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PEGASIS : Power-Efficient Gathering in Sensor Information Systems

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ABSTRACT

Sensor network consisting of nodes with limited battery power and wireless communications are deployed to collect useful information from the field. The main idea in PEGASIS is for each node to receive from and transmit to close neighbors and take turns being the leader for transmission to the BS. This approach distributes the energy load evenly among the sensor nodes in the network. Sensor nodes are randomly deployed in the sensor field, and therefore, the i^{th} node is at a random location. The nodes will be organized to form a chain, which can either be accomplished by the sensor nodes themselves using a greedy algorithm. The algorithm to resolve the unbalanced energy consumption problem caused by long distance data transmission of some nodes in a chain formed by the greedy algorithm.

Keywords: LEACH, MSC, PEGASIS, BS, Wireless Sensor Network, Greedy Algorithms

I. INTRODUCTION

A Wireless Sensor Network consists of a number of energy constrained sensor nodes. These nodes are deployed in a random fashion and can communicate among themselves to make an ad-hoc network. The sensor nodes communicate with the sink node in a wireless faction. The wireless medium may either of radio frequencies, infrared or any other medium having no wired connection. The primary concern in Wireless Sensor Network (WSN) is to maximize the network lifetime as long as possible, as it is not possible to replace or recharge the batteries of thousands of sensor nodes as they are often deployed in a remote or impractical environment. If each node transmits its data directly to the sink, some nodes that are far away from the sink will die much earlier than the other sensor nodes. This is as a result of rapid energy depletion due to long distance data transmission. Consequently, this problem limits the use of WSN to gather data in certain regions. This becomes a cause that cannot be done to gather data in certain regions. Thus, a more effective use of energy becomes the major challenge in WSNs. To improve energy efficiency, many researchers have suggested various routing algorithms.

In area of sensor network lot work has been done in the area of Wireless Sensor Network, but still a long way to go. Wireless Sensor networks consist of hundreds of thousands of low power multi-functional sensor nodes, operating in an unattended environment, with limited computation and sensing capabilities. Sensor nodes are equipped with small, often irreplaceable batteries with limited power capacities. The use of wireless sensor networks is increasing day by day and at the same time it faces the problem of energy constraints in terms of limited battery lifetime. Various approaches can be taken to save energy caused by communication in wireless sensor networks. One of them is to adopting energy efficient routing algorithms. The routing algorithms in the sensor networks broadly classified into three categories: Flat, Hierarchical and Location based routing. The cluster based routing holds great promise for many-to-one and one-to-many communication paradigms that are prevalent in sensor networks. This dissertation work includes the survey of various cluster based routing protocols and implementation of LEACH routing protocol. The idea proposed in LEACH has been an inspiration for many hierarchical routing protocols. The finally it propose some modifications to improve the performance of the LEACH routing protocol. The simulation results were then analyzed based on the suggested evaluation metrics in order to verify their suitability for use in wireless sensor networks.

II. METHODS AND MATERIAL

A. LEACH

Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol uses the hierarchical routing for wireless sensor networks to increase the life time of the network. In a cluster based architecture one node acts as a cluster head and all other nodes in a network are the member nodes of the network. The member nodes collects the information and send their collected data to the cluster head and cluster head receives data from all these nodes, process it and send it to the destined base station. So cluster head is more energy demanding than other nodes. When a cluster head dies all other cluster member nodes become unable to communicate. LEACH incorporates randomized rotation of the cluster head position such that it rotates among the sensors to avoid draining the battery of any sensor node in the network. So, the energy load associated with being a cluster head is evenly distributed among the nodes to save the network energy. However it has a number of disadvantages, one of them is that the Cluster head directly communicates with BS ignoring the distance between CH and BS.

