A Survey on Cluster Head Selection Routing Protocols in WSN

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ABSTRACT
Energy is the most important parameter of sensor nodes in a Wireless Sensor Network. Energy Efficiency is one of the challenging issues.One of the solutions is data aggregation which will in turn reduce the traffic on the network. Data aggregation can be done through Clustering Scheme and this scheme will extend the lifetime of a sensor node through reducing energy consumption. Clustering will increases the network scalability also. The main idea behind clustering technique is it groups the sensor nodes and compresses the collected data together and transmits the data.In this process cluster head selection is the crucial part. So many algorithms were proposed for Cluster head selection. This paper will survey such algorithms.

Keywords
WSN, Cluster Head, Energy Efficiency

1. INTRODUCTION
Energy Efficiency of a sensor node is one of the critical research areas in Wireless Sensor Networks. Sensor nodes can usually consist of a sensing module, processing unit with limited computational power, communication module. Every sensor node has a power source typically in the form of a battery. The base stations may have one or more components of the WSN with infinite computational, energy and communication resources. They act as a gateway between sensor nodes and the end user as they typically forward data from the WSN on to a server

One of the advantages of wireless sensors networks (WSNs) is they can manage their network as unattended in harsh environments where human involvement is impossible. In some areas sensors are deployed randomly. In this situation Energy Efficiency is the critical issue where the whole network operation depends on. There is a huge demand on energy efficiency routing protocols which saves the network lifetime while communication.

2. CLUSTERING IN WSN
Sensor nodes will have limited amount of energy. One of the effective channels to utilize the energy in efficiently is Hierarchical clustering. Sensors that perform similar tasks are formed as clusters.Hierarchical clustering contains cluster head, sensor nodes and base station. Cluster head will collects the data from nodes and aggregates the data which in turn saves lot of energy in transmitting data to the base station.

2.1 Cluster Formation
Power is very critical factor which is typically used by Sensor nodes while it is performing computing, communicatingetc. LEACH protocolhas been introduced [7] which performs hierarchical clustering to make sensors energy efficient. The CH will takes care of aggregating information after collecting it from its cluster and passes to the Base Station. But, the main problem with LEACH is it chooses too many cluster heads in an amount of time.

The Parameters involved in formation of a cluster are [5] Number of Clusters, Intra-cluster Communication, Nodes and CH Mobility, Node Type and Roles, Cluster Head Selection, Multiple Levels, Overlapping

2.2 Advantages of Clustering
Clustering routing protocols have so many advantages over normal routing protocols in scalability, energy consumption, and robustness. [24]

Scalability: Because of network is divided into clusters, It is very easy to manage when compared with normal networks. These types of networks will respond very fast.

Data Aggregation/Fusion: This is best technic in cluster routing protocols where data from different nodes will be collected and aggregated which in turn reduces the data transmission time because of redundant data transmission is avoided.

Load and Energy consumption: since the data is aggregated load and energy consumption are lowered at maximum extent.

Robustness: Cluster head responsibility is rotated over all the nodes in the networks which eliminates the problem of "single point of failure" and increase the robustness to the network.

There are so many other advantages like Latency reduction, Fault Tolerance, Guarantee of connectivity, increasing the network life time, Providing Quality of Service.

3. COMPARISON OF VARIOUS BASE STATION ASSISTED ADAPTIVE SCHEMES
The base station forms the clusters in the network. Based on election CH is selected.

