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**SURVEY ARTICLE**

# Data Aggregation to Improve Quality of Service in Wireless Sensor Network: Survey

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***Abstract- Wireless sensor Networks (WSN) comprises of sensor nodes which have the capability to sense and communicate. The capabilities of these nodes have certain limitations. These networks have wide applications in the fields of habitat monitoring, security & military, disaster management, etc. Due to the restriction of resources in memory, communication capability, sensing computational capability, battery power of sensor nodes, it is very essential to curtail the amount of data transmission. One of the crucial techniques in wireless sensor networks is data aggregation. Data aggregation is a process which uses aggregation function to aggregate the incoming data from different sources in order to reduce redundancy in the transmitted data. The data aggregation algorithms mainly focus on enhancing the network lifetime by gathering and aggregating data in an energy efficient manner; this further improvises the average lifetime of a sensor and the overall utilization of the bandwidth. These algorithms help in reducing the overhead in transmission and also provide better security. There are several proposals on Data aggregation schemes for WSN in which the intermediate node perform s in-network aggregation of sensor data. In this survey, drawbacks of tree-based data aggregation are highlighted and an improvised model has been proposed.***

***Keywords- Data Aggregation, forward aware factor, power aware, quality of service***

## I. INTRODUCTION

WSN is defined as a special class of ad hoc wireless network. Wireless sensor network contains several thousand of sensor nodes distributed in a target detecting environment within its vicinity, collects the data and computes it. Sensor nodes are made up of simple processor, application specific sensors, wireless transceiver and battery. Due to limited amount of power in sensor nodes and to reduce transmission overhead, a commonly used employed technique of data aggregation is used.[1] Various schemes for data aggregation are provided.

 

The sensors coordinate among themselves to form several clusters and cluster heads which build a communication network such as a single multi-hop network or a hierarchical organization. Data is periodically sensed, processed, and transmitted to the base station. The frequency and the data by the number of sensors usually depend on the application. [3] Sums up on the comprehensive survey on wireless sensor networks. Data gathering is the systematic collection of sensed data from multiple sensors to be transmitted eventually to the base station for processing. Since sensor nodes are energy is major issue, the direct data transmission to the base station by the sensor nodes becomes inefficient. Data generated from neighboring sensors is often redundant and highly correlated and also the amount of data generated in large sensor networks is usually enormous for the base station to process. Therefore this makes it necessary to use methods to combine data into high quality information at the sensors or intermediate nodes which reduce the number of packets transmitted to the base station which results in conservation of bandwidth and energy. We can accomplish this using data aggregation.

The four basic components of a sensor node are sensing unit, a processing unit, a transceiver unit and a power unit. As per fig 1 sensing devices are usually composed of two subunits: sensors and analog to digital converters (ADCs). The sensor produces analog signals which are converted into the digital signals and are further fed into processing unit. The processing unit consists of a small storage unit, manages the procedures. The nodes are connected to the network by the transceiver. Power unit is the most important component of the sensor node which comprises of secondary power storage units like batteries or a power scavenging unit such as solar cells. There are also other subunits which depend on the application. There are different types of sensors used. Like, seismic, low sampling rate magnetic, thermal, visual, infrared, acoustic and radar, which are able to monitor a wide variety of ambient conditions that include the following [4]: temperature, humidity, vehicular movement, lightning condition, pressure, soil makeup, noise levels, the presence or absence of certain kinds of objects, sand size of an object.

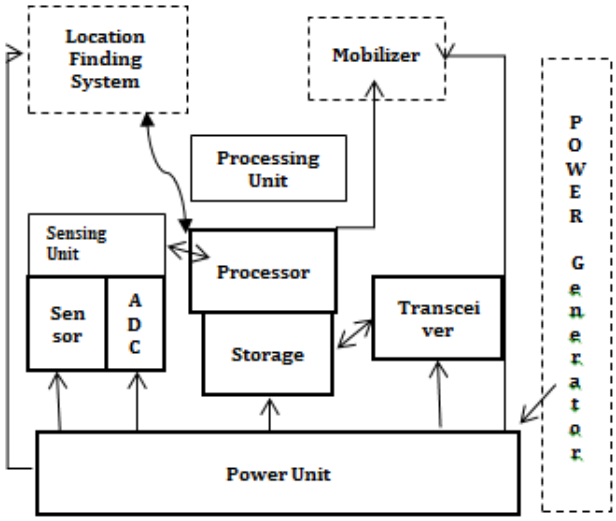


**Fig. 1: Sensor Node-Components**

Sensor nodes can be used for continuous sensing, event detection, even ID location sensing, and local control of actuators (fig.1).

