Cluster Based Algorithm for Energy Conservation and Lifetime Maximization in Wireless Sensor Networks

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***Abstract*— one of the most critical issues in designing Wireless Sensor Network (WSN) is to minimize the energy consumption. In Wireless Sensor Networks, data aggregation reduces the redundancy among sensed data and optimal sensor routing algorithm provides strategy for data gathering with minimum energy. The energy consumption is reduced by combining data fusion and cluster based routing. In this paper, we propose a K − means Fusion Steiner Tree (KFST) for energy efficient data gathering in sensor networks, which optimizes data transmission cost and the data fusion cost. This cost reduction increases the lifetime of a Sensor Network. The result of the proposed protocol KFST is compared with Adaptive Fusion Steiner Tree(AFST) and KFST produces better result than the existing protocols.**

Keywords-Clustering; Data Aggregation; Data fusion; k-means Fusion Steiner Tree (KFST); Wireless Sensor Networks.

I. INTRODUCTION

Wireless Sensor Network (WSNs) uses battery operated wireless micro-sensor nodes to collect the information from a geographical field and transmits in multi hop to the sink. Hundreds or thousands of these micro-sensors are deployed to watch the environment and collects the data about it. These sensor batteries are impractical to replace or recharge and hence energy of the sensor nodes are to be saved to increase the lifetime of the Network. The operational lifetime of a sensor node is in terms of weeks or months. Sensor node spends energy for each process like sensing, transmitting and receiving data. Hence, energy is an important criterion in Wireless Sensor Networks.

WSN has considerable technical challenges in data processing and communication to deal with dynamically changing Energy, Bandwidth and Processing power. Another important issue in Wireless Sensor Network is to maximize Sensor Network lifetime. The vital issue in WSN is to maximize the network operational life. In order to achieve this, it is necessary to minimize the energy utilization of a node.

Efficient routing and data aggregation can conserve energy. Another important issue is security because it operates in a hostile environment. WSN needs to be protected against intrusion and spoofing. Data aggregation, Effective routing, cross layer optimization, clustering and optimal deployment of nodes. These issues are addressed in wireless sensor network to reduce energy consumption of node because low power battery operated sensors are involved in a Network. Applications of sensors can be viewed in environmental monitoring, habitat monitoring, agriculture, intelligent systems, medical field, disaster management and object tracking. While designing sensor networks, resource constraints such as power consumption, communication bandwidth, computing power, memory size and uncertainty in sensor readings are important parameters. Energy optimization is a paramount issue in WSN. The collection of information from sensors must be carefully managed with limited power and radio bandwidth. [1].

Motivation: Transmission cost and fusion costs are two important parameters in data transmission. Sensed data may poses duplication of information during aggregation. Effective routing with data aggregation reduces the energy consumption. Sometimes fusions at all nodes are less efficient than sending data directly.

This observation motivates us to initiate fusion only at the cluster heads which reduces the energy consumption than fusion at all nodes.

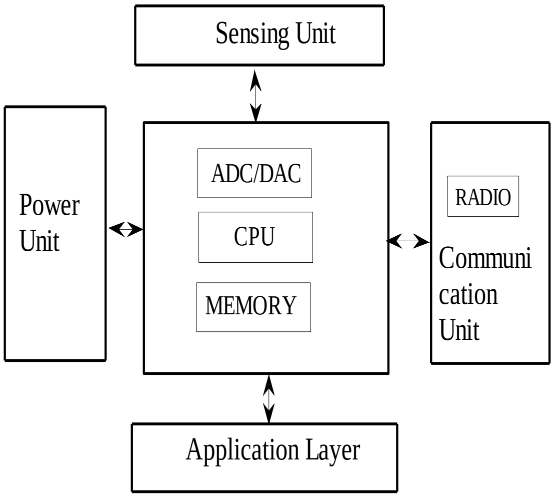

Figure 1. Wireless Sensor Network Architecture

Contribution: In this paper, we have proposed a k − means Fusion Steiner T ree(KFST) algorithm to reduce both transmission and fusion cost. It dynamically adjusts fusion decisions and cluster head needs to perform fusion during the routing process. KFST clustering algorithm formulates the clusters and minimizes the energy consumption by fusing data only at the cluster head.

Organization: The remainder of this paper is organized as follows. In Section II, we describe the related work. Section III gives an overview of System Model and Problem Formulation. Section IV discusses about design and analysis of proposed k-means with AFST algorithm. Section V describes about Simulation Setup and Analysis of the results. Section VI concludes the paper.

A. WSN ARCHITECTURE

Figure 1, Illustrates the generic architecture of a sensor node. It is composed of a power unit, Processing unit, sensing unit and communication unit. The processing unit is responsible to collect, process signals captured from sensors and transmit them to the network. The processing unit is used to compute and process the data locally. Sensors are the devices that produce a measurable response to a change in a physical condition like temperature and pressure. The wireless communication channel provides a medium to transfer signals from sensors to the external world or to a computer networks and helps to establish and maintain wireless sensor network which is usually adhoc. Advances in Micro Electro Mechanical System (MEMS) technology and its associate interfaces, signal processing and Radio Frequency (RF) circuitry have enabled the development of Wireless Sensor Nodes.

