



AN ANALYTICAL REVIEW ON WIRELESS SENSOR CLUSTERING FOR THE PROLONG NETWORK LIFE TIME

Navdeep Kumar Chopra
Ph.D (Research Scholar), CSE
IKGPTU, Jalandhar, India

Rajesh Kumar Singh
Professor & Principal
SUS Institute of Computer, Mohali, India

Abstract: Wireless sensor network is the group of small units called nodes which has gained a lot of light due to its variant applications in various sectors. The tiny mechanical devices referred as sensor nodes are deployed in the very rough area and they are left unattended to uninterruptedly report about the environment parameters. Nodes in rough areas rapidly diminish energy resources, which lead to disruption in network services. This is the main problem of data collection scenarios in which CH's have a huge burden of collecting and relaying statistics. The relay load on heads particularly intensifies as the sink distance decreases. For balancing the load of traffic and the energy consumption in WSN, the CH role must be switched among all the network nodes and the sizes of cluster must be carefully determined at every portion of the network. These devices have energy which is consumed during a long time at processing, gathering, aggregation and transmission of data. So, clustering approach is applied to reduce the consumption of data and give prolonged life to the network. This paper surveyed about the clustering mechanism, its protocols and various issues regarding it. The various parameters of the clustering in WSN are discussed.

Keywords: cluster heads (CH); distributed clustering protocol; periodic clustering; time division multiple Access (TDMA)

1. INTRODUCTION

In the modern era, the interest in the wireless sensor network has increased enormously. All the application like military, defense and environment monitoring use the sensors to have knowledge about the parameters like pressure, temperature, light, humidity and chemical activity without even bothering about it [1]. The sensors in the nodes even work if left unattended. The researchers gather the information transferred by sensors. In the field of military, while the work of chemical activity and radiation is in growth, the maximum value needs to attentive the workers. For the enhancement of the network fidelity in the measurement, the data aggregation is helpful in energy saving by lessening the communication overhead within the network [2]. With the development in the system of micro electro mechanical, the integration of wireless sensors with wireless communication takes place [3]. It is the gathering of small devices like sensor nodes which are distributed all over

the network. Nodes are the tiniest device in the network which is the combination of processing, interaction and sensing capabilities [4]. The main components of the node like battery, processor, transceiver and energy are limited. The wireless sensor nodes are mainly of two types: (a) heterogeneous (which has variable sensing, communication and processing capabilities) (b) homogeneous node (fitted with small amount of energy, sensing, communication and processing capabilities'. Wireless sensor network are used in various application of military, surveillance, security, healthcare and disaster management. There are large number of nodes or terminals in the wireless sensor network with restricted processing and energy levels. These all components are collaborated together to work in an ad-hoc network without the need of any infrastructure and central control point. The sensor node takes information (packets) from the moving vehicles (targets) and transfers it to the base station.

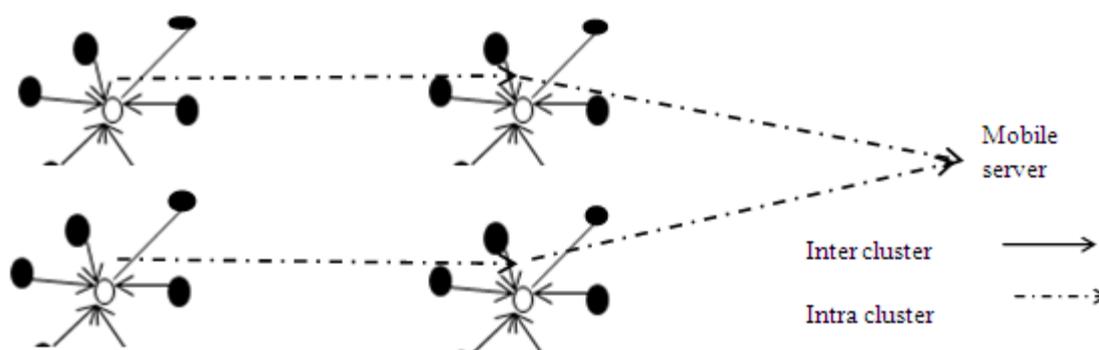


Figure 1. Flow of data in a clustered network

The sensor nodes in the ad-hoc network are energy constrained and can also do data aggregation in order to use energy efficiently [5]. The energy needed to send data is determined based on the distance between the nodes and the

