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Implementation of Load Balanced Data Gathering of Nodes in Wireless Sensor Network

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Abstract- Data Gathering is a basic task in Wireless Sensor Networks (WSNs). Data gathering trees capable of performing aggregation operations are also referred to as Data Aggregation Trees (DATs). Recent work focus on constructing DATs according to different user requirements under the Deterministic Network Model (DNM). However, due to the existence of many probabilistic empty links in WSNs, it is more practical to obtain a DAT under the realistic Probabilistic Network Model (PNM). Moreover, the load-balance factor is neglected when constructing DATs in current literatures. Therefore, it is focused on constructing a Load-Balanced Data Aggregation Tree (LBDAT) under the PNM.In this paper, we did simulation of the same as above stated WSN in NS2 network simulator.

Keywords*- WSN, Data Aggregation Trees, Probabilistic Network Model, LBDAT.*

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I. INTRODUCTION

In Wireless Sensor Networks (WSNs), sensor nodes periodically sense the monitored environment and send the information to the sink, at which the gathered/collected information can be further processed for end-user queries. In this data gathering process, data aggregation can be used to fuse data from different sensors to eliminate redundant transmissions, since the data sensed by different sensors have spatial and temporal correlations. Hence, through this in-network data aggregation technique, the amount of data that needs to be transmitted by a sensor is reduced, which in turn decreases each sensor's energy consumption so that the whole network lifetime is extended.

For continuous monitoring applications with a periodical traffic pattern, a tree-based topology is often adopted to gather and aggregate sensing data because of its simplicity. Compared with an arbitrary network topology, a tree-based topology conserves the cost of maintaining a routing table at each node, which is computationally expensive for the sensor nodes with limited resources.

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The investigated problem is distinguished from all the prior works in three aspects. First, most of the current literatures investigate the DAT construction problem under the DNM, whereas the proposed work is suitable for both DNM and PNM. Second, the load-balance factor is not considered when constructing a DAT in most of the aforementioned works. Finally, the DAT construction problem is our major concern, whereas the prior works focus on the aggregation scheduling problem. DAT construction problem is explored under the PNM considering balancing the traffic load among all the nodes in a DAT. To be specific, in this paper, we construct a Load-Balanced DAT (LBDAT) under the PNM in three phases.

II. BACKGROUND

Data gathering trees capable of performing aggregation operations are also referred to as Data Aggregation Trees (DATs), which are directed trees rooted at the sink and have a unique directed path from each node to the sink. Additionally, in a DAT, sensing data from different sensors are combined at intermediate sensors according to certain aggregation functions including COUNT, MIN, MAX, SUM, and AVERAGE. Due to the dense sensor deployment,

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many different DATs can be constructed to relay data from the monitored area to the sink.

According to the diverse requirements of different applications, the DAT related works can be roughly classified into three categories: Energy-Efficient Aggregation Scheduling, Minimum-Latency Aggregation Scheduling and Maximum-Lifetime Aggregation Scheduling. It is worth mentioning that aggregation scheduling attracts a lot of interests in the current literatures. However, unlike most of the existing works which spend lots of efforts on aggregation scheduling, we mainly focus on the DAT construction problem.

