Qualitative Analysis of Intra-Class and Inter-Class Clustering Routing and Clusterization in Wireless Sensor Network

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Qualitative Analysis of Intra-Class and Inter-Class Clustering Routing and Clusterization in Wireless Sensor Network

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Abstract: A wireless sensor network is a group of large number of nodes which are randomly deployed in a specific area. This deployment of nodes is in form of number of clusters. The main purpose of these nodes is to sense the surrounding condition like temperature, humidity etc. and send it to the central processing unit through the intermediate nodes following some routing protocol. The main concern here is the energy consumption by these nodes during the data communication as these nodes are equipped with non-rechargeable batteries. Currently much of the research is going on to design such routing protocol which can make the network energy efficient or to increase the lifetime of network. This paper provides a comparative review of clusterization and routing algorithms provided in the different literatures for wireless sensor network. Comparison was carried out on the basis of node density, types of nodes connectivity, network coverage area and cluster head selection probability.

Keywords: Clustering; Inter-class communication; Overhead, Routing; Throughput.

1. Introduction

A wireless sensor network consists of many numbers of nodes, which comprises battery, processor, memory and radio devices as shown in Figure 1[1)]. Wireless sensor network (WSN) are mostly utilized at large scale[2)]. In recent technology, less power consuming WSNs are designing. There are many challenges while designing wireless sensor networks. The energy constraint is big issue in many applications. Battery life decides the life of sensing node. Thus, mostly researchers are pointing on power saving in hardware designing, protocol, architecture, and routing instructions perspective in WSNs[3)]. A huge count of sensing points (thousands or more than thousands) are deployed in environmental monitoring as one application.

According to the Precautionary Principle (PP) there are many tradeoffs in lots of ways to save environments using sensor network[4)].The huge data is present at the sensing points in environmental monitoring due to complex, serious and fast increasing pollution[5)].

Distance may be varying among them. To reduce the frequent failure of sensing nodes which are inaccessible and unattended, maintenance topology is challenging. On the basis of deployment of sensing nodes, many sets of instructional routing or topologies are being proposed annually[6)].Next generation advance cooling strategy can also save some power at hardware end of sensing point[7)]. Clustering is the first basic step in network topological working model. According to Ali Shokouhi Rostami et al. [1)], number of groups of same members can be formed automatically with selected samples. Clustering is also considered as unsupervised learning. All sensing nodes are of same type within a cluster and may or may not different than other cluster. Similarity can be considered in different manners like, similarity in sensing, distance from base station, distance from other clusters, distance among sensing points and density of sensing points etc. If we consider distance manner then clustering can be known as distance-based clustering. The target is to select same number of sensing nodes of clustering method [1)]. There is no fixed parameter for selection of best clustering. For different applications priority of parameters are different. Intra clusterization energy requirement can also be improve using green building strategies[8)].There are several applications in which clustering methodology has been used. Some of those are following [9)]:

- Medical science
- Biological science
- Social science
- Electronics hardware science

- Software science
- Astrological science
- Environmental science

According to M. Demirbas et al. [2] clustered networks also known as the multi-tier or hierarchical networks, are more scalable, more reliable, more area coverage, better fault tolerable and have good energy awareness.

M. Abdullah et al.[10] trade that the clusterization can be considered as a pictorial partitioning issues with few extra parameters because the area and the dimensional view of the achieved graphs for clusters is not known previously.

Because of these problems, the clustering method is complex optimization problem [11]. Many protocols are developed for hierarchical routing problems in WSNs. According to comprehensive review many protocols are heuristic and meta-heuristic based methods.

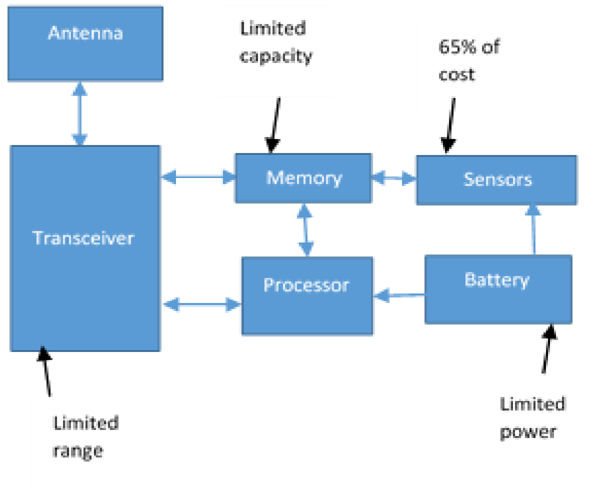

Fig. 1: Sensor node structure

2. Clusterization

In clusteriztion process whole network consists of nodes, wired or wireless connectors, routers are partitioned into some sub-networks of smaller size known as clusters[9]. The supervisor of these sub-networks or clusters is known as cluster head (CH). All the connections among cluster participants or cluster members and data communicating members are controlled by cluster head. Efficiency and energy utilization both can be improve by clusterization. At the place of sending sensed data individually in the direction of base station, nodes follow some hierarchy of supervisor cluster and optimize energy requirement. In this way life time of battery is improved.

In clustering protocol sensing nodes can act as either CH or cluster participant. In clustering process, participants or nodes are restricted to connect the base station directly. Only cluster head communicate with base station either in direct manner or in the manner of indirect. Each one of the nodes send respective observed data in the direction of supervisor cluster. Energy requirement is more in CH comparatively other participants due to many computational duties and larger distant communications[11].

Already many literature reviews have been presented on clusterization. Many proposed algorithms are based on different parameters for classification. These parameters may be in the form of expressed challenges. Convergence time is basic parameter of classification and categorize as Variable and fixed convergence algorithm[12]. In variable convergence algorithm convergence time depends on network size and condition on other hand in fixed convergence algorithm convergence time does not depend on network size. Homogeneity and heterogeneity of network are the basis of energy efficient clustering algorithms[13].

Summary of many proposed clustering algorithms from 2002 to now a days is presented in this paper. Comparison of algorithms has been done on different basis.