## II. EXISTING WORK

### 1. Energy Balanced Routing Method for In-Network Data Aggregation in Wireless Sensor Networks[1]

This paper propose an Enhanced Forward Aware Factor-Energy Balanced Routing Method (EFAF-EBRM) based on Data aggregation technique that has some key aspects such as a reduced number of messages for setting up a routing tree, maximized number of overlapping routes, high aggregation rate, and reliable data aggregation and transmission.

 

**2. Data Aggregation in Wireless Sensor Network: A Survey**
In this paper authors discuss about data aggregation and its various energy-efficient technique used for data aggregation in WSN.

**3. Requirements of Quality of Service in Wireless Sensor Network [13]**
In this paper authors define WSNs QoS requirements within a WSNs application, and then analyzing Issues for QoS Monitoring.

## III. DATA AGGREGATION

Data aggregation is a process in which data is been fused from multiple sensors at intermediate nodes and transmitting aggregated data to the base station/sink. Data aggregation involves collection of critical data and makes data available to the sink in an energy efficient manner with minimum latency. Basically data aggregation protocols can be divided into two types based on the topology. They are tree based data aggregation protocols and cluster based data aggregation protocols. By grouping the nodes cluster based data aggregation reduces the latency in tree based data aggregation. Group of nodes form a cluster. The grouping of these nodes into clusters is called clustering. In cluster based data aggregation protocols cluster head performs data aggregation, where as in tree based data aggregation protocols the intermediate parent nodes near to the sink perform data aggregation. Tree based aggregation method is not robust to communication loses which result in node and transmission failures which are relatively common in sensor networks [16, 34, 35]. Since this communication failure loses an entire subtree of readings, a large fraction of sensor readings are potentially unaccounted at the data sink which leads to a significant error in the computed aggregation. Researchers have proposed that work in conjunction with multipath routing for computing aggregates in lossy networks [6]. There are different types of networks based on data aggregation

### HIERARCHICAL NETWORKS

In flat network, all the computation and communication in on the sink resulting in high energy consumption. But, in hierarchical network aggregation of data is done at special nodes, and these special nodes help us in reducing the number of data packets transmitted to the sink. The energy efficiency of the whole network is improved by this network [4].

### FLAT NETWORKS

In flat networks, every sensor node has equal battery power and plays the same role in the network. In such networks, centric routing manner is used for data aggregation, where a data packet is sent to the sensor nodes by the sink, such as flooding .The flooding sensors which hold the data matches the data packet and transmits the response data packet back to the sink.

## IV. ARCHITECTURE OF DATA AGGREGATION

There are several existing architectures for data aggregation based on various applications and requirements [21][22].

### CENTRALISED ARCHITECTURE

Centralized architecture is the simplest of all wireless sensor network architectures in which data fusion process can be applied, which means there exists one central node, called central processor fusion node to which each sensor node transmits the sensed data. The reports collected by all the sensor nodes are fused by this central processor. The responsibility of the entire network is held by the central node in this architecture. This architecture has a basic advantage where in, any erroneous report of information which is taken by the wireless sensor network can be detected easily. The main drawbacks are that it is inflexible to sensor changes and the workload is concentrated at a single point.

 

DECENTRALISED ARCHITECTURE

The decentralized architecture of wireless sensor network has no single centralized node which makes decisions on behalf of the sensor nodes.

