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Study of Energy Efficient Clustering Algorithm for Wireless Sensor Networks

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***Abstract*:**

Use of wireless sensor networks has increased to monitor the disaster management, surveillance and industrial automation. For such applications the sensors have to be grouped together to deploy in large numbers and to operate autonomously in the network. Several researchers have provided different cluster based routing protocol for sensor networks to enhance power control and node lifetime improvement. Wireless sensor network (WSN) require a various power management protocols to reduce the energy consumption. Different cluster-based schemes are discussed as a solution for this problem. In this paper, analysis of the present-day classification and general grouping of published clustering schemes. This paper surveys different clustering algorithms for WSNs; give emphasis to their purposes, characteristics, importance, complexity, etc. We also analyse these clustering algorithms based on metrics such as energy efficiency, cluster stability, location awareness, node mobility and QoS support.

Keywords— sensor network, clustering, energy efficiency, lifetime

I. INTRODUCTION

A sensor network is an integrated circuit of sensor, embedded compute, modern network, wireless communication and distributed information process. Wireless sensor network is a new information acquiring and processing technology which yields by the recent advances in miniaturization and low power design that led to the development of small-sized battery functioned sensors that are capable of detecting ambient conditions such as temperature and sound [2].

Sensor networks are widely used in variety of applications such as civil as well as military applications because of its miniaturization in size, low cast and large lifetime. In order to keep the cost and size of these sensors small, they are equipped with small batteries that can store at most 1 Joule. A sensor in such a network can therefore communicate directly only with other sensors that are within a small distance [1]. In order to communicate for a very long distance they must create an organization structure amongst these nodes.

Since the fundamental advantage of wireless sensor networks is the ability to deploy them in an ad hoc manner, as it is not feasible to organize these nodes into groups pre-deployment. For this reason, there has been a large amount of research into ways of creating these organizational structures [2].

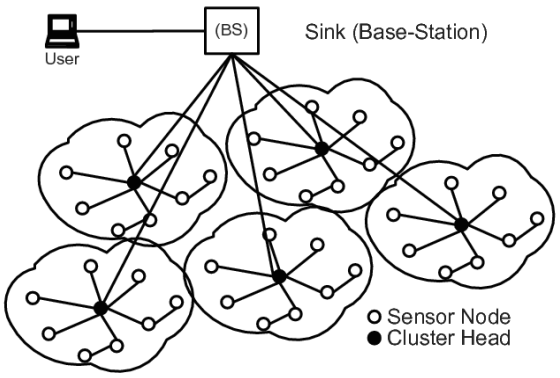

Fig.1 General Architecture of sensor network

Figure.1 shows the general architecture of sensor network. The basic parameters of the sensor networks are Sensor Node, Cluster, Cluster head, Base Station and user, in the hierarchical architecture of the group the base station is at the upper level which provides communication link between the user and the clusters. The data in the sensor network are gathered for providing the answers for the queries raised by the user [1]. An essential part of developing WSNs is being energy aware by reducing the power consumption because of the power limitation. There are many possible solutions in order to reduce the power consumption of the wireless sensor nodes such as enhance the storage systems energy density, improve

a technique to distribute the power among the nodes, and produce a mechanism to make the nodes scavenge their own power [16]. The clustering algorithms play an important role in not just organizing the network but also control the performance of the network organization. There are several key limitations in wireless sensor networks, that clustering schemes must consider are Energy, Lifetime of Network , Application, Accuracy, Receiver Sensitivity, Type of transmitting signal , Distance ,response time, cluster stability, cluster overlapping, location awareness, QoS support and node mobility. [1]

II. ENERGY EFFICIENT CLUSTERING ALGORITHMS

1. Linked Cluster Algorithm:

D.J. Baker, A. Ephremides (1981) proposed the one of the classical clustering algorithms ever. It first developed for wired network, but later implemented in wireless sensor networks. The name implies the clustering is achieved by linking each node with other node. Authors focused on forming an efficient network topology that can handle the mobility of nodes. The channel header of this network is the basic back bone of the cluster. In this algorithm is to form clusters such that a channel header is directly connected to all nodes in its cluster. Each node in the cluster must satisfy the following three characteristics.
1) Every node has a unique ID and knows the ID's of its one-hop neighbors. This can be provided by a physical layer for mutual location and identification of radio nodes.2) A message sent by a node is received correctly within a finite time by all of its one-hop neighbors. 3) Network topology does not change during the algorithm execution. This technique is geared for maximizing network connectivity. This algorithm assumed synchronized nodes and time-based medium access. Since the selection of channel header in this method is randomly chosen the lifetime of the network will depend on the power in the header node. It also increases the delay in the networking [3].

