Probabilistic Network Model (PNM) Based Data Aggregation Method for Load Balancing In WSN

Ms. Jayashree A.Vanmali[1], Prof. Rahul Patil[2]
[1]PG Scholar, Computer Engineering Department, Bharati Vidyapeeth College Of Engineering, Navi Mumbai, India
[2]Assistant Professor, Computer Engineering Department, Bharati Vidyapeeth College Of Engineering, Navi Mumbai, India

Email: jagruti.vanmali@yahoo.com

Abstract— Data aggregation is the process of collecting and aggregating the useful data. Data aggregation is considered as one of the fundamental processing procedures for saving the energy. Advancement in computing technology has led to the production of wireless sensors capable of observing and reporting various real world phenomena in a time sensitive manner. However such systems suffer from bandwidth, energy and throughput constraints which limit the amount of information transferred from end-to-end. Data aggregation is a known technique addressed to alleviate these problems but is limited due to their lack of adaptation to dynamic network topologies and unpredictable traffic patterns. In WSN, data aggregation is an effective way to save the limited resources. The main goal of data aggregation algorithm is to gather and aggregate data in an energy efficient manner so that network lifetime is enhanced. Wireless sensor nodes are very small in size and have limited processing capability and very low battery power. This restriction of low battery power makes the sensor network prone to failure. Data aggregation is a very crucial technique in WSNs. Data aggregation helps in reducing the energy consumption by eliminating redundancy. Most of the existing DAT construction works are based on the ideal Deterministic Network Model (DNM), where any pair of nodes in a WSN is either connected or disconnected. Under this model, any specific pair of nodes is neighbors if their physical distance is less than the transmission range, while the rest of the pairs are always disconnected. However, in most real applications, the DNM cannot fully characterize the behaviors of wireless links due to the existence of the transitional region phenomenon. The load-balance factor is also neglected when constructing DATs in current systems. And most of the current literatures investigate the DAT construction problem under the DNM.

In this project we are concentrating on load balancing factor and also on construction of DAT using Probabilistic Network Model (PNM). Therefore, it is focused on constructing a Load-Balanced Data Aggregation Tree (LBDAT) under the PNM. More specifically, three problems are investigated, namely, the Load-Balanced Maximal Independent Set (LBMIS) problem, the Connected Maximal Independent Set (CMIS) problem, and the LBDAT construction problem. LBMIS and CMIS are well-known NP-hard problems and LBDAT is an NP-complete problem.LBDAT will be NP-Complete and will be constructed in three steps: Load-Balanced Maximal Independent Set (MDMIS), Connected Maximal Independent Set (CMIS) and Load-Balanced Parent Node Allocation (LBPNA). Approximation algorithms and performance ratio analysis will also be covered. The simulation is done using NS2 tool.

Keywords— Sensor node, Data collection, Data aggregation, WSN, Network load balancing, Data Aggregation Trees (DATs), Load-Balanced Data Aggregation Tree (LBDAT), Deterministic Network Model (DNM), Probabilistic Network Model (PNM)

INTRODUCTION

Wireless sensor networks have limited computational power, limited memory and battery power, hence increased complexity for application developers which results in applications that are closely coupled with network protocols. In Wireless Sensor Networks (WSNs), sensor nodes periodically sense the monitored environment and send the information to the sink (or base station), at which the gathered/collected information can be further processed for end-user queries. In this data gathering process, data aggregation[1,2,4] 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.

Data coming from multiple sensor nodes is aggregated as if they are about the same attribute of the phenomenon when they reach the same routing node on the way back to the sink. Data aggregation is a widely used technique in wireless sensor networks. The security issues, data confidentiality and integrity, in data aggregation become vital when the sensor network is deployed in a hostile environment. Data aggregation is a process of aggregating the sensor data using aggregation approaches. Sensor nodes are deployed in remote environments to a multi-hop WSN over a wide range of area. Very rarely do the users have global information on the sensor nodes' distribution. That is why when users request state-based sensor readings of the attributes like temperature and humidity in an arbitrary area, networks may suffer the unpredictable heavy traffic. This problem needs data aggregation to comply with user requirements and manage overlapped aggregation trees of multiple users efficiently.