amount of bits which are being transmitted. The energy needed for receiving also depends on the amount of bits being received [6]. The data aggregation is supported through clustering if efficient work organization in the network has to

be done. The nodes are partitioned into smaller groups called cluster, every cluster has its own coordinator which is known as cluster head. Considering the cluster head, numbers of member nodes are there in two-tier architecture. The flow of data is depicted in the figure 1 within the clustered network. It is being shown that the cluster heads are at above level in the hierarchy of two-tier while the other nodes are considered as the member nodes at the low level. The member nodes provides the data to the linked CH (cluster heads) [2]. The CH accumulates the data and transferred it to the central base by means of other CHs.

As the CHs forward the data over lengthy distances thus there is a huge energy loss. To solve this problem, network re-clustering is required in which the nodes which have abundant energy will serve as the cluster heads.

The concept of re-clustering resulted in the division of energy to all nodes. With the achievement of energy

efficiency, the clustering lessens the packet collision and channel contention for improved network with more loads [7]. The major objective of clustering is the improvement of network lifetime and is also considered as the main parameter for evaluating the network performance.

The normal clustering used in the data processing and wired networks cannot be used as the deployment of the network is dynamic and no nodes are aware about the other node location. WSN (Wireless sensor network) is entirely dynamic. The nodes in the network operate with battery power having limited energy. In this type of WSN network distributed clustering protocol is used and it should have low message overhead. The researchers mainly focus on the creating the centralized and distributed overhead to evaluate the connected dominating sets (collection of cluster heads in the network) [8].

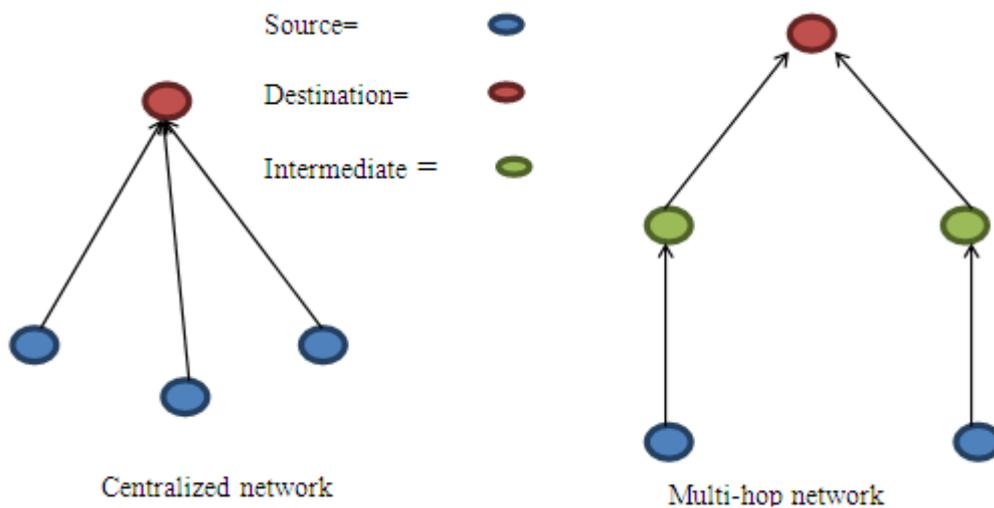


Figure 2. Centralized with multi-hop networks

Sometimes due to harsh environmental circumstances, an unexpected failure in the network occurs. To resolve this, periodic clustering is needed to heal the disconnected regions as the parameters (like remaining energy and node degree) used are dynamic. The sensor nodes in the network have transmitter and receiver which have some energy requirements which are described as follows:

$$E_{transmitting} = (E_{elec} + K) + (E_{amp} * K * d^2)$$

$$[1] E_{transmitting} = (E_{elec} + K) \quad [2]$$

In the above equation 1 and 2, there are some terms which are defined as follows:

E_{elec} = Energy being dissipated for running the transmitter

A. Protocol in wireless sensor network

In the wireless sensor network, the protocols are adapted to organize the network working and conditions. Based on protocol condition the whole working of the network is organized. Below section defines the routing protocols:

B. LEACH (Low energy Adaptive Clustering Hierarchy)

This protocol is utilized for data fusion in hierarchical routing. In this main task of communication, data aggregation and data fusion is with cluster head node. The

E_{amp} = Transmission amplifier energy dissipation

K = Length of the message (bits)

d = Distance between transmitter and the receiver

When there is direct transmission of data between sender and the receiver, so at this time energy required for transmitter amplifier circuit is evaluated by equation 1 [8]. But, in a multi-hop network energy needed for transmitting packets or information from source to terminal node in the multi hope network will be half to that of direct transmission which is described in the equation 3 [6, 8, 9].

$$E_{transmitting} = (E_{elec} + K) + (E_{amp} * K * (\frac{d}{2})^2) \quad [3]$$

non-cluster nodes send the data to their major head [9]. The clustering approach is adopted because many nodes send same data in the network due to which there is a lot of redundancy. Because of the clustering of the similar nodes in one CH, the data is composited and is transferred to head that processes and transferred the data to another node. This protocol lessens the communication energy being degenerated by CH and member to eight times.

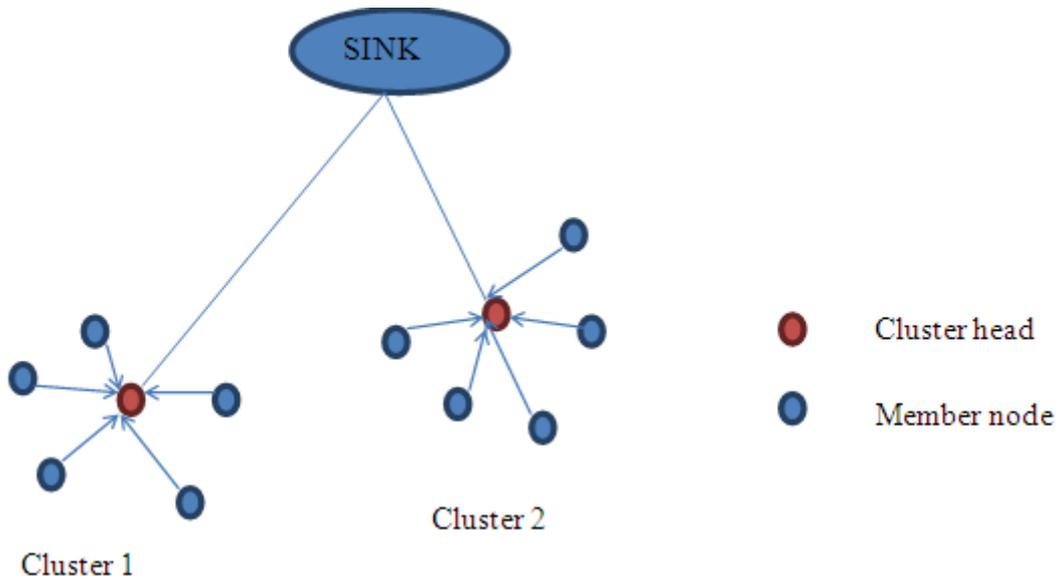


Figure 3. Leach (Low energy Adaptive Clustering Hierarchy) protocol

LEACH protocol has arbitrary rotation with enhanced energy CH position so that it surrounds between the sensors to evade the battery drainage of some sensor in the network.

By applying this process, the energy load linked with a cluster-head is consistently distributed among the nodes. As the cluster-head node has knowledge of all the cluster members, a TDMA schedule is created that tells the time at which every node needs to transmit the data. Furthermore, by

utilizing TDMA schedule for transmitting the data by circumventing the intra-cluster collisions [10].

The process of LEACH is separated into rounds. Each round starts with **set-up phase** in which cluster organization take place. After that, **steady-state phase occurs** where numerous frames of information are transmitted from the member nodes to the cluster-head and at last to the base station [11].