2. Adaptive Clustering:

C.R. Lin and M. Gerla (1997) Lin and Gerla et al. established the adaptive clustering algorithm which is very much similar to the linked clustering algorithm. Similar to the linked cluster algorithm the nodes in the clusters also transmit its ID and thus channel header is selected as it on the linked cluster algorithm. A channel header arbitrates the selection and communication codes with the neighboring headers. This technique is used to control the cluster size by balancing the interest in the spatial reuse of channels, which in increased by having small clusters, and data delivery delay, which gets reduced by avoiding inter-cluster routing. It is used for Multimedia applications in the general multi-hop mobile ad-hoc networks using CDMA based medium arbitration. The stability of the network was less compared to other algorithms [4].

3. Hierarchical control clustering:

The hierarchical clustering algorithm proposed by Banerjee and Khuller (2001) is to form multi-tier hierarchy of cluster. It has two phases for cluster formation when multiple nodes initialize the cluster formation otherwise it just forms the cluster. The first phase is Tree discovery in which basically a distributed formation of a Breadth-First-Search (BFS) tree rooted at the initiator node. Each node in the cluster broadcast a signal which contains the following in formations Source ID, Parent ID, Root ID and sub-tree size. Every node in the cluster will update the information about the neighbor nodes which are near to the node or shorter in distance to the node. The nodes which transmit the signal will be considered as a parent node for the node which is near to the other node in the cluster. At the second phase the small sub-trees are grouped together to form the clusters which is called as cluster formation process. At this phase keeping cluster information is crucial for clusters while maintaining BFS tree is unimportant. Since it transmits data to the node which are very closer to the nodes the energy requirement is very low and thus increase the life time of the cluster. Since the cluster formation has to two steps for multiple nodes clustering it will increase the time delay of the clustering. This algorithm is very much helpful for handling the dynamic environments and used for the mobile sensor nodes [5].

4. Grouping clustering algorithm:

Zhang and Arora et al.,(2002) works describe a new clustering algorithm which is called as GS3 other than a grouping algorithm which is converting the geometric area of a cluster group in a form of hexagonal shape. In this type of clustering the authors proposed the logical radius instead of geographical boundary of clusters. The authors define the radius of the circle that contains all nodes in the cluster as a measure for the geometric size. In this work two kinds of nodes big and small node were proposed. The big nodes initiate the cluster formation process and also interfere with the small nodes in other cells and other work. The big node is forming a graph with the headers in each cluster. The small node is forming of a graph with the other nodes in each cluster. So, the interfacing with big node with the small node is

very much easy. Since the area to be sensed is assumed as hexagon which will reduce the overlapping of clusters .This scenario will reduce the energy required to transmit the data to the head. So, it increases the life time of the clusters [6].

5. Energy Efficient Hierarchical Clustering (EEHC):

This algorithm is proposed by Bandyopadhyay and Coyle (2003) for minimizing the energy consumption and thus increase the life time of the cluster. It basically collects the information from the neighbor nodes and distribute to the base station with two strategies.
The first strategy is initial, it is otherwise called as single level clustering in which each node in the network announces itself as a header that are known by volunteer headers. The nodes in the radio range of header will receive the information broadcasted by the header either by direct communication or by forwarding. Any node that receives such announcements and is not itself a header becomes the member of the cluster. The nodes which doesn't get the announcement will wait for the time interval for calculate the time taken to reach the data to the neighbor node in the network this nodes will be called as Forced headers.
The second strategy is extended or multi-level clustering which is same as the process of hierarchical clustering algorithm. In this process the nodes are connected by a header in a cluster (level 0) and information delivered by this header will be received by another node and delivered to the base station at the next (level 1) level which will reduce the energy required for transmission of data to the base station and also increase the life time.
This algorithm ultimately reduces the energy requirement in the transmission of data to the base station and also increase the life time of the clusters. The cluster formation both strategy requires some time to take so this algorithm produces some time delay in the network. This algorithm is widely used for wireless sensor networks [7].

