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Various Clustering Techniques in Wireless Sensor Network

Mamta
Geeta Institute of Management and Technology
Kurukshetra University
Kurukshetra, Haryana
India

Abstract: This document describes the various clustering techniques used in wireless sensor networks. Wireless sensor networks are having vast applications in all fields which utilize sensor nodes. Clustering techniques are required so that sensor networks can communicate in most efficient way.

Keywords: wsn, wireless sensor networks, clustering, weight based clustering ,leach, Network.

1. INTRODUCTION

A wireless sensor network [1] can be an Unstructured or Structured network. An unstructured network does not have a fix topology. A structured network have a fix topology.WSN are unstructured network because sensors keep on changing their location continuously. WSN can efficiently create routes among the nodes of a network. A WSN can be static and dynamic depending upon nature of route created. In static network, the configuration of nodes is done manually. Network administrator makes these entries in a static table and routers uses entries from these routing table for performing their routing function well. In dynamic networks all configuration is made dynamically by a dynamic routing protocol. Node can leave and join the network dynamically at run time. As sensors in wireless sensor network changes there location constantly, so arranging a communication system for them is a typical task. To resolve this problem clustering algorithms for WSN are proposed which provides a structured way of communication for unstructured WSN. This algorithm divides WSN nodes into clusters choosing a cluster head for each node which performs data aggregation and data processing task for whole cluster thus saving energy. Cluster head thus consume more energy than other nodes.

Clustering is the activity [5] of creating sets of similar objects. Various researches are performed on clustering. Nodes in a clustered wireless sensor network can also be classified as primary nodes and secondary nodes. Primary nodes can perform data aggregation and data processing function instead secondary nodes only performs data forwarding functions.

Clustering increases the network scalability and life. It makes distribution control over the network more diverse. It saves energy by distributing load by making intelligent decision. Nodes having high energy are allocated more loads thus increasing the lifetime of the network. The clustering is done in such a way that data has to travel minimum. Only cluster heads communicates with cluster head thus reducing the data redundancy which usually happens when each node perform its own data aggregation and transmission [8] function separately. This algorithm provides very efficient way of communication in sensor networks. Such algorithm creates easy to maintain algorithms. Clustering in WSN network makes them suitable for use in uneven environments.

In this paper we will perform a survey on wireless sensor network with dynamic capability. Topic is less frequently discussed through surveys. We will see each clustering algorithm developed for wireless sensor networks with dynamic capability.

2. TYPES OF CLUSTERING ALGORITHMS

A. Event-to-Sink Directed Clustering

Event-to-Sink Directed Clustering is another type of protocol which provides high efficiency in terms of energy consumption. When a node discovers an event, it sends its report to sink. A sensor node sends this collected data to cluster head thus avoiding redundancy. This technique provides two new improvements:

1. Clustering is only performed when an event occurs, so no unnecessary clustering rounds need to perform.
2. There is minimum movement of data in the cluster because clusters are form in the direction from event to sink.
3. Cluster heads are selected from up-stream nodes and non-cluster nodes are selected from downstream nodes. So flow of data is almost one directional.

The author Alper Bereketli,Ozgur B. Akan [2] has evaluated the performance of Event-to-Sink Directed Clustering algorithm in his paper ”Event-to-Sink Directed Clustering in Wireless Sensor Networks” and compared it with LEACH algorithm. They kept total reporting nodes and total nodes in the ratio of one third.They analyzed that per hop delay in Event-to-Sink Directed Clustering in Wireless Sensor Networks was around 200 ms as compared to LEACH which has a 460 ms delay almost double of Event-to-Sink Directed Clustering.

B. Load balanced clustering scheme

Another algorithm called load balanced clustering scheme was proposed by Shujuan Jin, Keqiu Li [8]. Whole heavy tasks of a network are performed by cluster head. This much excessive load can kill it by consuming all of its energy. In load balanced clustering scheme an assistant node is selected to help the cluster head to perform its data aggregation and data processing task. Assistant node transmits the data to base station. Cluster head process the received data and sends it to assistant node. Assistant node sends this data to base station.Multi hop data transmission is used to avoid early death of assistant node.

Disadvantage of this scheme is that data flow among nodes is not uniform. Nodes closer to base station receives more data than nodes which are farther away. So closer nodes consumes excessive energy hence get depleted very soon.

C. K-means algorithm

K-means algorithm [5] was another Clustering algorithm which uses following two factors as its selection criteria for a cluster head:-

1. Euclidian distances

2. Residual energies of nodes.

All nodes send their data to a central node which stores this information in a list. After it has collected data from all its nodes it performs the k-mean clustering algorithm.

This technique works better when clustering is performed by distributed method instead of doing it centrally. If central node is installed at one place, whole system will break down if this node got failed. In distributed computing even if a single node fails it cannot harm other nodes.

There are more chances of packet loss in centralized system since if packet is lost; it has no other copy to reach other nodes. In distributed System, even if a packet to a node fails, node will get it through any another way since in distributed network every node in receiving range broadcasts its packets to its neighbors.

To enhance the efficiency [6] of clustering in wireless sensor networks, another technique is used is which is called capability of energy harvesting. Nodes that have the capability of energy harvesting can generate energy from various sources like sun, water and air etc.As nodes are charged again and again by using conventional sources of energy so they never go out of energy. However it is not feasible to embed capability of energy harvesting in all nodes of a wireless sensor network due to various infrastructural limitation. So nodes with energy harvesting capability are evenly distributed in wireless.

