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Clustering Methods for Cluster-based Routing Protocols in Wireless Sensor Networks: Comparative Study

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Abstract

Wireless Sensor Networks are used in large area of applications since they can be suitable for various environments. It can function independently in the condition of harsh or risk places where a human's apparition is impossible or very hard. Nevertheless, the sensor's life-time is only related to their batteries, which are impossible for replacing or recharging. So, the energy-efficient routing protocols are very necessary and considers vital task for sensors networks. Various approaches of clustering algorithms are used to optimize the energy of routing protocols. Also, the clustering approaches support the scalability of Wireless Sensor Networks. In this paper, numerous energy efficient routing algorithms for hierarchical routing protocol in Wireless Sensor Networks have been discussed based on the clustering approaches. These approaches of clustering algorithms whether Distributed, Centralized, or Hybrid are reviewed very well, since the most of clustering algorithms have been developed by many researches based on these approaches. Our objective is exploring the literature to present a brief discussion of these algorithms, as well as examine and compare some of distributed, centralized and hybrid clustering algorithm based on several attributes. This work aims to give a clear vision for the developers and researchers about cluster-based hierarchical routing protocols, and how can classified the clustering approaches according to literatures.

Keywords: Hierarchical routing protocols, Clustering algorithms, Distributed, Centralized and Hybrid.

INTRODUCTION

A network wireless sensor might have many sensor nodes. Each of these sensor nodes has a capability of sensing, computation, and communication along with limited energy source. The medium communication of the nodes is a wireless communication and it's self-organize when the ad hoc fashion is deployed in. Due to the limitation and non-rechargeable energy of resources for the sensor nodes, the energy efficiency is considered as very vital issue in designing protocol since it affects the networks of the sensor's life big times. Therefore, to increase the efficiency of energy and decreases the delay of transmission, a combination of nodes is required to form many small groups which is called clusters. The combination method of the sensors nodes is called clustering, and for the selected node in every cluster is named as cluster head. The Cluster Head (CH) is gathering and fusing the sensed data from the others sensor nodes in the cluster and transmitting it to the base station (BS). A cluster head is considered as the node that has more capability and higher energy compared to others sensor nodes. In addition, the cluster head is reducing the consumption of energy and providing the scalability for large node counts.

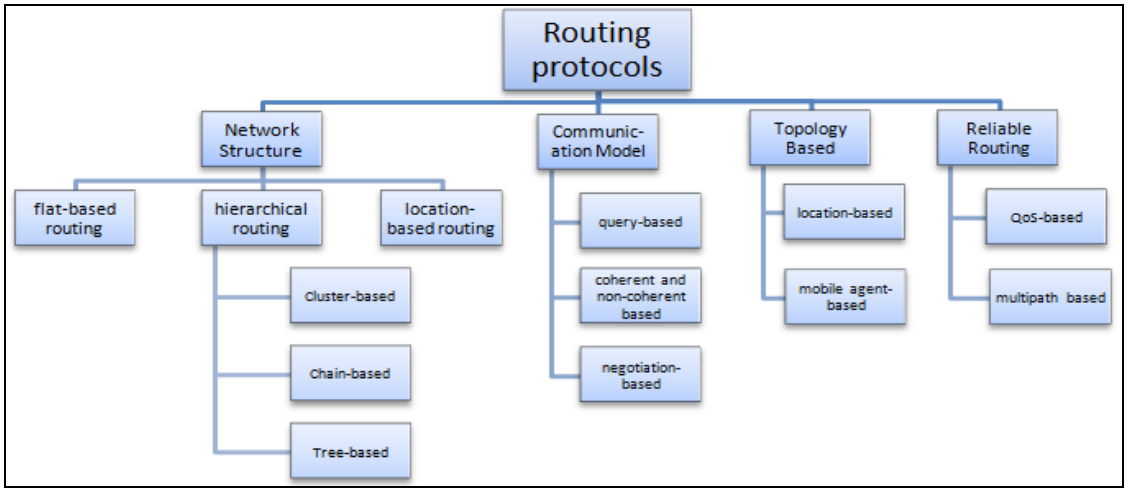

Figure 1: Classification of routing protocols in WSNs.

Thus, it is very necessary to consider the selection of the cluster head during the design of the clustering protocols. The features of the cluster head in the clustering protocols are:

- Cluster head with greater remaining energy or residual energy [1],
- Periodically, rotating the cluster head for balancing the consumed energy of the network [2].
- Introducing the optimization of the management strategies to the cluster head for enhancing the operation of the network and prolong network life by saving energy for the individual sensors [3].