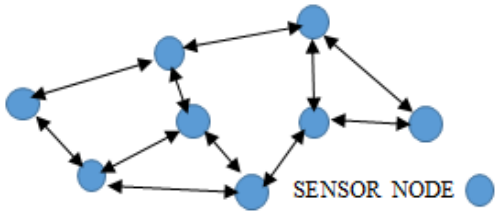


Fig 2. **Decentralized architecture**

On the basis of information obtained from the neighbouring nodes and local observations in which all sensor nodes are connected to each other, data fusion occurs at each node (fig.2). The advantage this architecture provides is tolerant and scalable to the dynamic changes or addition or loss of sensing nodes in the network.

CLUSTER BASED ARCHITECTURE

Since wireless sensor network is resource constraint sensor cannot directly transmit data to the base station, in which the cluster head receives data from all regular sensors, aggregates data packet from all the regular sensors in its cluster and sends the concise digest to the base station. With the help of this scheme we save the energy of the sensors. It is inefficient for the sensors to transmit data directly to the sink, in energy-constrained sensor networks of large size. In such cases, sensors can transmit data to a cluster head or a local aggregator which aggregates data from all the sensors in its cluster and transmits the concise digest to the sink. The process of clustering in a wireless sensor network involves some issues. If, how many clusters should be formed that could optimize some performance parameters is the first issue, how many nodes should be taken into a single cluster, becomes the second. The selection procedure of the cluster-head in a cluster is the third important issue. Another issue faced is that some more powerful nodes can be put by the user, in terms of energy, into the network which can act as cluster-head and other simple nodes work as cluster-member only.

TREE-BASED ARCHITECTURE

In this tree- Tree based method (fig3), the aggregation can be performed by constructing a minimum spanning tree, wherein sink acts like a root and source nodes are considered as leaves. Each node has a parent node which for transmission of a data. Transmission of data begins from the leaf node till the root node and data aggregation can be done by the parent nodes. Here the nodes are organized in the form of a tree means hierarchical, with the help of the intermediate nodes we can perform the aggregation and data transmission can be done with the help of the leaf node and the root node. Main aim of this tree-based network is the construction of an energy efficient data-aggregation tree.

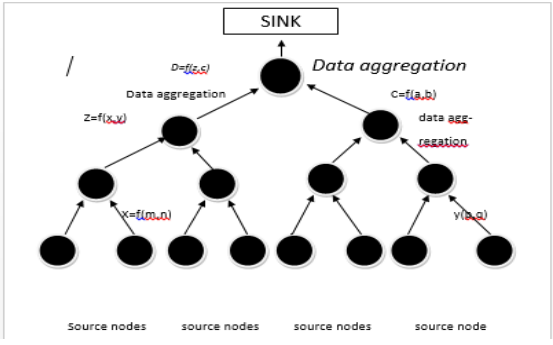


Fig3: Tree architecture

 

CHAIN BASED ARCHITECTURE

In this architecture, the each node sends data to the close neighbor. All sensors are grouped together to form a linear chain for data aggregation. The chain can be formed by using greedy method or the sink can decide the chain in a centralized manner. In the greedy chain formation assumes that all the sensors have inclusive knowledge of the network. The node which is far away from the sink initiates the formation of the chain and at each step in the formation of the chain the closest node is selected as its successor node in the chain. While we are gathering the node, the node receives data packet from one of its neighbors, it aggregates the data with its own, and it sends the aggregated data to its neighbor along the chain. Finally, leader node sends the data to the base station.

GRID BASED AGGREGATION

In this architecture, the set of nodes are considered as the aggregator nodes in a static region of the network. The sensor in the grid sends data packet directly to the aggregator of that grid. Hence, here sensors will not communicate based on data aggregation with differences. Any nodes till the last node, can take the role of aggregator. Here also, cluster heads are fixed. In-data aggregation involves the sensor node aggregates the data packets and sends the data to the sink. Each sensor will transmit its signal strength to its neighbour. The sender stops sending the packets if the neighbor has a higher signal strength. The node having maximum signal strength becomes the aggregator soon after collecting data packets from all the neighbours. Where events are highly localized, the in-network aggregation scheme is the best suitable.

**Advantages and Disadvantages**

Data aggregation has following advantages.