3. Homogeneous Sensor Systems

In homogeneous various leveled sensor network, sensing points of same limit are composed inside the clusters. Supervisor cluster, works like relay of information transmission because supervisor cluster or CHs are of similar transmission limit like sensing points. The base quantity of needed clusters are decided by highest limit of throughput required. Obviously, the more noteworthy throughput acquired with utilizing clustering process, generates the expense of extra nodes in sense of cluster supervisors[14]. Aggregated data of layered structure includes grouped information of supervisor clusters, which decreases the quantity of communicated data in the direction of BS. Along these lines, efficiency can be expanded as far as power utilization.

4. Heterogeneous Sensor Systems

For these types of systems, versatile main stations are put in system territory and can move their position randomly, gather information legitimately from common sensor node or utilize some sensor node to replay information[15]. Once in a while sensor node might be conveyed in a dissipated way, and separation of the sensing points could be increased. High separation of sensing points implies towards higher battery power requirement for communication. In the situation of heterogeneous node, regular or irregular forms can be consider for efficiency calculations of clusterization algorithms[16].For multi-hops communicating algorithms, the cluster supervisor close to main station goes to work like repeater for large distant cluster supervisor and resulting quick decrement in battery energy, and creates area issue[17]. For resolving the created issue, another clustering protocol is “Unequal Multi-hop Balanced Immune clustering" (UMBIC)[18]. This algorithm convention has different sections for altering power utilization: (1) Unequal clusterization Methodology

(UCM) of within group power utilization which parcels the system into no equal-scaled areas clusters. (2) Multi-Objective Immune Clustering (MOIC) for different group's power utilization which makes efficient clustered group and forms a steering hierarchy with consideration of the whole system connectivity [19]. That stage guarantees for all connections and limits the transceiving expenditure of all sensing points. If the remaining power of single supervisor turns out lower than required limit, UMBIC relocate the cluster supervisor. Thus, complexity decreases.

Another two-stage firefly-basis methodology is considered for grouping in WSNs[20]. The primary stage is small scale clusterization stage, where sensing points can be self-sorted out into group, along with this the next stage is full scale clusterization. In full scale clusterization clustered area are cleaned and less numbers of nearest groups are combined[21]. Settlement of the number of clusters is main target of this work.

A power effective system is recommended which powerfully migrates a flexible BS of clustered basis (CB) network systems. In this, system considered another steering algorithm known as Sleep-wakeful Energy-efficient Distributed (SEED) clusterization calculation, in this the system detecting area is isolated into various three power regions on the basis that in SEED, cluster supervisor is transceiving in direct form[22]. Same sensing points make low level clusters to minimize the number of transmissions [23]. Actualized braces technique on dense system and partitioned the system into numerous cells with various densities (upper, down and middle)[6]. By consolidating frameworks, two groups as ordinary and advance groups are made. At every clustered group, a more-power sensing point is chosen as cluster supervisor[24].

A power fuzzy clusterization algorithm comprises fuzzy c-implies protocol and Sugeno fuzzy interface model to utilize in grouping of all sensing point into adjusted groups and choosing suitable CHs, separately. Contrasted with different algorithms, this algorithm utilizes counterfeit honey bee protocol to modify the fuzzy guidelines of LEACH-SF[25].Neural network comprising with the prediction of time slots can be used for easy implementation of algorith[26].

A Need-Based Clusterization (NbC) with Dynamic base station mobility (DSM-NbC) plot of system which incorporates dynamic base station portability such that movable station goes from thick place to meager place. As many sensing points can transmit information directly towards the portable sink[27].

A low power required overlapping clusterization protocol known as EEAOC in regular checking of applications in WSNs, here a 2-intelligent inclusion overlapping clusterization methods are used so that neighboring sensing points in the occasion region can be gathered into a similar group for information combination. Moreover, hybrid information announcing procedure is considered to additionally diminish power utilization[28].

The execution of DDEEC algorithm is expanded by utilizing EK-DDEEC genius convention. Mobile Anchor sensing points pathway plan (MAPP) algorithms consolidate network density basis inter clusterization and intra-clusterization way arranging with each other to modify restriction execution and the utility of expected reference points [29].

This paper is sorted out as pursues: Part 5 will discuss about the various arrangements of clusterization procedures and count a lot of traits for arranging distributed protocols.

5. Low Energy-Inspired or Meta-Heuristic Based Approaches

5.1 Low Energy Adaptive Clustering Hierarchy – Centralized

LEACH-C is a centralized algorithm, having centralized control for electing the cluster supervisors that is supervisor of cluster, at the starting of every networking cycle, means during the setup phase[30]. LEACH is a distributed algorithm. The LEACH-C, is utilizing a centric controlling protocol in the decision of cluster supervisor. At the initiating of every network cycle, means in setup phase base station launches the clustering process with addresses and energy levels of receiving sensors[27]. This base station concludes an average power level on the basis of all energy levels of different sensor receivers for even distribution of energy load[31]. Even load distribution is necessary for avoiding over utilization of sensors.

One cluster is selected to reduce the amount of energy for ordinary sensors to sending messages to the cluster supervisor by reducing the summation of squared distances among all the ordinary sensors and nearest cluster head according to equation (1)

$$f = \sum_{i=1}^{N} \binom{min}{s_k \in K} (d^2 \ (s_{i,} s_k)) \qquad (1)$$

In above relation N represents the count of sensors represents set of cluster heads, $d(s_i,s_k)$ represents Euclidian distance between sensor s_i and cluster supervisor s_k.

Due to the centralized control, known address and residual energy at the base station can form better cluster and minor power is needed in communication. The count of cluster heads in every cycle is same as prerecorded threshold margin. But in LEACH, the count of cluster heads differing in every cycle due to lack of proper coordination among many sensing points[11]. Single-hop adoption in routing process having some restrictions. The LEACH-C is better than LEACH protocol in the form of communication and energy requirement[32].

