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Level Controlled Clustering In Wireless Sensor Networks

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Abstract-Sensor networks can be used for various applications areas like health, military, environmental etc. For different application areas, there are different technical issues that researchers are currently resolving. This paper deals with a distributed sensor network employing level controlled clustering. Level controlled clustering is a technique that uses leveling and clustering together. This technique reduces the number of messages in the direction of base station and thereby increases the life time of the wireless sensor network. We divide the network into levels of different power levels. By using various power levels at base station, the sensor field is hierarchically partitioned into levels of increasing radius each level containing various sensor nodes. Leveling divides the network into logical zones based on proximity from base station, whereby the packet is transmitted from a node in the next zone with lesser depth. The transmission probability is fixed. The primary advantage of this protocol is transmitting a critical event and at the same time conserving life time of the network for future monitoring.

***Index Terms*— Clustering, Leveling, Sensor Nodes, Sensor networks**

I INTRODUCTION

Sensor networks consisting of nodes with limited battery power and wireless communications are deployed to collect useful information from the sensor field. Gathering sensed information in an energy efficient manner is critical to operate the sensor network for a long period of time. Current technological advances in electronics have enabled the development of inexpensive multifunctional sensor nodes that are small in size and communicate untethered in short distances. These tiny sensor nodes,[1] are capable of significant computation and wireless communication leverage the idea of sensor networks. A sensor network is composed of a large number of sensor nodes that are densely deployed either inside the phenomenon or very close to it. Sensor networks consist of nodes which are constrained by the amount of battery power available, limiting the lifetime and quality of service, which are deployed to collect useful information from the field. Realization of these and other sensor network applications require wireless ad hoc networking techniques. Although many protocols and algorithms have been proposed for traditional wireless ad hoc networks, they are not well suited to the unique features and application requirements of sensor networks. To illustrate this point, the differences between sensor networks and ad hoc networks are:

• The number of sensor nodes in a sensor network can be several orders of magnitude higher than the nodes in an ad hoc network.
• Sensor nodes are densely deployed.
• Sensor nodes are prone to failures.
• The topology of a sensor network changes very frequently.
• Sensor nodes mainly use a broadcast communication paradigm, whereas most ad hoc networks are based on point-to-point communications.
• Sensor nodes are limited in power, computational capacities, and memory.
• Sensor nodes may not have global *identification* (ID) because of the large amount of overhead and large number of sensors.

In this article we propose a protocol a level controlled clustering protocol .The key idea in this protocol is to divide the sensor network into logical zones of different power from the base station. The packet is then transmitted from a zone to a next zone with lower depth.

The remained of this article is organized as follows. We discuss an overview of the sensor network as well as architecture and design issues in wireless sensor networks. We provide a detailed description of our algorithm. We then conclude our article.

II SENSOR NETWORKS AN OVERVIEW

A. Applications of Sensor Networks

Sensor networks have a variety of applications. Examples include environmental monitoring – which involves monitoring air soil and water, condition based maintenance, habitat monitoring (determining the plant and animal species population and behavior), seismic detection, military surveillance, inventory tracking, smart spaces etc. In fact, due to the pervasive nature of micro-sensors, sensor networks have the potential to revolutionize the very way we understand and construct complex physical system.

B .Challenges

In spite of the diverse applications, sensor networks pose a number of unique technical challenges due to the factors mentioned below:

Ad hoc deployment: Most sensor nodes are deployed in regions which have no infrastructure at all. A typical way of deployment in a forest would be tossing the sensor nodes from an aero plane. In such a situation, it is up to the nodes to identify its connectivity and distribution.

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Unattended operation: In most cases, once deployed, sensor networks have no human intervention. Hence the nodes themselves are responsible for reconfiguration in case of any changes.
Untethered: The sensor nodes are not connected to any energy source. There is only a finite source of energy, which must be optimally used for processing and communication. An interesting fact is that communication dominates processing in energy consumption. Thus, in order to make optimal use of energy, communication should be minimized as much as possible.
Dynamic changes: It is required that a sensor network system be adaptable to changing connectivity (for e.g., due to addition of more nodes, failure of nodes etc.) as well as changing Environmental stimuli.