In this paper we discuss the clustering methods in cluster base hierarchical routing protocols. It can be classified into three categories which are: distributed clustering, centralized clustering and hybrid clustering. The cluster head in the first category is not dynamically moving whereby, the location of the cluster head is changing from node to node depends on some parameters. On the other hand, the cluster head is selected by base station in the centralized clustering method based on several parameters, while remaining nodes are still the Member Nodes (MN). Furthermore, the hybrid clustering is considered as the one which formed to choose the features of both; distributions and centralization clustering methods. Whereby, we try to examine some of clustering algorithms under these methods according some features of cluster formulation (clustering) to give clear perception for algorithm properties.

The rest of this paper will be: Section 2 discusses Network Structure Routing protocols for WSNs. The clustering and its objective in Hierarchical Routing protocol will discuss in Section 3. In Section 4 the Clustering Parameters are explained. Clustering Methods with comparison several algorithms will illustrates in Section 5. The conclusion and future work in Section 6.

NETWORK STRUCTURE ROUTING PROTOCOLS

The network's lifetime extension and the consumed energy are the most vital features for routing protocol for WSNs. There are many routing protocols for WSNs has been proposed during the recent years. Figure 1 the Classification of routing protocols in WSNs [4].

The figure 1 demonstrates the classification of the routing protocols in WSNs. It can clearly be seen that the routing protocol is divided into four main schemes structures which are: network structure, Communication model, Topology Based and Reliable Routing. The structure of network category can be divided into three parts which are location based, flat and hierarchical. While the routing protocols belongs to the communication model which can be divided to Negotiation-based, Query based and non-coherent and coherent based. On the other hand, the routing protocols belongs to the Reliable Routing can be divided into Multipath based and QoS-based. While the routing protocol which is belong to the Topology based is divided into Mobile Agent-based and Location-based [4].

Generally, the routing protocols according to the network structure category can be categorized into three topologies (flat-based routing, hierarchal routing, and location-based routing), as mention above. In flat-based routing protocols, typically, all the nodes can be assigned to their function or roles equally, since this topology is effective in the networks of the small-scale. Whereby, in the hierarchical routing topology that will be our attention in this paper because it is considered as an efficient method to reduce the consumption of energy within a cluster and successful for solving battery issues. Where, the nodes will play various task or roles in the hierarchical network, such as the cluster head in one or more than that in every cluster which will process the data and then transmit the massage between cluster heads and with the base stations. The remaining nodes is called ordinary node or

known as the member nodes which perform the sensing and transmit the data to the cluster head. Figure 2 illustrates the hierarchical protocols. Furthermore in location-based routing protocols, the positions of the sensors nodes will be exploited to route data using the real-time applications in the network. Considering the routing protocol as adaptive, if the certain parameters of the system is controlled to adapt the conditions of the current network with the levels of the available energy [5].

HIERARCHICAL ROUTING IN WIRELESS SENSOR NETWORK

The Hierarchical routing is considered as an efficient method to reduce the consumption of energy within a cluster. Not only that but also performing aggregation of the data and fusion for reducing the messages' numbers that is transmitted to the base stations or sink. Routing protocol in the Hierarchical architecture is also introducing a hierarchy into the network by grouping the nodes of the network into small groups named as clusters.

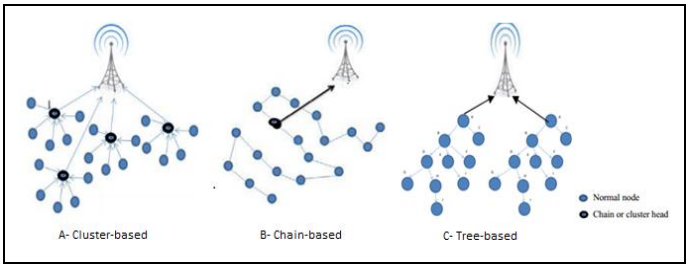

Figure 2: Categorization of Hierarchical routing protocols

This architecture classified for three categories according to the structure of cluster as [6]. Figure 2 illustrates differentials among the hierarchical routing protocols categories, and the categories are:

- Cluster-based; where selecting one or two nodes to be considered as cluster head and other nodes will be connected to the closest cluster head as MNs.
- Chain-based; where arranging the nodes in a chain-like topology and only one of nodes works as cluster head in order to transmit to the base stations.
- Tree-based protocols; where sending all the sensing data from the sensor node to its parent.