5.2 PSO protocol an Energy Aware Clusterization in WSNs

Particle Swarm Optimization (PSO) algorithm developed on the basis of nature of bird flocking or fish schooling[33]. This protocol adopting a central control algorithm at base station. Euclidian distance between node and cluster supervisor and power level are important parameters for selection of sensing nodes to come in cluster range. Centralized- PSO algorithm processing in cycles[34]. Setup phase is the initiating phase for clustering process and steady state phase for further processing. In setup phase nodes transmitting their positioning address and power levels to the base station. The nodes having power more than threshold, are elected as participants to become cluster head in present cycle[35]. A cost function is also included that aiming to minimize the intra- cluster separation while minimizing the power consumption[36]. The best k count of cluster supervisor can be chosen using PSO in cost and energy prospection[37]. The cost function is given by equation (2)

$$f = \beta * f_1 + (1-\beta) f_2 \qquad (2)$$

$$Where \ \ , f_1 = \max_{1\in|1,k|} \left(\sum_{s_i \in C_{p,k}} \frac{d(s_i, CH_{p,k})}{|C_{p,k}|}\right)$$

$$and \quad f_2 = \frac{\sum_{i=1}^{N} E(S_i)}{\sum_{k=1}^{K} E(CH_{p,k})}$$

Where β represents user defined weight term, N represents count of sensors,

$|C_{p,k}|$ Represents the count of sensors that related to cluster C_k of part p ,

f_1 Represents maximum average Euclidean separation of sensing points and their related cluster heads,

f_2 Represents the ratio of initial total power and total present power of all participants of cluster heads in present cycle[37].

When comparing the PSO-C with LEACH or LEACH-C, network is of longer life in PSO-C. Since PSO-C algorithm assumes that sensing nodes aware their position, realistic deployment of sensors are not scalable[38].

5.3. Cluster-based WSN Routing using the ABC Algorithm

In this algorithm distance and energy levels are concluded at base station[39]. As in LEACH, to find the positions, sensing nodes transmit advertisement messages to the clustered network. According to gathered different signal strengths, every sensing node calculate the distances among different sensing nodes. If s_i and s_j are sensing nodes than the distance can calculated as equation (3)

$$d_{ij} = \ c * \frac{\sqrt{P_s}}{4\pi f \sqrt{P_r}} \qquad (3)$$

Where c represents the speed of light

P_r Represents received signal strength

P_s Represents sender signal strength

f Represents communicating frequency

As in LEACH, the ABC-C deciding the CH periodically[31]. In this manner overhead communication is introduced in the network. Nevertheless, due to their considered semi-distributed method, the cluster head finding way is obtained in a centric manner by the base station, the power expenditure of the cluster head finding scheme is reduced on sensing points[32].

5.4.Multi-tier Cluster-based Routing Protocol for Sensor Networks

Bee-C multi-tier cluster-basis routing protocol is based on Honey Bee Mating Optimization. HBMO is depends on nature of honeybees in reproduction sense[35]. To reduce the energy requirement new objective functions are defined.

For best cluster selection, HBMO basis algorithm is used at base station. Primary objective is calculated by equation (4)

$$F_1 = \sum_{k=1}^{p} \frac{E_{T_k} - E_{C_k}}{N_k} \qquad (4)$$

Where

E_{T_k} Represents total energy in k^{th} cluster

E_{C_k} Represents total spent energy in k^{th} cluster

N_k Represents count of sensors in k^{th} cluster

p Represents count of clusters

Second objective is given in equation (5)

$$F_2 = \left(\sum_{i=1}^{N} \left(\min_{s_k \in K}\right) (d^2(s_i, s_k))\right) * \left(\frac{\sum_{i=1}^{N} E(S_i)}{\sum_{k=1}^{K} E(S_k)}\right) * \left(\sum_{k=1}^{K} d(s_k, BS)\right) \quad (5)$$

where

K Represents number of cluster heads

$E(s_i)$ Represents energy of sensor

$E(s_k)$ Represents energy of cluster head K

$d(s_i, s_k)$ Represents Euclidean distance between sensor s_i and cluster head s_k

$d(s_k, BS)$ Represents Euclidean distance between cluster head K and BS

When increasing the sensing points this algorithm provide poor results and indicating that it is not scalable.

5.5. Energy-efficient Clustering and Routing Algorithms for WSNs

Linear Programming (LP) and Non-Linear Programming (NLP) are used in clustering and routing process. The routing instructions are designed with a trade-off between communication separation and size of messages sending with a significant particle coding strategy and many-goals fitness operator.

The clustering rules are described by including power saving of sensing points through load equalization[36].

This method considering a network modeling system where all sensing points are randomly deployed and after deployment sensing points remain fixed[32]. In this network, model is configured in following parts as: the clusterization, bootstrapping, and the direction management.

The routing issues are resolved by reducing the maximum communicating separation between two sensing points in the route and maximum hop count as in relation (6). The first target is to reduce the greater separation among sensing points and the next target is to reduce the greater count of hops required at base station as in equation(7)

$$Max_{Dist} = \max_{1 \le i \le M|} d(g_i \ , Next\ \ Hop(g_i)) \quad (6)$$

$$Max_{Hop} = \max_{1 \le i \le M|} (HopCount(g_i)) \quad (7)$$

$Where$

g_i Represents the i^th^ gateway

$Next\ \ Hop(g_i)$ Represents next gateway towards Base Station

$d(g_i\ \ , Next\ \ Hop(g_i))$ Distance between gateway g_i and it's subsequent

$HopCount(g_i))$ Represents the count of next hops required to reach to Base Station.

5.6. PSO protocol for Hierarchical Clustering in WSNs

PSO basis algorithm for hierarchical or levelled clustering (PSO-HC) in centralized manner is proposed for WSNs, in which practical energy method has been utilized[40]. This protocol is implemented at base station.

The clusterization methods including the sensing point's gained signal power and its signal strength[41]. The gained signal strength supports in the checking of the transmission lines quality among sensing points. For betterment of the scalability, a double-tier group is used in such a manner that the supervising area is increased[37].

The results analysis shows that PSO-HC performance is better than PSOC, LEACH and LEACH-C algorithm in form of the average needed power and the throughput[42].

5.7. Energy-efficient and Scalable Multipath Routing Protocol for WSNs

Bee-sensor-C algorithm is mainly developed for running event sensing network. This algorithm uses dynamic clustering strategy for reducing path load and betterment of scalability[43]. Author considered on-demand multi-route clustering process in the view of foraging nature of a bee swarm. Indeed, the Bee-Sensor-C creates a cluster form and find the cluster head while an event happens. Bee-Sensor-C is working in three main stages known as: the cluster generation, the multi-route establishment and the messages communication[44]. The initial stage is to create a cluster form when an event occurs. The secondary stage including the construction of multi-rout source and corresponding sink, followed by transmitting messages to sink across the stochastically chosen route. The last step is of the path maintenance.