Each of the sensors is a separate data source that consists of node location, time stamp, sensor type and the value of the reading. Sensor data might contain noise and it is not often possible to obtain accurate results; but it is possible to obtain accurate results by fusing data from several sensors. Aggregation of raw sensor data is thus more useful in sensor applications than individual sensor readings. For example, when monitoring the pressure of a fluid flow in an industry, one possible query is to measure the average value of all sensor readings in that region, and report whenever it is higher than some predefined threshold.

Battery life of a sensor node is 2 to 3 years which operates in 2.4GHz frequency. It can transmit data at the rate of 250K bits/sec. To conserve energy, most of the nodes are in sleep state except few nodes which needs to be in active state. Sensor nodes can cover 300m without repeaters.

II. RELATED WORK

Jamal et al., [2] surveyed the routing protocols for WSN. Network architecture, protocol operation, multipath query, negotiation, Quality based protocols are considered in this paper.

Yang et al., [3] addressed the problem of Scheduling packet transmission for data gathering over the aggregation tree in WSN. A distributed algorithm that relies on the local information of the sensor node is employed in scheduling the packets in order to reduce energy and latency. They have also discussed about the techniques to handle interference among the sensor nodes. He has not considered reliability of the output data. Chalermek et al., [4] constructed an energy efficient aggregation tree using data centric reinforcement mechanisms. Inefficient paths are pruned using a greedy heuristic approach.They have not considered delay and distinct event delivery ratio. Dasgupta et al., [5] proposed energy efficient clustering approach to adapt lifetime maximization of large sensor network. Delay constraints has not been considered in this work.

Chiranjeeb et al., [6] designed energy efficient routing algorithm utilizes fully aggregated trees and partially aggregated tree. Jian-wu et al., [7], proposed Weighted Clustering Algorithm based Low Energy Adaptive Clustering Hierarchical (WCA-LEACH) routing protocol to address the problem of energy conservation in WSN. The result of proposed WCA-LEACH has been compared with LEACH protocol, to improve the lifetime of WSN. Cristescu et al., [8] developed a clustered slepian wolf model to address the problem of minimization of total transmission cost of information. Transmission cost was reduced by aggregation of correlated data. Jisul Choe et al., [9] proposed Energy Aware Directed Diffusion(EADD) for Wireless Sensor Networks(WSN). The protocol selects the reinforced path from the source to the destination and then forwards the packets through the reinforced route rather than broadcast the packets. It achieves balanced energy distribution and increases the lifetime of the WSN.

Maggie et al., [10] presented a mathematical model to handle Energy and Bandwidth constraints in WSN. It uses a uniform transmission power for routing without data aggregation and handles non uniform transmission power to improve throughput and lifetime. Nam et al., [11] designed dynamic and distributed protocol to reduce energy consumption of Sensor Network. Energy among sensor nodes are balanced by constructing clusters and selectingcluster heads, based on round robin.The energy consumption of abnormal nodes are not accounted here. Amir et al., [12] proposed routing algorithms for hypercube topology of WSN. The results are compared for random, round robin, probabilistic, edge, Var edge and neighbour One routing algorithms. The neighbour One Algorithm has lower deviation i.e, consumes less energy for hypercube of Sensor Network. Raja et al., [13] presented a cross layer frame work to optimise global power consumption and balancing the load in WSN through greedy local decisions. Cost function is used at the routing layer;adaptive duty cycles and radio duty cycles are considered to reduce the energy consumption. The dynamic nature of Sensor Networks are exploited to reduce power consumption.

Stephanie et al., [14] proposed PEGASIS (Power-Efficient GAthering in Sensor Information Systems), a near optimal chain-based protocol. Each node communicates only with the closest neighbor and take turns to transmit data to the base station reducing the energy consumption.This does not address the System life time of the Networks.

Marios et al., [15] proposed an optimal solution to find the target matching schedule for sensors that achieve the maximal lifetime.The solution consists of three steps (a) Form a workload matrix by using the linear Programming Technique (b) Decompose the work load matrix into a sequence of schedule matrices (c) Routes to pass the sensed data to the base station. The solution is not optimal because there is no guarantee of performance.

Yang et al., [16] formulated an Energy Efficient Routing for Signal Detection using the Neyman- Pearson criterion. The Routing metrics are considered for an appropriate tradeoff between performance and energy expenditure.Parallel route and target tracking are not considered in this work.

III. SYSTEM MODEL AND PROBLEM FORMULATION

A. Network Model

The sensor network is modeled as an undirected graph $G = (V, E)$ where, V is the node set and E is an edge set, representing the communication links between node-pairs. We assume source node set $S \in V$ of n nodes (data sources) and data gathered at a target node $t \in V$. We refer the time required for information gathering from sensor node to target node as one round. For a node $v \in S$, we define the term load as $l(v)$ i.e., the amount of information outgoing from v in every round. It results in different loads for various data fusion. Therefore, in data gathering nodes load weight is dynamic.

