Adaptive Data Aggregation method for WSN

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Abstract— A wireless sensor network (WSN) of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. There are various data aggregation models designed for WSN, mainly cluster based and tree based. Both of these model have some of advantages and disadvantages constrained upon the scenario. This abstract summarizes the proposed work of adaptive and effective solution to overcome the disadvantages of both models depending upon the scenario. The main aim is to increase the lifetime of a wireless sensor network.

Keywords— Wireless Sensor Network, Data Aggregation, Tree model, Cluster model, Wireless Sensor Node.

I. INTRODUCTION

Wireless sensor network Sensor networks are collection of sensor nodes which co-operatively send sensed data to base station. As sensor nodes are battery driven, an efficient utilization of power is essential in order to use networks for long duration hence it is needed to reduce data traffic inside sensor networks, reduce amount of data that need to send to base station. The main goal of data aggregation models is to gather and aggregate data in an energy efficient manner so that network lifetime is enhanced. Wireless sensor networks (WSN) offer an increasingly Sensor nodes need less power for processing as compared to transmitting data. It is preferable to do in network processing inside network and reduce packet size. One such approach is data aggregation which attractive method of data gathering in distributed system architectures and dynamic access via wireless connectivity. Wireless sensor networks have limited
computational power and limited memory and battery power, this leads to increased complexity for application developers and often results in applications that are closely coupled with network models and protocols.

Data produced by nodes in the network propagates through other nodes in the network via wireless links. When compared to local processing of data, wireless transmission is extremely expensive. Researchers estimated that sending a single bit over radio is at least three orders of magnitude more expensive than executing a single instruction. With the new developments in the hardware of the motes, increasing memory size is giving us the chance to process the data, perform buffer management operations, so as to reduce the number of trans-actions over the radio. For Scalability and flexibility of WSN applications, we need to consider data aggregation as its results in energy saving and optimized performance. Indeed, several research efforts have been proposed in different forms of aggregation to achieve energy efficiency.

The aggregation process can be lossless or lossy. In lossless aggregation, more information is embedded into a single packet (instead of one packet for every information) thereby combining all headers into single header and same data bits. In lossy aggregation many data packets are passed through aggregation function that generates a single packet which has no information about the original data. These functions are computed by the intermediate nodes based on the data received. Thus, at each intermediate node, the amount of outgoing data is considerably lower than the amount inputted, resulting in increase of computational overhead thereby decreasing the transmitted data. The degree of aggregation (DoA) is defined as the ratio of number of bits present in all the packets considered for aggregation in one round of aggregation and the number of bits present in the aggregated packet.

There are two different types of routing in WSN literature, namely address centric and data centric. Data centric routing is used as one of the key techniques to support in-network aggregation. Based on the data rather than the data sources and destinations, data centric routing aims to find path from multiple sources to a single destination that promote data aggregation.

Another approach is using hierarchies, where sensor nodes are usually organized into clusters. To perform the data aggregation nodes communicate with each other and form the clusters in order to share their sensed data. Even though such energy savings are desirable, data aggregation is sensitive with delay. WSNs have wide range of applications. We focus on adaptive data aggregation technique that target all classes of sensor network applications from monitoring to industrial grade applications.

With advance in technology, sensor networks composed of small and cost effective sensing devices equipped with wireless radio transceiver for environment monitoring have become feasible. The key advantage of using these small devices to monitor the environment is that it does not require

infrastructure such as electric mains for power supply and wired lines for Internet connections to collect data, nor need human interaction while deploying. These sensor nodes can monitor the environment by collecting information from their surroundings, and work cooperatively to send the data to a base station, or sink, for analysis. The main goal of data aggregation algorithms is to gather and aggregate data in an energy efficient manner so that network lifetime is enhanced. Wireless sensor networks (WSN) offer increasingly attractive models of data gathering in distributed system architectures and dynamic access via wireless connectivity.

Various data aggregation techniques in WSNs are classified as follows:
1) Structure free data aggregation
2) Structured data aggregation
3) Data aggregation in Flat networks
4) Hierarchical or cluster based Data Aggregation.

The models for data aggregation considered here are:
1. Cluster based model
2. Tree based model

1. Cluster based model

In this approach, entire network is divided in to number of clusters. There is a cluster-head in each cluster, which is selected among cluster members. Cluster-heads do the role of aggregator which aggregate data received from cluster members locally and after that transmit it to the base station (sink).