The various paths formation from supervisor head sensing node to targeted sensing node is defined by calculating a resultant value according to the equation (8)

$$R_{jp} = \frac{w_1 E_{av} + (1 - w_1) E_p^j}{H_{jp}} \quad (8)$$

$Where$

E_{av} Represents average remaining energy of route

w_1 Represents controlling parameter

H_{jp} Represents number of hops when going from s_j to s_i

At the third step, when the backward scout with rout id reaches at the cluster head, it selects foragers and message is communicated via stochastically decided route by calculating the dance value, which indicating the quality of the route as in given equation (9)

$$DN_{pid} = [\frac{\beta - H_{pid} * (w_2 \ (E_{initial} - E_{avg} \ \ ) + (1 - w_2) E_{min}))}{\gamma}] \quad (9)$$

$Where$

w_2Represents value of weight

$\gamma \ and$ β Represents user defined constant

$E_{initial}$ Represents starting energy of sensing node

E_{min} Represents minimum energy of sensing route

E_{avg} Represents average energy of sensing route

H_{pid} Represents hop count of route

The formation of cluster on demand basis, produces good overhead especially in large scale networks. Bee-sensor-C is better than Bee-C, in network performance perspective[34].

6. Heuristic Based Approaches

6.1. Low Energy Adaptive Clustering Hierarchy

LEACH is the highly preferred and texting, message or information collecting routing algorithm in WSNs. The used clustering process is the type of distributed in LEACH, in which cluster head generation is need basis and random to maximizing the life cycle of WSNs. In LEACH algorithm, the working is subdivided into modes. During the setup mode, cluster head are elected and clusters are structured. Cluster head supervising the aggregation, data handling and communicating process among sensing points and base station[26]. The probability of sensing points decide that they will be cluster head or not in current cycle. The selection of cluster supervisor is done by choosing a probable number between 0 and 1. If chosen number of sensors is lesser than threshold value, the sensor become a cluster head for ongoing cycle. The threshold can be found as equation (10)

$$T(n) = \frac{P}{1-P*(r*mod\frac{1}{p})} \quad \text{If n} \in \text{G}$$

$$= 0 \qquad (10)$$

$Where$

P Represents the needed percentage of cluster head

r Represents the current cycle

G Represents the group of sensing points

n Represents the position number of sensing point

Data is forwarded in successive direction in one hop manner means single tier. Which is not practical for large scale sensor network. Due to this more energy is required in WSNs, which causes early death. In other side LEACH allows a cluster head to change their position. Adopted non static scheme for cluster head finding increase the overhead. The distance between randomly elected cluster head and sensing point may be too long which cause's weak distribution of cluster head.

6.2. Energy Efficient Hierarchical Clustering

EEHC (Energy efficient Hierarchical Clustering is distributed clustering method for designing the sensors in the form of clusters. EEHC algorithm considers that transmitting environment is contention and free from disturbances and does not required clock synchronization among sensing points. In any particular cluster the sound pollutants and poisonous gases monitoring in environment need more energy [45].

Moreover, the cluster supervisor in EEHC collect the recorded data from sensing points and send analyzed format to the base station via cluster supervisor. This algorithm permits the hierarchical designing of cluster heads to save the energy. For a cluster head selection, each sensing point find the probability p as given in equation (11)

$$p = (\frac{1}{3c} + \frac{\sqrt[3]{2}}{\sqrt[3]{(2+27c^2+3\sqrt{3c}\sqrt{27c^2+4})}} + \frac{\sqrt[3]{(2+27c^2+3\sqrt{3c}\sqrt{27c^2+4})}}{3c} * \frac{1}{\sqrt[3]{2}}) \qquad (11)$$

$Where$

$c = 3.06a\sqrt{\lambda}$; 2a Represents length of side of sensing square

λ Represents Poisson process

The declared information about participants is sending to all sensors that are not more than k tiers far from cluster head, k is given as in equation (12)

$$k = \left\lceil \frac{1}{r} * \sqrt[2]{\frac{(-0.917\ln\frac{\alpha}{7})}{p\lambda}} \right\rceil \qquad (12)$$

$Where$

r Represents radio coverage of each sensing point

α Represents for proper selection

6.3. Greedy Randomized Adaptive Search Procedure

A common problem in clusterization in WSN is the formation of clusters in a combined optimization scheme seek the need for exact and heuristic methods for a solution[34]. The main characteristics of exact methods is to ensure that the best solution can be found for the problem. Hence, a trade-off between high computational costs and performance which means they are not feasible for deployment with many nodes.

Notwithstanding, solutions close to optimality in a small computation time can be reached with heuristic methods, without being able to guarantee the best solution. Examples include Iterated Local Search, genetic algorithms and differential evolution, ant colonies, Routing Label Propagation and hybrid GRASP metaheuristics with Path Relinking.

GRASP (Greedy Randomized Adaptive Search Procedure) is a heuristic employed for solving problems of combined optimization in which a new solution is found in each iteration through a randomized greedy procedure[46].

The operation of GASP is divided into two phases namely: constructive phase and local search phase. Constructive phase provides a feasible solution from set of candidates by randomly selecting an element to be incorporated into a partial solution. A feasible solution is that sensor nodes in which coverage area, the limits of energy of the nodes and the network connectivity at every time is guaranteed. The optimal solution is the one that gives the best possible coverage, for every period, at a minimal energy cost to extend the network lifetime.

Local search attempts to improve the solution provided by the constructive Phase in an iterative manner by successively substituting the current solution, until a better solution is realized in the neighborhood. At the end of the process, the best solution found that complies with some criterion for stopping is returned, such as time or the number of iterations without any improvements[47].

Based on experiments and comparative analyses, it was verified that the application of our algorithm in the process of choices of cluster heads allowed to obtain a longer life and a lower energy consumption when compared to other algorithms such as LEACH and LEACH-C[48].

