

# ENERGY EFFICIENT DATA TRANSMISSION USING TREE-CLUSTER BASED DATA AGGREGATION IN WIRELESS SENSOR NETWORK

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**Abstract:** In WSN sensor nodes have batteries of limited capacity which will cause node failure after energy depletion. Cluster-based data aggregation consumes more energy as all nodes in the network sends the packet to the cluster head. This clustering method leads to overhead at cluster head. So to overcome these issues we proposed genetically derived tree-cluster based data aggregation technique based upon tree-cluster based data aggregation approach. Initially, nodes are deployed in the network in the form of tree cluster model. Then CH is selected on the basis of node connectivity and fitness function of every individual node. Once all the factors are computed then data is transmitted in the network. By simulation results, we show that proposed technique reduce energy consumption.

**Key Words:** GDSDA, GDTDA, LEACH, WSN, CH, etc

## 1. INTRODUCTION

A wireless sensor network (WSN) is an ad-hoc network consist of small sensors which is useful to sense the physical environment. As we know that ad-hoc network is an address centric but WSN is the data-centric and self-configuring, because of which it is used as the most appropriate method for data processing. WSN has very vast area of application both for civilian as well as military [7]. It includes monitoring of animal habitat, tracking in military, weather forecasting and much more. In WSN data aggregation is based on statistics like sum, average, maximum/minimum of data [8]. The main application of sensor network is gathering the data from different nodes and aggregate that generated data and further transmit it to the sink node. And in the meantime, all nodes sense the physical environment and gather the data. To transmit the data over a long distance more energy is required so the technique used is to have some nodes sense the data and send to the sink. These nodes are called as aggregator nodes. And the process is called as data aggregation in WSN [2].

Nowadays we have plenty of algorithm in WSN like for energy efficiency, for cost minimization, etc. The energy efficient algorithm must reduce the energy of transmitted data and also reduce the energy consumption of each node. It is called as energy efficient if it improves the functionality of the network. Data aggregation is one of the energy saving mechanism in WSN. In

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which we collect the data at different nodes and then compressed. It after that further send data into the environment. It reduces the overhead of data at the base station. As in sensor network, the generated data is based on the sensing mechanism of nodes and transmit sensed packet to the sink. Sometimes these aggregator nodes may be attacked by the malicious attacker. In that case accuracy of data is not guaranteed. Due to this nodes may send the different copies of the same data which may increase the energy consumption. By limiting the data transmission we can increase the network lifetime and bandwidth consumption. This can be achieved by deriving the different algorithm in the WSN.

LEACH is a basic data aggregation protocol which uses clustering process to aggregate data. This is normal energy efficient protocol from which we can derive more algorithm to save the energy. LEACH is better than simple data aggregation. It consumes less energy and packet loss as compare to simple aggregation [13]. There are different techniques for data aggregation in WSN i.e. Clustered based Data aggregation, Tree based data aggregation and Chain based data aggregation. In cluster based data aggregation external nodes send their data to the local aggregator. Then that local aggregator further sends their data to the cluster head. From cluster head data is sent to the sink. With this mechanism consumption of energy is reduced and the data congestion is also reduced.

## 2. IMPORTANT PARAMETERS

Aggregation depends on different parameters. That will lead to the high performance of the network.

**Energy Efficiency:** Data aggregation increase the functionality of WSN. Each node sends its data to the neighbouring node or neighbouring cluster head depends on the type of data aggregation. Same amount of energy is spent by each node in each round. But by gathering the data at single node energy consumption is reduced. Which will lead to reducing communication overhead in the whole network [1].

**Network lifetime:** Network lifetime depends upon the time till the sensor nodes are run out of energy. As in WSN, each node is having limited power. By increasing the lifetime energy consumption is also enhanced. If the network lifetime is high then only a node can use its energy efficiently for more time.

**Latency:** Latency is the delay experienced by base station while receiving the data. It is the time interval after which base station receives data send by sensor nodes.