Thus, unlike traditional networks, where the focus is on maximizing channel throughput or minimizing node deployment, the major consideration in a sensor network is to extend the system lifetime as well as the system robustness

B. *System Architecture and Design Issues*

The sensor nodes are usually scattered in a *sensor field* . Each of these scattered sensor nodes has the capabilities to collect data and route data back to the *sink*. Data are routed back to the sink by a multi hop infrastructure less architecture through the sink as shown in Figure. The sink may communicate with the *task manager node* via Internet or satellite.

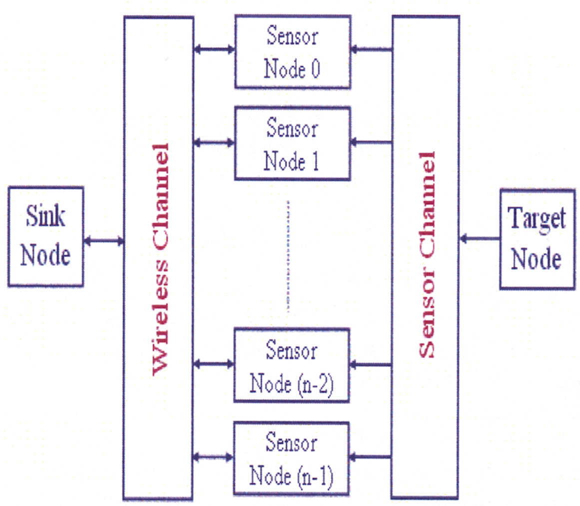

Figure 1. System Architecture

Depending on the application, different architectures and design goals/constraints have been considered for sensor networks. Since the performance of a routing protocol is closely related to the architectural model, in this section we strive to capture architectural issues and highlight their implications[2]. [1] describes the factors that serve as a guideline to design a protocol or an algorithm for sensor networks. In addition, these influencing factors can be used to compare different schemes. These factors include :Fault Tolerance ,Scalability ,Production Costs ,Hardware Constraints, Sensor Network Topology, Environment, Transmission Media, Power Consumption, Data Delivery Models ,Data Aggregation/Fusion .

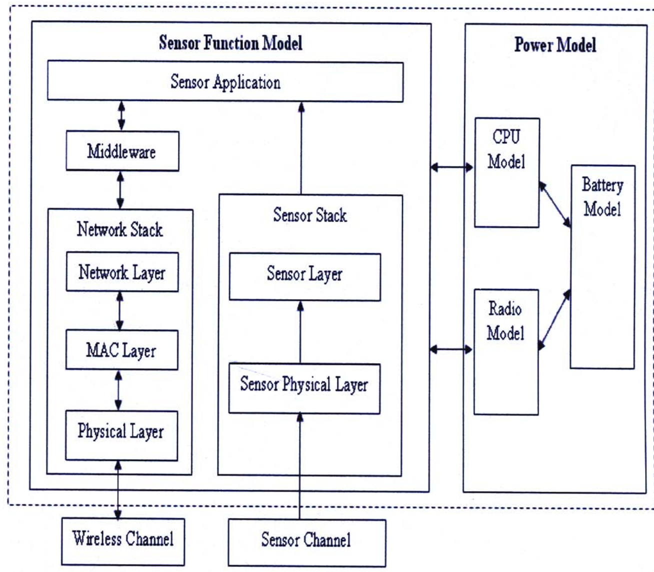

Figure 2. Sensor Network Protocol Stack

C. *Related Work*

A typical application in a sensor web is gathering of sensed data at a distant base station (BS) [3].Each sensor node has power control and the ability to transmit data to any other sensor node or directly to the BS [4,5]. We assume that all nodes have location information about all other nodes. However, if this were not the case, our scheme would still work. Nodes would have to expend some extra energy to find their close neighbors. They could do this by sending with enough power to signal a node, and then gradually reduce its power to find which neighbor is closest to it. In this paper, our model sensor network has the following properties:
· The BS is fixed at a far distance from the sensor nodes.
· The sensor nodes are homogeneous and energy constrained with uniform energy.
· No mobility of sensor nodes.