CLUSTERING IN WSN

A clustering is considered as the process of sensor node division into small groups based on the attribution and some parameters while the clustering loose definition can be known as the process of the organized objects into some groups whose members are similar in the same way [7]. The cluster head has more responsibilities compared to the cluster members since it is selected for each cluster. Sensor network clustering and election of the cluster heads; whether it is distributed, hybrid, or centralized, can be independent of algorithm clustering. Each sensor node is broadcasting its distance from BS and the level of energy to its one hop neighbours in the distributed method, in sometime there are several parameters that nodes have to share it with neighbours in addition to energy and distance. Node that have the most energy level or higher priority will be elected to be a cluster head. While, in the centralized method, all the nodes will have to transmit their residual energy and location to the BS, also sometime there are several parameters in addition to residual energy and location that node should transmit to BS, and the BS will form some new clusters along with the cluster head and then broadcast it towards the nodes [8][8]. On the other hand, the one that formed to choose features of both distributed and centralized clustering is known as the hybrid clustering mechanism [9].

Objectives of Clustering and its Importance

To achieve efficiency of energy and scalability in WSNs applications, the node clustering methods have been used because of the constraints of the inherent resource in energy consumption and communication. Clustering is providing a scalable and efficient structure of network for sensor nodes collaborations by gathering and grouping the nodes into a hierarchy. High contribution of hierarchical clustering in WSNs to overall scalability of the system, life time and efficient energy. It is an efficient and appropriate way to lower the consumption of energy through a cluster, for performing aggregation of the data and fusion and decreasing and reducing the number of the messages that is transmitted towards the base-station [4]. Figure 3 shown the different between the clustering approach and non-clustering approach. Such structures of hierarchical are built by different clustering techniques at various network layers for example the Network layer and the Data Link Layer. Clustering has many features in improving the wireless sensor network performance. Wherever, it keeps the traffic load of the network and therefore reducing the dissipated energy of transmission in long-distance and the amount of the routing information which is stored at the node of each sensor [10].

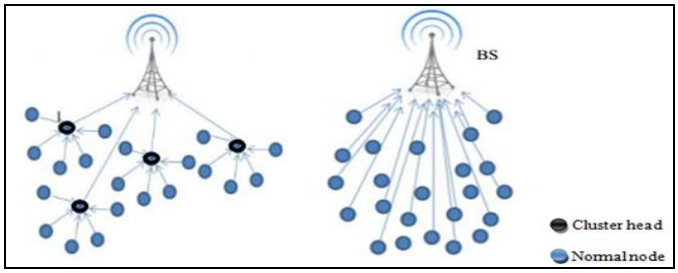

Figure 3: Clustering and Non-clustering.

Employing cluster heads in clustering which can further conserve energy in order to perform the aggregation of the local data and scheduling activity along with the local members. Thus, the members of inactive can be in a sleeping mode or operate in low power. In additions, reducing the topology cost of the maintenance is an advantage of clustering as a reaction to dynamic changes of topology. A structure collaboration is needed to be adaptable and configurable to the dynamic phenomenon in order to be responsive to the changes of dynamic phenomenon. With the network cluster, the reconfiguration of topology is performed on the cluster head level only and does not affect the local cluster nodes. Therefore, the adaptation of the dynamic topology overhead can be significantly minimized [4]. Approaches of clustering have been magnificently used for saving energy and times. These optimizations principally reflect the clustering algorithm usage for resources allocation and task. Necessary resources and tasks can be distributed in this network in optimized way since the clustering helps for organizing large-scale and the unstructured networks of the ad hoc in well-defined groups along with the requirements of specific applications. Considering the clustering as the most important and vital unsupervised learning of the problem thus, it deals with finding a structure in unlabelled data collection as each other problem of this kind.

CLUSTERING ATTRIBUTES

The impact of designing efficient routing algorithms can be influenced by the WSNs which have various attributes. These attributes are used in order to compare the differences of algorithms and protocols. There are several attributes for clustering, such as [11]:

The Selection of the Cluster Head

The cluster head selection is considered as the first step in cluster based protocols. It is also considered as the local coordinator which is the cluster handles various tasks of coordination in the work between node members, information collection within the cluster, fusion of the data processing and aggregation of transmitted data towards the global sink. The selections of cluster head are also depending on parameters variation. Furthermore, the nodes division into clusters is also dependent on the location and the cluster heads number. For this reason, the cluster head selection plays as important role in the procedures of the subsequent for the clustering algorithm to enhance the performance, save lifetime, and high energy efficiency of the network.

Equal clustering based algorithms

In large scale WSN energy efficiency and prolonging network life time were main issues. Clustering of network made data aggregation and communication between node and BS more efficient, thus saving node energy and prolonging network lifetime. In this section we discuss some equal clustering distributed algorithms [8].The cluster heads closer to the BS are exposed to heavy network traffic since they are massively engaged in forwarding the data from the nodes which are far from the BS. This leads to hot-spot issues. One popular solution to this hot-spot problem is to form unequal clusters in WSN which makes the clusters near to the BS smaller in their size to the clusters far from the BS [12].