- Data aggregation helps to enhance the robustness and accuracy of information which is obtained by the network.
- Data fusion processing is needed to reduce the redundant information wherein data collected from the nodes there exists certain redundancy.
- It reduces the traffic loads and conserves energy of the sensors.

Data aggregation has following disadvantages.

- The cluster head means the nodes which are fused which send these data to the base station. The malicious attacker can attack this cluster head or fusion node.
- The sink cannot ensure the correctness of the fusion data which is sent, if the cluster head is compromised.
- The uncompromised nodes send the several copies of the fusion to the sink is one of the disadvantage in the existing systems. At these nodes the power consumed can be increased.

## V. QUALITY OF SERVICE (QOS) PARAMETERS

The various influencing factors that serve as a challenge in the design of the WSN are scalability, network topology, operating environment, fault tolerance; transmission media, production cost and others have to be considered. The networks performance is measured on the basis of the quantifiable parameters called performance metrics.[14]

**Latency:** Latency is defined as the delay involved in data transmission, routing and data aggregation.[15] It is the time delay between the data generated at the source nodes and data packets received at the destination.

**Network Lifetime:** Network lifetime is defined as the number of data aggregation rounds till some percentage of sensors dies. For example, if total time of nodes are important, lifetime is can be the number of rounds until the first sensor is drained of its energy.[14]

 

**Bandwidth, Capacity and Throughput:** These indicate the capacity of data which can be sent over a link within a given time, however since the data size is very small bandwidth rarely matters.

**Energy Efficiency:** The functionality of the sensor network should be extended as long as possible. In an ideal data aggregation scheme, each sensor should have expended the same amount of energy in each data gathering round. An efficient data aggregation should maximizes the functionality of the network. If we assume that all sensors are equally important, we should minimize the energy consumption of each sensor. This idea is captured by the network lifetime which quantifies the energy efficiency of the network.[14]

**Data accuracy:** The definition of data accuracy depends on the specific application for which the sensor network is designed. For instance, in a target localization problem, the estimate of target location at the sink determines the data accuracy.[14]

**Signal Strength:** SNR as an indication for the link quality and the distance between two nodes is helpful to compute and determine the nodes and their reach ability during the communication process.[14]

**Hop Count:** No of hop in communication determine the cost of path, and eventually the energy consumed in the process.

## VI. METHODS AND MATERIALS

This paper addresses the drawback of the EFAF EBRM based on Forward Aware Factor and Data Aggregation algorithm. Though this algorithm is efficient than the FAF-EBRM and LEACH. It uses Forward-aware factor in order to determine next-hop node and Data Routing for In-Network aggregation (DRINA) protocol. It has the following drawbacks-

1. This algorithm fails to correlate data and also waiting time taken by aggregator node is more.
2. Since it is tree based, it's difficult to find balance between overhead and quality of routing tree
3. Time taken to find forward aware factor to determine next hop

This paper proposes a technique which correlates and aggregates incoming data at nodes of wireless sensor network to ensure quality of service, minimize power consumption and increase overall network lifetime. It has the following features:

1. Each node acts as Data aggregator
2. Spatial and temporal correlation of data
3. An efficient technique for data aggregation
4. Control the waiting time for data aggregation by aggregator nodes.
5. Stochastically select nodes to be part of the communication structure.

**Working:**

This technique allows network to work in two mode.

**Mode 1:** basic WSN. Based on the traffic in the network, it switches between two different modes. Periodically, traffic of the network is evaluated and analysed. Threshold value is the maximum traffic node can handle. Threshold value is in line with maximum traffic of network. If the traffic is less than threshold value. Network works in mode 1 that is without data aggregation. The following flowchart depict the extended functionality of node with data aggregation-

**Mode 2:** WSN with data aggregation

If traffic of network is equal to threshold value, network switches to mode 2 that is aggregation mode (fig.5). In this mode, as soon as it found there will be bottleneck near the node, each node acts like a aggregator node along the route.