II HEIRARCHICAL ROUTING IN SENSOR NETWORKS

Similar to other communication networks, scalability is one of the major design attributes of sensor networks.[2] A single-tier network can cause the gateway to overload with the increase in sensors density. Such overload might cause latency in communication and inadequate tracking of events. In addition, the single-gateway architecture is not scalable for a larger set of sensors covering a wider area of interest since the sensors are typically not capable of long-haul communication. To allow the system to cope with additional load and to be able to cover a large area of interest without degrading the service, networking clustering has been pursued in some routing approaches. The main aim of hierarchical routing is to efficiently maintain the energy consumption of sensor nodes by involving them in multi-hop communication within a particular cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the sink. Cluster formation is typically based on the energy reserve of sensors and sensor's proximity to the cluster head [6][7]. LEACH [8] is one of the first hierarchical routing approaches for sensors networks. The idea proposed in LEACH has been an inspiration for many hierarchical routing protocols [10][11][14][15], although some protocols have been independently developed [13][14].

III ENERGY EFFICIENCY IN HEIRARCHICAL ROUTING

In this section we will analyze the cost of data gathering from a sensor web to the distant BS. We recall that the data collection problem of interest is to send a k-bit packet from each sensor node in each round. Of course, the goal is to keep the sensor web operating as long as possible. A fixed amount of energy is spent in receiving and transmitting a packet in the electronics, and an additional amount proportional to d^2 is spent while transmitting a packet. There is also a cost of 5 nJ/bit/message for data fusion. With the direct approach, all nodes transmit directly to the BS which is usually located very far away.

Therefore, every node will consume a significant amount of power to transmit to the BS in each round. Since the nodes have a limited amount of energy, nodes will die quickly, causing the reduction of the system lifetime. As observed in [10], the direct approach would work best if the BS is located close to the sensor nodes or the cost of receiving is very high compared to the cost of transmitting data. For the rest of the analysis, we assume a 400-node sensor network with the BS located far away. In this scenario, energy costs can be reduced if the data is gathered locally among the sensor nodes and only a few nodes transmit the fused data to the BS. This is the approach taken in LEACH[8], where clusters are formed dynamically in each round and cluster-heads(leaders for each cluster) gather data locally and then transmit to the BS. Cluster-heads are chosen randomly, but all nodes have a chance to become a cluster-head as in LEACH[8], to balance the energy spent per round by each sensor node. Although this approach is much better than the direct transmission, there is still some room to save even more energy. The cost of the overhead to form the clusters is expensive.

In LEACH, in every round 5% of nodes are cluster-heads, and they must broadcast a signal to reach all nodes. In addition, several cluster-heads transmit the fused data from the cluster to the distant BS. Further improvement in energy cost for data gathering can be achieved if only one node transmits to the BS per round and if each node transmits only to local neighbors in the data fusion phase.

IV LEVEL CONTROLLED CLUSTERED

The main idea in this algorithm is for each node to receive from and transmit to local cluster heads for transmission to the BS.

A. Leveling

We have assumed that the base station has the capability of transmitting at various power levels.[5] During the initial deployment, the base station sends a level-1 signal with minimum power level, all the nodes that receive the signal will set their level as 1. Next the base station increases its signal power to reach the nest level and sends a level-2 signal. All nodes that receive the signal, but do not have a level assigned previously set their level to 2.This process continues until the base station sends signals corresponding to all levels. The number of levels is equal to the number of different transmission levels at which the base station can transmit. Apart from this level information, there is no need of any local information. Leveling is done internally without the help of any external facilities such as GPS and in this manner, it differs from others protocols that assume local information. [11][12] At the end of leveling phase, all the nodes will be assigned to certain levels. Each node belongs to a single level and the probability of each level is the same. For proper communication between the levels, a node should have a coverage radius R, which is at least 2L, where L is the distance between any two adjacent levels. The coverage radius R=2L+e. where e should be minimal so as to decrease the energy wastage due to signal propagation beyond the intended levels.

