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Wireless Sensor Networks: Data Aggregation Using LEACH Routing Protocol

Dr K. Satya Rajesh
HOD, Dept. of Computer Science, SRR & CVR Govt. Degree College, Vijayawada
Dr P.Suresh Varma
Professor, Dept. of CSE, Adikavi Nannayya University, Rajamahendravaram
P. Hussain Basha
Dept. of CSE, SANA College of Engineering & Technology, Kodad

ABSTRACT

Wireless Sensor Network are in great demand from the recent years, as nowadays we have seen a wide growth of wireless devices including cellular phones, laptops, mobiles, PDA's etc. Wireless Sensor Networks consists of thousands of tiny sensor nodes. Data aggregation is very essential techniques in wireless sensor network. Reduce the energy consumption to improve the data aggregation by eliminating data redundancy. Wireless sensor network deployed in remote areas or hostile environment. In the wireless sensor network have the most challenging task is a life time of a sensor, if enhance the lifetime of the network the it made simple for aggregation of data .In this paper we discuss the data aggregation approaches based on the routing protocols, the algorithm in the wireless sensor network and also discuss the advantages of routing protocol for data aggregation in wireless sensor network.

Keywords

Wireless Sensor Networks, Data aggregation, LEACH routing protocol

I. INTRODUCTION:

Wireless sensor network consists of hundreds to thousands of inexpensive wireless nodes, each with some estimating power and sensing ability, working in an unattended mode. They are intended for a wider range of ecological sensing applications from vehicle tracking to habitat monitoring [1],[2],[3]. A sensor network consists of one or more "sinks" which give to specific data streams by expressing interests or queries. Sensors in the network act as "sources" which detect ecological events and push relevant data to the proper subscriber sinks. During the given time interval all sensors in the subsequent spatial portion of the network act as event based publishers.

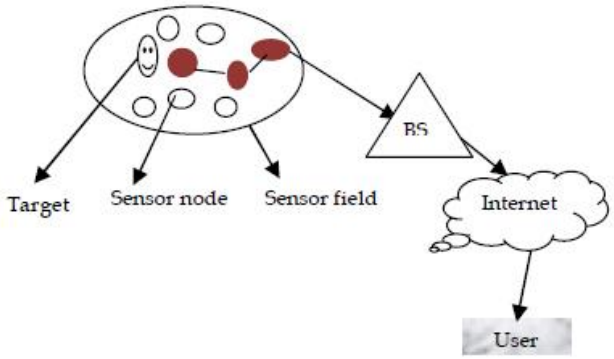

Figure 1 Architecture of the Sensor network

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They publish information toward the subscribing sink if and when they detect the indicated phenomenon. Because of the requirement in remote or even potentially hostile locations, sensor networks are extremely energy-limited. However since various sensor nodes often detect familiar phenomena, there is likely to be some redundancy in the data the various sources communicate to a particular sink. In network filtering and processing techniques can help preserve the scarce energy resources.

Data aggregation has been put forward as an essential paradigm for wireless routing in sensor networks [4],[5]. The idea is to combine the data coming from different sources eliminating redundancy, minimizing the number of transmissions and thus saving energy. Data aggregation is the process of one or more sensors data collect the detect result from other sensor. The collected data must be processed by sensor to shrink transmission burden before they are transmitted to the base station or sink. Wireless sensor network be expressed by three types of nodes. Simple regular sensor nodes, aggregator node and querier. Regular sensor nodes send data packet from the environment and transmit to the aggregator nodes basically these aggregator nodes collect data from multiple sensor nodes of the network, accumulates the data packet using a aggregate functions like sum, avg, count, max and min and then sends aggregates result to upper aggregator node or the querier node who generate the query.

II. DATA AGGREGATION

Data aggregation is the mixture of data from different sources, and can be implemented in a many number of ways. The simplest data aggregation function is to control duplicates. Other aggregate functions could be *max*, *min*, or any other functions with multiple inputs. We make a simplifying assumption - the aggregation function is such that each intermediate node in the routing pass on a single aggregate packet even if it receives multiple input packets. We will refer to the information received by the sink when it has obtained the messages transmitted by all sources in a given flow as a "datum".

A. Optimal Aggregation Say there are k sources, labelled S1 through S_k, and a sink, labelled D. Let the network graph G = (V,E) consist of all the nodes V , with E be contained of edges between nodes that can communicate with each other directly. With the assumption that the number of transmissions from any node in the data aggregation tree is exactly one, the data aggregation tree can be thought of as the reverse of a multicast tree: instead of a single source transfer a packet to all receivers, all the sources are transfer a single packet to the same receiver. It is well-known that the multicast tree with a minimum number of edges is a minimum Steiner tree on the network graph. The following can therefore be readily obtained:

Result 1: Optimum number of transmissions required per datum for the DC protocol is equal to the number of edges in the minimum Steiner tree in the network which contains the node set (S1, ...Sk,D).

Corollary: Assuming an arbitrary placement of sources, and a general network graph G, the task of doing DC routing with optimal data aggregation is NP-hard. The latter follows from the NP-completeness of the minimum Steiner problem on Graphs [6].