3.1 PEGASIS (Power-Efficient Gathering in Sensor Information Systems):
It is proposed by Lindsey, it improvement and enhance of LEAH. The main idea is used in PEGASIS is that each node communicate with its closest neighbours only .In this algorithm the sensor nodes are organized to form of a chain, nodes are deployed in randomly, every sensor nodes which gathering the data fuse it with the data received by the neighbour node and transmit it to the next-nearest neighbour in chain format till reaches base station [27]. Every node in the network get a chance to become a leader of the chain and its responsible to transmit the whole fused data collected by the chain of nodes to the base station. By using this process

the average amount of energy spent by each sensor node is decreases. Greedy approach is used to see that all nodes are used during the chain formation. PEGASIS assumes that all the nodes with varying or low energy levels can be compensated in order to calculate the energy cost of the transmissions with the remaining energy they are left with. All the nodes need not to know who is the neighbours, the Base station take care of formation chain and path to all nodes or nodes can figure out their neighbouring nodes by sending a signal, Based on the strength of the signals they listen nearest neighbours in the network.

Limitations of the PEGASIS protocol: When a head node is selected, there is consideration how long from BS is the head node is located. When a head node is selected its energy level is not considered. Since there is only single node head, it may be the bottle neck of the network causing delay. Redundant transmission of data as only one head node is selected.

3.2 EEHC (Energy - efficient hierarchical clustering)

EEHC is proposed by Bandyopadhyay and Coyle, It is a heterogeneous, hierarchical, distributed randomized clustering algorithm to increase the network lifetime with a large number of sensor nodes. In the process EEHC consist two phases- Initial phase and extended phase. In the first phase is also called single level clustering [26] ever sensor nodes announce their self as Cluster Head with a probability (p) to neighboring nodes in their communication range, The Cluster Head nodes are called as the volunteer nodes.

Those who are neighbours with in communication range of k-hop receive announcement send by volunteer node through intermediate node or directly .The neighbours within the range of k-hop distance receive this announcement directly. Any node receives the annocement, it is neither a CH nor a member then it is forced to become a CH. In the second phase or the extended phase built hierarchical cluster of h-levels, where the Cluster Heads of every level directly communicate with the Base Station. EEHC increases the life time of the network than LEACH or other hierarchical protocols.

3.3 LEACH (Low Energy Adaptive Clustering Hierarchy)

LEACH is clustered and routing TDMA based MAC routing protocol in wireless sensor networks. The main purpose of LEACH is to decreases energy consumption to required, create and maintain clusters in order to increases the life time of a wireless sensor network.

The operation of LEACH protocol is divided into rounds; each round has two phases' setup and steady state phases.

Setup phase to organize the networks into clusters in this phase has consisted of 3 fundamental steps 1. Advertisement for Cluster Head 2. Setup the Cluster 3. Transmission Schedule Creation.

first step of setup phase Each node that elected itself a cluster-head for current round broadcasts advertisement message to rest of cluster nodes by using CSMA MAC protocol to become current round a cluster head on basis of

$$T(n) = \begin{cases} \dfrac{p}{1 - p(r \bmod \frac{1}{p})} & if\ n \in G \\ 0 & otherwise \end{cases}$$

Where n is the given node, G is the set of nodes that have not selected as Cluster head in past 1/P rounds, r is current round number and p is the a priori probability of a node being elected as a cluster head. Every node during cluster head selection process will generate a random number between 0 and 1. If the random number of cluster head <T(n) the sensor node become a cluster head. Where T (n) is threshold.

In second step the non-cluster nodes receive advertisement sent by the cluster head and send their membership request to cluster head to join as members. The non-cluster nodes save more energy by turning off their transmitters.

In the third step, elected cluster head node creates a transmission schedule by using TDMA for the member nodes of their cluster. During second phase of LEACH the sensor nodes can being sensing and transmitting data to the CHs.

Limitations of LEACH is Not efficient for large-scale networks, cannot ensure real load balancing in the case of sensor nodes with different amounts of initial energy, The idea of dynamic clustering brings extra overhead.

Low-Energy Adaptive Clustering Hierarchy is one of the best routing protocol in wireless sensor networks. The main idea behind this technique is Cluster Heads are selected among the available node in rotation basis which will in turn communicate with the base station. This operation may be run in different steps.

