

Grid based Clustering Protocols in Wireless Sensor Networks – A Review

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Abstract: *A wireless sensor network consists of sensor nodes or motes which are operated by non rechargeable batteries hence it is requisite to curtail the total energy consumption in the network for prolonging network lifetime. Various energy efficient clustering algorithms are used to address the problem of energy consumption. The key issues of clustering algorithms are the selection of cluster head in each cluster and data transfer from cluster head to sink node or base station in efficient manner. Grid clustering is most preferred clustering technique in wireless sensor network since all operations are performed on each grid rather than individual data object or block hence have less processing time. This paper reviews various grid based clustering protocols or algorithms and research challenges faced in various applications of wireless sensor networks.*

Keywords – *wireless sensor networks, grid clustering, energy consumption, clustering algorithms, network lifetime*

1. Introduction

Wireless sensor network (WSN) is a type of wireless network which basically have extent number of sensor nodes distributed in a network area in randomly deployed manner. A sensor node has capability to sense the data such as temperature, pressure, moisture, light, humidness, acceleration, acoustics, force etc from physical environment, converts this sensed data into digital form for processing and store or transmit the sensed data to other sensor nodes. These tiny sensor nodes are little, battery operated embedded devices connected to each other wirelessly to form a network. A sensor node unit is also known as a mote. They communicate to each other by transceivers. The number of sensor nodes or motes in a wireless sensor network varies from few hundred to thousands according to the applications. As compared to ad hoc network, wireless sensor network have more sensor nodes and ad hoc networks are unstructured. The energy of nodes, computation capability and storage capacity are limited so efficient clustering and routing algorithms are required for prolonging network lifetime. In harsh environment where detection and monitoring of any process is dangerous and hazardous, wireless sensor network are the only solution. High sensor density sensors will increase the chances of target coverage.

2. Clustering in Wireless Sensor Networks

Hierarchical or cluster based routing is most energy efficient routing in wireless sensor network. The energy efficiency and network lifetime are the key issues to design optimize WSN. In cluster based routing, the sensor nodes are grouped together to form a cluster. Each cluster have a cluster head(CH) which collects the data from its member nodes in a cluster and forward this data to sink node or base station. Cluster base routing network can be classified at two levels- at first level the entire sensing area is divided into clusters and selecting a cluster head which node has maximum residual energy, member nodes send their data to cluster head(CH). At level two, cluster head send the collected data to sink node via either in single hop or in multihop. The main concern of various clustering protocol is to minimize the total energy consumption in inter and intra cluster transmission and prolonging network lifetime.

Each cluster consists of two types of nodes –

1) Cluster Head Nodes

2) Cluster Member Nodes

1) Cluster Head (CH) - In clustering, the main function of cluster head is to collect the gateway node through either directly to base station or via different clustering heads(CH). The research work in WSN is done on to select the energy efficient cluster head and time is divided into number of rounds, after each round the role of cluster head is rotated to balance the load in the network.

2) Cluster Member Nodes – member nodes are those sensor nodes of a network which sense the data from physical environment, convert this data into digital form by means of analog to digital converters and process this data.

3. Literature Review

Muyiwa Olakanmi et al., has proposed a heuristic algorithm for clustering hierarchy protocol in wireless sensor network. In the proposed algorithm author describe two mechanism- firstly cluster head (CH) using a genetic algorithm (GA). Secondly, a boltzman inspired selection approach was used to select the inactive nodes or nodes sends to sleep mode to efficiently use the energy without adversely affect the coverage. simulation result shows that proposed protocol performs better as compared to SEECH, TCAC and LEACH protocols.

Jitnder Singh et al., reviewed clustering algorithms for wireless sensor networks. The author analysed that energy efficiency of nodes and lifetime of network are main concerns of wireless sensor networks. In this paper, author focused on distributed clustering which again can be

categorized as equal and unequal clustering. Author concluded efficient clustering algorithms are required to provide scalability, energy efficiency and network lifetime of WSN.