6. Energy Efficient Strong Head Clustering (EESH):

EESH clustering is a recently published clustering scheme by Zhou Wei Chen Hui-min Zhang Xue-fan (2007). In EESH, nodes are promoted cluster headers according to their respective residual energies, their respective degrees and the distance to and the residual energy of their neighbors. In order to achieve this, it calculates the cost function for every sensor in the network and selects the node having the greatest cost as header. This process terminates when all the sensor in the network are connected to at least one cluster header.
Basically the sensors are deployed in a redundant fashion. Since sensor nodes might generate significant redundant data, similar packets from multiple nodes can be aggregated so that the number of transmission would be reduced. The suppression technique can be used to minimize the data redundancy. The basic operations used are min, max and average. Some of these operations were performed by allowing sensor nodes to conduct in-network data reduction. By using these energy savings can be obtained [8].

7. Fast Local Clustering Service (FLOC):

In the FLOC algorithm proposed by Murat Demirbas et al. (2004) the whole network sub-divided into two groups such as i-band (inner band) and o-band (outer band). Among these two groups the o-band signals are more affected by the network sometimes it may get lost also, but while in i-band network the signals get some interference while communicating with the header. The i-band membership is used to increase the robustness of the intra-cluster traffic. A node is said to be idle when an invitation is received from the header otherwise it is a candidate of a header and broadcasts a candidacy message. Upon hearing the candidacy message a recipient node a recipient node which is already in an i-band network will reply back to inform the candidate header about such membership FLOC is a scalable and very well converging in a constant time regardless the size of the network. It is also self-healing capabilities since o-band nodes can switch to i-band node in another cluster. New nodes can execute the algorithm and either joins one of the existing clusters or forms a new one that possibly would attract some of the current o-band nodes in neighboring clusters. It produces minimum overlap. For rare case of FLOC the cluster head selection will be very much complicated than the other network clustering algorithms [9].

8. Distributed Weight-Based Energy-Efficient Hierarchical Clustering (DWEHC):

The DWEHC is proposed by Ding et al. It proceeds in the manner of distributed time complexity. In this structure each sensor (n algorithm mode) in a network calculates its weight after locating the neighboring nodes in its area. The weight is a function of the sensor's energy reserve and the proximity to the neighbors. In the network the network a node with largest weight will be considered as the head of the cluster. Others become the member of the cluster. In this network the nodes (other than header) are considered to be the first level members since they have direct contact with the header. A node progressively adjusts its members in order to achieve the least amount of energy. A node checks its distance between its neighbors to find out the minimal cost of energy. Given the best knowledge about the distance to its

neighbors, it can assess whether it is better to stay a first-level member or second-level member. This process is repeated until nodes settles on the most energy efficient intra-cluster topology. To limit the number of levels, every cluster is assigned a range within which member nodes should lay. This algorithm reduces the amount of energy used to transfer the data and also increase the life time of the cluster. It provides more balance then the HEED algorithm and also provides more efficient communication in the intra-cluster and inter-cluster communication with lower amount of energy in the network. The weight of the node is more important in this algorithm if more than two nodes in the network have the same weight then the complexity will arises at the header selection process [10].