**Communication overhead:** Communication overhead is defined by the data packets are increase at the receiver side then its queue value. This will lead to the packet congestion at the receiver side which will lead to wastage of energy.

**Data accuracy:** It is evaluated at the total number of packets received at the base station successfully to the total number of packets generated from the sensor node [1].

### 2.1 Data aggregation approaches in wireless sensor network

Data aggregation process in which the overhead and energy consumption can be highly minimised. Our aim is to minimise the energy consumption of nodes. We have different approaches to data aggregation in wireless sensor network.

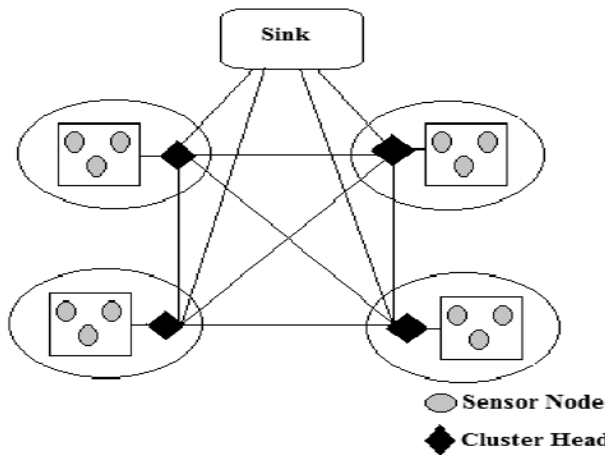
#### *Cluster Based Approach*

As in sensor network is very wide in range and to transmit to packet from one node to the other is difficult as it consumed more energy. So to minimise the energy we make clusters of nodes and

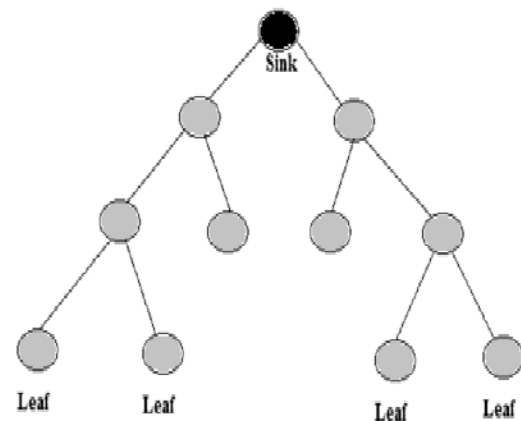
in that cluster one cluster head (CH) is chosen. All the nodes in the cluster send their data to the CH and CH aggregate that data and further send it to the sink node and then to the base station (BS). Figure 1 shows cluster based data aggregation model. There are different protocols is used for selection of CH, where LEACH is a basic protocol of clustering [10].

### ***Tree Based Approach***

The tree-based approach is that in which nodes are deploy in the tree structure which is in the form of spanning tree. Sink node is considered as a root node and source node consider as a leaf node. And data is transmitted from the leaf node to sink node in such a way that a node can receive data from lower node and aggregate received data, then forward it to the uppermost nodes.



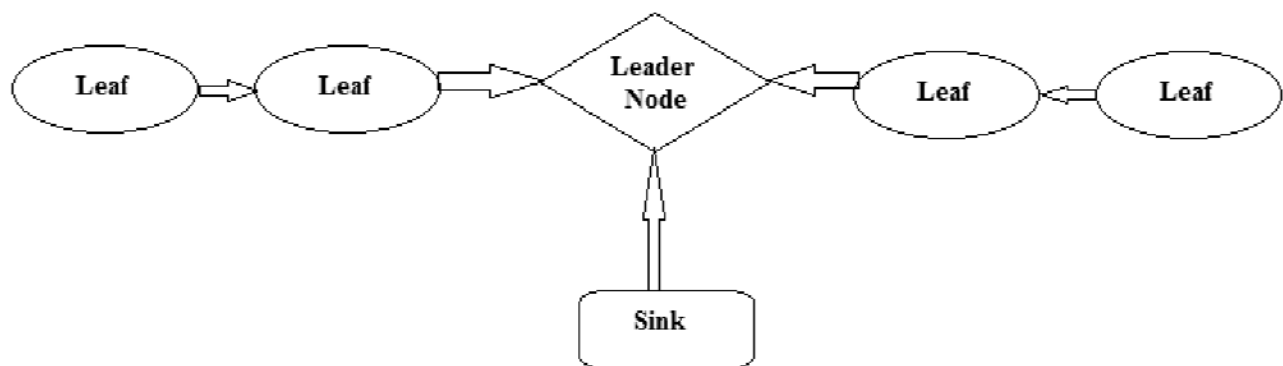
**Figure 1: Cluster based data aggregation**



