A STUDY OF ROUTING PROTOCOLS AND CLUSTER HEAD SELECTION ALGORITHMS IN WSN

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Abstract :
Wireless sensor network have emerged as research field since they act as a bridge between the real and virtual world. WSN are becoming pervasive in every day and used in various domains such as healthcare monitoring, environmental monitoring, surveillance, disaster monitoring etc. It is a distributed system for collecting the data by monitoring the environment conditions and sending data to the central base station. Routing protocol specifies how routers communicate each other and send data from sensor nodes to the base stations. Since these sensors are energy constraint and their batteries cannot be recharged, we need energy aware routing and data gathering protocol offers high scalability. For efficient data gathering without compromising energy consumption, clustering topology is used in wireless sensor networks. In this topology, every sensor node send the data to their respective coordinator called cluster head of their respective cluster. Cluster head is responsible for aggregation and routing the data to the base station. Selection of cluster head plays a vital role for energy saving in these type of network. In this paper, we have discussed the various cluster algorithms in detail.

Keywords: Base Staion, Cluster Head, Cluster Head, Node

1 INTRODUCTION

Wireless sensor networks are widely used in development application which does not require human intervention. Wireless sensor networks composed of thousands of sensor nodes that can communicate with each other. These nodes are small, inexpensive and programmable, resource constrained sensors which are used to monitor the physical or environmental conditions. WSN are usually operated in unattended environments for monitoring pressure, temperature, sound etc. The sensing and tracking can be completed with the help of communication between nodes.These nodes are generally operated using batteries. Those batteries cannot be recharged thus results in network disconnection. Sensor nodes consume lot of energy during their communication between nodes. In order to optimize the communication, resources must be utilized efficiently. In many situation, data collected by the nodes are same thus leads to the redundant transmission. Since nodes are energy constrained in nature, efficient organization of nodes into clusters and selection of cluster head is an important aspects of WSN. All nodes can send data to the cluster head where the aggregation of data can takes place. The energy required to send data depends on the distance between the nodes and the number of bits which are being transmitted. Routing protocols are classified as location based, data centric and hierarchical protocols. Clustering protocols utilizes the distributed algorithm for Cluster Head selection.

II CLUSTER BASED ROUTING AND CLUSTER HEAD SELECTION

Cluster based routing [1] [2] protocols are based on Hierarchical routing. In this protocol, nodes are organized into the clusters and node with higher energy will be elected as cluster head. Designing the clusters includes various parameters such as number of clusters, Intra-cluster communication, Nodes and Cluster head mobility, Node types, Cluster head Selection and multi level clustering. [3]. Energy and network life time are major concerns of designing the clustering. Clustering is organizing a network into connected hierarchy but it balances the network load, thereby lifetime of the system is increased.

2. 1 Low Energy Adaptive Clustering Hierarchy [4]

In LEACH, cluster formation is in a distributed manner. In this algorithm, cluster head is rotated among all the nodes and any sensor node can be the head randomly during each round. LEACH [4] [5] [6] [7] is a specialized hierarchical clustering protocol for minimizing the energy dissipation in the network. In this protocol, cluster set up and operation is well coordinated with the localized control and selection of the cluster head is based on random rotation. Local compression techniques are used for reducing global communication from the cluster head to the base station. Each and Every cluster, local computation is performed, thus reducing the communication cost for sending the data to the base station.

It is a self-organized [4] , distributed protocol and energy is distributed uniformly among the sensors in the network. The operation is divided into two phases: set-up phase and steady state phase. In the first phase, selection of clusters and cluster head is decided for further processing. Cluster head selection is based on percentage of the cluster head for this round and number of times that particular node has been selected as a cluster head. Cluster head is rotated between all nodes in each and every round.

Once the cluster head selection is over, the message will be communicated to all the nodes in that particular cluster. After this phase, each node decides to join a particular cluster based on the signal strength. [4] .After the creation of cluster head and cluster,

cluster head starts collecting the data from the nodes in their particular cluster. In this algorithm, nodes does not require the knowledge of the entire network.

2.2 Hybrid-Energy-Efficient Distributed [8]

A distributed, hierarchical energy efficient clustering protocol HEED [8] [6, 5] [7] selects the cluster head periodically. The parameter for selecting the cluster head is sensor node energy. In this protocol also, life time is enhanced by distributing the energy in the entire network. The cluster head selection process will be terminated after a particular number of iterations. In this approach, authors [8] assumed that the sensor nodes can control their transmission power level. Heed protocol allows single hop communication within the cluster and multi hop communication between cluster head and base station.

There are two parameters playing a major role in the cluster head selection. Energy is used for initializing the cluster heads and intra communication cost is the deciding factor for joining a cluster. This cost is basically calculated on node's proximity or cluster density.