B .Clustering

The idea is to form clusters of the sensor nodes based on the received signal strength and use local cluster heads as routers to the sink. This will save energy since the transmissions will only be done by such cluster heads rather than all sensor nodes. Optimal number of cluster heads is estimated to be 5% of the total number of nodes. The main aim of hierarchical routing is to efficiently maintain the energy consumption of sensor nodes by involving them in multi-hop communication within a particular cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the sink. Cluster formation is typically based on the energy reserve of sensors and sensor's proximity to the cluster head . Custer based approach introduces a form of hierarchy.

In this algorithm we propose to divide the sensor network into levels. Each level is then divided into clusters of maximum of 10 nodes each. The left and right adjacency of each node is maintained. The cluster head is selected from among the nodes having maximum energy and which is almost equally accessible from all the nodes. The cluster heads then broadcast the message to the next level. At the next level the nodes aggregate their data and a fewer number of cluster heads are formed. In this manner the cluster head at the last levels sends the message to the base station. We find that the combination of leveling and clustering is more efficient than any individual approaches.

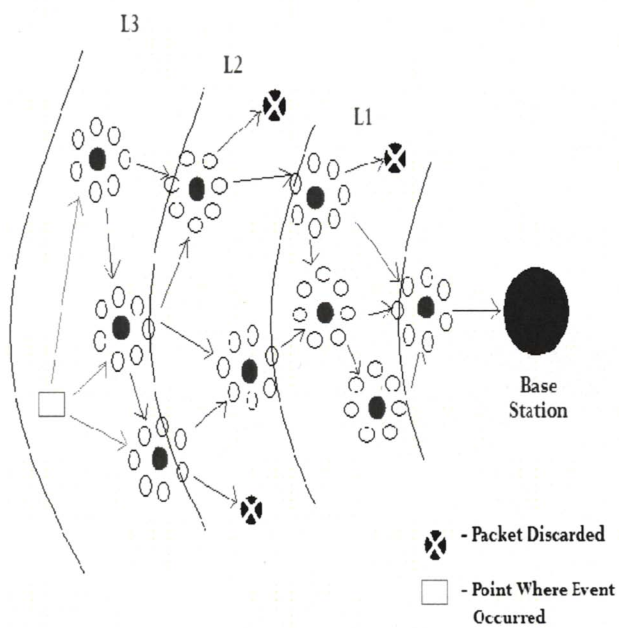

Figure 3 Pictorial Description of Problem

V EXPERIMENTAL RESULTS

Extensive simulation work has been done and the graphs plotted are based on the results obtained from a series of simulations. These algorithms were implemented using C language. From the plotted graphs it is proven that, the algorithm we proposed will increase the network life time when compared to Gossiping or level controlled Gossiping approach. The algorithm achieves near optimal performance and balanced energy dissipation among the sensor nodes to have full use of the sensor web.

Network Model

For the purpose of evaluating the algorithms, we simulated them by varying the number of nodes in the network. For each algorithms we started with a 200 node network and thereby generating the number of events that the network could handle. Similarly, the number of nodes have been varied up to 400 and the corresponding number of events that these networks could handle were plotted in the plot.

The two metrics of interest provided by the simulator are

Definition 1: Number of events: It defines the life time of the network.

Definition 2:Number of Nodes: The number of nodes that are present in the network.

