Energy And Time Delay Efficient Wireless Sensor Network By Least Spanning Tree Algorithm: A Survey

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Abstract

In this paper we are going to survey the different type of topology and techniques for making an energy efficient WSN with least time delay approach .WSNs are used in defense field where lest time delay and life of sensors are most important because the life of solider are depends on fast information transmission . Hence energy and time delay are very scarce resources for such sensor systems and has to be managed wisely in order to extend the life of the sensors and minimizing time delay for the duration of a particular mission. In past a lot of cluster based algorithm and techniques were used. In this paper we also find out all type of algorithm, their application and limitation and present techniques to overcome the problems of low energy and time delay of sensor and compare them with least spanning tree based algorithms and techniques .

Keywords: Wireless sensor networks, energy efficient clustering, LEACH, energy efficient algorithms, least spanning tree algorithm.

1. INTRODUCTION

Advances in sensor technology, low-power electronics, and low-power radio frequency (RF) design have enabled the development of small, relatively inexpensive and low-power sensors, called microsensors[1] The emerging of low power, light weight, small size and wireless enabled sensors has encouraged tremendous growth of wireless sensors for different application in diverse and inaccessible areas, such as military, petroleum and weather monitoring. These inexpensive sensors are equipped with limited battery power and therefore constrained in energy [4]. One of the fundamental problems in wireless sensor network is to maximize network lifetime and time delay in data transmission. Network lifetime is defined as the time when the first node is unable to send its data to base station. Data aggregation reduces data traffic and saves energy by combining multiple incoming packets to single packet when sensed data are highly correlated. In a typical data gathering application, each node sends its data to the base station, that can be connected via a wireless network. These constraints require innovative design techniques to use the available bandwidth and energy efficiently. Energy usage is an important issue in the design of WSNs which typically depends on portable energy sources like batteries for power .WSNs is large scale networks of small embedded devices, each with sensing, computation and communication capabilities. They have been widely discussed in recent years. Coverage is one of the most important challenges in the area of sensor networks. Since the energy of sensors are limited, it is vital to cover the area with fewer sensors. Generally, coverage in sensor networks is divided into area coverage, point coverage, and boundary coverage subareas. Coverage does not ensure connectivity of nodes.. In WSNs the sensor

nodes are often grouped into individual disjoint sets called a cluster, clustering is used in WSNs, as it provides network scalability, resource sharing and efficient use of constrained resources that gives network topology stability and energy saving attributes. Clustering schemes offer reduced communication overheads, and efficient resource allocations thus decreasing the overall energy consumption and reducing the interferences among sensor nodes. A large number of clusters will congest the area with small size clusters and a very small number of clusters will exhaust the cluster head with large amount of messages transmitted from cluster members. In this paper we are going to survey different types of energy efficient and coverage efficient wireless sensor network.

2. SURVEY

2.1 LEACH [Low Energy Adaptive Clustering Hierarchy][4] and Its Descendant

One of the well known clustering protocols called LEACH[**L**ow **E**nergy **A**daptive **C**lustering **H**ierarchy][2]. LEACH is a cluster-based protocol that includes distributed cluster formation in which the nodes elect themselves as cluster heads with some probability. The algorithm is run periodically and the probability of becoming a cluster head for each period is chosen to ensure that every node becomes a cluster head at least once within 1/P rounds, where P is the predetermined percentage of cluster heads. LEACH organizes its operation into rounds, where each round consists of a setup phase where clusters are formed and a steady state phase that consists of data communication process. LEACH provides significant energy savings and prolonged network lifetime over conventional multihop routing schemes, such as the **M**inimum **T**ransmission **E**nergy (MTE)[2] routing protocol.

2.1.1 LEACH-C [5]

However, LEACH does not guarantee that the desired number of cluster heads is selected and cluster heads are not evenly positioned across the network. A further improvement of this protocol known as LEACH-C[4].

