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Survey on Clustering Algorithms of Wireless Sensor Network

Mohini Kumrawat
Department of Information Technology
Shri Vaishnav Institute of Technology and Science
Indore, India

Manoj Dhawan
Department of Information Technology
Shri Vaishnav Institute of Technology and Science
Indore, India

***Abstract*—Wireless sensor network is collection of sensor nodes. These nodes can communicate by transferring data to neighbor node. Nodes also have some resources those are limited. In this paper we discuss the different clustering algorithms for efficient utilization of resources. Also discuss the quality parameters of nodes. And gives the proposed solution method "Distributed Weighted Clustering Algorithm" for energy efficient and scalable network.**

Keywords—wireless sensor network, distributed, clustering, weighted.

I. INTRODUCTION

Wireless sensor network consist of distributed autonomous devices, called sensors which monitor physical conditions of environment for support of different types of applications. As Sensors have the ability to sense data, process and forward data to neighbor sensor node. For these purpose sensors use their resources energy, storage and computation capacity [1].

The major concern of sensor network is network performance and scalability. Network performance is achieved by increasing network lifetime/optimizing energy. Scalability is measured such that network performance should be constant with increasing network nodes. Hence wireless sensor network works as one in association as a network towards achieves a frequent goal of sensing a physical parameter over a huge geographic region with energy optimization [2].

In wireless sensor networks sensor nodes sense data, process data then forward to the Base station. For efficient processing routing algorithms are responsible to select efficient path and forward data to base station and increase network lifetime also. Routing algorithms for sensor network should be QoS efficient. These QoS requirements include end-to-end delay guarantee, bandwidth resource, energy consumption, loss packet ratio and the lifetime of network, etc. In wireless sensor networks field, there exist some algorithms to research the routing problem. But most of all routing algorithms try their best to consider the energy consumption because the energy is a scare resource to wireless sensor node. Only a few algorithms consider the QoS support at the same time. Many different categories of routing algorithms are developed like Hierarchical, Heuristic, grid schemes, weighted clustering algorithms. Those typical algorithms include LEACH, HEED, LCA, PIGASIS, WCA, and TASC etc. In this paper, we propose a new technique which supports the QoS for wireless sensor network. This algorithm has following design goals: Increase energy optimization, and provide scalability to network [2][3].

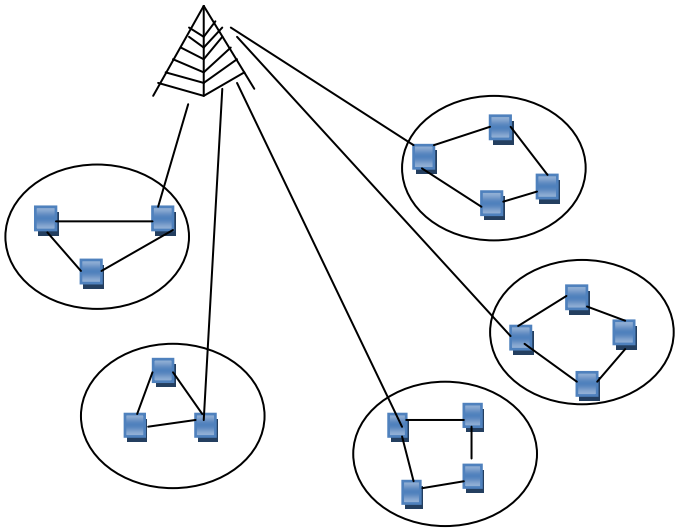

Fig: Wireless Sensor Network

II. LITERATURE SURVEY

In order to develop energy efficient technique for wireless sensor network required to evaluate and understand the technology and their normal functioning. This section provides keen observation of different techniques and their functions. To prolong the lifetime of wireless sensor network is to maintain QoS parameters and improve the lifetime and scalability of network.