**Figure 2: Tree based data aggregation**

Figure 2 shows tree based data aggregation model, where TREEPSI is a basic protocol for tree-based approach [9].

### ***Chain Based Data Aggregations Technique***



**Figure 3: Chain based data aggregation**

As we know that in cluster-based approach sensor nodes transmit the data to the CH but if the CH is far away from the sensor node then data will consume more energy to reach the CH node. Whereas in the case of chain based approach nodes transmit data packets to the nearby node. Then that node aggregates its own data with receiver data and further send it to the nearby node until data is received at the sink. Each and every node sends data to the nearby node rather than transmits data to the CH node. The chain is formed by the different protocol. Figure 3 shows chain

based data aggregation model, where PEGASIS is a basic protocol of chain based data aggregation approach [11].

## 2.2 Problem identification

Initially, a FBSDA technique is proposed which is overcome by Genetically Derived Secure Cluster-Based Data Aggregation (GDSDA). In GDSDA clustering is performed and selection of cluster head depends upon the connectivity of nodes in the cluster. Then fitness function is evaluated on the basis of power, distance and trust value of each member in the cluster. This paper concentrates on energy. But the energy consumed is not that much less. In order to overcome energy problem, we proposed Genetically Derived Tree-Cluster Based Data Aggregation (GDTDA). In which we take network model of tree cluster based. The data is aggregated in both the ways. Both approaches are used in the network model. In which first data is aggregated in the cluster formed then further transmit data to other cluster but in the form of the tree. This proposed technique consume less energy than existing technique. As if the CHs is far away from each other then this technique will helpful for saving energy.

## 3. LITERATURE REVIEW

Lathies *et al.* [1] have proposed Genetically Derived Secure Cluster-Based Data Aggregation (GDSDA). In GDSDA cluster is chosen on the basis of maximum connectivity of the node to the other nodes. Now this cluster node act as a cluster head which further aggregate the data coming from different sensor nodes. Using Genetic Algorithm (GA) technique the whole process is executed. GDSDA is the enhancement in the genetic algorithm technique.

Ehsan Heidari and Ali Movaghar *et al.* [12] have proposed a technique which based on genetic algorithm (GA). Basically, it is a chromosome based algorithm and from that idea is taken. From the group of nodes some nodes are taken and evaluated on the different types of the fitness function, higher the fitness higher will be the probability to be selected. Then a couple of individual nodes are taken together and produce one or more than one offspring node. After that new offspring node will be mutated randomly so that offspring node does not have same properties like parent node.

Hevin and B. Paramasivan *et al.* [15] have proposed Fuzzy Based Secure Data Aggregation technique (FBSDA). FBSDA work on three phase: In the first phase it perform clustering and choose cluster head. In second phase energy consumption, connectivity and distance values of each node is calculated within the cluster. In the third phase based on the fuzzy logics and the calculated parameter select the ideal node for data aggregation process.

Mehrjoo *et al.* [16] have proposed Artificial Bee Colony (ABC) and hybrid Genetic Algorithm (GA) technique which is based on clustering algorithm. GA is used to select cluster heads and ABC is used to select maximum nodes inside the each cluster head or we can say that cluster members. This approach consumes more energy because it uses algorithms like ABC.