Homogeneous or Heterogeneous Sensors

In this case, the WSNs can be classified as either a network of heterogeneous or homogeneous. Where the networks of Homogeneous are those with sensors which have similar abilities of processing and communications. On the other hands, in the networks of Heterogeneous, the node which is having more energy than other nodes is selected as cluster head. There is a variation in the communication, processing, or the capabilities of battery in the sensor nodes. Particularly, there is a variation on their hardware design [13]. Furthermore, the cluster head is selected form the available nodes only in case of network sensor homogenous. Those cluster heads are relieved from the activities of other sensor such as environment monitoring in order to conserve the energy for aggregation of data and communication with the base station.

Single or Multi-hop Networks

The WSNs is classified into either single hop or multi hop network which is dependent on hops number from sensors to the sink. The sensors are directly delivered their sensed data to the sink in case of single-hop networks. However, in case of the network of multi-hops, the sensors are transmitted their sensed data to the sink by using intermediate nodes [14]. Figure 4 shows an example of networks of the single and multi-hop. It observably can be seen from this figure, some of the nodes operates as the main direction for other nodes in the network of multi-hops. Therefore, their energy may be drained quicker compared to others.

Location-aware or Location-unaware Sensors

The Sensor nodes can be classified as location-aware or unaware. The location-aware nodes can know their network position by using GPS capable antenna equipment while the location-unaware sensor does not know their position in the network.

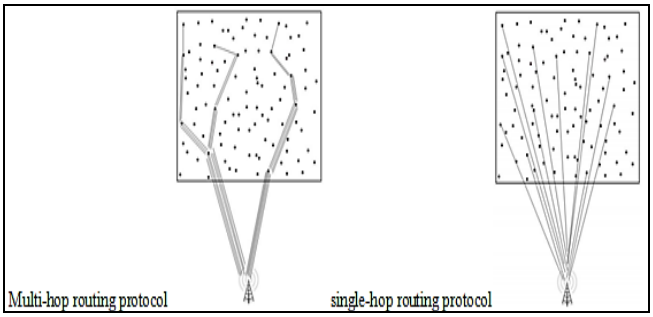

Figure 4: Single and Multi-hop routing protocol.

The used technique for location-aware sensors is the centralized algorithms techniques since they are based on sensors positions. Whereas, the used technique for the location-unaware sensors is the distributed algorithms techniques [15].

CLUSTERING METHODS FOR CLUSTER-BASED ROUTING PROTOCOLS

In this section we discussed the clustering methods in cluster-based routing protocol. Clustering algorithms surveyed here are divided on the basis of clusters methodology such as distributed, centralized and hybrid clustering, as indicated in Figure 5. These are several clustering algorithms developed under cluster-based routing protocols, so we examine a number of them according to various attributes or parameters.

Distributed Clustering Algorithm

The distributed clustering algorithms is known as the algorithms in which cluster head keeps on moving from one node to another. In this section, some distributed clustering algorithms are introduced based on their cluster size. The distributed technique of the clustering algorithms will be used and applied for location-unaware of the sensors. Which means that these sensors do not aware of their network positions and all of their decisions of the routing must be made which is dependent on their internal information. There are a number of familiar routing algorithms distributions for WSNs are as indicated below.

Low Energy Adaptive Clustering Hierarchy (LEACH)

LEACH is considered as one of the most popular WSNs algorithms clustering [2]. LEACH is well-known algorithm not due to its efficiency and clarity only, but also the introduction that it provided of the cluster heads rotation theory. The rotation of cluster heads addresses the load balancing need for the sensors' networks. The lifetime in the algorithm of the LEACH is classified into a variety of rounds. Each one of these rounds is containing a set-up and stable phase. The cluster is shaped, and the CH is elected in the set-up phase, while in stable phases, sensors sensed the events and sent to them to sink through CHs. The process of the election in CH is performed in an ad-hoc method, using numbers randomly that generated in each sensor. In LEACH, all CHs advertise their roles to the other sensors at the same time by using the strength of the received signal the other sensors join the nearest cluster heads. In the LEACH algorithm, the collected data aggregated by the CHs in order to reduce the transmitting data amount and the consequent cost of energy. The primary disadvantages in the algorithm of LEACH is that the random cluster heads election in the network might not lead to orderly distribution of them over the network and the algorithm might not be helpful from the technique efficiently of clustering.