In LEACH-C[3] Sensor nodes will communicate with the base station.Based on the information provided by the nodes the average node energy will be calculated. Sensor nodes which are having energy below this average value are not allowed to become cluster heads.To minimize the Energy required fornormalnodes to the cluster head for data transmission BS will divide the network into required number of clusters.

In LEACH-F [4] clusters will be formed only once. rather the responsibility of cluster data gathering is rotated within the nodes. For Cluster formation LEACH-F depends on LEACH-C algorithm.

W-LEACH directly extends LEACH-C [23] to introduce the concept of weighted sensors that isused to decide which sensors are chosen to be cluster heads and which sensors are chosen to send data at certain rounds. Weights are assigned to sensors based on their remaining energy as well as their density; a newly developed measure that defines the percentage of its surrounding sensors to the total number of sensors.

3.4 TEEN (Threshold sensitive Energy Efficient sensor Network protocol):

TEEN is an efficient Routing Protocol than conventional sensor network protocols which is used for reactive networks. This protocol gives a chance to every node to become CH for a cluster period. At every cluster change time the CH will broadcasts hard and soft thresholds in addition to its parameters. Hard threshold is the threshold value for the sensed attribute. Soft threshold is the small change in the value of the sensed attribute. The nodes sense their environment continuously and the sensed value is stored in internal variable.

TEEN Disadvantage: The nodes unable to communicate if it fails to reach the threshold. So this is not well suited protocol

for applications where the user needs to collect the data on regular basis.

3.5 APTEEN (Adaptive Periodic Threshold-sensitive Energy Efficient Sensor Network Protocol)

In this protocol, The CH broadcasts the attributes, thresholds, schedule, count time (CT). Attributes includes user interested parameters. Hard and Soft thresholds will comes under thresholds, Schedule includes the slots that are assigned to nodes, count time is the maximum time period between two successive reports.

In this protocol, each node senses the environment continuously and whenever it finds a value at or beyond the threshold value, it immediately transmits. If a nodes does not transmits the data within the count time, it will be forced to retransmit the data.

3.6 SPIN: (Sensor Protocols for Information via Negotiation)

SPIN protocol internally contains two modules: Negotiation and Resource adaptation. Before data transmission nodes will negotiate with each other to see that there is no implosion. Nodes will send only useful information and meta-data is used to describe the observed data. Under Resource adaptation, a Resource manager which is available in each sensor node will manage the resources and grant access or permission to each activity based on the resources available. In this context, each application on the sensor node that needs to transmit the data must approach the resource manager.

Metadata should completely describe the data and it must be smaller than actual data and it should be application specific. It is useful in camera sensor networks or applications that based on geographical locations.

3.7 Comparison of various Clustered Routing Protocols

Protocol Name	Clustering method	Network Lifetime	Energy Efficiency	Scalability	Mobility	Network Model Type	Algorithm Complexity
PEGASIS	Distributed	VeryLow	Low	Very Low	Fixed base station	Homogeneous	High
EEHC	Distributed	Very High	High	High	Limited	Heterogeneous	High
LEACH	Distributed	Low	Very Low	Very Low	Fixed base station	Homogeneous	Low
TEEN	Distributed	High	Very High	Low	Fixed base station	Homogeneous	High
APTEEN	Distributed	Modarate	Modarate	Low	Fixed base station	Homogeneous	Very High
SPIN	Distributed	Low	Modarate	Low	Fixed base station	Homogeneous	Low

4. CONCLUSION

In this paper, various cluster head selection routing protocols are discussed with their cluster head selection strategies. They are compared with respect to their clustering method, network life time, network lifetime, energy efficiency, scalability, mobility, network model type and algorithm complexity. This survey will also give basic knowledge on cluster head routing protocols. The parameters that are considered in the particular algorithms were also discussed in this paper. It is observed that the algorithms that are here are not very efficient and it is concluded that, it is highly needed to find more efficient protocols that are scalable, energy efficient, stable clustering protocols with very low algorithm complexity for wireless sensor networks.

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