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Efficient Clustering Methods for Improving the Lifetime of Wireless Sensor Network

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ABSTRACT

Wireless sensor network (WSN) consists of large number of tiny sensor nodes randomly distributed in some regions. Each node has a limited energy supply and generates information. It has been proved that the nodes closer to the sink node will use up their energy more quickly, as a result, the network lifetime will be affected. Due to inhospitable conditions these sensors are not always deployed uniformly in the area of interest. Therefore, how to optimize the network lifetime and keeping energy efficiency improving becomes an important problem. To overcome this, the existing clustering algorithm such as Energy Efficient Clustering Scheme (EECS),Power-Aware Dynamic Clustering Protocol (PADCP)for Wireless Sensor Network, A Hybrid, Energy-Efficient, Distributed Clustering (HEED), An Energy-Efficient Unequal Clustering (EEUC), Distributive Energy Efficient Adaptive Clustering(DEEAC), A Hybrid, Energy-Efficient, Distributed Clustering (HEED) are used. In this paper performance has been analyzed for the above Clustering protocols in WSN. The behavior of these protocols has been analyzed under realistic scenarios by means of simulation with a network simulator tool NS-2. Furthermore, I present a concise description of WSN lifetime maximization process along with the techniques associated with the various factors that affects the process.

Keywords: *Wireless Sensor Network (WSN),* EECS, PADCP, HEED, EEUC, DEEAC, and Energy consumption

1. INTRODUCTION

The advances in MEMS (Micro Electro-Mechanical Systems) as well as in wireless communication have motivated the development of billions of tiny and low cost wireless devices as well as various kinds of wireless networks which connect these devices with or without any existing infrastructure.

Wireless Sensor Network (WSN)[1,4]is an important supplement of the modern wireless communication networks. It can be viewed as a network consisting of hundreds or thousands of wireless sensor nodes which collect the information from their surrounding environment and send their sensed data to remote control center which is called Base Station (BS) or sink node in a self organized manner. In recent years, with advance in wireless communication technology, sensing technology, micro-electronics technology and embedded system, wireless sensor networks can be used for a wide variety of applications and systems with vastly varying requirements and characteristics, such as environmental monitoring, disaster management, factory automation, health care or military.

A wireless sensor network (WSN) is an ad hoc network formed from many sensor nodes that gather data and uses wireless communication to transmit the information that they collect and the number of nodes depends on the application [5]. Because sensor nodes are battery powered, and their lifetime should be maximized, one of the most important design criteria for this type of network is energy efficiency [20]. Sensor network interfaces with the other networks (e.g. wired network) by one or several sinks the sensory data collected by the sensors is sent to the closest sink where it is further aggregated, it was noticed that the sensors closest to the sink are easier to use up their energy than other sensors [13], [17], [8], as a result, it is clear that lifetime of the network will be significantly affected. By researching the network lifetime, we can arrive at the purpose of improving the energy efficiency; Each node must be designed to manage its local supply of energy in order to maximize total network lifetime. In many deployments it is not the average node lifetime that is important, but rather the minimum node lifetime.During the large number of sensors are deployed for communicate and connect the information broadcast throughout the network .At that time data congestion and collisions will be happened. This will drain energy quickly from the sensor network. To overcome these issues by Clustering. In clustering, some sensors are elected as Cluster Heads (CHs) for each cluster created. All data's are transmitted to respective CH and the CH collects the data .It can be transmitted to a central base station. Clustering make easy efficient utilization of limited energy of sensor nodes and hence extends network lifetime. Although sensor nodes within the clusters transmit messages over short distances and outside of the cluster more energy is transmitted from CHs to base station over long distances. Compared to other sensor nodes in the cluster. In intermittent reelection of CHs within clusters based on their residual energy is a possible solution to balance the power consumption of each luster. Clustering is to reduce the no of sensors by improving the efficiency by transmit data to base station. Clustering is projected because of its network scalability, energy saving and network topology stability [11].Clustering schemes also reduce the communication overheads among the sensor nodes. Existing Clustering algorithms have some drawbacks such as additional overheads during Cluster head (CH) selection, cluster formation process.. The following are the components of a clustered WSN.There are three important components in clusters such as sensor node, Clusters, Cluster heads, and End users.