9. Save Energy Clustering Algorithm (SECA):

The SECA protocol proposed by Jau-Yang Chang and Pei-Hao Ju(2012). In the proposed clustering scheme, the cluster head election process incudes location, residual energy for each sensor node and the average residual energy of sensor. When the residual Energy of sensor node is higher than the average residual Energy, the sensor node becomes a candidate of cluster head. The lifetime of wireless sensor networks is prolonged by using the uniform cluster location and load balancing among the clusters. Simulation results indicate our proposed algorithm achieves .The simulation result of shown that SECA can be better performance compared to LEACH, LEACH-C and HEED. [11]

10. Energy Driven Adaptive Clustering (EDAC):

In this paper Kyung Tae Kim et al. proposed a new approach called energy-driven adaptive clustering hierarchy (EDACH), this algorithm uniformly distributes the energy dissipation among the sensor nodes to maximize the network lifetime. This is achieved by using proxy node replacing the cluster-head of low battery power and forming more clusters in the region relatively far from the base station. Enhancement of the network lifetime is achieved by distributing the cluster-heads according to the distance to the base station. The proposed approach will be more important when the wireless sensor network is deployed in large area.[12].

11. 2-level Random Time Delay (2RTD) Clustering Approach:

The 2RTD clustering approach is an improved version of the TDC which was proposed by Jutao Hao et al. (2011) has the drawback as to achieve uniform cluster distribution, but its restriction that a cluster head must be the node with the highest energy in the neighborhood may require additional communication packets, thus increasing energy consumption. It uses the linear piece wise operation for the cluster formation. The 2RTD also uses the same linear piece wise operation for the cluster formation for short. It uses the residual energy of a cluster head as the piecewise boundary of a local network to classify all neighbor nodes into two energy levels. The cluster head selection in this algorithm is like a RCC. In this approach the nodes in the sensor networks randomly sets its time delay for a particular time period and decreases until it reaches zero. When a node does not here any announcement about the header before time out, then the node will declare itself as the header. The remaining nodes in the network will be the members of the cluster. These nodes will send the join request to the header to form the cluster group. After the cluster was formed the data will be transferred to the header for the transmission to the base station. When the energy level of the sensor information is strong enough to get the full information then that particular node data will be transferred others will be rejected. This will increase the efficiency as well reduce the redundancy [13].

12. Imperialist Competitive Algorithm (ICA):

An imperialist competitive algorithm was proposed by Po-Jen Chuang, Sheng-Hsiung Yang and Chih-Shin Lin (2011). This algorithm works as the same principle as imperialist competition. Hence it's so called imperialist inspired clustering algorithm. The nodes which are having higher in energy level then the other nodes will be said to be the cluster head node. The remaining nodes will be said to be as the normal nodes. Based on the energy consumption in the node the cluster head is selected. Another important characteristic for the node to be as the cluster head it should have to minimize the transferring energy to the base station. In this method first of all the entire network is converted into the counties based on the population of the nodes. These countries will be further divided into two major categories as imperialist and colony based on the energy level of the cluster group. Imperialist in each period, try to assimilate the colonies. So, by making the changes in their colonies structure, they absorb them toward themselves. During the act of absorption, a little change is made and a colonial power maybe outweighs the imperialist. In this case they just exchange their positions. It is assume d that all the clustering operations are performed in base station only. The cost of each country is related directly to its proposed method energy consumption for nodes clustering. It suggested better optimal method and it's more powerful. After several periods we can select the most powerful imperialist as final answer [14].

13. Dynamic Clustering Protocol:

Liu, Zhi-kun; Liu, Zhong(2011) In order to solve the problem of dynamic clustering for wireless sensor networks (WSN) authors proposed a dynamic clustering protocol, focusing on cluster head selection, cluster member solicitation and cluster reorganization, is proposed. In cluster head selection mechanism, authors proposed selection approach takes the detected signal strength, residual energy of node and distance between the cluster head and the sink node into consideration. Through this method, the cluster size is constrained and the energy consumption of intra-cluster communication is reduced. The simulation results show that the proposed protocol can efficiently conserve energy and prolong the lifetime of WSN, especially when the sink node is located far from the network [15]

14. QoS Enhanced base Station controlled Dynamic clustering protocol:

M.Sheik Dawood et al. (2011).The cluster based routing protocol is proposed for the purpose of reducing the consumption energy in wireless sensor networks. To overcome lack of QoS, inefficient transmission problems, modified QoS enhanced base station controlled dynamic clustering protocol for wireless sensor networks is proposed by authors [16]. Better energy consumption is achieved by this protocol with enhanced Quality of Service.