In LEACH-C, the cluster formation is done at the beginning of each round using a centralized algorithm by the base station. The base station uses the information received from each node during the setup phase to find a predetermined number of cluster heads and configures the network into clusters. The cluster groupings are then chosen to minimize the energy required for non-cluster head nodes to transmit their data to their respective cluster heads. Results in[4] have shown that the overall performance of LEACH-C is better than LEACH due to improved cluster formation by the base station. Moreover, the number of cluster heads in each round of LEACH-C is equal to the desired optimal value, whereas for LEACH the number of cluster heads varies from round to round due to the lack of global coordination among nodes.

2.1.2 LEACH-Fixed on of cluster[6]

LEACH-F is an algorithm in which the number of clusters will be fixed throughout the network lifetime and the cluster heads rotated within its clusters. Long term phase of LEACH-F is identical to that of LEACH. LEACH-F have some limitation because it may or may not be provided energy saving and this protocol does not provide the flexibility to sensor nodes mobility or sensor nodes being removed or added from the sensor networks

2.1.3 LEACH-Energy Threshold [6]

In this cluster will change only when one of the following conditions is satisfied: first, Energy consumed by anyone of the cluster head nodes (CHs) reach energy threshold (ET) in one round. Second, every sensor node should know the energy threshold (ET) value. If in initial phase, anyone of the cluster head nodes dies. If any sensor node acts as a cluster head node (CHs) in a certain round, it should have the energy dissipated value and compares the dissipated value with the energy threshold (ET) value.

2.1.4 MS-LEACH [Multi-hop and Single hop-Low Energy Adaptive Clustering Hierarchy][6]

In this paper the authors have analyzed the problem of energy consumption of the single-hop and multi-hop transmissions in a single cluster. Finally a critical value of the cluster area size is determined. MS-Leach is based on the critical value. Simulation results clearly show that MS-Leach outperforms at most by 200% in term of network lifetime. It is proposed as future work its relationship between multi-hop and single-hop transmissions will be analyzed in-depth in various protocols and new mechanisms of routing will be developed.

2.1.5 LEACH-Heterogeneous [7]

In this paper, LEACH-HPR introduced an energy efficient cluster head election method and using the improved Prim algorithm to construct an inter-cluster routing in the heterogeneous WSN. Simulation results show LEACH-HPR is more efficient to reduce and balance energy consumption and hence enhance the lifetime of WSN

2.2 Power-Efficient Gathering in Sensor Information Systems [PEGASIS][8]

Another clustering protocol which aims to enhance the network lifetime is (PEGASIS)[5]. Power-Efficient Gathering in Sensor Information Systems (PEGASIS) uses a greedy algorithm to organize nodes into a chain, so that each node transmits and receives from only one of its neighbors. In each round, a randomly chosen node from the chain will transmit the aggregated data to the base station and reduce the number of nodes that communicate directly with the base station.

2.3Hausdroff Clustering [16]

Authors considered that, once cluster formations take place it's remaining same throughout the network lifetime. This algorithm maximizes the lifetime of each cluster in order to increase the life time of the system. Cluster life time can be enhanced by rotating the role of cluster heads (CHs) among the nodes in the cluster. Cluster heads selection basically based on the residual energy of the sensor nodes and it also used the proximity of neighbors as a secondary criterion for enhancing energy efficiency and further prolong the network lifetime. The Hausdroff clustering algorithm is equally applicable for both uniform and nonuniform sensor node initial energy distribution.

2.4 PDCH: Pegasis Algorithm Improving Based on Double Cluster Head [20]

Authors proposed an algorithm based on hierarchical chain topology and this algorithm using bottom level cluster head and super level cluster head to improve the load balance. In the hierarchical structure, base station (BS) is the center of a circle. The BS will predefine the number of levels and every node's distance to BS decided the level which it belongs to. Every node receives the signal from the BS, then according to the signal strength to detect the distance to BS. PDCH outperform to

PEGASIS algorithm and it is also useful for large networks.

2.5 Base station Controlled Dynamic Protocol [BCDCP][9]

An approach called Base station Controlled Dynamic Protocol (BCDCP)[7] is proposed which produces clusters of equal size to avoid cluster head overload and to ensure similar power dissipation of nodes.