Table 1. Phases of LEACH

<i>Phases of LEACH</i>	<i>Description</i>
Set-up phase	Clusters are organized and cluster head is selected.
	Any random number is selected by the each node between 0 and 1 and comparison is done with the threshold computed by the given equation 3, if the number selected by node is less as compare to threshold, the nodes is chosen as the cluster head
	$T(n) = \frac{P}{1 - P * (r \bmod \frac{1}{P})} \text{ if } n \in G, 0 \quad [4]$ <p>In equation 4 the terms referred are described below: r= current round G= Set of those nodes which have not been cluster head in last $\frac{1}{P}$ rounds P= cluster head percentage</p> <p>In every round a message is forwarded by selected cluster head to the nodes to inform about their status. TDMA is generated and schedules are forwarded.</p>
Steady phase	Nodes transmit the data and the cluster head do the data aggregating, fusion and compressing process and in addition forward the data to the base station.

After the completion of one round, next round is started which selects all over again with new priorities. With the

advantages there are some limitations of LEACH protocol which are described in table 2:

Table 2. Limitation of Leach Protocol

<i>S.No</i>	<i>Limitations of LEACH</i>
1	As the energy consumption is the main problem in the network, LEACH does not take the residual energy of nodes for choosing the cluster heads.
2	When the node of low energy (who can be CH due to the network probabilistic nature) dies , whole cluster becomes dysfunctional.
3	Some CH' s are not distributed well in the network
4	LEACH is not appropriate for wireless sensors in large areas

C. HEED (Hybrid Energy Efficient Distributed Clustering)

HEED is considered as the effective clustering dependent technique in WSN for routing. It is energy efficient as well as distributed.

It takes two parameters in account which are as follows [12]:

- a) *Sensor residual energy* : Primary parameter
- b) *Intra communication (node degree and node proximity)*: Secondary parameter

There are some objectives which are focused to accomplish to make the network more reliable are discussed in table 2.

Table 3. Objectives of HEED

S.NO	Objectives of HEED
1	Extending network lifetime by allocating energy consumption
2	Dismissing the clustering process inside a constant number of iterations
3	Reducing control overhead
4	Creating cluster-heads which are well-distributed

There are three phases in the HEED through which the whole process of energy efficient clustering takes place. The table explains the phases with the description in table 4.

Table 4. Phases of HEED

S.NO	Phases of HEED	Description
1	Initialization phase	Sensors put their possibilities to turn into CHs.
2	Main processing phase	Sensors go through various steps to get chosen for the CHs
3	Finalization phase	Every sensor join least communication-cost Cluster head or proclaim itself as a Cluster head

The HEED clustering process is mainly for invoking every node for electing the cluster head or become a member. The dependability of the cluster head is to create inter-cluster co-ordination with intra-cluster communication.

1) PEGASIS

It is the improvement in the routing protocol of LEACH in wireless sensor network and stands for power efficient gathering in sensor information. Each sensor joins the least communication-cost CH or announces itself as a CH [13]. In PEGASIS, one node is considered as CH node that transfers the collective data to the base station round.

It is optimal chain-based protocol which is enhancement over LEACH protocol. In this, each node communicates by nearest neighbor and later it sends the data to the base station. It has better computational power than LEACH. The data is fused with the help of different sensor measurement to create a single packet. The main goal is to create a chain in the nodes which connect all the nearest nodes to each other so that the sending and receiving can be from the neighbor node. The data usually moved from one node towards another and ultimately, last node transfers it to the base station. There are different steps in the PEGASIS protocol which is described in table 4.

Table 5. Stages in PEGASIS protocol

Steps	Description
Chain construction	The chain is constructed from the farthest node to the base station to send and receive data through the nodes as data is transmitted to the nearest neighbour.
	This whole process is created by using the greedy approach.
Gathering data	Leader of every node is randomly selected. If number of nodes = N, I = round so $i \text{ mod } N$ node is chosen as the main node.
	With the termination of various nodes, the chain get reconstructed to ignore the dead node.

D. Performance Metrics of WSN

The wireless sensor systems are evaluated on the basis of various parameters. These parameters show the performance

and quality of system at different environmental conditions [14].