N.C. Nethravathi and Prathibha A. Ballal *et al.* [17] have proposed Energy based-Genetically Derived Secure Cluster-based Data Aggregation (EB-GDSDA), in which GDSDA technique is enhanced, but only in the case of energy. In this paper, they used three steps. First is the formation of the cluster. In second step cluster head is chosen on the basis of connectivity. And in the third step, EB-GDSDA technique is applied for enhancing the energy efficiency and securing the data by encrypted it with RSA algorithm.

### 3.1 Proposed system

In this paper, we have taken the idea from GDSDA [1], in which nodes are deployed randomly and on the basis of fitness function cluster head is chosen. GDSDA is based on the clustering approach data aggregation. We proposed energy efficient Genetically Derived Tree-Cluster Based Data Aggregation (GDTDA). In proposed technique we merge two approaches of data aggregation that are clustering approach and tree approach. In our network model we make the tree of clusters in such a way that from every cluster, CH sends the information to uppermost node of the different cluster like in the tree approach. With the help of this approach, we minimise the energy consumption. This technique increases the life span of nodes.

### 3.2 GDSTDA Algorithm

The algorithm which is used is written as follows:

- Formation of sensor nodes.
- Arrange all sensor nodes in the form of tree-cluster model.
- Calculate the connectivity of each sensor nodes with other nodes in a cluster.
- Calculate the fitness function of each individual node.
- Cluster head is chosen on the basis of the fitness function.
- Perform encryption on data to make it secure.
- After that transmission is started in each cluster until the data reached to the sink node.

### 3.3 Estimations to be performed on data

To create energy efficient transmission derived GA is used, which is initially used to perform on biological organisms [12]. In which initially from the number of nodes CHs are chosen on the basis of connectivity of nodes. And after that, a fitness function is applied on the CHs. Then the clustering process is executed using the proposed algorithm. In which tree cluster formation of the nodes is used to minimise the energy consumption. The fitness function ( $f$ ) depends on different parameters like the distance of all nodes to the sink nodes, the distance of all clusters to the sink node, number of nodes and the total number cluster-head nodes.

After that cluster function  $F$  is calculated which is based on three parameters that are:

- Distribution factor ( $\alpha$ ): It is calculated as the average number of nodes per cluster.
- Cost factor ( $\beta$ ): It is calculated as the distance between the sensor nodes [1].
- Energy factor ( $\gamma$ ): Energy is calculated as the sum of transmission energy ( $E_{tx}$ ), reception energy ( $E_{rx}$ ), energy in ideal stage ( $E_{ideal}$ ) and energy during sensing ( $E_{sen}$ ) [19].

All the mathematical expressions are referred from the base paper [1].

The network model which we are using in our technique is tree-cluster based data aggregation, which is shown in figure 4.