2.6 EECS: Energy Efficient Clustering Schemes [12]

Authors proposed an algorithm in which cluster formation is different from LEACH protocol. In LEACH protocol cluster formation takes place on the basis of a minimum distance of nodes to their corresponding cluster head. In EECS, dynamic sizing of clusters takes place which is based on cluster distance from the base station. The results are an algorithm that addresses the problem that clusters at a greater distance from the sink requires more energy for transmission than those that are closer. Ultimately it provides equal distribution of energy in the networks, resulting in network lifetime. Thus main advantage of this algorithm is the full connectivity can be achieved for a longer duration. So we can say it provides reliable sensing capabilities at a larger range of networks for a longer period of time. It provides a 35 percent improvement in network life time over LEACH algorithm.

2.7 EEUC: Energy Efficient Unequal Clustering [14]

This scheme is distance based scheme similar to EECS and it also required that every node has global identification such as its locations and distances to the base station. Hotspot is the main problem in WSNs because of multi hopping that occurs when CHs closer to the sink tend to die faster compare to another node in the WSNS, because they relay much more traffic than remote nodes. This algorithms partition the all nodes into clusters of unequal size, and clusters closer to the sink have smaller sizes than those farther away from the sink. Thus cluster heads (CHs) closer to the sink can conserved some energy for the inter-cluster data forwarding. Energy consumed by cluster heads per round in EEUC much lower than that of LEACH standard but similar to HEED protocol.

2.8 BARC: Battery Aware Reliable Clustering [15]

In this clustering algorithm authors used mathematical battery model for implementation in WSNs. With this battery model authors proposed a new Battery Aware Reliable Clustering (BARC) algorithm for WSNs. It improves the performance over other clustering algorithms by using Z-MAC

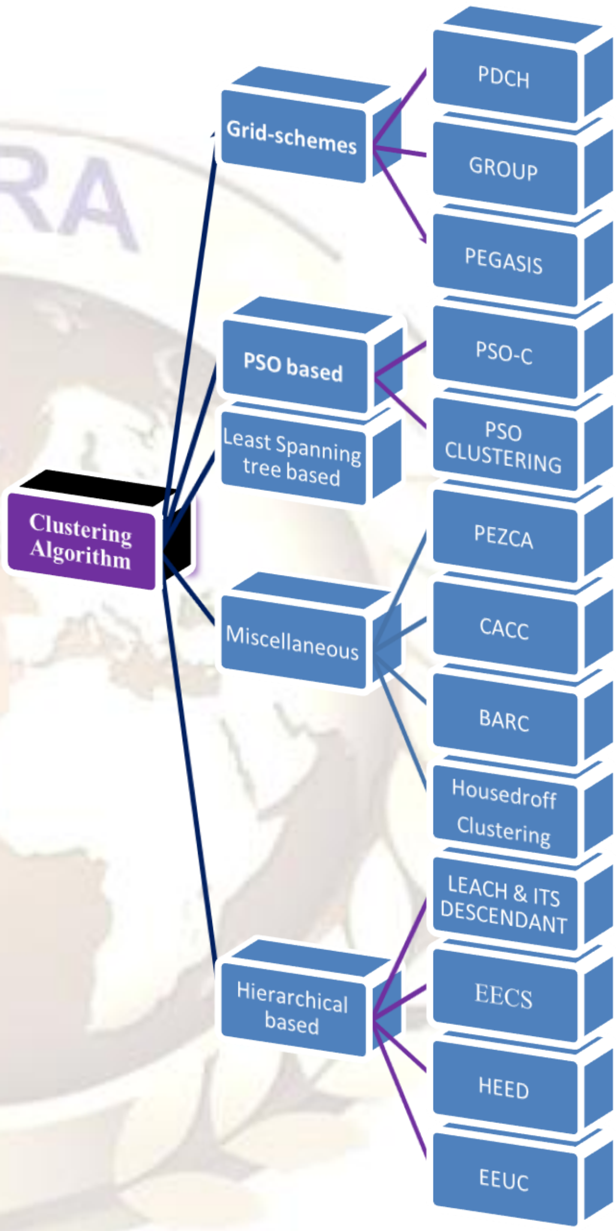

Fig-1 Different types of cluster based technique and it rotates the cluster heads according to battery recovery schemes. A BARC algorithm consists of two stages per round for selection of cluster heads: initialization or setup and steady state. In this formation of cluster, take place by electing a set of CHs. BARC enhances the network lifetime greatly compare to other clustering algorithms.