An edge e € E is denoted by e = (u, v), where u is the start node and v is the end node. The load of edge e is equivalent to the load of its start node, i.e., l (e) = l (u). Let the transmission cost be t (e) and fusion cost be f (e) on the edge.

B.Transmission and Fusion Cost

Transmission cost is defined as cost required for transmitting load from u to v. The abstract unit transmission cost denoted as c (e) for an edge. Thus, the transmission cost t(e) of edge e is given by t(e) = l(e)c(e) (1) where c(e) is an edge-dependent, various and varies for conditions such as different distances in between nodes and local congestions. The energy consumption for fusion process at the last node v is defined as f (e). We use abstract unit fusion cost q(e) which is varies from edge to edge and depends on load of fusing data. So, the data fusion cost of node u and v at node v is given as f (e) = q (e). (l(u) +$\tilde{l}$ (v)) (2) Where $\tilde{l}$ (v) and l(v) denotes the data amount of node v before and after fusion.

TABLE 1. NOTATIONS

Symbols	***Definition***
G	Undirected Graph
V	Node set
E	Edge set
S	Set of Sensor nodes
T	Sink node t € v
l(v)	Information outgoing from v
e	Edge of the node, l € E
v	Single node, where v€ V
l(u)	Information outgoing from u
f(e)	Fusion cost
t(e)	Transmission cost
l(e)	Load on edge e
q	Unit fusion cost
δ	Data fusion factor
c	Unit transmission cost
G^*	Sub graph G^*c G
Σ	Data reduction ratio
E_f	Fusion at node pair
E_n	Non-fusion at node pair
V^*	Node set for subgaph G^*
E^*	Edge set for subgaph G^*
$X_{u,v}$€{0,1}	Denotes fusion is there or not

C. Data Aggregation

In Sensor Network, data aggregation removes the redundancy among data collected by different sensors and consequently aims at load reduction over the network. We assume that data aggregation can take place at any intermediate node along the route. An intermediate node can explore the redundancy among multiple child node’s data and aggregate all into one compressed data stream.

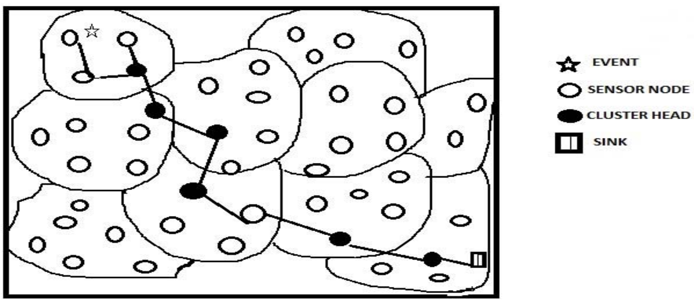

Figure 2. Illustration of clusters and routing in KFST

Sometimes aggregation cost is more than that of just relaying data. During this time, node v may choose not to perform data aggregation in order to realize maximum energy saving. Instead, node v will simply relay the incoming data of node u. In this case, the aggregation functions at node v as $l(v) = (l(u) + l(v))(1 - \sigma_{uv} X_{uv})$. Where $X_{uv} \in \{0, 1\}$ denotes fusion occurs at v on edge e = {u, v}.

D.Problem Definition

In a Wireless Sensor Network, consider a connected subgraph $G^* = (V^*, E^*)$ where diagraph G^* contains all sources S € V and the sink t € V . The edge set E^* can be divided into two disjoint subsets, fusion edge set E_f and non-fusion edge set E_n where, E_f = e|e € E,X_e = 1 and E_n= e|e € E,X_e = 0. When data fusion is not performed X_e=0, otherwise X_e=1. Energy consumption is reduced by routing only through the cluster head.

Given the source node set S and target node t, our objective is to design a routing algorithm that minimizes the energy consumption when delivering data from all source nodes in S to t. Sensor are grouped into clusters using k-means clustering algorithm. Cluster head are elected for each cluster based on the energy availability of each node in the cluster. We need to design the shortest routing path from s to t through the cluster heads. Our goal is to find a feasible subgraph to reduce the transmission cost and fusion cost.

Objectives

- To increase the lifetime of the Wireless Sensor Network.
- To decrease energy consumption in Sensor Network by fusing the data.
- Find the optimal routing method to reduce the transmission cost.
- To improve data aggregation method to reduce fusion cost.

Assumptions

- The sensor nodes are homogeneous in nature and contain uniform energy.
- Sensor nodes are static in nature.
- The Base Station(BS) is at a far distance from the sensor nodes.
- High energy node will be the Cluster Head(CH).
- Fusion only at the Cluster Head(CH).