In LEACH, it considers the energy dissipation of the receivers and concludes that multi-hop is energy efficient only in certain network topology and radio parameters of the system. The main idea of LEACH is to consider the local data fusion in each cluster to reduce the amount of redundant data that must be transmitted to BS. Each cluster head, instead of each sensor node, directly sends fusion data to BS, thus it extends the lifetime of major nodes

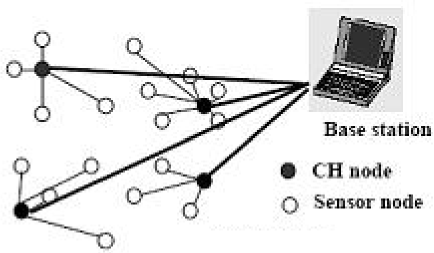

Figure 1: LEACH

Goal of LEACH: Evaluate the energy efficiency of cluster-based routing protocols such as LEACH and PEGASIS with extended conditions of general complexity of data fusion algorithm, general data compressing ratio and long distance.

The nodes of wireless sensor networks, with limited computing, communicating and sensing capabilities as well as limited energy, can make the best use themselves to gather data from sensor nodes to Base Station (BS) by using excellent network topologies, optimized routing schemes or data fusion algorithms in order gain the lifetime as long as possible. In the simplest direct communication routing protocol, each sensor node directly communicates with base station. Since the distance is large, it consumes the energy quickly in most cases

B. Power-Efficient Gathering in Sensor Information Systems (PEGASIS)

Lindsey et al proposed this protocol, which is an enhancement over the LEACH protocol. The main idea in PEGASIS is for each node to receive from and transmit to close neighbors and take turns being the leader for transmission to the BS. This approach distributes the energy load evenly among the sensor nodes in the network. Sensor nodes are randomly deployed in the sensor field, and therefore, the ith node is at a random location. The nodes will be organized to form a chain, which can either be accomplished by the sensor nodes themselves using a greedy algorithm starting from some node. Alternatively, the BS can compute this chain and broadcast it to all the sensor nodes. For constructing the chain, it is assumed that all nodes have global knowledge of the network and employ the greedy algorithm. The greedy approach to constructing the chain works well and this is done before the first round of communication. To construct the chain, it starts with the furthest node from the BS. To begin with this node in order to make sure that nodes farther from the BS have close neighbors, as in the greedy algorithm the neighbor distances will increase gradually since nodes already on the chain cannot be revisited.

The goals of PEGASIS are as follows:

- To minimize the transmission distance of each node
- To minimize the overhead
- To minimize the messages that need to be sent to the BS
- To pass out the energy consumption equally across all nodes

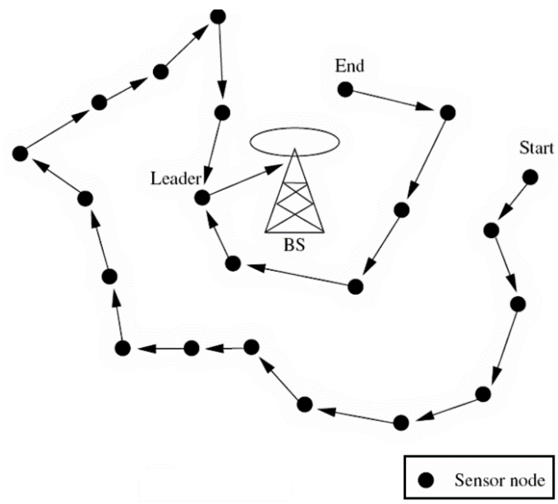

Figure 2: Illustration of PEGASIS protocol

C. Greedy Algorithms

A greedy algorithm is an algorithm that follows the problem solving heuristic of making the locally optimal choice at each stage with the hope of finding a global optimum. In many problems, a greedy strategy does not in general produce an optimal solution, but nonetheless a greedy heuristic may yield locally optimal solutions that approximate a global optimal solution in a reasonable time.

Wireless Sensor Networks have found popularity in a variety of applications ranging from warfare tactics to medical sciences to oil pipelining in recent years. And such wide variety of applications has resulted in a lot of research into finding better ways of implementing these networks and maintaining them with minimal loss of energy. Problems involved with deployment, communication and routing and many more are being considered and attempts to find better solutions made. Target Coverage Problem is another such problem that discusses about the activation and scheduling of the sensors in such a way so that the network lifetime is maximised. Now in the last chapter a conclusion was drawn regarding the nature of this problem which was found to be NP-Hard. The implications of this are that no known algorithm thus exists that can solve the problem in polynomial time and also proving us with the optimal solution. That is why most of the research has been performed for finding out better heuristic algorithms that can provide if not optimal, at least a sub optimal or near optimal solution to this problem.