Table 6. Parameters description

Parameters	Description
Network lifetime	Each node in the wireless sensor network should be planned to manage the supply of energy to prolong network’s lifetime.
Coverage	The coverage of the network nodes is helpful when the nodes are dispersed all over the

	area to be monitored.
Scalability	No change in the performance of the network should occur whenever in future new nodes are added to network.
Response time	Response time must be fast for alarm oriented application in the WSN application like Fire Detection
Temporal accuracy	The co-relation of samples should be done on time and exact measurement should be send to user
Cost	For a prolonged network the sensor node should be accurately done and on accurate distance which should be measured initially.

2. OPTIMIZATION TECHNIQUES

These techniques are used for enhancing the energy efficiency of the network clusters, prolonging the network lifetime and resolve issues related to the data aggregation, clustering and node localization.

A. Genetic algorithm

GA enables development of the population using operators such as crossover, mutation, and selection. It also assists in generating energy effective clusters and later chooses their members [15]. The output of the GA identifies

the best cluster head for the network. By using the minimal distance technique, the base station gives member nodes to each of the cluster heads. The entire information is transmitted to the sensor node with the help of base station.

Nodes in the wireless network are defined by the bits of chromosome. The fitness of these chromosomes is defined by many parameters such as energy consumption and node density. The fitness parameter is created to lessen the energy consumption and prolong the network lifetime. Few fitness parameters are described below in table 7:

Table 7. Fitness Parameters

<i>Fitness parameter</i>	<i>Definition</i>
Direct distance to sink	It sum up all the distances from the sensor to the sink
	Distance is defined by: $D = \sum_{i=1}^m d_{is}$ d_{is} = distance from node (i) to sink node (s) For the huge network, the distance should be less otherwise node's energy will be wasted.
	In small network as the nodes are closely located, direct transfer is a good option.
Cluster distance	It is sum of distances between the nodes and CH in addition the distance from the cluster head to the sink. The cluster head which have k member nodes have the cluster distance (C) of : $C = \sum_{i=1}^k d_{ih} + d_{hs}$ d_{ih} = distance from nodes i to cluster head (h) d_{hs} = distance from the cluster head (h) to sink node (s)
	When the nodes are widely deployed in the huge network the cluster distance (C) is more.
	For minimum energy consumption, the value of C has to be less or not to huge.
Standard Deviation	For accurate spatial distribution of the node in the network, the variance in the cluster distance (C) should be small
	Variance is the strong point in the deployment of the nodes as in the uniform node deployment variance is the strong sign of right clusters but opposite when nodes are randomly deployed.
Transfer Energy (E)	Energy used to send an aggregated message from cluster to sink.
	A cluster which have (k) member nodes, the energy (E) is defined by the below formula $E = \sum_{j=1}^k E_{T_{jh}} + k \times E_R + E_{T_{hs}}$
Number of Transmissions (T)	For every transfer , base station assigns the transmission number

B. Ant bee colony optimization

The main aim of this algorithm in the wireless sensor networks is to prolong the network life time by maximizing transferred amount of data packets through clustering. The

cluster head formation is done by the ABC algorithm. In the [16], LEACH and the ABC algorithm works together to perform the data aggregation technique for cluster head.

C. Particle swarm optimization

This algorithm behaves like flock of birds. It contains a swarm of k candidates that discover an-dimensional hyperspace in hunt of global solution. Here n defines the amount of correct parameters which are to be determined. Every particle in hyperspace is evaluated through an objective function f (x1, x2, x3xn). The fitness of particle near to global solution is higher than particle which is far away. Many of the methods suffer from lack of convergence to final solution so at this point the particle swarm optimization technique is used for creating the quality

solution by utilizing minimum resources. It is an extremely accepted technique for resolving the issues of optimization in WSN because of its high QoS (Quality of Service), fast convergence with it simplicity [17]. Its main function is to resolve the issue of the wireless sensor network like optimal deployment, clustering, data aggregation and node localization. It also thrives to change the fitness function according to some circumstances. There are some advantages of the particle swarm optimization which makes it more efficient for large network which is described in table 7.

Table 8. Advantages of PSO

S.No	Advantages of the PSO
1	Can be easily implemented on hardware or software
2	Availability of different guidelines for selecting the parameters
3	As it can easily escape from the local optima, it results in high quality solutions.
4	Availability of alternatives for real, binary domains and integers.
5	Fast convergence

3. RELATED WORK

The comparative analyses of the previous clustering techniques are done to show the relative results of the

combination of different techniques with different wireless sensor networks.

