IMPLEMENTING LOAD BALANCED DATA AGGREGATION TREE IN WIRELESS SENSOR NETWORK TO ANALYSE AND IDENTIFY NETWORK TRAFFIC

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ABSTRACT

The fundamental task in wireless sensor networks (WSNs) is Data Gathering. Data gathering trees capable of performing aggregation operations are also referred to as Data Aggregation Trees (DATs). It is more practical to obtain a DAT under the realistic Probabilistic Network Model (PNM), due to the existence of many probabilistic lossy links in WSNs. In Wireless Sensor Networks (WSN), the sensor nodes sense the same kind of data and forward it to the sink node. There is a need to eliminate the redundancy in sensed data up to adequate level in order to maintain the tradeoff between energy conservation and reliability. This redundant information sustains the reliability; but at the same time, sink node wastes its energy in processing the redundant data. So Data Gathering is a crucial technique in Wireless Sensor Networks (WSNs). Moreover, the load-balance factor is neglected when constructing DATs in current literatures. Therefore, this paper focuses on constructing a technique through which the heavy loaded traffic on the node is reduced, which in turn decreases each node's energy consumption so that the whole network lifetime is extended and to build the load balanced DAT under PNM

Keywords- Data Aggregation Tree, Wireless Sensor Networks, Probabilistic Network Model, Load Balanced Data Aggregation Tree, Energy Consumption.

I. INTRODUCTION

Mostly, a large number of sensor nodes in a typical wireless sensor network gather application oriented information from the environment and transfer this information to a central base station where it is processed, analyzed and used by the application. Wireless sensor network is a resource constrained network; the general approach followed is to mutually handle the data created by different sensor nodes before being forwarded toward the base station. Such distributed in-network processing of data is generally known as data. The primary objective of data aggregation is to expand the network lifetime by reducing the resource consumption of sensor nodes. In order to reduce the communication overhead and energy consumption of sensors while gathering, the received data can be combined to reduce message size. A simple way of doing that is aggregating the data. An example application is radiation level monitoring in a nuclear plant where the maximum value provides the most useful information for the safety of the plant. One of the main aspects of tree-based networks is the construction of an energy efficient data aggregation tree. Most of the current literatures investigate the DAT construction under the deterministic network model (DNM). In DNM there exist the “transitional region” phenomenon Beyond the ‘‘always connected’’ region, there is a transitional region where a pair of nodes are probabilistically connected via the so called lossy links. Load-balance factor is not considered when constructing a data aggregation tree (DAT). These strategies causes following disadvantages:

- 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.
- Heavy loaded traffic causes end to end delay in data delivery
- Usually there are much more lossy links than fully connected links in a WSN. Data transmissions over lossy links cannot be guaranteed. These lossy links are responsible for the transmission of malicious packets.

II. PROPOSED SYSTEM

As without data aggregation, the energy consumption of a particular node is increased due to redundant transmission of data. Also it is critical to balance traffic load on each node. In this paper, to prevent energy consumption of a particular node, we have developed and analyzed a technique is in which the amount of data that needs to be transmitted by the node is reduced, which in turn decreases each node’s energy consumption so that the whole network lifetime is extended. Also potential load is defined to measure load balance of the nodes in a DAT. Under Probabilistic Network model (PNM), there is a transmission success ratio associated with each link connecting a pair of nodes which is used to indicate the probability that a node can successfully deliver a package to another. Thus WSN is fully characterized.

2.1 Algorithm

2.1.1 Network Creation

The network consists of a collection of nodes connected via wireless links. Nodes may communicate directly if they are within communication range, or indirectly via multiple hops in the network structure, the nodes are in tree structure with two levels wherein 2nd level nodes will be indirectly connected to 1st level which will finally be connected to the main node. Thus the network will have 2 sub trees. Sensor Network communication using AODV will be facilitated.

III. LOAD BALANCED NETWORK IDENTIFICATION

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This module will analyze load handled by each of the nodes and identify behavior of each node to facilitate optimized data transmission. Identification is done in following steps:

- **Identify independent nodes:** A minimum-sized set of nodes are identified to make the load balanced maximum independent set connected and one sink node v0. All aggregated data are reported to the sink node, hence the sink node is deliberately set to be an independent node. All the nodes have the same transmission range. The transmission success ratio associated with each link connecting a pair of nodes is available, which can be obtained by periodic hello messages. The links are undirected (bidirectional), which means two linked nodes are able to transmit and receive information from each other with the same value. Since load-balance is the major concern of this work we first define potential load to measure the potential traffic load on each node. Taking the load-balance factor into consideration, we seek 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.
- **Identify connecting nodes:** Connecting nodes are identified with respect to source or sink node v0. While finding the connecting nodes, it must satisfy the condition that two independent nodes should not be neighbours to each other. The dependent nodes (white nodes) are assigned as 0 and the independent nodes (black nodes) are assigned as 1. Thus a dependent node can have one or multiple independent nodes.
- **Identify connecting links & connected network:** A sensor network consists of pairs of nodes such that nodes can directly exchange messages between each other. An active node is a node that has not failed permanently. The number of neighbours of node is called its degree. A path formed between the pair of nodes is a sequence of edges connecting them. A graph is called connected if there is a path between every pair of nodes. From source node to destination node, neighbour of a source node are taken and all possible paths are created.

IV. LOAD BALANCED TRANSMISSION WITH DATA AGGREGATION

This module will analyze the network traffic transmitted by leaf nodes and identify the energy consumption of each node. Also it will analyze the end to end delay and throughput of the data transmitted.

4.1 Network Simulator

A network simulation is a virtual representation of a network. In current era, the simulation is one of the most important technologies which simulate the imaginary and real life objects on computer. The basic idea to study the simulator in computer is same as it can model hypothetical and real life objects. To simulate or implement a network on computer a technique is used called network simulation. “The Network Simulator provides an integrated, versatile, easy-to-use GUI-based network designer tool to design and simulate a network. These network simulator are used to

- Specifying nodes
- Specifying the link between those nodes

- Specifying the traffic between these nodes
- Specifying everything about the protocols that used to handle traffic in the network.
- Visualize the working of network graphical applications
- Customization text based applications.
- Providing a programming environment that customized to create an application that test the networking environment.

Category	Network Simulator Name
Commercial	OPNET, QualNet
Open Source	NS2, NS3, OMNET++, SSFNet, J-Sim

Table1: Network Simulators

4.1.1 Network Simulator – 2 (NS2)

The one of the most widely used network simulators and object-oriented discrete-event network simulator is NS-2 that was originally developed at Lawrence Berkeley Laboratory at the University of California. Basically it was designed for network research community to simulate routing algorithms, TCP/IP protocols and multicast. It is written in C++ and uses OTcl as a command and configuration interface.

Features of NS-2:

- It is a discrete event simulator for networking research
- It provides substantial support to simulate bunch of protocols like TCP, FTP, UDP, HTTP and DSR.
- It simulates wired and wireless network.
- It is primarily Unix based.
- Uses TCL as its scripting language.
- OTcl: Object oriented support.
- Tclcl: C++ and otcl linkage.
- Discrete event scheduler.

V. PERFORMANCE EVALUATION

The main constraint of sensor nodes is their very low finite energy, which limits the lifetime and the quality of the network. For that reason, the data running on sensor networks must consume the resources of the nodes efficiently in order to achieve a longer network lifetime. Graph1 shows the energy analysis of the nodes. It is seen that node ID is defined on x-axis and energy left is defined on y-axis. Table 2 shows that without aggregation, the energy consumption of the nodes in the network is not equally distributed. Nodes 7, 18, 23 are