IV. BACKGROUND

A. Shortest Path Tree (SPT)

In this data aggregation scheme [17]; each source sends its information to the target (sink) node, along the shortest path between source and sink where some more overlapping paths are combined to form the aggregation tree. Each node drains energy in establishing the shortest path. Thus, the lifetime of the sensor network is reduced.

B. Greedy Incremental Tree (GIT)

This is a sequential scheme [17], initially the aggregation tree consists of only shortest path between the sink and the nearest source node. After each step, the nodes are attached to generate the path between source and the destination by using the shortest path, and then the information is forwarded to the sink node. This technique uses more numbers of intermediate nodes and the energy of these intermediate nodes are wasted.

C. Minimum Fusion Steiner Tree (MFST)

In MFST [18] [19] [20], source nodes are paired up (or a source with the sink) based on the metric M(e) and then the algorithm randomly selects a fusion node from the node-pair. The weight of the non-fusion node is transferred to the fusion node, paying appropriate transmission and fusion costs on that edge. Subsequently, the nonfusion node is eliminated and the fusion node with aggregated weight is grouped into new set of sources. This process repeats until sink is the only remaining node. This method consumes more energy because aggregation needs to perform at each node.

D. Binary Fusion Steiner Tree (BFST)

BFST [18] [19] [20] obtains a routing tree using the MFST algorithm, where fusion is performed by every intermediate node. A node-pair will be selected for fusion only if the node pair reduces the consumption of energy, otherwise data will relayed without fusion. Strong correlation and high aggregation ratio usually are due to spatial correlation resulting from short distances between nodes. In turn these, short distance leads to small unit transmission cost. Based on the metric M(e) defined in MFST [19](which is a combination of fusion cost and transmission cost), Strongly correlated nodes are selected in comparison to weakly correlated nodes. Therefore, for edges on a source-sink path, the aggregation ratio for edges near the sink will not be larger than those farther away. The reason for skipping virtual edges is that their data aggregation ratio is set to 1 and does not affect the actual energy consumption of the network. Second, the unit fusion cost q is determined mainly by the complexity of the fusion algorithm and the input data set. As the information is being routed toward the sink, the data size and complexity will naturally increase due to aggregation on the route. Therefore, performing fusion thereon will incur more computation and, hence, more energy consumption per unit data.

E. Adaptive Fusion Steiner Tree (AFST)

AFST [18], [19], [20] improves MFST and BFST by combining the benefits of both the methods. It performs a matching process as in MFST in order to jointly optimize over both transmission and fusion costs. During the matching process, it also dynamically evaluates whether fusion can be performed or not. If it determines at a particular point that fusion is not beneficial to the network, as shown by the analysis of BFST, it concludes that the succeeding nodes on the routing path need not to perform fusion. Consequently, it can employ SPT as the strategy for the remainder of the route. SPT is optimal for routing information without any aggregation. Analysis shows that AFST achieves better performance than BFST and MFST. Cluster heads (roots of the branches) sends the aggregated data to the sink through the shortest path without fusion.

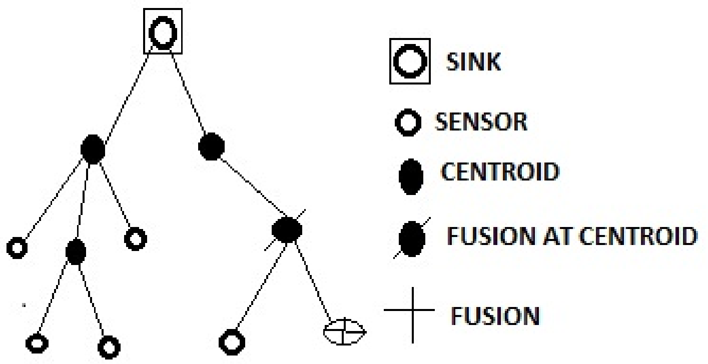

Figure 3. Aggregation in Centroid of the Cluster

V. MATHEMATICAL MODEL OF PROPOSED SYSTEM

A. K-means Fusion Steiner Tree (KFST)

The algorithm [21][22] is initialized by partitioning the input node into k initial sets, then it computes the mean point or centroid for each set by calculating the distance between the nodes as given below.

$$Centroid_i = \sqrt{(x_i - x_{i1})^2 + (y_i - y_{i1})^2}$$

where, $centroid_i$ is the centric of a ith cluster i.e. Ci and x, y represent the position of the centroid in each region. KFST constructs new partitions by associating each point with closest centroid, the position of the centroids are recalculated as new $centroid_i$ for the clusters by keeping the record of pre $centroid_i$ i.e., previous centroid. This algorithm is repeated until the centroid is no longer changed. Fig.3 shows that tree formation of the cluster head with sink node. Fusion and aggregation happens at the cluster head only.