Data Gathering is a fundamental task in Wireless Sensor Networks (WSNs). Data gathering trees capable of performing aggregation operations are also referred to as Data Aggregation Trees (DATs).Existing works spend lots of efforts on aggregation scheduling and not on the DAT construction problem. Existing DAT construction works are based on the ideal Deterministic Network Model (DNM), where any pair of nodes in a WSN is either connected or disconnected. They did not consider the load-balance factor when they construct 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.

Key Points in data aggregation are as follows:

i. Nodes sense attributes over the entire network and route to nearby nodes.
ii. Node can receive different versions of same message from several neighboring nodes.
iii. Communication is usually performed in the aggregate.
iv. Neighboring nodes report similar data.
v. Combine data coming from different sources and routes to remove redundancy.

Most of the existing DAT[5] construction works are based on the ideal Deterministic Network Model (DNM), where any pair of nodes in a WSN is either connected or disconnected. Under this model, any specific pair of nodes is neighbors if their physical distance is less than the transmission range, while the rest of the pairs are always disconnected. However, in most real applications, the DNM cannot fully characterize the behaviors of wireless links due to the existence of the transitional region phenomenon. The load-balance factor is also neglected when constructing DATs in current systems. And most of the current literatures investigate the DAT construction problem under the DNM.

In this paper we are discussing on load balancing factor and also on construction of DAT using Probabilistic Network Model (PNM). Therefore, it is focused on constructing a Load-Balanced Data Aggregation Tree (LBDAT) under the PNM. More specifically, three problems are investigated, namely, the Load-Balanced Maximal Independent Set (LBMIS) problem, the Connected Maximal Independent Set (CMIS) problem, and the LBDAT construction problem. LBMIS and CMIS are well-known NP-hard problems and LBDAT is an NP-complete problem.

The main contributions of this paper are summarized as follows:

i. Analysis of Data aggregation technique
ii. Constructing a Load-Balanced Data Aggregation Tree (LBDAT) under the PNM
iii. Investigation of three problems namely, the Load-Balanced Maximal Independent Set (LBMIS) problem, the Connected Maximal Independent Set (CMIS) problem, and the LBDAT construction problem
iv. Simulation using NS-2.34 under Fedora Linux environment.

METHODOLOGY

WSNs are one of the most important technologies which are used in a variety of applications. To impact these applications in a real-world environment, we need more efficient strategies to guarantee secure communication on the sensor readings as well as to maximize the whole network lifetime. Since the sensor nodes are equipped with limited energy batteries, the energy conservation is the primary challenge for WSNs.We solved the LBDAT construction problem in three phases in this paper. First, we constructed a Load-Balanced Maximal Independent Set (LBMIS), and then we selected additional nodes to connect the nodes in LBMIS, denoted by the Connected MIS (CMIS) problem. Finally, we acquired a Load-Balanced Parent Node Assignment (LBPNA). After LBPNA is determined, by assigning a direction of each link in the constructed tree structure, we obtain an LBDAT.

A. Data Aggregation overview[13]

Data aggregation is the process of collecting and aggregating the useful data. Data aggregation is considered as one of the fundamental processing procedures for saving the energy. A data aggregation scheme is energy efficient if it maximizes the functionality of the network. If we assume that all sensors are equally important, we should minimize the energy consumption of each sensor. As soon as a query is sent by the BS to a sensor, the first step followed is to handle the query. This is followed by data collection from sources and aggregation of that data.
Network Data aggregation is of two types:

a. Address-centric (AC) and
b. Data-centric (DC)

a) Address-centric (AC)

In AC routing protocol [2], query is routed to a specific address or a given sensor based on the address specified in the query. Each source independently Address Centric Routing sends data along the shortest path to sink ("end to-end routing"). Data is then sent from this specific location to the BS(Base Station). The source with the address specified in the query, sends its data directly to the BS.

b) Data-centric (DC)

However, in DC routing [2], based on the condition specified in the query, all sensors satisfying that condition, need to respond and therefore, the query is broadcast to all the nodes (within range) in the network.