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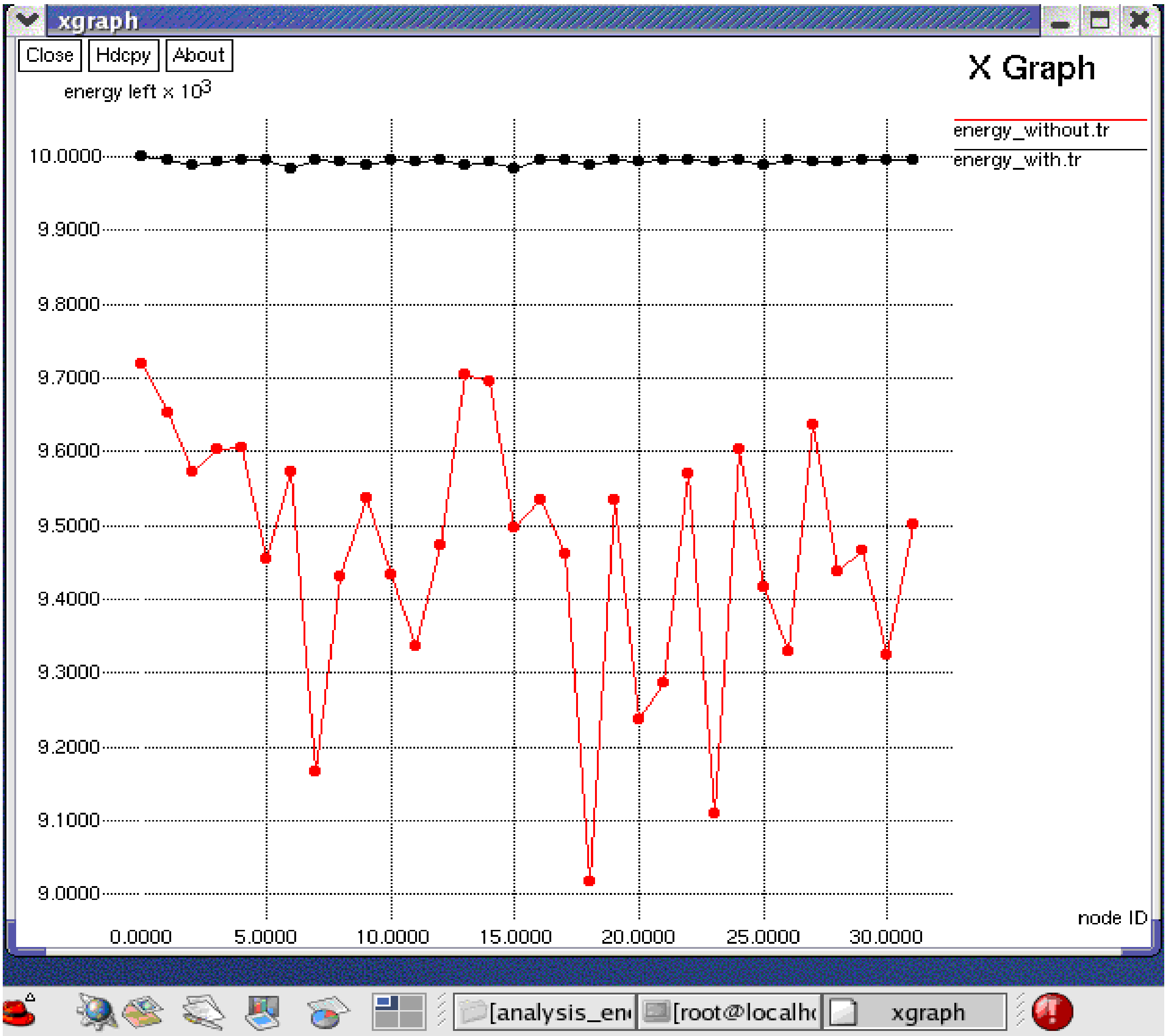
more exhausted due to heavy loaded traffic at this nodes. With aggregation, the traffic load is evenly distributed over all the intermediate nodes which in turn have decreased each node's energy consumption upto 82.9%, 97.1% and 88.3% respectively.