Wireless sensor network is resource constraint that's why sensor cannot directly transmit data to the base station. In which all regular sensors can send data packet to a cluster head (local aggregator) which aggregates data packet from all the regular sensors in its cluster and sends the concise digest to the base station. With the help of the scheme we save the energy of the sensors. In energy-constrained sensor networks of large size, it is inefficient for sensors to transmit the data directly to the sink. In such scenarios, sensors can transmit data to a local aggregator or cluster head which aggregates data from all the sensors in its cluster and transmits the Concise digest to the sink. There are some issues involved with the process of clustering in a wireless sensor network. First issue is, how many clusters should be formed that could optimize some performance parameter. Second could be how many nodes should be taken in to a single cluster. Third important issue is the selection procedure of cluster-head in a cluster. Another issue is that user can put some more powerful nodes, in terms of energy, in the network which can act as a cluster-head and other simple node work as cluster-member only.

The cluster based model assumes that the base station is able to communicate with each sensor directly. The election of the cluster head is based on the same factors as those discussed for aggregators in a tree model below. The sensors in each cluster send their data to the cluster head, which aggregates this data and communicates it to the sink. Cluster heads are always active and must keep their radios on at all times to receive data causing quick battery drain. The cluster heads are capable of communicating with each other at any time as per the requirement. We can conclude that cluster based data aggregation model have some advantages in some specific scenarios whereas it does not produce the optimal data aggregation due to certain reasons mentioned above.

2. Tree based model

Aggregating data by constructing an aggregation tree is called tree based approach. The tree is minimum spanning tree with sink node as root and source nodes as leaves. This approach is appropriate for designing optimal aggregation techniques.

In the tree-based approach data aggregation is performed by constructing an aggregation tree, which could be a minimum spanning tree, rooted at sink and source nodes are considered as leaves. Each node has a parent node to forward its data. Flow of data starts from leaves nodes up to the sink and therein the aggregation done by parent nodes. In which all nodes are organized in form of tree means hierarchical, with the help of intermediate node we can perform data aggregation process and data transmit leaf node root node. One of the main aspects of tree-based networks is the construction of an energy efficient data-aggregation tree. In tree based model the intermediate nodes perform data aggregation and forward the aggregated data to their parent node which is one level closer to the sink.

The leaf nodes are the sources which collect the data from the environment. Aggregators may or may not be sources. Intermediate nodes are designated as aggregators, which receive the data sent from other nodes and aggregate them. Which sensors are designated aggregators depends upon various factors like, amount of resources left on the sensor, position of the sensor within the network, processing costs etc. Data flows from the leaf nodes upwards and is aggregated by the designated aggregators at each level until it reaches the root. Calculation of optimized paths for routing data through the tree is a complex process. This is often done at the resource rich sink node, and the sensor nodes are arranged accordingly. An evident drawback of this scheme is if a packet from a particular node is lost (due to channel issues or due to node failure) the data of the whole sub tree under that node is lost.

Generally, data aggregation tree model is used to find an energy efficient solution. However, even the best aggregation tree does not share the load of data packets to the transmitting nodes fairly while it is consuming the lowest

possible energy of the network. Therefore, after some rounds, this problem causes to consume the whole energy of some heavily loaded nodes and hence results in with the death of the network. Therefore, for tree based data aggregation model, we can conclude that there are some vital advantages of this model constraining the scenario and some disadvantages. Multi-path approach is proposed to overcome the drawback of tree based approach which is the limited robustness of the system. In multi-path approach, partially aggregated data is sent to single parent node in aggregation tree. A node could send data over multiple paths in which each node can send data packets to multiple neighbors. Consequently aggregation is done in every intermediate node. Disadvantages are addressed in solution discussed below.

II. PROPOSED SOLUTION

To address the problem of wireless sensor nodes running out of energy due to lack of efficiency in selecting proper data aggregation model, we have proposed the solution of selecting an adaptive method of data aggregation model. As mentioned above, both cluster and tree based data aggregation model have advantages and disadvantages depending upon the scenario. The proposed solution is trying figure out the scenario status and evaluating it against which of the two models studied would provide energy efficient data aggregation and ultimately saving the energy of wireless sensor nodes. The proposed solution deals with designing the adaptive and automated method which will determine which of the model to choose by examining the given set of constrains. The main goal considered while evolving the proposed solution would be increasing the life time of sensor nodes and hence maximizing the lifetime of wireless sensor networks.

III. CONCLUSION

We have enlightened importance of the data aggregation in wireless sensor networks and also its direct relation with energy consumption of wireless sensor nodes and lifetime of WSN. This paper summarizes the proposed work of adaptive and effective solution to overcome the disadvantages of tree and cluster models depending upon the scenario. The main aim is to increase the lifetime of a wireless sensor network. The proposed work would be a small step towards achieving improved data aggregation in WSN.

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