Unequal Clustering Scheme based LEACH (U-LEACH)

An improved model proposed by the authors for LEACH, which added extra different set-up stages. In the selection of CH stage, the round robin is used and "HELLO" message is sent to provide a competition distance from base station for the selection of CH [16]. Each node uses a distance matrix to decrease consumption of the energy and get details about neighbour nodes and ratio of energy for the current to main energy and distance competition where it is used for the structure of network generation with unequal clusters. In order to interact with BS single hop communication techniques was used. BS creates matrix for the distance and the residual energy, and then transmit it to all the network sensor nodes. CH is defined by the generation of the random numbers, $a \in (1,0)$ by the nodes and by the comparison with the T(i) threshold value, the judgments of becoming a CH are made.

Hybrid Energy-Efficient Distributed (HEED)

In [13] another clustering algorithm is well-known as HEED which offers distribution uniform of Cluster Heads over the network. The HEED is considered as the residual energy of sensors and their cost of communication in order to shape the clusters. Two sensors in HEED are considered as neighbouring sensors if they are in the power range of each other. So, the two neighbour sensors will not be elected as cluster head coincidently. Like LEACH in HEED, CHs form a protocol of a single-hop which is routing from cluster heads in the sink. When it compared with LEACH, HEED provides a significant outperformance in terms of efficiency of the energy.

Energy-Driven Unequal Clustering (EDUC)

EDUC proposed in [17] for heterogeneous WSN. To achieve the energy balance depletion in many different clusters EDUC

is using energy driven adaptive CH rotation technique. Waiting time of all the nodes is calculated during the stage of CH competition based on the residual energy, which we can calculate by using the below equation:

$$WT = (1-(Eri/ Emax)) *V1*T1$$

Where WT is the waiting time and E_{ri} is the node residual energy, and E_{maxis} the max network residual energy.

Energy Efficient Unequal Clustering (EEUC)

During the transmission of the data between the nodes to the BS the nearest CHs to the base station which are suffered along with the large traffic of the relay because of more uses of energy which make these nodes die early, To address the hot spot problem Liet et al.[18], proposed an Unequal Clustering (EEUC) technique for periodical gathering of data. As cluster heads that locate a close to the base-station act as cluster heads routers a bit away from the base-stations during the information delivery to BS, the cluster which is closer from the BS is smaller than the far cluster from BS.

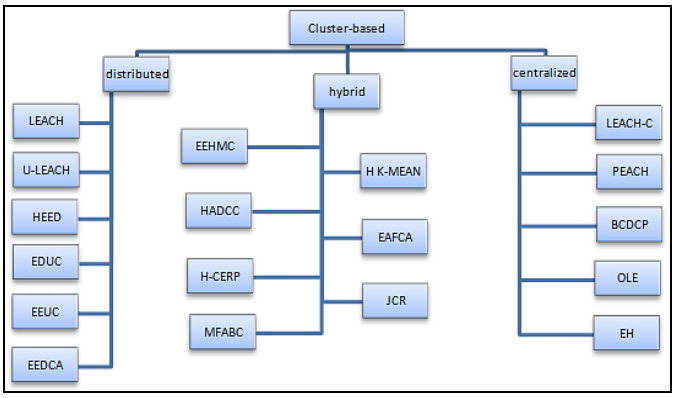

Figure 5: Clustering methods in cluster-based routing protocol

Energy Efficient and Density Control Clustering Algorithm(EEDCA)

Authors in [19] developed an algorithm called Energy Efficient and Density Control clustering. Where seek to select the finest nodes in the network to be cluster heads. Next step, it groups the network into clusters. On this approach, the elect of the cluster head depends on residual energy, distance and density. Each node examines its residual energy according to other nodes located on its range. The simulation result of EEDCA algorithm show that, its increase the lifetime of the wireless sensor network, and network more efficiently.

Centralized Clustering Algorithms

For the sensors location-aware Centralized clustering algorithms can be used. These sensors are designed to aware of the routing decisions and network position are made in a central location like the sink. A variety of WSNs which known as algorithms of the centralized routing are as follows:

Low Energy Adaptive Clustering Hierarchy- Centralized (LEACH-C)

LEACH-C is a centralized LEACH version. It was firstly proposed by [20]. The idea of LEACH-C algorithm is that all sensors know their network positions and also the number and CHs position are chosen in optimum manner. In the result, compared with LEACH 40% out performances are showed up by LEACH-C using energy efficiency metric

Power Efficient and Adaptive Clustering Hierarchy (PEACH)

In PEACH algorithm[21], each one of the sensor is obtaining the destination and source of the packets by hearing the sensors of its neighbouring. Based on these information's that heard, the clusters can be shaped by this algorithm without the clustering number overheads like joining, synchronising, and advertising. In a comparison with the existing clustering techniques PEACH improved the consumption of the energy and decreases the costs of the message communication and network lifetime.