Table 9. Comparison of existing approaches

Author	Algorithm used	Advantage	Result
Hoda Taheri [4]	Energy aware distributed dynamic clustering protocol was proposed	Remaining energy of nodes was used for selecting the next cluster head	Network life time was prolonged
		Fuzzy was implied to evaluate the fitness cost of node	Saved energy
Mehdi Tarhani [5]	Distributed algorithm named scalable energy efficient clustering hierarchy (SEECH	Chosen CHs and relays separately and based on nodes eligibilities due to more energy efficiency was achieved.	Better than LEACH and TCAC in terms of cluster head distribution
		Modified CHs energy burden process as it was distributed clearly.	Fine for huge scale networks
Ruonan Zhang [6]	Hybrid approach was proposed, known as Node Density based Clustering and Mobile Collection (NDCMC)	Combined hierarchical routing and Mobile element data gathering in WSNs.	Enhanced efficiency of intra-cluster routing with Mobile element data compilation. Suitable trade-off amid the network energy saving and data Collection latency.
		Nodes which were bounded by more installed nodes are more expected to be Cluster heads	
Dali Wei [7]	Distributed clustering algorithm, Energy-efficient Clustering (EC	Decided suitable cluster sizes depending on hop distance to data sink	Extended network lifetime
		Attained predictable equalization of the node	Achieved energy equalization more efficiently than two

		lifetime	clustering procedures, HEED and UCR.
		Reduced levels of energy consumption	
Jin-Shyan Lee [8]	hybrid hierarchical clustering approach (HHCA)	Extensional work on former two-layer based LEACH clustering approach. Grid heads were determined in centralized manner whereas cluster heads were found in distributed manner Number of nodes which connected with base station were reduced	Energy conservation was achieved.
Kun-chan Lan [9]	Compressibility-Based Clustering Algorithm (CBCA) for Hierarchical Compressive Data Gathering	Enabled less data transmission as compare to random Clustering method formerly used for HCDG	Achieved PRD (Percentage Root-mean squared Distortion) of less than 5%
Mihaela I. Chidean [10]	In-network processing methods and clustering algorithms were jointly used	Controlled number of transmissions with high data quality by usage of aggregation function and an energy efficient network partition. Increased energy efficiency, though no data quality was sacrificed	Energy efficiency was achieved Good data quality was achieved
Salim EL KHEDIRI [12]	Low Energy Adaptive Clustering Hierarchy (O-LEACH)	Minimized traffic in the network. Lessen energy consumption Accurate cluster is being selected on the basis of residual energy for the nodes	Achieved longer stability of static networks
Sadia Din [13]	hybrid algorithm	Blind broadcast messages were efficiently reduced and also decreased the signal overhead which was due to cluster formation. Efficiently minimized the direction-finding paths toward the base station	Less energy consumption Reduced packet loss Good cluster formation

4. EXISTING WORK

Depending on the different clustering algorithms and optimization techniques, different authors have proposed different results based on the parameters such as energy consumption, network lifetime, nodes distance and reduction in packet loss. The comparative analysis of network lifetime has been taken place. The description is given below:

When there are long transmission distances between the cluster head and the base station, the energy is consumed more. So in the [6], the comparison between the leach protocol and node density based clustering and mobile collection is done on basis of long network lifetime. The result shows that the 50% of the network lifetime is increased with the usage of NDCMC is depicted in table below:

Table 10. Comparison between the NDCMC and LEACH [6]

<i>Algorithms</i>	<i>Longest Network life time</i>
LEACH	7 *10 ²
NDCMC	2.2* 10 ⁸

5. CONCLUSION

Energy conservation is a significant issue in wireless sensor networks. To have the effective energy, variety of clustering algorithms have been presented. This paper presented different clustering approaches which makes the cluster formation and choosing of CH in a better manner. These clustering approaches are used in multi-hop scenarios in WSN networks. The extended o-leach protocol is considered as way better than the former leach protocol. In the studies, many hybrid approaches were created which reduced the packet loss and energy consumption. The comparison study of the existing approaches has been done which shows the hybrid approach with optimization algorithm is better than the sole algorithm.

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