Sensor node: A sensor node performs sensing; data storage; routing; and data processing.Clusters: Clusters are the hierarchical units for WSNs. Many sensor networks are broken down into clusters. It simplify the tasks such as communication between the base station and the Cluster heads. Cluster heads (CHs) are the master of a cluster. CHs are often required to organize Clusters. These include data collection, organizing and transmitting the communication schedule of a cluster. Base Station involves the communication link between the sensor network and the end-user. It is normally the sink in a WSN. The data in a sensor network can be used for a wide-range of applications [12]. Data are generated in WSNs in response to queries received from the end user.

We consider a system of sensor nodes that are homogeneous and highly energy-constrained. Further, replenishing energy via replacing batteries on hundreds of nodes (in possibly harsh terrains) is infeasible. The basic operation in such a system is the systematic gathering of sensed data to be eventually transmitted to a base station for processing. The key challenge in such data gathering is conserving the sensor energies, so as to maximize their lifetime. To this end, there are several power-aware routing protocols for wireless ad hoc networks discussed in the literature [20, 21]. In the context of sensor networks, leach [11] proposes a clustering-based protocol for transmitting data to the base station. The main features of this clustering include local co-ordination for cluster formation among sensors, randomized rotation of cluster heads (CH) for improved energy utilization, and local data compression to reduce global communication.

This paper includes in Section II is challenges and progression of clustering algorithms and Section III contains comparisons among some cluster. Section IV include concludes of this paper.

II. Clustering in WSN

A. Challenges for Clustering Algorithms

A various Clustering algorithms are play the important role in WSN.It improve the network lifetime. There are several key boundaries are identified by clustering in WSNs.

such as limited energy, network lifetime, Cluster formation and CH selection, Synchronization
Data Aggregation, Quality of Service (QoS).

• Limited Energy: In every sensor nodes are small size battery operated sensors, so they have limited energy storage in WSN's. It is not easy to recharge or replace their batteries after overtiredness. For this, the routing algorithm is not a more energy efficient compared to clustering algorithms. It can be achieved by balancing the energy consumption in sensor nodes. It is done by optimizing the cluster formation, periodically re-electing CHs based on their residual energy and efficient intra-cluster and inter-cluster communication.

• Network Lifetime*:* Clustering schemes help to extend the network lifetime of WSNs by reducing the energy usage in the communication within and outside clusters

• Limited Abilities*:* The small physical size of node and little amount of energy stored in a sensor node. It limits many of the abilities of nodes in terms of processingmemory, storage, and communication.

• Secure Communication*:* The ability of a WSN to provide secure communication when considering these networks for military applications [4]. An organization of secure and energy efficient intra-cluster and inter-cluster communication is one of the important role for designing clustering algorithms.

• Synchronization***:*** In a clustering scheme, synchronization and scheduling is the most important role on the overall network performance. TDMA schemes allow nodes to regularly schedule sleep intervals to minimize energy used. Such schemes require synchronization mechanisms to maintain the transmission schedule.

• Data Aggregation*:* Data aggregation eliminates duplication of data. In a large network, the multiple nodes are sensing the same information. Data aggregation allows as to differentiate sensed data and useful data. Many clustering schemes given those data aggregation capabilities [36] must carefully select a appropriate clustering approach.

- Quality of Service (QoS)*:* Many of these requirements are acceptable delay and packet loss tolerance. In many clustering algorithms provides energy efficient network utilization in WSN's.

WSN. For the design process QoS metrics must be taken into account.

B. Clustering progression

There are two main steps in clustering, which are CH selection and cluster formation.
CH selection:
CH selection consist of three types, integrate by the BS, disperse by the sensor nodes or hybrid selection by some information provided by the BS and some by the nodes themselves.
1. The steps for selecting CHs are:

- Distance between CHs and the BS to ensure that (CHs are situated near to the BS)
- In Uniform CH distribution so that CHs are not cluttered. Cluttered CHs can root long distance between non-CH nodes another words causing high energy consumption for intra-cluster communication
- CHs perform extra tasks for WSNs such as: data aggregation and forwarding
- Residual Energy in a nodes to be nominated as a CH.
- Time delay: how long it takes to select a CH and to form a cluster. This parameter could mean the communication distraction during that period.