The nodes with harvesting capability cannot be elected as cluster heads since they are highly dependent on nature for their source of energy which is not a reliable source of energy. But these nodes can be made to serve as relay nodes between cluster head and base station. Pengfei Zhang, Gaoxi Xiao and Hwee-Pink Tan (2011) in their paper “A Preliminary Study on Lifetime Maximization in Clustered Wireless Sensor Networks with Energy Harvesting Nodes” has proposed an algorithm called single cluster algorithm. This algorithm selects the optimal position of cluster head. Position of cluster head is made to choose in such way that it maximizes its battery lifetime. They then observed the effect of installing the energy harvesting relay nodes between cluster heads and base station. There algorithm which has utilized the use of energy harvesting node has increased the lifetime of network by approximately 8.59%.However algorithm worked for single cluster only.

The normal notion of network lifetime [9] is time consumed until first now in the network becomes dead. However this notion does not go well with wireless sensor network’s lifetime. Since nodes in the wireless sensor are not even in terms of energy. Cluster heads consumes high energy instead of non-cluster heads which uses comparatively less energy than cluster heads. Network lifetime of a wireless sensor network can be better defined in terms of time for which a cluster has worked properly. However only network lifetime does not serve as better criteria for evaluating the performance of the network. Other factors like amount of data gathered also plays a key role. Tianqi Wang, Wendi Heinzelman, and Alireza Seyedi has proposed a new optimization technique in their paper,” Maximization of Data Gathering in Clustered Wireless Sensor Networks for maximizing the amount of data gathered during the lifetime of a network.

D. Low-Energy Adaptive Clustering

Low-Energy Adaptive Clustering [10] is one of the milestones in clustering algorithms. The aim of Low-Energy Adaptive Clustering was to select nodes as cluster heads in such a way that every node gets a chance to become cluster head. As cluster head consumes higher energy then non cluster heads, so load is evenly distributed among nodes. So a single node does not go out of energy after a short time span just because it was frequently elected as cluster head.

Low-Energy Adaptive Clustering involves two phases of operation

1. Set up phase
2. Steady state phase

In Set-up phase clusters are made and a cluster head is selected for each cluster. Cluster head is selected based upon a probabilistic factor. Probably of a node to become a cluster head is calculated on the basis of two factors which are as follows:

1. Number of times a node has been a cluster head.
2. Suggested total number of cluster heads for a network.

If the value of probabilistic factor for a node is less than threshold, then it is elected as cluster head.

In steady state phase all data collected by cluster heads is sent to base station.

Disadvantage of Low-Energy Adaptive Clustering is that it does not consider initial energy as a factor to elect cluster head. So Nodes which have become cluster heads for same number of time as others but have less initial energy than other nodes are likely to become dead sooner than nodes which have high initial energies. The algorithm does not work well with large sized sensor networks since algorithm utilizes the single-hop inter-cluster technique which is not optimal for large size networks.

E. Hybrid Energy-Efficient Distributed clustering

Hybrid Energy-Efficient Distributed clustering considers two factors to decide whether to make a node cluster head or not. These are as follows:

1. Residual Energy
2. Intra-cluster communication cost

The main goal of Hybrid Energy-Efficient Distributed clustering is that all the cluster heads in the network get uniformly distributed.

Algorithm conserves more energy and is more scalable.

The disadvantage of Hybrid Energy-Efficient Distributed clustering is that sometimes it elects extra cluster heads. As cluster heads consumes more energy so efficiency of network considerably decreases. Also it consumes large bandwidth since it takes a lot of iterations to make clusters and a lot of packets are broadcast during each iteration.

F. Energy Efficient Hierarchical Clustering

Energy Efficient Hierarchical Clustering [3] is a probabilistic clustering algorithm. Algorithm was a extended version of LEACH with multiple hope architecture.

At first each node decides whether it can become cluster head or not. If it became cluster head it advertises its presence to all its neighbor nodes. The cluster head is now called volunteer cluster head. All nodes that are not k-hop farther away from cluster head receives all messages from cluster head. Any node which is not a cluster head if receives this advertisement message becomes a member of cluster head from which it has received its advertisement.

G. Weight-Based Clustering Protocols

In weight based clustering protocols, Weight is used as criteria for election of cluster head. This weight can be measured in terms of many factors like residual energy and distance of nodes from cluster head or no of times a node has become cluster head depending upon the algorithm.

Each node calculates its weight in each iteration of clustering. Clusters are formed in such a way that minimum energy consumption occurs in a wireless sensor network.

Weight Based Clustering [7] is a clustering technique for heterogeneous networks. It chooses the better cluster heads thereby increases the lifetime and throughput of WSN by its efficient clustering algorithm.

The goals of Weight Based Clustering is as follows

i. To increases the life of sensor nodes by electing sensor nodes which has high residual energy.
ii. To avoid the election of low energy sensor nodes as cluster heads.

Weight Based Clustering algorithm chooses cluster head in such a way that cluster head always has highest residual energy. Residual energy is energy left in a node after performing its processing and data transferring functions. It avoids the selection of low energy sensor nodes as cluster heads. It upgrades the life time of wireless sensor network. Other than residual energy it also considers other factors like number of live neighbors and distance from base station to elect the cluster head.

If the energy of the sensor node is greater than residual energy it is elected as a cluster node otherwise it is considered as a normal node. A sensor node is considered dead if its energy drops below a particular threshold level.

Every node broadcast an “I am alive” message after each clustering round. Thus it calculates the number of live neighbors of each node. Then it calculates the residual energy of each node using first order radio energy model. Node having highest residual energy is elected as cluster head.

But this scheme has a disadvantage that it unnecessarily elects extra cluster heads. As cluster heads consume more energy so somehow it degrades the efficiency of network.

3. CONCLUSION

In all clustering techniques, Weight based clustering technique is best. Weight based clustering technique is more efficient. There is less number of dead nodes as compared to other clustering techniques. Also first dead takes considerable delay. Technique also perform better in dynamic networks. But this technique sometimes generates unnecessarily extra cluster heads.

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