Petru Junie et al., introduced a wireless sensor network based monitoring system for oil and gas transportation through pipelines. Proposed monitoring system include four hierarchical levels- the central dispatcher, the zonal dispatcher, the local dispatcher and the sensor node. In the proposed model, leaks are detected by either comparing the debit measurement or temperature management. This research article addresses the problem of oil and pipeline monitoring in order to avoid disasters caused by leakage.

Xiaoliang Meng et al., has proposed a novel grid based routing protocol with randomly distributed clusters. This paper basically deals with network layer/routing protocol of five layered protocol stack. In this paper, the 2-D wsn is divided into equally square shape grids either with zero or some sensor nodes in a grid, then cluster is formed by merging two or more grids and a cluster head is selected which is responsible for effective intra cluster and inter cluster routing. From the simulation results, it can be concluded that as node density increases correspondingly lifetime increases.

Manal Abdullah et al., has proposed a density grid based clustering for wireless sensor networks. In this paper, the density grid based clustering algorithm divides into three stages. First is partitioning the data space into equally space square shape grids then each data point in data set is mapped into a grid. Finally one of density based algorithm is performed to form the clusters. In this algorithm, author classified cluster nodes as normal and advanced nodes. Simulation result reveals that proposed algorithm outperforms in terms of network lifetime and computation time.

Seema Dahiya et al., has introduced an optimized mobile sink based grid coverage aware sensor deployment and link quality based routing in WSN. Author proposes two phases of this protocol, first is grid based firefly simulated annealing (GFSA) and another one is link stability estimation routing. Author compares the proposed algorithm with overlap sense ratio based coverage enhancing algorithm (OSRCEA), virtual centripetal force based coverage enhancing algorithm (VCFCEA). Simulation results revealed that the proposed approach is more efficient in terms of maintaining the coverage ratio and energy consumption.

Ketki Ram Bhakare et al., has proposed an energy efficient grid based clustering topology for a wireless sensor network. In this paper, author focused to reduce energy consumption of sensor nodes and to prolong network lifetime of wireless sensor networks. In proposed scheme, there are three steps- clustering, cluster head election and intra cluster routing. Here cluster head is selected by comparing weights of all sensor nodes present in cluster and highest weight value node is elected as cluster head.

Utpal Kumar Paul et al., has introduced a novel grid based energy efficient routing algorithm for wireless sensor network. In this algorithm, cluster head is selected which is nearer to the center of grid, in each round the role of cluster head changes to prevent the over burdening of cluster head. From the simulation result, it is concluded that as number of round increases, the percentage of number of alive nodes also increases hence proposed algorithm outperforms as compared to LEACH, SEP and DR.

Manoj Pant et al., introduced a multi hop routing protocol for wireless sensor network based on grid clustering. The proposed protocol is based on rounds and each round has two phases. The entire sensing network area is divided into rectangular regions called grids, cluster head node is selected based on highest residual energy in each grid. The farther away grid from sink is bigger and has more sensor nodes for cluster head rotation. From the simulation result, it is concluded that the proposed algorithm outperforms in terms of node death percentage with respect to number of rounds.

Hsuan Peng et al., has proposed an upper and lower bounds of the transmission energy cost for grid based wireless sensor network. . In this paper, the author studied the selection of grid nodes and routing issue for the sensor networks. The author derives the upper and lower bounds of energy consumption for forwarding the information in grid topology. From the simulation result, it is concluded that the data transmission consumes approximately 80% energy of sensor node.

Seifemichael B., has proposed an energy efficient grid clustering hierarchy routing protocol for wireless sensor networks. In this paper, author focused on developing a routing protocol that enhances the network lifetime. The complete operation of GCH is partitioned into three phases- gridding, cluster formation and steady state phase. In this paper, three level grid formation is presented, first level when the average energy of the network is greater than two third of initial energy, second level when the current average energy is between two third and one third of initial energy, third level when current average energy is below one third of initial energy. Simulation result reveals that the proposed protocol performs better than LEACH in terms of the number of packets received by base station.