With the RSM technology (Response Surface Methodology) the optimized value of sensed data can be find. Optimized data further require less numbers of power signals [49]

7. Parameters of Clustering Strategies

In this section we describe different clustering strategies basis on different parameters[50, 51]. Classification of clustering strategies are shown in Fig. 2. In this paper we focus on different energy efficient protocols. Most of the clustering protocol required location, coverage information, node density variation basis algorithm[52]. This algorithm discovers a cluster of same relative density nodes and automatically calculate density variation threshold parameter "α" for each cluster locally instead of using unique global density variation threshold for all clusters in the network. Connectivity based clustering is otherwise called progressive or hierarchical grouping, where clustering investigation manufactures the group in a chain of command. Consequently, grouping parameters are distinctive for homogeneous and heterogeneous systems as introduced in review. We can do clustering of nodes in a system with basic parameter that works for both homogenous and heterogeneous WSN. One parameter that stands normal between them is there is location or position that is spatial coordinates[53].

8. Various Types of Clustering Algorithm

The prologue to clustering is examined in this section. The clustering Algorithms are of numerous kinds. The accompanying review will just rundown the most noticeable instances of clustering calculations, as there are conceivably more than 100 distributed clustering calculations. In distribution-based techniques clustering model we can fit the information on the basis of likelihood that how it might have a place with a similar dissemination. The distribution done might be typical or Gaussian. Centroid based technique is fundamentally one of iterative clustering calculation in which the clusters are shaped by the closeness of information focuses to the centroid of clusters. Mostly the classification depends on the way, they used for clustering and election of cluster head.

In some clustering calculations, the CH choice and the procedure of group development are totally arbitrary. A few calculations shape clusters utilizing information got from their neighbors. Connecting methods of nodes in WSN can be an important parameter for classification. (Fig. 3, 4).

We have considered energy efficient clustering algorithms on the basis of inter-cluster and intra-cluster communication among the nodes of WSNs.