Base Station Controlled Dynamic Clustering Protocol (BCDCP)

In [22], the authors propose the centralized algorithm clustering BCDCP for WSNs. By using clustering of multi-level, each cluster head serves an almost same sensors' numbers. In the proposed BCDCP, sensed data is sent by the CM to its CH and a CH to CH multi-hop routing conducted by sending the packet to higher levels of CH, which is randomly selected. Finally, the sink can communicate with only one cluster head directly. In terms of extending the network's lifetime and energy efficiency, the experiments have demonstrated BCDCP out- performs PEGASIS, LEACH, and LEACH-C.

Optimized Lifetime Enhancement (OLE)

Enhancement of optimized lifetime is another algorithm that is forming a series of sensors in the sink. Every one of those nodes transmits a sensed event to the closest neighbour that is located within the chain. This algorithm [23] used a certain swarm of the optimization heuristic rather than the PEGASIS of the greedy algorithms. EOL algorithm allowing the directed

communications between the nodes and the sink with different time period based on energy residual. In the sink EOL is executed and distribute the results into the networks before the starting of the second phase which is the stable phase is starting. Nevertheless, in the deficiency event of the frequent communication with certain sink, the execution of the EOL is done within an individual cluster using the local leaders and for the optimised chain to be shaped the local information is transmitted to the sink. Compared with PEGASIS the experiments result, this EOL prolonged the network lifetime.

Clustering algorithms using Energy-Harvesting sensors (EH):

Several of efficient clustering algorithms were presented in [24], for the WAN lifetime maximization, i.e., the time till a particular nodes proportion end. Specifically, a proposed EH algorithm, for reducing the lifetime of the single network, follows by extensions for handling the multiple networks. Then the researcher studied the joining prolonging network lifetime problem by introducing energy harvesting (EH) node. To maximize the network lifetime, an algorithm is proposed where the EH node works as dedicating node relay for the cluster head (CH). An extensive simulation results and theoretical analysis showed that their EH algorithms is achieving a perfect or almost perfect and efficiently solutions and hence it helps to provide a useful benchmarking for various distributed and centralized clustering scheme.

HYBRID CLUSTERING ALGORITHMS

Lately lots of interest is shown by the researchers in developing algorithms for clustering using the techniques of Hybrid Clustering i.e. combining the features of different algorithm in one. In the coming section we present some of the recently proposed hybrid clustering techniques for WSN.

Energy Efficient Hybrid Multi hop Clustering (EEHMC)

EEHMC has proposed to prolong life of the network by using a hybrid communication of multi hop between BS and CH. In the proposed scheme cluster head decisions arrangement are executed centralized at the base station and formation of the cluster, selection of relay node and decisions of the data transmission are collected by sensors (distributed). For the CH to be selected, base stations use the rest of the nodes energy, neighbour's number in range of transmitters and separation distance between the CHs as decision parameters. In [25] Algorithm presented the election of CH, the distribution and multi-hop the transmission scenario. Compare to LEACH-C , a EEHMC increased lifetime of the network up to 27.63%.

Hybrid Clustering Algorithm for Optimal Clusters (H k-mean)

In [12] the authors proposed a new hybrid of self-decisive based on technique of Hierarchical Agglomerative clustering and the algorithm of the k-means proposed by Kanungo. Their proposed solution used a new algorithm that combines the k-mean and the algorithm of hierarchical. Two closest clusters were grouped in the hierarchical approach recursively until the arrival of single cluster. A specific number of disjoint presented by K- Mean clustering and non-hierarchical clusters. The configuration of the Cluster along with the cluster centroid is gained and node is selected which is nearest to centroid as CH. The hybrid technique then obtains an optimal number cluster.

Hybrid Advanced Distributed and Centralized Clustering (HADCC)

In [26] the author proposed algorithm that base station can be positioned at centre of the algorithm and network is working in two levels. Network cluster formation is completed in the1stand in 2ndlevel the selection of distributed cluster heads is performed. For the selection of CH parameters used are node positioning and the energy of residual. The cluster head can be selected if the suitability of each of the nodes m is expressed as:

$$Suitability = \frac{Er}{ECR * Dbs}$$

Where: ECR stand for energy consumptions ratio, and Er stand for energy residual.

A flexibility is added by HADCC in cluster formation.