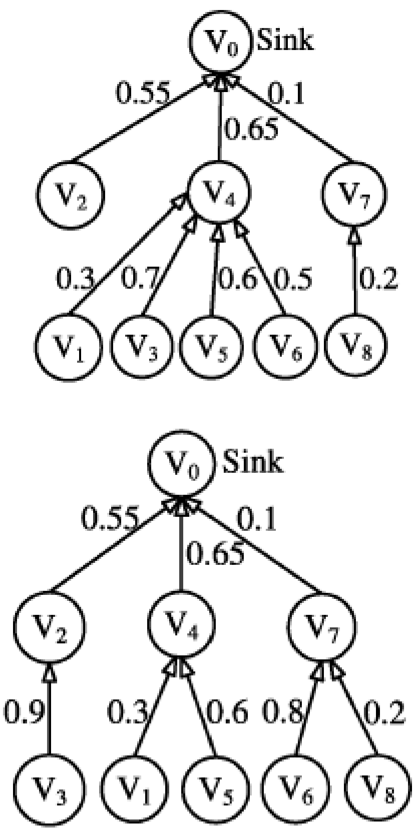

Figure1. DAT

Here, load-balance factor is not considered, while constructing a DAT. Without considering balancing the traffic load among the nodes in a DAT, some heavy-loaded nodes may quickly exhaust their energy, which might cause network partitions or malfunctions. For instance, for aggregating the sensing data from 8 different nodes to the sink node v0, a shortest-path-based DAT for the probabilistic WSN is shown in above figure. The intermediate node v4 aggregates the sensing data from four different nodes, whereas, v7 only aggregates one sensing data from v8. For simplicity, if every link is always there and every node has the same amount of data to be transferred through the intermediate nodes with a fixed data rate, heavy-loaded v4 must deplete its energy much faster than v7. It is known that the intermediate nodes usually aggregate the sensing data from neighboring nodes in a shortest-path-based DAT. Actually, the number of neighboring nodes of an intermediate node is a potential indicator of the traffic load on each intermediate node. However, it is not the only factor to impact the traffic load on each intermediate node. The criterion to assign a parent node, to which data is aggregated for each node on a DAT, is also critical to balance traffic load on each intermediate node.

Load-Balanced DAT (LBDAT)

It refers the procedure that assigns a unique parent node for each node in the network, as the Parent Node Assignment (PNA). Evidently, with respect to load-balance, the PNA shown in the below Fig is the best, which also implies the LBDAT and can extend network lifetime notably compared with the DATs, since the traffic load is evenly distributed over all the intermediate nodes.

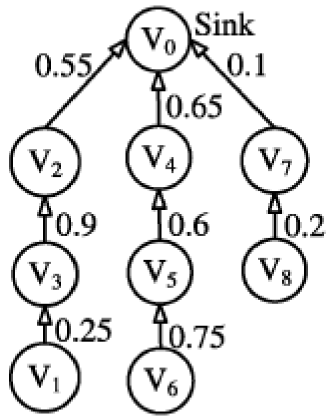

Figure1.2: LBDAT

III. METHODOLOGY FOR CONSTRUCTION OF LBDAT

1. To explore the DAT construction problem under the PNM considering balancing the traffic load among all the nodes in a DAT.
2. To construct a Load- Balanced DAT (LBDAT) under the PNM in three phases.
3. To investigate how to construct a Load-Balanced Maximal Independent Set (LBMIS).
4. To find a minimum-sized set of nodes called LBMIS connector set C to make this LBMIS M connected, which is called the Connected MIS (CMIS) problem.
5. To seek a Load-Balanced Parent Node Assignment (LBPNA).

6. After an LBPNA is decided, by assigning a direction to each link in the constructed tree structure, to obtain an LBDAT.

A. Network Model

First, Create statically connected WSN with the set of 28 nodes one can take any number of nodes and one sink node . All the nodes have the same transmission range. The transmission success ratio associated with each link connecting a pair of nodes is available.It is also assumed that the transmission success ratio values are fixed.

Below isWSN created in NS2 for Network Model stable in a static environment. Furthermore, no node failure is considered since it is equivalent to a link failure case. No duty cycle is considered neither. It is assumed that the n nodes monitor the environment in the deployed area and periodically report the collected data to the sink node v0 along the LBDAT Tree.

Every node produces a data package of B bits during each report interval. Moreover, an intermediate node can aggregate multiple incoming B-bit packets, together with its own package into a single outgoing B-bit package. Furthermore, we assume the data receiving rate of each node vi is γi, and R denotes the maximum data receiving rate of all the nodes. Finally, the degree of a node vi is denoted by di, whereas δ/D denotes the minimum/maximum node degree in the network.

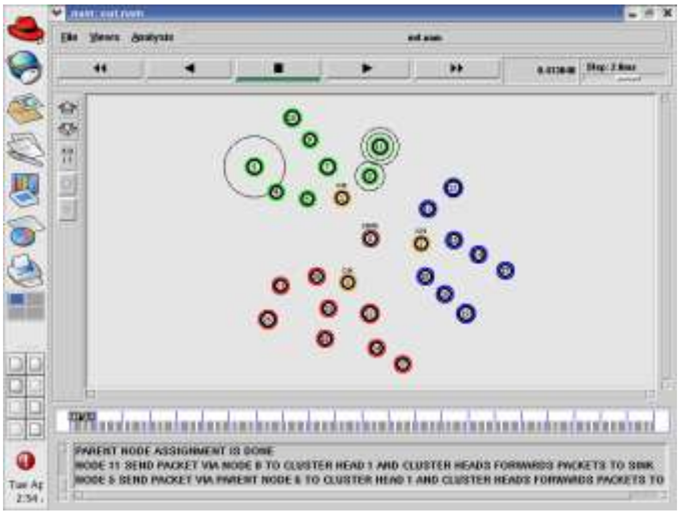

Figure.3.1Snapshot For WSN with 28 nodes.