2. The main concerns in combine a CH for a sensor node are:

- The signal strength can be measured by distance between a node and a CH
- Cluster size: The number of nodes in a cluster represents the accumulated energy in a cluster and also extra energy consumption for the CH to serve its cluster.

III. LITERATURE SURVEY

This section describes the various literatures on clustering protocols in wireless sensor networks. The input test in wireless sensor network is achieving a extended lifetime of nodes that transmit partial amount of battery energy. It might be not possible or else difficult to boost the battery in the distant locality so, the essential necessity is to extend the network life time. Here at wireless sensor networks the key intention is to exploit the least lifetime of each node. Lifetime is maximized by matching the energy expenditure of each node, by energy capable routing. There are lots of researches accessible on wireless sensor networks based on this energy expenditure. Traditional (or flat) routing protocols for WSN may not be optimal in terms of energy consumption. Clustering can be used as an energy-efficient communication protocol. The objectives of clustering are to minimize the total transmission power aggregated over the nodes in the selected path, and to balance the load among the nodes for prolonging the network lifetime. It is described as follows.

Mudasser Iqbal et al. [22] have recommended that Energy efficient dynamic clustering (EEDC) offers a flexible example to reconfigure the network in order to exploit network's life-time in resource controlled ad hoc sensor networks. The content summaries of parent nodes (PNs) can be used to describe its present state as well as to calculate possible failures initiated by energy loss due to high loads on particular PNs. Their paper offered a novel dynamic clustering algorithm for contents balanced routing based upon route efficiency. The set of rules exploits the pattern and contents of traffic and energy indulgence rate of each node on the route to calculate the node and route effectiveness. Disagreeing to the procedure recommended in **[23]**, that at all times selects the path with least hop count to the base station, their recommended routing procedure may select a extended path that will arrange for better sharing of the energy intake among the sensor nodes. Virtual reality effects point out clearly that associated to the routing procedure recommended in **[24]**, their recommended procedure uniformly distributes the energy intake between the network nodes consequently exploiting the network life time.

Energy efficiency is a bulging design standard for any wireless sensor network protocol. E.M. Saad et al. [25] have defined a distributed network topology geared for exploiting network durability and sensing exposure. The main hint behind the suggested topology is to develop an energy attentive clustering protocol resilient for network dynamics. Their proposed clustering protocol was pointing at efficiently cluster the network sensor nodes around relatively high residual energy cluster head nodes. In the meantime, guarantying identical distribution of cluster heads all over the entire sensing field.

Jing Yung et al[26] introduced a Multipath routing protocol (MRP) based on dynamic clustering and ant colony optimization (ACO) was recommended by Jing Yang et al. [26]. Such a methodology can exploit the network lifetime and reduce the energy consumption. An important characteristic of WSNs was its limited power supplyIn the proposed dynamic methods, a cluster head (CH) was selected among the nodes located in the event area permitting to some parameters, such as residual energy. Secondly, an improved ACO algorithm was applied in search for multiple paths between the CH and sink node.

Tao Shu and Marwan Krunz [27] proposed examined the growth of the coverage time for a clustered wireless sensor network by optimal balancing of power intake among cluster heads (CHs). They offered a coverage-time-optimal joint clustering/routing algorithm, in which the optimal clustering and routing parameters are figured using a linear programming technique. For the stochastic setup, they consider a cone-like sensing region with evenly distributed sensors and deliver optimal power allocation strategies that assurance (in a probabilistic sense) an upper bound on the end-to-end (inter-CH) path reliability. Here, Two mechanisms were offered for achieving balanced energy consumption among nodes. They are routing-aware optimal cluster planning and a clustering-aware optimal random relay.

Clustering was an effective topology control approach in wire- less sensor networks, which can increase network scalability and lifetime. Mao Ye *et al*. [28] have described a novel clustering schema EECS for wireless sensor networks, which better suits the periodical data gathering applications. Their approach elects cluster heads with more residual energy through local radio communication while achieving well cluster head distribution; furthermore, it introduces a novel method to balance the load among the cluster heads.