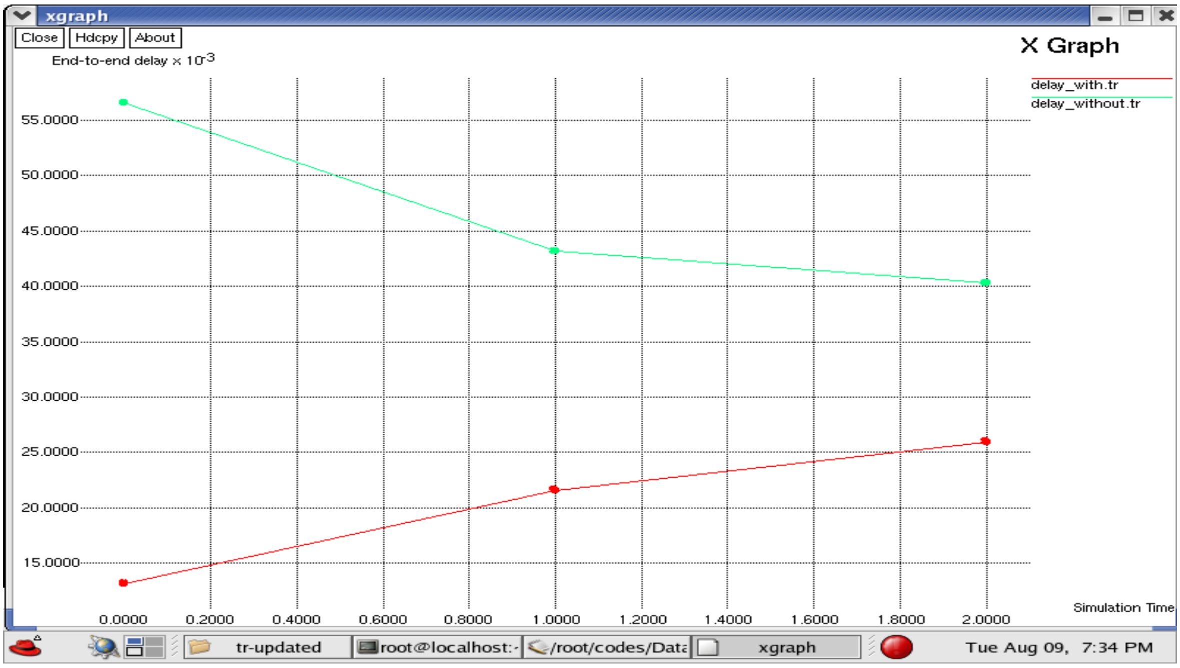


Graph1. Energy Analysis

Node ID	Energy Consumption without aggregation	Energy Consumption with aggregation	Diff-erence (%)	Node ID	Energy consumption without aggregation	Energy Consumption with aggregation	Diff-erence (%)
0	*9.718*	*10.000*	*28.2*	*16*	*9.535*	*9.996*	*46.1*
1	*9.653*	*9.996*	*34.3*	*17*	*9.462*	*9.996*	*53.4*
2	*9.572*	*9.988*	*41.6*	***18***	***9.017***	***9.988***	***97.1***
3	*9.603*	*9.992*	*38.9*	*19*	*9.535*	*9.996*	*46.1*
4	*9.606*	*9.996*	*39.0*	*20*	*9.238*	*9.992*	*75.4*
5	*9.454*	*9.996*	*54.2*	*21*	*9.286*	*9.996*	*71.0*
6	*9.573*	*9.984*	*41.1*	*22*	*9.570*	*9.996*	*42.6*
7	***9.167***	***9.996***	***82.9***	***23***	***9.109***	***9.992***	***88.3***
8	*9.430*	*9.992*	*56.2*	*24*	*9.603*	*9.996*	*39.3*
9	*9.536*	*9.988*	*45.2*	*25*	*9.417*	*9.988*	*57.1*
10	*9.432*	*9.996*	*56.4*	*26*	*9.328*	*9.996*	*66.8*
11	*9.337*	*9.992*	*65.5*	*27*	*9.636*	*9.992*	*35.6*
12	*9.473*	*9.996*	*52.3*	*28*	*9.437*	*9.992*	*55.5*
13	*9.705*	*9.988*	*28.3*	*29*	*9.467*	*9.996*	*52.9*
14	*9.696*	*9.992*	*29.6*	*30*	*9.325*	*9.996*	*67.1*
15	*9.497*	*9.984*	*48.7*	*31*	*9.502*	*9.996*	*49.4*

Table2. Result of energy analysis

End - to- end delay or one way delay refers to the time taken for a packet to be transmitted across a network from source to destination. As the traffic is balanced on each node the delay in transmitting the data from leaf nodes to root node is also reduced. Graph 2 shows the end to end delay analysis. As seen from the results in table 3, after aggregation the end to end delay is decreased by a difference of 4.34s, 2.15s and 1.44s at time instances 0, 1 and 2 respectively.