A. *Parameters of Sensor are:*

a) Energy Efficiency: Energy is scarce resource of sensor network. So Energy consumption is one of the most challenging factor in designing the wireless sensor network. Energy consumption should be low for sensor network.

b) Scalability: Wireless sensor network increases in size as the number of nodes increase. So performance should not degrade with the increase in number of nodes.

c) Security: Wireless sensor network should introduce effective security mechanism for secure data transmission and avoidance of malicious attack.

d) End to end delivery: The sink must be able to receive any notification or data within short time period. So

that any action can be taken by sink. Wireless sensor network should have stricter delay constraint.

e) Packet Loss: Whole packets should be delivered at the destination without losing a single packet.
f) Small node size: Sensor node size should be small so that can easily deploy in harsh environment and reduce power consumption and cost.
g) Reliability: Network protocol designed for sensor network should provide error control and correction mechanism for reliable delivery of data packet.
h) Self Configurability: Sensor network, once deployed, should reconfigure autonomously in communication range according to changes in topology. This would result changes in density and topology.
i) Adaptability: In sensor network, node may join, fail and move to/from sensor network. Sensor network should have adaptive to such density and topology.
j) Channel Utilization: Sensor network have limited communication bandwidth, protocol designed for sensor network should efficiently use bandwidth. [4][5]

B. Application of Wireless Sensor Network:

a) Military applications
b) Environmental monitoring
   I. *Indoor environmental monitoring and emergency services*
   II. *Outdoor Monitoring – Application to Ecology*
   III. *Outdoor Monitoring – Applications to agriculture*
c) Support for logistics
d) Human-centric applications
e) Applications to robotics [6]

C. Network Clustering:

Wireless sensor network present vast challenges in implementation. Many techniques have been implemented for wireless sensor network. Clustering is most efficient technique for improvement of lifetime of network. Clustering is the standard technique to achieve energy efficiency and scalability. Clustering perform by grouping the sensor nodes in one region based on some predefined logic or method. Each cluster has one cluster head and other (non cluster head nodes) nodes. Each non cluster node sense data and send to cluster head which perform data aggregation and send to the Base Station. There are several key attributes are considered in designing clustering.

a) Number of Clusters**:** In some routing protocols numbers of clusters are predefined and in some protocols numbers of clusters are depend on connectivity and area of sensor network.
b) Intracluster Communication: Cluster head and non cluster head nodes can communicate either by single hop or by multi-hop communication.
c) Mobility of CH node**:** If the cluster head is stationary then it provides stable structure to the network. On the contrary if sensor nodes are mobile nodes so their topology dynamically changes and maintain automatically.
d) Nodes type and role**:** there are two types of nodes heterogeneous and homogeneous. In heterogeneous network nodes with high computation are assumed as cluster head.
e) Cluster head selection**:** In heterogeneous network cluster heads are preassigned. In homogeneous network according to some defined parameters cluster head is elected.
f) Overlapping**:** Protocol designed should not overlap the clusters.

D. Clustering Techniques:

a) Connectivity – based clustering
b) Mobility Aware clustering
c) Identifier based clustering
d) Combined weight based clustering

Connectivity – based clustering:

In connectivity based clustering techniques connectivity between nodes is essential parameter for cluster formation.

a) K-hop connectivity ID clustering algorithm (K-CONID):[7]
In this algorithm two parameters are maintained: Lowest ID and Highest degree of connectivity. Process starts, flooding of cluster request by each node. Any node will be elected as cluster head which has highest degree of connectivity and lowest ID. If two nodes have same number of connectivity then node with lowest ID will elected as cluster head.

b) Highest connectivity clustering algorithm (HCC):[8]
In HCC each node sends their ID to neighbour nodes within its transmission range. Node with highest number of connectivity is elected as cluster head. Nodes from cluster are 2-hop away and cluster heads are directly connected to each other.

Limitation:
This technique has low through put.
Number of nodes within cluster is unlimited.

Mobility-aware clustering

a) Mobility Based Metric for Clustering (MOBIC):[9]
This technique proposes ad hoc network into d-hop clusters based on mobility metric. Node with relatively low speed with their neighbours is becomes cluster head. Each node sends their mobility metric to its neighbour node and updates their tables then calculates the aggregate mobility metric, node with lowest mobility metric is select as cluster head. This mobility metric based technique gives better results.

b) *Mobility-based d-Hop Clustering Algorithm (MobDHop):[10]*
This technique based on type of mobility pattern of group of nodes. It creates the inconsistent diameter clusters based on mobility pattern. Relative mobility metric of two nodes is measured by variation of distance between nodes over time. This algorithm reduces the number of clusters by group mobility pattern, which is group of nodes moving with similar speed and direction. This concept also provides stability to network.