In each cluster, the cluster head is selected based on the maximum power available in the cluster. If S_i is the source node of cluster C_i for every pair of non sink nodes (u, v) € C_i, the minimum cost path metric M(e) is computed as follows

$$M(e) = qC_{u_i} \; C_{v_{i+1}} (lC_{u_i} + lC_{v_i}) + \alpha_i (lC_{u_i}, lC_{v_i}) c(e) \qquad (4)$$

where, α =0, 1 - data fusion factor, *c(e)* -unit transmission cost on edge e, - load on node u of i^{th} cluster *Ci*, lC_{u_i}- load on node v of i^{th} cluster C_i and qC_{u_i} v_{i+1}– unit fusion cost on edge between node C_{ui} and C_{vi+1} of C_i.

If a node is not performing data fusion, neglect that node and compute the fusion benefit δ for *u* and *v* respectively, as shown below;

$$\delta C_{u_i}, C_{v_{i+1}} = (lC_{u_i} + lC_{v_i}) SP(v_i,t) - q_{e_i} (lC_{u_i} + lC_{v_i}) + (lC_{u_i} + lC_{v_i})(1 - \sigma_{e_i}) SP(v_i,t)) \quad (5)$$

where, $SP(C_{vi}, t)$ summation of unit transmission cost from C_{vi} to sink *t*, qC_{ei} – unit fusion cost on *ith* edge *e*, σ_{e_i} correlation factor on *ith* edge *e* and the matched pair node (C_{ui}, C_{vi}) belongs to *Ci.*

KFST Algorithm

Algorithm: KFST ( )
The sub graph diagraph $G \in G^*$ for all k, vectors V^*, E^*, P, C, l, initial index S_0 and target index S_t are taken as input to the algorithm
Initialize $k = k_0$
for i = 1 to k **do**
randomly choose centroid belongs to C_i ;
endfor

L1: calculate object centroid distance
for i = 1 to k **do**
for i = 1 to n **do**
Calculate distance between all the nodes with respect to centroid to form cluster;
total_distance = total_distance + distance;
endfor
endfor
calculate minimum total distance; // calculate the new position of the centroid in the cluster
for i to j **do**
calculate $new\_centroid_i$;
pre $centroid_i$= $new\_centroid_i$;
endfor
if new $centroid_i$ == pre $centroid_i$ **then**
goto **L2**;
else goto **L1**;

L2: **for** i = 1 to k **do**
If $P_{ui} \leq P_{vi}$ **then**
Select v_i as cluster head belongs to C_i;
else
Select u_i as cluster head belongs to C_i;
endif
select source S_i belongs to C_i;
calculate Number of node n_i present in the cluster C_i;
for non_sink_pair(u, v) **do**
for j = 1 to n_i **do**
calculate minimum cost path according to (2);

endfor
endfor

calculate fusion benefit δ(pair node) for all nodes belonging to Ci;
if δ(pair node) == 0 **then**
select pairnodes as non fusion pairs belongs to set E_n;
else
select pair nodes as fusion pairs belongs to set E_f ;
transport the weight of non-centric node to its corresponding cluster head according to (4);
remove all the non-cluster head node then remaining center nodes induce to Si+1;
if $S_{i+1} \neq S_t$ **then**
goto **L2**;
else
return;
endif
endif
endfor