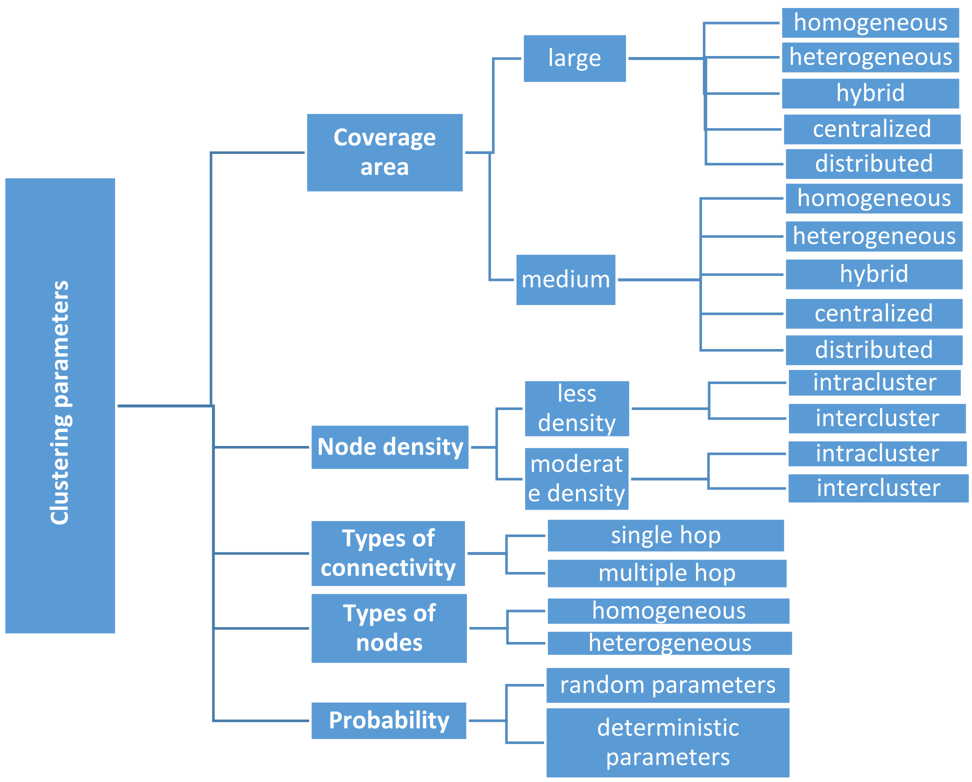

Fig. 2: Parameters of clustering strategies

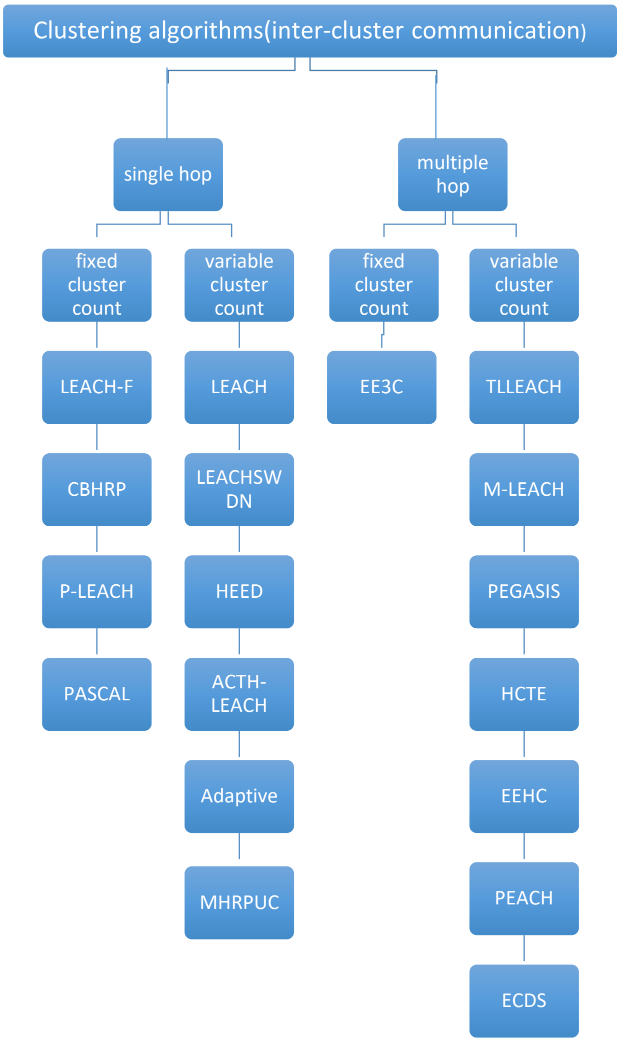

Fig. 3: Inter-class clustering protocols

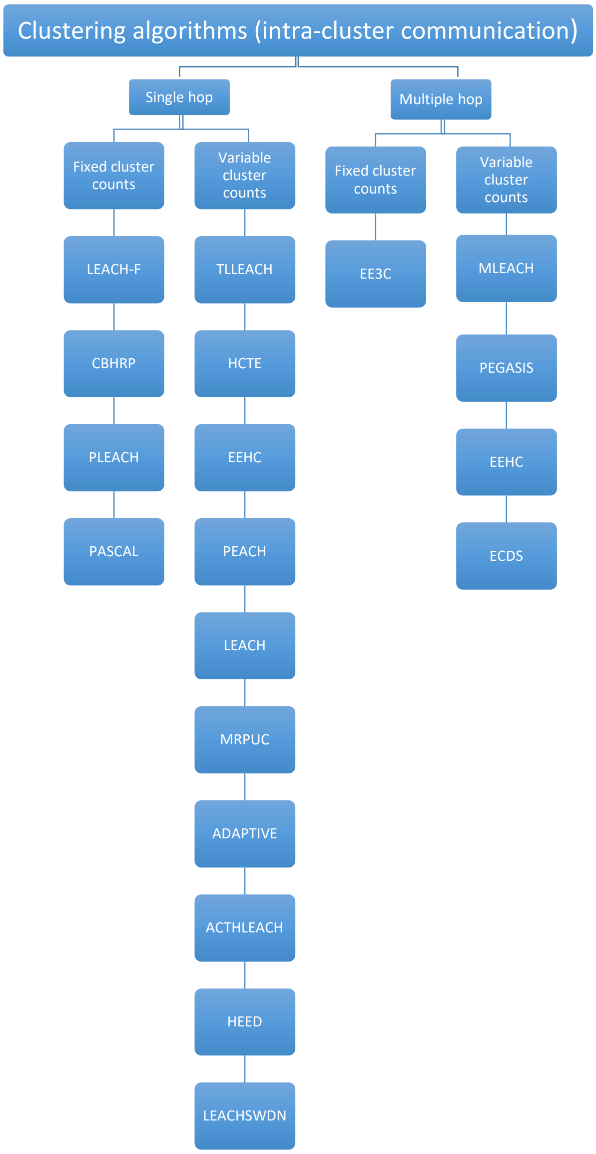

Fig. 4: Intra-class clustering protocols

8.1. Clustering Parameters

Clustering parameters can have a direct or indirect effect on the process of cluster formation depending on the relationship existing between them. The clustering parameters are therefore presented.

- Types of Nodes: This depends on whether the Cluster head is a homogeneous or heterogeneous node. In a homogenous network, communication and computation resources are constrained between the cluster head and other sensing nodes[54]. While in the homogenous network, all nodes are of equal capabilities and only few of them are selected as CH through efficient techniques.
- Cluster Head Selection: In most cases, cluster heads are selected on the basis of various parameters like energy level, distance from the nodes and centre or probabilistic approach[55]. However, it is stated in the previous point that the overall network performance is dependent on the selection of cluster head which many proposed works have shown that it is predefined (usually in heterogeneous network)[56].
- Mobility: It is clear there will be issues concerning continuous maintenance in a cluster if the nodes change their positions because the cluster and cluster head change from time to time. However, in the case of static network, a stable cluster is formed between cluster and cluster head which supports intra and inter cluster management [32].
- Intra Cluster Communication: This is the communication of the sensor nodes and the cluster

head elected within the cluster. It can be a single hop which depends on the distance between the node and the CH or multi hop which is usually employed in large scale networks.

- Cluster Count: It is a key parameter concerning clustering algorithm efficiency, which varies depending on network size.

8.2. Inter-cluster, single hop, fixed cluster count algorithms

LEACH-F, is fixed cluster LEACH protocol. Formed clusters cannot be changed. Only supervisor cluster would be exchanged among all the sensing points in a group [21]. Permanent grouping makes it possible for the cluster supervisor for proper deployment in environment. The main drawback of this process is choice to add on new node . CBHRP is double structured algorithm. A group of cluster supervisors is utilized here rather than single cluster supervisor. Each group of cluster supervisors, incorporates a functioning CH and some partner CH, just a single individual from group of cluster supervisors, is dynamic at every next cycle, and remaining are in rest stage .A modified (LEACH-C) protocol called partition basis LEACH (pLEACH), which divide the system into ideal number of divisions, and afterward chooses the cluster supervisor with large most power energy as the supervisor for every segment, utilizing the concentrated counts. The reproduction results and investigation demonstrate that pLEACH could accomplish much better execution of WSN as far as the energy lifetime, and quality of communication [27)].

8.3. Inter-cluster, single hop, variable cluster count algorithms Clustering Parameters

The first and most significant power consuming various leveled clustering algorithm is known as LEACH for sensor arrangement, in which CHs are chosen haphazardly to decrease power utilization. The job of being a CH is pivoted occasionally among the sensing points of the groups[30)]. Every cluster supervisor transmits its information to the BS in periodic manner. All cluster development stages and choice of CH are worked temporarily with no unified command. This element not just lessens the information sending per time to the base station yet additionally makes routing easy. The methodology in LEACH is divided into some cycles. Every cycle incorporates two stages: (1) setup stage (2) steady state stage [20)].

Sliding Window WDN is additionally founded on LEACH in which cluster head are chosen as CH dependent on their power. Every node produces a sliding window by normal energy of node that have not yet turned into a CH and utilizations it to pick the CH.

The methodology of ACHTH-LEACH incorporates three noteworthy stages: clustering, choosing the CH and information transmission. Notice is an expansion of LEACH convention, HEED utilizing residual power and network density as a measure for cluster determination to accomplish power adjusting in the system. This calculation comprises of three stages: Initialization, reiteration, and finalization phases [28, 29)]. In the redundancy stage, each node experiences a few cycles until it finds the least expense CH[57)].

MHRPUC is a distributed clusterization protocol processing through many cycles[30)]. Every cycle is separated into following stages: cluster setup, transmission directing, and information transmission. Every node accumulates data of nearby sensing points. MHRPUC chooses the node with increasingly leftover power as cluster supervisor, and group of sensing points near the base station have littler perimeter to save greater battery while intra-cluster transmission [21)].