First we see at a simple greedy based strategy which at any point selects that sensor which is covering the maximum number of target nodes. This step is required to understand the flaws with the normal approach and in which direction one needs to think in order to define new heuristics. Then we look at the algorithm in reference and simulate that existing algorithm which aims to provide a near optimal solution to the Target Coverage Problem in polynomial time.

Now the simple algorithm aims at generating a Maximum Set Cover (MSC), where the elements of the set cover are nothing but sensors that are to be activated. In any cycle, only those sensors included in the set cover are activated and rest are kept in sleep mode. The set cover is constructed so that the members of the set cover can cover all the targets and monitor them with their available energy. If there is at least one target which cannot be covered by the members of the set cover then that set cover is discarded and the operational time of that set cover is noted which is added to the total network running time, which is called the Network Lifetime of the network.

An Advanced Greedy Based Heuristic Algorithm

Usually the scenario is that there are a lot of sensors which are deployed in each other's vicinity and so the intersection of the set of target nodes that each of them cover can be large that is two sensors might be covering a similar set of target nodes.

If SN1 and SN2 are two sensors having lifetime LT1 and LT2 respectively, and are covering almost similar targets then our aim should be to activate these two sensors at different cycles so that the effective time that we get is (LT1+LT2). On the other hand it is easy to notice that if both the sensors get activated at the same cycle then the time for which their mutual targets are getting covered is maximum(LT1, LT2). This need can be satisfied by using the modified heuristic of selecting that sensor that covers the maximum number of uncovered target nodes at each iteration to construct the set cover.

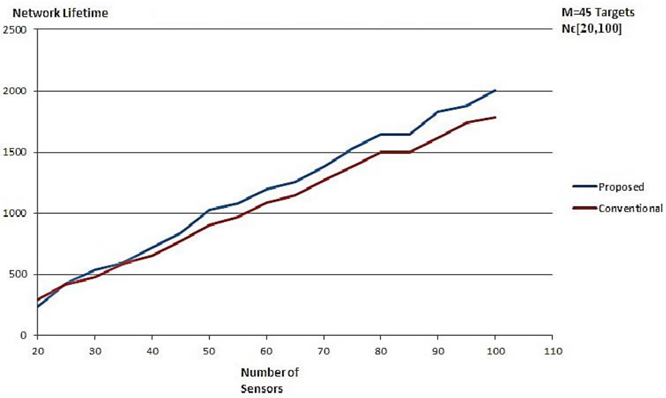

Figure 3: Performance of Proposed versus Existing Algorithm

III. RESULT AND DISCUSSION

The simulation is based on the exact same network as the earlier one. A stationary network with a fixed number of targets and sensors randomly deployed around the targets is simulated. The range of each sensor is considered fixed and so is the initial energy of the sensor which is kept equal for all sensors without any loss of generality.

After each iteration we increase the number of sensors and run the algorithm to note the new Network Lifetime. So the number of sensors is the variable parameter here. The main objective of is to record the increase in network lifetime as we increase the number of sensors. The number of sensors is increased and for every new number of sensors the network lifetime is noted. Then a graph is plotted. The formal procedure is as follows:

- The minimum number of sensors is taken to be 20.
- Then we assigned the sensors using the MSC heuristic algorithm and noted the network lifetime.
- The number of sensors was varied from 20 to 100.

IV. CONCLUSION

In this paper, we describe PEGASIS, a greedy chain protocol that is near optimal for a data-gathering problem in sensor networks. PEGASIS outperforms LEACH by eliminating the overhead of dynamic cluster formation, minimizing the distance non leader-nodes must transmit, limiting the number of transmissions and receives among all nodes, and using only one transmission to the BS per round. Gathering information from a WSN in an energy effective manner is of paramount importance in order to prolong its life span. This calls for use of an appropriate routing protocol to ensure efficient data transmission through the network. In this research project, we have proposed an Amend implementation of LEACH protocol based on energy heterogeneity and optimizes it through genetic algorithm. The result of simulations conducted indicates that the proposed approach is more energy efficient and hence effective in prolonging the network life time compared to LEACH.

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