A Cognitive Multi-hop Clustering Approach for Wireless Sensor Networks (EAFCA)

In this article [27], the author proposed a new IDS technique using hybrid anomaly detection, by using a data mining algorithm, the algorithm used is K-means clustering. For detection the intrusion, the K-means algorithm of the clustering builds the patterns of intrusions automatically over trained data. Matching the activities of the network against these patterns of detection the intrusions are detected. The author evaluated the approach over a wireless sensor network dataset that was created by OpNet modeller, that contained various attributes, such as traffic received traffic sent an end to end delay, the aim of the presented EAFCA is to provide a competent election process of the CH concerning all the important advantages that assisted along with a simple relay model inter-cluster. From the result that was taken from HNA and FND strategies proved that the sensor network longevity and hence certified the load throughout distribution the network functioning.

Hbrid clustering energy aware routing protocol H-CERP

The energy efficiency scheme for the Industrial heterogeneous wireless sensor network Applications energy aware routing protocol (H-CERP) has been proposed to form the efficiency of the clusters with lesser head count of the cluster than the optimal estimations and using the communication of multi-hop with gateways nodes for communication along with the base station [28]. This modern technique gives the systems more advantages that the coverage of the sensors and network lifetime are much necessary at no additional costs. Promised results showed in the term of the consumption of energy when deploying H-CERP in environmental design, lifetime of the nodes and residual energy as compared with the other generic techniques such as PEGASIS, LEACH and other current approaches. This proposed algorithm is working in rounds. Each one of the rounds performing these steps: Occasionally the base stations start a newly round by increasing the round number. From the conventional LEACH protocol ,the optimal cluster and CH count are estimated. For the network lifetime improvement, the H-CERP maintains the CH count and cluster count lower than the optimized values. Once a cluster head is formed, a node gateway is selected that lies nearest to it. Make the Clusters by the allocation of the head of the cluster to each network node on the basis on the lowest distance from the nodes to cluster heads. Sensor nodes are waking up, sensing data, and forwarding sensed data to respective cluster heads.

Joint Clustering and Routing (JCR)

Authors present a detailed with analysis on the relative of clustering to routing, and then they map a Joint Clustering and Routing (JCR) protocol to reliable and efficient data collection for big- size of wireless sensor network. JCR take on the back-off timer and gradient ratio for routing to generate joint and efficient inter-cluster topology, with the drawbacks for maximum transmission distance. The relation-ship of clustering with routing in JCR is exploited in numerical and theoretical analyses. The results illustrate that the multi-hop routing in JCR may act unbalanced in the selection of CH. in that case, the key solution for that, should optimize the lifetime of network via considering the gradient of one-hop neighbour nodes in the setting for back-off timer. Simulation results and theoretical analysis found that, the efficiency and connectivity of the network topology generated by JCR [29].

Multi objective Fractional Artificial Bee Colony (MFABC)

In this algorithm [30], authors provide an energy efficient clustering method, based on artificial bee colony algorithm and factional calculus. MFABC seek to maximize the network energy and life time of nodes by hybrid optimally selecting cluster head. This algorithm developed to control the convergence rate of Artificial Bee Colony with the lately designed fitness function which considered three objectives like, energy consumption, distance travelled and delays to minimize the overall objective. The performance for cluster head selection of MFABC is compared with three protocols; LEACH, PSO and ABC-based routing according to energy and life time. The simulation results shown that, FABC is maximizes the energy and life time of nodes as compared with existing protocols.

The table below 1 illustrates the comparison of clustering algorithms based on several attributes that used in clustering. Consequently, these clustering algorithms that examined above are assorted in the table as six algorithms are based on distributed methods, five algorithms for centralized method, and the rest of seven algorithms for hybrid method. Therefore, the table is including the result of each algorithm according to the benchmark provided in the literature. Furthermore, most of the algorithms that examined in the table have random node deployment except the HEED [13]algorithm is uniform nodes deployment. Additionally, other attributes are utilized to examine these algorithms as shown in the table below:

Table 1: Comparative study for several clustering algorithms

Clustering algorithm	*Clusters size*	*Advantage*	*benchmarks*	*Clustering type*	*CH parameter selection*	*Connectivity*	*position of nodes*	*Nodes capability*	*Nodes deployment*
LEACH [2]	Equal size	distribute energy dissipation between sensors and doubling the lifetime	Not mention	Distributed	Initial value of energy for sensors	Single hop	Location-unaware	Homogenous	Random
ULEACH [16]	Unequal size	Better energy balance and prolong network lifetime	LEACH	Distributed	Energy ratio with competition distance	Single hop	Location-unaware	Homogenous	Random
HEED [13]	Equal size	effective in prolonging the network lifetime and supporting scalable data aggregation	Generalized LEACH (gen-LEACH)	Distributed	Residual energy	Single-hop, Multi hop	Location-unaware	Heterogeneous	Uniform
EDUC [17]	Unequal size	balances the energy consumption well	LEACH, and HEED	Distributed	Distance, energy and delay.	Single hop	Location-unaware	Heterogeneous	Random