8.4. Inter-cluster, multiple hop, fixed cluster count algorithms

EE3C in this algorithm three important case: initialization, setup, steady-state. In first case sensing nodes are randomly created. In second case cluster supervisor and clusters are created. Here in this algorithm deployed sensing are partitioned in sectors of rectangular shapes. Due to rectangular shape, efficient energy distributed is possible. The main point is that clusters are represented in the rectangular shapes. Location and lifetime of nodes are decided by base station [17)].

8.5. Inter-Cluster, Multiple hop, Variable Cluster Count Algorithms

TL-LEACH is improved version of LEACH can save better energy consumption by forming hierarchy of double levels so called two levels LEACH. Higher density network is main network for utilizing this algorithm. LEACH and TL-LEACH both are adaptive that’s why overall performance can be affected by clustering procedure [18)].

Multi energy and interchanging of cluster supervisor in M-LEACH with can modify the efficient utilization of conservation energy.

PEGASIS is short form of Power-Efficient Gathering in Sensor Information System. It is queue basis hierarchal algorithm. All sensing points are connected in the form of chain. The production of queue can be used together for different applications point of view[24)]. PEGASIS methodology belonging to the considerations that system’s whole data is circulated to every sensing points. The decision of queue starts from the largest distant sensing point from the base station and its nearest sensing point selected as next point in the queue. The last sensing point should be base station and sensing point before base station goes about as a supervisor of the cluster. Data analyzing procedures and collection are cultivated with supervisor node.

In EEHC sensing points are arbitrarily appropriated and are fixed, the directions are known of the base station and all elements of sensing area. Homogeneous clustering conventions expect that all the sensor nodes are furnished with a similar measure of power and subsequently, they can't exploit the nearness of sensing point heterogeneity. In adjustment of this methodology, a power productive heterogeneous clustering process for remote sensor systems dependent on weighted selection probabilities of every node is considered [29].

With the LEACH protocol cluster supervisors are randomly chosen depending on remaining battery in the sensing points. This may cause falling flat group heads and therefore reduce the network life. This algorithm proposes a protocol called proxy less energy adaptive clustering progressive system (hierarchy) (PEACH), which can build the lifetime and unwavering quality of the sensor network. This is accomplished by choosing a proxy node which expect the job of cluster head during one round of correspondence. PEACH protocol expands the lifetime in comparison of the LEACH protocol up to about 15% in practical operational condition [32].

ECDS is an Energy-Constrained least Dominating Set-basis powerful clustering protocol considering requirement of power in election process of cluster supervisor. This distributed algorithm works arbitrarily. The Received Signal Strength Indicator (RSSI) is utilized to decide connect quality. Thus, the communicated quantity diminishes, but quality is modified that’s why energy requirement can be minimize. Adjustment of sensing point's neighborhood dependent on connection quality enables to utilize the most reduced conceivable power setting for transmissions so as to speak with different nodes in the group. This prompts some extra energy conservation [13].Converted electrical energy from ocean energy, wind energy, geothermal energy can also be used in sensing areas[58].

Parametric comparisons of different algorithms in Inter clusterization are as mentioned in Table 1.

Table 1. Comparisons of routing protocols while using in Inter clusterization

Types of connectivity	Cluster count	Algorithm	Coverage area	Node density	Types of nodes	Probability parameters
Single Hop	Fixed	LEACH-F	Medium	Moderate	Homogeneous	Random
		CBHRP	Large	Less	Heterogeneous	Deterministic
		PLEACH	Large	Moderate	Heterogeneous	Deterministic
		PASCAL	Medium	Moderate	Homogeneous	Random
	Variable	LEACH	Large	Moderate	Heterogeneous	Random
		MHRPUC	Medium	Less	Homogeneous	Deterministic
		ADAPTIVE	Large	Moderate	Heterogeneous	Random
		ACTLEACH	Large	Moderate	Heterogeneous	Random
		HEED	Large	Moderate	Heterogeneous	Random
		LEACHSWDN	Large	Moderate	Heterogeneous	Deterministic
Multiple Hop	Fixed	EE3C	Large	Moderate	Heterogeneous	Random
	Variable	MLEACH	Large	Less	Heterogeneous	Deterministic
		PEGASIS	Medium	Moderate	Homogeneous	Deterministic
		TLLEACH	Large	Less	Heterogeneous	Random
		HCTE	Large	Less	Heterogeneous	Random
		EEHC	Large	Moderate	Heterogeneous	Random
		PEACH	Medium	Moderate	Heterogeneous	Random
		ECDS	Medium	Less	Heterogeneous	Random

8.6. Intra-cluster, single hop, fixed cluster count algorithms

In these algorithms, no further addition of node is possible to formed cluster. In smart ventilation, these algorithms can be used to reduce power of appliances[59]. Re-clusterization like LEACH is not an option here.

Number of nodes remain fixed with no addition and subtraction in existing nodes. The benefit of this procedure is no initiating overhead toward the start of every node. LEACHF utilize the centered cluster arrangement calculation like LEACH-C [30].

Another two-layer various leveled routing protocol called Cluster Based Hierarchical Routing Protocol (CBHRP) is an expansion of LEACH[60, 61]. This protocol diminishes energy utilization essentially and draws out the existence life of sensing points arrange. CBHRP works superior than other all around acknowledged various leveled protocols [23].

Energy-Efficient Hierarchical Clusterization (EEHC) is a random and dispersed protocol. In this, cluster supervisor gets and totals information from participating sensing points and transmits it to the base station for commanding the chain of cluster supervisor[62]. In this protocol, it is expected that the correspondence channel is collisions/disturbances less[63]. Battery utilization relies upon two features: The likelihood of every sensor turning into a cluster supervisor at every dimension in the hierarchal order, and the most extreme count in the way of sensing point and cluster supervisor [34].

In this algorithm designing is done in multi-hops travelling and different clustering calculation utilizing leftover batteries of sensors and separation between sensing point to the base station to expand battery life[64]. In spite of the fact that these calculations can modify the system life time, but the overhead issue is not taken in account[65]. Thus, every one of the information will be sent to the base station, the closer from the sensing point to the base station, the more overhead it will tolerate. Greater burden implies sending information all the more as often as possible, and expending more power[66]. Unequal burden leads to unbalanced power requirement which reduces of system life cycle [14].