The past few years have witnessed increased interest in the potential use of wireless sensor networks (WSNs) in applications such as disaster management, combat field reconnaissance, border protection and security surveillance Ameer Ahmed Abbasi and Mohamed Younis [29] have presented a taxonomy and general classification of published clustering schemes. A most important goal in the design of wireless sensor networks is lifetime expansion, constrained by the energy capacity of batteries. Clustering technique is one of the greatest efficient techniques which cater to the requisite of energy conservation in wireless sensor networks. Rajni Meelu and Rohit Anand [30] have analyzed the performance of (DEEC) Distributed energy efficient clustering protocol in perspective to network lifetime, energy consumption and energy balancing. Similarly a new clustering protocol has been proposed for further extending the network life. Model results reveal that the lifetime of proposed routing protocol was 40% longer than DEEC and shows that energy was well balanced as compare to existing protocols .

IV. CLUSTERING ALGORITHMS

In this section, we describe the popular and effective clustering algorithms in WSNs and also we can analyze and classify those algorithms.

A. Energy Efficient Clustering Scheme (EECS)(31)

Energy Efficient Clustering Scheme is a single hop and efficient data gathering applications. There are two phases in EECS i) the *cluster head election* phase ii) *cluster formation* phase. In this cluster head election phase, the cluster head will be choosen by its residual energy. Further in the *cluster formation* phase, simple nodes are join not only consider within the cluster communication cost and also considering the cluster communication to the base station(BS).EECS provides the network lifetime and energy utilization is more compare to LEACH .It extends size of the clusters based on the distance from the base station. This algorithm is suitable for both heterogeneous and homogeneous techniques. EECS makes uniform distribution of cluster heads across the network through localized communication with little overhead. EECS algorithm requires that clusters at a greater range from the base station require more energy for transmission than those that are closer. It is the major problem of this algorithm.

B. Power-Aware Dynamic Clustering (PADC) (32)

This algorithm mainly focus on energy utilization and also improve the lifetime of the network.PADC contains low energy with multiple transmission levels .It is more better compare to other techniques like LEACH and HEED.PADCP avoids unnecessary interference and also save the more energy. PCDCP algorithm assigns different cluster size with different power-levels for transmission. On the other hand, it supports various transmission powers to each cluster head. In our technigues,the Cluster heads are chosen by node density instead of distance. Our algorithm should be re-elect the cluster head by whenever the remaining energy of the original one is below threshold levels and also it provide the new re-route to the cluster head. It allocates the cluster by dynamic cluster range selection and cluster heads are selected by its residual energy of clusters. after the cluster selection, it will transmit the message to its neighboring nodes and the information’s are stored in look-up table when the energy below the threshold levels, it will be chosen other cluster head and it form the updated look-up table.

C. An Energy-Efficient Unequal Clustering (EEUC) (33)

Energy-efficient unequal clustering (EEUC) is a distributed competitive algorithm .EEUC balances the energy consumption among cluster heads and it should increase the network lifetime. We calculate the optimal energy through data aggregation mechanism. It is to successfully solve the hot spots problem. It is to save the energy, when the cluster sizes closer to the sink node much smaller compared to far away the sink. In EEUC, Cluster size is equal to the distance to the base station. The residual energy and rotations are not enough to balance the energy consumption for this we need an Energy-efficient unequal clustering. It performs two communications i) intra cluster communication and inter cluster communications. It is not only helps the nodes to communicate with the base station with proper power level, but also it helps us to produce clusters of unequal size. EEUC is to only find energy consumption and prolonging the network lifetime

But also we need the optimal value of parameters according to network scale. It is the future work of our EEUC.

D. Distributive Energy Efficient Adaptive Clustering (DEEAC)(35)

Distributive Energy Efficient Adaptive Clustering (DEEAC) is distributed competitive algorithm. In DEEAC have data coverage rates and residual energy of each node within the network. It is to increase the network lifetime by distribute the energy among all sensors. In all the above approaches either the data is collected from the network at a times but not having any temporal variations in data delivered by the network. These specialties are available in our DEEAC protocol .It broadcast residual energy with collective data to base station (BS) and this base station should calculate all residual energy from the whole network. In DEEAC used the novel hotness approach and it acclimatize to the chronological deviation in data generation speed. In DEACC, residual energy of each node depends on the residual energy of whole network with chronological variations. In this algorithm ,energy consumption and increase the network life time is depend purely on the cluster head selection of our whole network .