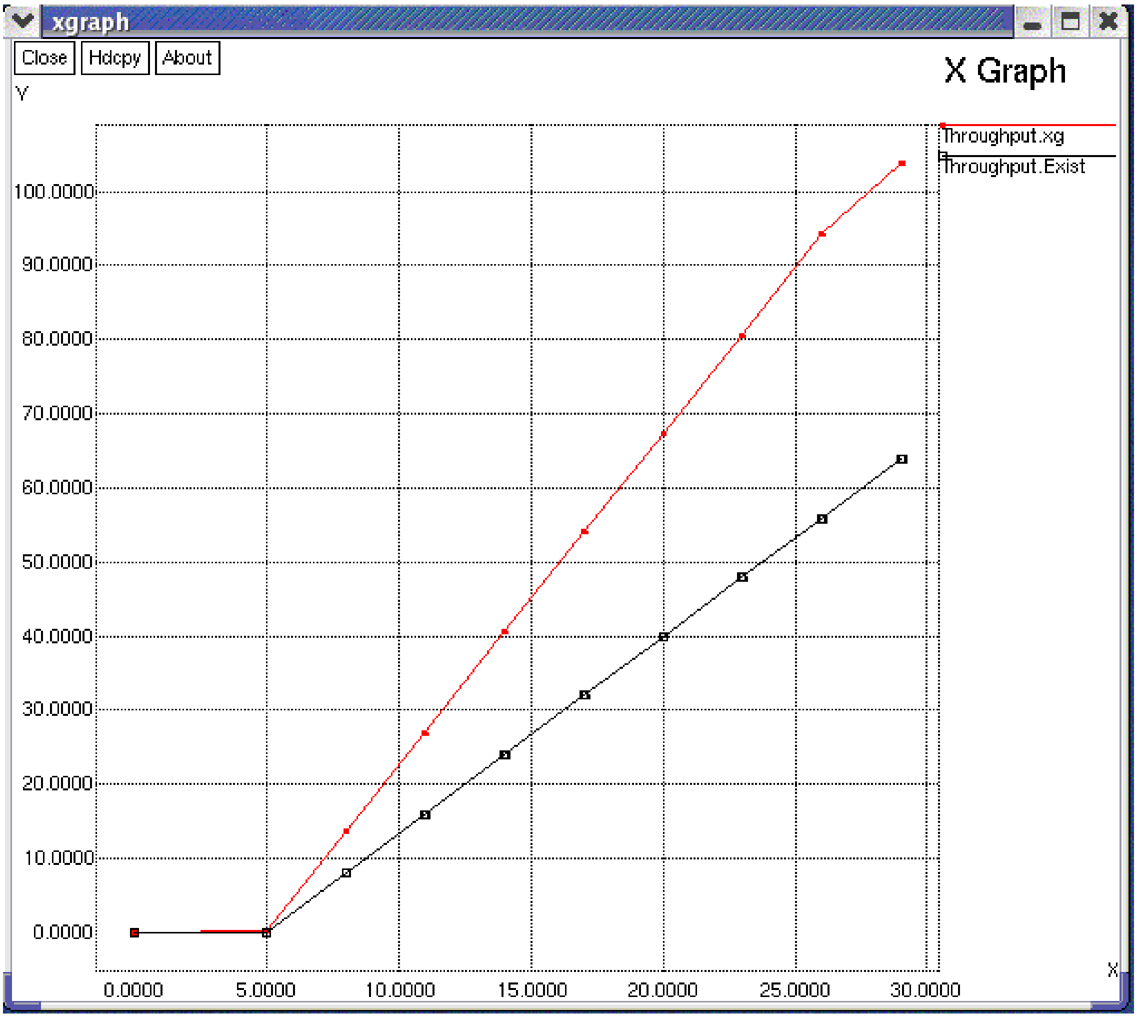


Graph2. End-to-end delay

Simulation time (s)	***End to End Delay without Aggregation***	***End to End Delay with Aggregation***	***Difference***
0	***0.0565***	***0.0131***	***4.34***
1	***0.0431***	***0.0216***	***2.15***
2	***0.0403***	***0.0259***	***1.44***

Table3. Results of End-to-end delay

Throughput is the rate of successful message delivery over a communication channel. In other words throughput is the traffic received by at the destination node i.e. packets/sec. As the delay is decreased, it is observed from graph3 in which throughput is plotted across different simulation time intervals on x-axis are increased. The difference between both the plots is clearly visible in the results of table4 showing that aggregation improves the throughput parameter of the network upto 39.847



Graph3. Throughput

Simulation time (s)	***Throughput without Aggregation***	***Throughput with Aggregation***	***Difference***
0	***0***	***0***	***0***
5	***0.0568***	***0.170***	***0.1132***

8	***7.923***	***13.637***	***5.714***
11	***15.923***	***26.970***	***11.047***
14	***23.923***	***40.570***	***16.647***
17	***31.923***	***54.170***	***22.247***
20	***39.923***	***67.370***	***27.447***
23	***47.923***	***80.570***	***32.647***
26	***55.923***	***94.170***	***38.247***
29	***63.923***	***103.77***	***39.847***

Table3. Results of Throughput

VI. CONCLUSION

The fundamental problems of constructing a load balanced DAT in probabilistic WSNs were studied. In the first part, we find the optimal MIS such that the minimum potential load of all the independent nodes is maximized. We adopted a tree based topology to gather and aggregate sensing data because of its simplicity for continuous monitoring of periodical traffic. We constructed the balanced tree in probabilistic network model to eliminate redundant transmissions. We identified independent nodes, connecting nodes and also connecting links & connected network. We had built the network under PNM, so as to fully characterize the network and to decrease the data transmission over lossy links. Thus we have successfully implemented a load balanced DAT under probabilistic network model and thus extended the network's lifetime by reducing its energy consumption.

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