In this algorithm, clustering process will be initiated in a particular interval for the selection of cluster heads. Probability value is estimated for the cluster head selection and that should not be beyond the threshold value. If the probability value is less than one, then the node becomes a cluster head tentatively and becomes permanent cluster head if the value reaches one. The parameters such as minimum selection probability and network operations interval can be tuned to optimize the resource usage [8]. This approach uses the availability of multiple transmission power levels at sensor nodes.

2.3 Threshold sensitive Energy Efficient sensor Network protocol [9]

TEEN [9] [7] is designed for reactive networks. In this protocol, closer nodes form the cluster and repeats until it reaches the base station. In every round, cluster head broadcasts hard threshold and soft threshold values to the other nodes in their cluster. Hard threshold [9] value indicates the sensed attribute value and beyond this value, the node transmits the value to the cluster head. This is called sensed value. Soft threshold refers the small change in sensed value which triggers the node to transmit its value.

The node transmits the current sensed value only if the value is greater than hard threshold and Sensed value is set equal to the current value of the attribute. Both Hard threshold and Soft threshold value is used to reduce the number of transmission by checking the value against sensed value.

2.4 Power-Efficient Gathering in Sensor Information Systems[10]

PEGASIS [10] [7] [11] [6] is a chain based protocol and a single node in a chain is used to send the data to the base station. Each node can communicate to its closest neighbour and chain is constructed in a greedy way. Then, data is gathered from node to node and moved in a chain. Designated node aggregates and transmits the data to the base station. Cluster head selection in this protocol is not considering about the energy of nodes and location of the base station. Nodes takes turns to transmit the fused data to the base station for balancing the energy depletion [10] .

2.5 Distributed Information storage and Collection[12]

Data storage is a major component of wireless sensor network. Storage can be local or distributed within the network. Distributed Data storage [12] is the major component of storage which protects the critical data from the failures. Authors [12] proposed a protocol called DISC for distributed storage and collection in the wireless network. A distributed Information Storage and Collection (DISC) protocol selects the backup node randomly. Bloom filters are used to store the data inside the network. This makes faster retrieval and searching of data from the network. They suggested primary cluster head (PCH), backup cluster head (BCH) and reader node in the architecture. Reader node acts as a base station in this protocol. [13]

The function of the protocol is divided into data dissemination and data collection process.PCH and BCH nodes are performing data dissemination process and data collection is executed by BCH and Reader node as well. Backup cluster head is selected randomly from the nodes. Sensor nodes are reporting the sensed value to the Primary cluster head which in turn forwards the data to the neighbouring Backup node after aggregating the data. A unique descriptor is included in the aggregated data. It includes epoch duration of the data, region identifier and type of data. Bloom filter [12] is used to obtain one element from the above parameters. After receiving the data, BCH does not store the data locally but distributes among the sensor nodes. BCH is managing trace – table which store the identifier of the node keeping a particular piece of information. [12] This protocol uses four types of messages for initializing, forming primary, backup cluster, discover the backup aggregators and disseminate the data.

2. 6 Randomness with data Recovery [14]

Authors [14] proposed the cluster head selection by Randomness with data recovery. In this approach, cluster heads and vice cluster heads are selected randomly and heterogeneity in energy is maintained. If the main cluster head drains in the power, then these vice- cluster heads can be selected as head node. Cluster head selection is based on three phases. In the set up phase, base station maintains the details of node location and power. Randomness will be calculated and if in the range between -2.04383 and 2.839258[38], the node will be selected as cluster head. In the next phase, selection of vice- cluster head process starts and checks for each and every node. If the node is a cluster head, it transmits the request for power and location from its neighbouring nodes within one hop distance.

From the list of one hop distance nodes, again randomness range will be checked. If it falls within that range, that node will be added in the VCH list. IN the third phase, cluster head checks for the power signal and the value is lesser than threshold value, first VCH from the list will be elected as a cluster head and all required data will be sent to that VCH. This information is broadcasting to all the nodes of the network.

This approach supports recovery mechanism also. Any node or cluster head gets crashed, broadcasts this information to all the nodes and new cluster head will be selected from the list of VCH. All the entries in the database table are updated and uncommitted values are removed from the database.

2.7 Energy-Efficient Level Based Clustering Routing Protocol [15]

EELBCRP [15] (Energy-Efficient Level Based Clustering Routing Protocol), a protocol for wireless sensor networks. This protocol considers the various power levels at base station and network is portioned into annular rings. It considers the residual energy of each node and distance between nodes and base station is the primary principle of cluster head selection.

2.8 Passive Clustering for Efficient Energy Conservation [16]

In PCEEC [16] there are six states are defined they are dead, initial, ordinary, cluster_ head ready, gateway and alternate cluster head. Initially, all nodes are in the initial state. This state continues till the time node receives the packet. When a node receives the packet, it checks for the state of the sender. If the sender is not a cluster head, receiver switches to cluster head ready, otherwise switches to gateway or ordinary node. Then it switches to gateway state in the case of number of cluster heads are greater than or equal to the number of gateways. In the case of failure, node with the highest level of energy will be elected as next cluster head. Ordinary state node will change to alternate state if the energy of that node is higher than all other nodes.