B. Probabilistic Network Model (PNM) based data aggregation method

We solve the LBDAT construction problem in three phases in this paper. First, we construct a Load-Balanced Maximal Independent Set (LBMIS), and then we select additional nodes to connect the nodes in LBMIS, denoted by the Connected MIS (CMIS) problem. Finally, we acquire a Load-Balanced Parent Node Assignment (LBPNA). After LBPNA is determined, by assigning a direction of each link in the constructed tree structure, we obtain an LBDAT. In this subsection, we formally define the LBMIS, CMIS, LBPNA, and LBDAT construction problems sequentially. The proposed method can be implemented using following flow(Fig.1)[13].The simulation parameters[13] are shown in table 1.And data aggregation for different network based schemes[1] are shown on Fig.2.

TABLE1
Simulation Parameters

Parameter/Specification	Details
No. of Nodes	50
Topology (Area)	500x500
NS2 version	NS2.34
Simulation Time	100 sec
Maximum Packet sent per second	1000
Energy threshold	0.3dbm

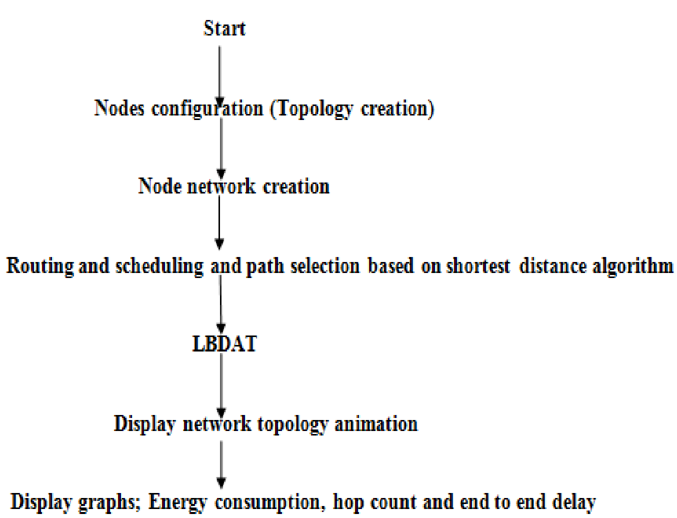


Fig.1.Method Flow

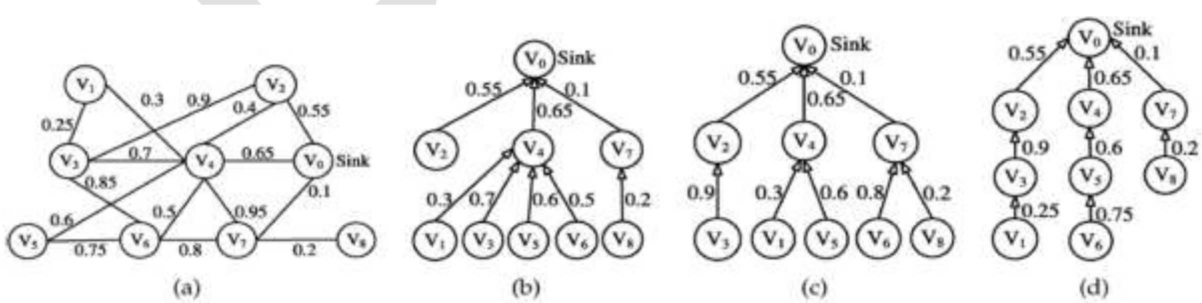


Fig.2.Data aggregation: Probabilistic WSN(a), DATs(b and c), and an LBDAT(d)

In this paper, we addressed the fundamental problems of constructing a load-balanced DAT in probabilistic WSNs. We first solved the CMIS problem, which is NP-hard, in two phases. In the first phase, we found the optimal MIS such that the minimum potential load of all the independent nodes is maximized. To this end, a near optimal approximation algorithm is provided. In the second phase, the minimum-sized set of LBMIS connectors are found to make the LBMIS connected. The theoretical lower and upper bounds of the number of non-leaf nodes are analyzed as well. Subsequently, we studied the LBDAT construction problem and provided an approximation algorithm by using the linear relaxing and random rounding techniques. After an LBPNA is decided, by assigning a direction to each link, we obtain an LBDAT.