B. One Hop Neighbor Detection

A sensor network with a graph G(k)= (V(k),e(k)), whose node set V(k) represents the sensor nodes active at time k and the edge set e(k) consists of pairs of nodes (u,v) such that nodes u and v can directly exchange messages between each other at time k. By an active node we mean a node that has not failed permanently. After the successful creation of WSN here NS2 terminal represents one hop neighbor for some nodes.

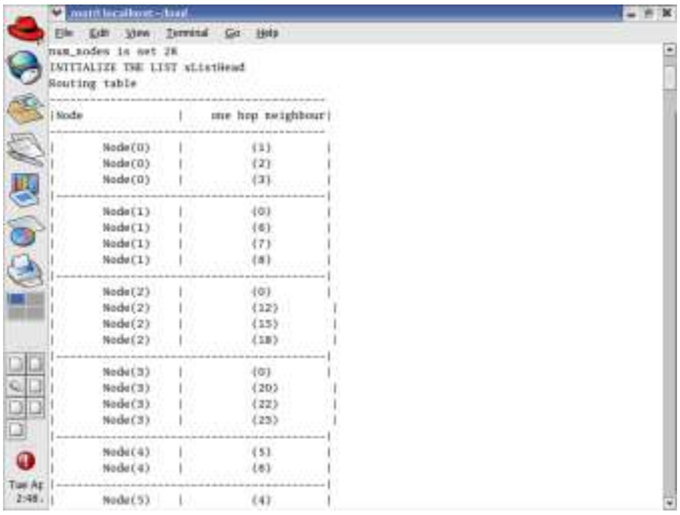

Figure 3.2Snapshot for One hop neighbor of node in WSN

IV.LOAD BALANCED DATA AGRREGATION IN WSN

Load-Balanced Maximal Independent Set (LBMIS) is required to do parent node assignment in WSN. All aggregated data are reported to the sink node, hence the sink node is deliberately set to be an independent node. Since an MIS is also a DS, we should formulate the DS constraint for the LBMIS problem first. The DS property states that each non independent node must reside within the 1-hop neighborhood of at least one independent node. Taking the load-balance factor into consideration, we are seeking an MIS in which the minimum potential load of the nodes in the constructed LBMIS is maximized. In other words, the potential traffic load on each node in the LBMIS is as balance as possible.

Approximation Algorithm to search for an LBMIS

Step 1: Sort sensor nodes by the w_i value (where 1 <= i <=n) in the decreasing order.

Step 2: Set the sink node to be the independent node, i.e., w_0=1.

Step 3: Set all w_i to be 0.

Step 4: Start from the first node in the sorted node array A. If there is no node been selected as an independent node in v_i's 1-hop

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neighborhood, then let $w_i=1$ with probability $p=w_i$.

Step 5: Repeat step 4) till reach the end of array A.

Step 6: Repeat step 4) and 5) for v, $w_i>0$ times.

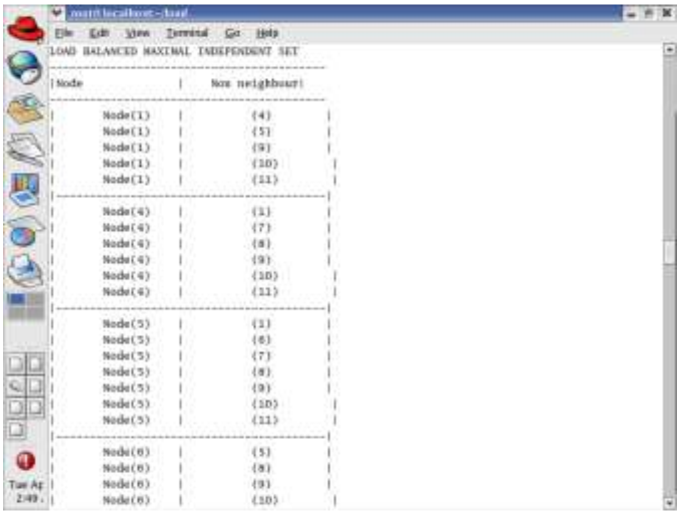

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Figure.4.1 Snapshot For LBMIS

A.Load Balanced Parent Node Assignment

The node ID is used to break the tie (small-ID with higher priority). After applying the above parent node assignment scheme to all the non-leaf nodes, v_i ЄD, its parent node is decided. Furthermore, for each v_i Є D, the traffic load of v_i introduced by its non-leaf child nodes is denoted by ψi. Considering that for v_iЄ D, it can has as many as O(n) leaf children.