2.9 PSO-Clustering [22]

In this paper authors proposed PSO-clustering which have four variants of PSO: PSO-TVIW (PSO with time varying inertia weight), PSO-TVAC (PSO with time varying acceleration constants), HPSO-TVAC (hierarchical PSO-TVAC) and PSO-SSM (PSO with supervisor student mode) for energy aware clustering in WSNs. This algorithm is applicable only when each node has fixed Omni-directional transmission range, the sensor field should be mapped into a 2-Dimensional space and nodes are randomly distributed. After deployment of the nodes, the nodes are static and the positions of the nodes are known to the base station. The base station runs the clustering algorithm and updates nodes about their cluster-head and all nodes should have same transmission ranges and hardware configurations.

2.9.1 PSO-C: Centralized-PSO [23]

Authors proposed centralized-PSO algorithms, in which the nodes which have energy above average energy resource are elected as the cluster heads. In this authors also compare this algorithm with LEACH protocol and with LEACH-C. Simulation results show that PSO outperform to LEACH and LEACH-C in term of network life time and throughput etc. It also outperforms GA and K-means based clustering algorithms.

2.9.2 Distributed PSO[23]

PSO control algorithm try to minimize radio power while ensuring connectivity of the network. In this paper author proposed an important metric for a sensor network topology that involve consideration of hidden nodes and asymmetric links. It minimizes the number of hidden nodes and asymmetric links at the expense of increasing the transmit power of a subset of the nodes may in fact increase the longevity of the sensor network. Author explores a distributed evolutionary approach to optimize this new metric. Author generates topologies with fewer hidden nodes and asymmetric links than a comparable algorithm and presents some results that indicate that his topologies deliver more data and last longer.

2.10. Least Spanning Tree based clustering[21]

In this paper, Authors proposed an novel energy-efficient routing protocol based on clustering and least spanning tree for wireless sensor network to prolong network lifetime and shorten path while emphasizing energy conservation at the same time. Clustering includes partitioning stage and choosing stage, namely, partitions the multi-hop network and then chooses cluster-heads, cluster-head is responsible for receiving, sending and maintaining information in its cluster. Then all cluster-heads will construct a least spanning tree to prolong network lifetime ,save energy and shorten path. Simulation results show that the system's performance have further improved by using clustering and least spanning tree, It is a promising approach and deserves more future research.

3. MAIN THEORY

THE Minimum Spanning Tree (MST) method that is an important and commonly occurring primitive in the design and operation of data and communication networks. For instance, in ad hoc sensor networks, MST is the optimal routing tree for data aggregation [2]. Traditionally, the efficiency of distributed algorithms is measured by the running time and the number of messages exchanged among the computing nodes, and a lot of research has gone into the design of algorithms that are optimal with respect to such criteria.

Cluster based spanning tree can improve lifetime of the network and also gives the shortest path for minimum propagation delay. Clustering includes partitioning stage and choosing stage, namely, partitions the multi-hop network and then chooses cluster-heads, cluster-head is responsible for receiving , sending and maintaining information in its cluster. Then all cluster-heads will construct a least spanning tree to prolong network lifetime ,save energy and shorten path. Paper review results show that the system's performance have further improved by using clustering and least spanning tree, It is a promising approach and deserves more future research. Sensors and cluster-heads are assumed to be stationary or limited moving inside clusters. Sensors receive commands from and send data to its cluster-head, which does pre-processing for the data and forward them to other cluster-heads. A cluster-head is located within the communication range of all the sensors of its cluster and can communicate with its neighbour cluster-heads. Since a cluster-head forwards traffic to other cluster-heads with longer distance as compared to its sensing nodes, in some applications it is more powerful than the sensing nodes in terms of energy, bandwidth and memory [11,12], while others select cluster–heads from the deployed sensors [13,14]. When a cluster-head is under failure due to insufficient power, another cluster-head will be selected among the sensors(assume a sensor can adjust its transmission power to a larger value (for relaying requirement) once it is selected as a cluster-head. The details on transmission power control issues are referenced in for example [15,16]). The cluster-based architecture raises many interesting issues such as cluster formation, cluster-head selection and cluster maintenances, which are beyond the scope of this work. Here,