SIMULATION RESULTS

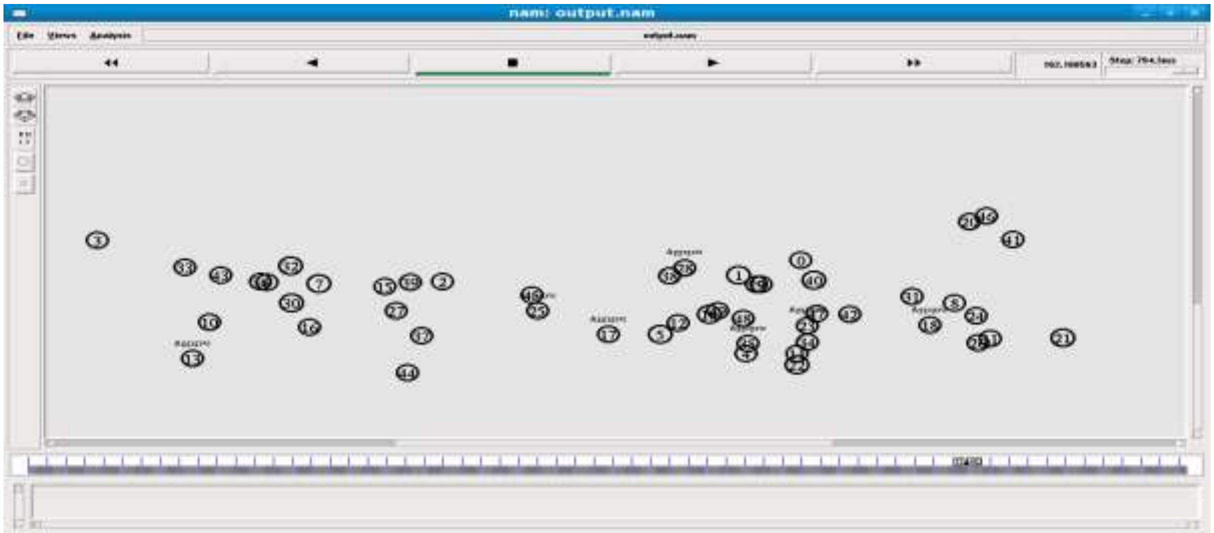
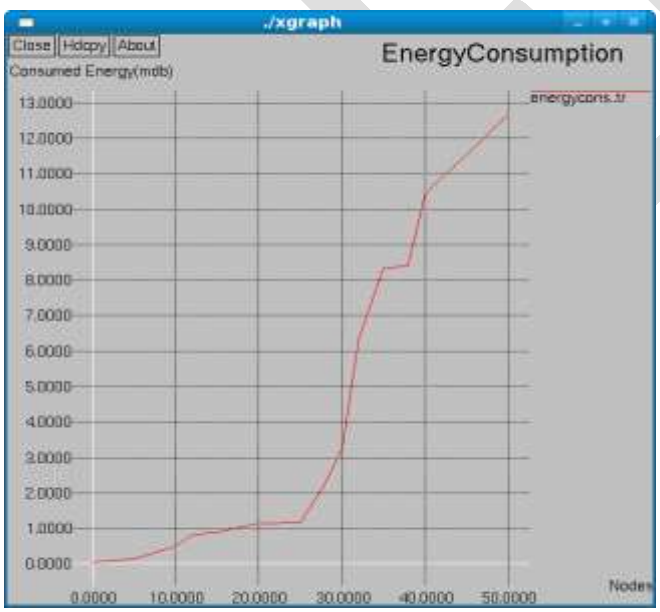