A tree structure is decided after the Load-Balanced Parent Node Assignment (LBPNA) A is produced, which includes LBPNA for non-leaf nodes and leaf nodes. By assigning a direction of each link in the constructed tree from the children node to the parent node, an LBDAT is obtained.

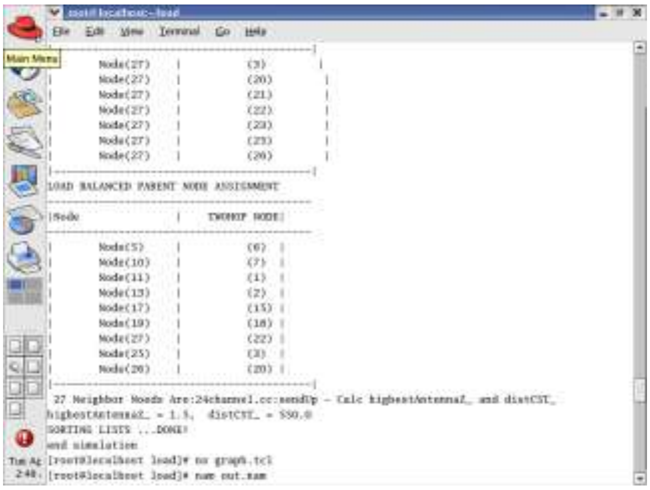

Figure.4.2 Snapshot For Load Balanced Parent Node Assignment

B.Load Balanced DAT in WSN Graph Analysis

The graphs are created for end to end delivery of packets and packet delivery ratio after balancing load of each node in WSN. This analysis for the packet delivery of all the nodes helps to find out the energy of the every node in active WSN.

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C.Load Balanced nodes in WSN

Following final snapshot shows load balanced data gathering of the nodes in WSN with assumption of sink node is active until all the load assignment is done.

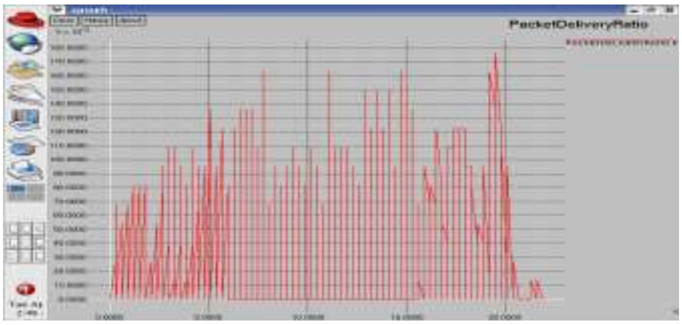

Figure.4.3 Snapshot graph for packet delivery ratio.

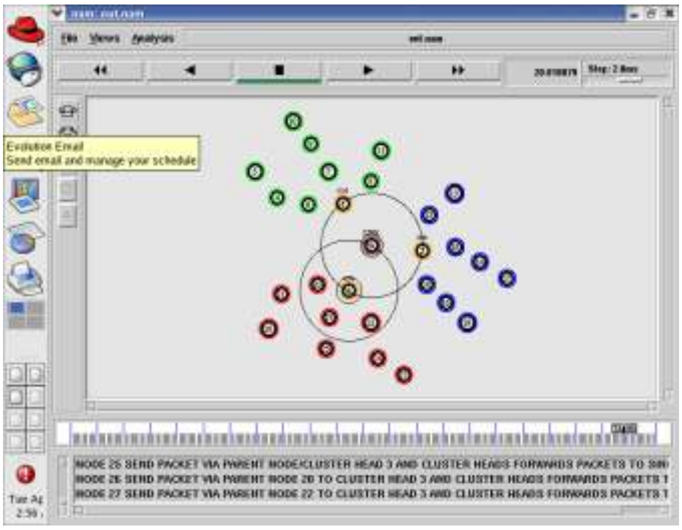

Figure.4. Snapshot For Load Balanced WSN with CH(Cluster Head)

V. CONCLUSION

The simulation results show that the proposed algorithms can extend network lifetime significantly. This is because three phases algorithm used in WSN might lead to performance loss or improvement which did not investigate the correlations among them. This simulation will be used as guideline to design distributed algorithms for the LBDAT construction problem under both DNM and PNM for WSN.

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