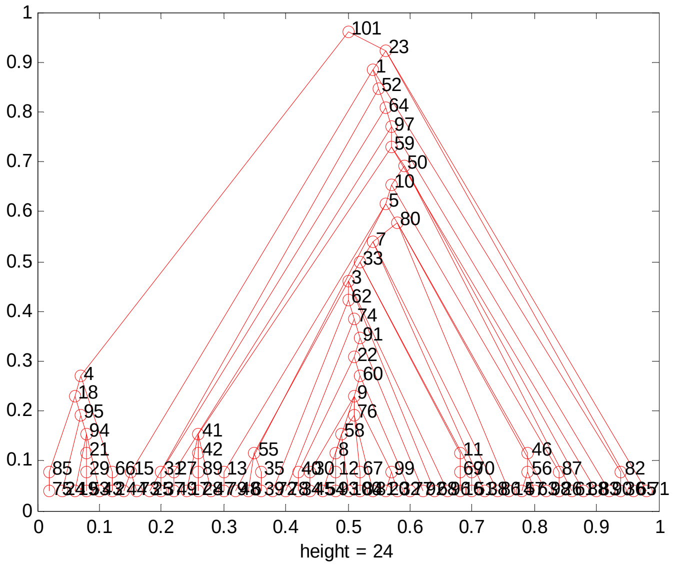

Figure 4. Spanning tree for AFST

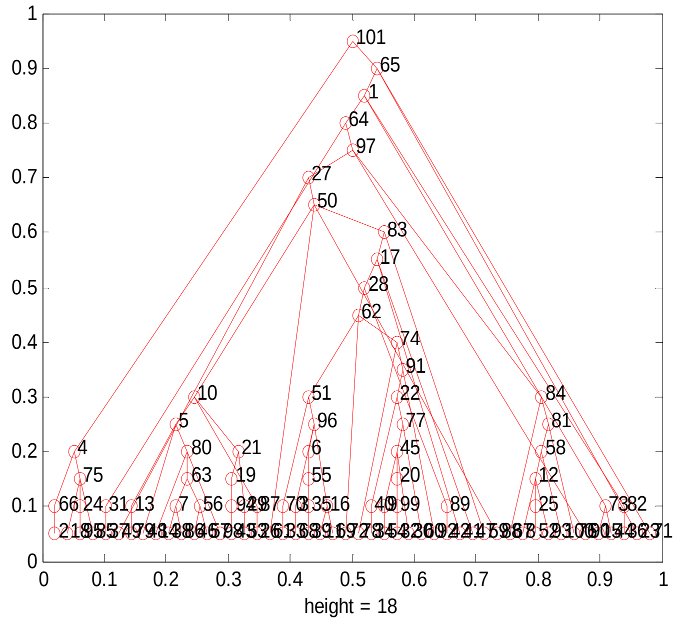

Figure 5. Spanning tree for KFST

If the fusion benefit of matched pair is less than zero then it is known as non–fusion pair which belongs to the non-fusion edge set E_n. Otherwise, the fusion pair belongs to the fusion edge set E_f . The weight of noncentric node is sent to the cluster head.

$$lC_{i+1}(\text{center}) = (lC_{u_i} + lC_{v_i})(1- \delta\ C_{ui}\ ,C_{vi}+1\ ) \qquad (6)$$

where, lC_{i+1} center- load on the cluster head.

TABLE 3. SIMULATION PARAMETERS

Parameter type	***Test values***
Number of nodes	100
Sink node	Mote 1
Radio model	lossy
Multi channel Radio Transceiver	433MHz
Sensor type	Light, temperature, Pressure
Outdoor Range	500ft

For each non fusion pair $(C_{ui}\ ,C_{vi}\ ) € C_i$

- Add the edges that are on the shortest path of $(C_{ui}\ , t)$ and $(C_{vi}\ , t)$ to set E^*_n.
- Remove both nodes *u* and *v* from S_i.

For each fusion pair $(C_{ui}\ ,C_{vi}) € C_i$

- Add the edges that are on the shortest path defining to set E^*_f.
- Choose C_{ui} to be the center with probability p, otherwise C_{vi} will be the center.
- Non center node load is transfer to the center node.

Remove all non centers from S_i, induce S_{i+1} If S_{i+1} is empty, contains only the sink node, return G^*

$$G^{*} = \text{argmin}_{G'} \sum_{e \in E'_T} f(e) + t(e) + \sum_{e \in E'_n} t(e) \qquad (7)$$

VI. SIMULATION SETUP AND RESULT ANALYSIS

In the setup of MATLAB simulation, 100 sensor nodes are deployed randomly in the area of 60mX60m. This region is further divided into 36 regions with size 10mx10m and is formed into clusters based on K-means clustering technique.Figure 6 shows the deployment of sensor network in the simulation environment.each grid repsrents the cluster, clusterhead is elected from the sensor nodes based on the highest energy.