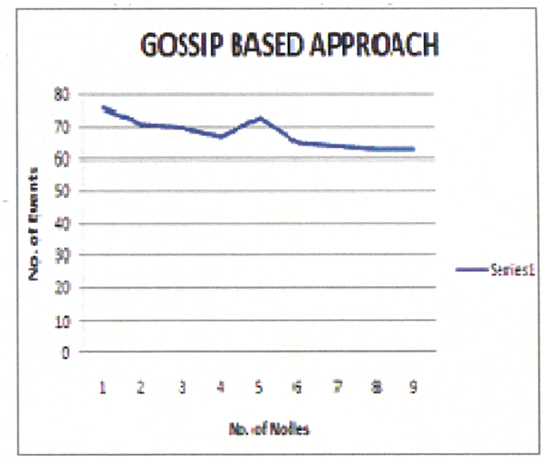

Figure 4. Nodes vs Network Life time for Gossip Based Approach

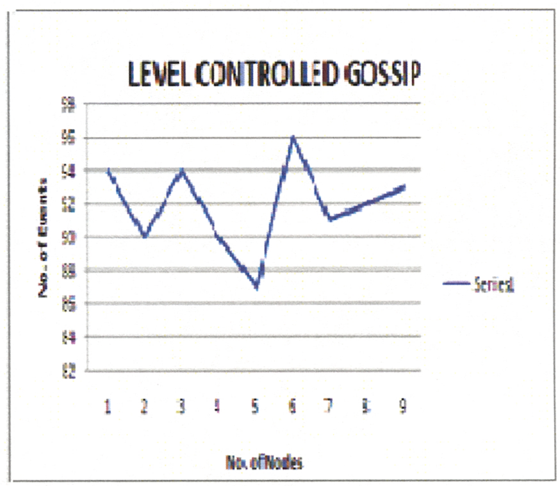

Figure 5. . Nodes vs Network Life time for Level Controlled Gossip Approach

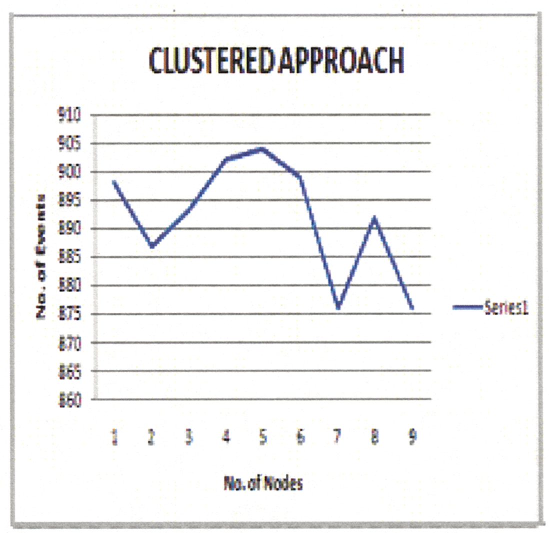

Figure 6. . Nodes vs Network Life time for Clustered Approach

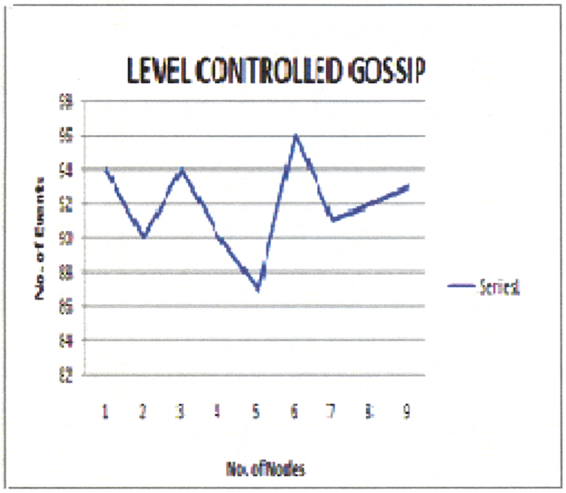

Figure 7. Nodes vs Network Life time for Level Controlled Clustering Approach

VI CONCLUSION

In this paper, we describe a novel idea of level controlled clustering which applies the concept of leveling and constant probabilities to pure clustering. It is near optimal for a a data-gathering problem in sensor networks. Initial studies have shown that level controlled clustering, with constant probabilities of levels, depending on the factors like node density, proximity from the base station, is a worthwhile improvement over pure gossiping and level controlled gossip. and other improvements of flooding which do not use GPS. Nodes take turns to transmit the fused data to the Bs to balance the energy depletion in the network and preserves robustness of the sensor network as nodes die at random locations at random intervals of time.

VII ACKNOWLEDGMENT

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