2.9 Refined Bacterial Foraging Optimization and Hybrid Algorithm [17]

Natural swarm inspired algorithms like Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO) are nowadays widely used in wireless sensor network. BFO is used to solve the practical problems to achieve optimal control and energy efficiency. Authors suggested BFO for the efficient cluster head selection. Reduced pocket delivery ratio, improved cluster formation, network life time and reduced end to end delay are achieved with the support of BFO. With the combination of BFO with Bee swarm optimization, authors analysed the number of cluster formed, end to end delay , packet drop ration and lifetime.

2.10 Fuzzy based enhanced Cluster head selection (FBECS) [18]

For efficient data gathering in context to energy dissipation, WSN is divided into clusters. In this paper, authors introduced Fuzzy based balanced cost algorithm for cluster head selection.The main objective of the algorithm is balancing the load by selecting best node as cluster head. Fuzzy logic algorithm uses the following inputs namely leftover energy level of the sink, ability to harness the energy, vicinity of the head to the nodes while creating eligibility index. This index helps in selecting cluster head from the potential nodes. It is a distributive protocol which is based on rounds namely building phase and forwarding phase.

2.11 Analytical Network Process based optimum [19]:

Authors extended their grid based network into analytical process model. They used merge and split techniques for constructing network topology. There are five parameters are considered for analytical network process model of cluster head selection. They are distance from the nodes, residual energy level, and distance from centroid, number of times node act as cluster head, and merged node. From these parameters, ANP method is used for optimum cluster head selection.

2.12 Collaborative Data Processing [20**]**

Existing protocols are considering only balance energy consumption is a key factor for the selection of cluster head. But, collaborative data processing between nodes are play an important role for the selection. In this paper, authors proposed an efficient cluster head selection approach considering collaborative data processing. Residual energy of the nodes are considered first, followed by classification in the competition. More residual energy node will be elected as cluster head and other normal nodes select the cluster head with more energy. Orthogonal variable spreading factor and multihop routing is used to reduce the energy consumption. Competition radius of the selected cluster heads are adjusted in such a way that cluster size is small near the base station compared to other clusters. This minimizes the unbalanced communication overhead with respect tto intra cluster communication.

2.12 **TOPSIS** [21]

Authors proposed cluster head selection by applying multi criteria decision making with the consideration of four parameters: residual energy, number of neighbours, distance between the base station and node and transmission range for each node. This algorithm uses Order preference by similarity to Ideal solution in two levels [23]. With the help of a relationship, number of cluster is calculated and when the nodes begin to die, smaller clusters are combined with larger cluster. Cluster Rank is calculated using TOPSIS and higher rank clusters are grouped together for clustering.

2.13 Node Rank Algorithm [22**]**

This protocol is the extension of LEACH and cluster head selection is based on Node-Rank algorithm. This algorithm improves the network life time of the network. This algorithm depends on both the cost and number of links between nodes to the cluster head[21]. This avoids the random selection of cluster head and reflects the real weight of specific node. This avoids the failure of the cluster head in the case of energy depletion. Node rank algorithm helps in distributing the energy among the sensor nodes. It also follows two phases: Setup phase and steady state phase. Node selection is based on weight of the node participating in the

network. Weight of the node is calculated by considering signal strength, residual energy of a node and connections with the other nodes.

2.14 Markov Chain Model [23]

This model based on optimal cluster head selection in WSN. Authors[23] introduced load balancing of the nodes by introducing optimal concept. In this model, base station controls the cluster head and cluster head controls the nodes in their clusters, thus ensuring load balancing in the cluster. Size of the cluster is also one of the major factor for the energy depletion. In this model, authors controlled the cluster size by checking suitability of the nodes for the cluster head selection. Finally , base station selects the nominated cluster head on the basis of selection criteria. Four phases namely setup phase, settling phase, scheduling phase and data transmission phase are working in each and every round of the cluster head selection,

III CONCLUSION

Recent advanced developments in the senor nodes leads to the many applications of wireless sensor networks such as health monitoring, environmental monitoring, weather forecasting etc. The major challeges of these network are limited, unrenewable energy. Energy constraint is a major factor while designing the routing protocol. Clustering is an effective method for preserving energy in turn results into extended network life time.\Optimal cluster head selection is playing a vital role in clustering. Cluster head requires more energy than other nodes. In this paper, we have studied different types of clustering protocol and cluster head algorithm in detail. Residual energy, number of neighbours, distance between the nodes and several other parameters are considered for the selection of optimal cluster head.

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