15. Distributed energy-efficient clustering algorithm with improved coverage:

Zhixin Liu, Qingchao ZhengLiang Xue and Xinping Guan (2011) proposed a DEECIC (Distributed Energy-Efficient Clustering with Improved Coverage) algorithm. DEECIC aims at clustering with the least number of cluster heads to cover the whole network and assigning a unique ID to each node based on local information. In addition, DEECIC periodically updates cluster heads according to the joint information of nodes' residual energy and distribution. The algorithm does not require time synchronization and knowledge of a node's geographic location.. Simulation results show that the proposed algorithm can prolong the network lifetime and improve network coverage effectively [17]

16. Energy-Efficient Multilevel Clustering Algorithm:

Surender Soni, Vivek Katiyar and Narottam Chand (2011).Wireless Sensor Networks (WSNs) are generally believed to be homogeneous, but some sensor nodes of higher energy can be used to prolong the lifetime and reliability of WSNs. This gives birth to the concept of Heterogeneous Wireless Sensor Networks (HWSNs). HWSNs are popular in real deployments (Corchado et al., 2010), and have a large area of coverage. In such scenarios, for better connectivity, the need for multilevel clustering protocols arises. In this paper, the authors propose an energy-efficient protocol called heterogeneous multilevel clustering and aggregation (HMCA) for HWSNs. HMCA is simulated and compared with existing multilevel clustering protocol EEMC (Jin et al., 2008) for homogeneous WSN. Simulation results demonstrate that the proposed protocol performs better. [18]

17. Energy-efficient Grid Based Clustering Algorithm:

Ketki Ram Bhakare, R. K. Krishna and Samiksha Bhakare (2012) Proposed an energy-efficient grid based clustering algorithm for WSN. In this paper energy efficient grid clustering algorithm implemented due to its great scalability and feasibility. Firstly the grid is formed in the network after that the clustering process is performed in the network. Cluster head chosen depends upon the weight of the nodes. The grid clustering simulation results shows that better performance than other cluster based routing techniques. [19].

18. Energy Efficient Dynamic Clustering Protocol (EEDCP):

An Energy Efficient Dynamic Clustering Protocol (EEDCP) proposed by K. Padmanabhan and Kamalakkannan (2012). This algorithm work is same principle of Cluster Based Energy Efficient Location Routing Protocol (CELRP) and Low-Energy Adaptive Clustering Hierarchy (LEACH), so it can be said to the Energy Efficient Dynamic Clustering Protocol (EEDCP). The sensor nodes are separate a various cluster by base station. The base station calculate the average energy level of a network and find the node have higher than the average level, and send that node as a cluster head to the all other cluster nodes. The cluster head collect the data from the cluster node and cluster head aggregate the information and compressed the data. In cluster heads the some cluster have the higher energy level then the cluster head sent the information to higher energy level cluster head. Then that node sent information to base station. So the energy consumption of cluster heads is evenly consumed. The simulation results of EEDCP to CELRP and LEACH its shows that proposed protocol have the low energy consumption and network prolong lifetime span [20].

19. Energy Efficient Genetic Algorithm for Clustering:

Sudakshina Dasgupta and Paramartha Dutt(2012) proposed a of evolutionary computing method for the selection of the Cluster-Heads. The Base Station periodically executes the proposed algorithm to select new Cluster-Heads after a certain

period of time. In this paper, clustering the senor nodes based on the genetic algorithm has been proposed. The derivation of this method is the smart selection of cluster heads in the network in an optimal way to increase the network lifetime .The simulation result of GA for clustering compared to DEEC, LEACH and M-LEACH .The results shows that minimum energy consumption and increased the lifetime of WSN achieved by proposed algorithm. [21].

III.CONCLUSION

Grouping sensor nodes into clusters is an effective way to improve the network performance .This study reviews some of these proposed clustering algorithms involving with its terminology and attributes. The parameters which are mostly included energy efficiency, cluster stability, location awareness, node mobility and QoS support. The general framework of clustering algorithms is discoursed here, which unseals up the panorama of enhancement on widely-used algorithms.

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