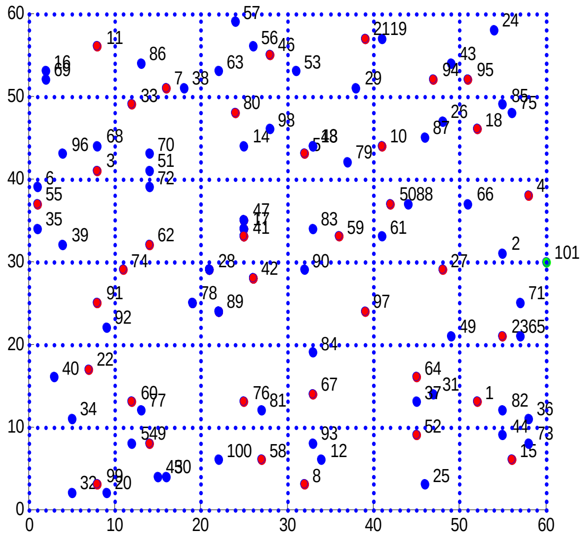

Figure 6: Deplyoment of the sensor node in the simulation environment

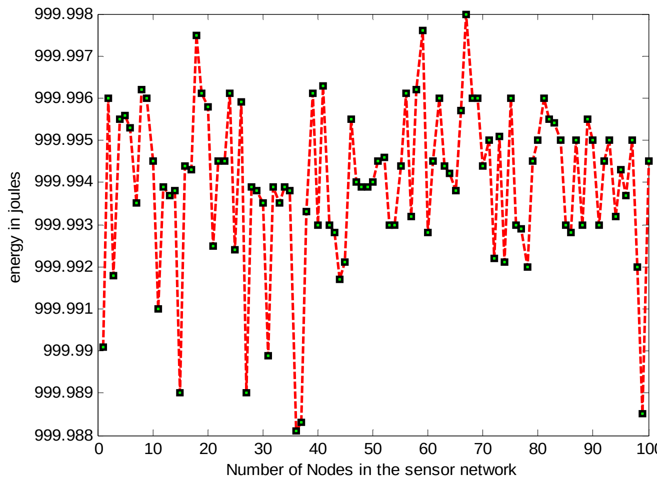

Figure 7. Energy graph for AFST

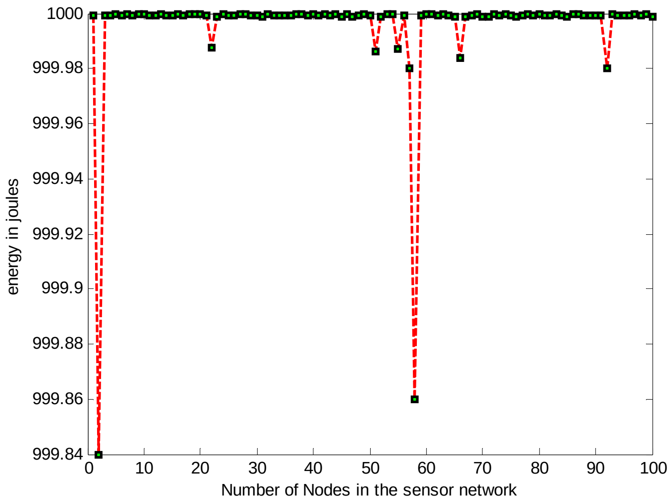

Figure 8. Energy graph for KFST

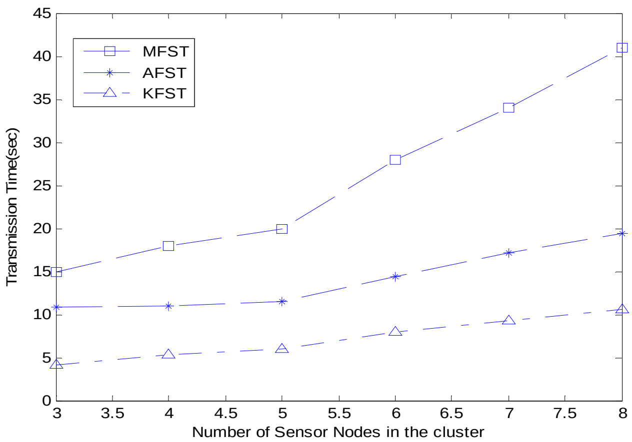

Figure. 9 Number of Sensor Nodes versus Transmission time

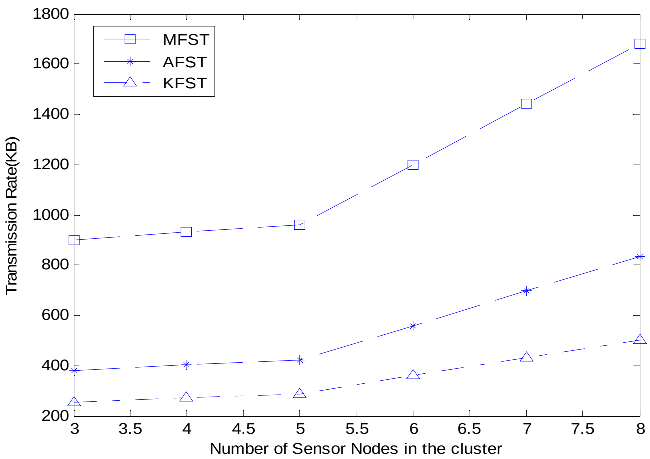

Figure 10. Number of Sensor Nodes with Time Transmission Rate

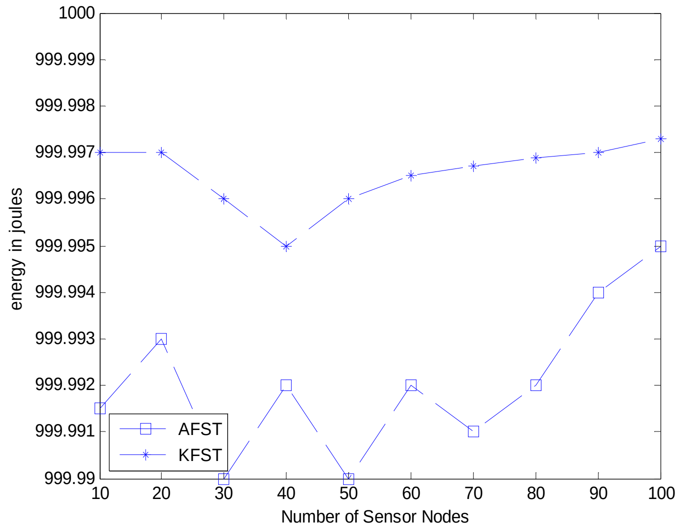

Figure 11. Energy Consumption

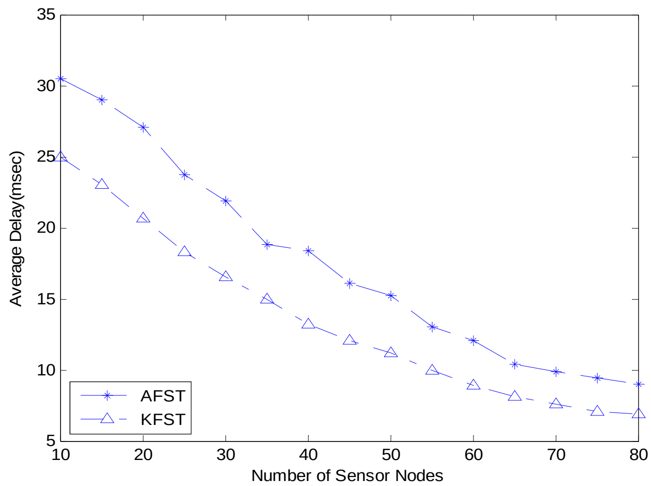

Figure. 12 Delay versus Number of Nodes in the Sensor Network

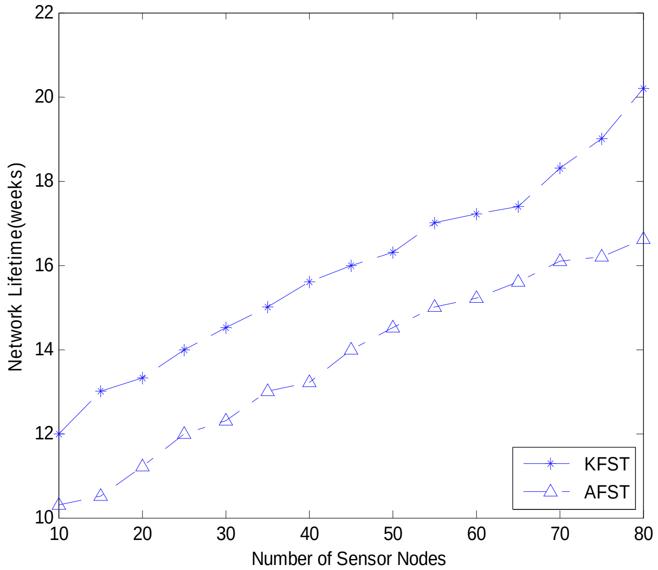

Figure 13 Network Lifetime versus the number of Sensor Nodes

Each cluster selects the highest energy node as the cluster head. Thus 36 cluster heads are elected. While transmitting data from source to sink in AFST, almost all the nodes are involved for routing, where as in KFST only Cluster Head is involved. Each node produces 12KB packet as original sensed data in each iteration (i.e., each node produces 12KB packet as original sensed data in each round). Figure 7 and 8 shows that number of nodes involved for routing in AFST is more than that of KFST. Number of nodes involved for routing in AFST is 21 where as KFST involves only 9 cluster head for the same route. All sensors behave as both sources and routers. Table 4 illustrates the performance of KFST system with various number of sensor nodes based on data rate and transmission cost. Figures 9, 10,11 show simulation results for different number of sensor nodes with Data Rate, Transmission Time and Energy Deception respectively.