		among the cluster heads and prolongs the network lifetime.							
EEUC [18]	Unequal size	balances the energy consumption and improvement on the network lifetime	LEACH and HEED	Distributed	Remaining energy and average degree	Multi hop	Location-unaware	Heterogeneous	Random
EEDCA [19]	equal	Improves lifetime and efficiency	MOFCA, LEACH, CHEF and EEUC	Distributed	Residual energy , density and distance	Multi hop	Location-unaware	Homogenous	Random
C-LEACH [20]	Unequal size	improve system lifetime	general-purpose multi-hop approaches	Centralized	Location and energy level	Multi hop	Location-aware	Homogenous	Random
PEACH [21]	Unequal	minimizes energy consumption of each node and extends the network lifetime	LEACH , PEGASIS, HEED and EEUC	Centralized	Location and residual energy	Multi hop	Location-aware/ unaware	Homogenous	Random
BCDCP [22]	Unequal size	reduces overall energy consumption and improves network lifetime	LEACH AND LEACH-C	Centralized	Sufficient energy and location	Multi hop	Location-aware	Homogenous	Random
OLE [23]	Unequal size	Improves the performance	PECASIS	Centralized	Location and residual energy	Multi hop	Location-aware	Homogenous	Random
EH [24]	Unequal size	maximizing the network lifetime	Not mention	Centralized	Location and residual energy	Multi hop	Location-aware	Homogenous	Random
EEHMC [25]	Unequal size	prolong the network lifetime up to 27.63%, and performs 2 times better than LEACH-C for first node die.	LEACH-C	Hybrid	Residual energy, no. of neighbours and distance to BS	Multi hop	Location-aware	Homogenous	Random
Hk-mean [12]	Unequal size	prolongs the network lifetime	existing clustering algorithms	Hybrid	Weighted residual energy	Multi hop	Location-unaware	Heterogeneous	Random
HADCC [26]	Unequal size	prolongs the network lifetime	existing clustering algorithms (both homogeneous and heterogeneous)	Hybrid	Residual energy and distance to BS	Single-hop	Location-aware	Heterogeneous	Random
EAFCA [27]	Unequal size	Improves the lifetime in term first node dies and half of the nodes alive	popular clustering algorithms	Hybrid	Residual energy, mean distance(intra-communication) and 2-hop coverage of the competing nodes	Multi hop	Location-aware	Homogenous	Random
H-CERP [28]	Unequal size	Reduces the energy consumption, and improve residual energy and life time	LEACH and PEGASI-S	Hybrid	Minimum distance between nodes	Multi hop	Location-unaware	Homogenous	Random
JCR [29]	Unequal size	Increases the connectivity and efficiency of the network topology	Not mention	Hybrid	Residual energy and no. of neighbour.	Multi hop	Location-unaware	Homogenous	Random
MFABC [30]	Unequal size	maximizes the energy as well as life time of nodes	LEACH, PSO and ABC-based	Hybrid	Energy consumption, distance travelled and delays.	Multi hop	Location-aware	Homogenous	Random

CONCLUSION AND FUTURE WORK

In this paper the classification of routing protocol has been presented. Then we study the hierarchical routing protocol and what its categories. Subsequently, we display the clustering methods with clustering attributes. Whereby, many researchers developed different clustering algorithms based on clustering methods (distributed, centralized and hybrid) to obtain the optimal clusters and seek to prolonging network life by minimize the consumption energy. The attempt to examine and compare for different routing algorithms based on clustering methods, has been made. The comparison of clustering algorithms in cluster-based routing protocols has been compared based on some attributes like cluster head selection, clusters size, clustering type, connectivity, position of nodes, nodes capability and nodes deployment.

From the comparison table we can see that, most of centralized algorithms depend on location and energy for select the CHs in network, because of the BS need to know the position of each node before the selection, along with that, almost nodes in centralized method is homogenous.

On other hand, the distributed algorithms are depending in foremost on the energy and the distance from BS, in addition to others parameters to select the cluster head. In the hybrid method, most algorithms used the centralized method in first stage to assign the cluster head then after cluster formulation, used the distributed method to rotate the CH between the nodes in side cluster, with some of complexity in CH selection parameters.

The issues which coverage in future are: study the cluster head selection parameters and what the effectiveness of it's on the selection process, comparison research about the position of BS with compare between position of BS in the center of sensing area and outside sensing area, survey on the data aggregation mechanisms.

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