B. Suboptimal Aggregation

The following are three generally suboptimal schemes for generating data aggregation trees:

(i). **Center at Nearest Source (CNS)**: The source which is nearest the sink acts as the collection point. All other sources send their data directly to this source which then sends the collected information on to the sink.

(ii) **Shortest Paths Tree (SPT)**: Each source sends its information to the sink along the shortest path between the two. Where these paths overlap for different sources, they are combined to form the aggregation tree.

(iii) **Greedy Incremental Tree (GIT)** : The aggregation tree is built sequentially. At the first phase the tree consists of only the shortest path between the sink and the nearest source. At each stage after that the next source closest to the current tree is connected to the tree. This is by no means an exhaustive list, but is representative of some of the data aggregation tree heuristics that can be implemented.

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III LEACH PROTOCOL

Low Energy Adaptive Clustering Hierarchy (LEACH) protocol is a Time Division Multiple Access (TDMA) based MAC protocol. The principal aim of this protocol is to increase the lifespan of wireless sensor networks by reducing the energy consumption required to create and maintain Cluster Heads. The operation of LEACH protocol contains several rounds with two phases in each [7][8]: Set-up Phase and Steady Phase.

In the Set-up phase the main goal is to create cluster and select the cluster head for each of the cluster by selecting the sensor node with maximum energy. Steady Phase which is relatively longer in duration than the set-up deals mainly with the gathering of data at the cluster heads and transmission of combined data to the Base station.

The algorithm for LEACH protocol is as follows:

The first phase of LEACH is Set-up phase and it has three fundamental steps.

1. Cluster Head Formation

2. Cluster setup

3. Creation of Transmission Schedule

During the first step cluster head send the packet to inform the cluster nodes that they have become a cluster head on the basis of the following formula [9]:

Let x be any random number between 0 and 1. Where n is the given node, p is the probability, r is the current round, G is the set of nodes that were not cluster heads in the previous round, T(n) is the Threshold.

$$T(n) = \begin{cases} \dfrac{P}{1 - P[r * \bmod(1/P)]} & if \ n \in G \\ 0 & otherwise, \end{cases}$$

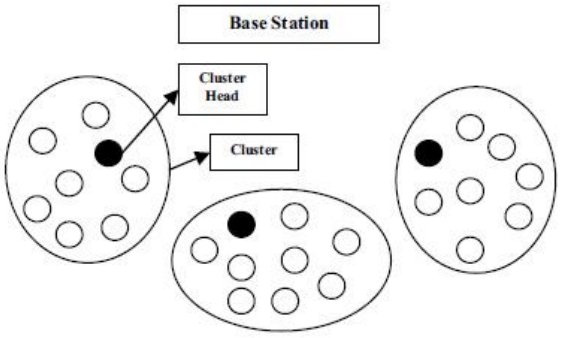

Figure 2 Cluster Formations in LEACH

The node becomes cluster head for the current round if the number is less than threshold T(n). Once the node is selected as a cluster head it cannot become cluster head again until all the nodes of the cluster have become cluster head once. This helps in balancing the energy consumption and suitable for data aggregation. In the second step, the non cluster head nodes get the cluster head information and then send join request to the cluster head that they are the members of the cluster under that cluster head. Non cluster head nodes save a huge amount of energy by turning off their transmitter all the time and turn it ON only when they have something to transmit to the cluster head. In the third step, each of the chosen cluster head creates a transmission schedule for the member nodes of their cluster. Time Division Multiple Access schedule is created according to the number of nodes in the cluster. Each node then transmits its data in the allocated time schedule

The second phase of LEACH is the Steady phase during which the cluster nodes send their data to the cluster head. The number of sensors in each cluster communicate only with the cluster head via a single hop

transmission. The cluster head then aggregates all the collected data and forwards this data to the base station either directly or via other cluster head along with the static route defined in the source code

IV ADVANTAGES OF LEACH PROTOCOL

The various advantages [10] of LEACH protocol are:

1. Cluster Heads aggregates the whole data which lead to reduce the traffic in the entire network.
2. As there is a single hop routing from nodes to cluster head it results in saving energy.
3. It improves the lifetime of the sensor network and used for data aggregation.
4. Location information of the nodes to create the cluster is not required.
5. LEACH is completely distributed as it does not need any control information from the base station as well as no global knowledge of the network is required.

V CONCLUSION

Wireless Sensor Networks would be of great use in future mission applications. If we analyze the previous research, we could examine that a huge work is being carried out on routing i.e. what is the best optimal path for the nodes to communicate with each other. In this paper, we have also discussed LEACH routing protocol for data aggregation in wireless sensor networks. Our analysis has focused on the case where there is a single sink. Although this is a reasonable scenario for many applications, it is reasonable to ask what would happen if there were additional sink. One solution is to think of the different flows in that case as a superposition of many single sink data-flows. However, this would yield an over-estimate of the energy costs, as further aggregation savings can be possible if there are redundancies in the sources and the data being requested by the various sinks.

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