we only focus on modelling the traffic behaviour along with the multi-hop cluster-heads by least spanning tree. The system model consists of five parts: (1) constructing cluster-head part, in each area dynamic constructing a cluster head according to the remainder energy.(2) constructing least spanning tree, according to the cluster-head, sink will dynamic construct least spanning tree to achieve maximum lifetime and prolong network lifetime.(3)sensing part, the sensors around the target area are responsible for probing the target/event and send the collected data to their cluster-head; (4) relaying part, the collected data are relayed among the cluster-heads by least spanning tree until to the sink; (5) sink, the sink performs system-level data analysis and process for an overall situation awareness.

The energy model based on the given energy equation:

$$Et(i) = (e_t + e_d r^n)B \qquad (1)$$

Where e_t is the energy/bit consumed by the transmitter electronics (including energy costs of in per strongly dominates other node functions such as fact duty cycling due to finite start-up time), and e_d accounts for energy dissipated in the transmit op-amp (including op-amp inefficiencies). Both e_t and e_d are properties of the transceiver used by the nodes, r is the transmission range used. The parameter n is the power index for the channel path loss of the antenna. B is the bit rate of the radio and is a fixed Topology management provides the distributed parameter in our study

On the receiving side, a fixed amount of power is required to capture the incoming radio signal where er is the energy/bit consumed by the receiver electronics used by the node. Typical numbers for currently available radio transceivers are et= 50× 10-9J/bit, er=50×10-9 J/bit, ed=100× 10-12J/bit/m (for n=2) and B=1 Mbit/s [18].

$$Er(j) = e_r B \qquad (2)$$

Now let us consider one-hop communication in a finite one dimensional network from the ith cluster-head to the jth cluster-head across a distance di,j. If the ith cluster-head will generate A Erlang and the distance of the ith cluster-head and the jth cluster-head is dij,so the power consumed by this communication is then simply as the Eq. (3).

$$Et(i, j) = (e_t + e_d d_{ij}^n) B A_i \qquad (3)$$

Where $d_{i,j} = \sqrt{(X_i - X_J)^2 + (Y_i - Y_J)^2}$

The jth cluster-head as the receiver, the power consumed by this communication is then simply as the Eq (4)

$$Er(j, i) = e_r B A_i \qquad (4)$$

By combining Eq. (1) to Eq. (4) we can make a cluster-based WSN model. We know the energy consumed at the cluster head is much larger than that at individual sensing node. The reason is as follows: (1) the cluster-head needs to relay all the traffic of the cluster; (2) for each data unit, the cluster-head needs to transmit longer distance due to transmission between clusters, while the sensing nodes just transmit data inside the cluster. In view of this, let Ep and Ec be, respectively, the current energy and clustering energy(Ec is fixed), after a period of time, the ith cluster-head has transmits information n_1 times and has receives information n_2 times before T1(suppose the energy of the ith cluster-head is not lower than the threshold and the information unit is A Erlang) .the remainder energy of the ith cluster-head at T1 is then simply as the Eq (5) .

$$Ep(i) = Ep(i) - \sum_{k=1}^{n_1} Et(i, k) - \sum_{l=1}^{n_2} Et(i, l) - Ec \times n_i \quad ..(5)$$

where i,j,k is respectively denote cluster-head, n_i is the clustering time in cluster i before T1

By Ep(5),we can compute the remainder energy, if Ep(i) is lower than Ev, then modify the information table of the ith cluster-head: set flag=0; broadcast information to it's children, .also inform the neighbor jth cluster-head doesn't transmits information to it, and let ith cluster-head i is in the sleeping state; else the ith cluster-head may go along the next clustering

or transmitting or receiving. According to Prim algorithm, suppose undirected graph G (V,E,D) ,where V is the set of cluster-heads and the number is N, E is the set of connections of cluster-head, and D is the distance of cluster-heads, the process of constructing least spanning tree as illustrated below:

