like to send its data to a base station located at a fixed point

2. Sensor nodes are stationary, homogeneous and energy

constrained.

3. Distance is estimated from the received signal strength.
4. Data fusion or aggregation is used to reduce the number of messages in the network. We assume that combining n packets of size k results in one packet of size k instead of size nk.
5. The radio channel is symmetric such that energy transmitting a message from node A to B [9]. Is same as the energy required in transmitting message from B to A.

III. THE PROPOSED TECHNIQUE

This proposed chain clustered communication protocol for wireless sensor networks designed utilizes the distributed approach extended by Khemka [3]. The aim is efficient transmission of all the data to the base station so that the lifetime of the network is maximized in terms of rounds, where a round is defined as the process of gathering all the data from sensor nodes to the base station, regardless of how much time it takes. Direct transmission is a simple approach for this problem in which each node transmits its own data directly to the base station. However, if the base station is far away, the cost of sending data to it becomes too large and the nodes will die quickly. In order to solve this problem, two protocols LEACH [9] and PEGASIS [1] have been extended and give improved results over [3]. In LEACH, the key idea is to reduce the number of nodes communicating directly with the base station and is achieved by forming a small number of clusters in a self organizing manner, where each cluster-head collects the data from nodes in its cluster, fuses it and sends the result to the base station. PEGASIS [1] protocol reduces the number of nodes communicating directly with the base station through one node by forming a chain passing through all nodes where each node receives from and transmits to the closest possible neighbour. The data is collected starting from each endpoint of the chain until the randomized head node is reached. The data is fused each time it moves from node to node. The designated head-node is responsible for transmitting the final data to the base station. In this paper, a new protocol is proposed which combines the idea of both protocols i.e. LEACH [9] and PEGASIS [1]. This protocol is simulated using MATLAB and it reduces the overheads (communication to base station) as compared to LEACH and PEGASIS. This protocol improves considerably the overall lifetime of the network.

IV.THE METHOD

At first N numbers of nodes are distributed randomly in a 100 × 100 area. Now five clusters are made in this area. Chain is formed starting from farthest node. In separate cluster separate chain is formed. The data transmission within the clusters is done through first layer chain formed within the cluster members. For data gathering in each round of communication, the farthest node in the chain initiates the data transmission. Data fusion is performed at each node except the farthest node in the chain. Each node receives data from one neighbour, fuses with its own data, and transmits to the other neighbour on the chain. This is done for all the chains formed within all the clusters respectively. After the data is gathered at the cluster heads, then the cluster head does not send the data directly to the base station as required in LEACH protocol.

But again cluster heads on tha chain transmits its data to the leader nodes in the cluster heads. Cluster head takes different turns in transmitting the data to the base station. The selection of leader among the cluster head is done by the formula (r mod n) where r is the number of rounds and n is the total number of cluster-heads. This selection is done in each round, thus reducing the energy dissipation of the cluster-heads. In each round of communication, whenever the residual energy of any of the cluster heads go below K*E, E is its initial energy and K is a constant, then it broadcasts within its chain to find a replacement, the node having the maximal residual energy in that cluster becomes the new cluster-head and the previous cluster-head becomes a normal node in the chain. This is done in order to avoid a node with minimum residual energy to become a cluster-head. Network lifetime is taken as the round when the first node dies.

4.1. ENERGY MODEL

In order to predict the performance of proposed algorithm has been used radio model given in [9]. In this model, a radio dissipates Eelec = 50 nJ/bit in the transmitter or receiver circuitry and Eamp = 100 $pJ/bit/m^2$ for the transmitter amplifier. The simulation is done for fixed packet size of 2000 bits.The radios have power control and can expend the minimum required energy to reach the intended recipients. An r^2 energy loss is used due to channel transmission. Thus, to transmit a k-bit message a distance d, the radio expends [3]:

$$ET \times (k,d) = ETx\text{-}elec\ (k) + ETx\text{-}amp(k,d)$$

$$ET \times (k,d) = Eelec * k + Eamp * k * d^c$$

where c is path-loss exponent usually (2<=c<=4). To

receive this message, the radio expends:

$$ET \times (k) = ERx\text{-}elec(k)$$

$$ER \times (k) = Eelec * k$$

V. ALGORITHM

The steps of this proposed algorithm are explained below :

I. INITIALIZATION

1. Take 100 Random nodes with (x,y) coordinates
2. Base station is located at least location 100m away from the deployment of nodes.
3. In this model, a radio dissipates Eelec = 50 nJ/bit in the transmitter or receiver circuitry and Eamp = 100 pJ/bit/ m^2 for the transmitter amplifier.
4. Five clusters are formed
5. Chain are formed in each cluster starting from fartest node.