Asmaa Amer et al., has proposed balanced energy efficient grid based clustering protocol for wireless sensor network. In this paper, author introduces BEEG based optimum because cluster size play vital role in reducing energy consumption in the network. This paper classifies the routing algorithm into three main types- direct transmission technique, multi hop transmission technique and clustering based algorithm. Simulation results show that proposed algorithm has large network lifetime and more energy efficient over other protocols such as LEACH, DCHS, MOD-LEACH and E-LEACH.

Haleem Farman et al., has introduced a grid based hybrid network deployment approach for energy efficient wireless sensor network. To balance the energy consumption in each grid, this algorithm uses merge and split technique. In proposed algorithm four splitting techniques are used. Zonal head is selected in each zone. A node in a zone which has maximum average distance value is selected as zonal head. The role of zonal

head is rotated to prevent the overburdening of a node. The simulation result reveals that the proposed algorithm have less energy consumption during zone formation, zonal head selection, zonal head reselection and transmission phase hence proposed algorithm is more energy efficient and prolonging network lifetime over other protocols.

K. Lalitha et al., has introduced an efficient grid based clustering and combinational routing in wireless sensor networks. In this algorithm, appropriate grid size is calculated according to the transmission range and size of the area. Cluster head selection is based on nearest distance from the center point of the grid. To route the collected data from the cluster head to base station, combinational routing is proposed in this paper. Combinational routing which included angular inclination towards the sink improves the network scalability. In combinational routing, the selection of cluster head is based on distance as well as direction towards the sink. The proposed algorithm is simulated for various transmission ranges with respect to number of rounds. It outperforms over other existing algorithm in terms of network lifetime and residual energy of the network for various transmission ranges.

Nelofar Aslam et al., has proposed an energy aware adaptive weighted grid clustering for renewable wireless sensor network. In this paper, a wireless portable charging device is moved along with shortest path of nodes for speedy charging of nodes with the help of wireless power transfer. In this algorithm, cluster head selection depends on the residual energy of nodes, buffer size and distance from each node. Proposed algorithm shows 50% higher vacation time over single hop routing. Simulation result reveals that grid based clustering is most energy efficient technique for prolonging network lifetime.

Srikanth Jannu et al., have introduced a grid based clustering algorithm for solving hot spot problem in wireless sensor networks. The nodes which are near to base station or sink node getting overburdened and their battery dies quickly, this problem is known as hot spot problem in wireless sensor networks. The proposed algorithm addresses the hot spot problem and fault tolerant algorithm. Simulation result reveals that the proposed algorithm outperforms over LPGCRA and GBR in terms of residual energy, total number of alive nodes and network lifetime.

4. Research Challenges in WSNs

Challenges and issues which mostly affect the design of a wireless sensor network are as follows:

- 1) Sensor nodes uses non rechargeable batteries hence energy consumption is the key issue to prolong the network lifetime of wireless sensor networks.
- 2) Wireless sensor networks should configure, maintain and repair itself without any intervention when used in dynamic configuration.
- 3) WSN should be scalable means as if the number of nodes in a network increases or decreases, the performance of the network should not degrade.
- 4) As communication in WSN is through wirelessly, there are more chances of data hacking in channel so security is the main issue in WSN.
- 5) WSN is also used for real time applications so it should have good quality of service.
- 6) Data gathering is main objective of any sensor node in wireless sensor network. A sensor node sense the data, collect the data and transmits the processed data to the sink node or base station. WSN should not send the redundant data to the base station to save the energy.

5. Conclusion

The network lifetime of a wireless sensor network depends upon the total energy consumption in the network and the energy consumption is directly proportional to the processing time hence by reducing the processing time one can reduce the energy consumption in the network. Further processing time can be reduced by removing the redundant data from the network and avoiding collisions in the network. Wireless sensor networks are widely used for various applications such as health care monitoring, military applications, many industry and consumer applications, machine health monitoring, soil health monitoring etc. The main concern of researchers is to develop the energy efficient clustering and routing protocols and to increase the throughput in wireless sensor networks.

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