International Journal of Applied Information Systems (IJAIS) – ISSN : 2249-0868
Foundation of Computer Science FCS, New York, USA
Volume 5– No.2, January 2013 – www.ijais.org

Clustering Protocols in Wireless Sensor Networks: A Survey

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ABSTRACT
In recent years, the applications of Wireless Sensor Networks (WSNs) have grown enormously. In WSNs there is one mechanism used to enlarge the lifespan of network and provide more efficient functioning procedures that is clustering. Clustering is a process to subdivide the sensing field of sensor network into number of clusters. Each cluster selects a leader called cluster head. A cluster head may be elected by the sensor node in the cluster or pre assigned by the network designer. Optimized Clustering can save lot of energy in the network. In our paper we have surveyed various clustering protocols for wireless sensor networks and compared on various parameters like cluster count, cluster size, cluster density, message count, node deployment, heterogeneity of nodes, location awareness and cluster head selection process etc.

Keywords
Cluster count, cluster size, cluster density, lifetime.

1. INTRODUCTION
Recent developments in the areas of Micro Electro Mechanical Systems (MEMS), wireless communication and low power designs have enabled the small sized battery operated sensor nodes. A WSN is a set of sensor nodes deployed in a physical area and connected through wireless links. A sensor node consists of mainly four units that are sensing, communication, processing and power supply. The sensing circuitry measures the different parameters from the environment like temperature, humidity, pressure etc and converts them into an electrical signal. Processing of such signals reveals some properties about the objects or events happening in the surrounding of sensors. After processing these signals can be transmitted to destination (base station) by using radio transmitter either directly or through an intermediate gateway. The basic features of a sensor network are self organizing capability, dynamic network topology, limited battery power, short range broadcast communication, nodes mobility, routing and large scale of deployment. Due to the capability of self organization and wireless communication, sensor networks are expected to be used in civil, commercial and military applications such as surveillance, climate and habitat monitoring, vehicle tracking, disaster management, medical observation and acoustic data gathering. There are many challenges in wireless sensor networks. The key challenge is to maximize the stability as well as lifetime of network. It is not feasible to replace the batteries of hundreds or thousands of sensor nodes after deployment. In sensor network, grouping of sensor nodes into a cluster is called clustering. Every cluster has a leader called cluster head. A cluster head may be pre assigned or elected by the members of the cluster. A cluster head collects the data from the nodes within cluster and transfer to destination (base station). The clustering techniques widely perused by researchers increase the lifetime as well as scalability objectives. Many clustering protocols can be use to create hierarchical structure that reduces the path cost when communicating with the base station.

2. CLASSIFICATION OF CLUSTERING PROTOCOLS
In this section we discuss the set of attributes can be used to differentiate clustering protocols for wireless sensor networks [3, 10].

2.1 Clustering Method
The two basic approaches for the co-ordination of entire clustering process are distributed and centralized. In distributed clustering, where each sensor node can run their own algorithm and takes the decision of becoming cluster head. In centralized clustering, a centralized authority groups the nodes to form clusters and cluster heads. Sometimes hybrid scheme can also be implemented.

2.2 Cluster Properties
In clustering approaches, there are some characteristics for the cluster formation. The following are characteristics that are related to the internal structure of the cluster.

2.2.1 Cluster count
Cluster count is the number of clusters formed in a round. More number of cluster lead to small size cluster distribution, which is better in term of energy consumption. In some clustering approaches, the selection of cluster heads are pre assigned from the deployed sensor nodes for fixed clusters or cluster heads can be selected randomly results in variable number of clusters.

2.2.2 Cluster size
Cluster size is the maximum path length among the member nodes from cluster head. Small sized cluster is better in term of energy consumption because it minimizes transmission distance and load of cluster head. In some clustering approaches, cluster size is fixed when cluster are fixed throughout the life time, otherwise it is variable for each cluster.

2.2.3 Cluster Density
Cluster density is defined as proportion of the number of cluster member in the cluster and cluster area. There is big

challenge to minimize the energy consumption of cluster heads in dense clusters. Some of the clustering approach use fixed clustering always has sparse density of cluster, but in dynamic clustering approaches cluster density variable.

2.2.4 Message count
Message count is the number of message transmission is requiring for cluster head selection. More number of message transmission lead to large amount of energy consumption for cluster head selection procedure. There are many algorithms which is nonprobabilistic, require the message transmission for cluster head selection.

2.2.5 Stability
If the members of a cluster are not fixed the clustering schemes are said to be adaptive. Otherwise we can consider as fixed because the cluster count are not varied throughout the clustering process. The fixed cluster count increases the stability of a sensor network.