Fig. 12 represents the delay requires for the transmission of data from the source to destination sink for KFST and AFST. We observe that KFST takes the less amount of delay due to cluster formation in comparison with the AFST. Fig.13 represents the lifetime of the network for AFST and KFST algorithm for various number of sensor nodes in the network. As the number sensor node increases in the network it improves the lifetime of the network. Since we form clusters, participation of all sensor node is reduced and thus it increase the lifetiome of network.

TABLE 4. SIMULATION RESULTS FOR PROPOSED SYSTEM

Number of sensor nodes	***Existing protocol(MFST)***		***Existing protocol(AFST)***		***Proposed protocol(KFST)***	
	Total data rate (KB)	***Total transmission time(sec)***	***Total data rate (KB)***	***Total transmission time(sec)***	***Total data rate (KB)***	***Total transmission time(sec)***
3	900	15	382	10.8	253	4.2
4	930	18	402	11.0	271	5.3
5	960	20	424	11.5	288	6
6	1200	28	560	14.4	360	7.9
7	1440	34	696	17.2	432	9.3
8	1680	41	832	19.4	504	10.6

VII CONCLUSIONS AND FUTURE WORK

Wireless Sensor Network has the issue of energy conservation since the battery of the sensor node cannot be replaced or recharged. In this paper, we propose K means Fusion Steiner Tree based on aggregation and optimized routing technique to minimize the energy consumption in Wireless Sensor Network. KFST - algorithm divides the network into k number of clusters, each cluster selects its own cluster head based on the energy. The highest energy node is selected as the cluster Head. AFST and MFST do aggregation in all nodes in its enroute. Our algorithm does the aggregation only in the cluster head and hence the transmission and fusion cost is reduced. In our previous[24] work, we have considered only energy conservation. We enhanced the work, by considering lifetime and delay. The simulation result shows that lifetime is maximized and delay is reduced along with energy conservation. This work can be extended for sensor nodes with different energy levels.

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