Table 2. Comparisons of routing protocols while using in Intra clusterization

Types of connectivity	Cluster count	Algorithm	Coverage area	Node density	Types of nodes	Probability parameter
Single Hop	Fixed	LEACH-F	Medium	Moderate	Homogeneous	Random
		CBHRP	Large	Less	Heterogeneous	Deterministic
		PLEACH	Large	Moderate	Heterogeneous	Deterministic
		PASCAL	Medium	Moderate	Homogeneous	Random
	Variable	TLLEACH	Medium	Moderate	Heterogeneous	Random
		HCTE	Medium	Moderate	Heterogeneous	Random
		EEHC	Large	Moderate	Homogeneous	Deterministic
		PEACH	Large	Less	Homogeneous	Random
		LEACH	Large	Moderate	Heterogeneous	Random
		MRPUC	Medium	Less	Homogeneous	Deterministic
		ADAPTIVE	Large	Moderate	Heterogeneous	Random
		ACTLEACH	Large	Moderate	Heterogeneous	Random
		HEED	Large	Moderate	Heterogeneous	Random
		LEACHSWDN	Large	Moderate	Heterogeneous	Deterministic
Multiple Hop	Fixed	EE3C	Large	Moderate	Heterogeneous	Random
	Variable	MLEACH	Large	Less	Heterogeneous	Deterministic
		PEGASIS	Medium	Moderate	Homogeneous	Deterministic
		ECDS	Medium	Less	Heterogeneous	Random

Here cluster head are chosen basis on two main parameters, first parameter is leftover battery energy and second of intra cluster communication cost. For budget perspective electrical energy produced by coal is easily affordable[67]. Various protocols in literature provide less energy conservation but not definitely improving the life period of network. HEED can be considered as improved form of LEACH. Regard is an expansion of LEACH algorithm, utilizing leftover energy and node density a paradigm for cluster selection to accomplish power adjusting in the system. Three important stages of protocol are Initialization, reiteration, and finalization. In starting stage, every sensing point calculate the popularity with higher proximity of electing a cluster supervisor dependent on its remaining power along with probabilistic characteristics [68]. In the reiteration stage, each node experiences a few cycles until it got the minimum expensive cluster supervisor. Four essential objectives of this protocol are: 1. Dragging out system period by circulating power utilization. 2. Ending the clusterization procedure inside a consistent count of cycles/steps. 3. Limiting control overhead. 4. Generating appropriate cluster supervisor, group of sensing points [34].A high capacity transmission over WSNs to save the energy has been proposed using Low-Density parity check code for better and energy efficient transmission through Nakagami-n channel in WSNs [21]. Different techniques also can be accomplished with navigational data using RFID system in wireless sensor network. Graphical user interface also allows distant monitoring [16].

A powerful transformation with efficient and appropriate scheduling is proposed known as HBCA-EST[69]. The fitness function abruptly increases due to proper scheduling of heavy data and simulation time is 93% lesser then other strategies [17].

Parametric comparisons of different algorithms in Intra clusterization are mentioned in Table 2.

8.7. Advantages of Clusterization

- Scalability: In clustering, sensor nodes are grouped into variety of clusters with different assignment levels[70]. The member nodes are responsible for sensing and collecting information from the environment and the CH performs data aggregation and network management. As a result, the clustering topology can localize the route set up within the clustering thereby reducing the routing table on individual sensor node [37].
- Robustness: As a result of network topology control, clustering routing protocols respond conveniently to changing network like increasing nodes, node mobility and unprecedented node failures[71]. Clustering enables each and every node in the cluster to the changes making it more robust to network management[72].
- Data Aggregation: Data aggregation/fusion, which is the process of aggregating the data from multiple nodes to eliminate redundant transmission and provide fused data to the BS, is an effectual technique for WSNs to save energy [38].Aggregating data before sending it to the sink results in significant energy saving[73]. In essence, CHs are created as a tree structure to transfer aggregated data by multi-hopping through other CHs to the intended base station[74].
- Low Energy Consumption: In clustering routing scheme, data aggregation helps to reduce transmission data considerably and save lot of energy. Integrated energy system also provide a sustainable life in clusterization[75].
- Low Latency: In flat routing WSNs, data transmission is performed hop by hop usually using the method of flooding. In contrast, in clustering based WSNs, only cluster heads perform the task of data transmissions from one cluster to another one. This helps decreasing the hops from data source to the base station, accordingly it reduces the delay.
- Fault Tolerance: WSN suffers from energy depletion, transmission errors, hardware malfunction, malicious attacks etc. Sensor nodes deployed in hostile environments are prone to failure. Thus, fault-tolerance is an important challenge in WSNs [39]. Fault-tolerance of CHs is usually required in this kind of applications to avoid the loss of significant data from sensor nodes. As such, effective fault-tolerant approaches must be designed in WSNs. Re-clustering is the most intuitive method to recover from a cluster failure, though it usually disarranges the on-going operation [36].
- Throughput: the amount of compressed and coded data passing through a network is very precise challenge. The HEESR (Hybrid Energy Efficient static routing protocol for homogeneous heterogeneous large scale WSNs) is providing maximum throughput using less energy. The Dormant nodes are not require input energy in sleeping modes[76].

9. Conclusions

In this paper number of protocols for clusterization and routing in wire-free sensor network were reviewed. Energy requirement in wireless sensor networks can be decreased by various energy conservation algorithms. In this paper, we gave a concise presentation and fundamental information of inclusion ideas utilized in sensor networks. We have taken energy effective inclusions dependent on heterogeneity, homogeneity and number of hops and portrayed the process of algorithm with a top to bottom examination. Power protection can be accomplished by decreasing included area coverage and ideal node planning which would expand the node and system lifetime. Our analysis of the current power effective algorithms depends on the clustering, routing mechanism, node scheduling, node failure likelihood probability and node lifetime. At long last, energy conservative algorithms in WSNs are outlined. Still the wireless sensor network is facing many challenges like cross layer modeling, compression and coding of sensed data, accuracy and efficiency, large bandwidth requirements and power consumption in WSNs. Further research is required to handle these parameters in an exact way which could improve the energy efficiency and other areas in sensor systems. Our review can be utilized as a beginning stage for future research in WSN.

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