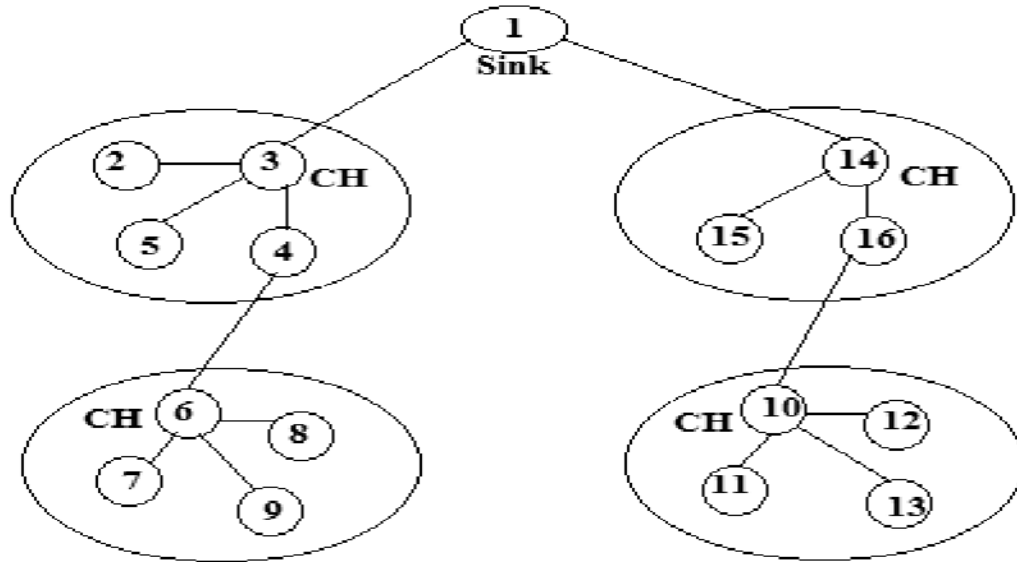


Figure 4: Tree-Cluster based data aggregation

#### 4. SIMULATION PARAMETERS

We evaluate our technique through NS-2. We use a region of  $800 \times 800$  sqm, in which deploy the sensor nodes in uniformly distributed manner. The number of nodes that we have taken is 16 and 30. We give the power to the nodes in such a manner that they can communicate within the range of 250 m. the channel capacity that we have taken is 2 Mbps. IEEE 802.11 is used for wireless local area networks (LANs). The Media Access Control (MAC) layer protocol is used and traffic control is constant bit rate (CBR). All the simulation parameters are shown in the table 1 which is listed below.

Table 1  
Simulation parameter

<i>Simulation Parameter</i>	
No. of node	16,30
Size of NS2 window	800*800
MAC	802.11
Time of simulation	6sec
Packet size	1000
Traffic source	CBR
Rate	50
Transmission range	250m

##### 4.1 Simulation result:

We evaluate GDSTDA with through NS2. In which we are using a bounded region of  $800 \times 800$  sqm. Where nodes are placed in the form of tree-cluster based structure, where CHs are chosen by considering different factors. By varying node from 16 and 30. We assign same power level to nodes and 250m of range. IEEE 802.11 wireless LAN and MAC protocol are used in the simulation.

In figure 5 comparison of energy when 16 nodes are used in both the techniques, where energy.tr is the trace file of proposed technique and energy1.tr is trace file of the technique used in base the paper.