E. Hybrid Energy Efficient Distributed Clustering (HEED) (34)

Hybrid Energy Efficient Distributed Clustering (HEED) is a distributed clustering approach. In this approach does not have any postulation of node abilities. HEED is to perform increasing the network lifetime and it supports scalable data collection. HEED has four main ideas i) It is to increase the network lifetime ii) removing the clustering method by even number of iteration iii) linear number of nodes are reduce the control overhead (iv) it is constructing well-distributed cluster heads. . HEED provides a better load balancing because it provides consistent cluster head (CH) allocation across the network. CHs are selected based on two important parameters: i) primary parameters ii) secondary parameters .The primary parameters depends on the residual energy and secondary parameters depend on the intra-cluster communication cost. Cluster range is finding by the transmission power level with the help of intra-cluster statements. Low cluster power levels support an increase in spatial reuse while high cluster power levels are required for inter-cluster communication. Each node sets its probability of becoming a cluster head (CH) probability,CHp as follows, CHp = Cp * Er/Ema, where Er is the residual energy of the node and Ema is the Maximum energy of the node. HEED distribution of energy consumption extends the lifetime of all the nodes in the network. HEED algorithm is divided into three phases i) Initialization phase ii) Repetition phase iii). Finalization phase.

1. Initialization phase:

The algorithm allocates initial proportion to CHs among all sensors. This cluster head probability is not permitted to go down the minimum probability threshold value, which is elected to be converse of Emax.

2. Repetition phase:

In this phase, several iterations are performed in every sensor nodes until it finds the CH.After the selection of CH ,it can broadcast the least cost (inverse transmission power) .When it hears no CH,the node selects itself to be a cluster head and it broadcast message to its neighbors. Finally, each node twice its cluster head probability value and it goes to the next iteration of this phase.

concluding status: The sensor permanently becomes a cluster head if its cluster head probability has reached one.

3. Finalization phase:

In this phase, each node decides a final decision on its status. HEED allows distributed cluster heads across the network. Several iterations concerned in cluster formation in HEED.

Cluster heads closer to the base station may die earlier.

HEED is not only performing uniform distribution but it also performs non-uniform node distribution in the network field. HEED mainly selects CH according to their residual energy, which is independent of node distribution. HEED uses less energy in clustering than gen-LEACH, because gen-LEACH promulgates residual energy information. HEED is better than gen-LEACH because network lifetime of HEED is maximum. But HEED only supported for two-level hierarchy.

5. Evaluation of the Clustering Algorithms.

Tables 1 review the various clustering algorithms as shown below.

types	PADCP	HEED	EECS	DEEAC	EEUC
Distributed/Centralized/ Hybrid	Distribut ed	Distributed	Distributed	Distributed	Distributed
Cluster size Equal/Unequal	Unequal	Unequal	Equal	Equal	Equal
CH distribution	Non uniform	Uniform	Uniform	Uniform	Uniform
Overhead in CH selection	High	High	Low	High	Low
Threshold Energy Level	50%	60%	70%	65%	55%
Delay	High	High	Low	Low	High
Re-election	Yes	No	Yes	No	No
Applicable for either Homo/Heterogeneous	Homo geneous	Homo geneous	Homo geneous	Hetero geneous	Hetero geneous
Rounds	No	Yes	No	No	Yes

6. CONCLUSION

In this paper, some of the popular existing clustering algorithms has been studied by highlighting their objectives,features,complexity.Also these algorithms are compared based on different parameters such as i)whether the approaches are Centralized/Distributed/Hyprid ii0Clustring type whether equal or unequal clustering. Our clustering algorithms are better for large scale wireless sensor networks. In above algorithms are more popular distributed Clustering approaches. We know the cluster head selection and cluster formation of various algorithms. We study the intra cluster communications and inter cluster communications and residual energy of each node and energy consumption across the network and load balanced among clusters and prolongs the network lifetime.

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