2.2.6 Intra-cluster topology
It indicates the communication within the cluster as direct or multihop. It may be single hop or multihop from sensor node to sensor node or sensor node to cluster head. However this communication also depends on the sensor's range. This limited range bounded the cluster head count.

2.2.7 Inter-cluster head connectivity
It indicates the capabilities of sensor nodes /cluster heads communication to base station. If the cluster heads are not having long haul communication capabilities, clustering schemes has to ensure some intermediate provision of routing to base station.

2.3 Cluster-Head Capabilities
The capabilities of cluster heads in clustering schemes influence the overall clustering process in terms of stability and lifetime of sensor network. The following are some attributes for differentiating the clustering schemes.

2.3.1 Node Type
At the time of deployment some of the sensor nodes are pre assigned as cluster heads on the basis of more energy, communication and computation resources.

2.3.2 Mobility
The mobility of cluster heads in sensor networks can be assigned on the basis of objectives defined in clustering schemes. If the cluster heads are mobile, we can use this to make balanced cluster for better network performance. Mobile cluster heads can also be relocatable if there is any need in the sensor network.

2.3.3 Role
The role of cluster heads in the sensor networks can act as a relay for the information generated by the cluster members or perform the task of aggregation or fusion of data.

2.4 Cluster Head Selection
Cluster heads can be pre-assigned or picked randomly from the deployed set of nodes [3].

2.4.1 Probability Based
In probability based clustering algorithms, each sensor node uses pre assigned probability to determine the initial cluster heads.
2.4.2 Non Probability Based
In nonprobability based clustering algorithms more specific criteria for cluster head selection and cluster formation are primarily considered which are mainly based on the sensor nodes proximity, connectivity and degree etc.

2.5 Cluster Formation
In cluster formation process the cluster heads will broadcast request packet to the sensor nodes come in radio range to form cluster. In single hop nodes transmits to the cluster head directly and in multi hop all sensor node will send their data through neighbor node. Fig. 1 summarizes the classification of different attributes of clustering in wireless sensor networks.

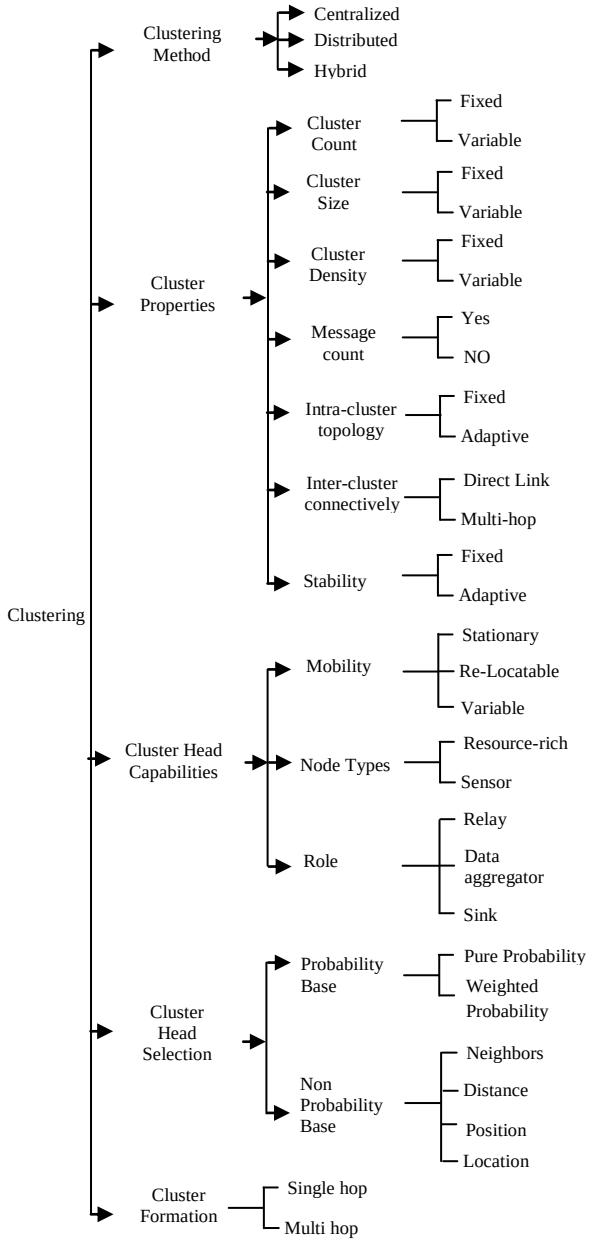

Figure. 1 Classification of the different attributes of clustering in WSNs.

3. CLUSTERING ALGORITHMS AND PROTOCOLS FOR WSN

There are several different ways to distinguish and classify the clustering algorithms used in WSN. Most of the known clustering algorithms for WSNs can be distinguished on the basis of cluster head selection process.