Fig.3.Animation View in NS2



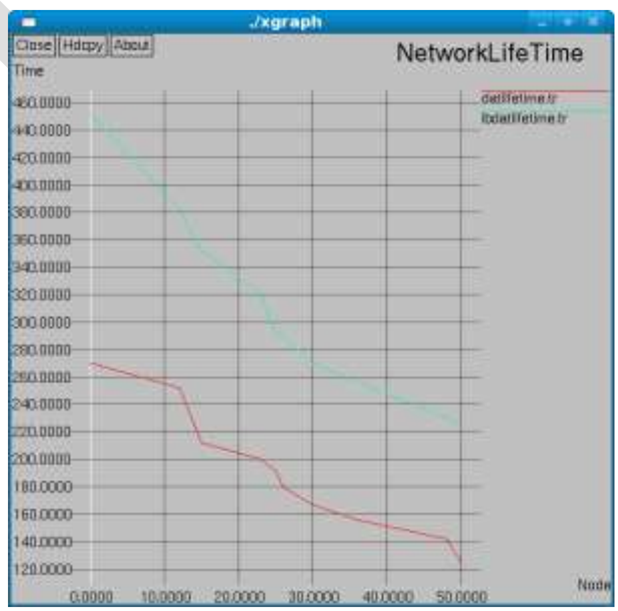


Fig.4.Energy Consumption graph

Fig.5.Network Life time graph

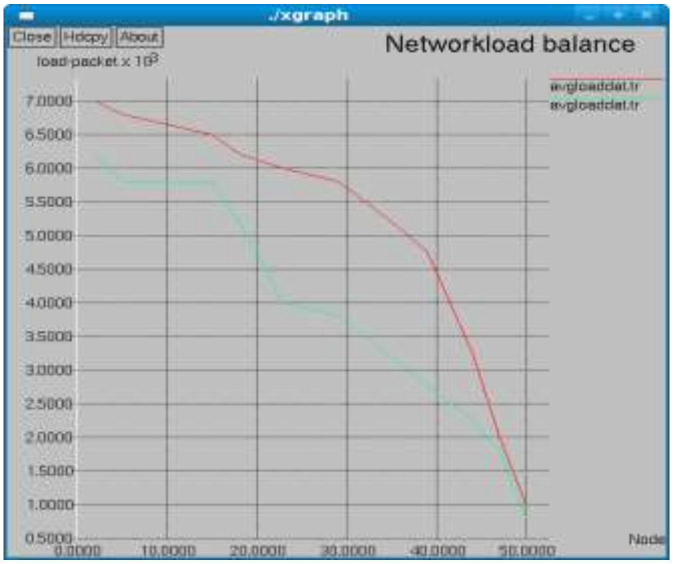


Fig.6.Network Load Balance graph

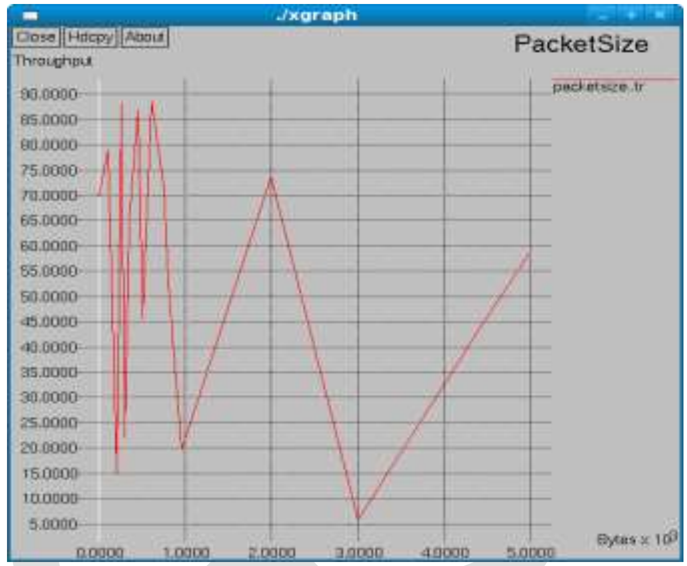


Fig.7.Packet size graph

CONCLUSION

From the simulations, we can study the parameters for the mentioned method .The network life time, energy consumptions and load balancing signifies the significance and effectiveness of the method. We studied the WSN and data aggregation in WSN. In this paper we concentrated on load balancing factor and also on construction of DAT using Probabilistic Network Model (PNM). Therefore, it is focused on constructing a Load-Balanced Data Aggregation Tree (LBDAT) under the PNM as shown in figure 6. More specifically, three problems are investigated, namely, the Load-Balanced Maximal Independent Set (LBMIS) problem, the Connected Maximal Independent Set (CMIS) problem, and the LBDAT construction problem. LBMIS and CMIS are well-known NP-hard problems and LBDAT is an NP-complete problem. LBDAT will be NP-Complete and will be constructed in three steps: Load-Balanced Maximal Independent Set (MDMIS), Connected Maximal Independent Set (CMIS) and Load-Balanced Parent Node Allocation (LBPNA). The results show importance of the method.

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