 

There is no clustering overhead. Since any node can act like aggregator there will not be more overhead on the algorithm to form cluster, nominate cluster head. Also, in tree-based aggregation, aggregator node will collect all data and performs aggregation. If aggregator node fails, then data is lost. In the proposed method, since all nodes perform aggregation these drawbacks are overcome.

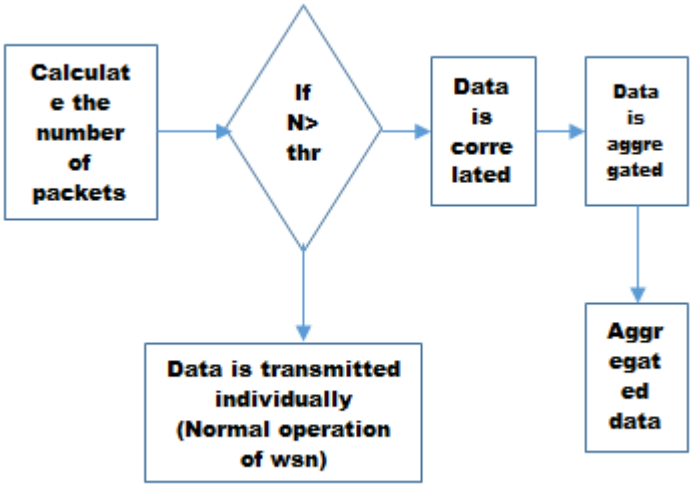


Fig4: Node-level data aggregation and correlation

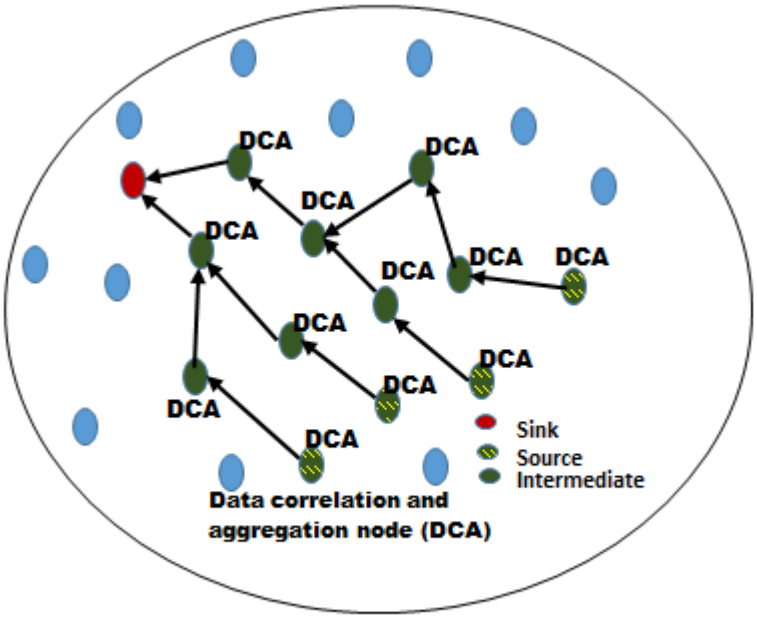


Fig.5: WSN in mode 2

It uses hybrid approach in which both tree and decentralized data aggregation is used. Using tree approach, it find aggregation tree which is minimal spanning tree. Unlike in traditional approach, instead of only parent node aggregating data, in this new approach any node along the tree can perform data aggregation (fig.4). Hence features of both tree base and decentralized data aggregation is used.

 

The proposed technique can minimize the number of data transmission, number of sensing state of node, active time of node and combines energy efficiency and fault tolerance. Thereby, it prolongs the lifetime of the network.

## VII. CONCLUSIONS

This paper presented a comprehensive survey of data aggregation algorithms in wireless sensor networks. All of them focus on optimizing important performance measures such as network lifetime, data latency, data accuracy and energy consumption. Efficient organization, routing and data aggregation tree construction are the three main focus areas of data aggregation algorithms. The main features, the advantages and disadvantages of each data aggregation algorithm are described. Authors are doing survey on efficient data aggregation and correlation algorithm. Though few QoS parameters can be achieved but in the cost of energy of the node as it should do additional data analysis and correlation.

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