(II) MAIN PROCESSING

Repeat after every run r

1. Cluster head is selected for $E_{(x,y)}>K*E_{initial}$ (K=0.5 here)
2. Leader node is selected out of all cluster heads by using formula mod(r,n)th cluster
3. d= sqrt[(x(i)-x(i+1))^2+(y(i)-y(i+1))^2]; d-distance between neighbours
4. $E_{(x,y)}$=(Einitial-2*r*Eelec*k)- (Eamp*r*k*d^2)-(E_{diff}*K*r), (k=2000, number of bits in one message)
5. If $E_{(x,y)}<E_{min}$(dead node), E_{min}=2.101*10^(-4); minimum energy required to be a live node E_{min}=(2*50*10^(-9)*2000)+(100*10^(-2)*100*2000) +(5*10^(-9) * 2000)J

(III) FINALIZATION

1. n(1)=no. of runs when first node get dead
2. n(2)= no. of runs when 20 nodes get dead
3. n(3)= no. of runs when 50 nodes get dead
4. n(4)= no. of runs when 100 nodes get dead
5. plot=no. of runs v/s % of dead nodes

VI. SIMULATION RESULTS AND DISCUSSION

To evaluate the performance of proposed protocol, it has been simulated on a random 100 -node network. The base station is located at (50,300) in a 100m*100m field.

In this model, a radio dissipates E_{elec}=50 nj/bit to run the transmitter and receiver circuitry and E_{amp}=100 pj/bit/m^2 for the transmitter amplifier. There is also a cost of Ediff= 5nj/ bit/message for a 2000 bit messages in data fusion. Each node has same initial energy of 0.25 joule [1].

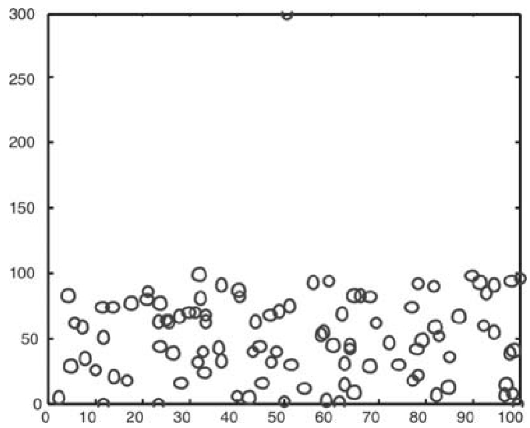
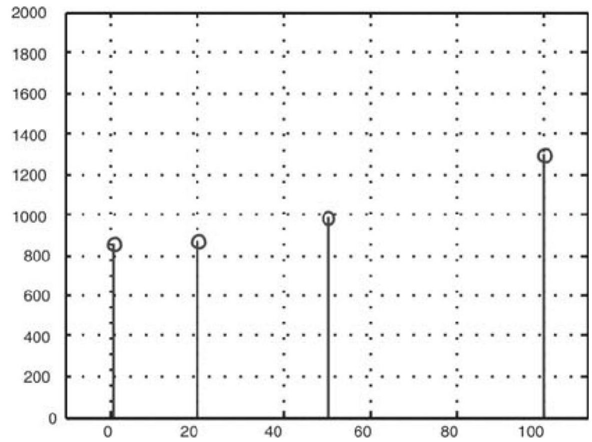


Fig. 1

The results of the simulation are shown in the Fig.1 for the network of 100*100 meter area and where base station is far away from the field. When the base station is far away it is taken at (50,300) in a 100 × 100 field. From the simulations, it has been observed that the performance of the protocol was optimal for K=0.5 [1]. In order to show the performance of this proposed protocol, it is simulated using MATLAB. The simulations are run to determine the number of rounds of communication when 1%, 20%, 50%, 100% of the node die with each node having the same energy 0.25 joule. The results are shown in Fig. 2.



From the Fig. 2 the number of runs for different failures is as under:

Number of runs when 1st node failure occurs :858

Number of runs when 20 nodes are fail to work :878

Number of runs when 50 nodes are fail to work :986

Number of runs when 100 nodes are fail to work :1300

VII. CONCLUSION

The proposed routing protocol is highly efficient for a data gathering problem in sensor network. This protocol outperforms LEACH [9] by eliminating the overhead of dynamic cluster formation, minimizing the distance non leader-nodes must transmit and using only one transmission to the base station in each round. In PEGASIS [1] the clustering overhead is avoided but it still requires dynamic topology adjustment since a sensor node needs to know about position of its neighbours in order to know where to route its data. Such topology adjustment introduces significant overhead. Here the nodes also require global knowledge of the network. So this protocol is better than these two protocols.

CCCP gives 200% improved performance over LEACH [9] and 60% over PEGASIS [1] in terms of network lifetime. Also in this protocol, the cluster-head is changed when its residual energy falls below a threshold value and is replaced by a node with maximum residual energy in that cluster because of this also the performance of the algorithm is improves.

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