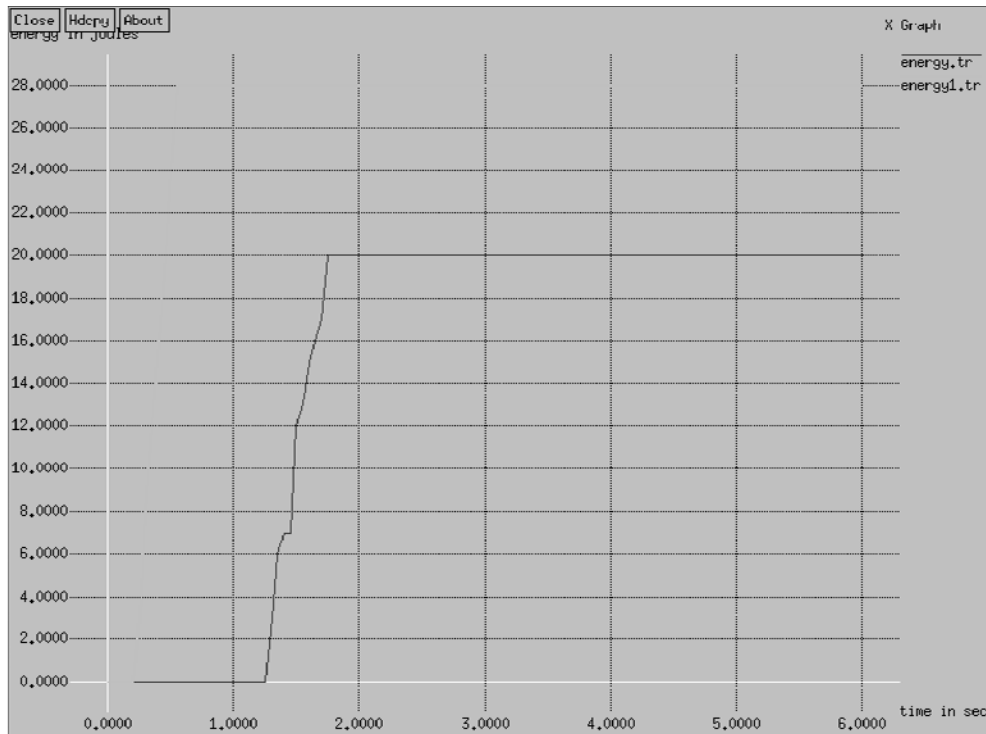


Figure 5. Comparison of 16 nodes

In figure 6 comparison of energy when 30 nodes are used in both the techniques, where energy.tr is the trace file of proposed technique and energy1.tr is trace file of the technique used in base the paper.

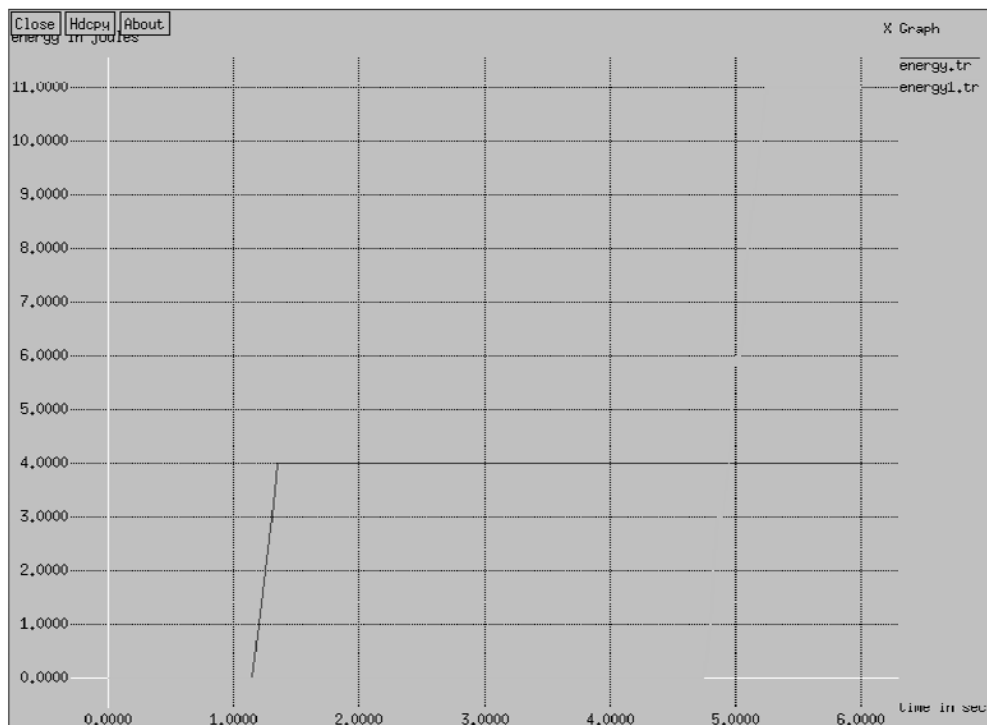


Figure 6. Comparison of 30 nodes

We can check that the energy used in both cases are less. Which means that proposed technique is efficient. When we consider 16 and 30 nodes then energy will be reduced. So we can say that GDSTDA is efficient when we increase the number of nodes.

## 5. CONCLUSION

In this paper, we proposed GDSTDA to minimise the energy of the network in WSN, where initially nodes are deployed in the network in the form of tree-cluster structure. We are using NS2 simulator for the better result. Cluster-based technique consumes more energy so to overcome this problem we propose a tree cluster based technique. Simulation result shows that proposed scheme consume less energy. On minimises the energy we can increase the life span of the nodes. On comparing clustering and tree cluster approach the consumption of energy is less in the case of tree-cluster approach when 16 and 30 nodes are considered

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