- Initializatio:V1=Sink, E′=null, ,and V2=V-V1.
- Set a edge: which has minimum distance from Sink to one cluster-head (suppose is Vi),where Vi is directly connected to Sink, then set,V1={Sink,vi}, E ′={(Sink,vi)} , V2=V2-V1.
- For each cluster-head Vk in V1 do :select a minimum distance dk,j,which Vk∈V1,Vj∈ V2 and e′=(Vk,Vj) ∈E ,but is not∈E′, then V1=V1∪Vj, E′={(Vk,Vj)} ∪e′, V2=V2-Vj.
- if V2 is empty then end, else go to (3).

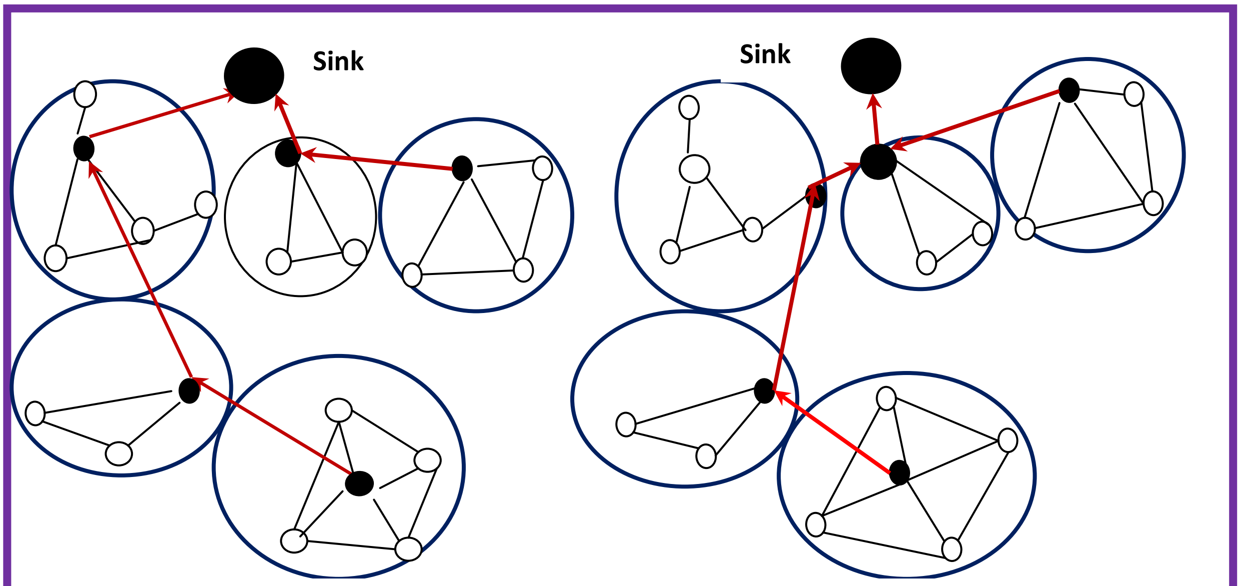

Fig-2 The least Spanning Tree

When a cluster-head's energy is lower than threshold, then first renewably select a node as new cluster-head in the cluster, second renewably execute constructing least spanning tree algorithm, so a new constructing least spanning tree has constructed, all sensing information can be send to Sink along the new least spanning tree, this algorithm can efficient shorten path and prolong network lifetime. As illustrated in Fig.1. Fig.1(a) show the initial least spanning tree, after some time ,if the power of C1's cluster head is lower threshold ,nodes in C1 will execute re-clustering to choose a new cluster-head, this time system will execute constructing least spanning tree algorithm, and make a new least spanning tree as Fig.1(b).we can know the total-path of new least spanning tree is shorter than old least spanning tree.

3. CONCLUSION

From the literature review of cluster based Minimum Spanning Tree and other cluster based algorithm we have a lot of advantages of cluster based Minimum Spanning Tree over other algorithm. Since with cluster based Minimum Spanning Tree we can add more application of other algorithm such as power gathering and distributed least spanning tree. By these applications we can improve the efficiency of WSN and also reduce the power delay of the information and increase the range of sensor nodes.

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