- ***Identifier-based clustering***

In this technique unique ID is assigned to each node and based the ID properties cluster head is elected.

a) *Lowest-ID Clustering Algorithm (LIC):[11]*
In this algorithm, node with minimum ID is elected as cluster head. So the nodes within cluster will have higher IDs than cluster head. Node provides routing between clusters head called as gateways. Gateways lie between transmission ranges of two or more cluster heads.

b) *Max-Min d-cluster formation algorithm:[12]*
In this author proposed the technique, where distance between cluster head and other (non-cluster head nodes) is not exceeds than d-hop. This technique provides load balancing between cluster heads. Procedure initiate with each node starts the flooding of 2d rounds and collect some results. In first d rounds collect nodes with maximum IDs. And next d rounds collect nodes with minimum IDs. Then follow some set rules to elect cluster head.
Rule1: Each node sees the nodes ids of 2^{nd} d round. If node finds its own id then, will declare itself as cluster head. And ignore the next rules. Otherwise switch to rule2.
Rule2: Each node checks the node pairs. The minimum node pair is selected as cluster head. If node pairs do not exist then switch ti rule3.
Rule3: If above two rules are fails then node with maximum id in 1^{st} d round will elect as cluster head.
This algorithm provides load balancing among cluster heads.

Combined weight based clustering

In this type of clustering algorithm normalized weight calculation is done to form cluster.

a) *Weighted clustering algorithm (WCA):[13]*
In this algorithm, weight metrics are calculated based on parameters of node such as number of neighbours, distance with all neighbours, mobility, and the time for which node act as cluster head. Each node shares their metric value with neighbour nodes by broadcasting messages. Node with highest value will elect as cluster head. If any node moves from the cluster head range then cluster head selection process is again executed which cause re-affiliation.
Weight calculation of node:

$$W_v = W_1 * \Delta_v + W_2 * D_v + W_3 * M_v + W_4 * P_v$$

b) *An Efficient Weighted Distributed Clustering (CBMD): [14]*
This algorithm provides the load balancing by specifying the maximum and minimum number of nodes for cluster range. Weight calculation parameters for this algorithm are Connectivity(C), residual Battery power (B), Mobility (M) and Distance (D).This technique provides the stability to the network, reduce communication overhead and messages to cluster head maintenance.

c) *Distributed Weight-Based Energy-Efficient Hierarchical Clustering (DWEHC):[15]*
This is 2-hop weighted clustering algorithm. This algorithm is mainly focus on energy efficiency by forming the balanced clusters and optimizing intra-cluster topology. Each node calculates the combined weight by considering the two parameters residual energy, and proximity of nodes. Node which has highest weight is elected as cluster head. Nodes those directly connected to CH are first level nodes. Nodes those are not directly connect search path through neighbor nodes are called two-level nodes. DWECH is effective algorithm then HEED consumes less energy in Intracluster and Intracluster communication.

d) *Topology Adaptive Spatial Clustering—TASC:[16]*
This is another distributed, non-overlapping clustering algorithm which doesn't have prior knowledge about number of clusters, cluster nodes.
It includes the parameters for weight calculation parameters are distance, connectivity, and density information within locality of each node.

III. PROPOSED WORK

As wireless sensor network is collection of nodes those communicate with each other for information sharing which is sense by nodes for monitoring different activities of environment. As nodes of WSNs have mobility so due to dynamic topology some issues such as performance and security are arises. On the other hand energy is another limited resource. So, new energy efficient clustering technique is required. We will propose a Distributed Weighted Clustering algorithm, which consider the parameters Connectivity, Remaining Energy, SNR, Mobility, Buffer length. Based on these parameters global weight is calculated. Nodes share the weight with their neighbors and compare their weights; node with highest weight is elected as cluster head.

$$W = w_1 * c + w_2 * e + w_3 * M + w_4 * SNR - w_5 * B$$

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