3.1. Probabilistic (random or weighted) clustering algorithms

In the category of probabilistic selection clustering algorithm a priori probability assigned to each sensor node is used to determine the initial cluster heads or other type random selection procedure [36].The probabilities initially assigned to each node often serve as the primary criterion in order to decide individually on their election as cluster heads. However other secondary criteria may also be considered either during cluster head election process i.e. the residual energy, initial energy, average network energy etc. Beyond the high energy efficiency, the clustering algorithms of this category usually achieve faster execution or convergence times and reduced volume of exchanged messages.

3.2. Non probabilistic clustering algorithms

In the category of nonprobabilistic clustering algorithms, more specific criteria for cluster head election and cluster formation are primarily considered. They are mainly based on the sensor nodes proximity, connectivity, position, location and degree etc. They are also depends on the information received from other closely located nodes. This type of algorithms generally requires more exchanges of messages and probably graphs traversing in some extent, thus leading sometimes to worse time complexity than probabilistic or random clustering algorithms. One the contrary, these algorithms are usually more reliable toward the direction of extracting robust and well-balanced clusters. In addition to node proximity, some algorithms also use a combination of metrics such as the remaining energy transmission power, and mobility (forming corresponding combined weights) to achieve more generalized goals than single-criterion protocols.

3.3. Popular Probabilistic Clustering Protocols

- **Energy-Efficient Communication Protocol for Wireless Micro sensor Network (LEACH)**

W. B. Heinzelman et al. [1] proposed first well known clustering protocol LEACH for wireless sensor networks. In this sensors are organized into clusters and randomly select a few nodes as cluster head with a certain probability of becoming a cluster heads per round. The task of being a cluster head is rotated between nodes. The rotation role balances the energy dissipation of the nodes in the networks. LEACH is a distributed algorithm but cluster count (cluster head) is not fixed in each round per epoch. Due to distributed algorithm each node is capable to select itself as a cluster head by choosing random number. There is possibility that each node choose same number for cluster head selection, due to randomness property of random number generator. So cluster head count is varying in each round.

- **An application-specific protocol architecture for wireless microsensor networks (LEACH-C)**

W. B. Heinzelman et al. [2] this protocol uses a centralized approach where the information of node location and energy level was communicated to base station. The base station decides about the cluster head selection and cluster formation. In this protocol the selection of cluster heads is random and the cluster head number is limited. The base station sure those nodes have less energy than it cannot become a cluster head. This protocol is not suitable for large scale network because there is a problem to send the status of a node which are far from the base station. The cluster head role rotates every time so it is not feasible to send information every time in a quick time. It increases the latency and delay.

- **A Stale Election Protocol for Clustered Heterogeneous Wireless Sensor Networks (SEP)**

Georgios S. et al. [4] introduces the heterogeneity that prolongs the time interval before the death of first node called stability period. This protocol is based on the weighted election probabilities of each node to become cluster head according to the remaining energy in each node. In this there are two types of nodes was considered as normal and advanced. This protocol does not require global knowledge of energy at every round to select cluster heads. Authors extended the LEACH protocol except the heterogeneity awareness. Cluster count is variable in this algorithm and also unstable period is not good.

- **Hybrid Energy-Efficient Distributed Clustering (HEED)**

O. Younis et al. [5] improves the LEACH protocol by using residual energy, node degree or density as a main parameters for cluster formation to achieve power balancing. This protocol was proposed with three main parameters: First parameter is to enhance network lifetime by distributing energy consumption, second clustering terminates within a fixed number of iterations third minimum control over head and fourth the cluster heads was well distributed. The algorithms proposed in this protocol periodically selects cluster heads based on the two basic parameters. The first primary parameter is the residual energy of each node; second parameter is the intra-cluster communication cast as a function of cluster density or node degree. The primary parameter selects initial set of cluster heads probabilistically which secondary parameter is breaking ties. HEED is not able to fix the cluster count in each round and it is also not aware of heterogeneity.

- **Distributed Energy Efficient Hierarchical Clustering for Wireless Sensor Network (DWEHC)**

P Ding et al. [6] proposed a distributed weight based energy efficient hierarchical clustering protocol which aims at high energy efficiency by generating balanced cluster sizes and optimizing the intra cluster topology. Each sensor node calculates its weight after finding the neighboring nodes in its area. The weight is a function of the sensors residual energy and the proximity to the neighbors. In a neighborhood, the node with largest weight would be elected as a cluster head and the remaining nodes become members. At this stage the nodes are considered as first level members because they have a direct link to the cluster head. A node progressively adjusts such membership to reach a cluster head using the least amount of energy. Basically, a node checks with its non-CH neighbors to find out their minimal cost for reaching a cluster head. Given the node's knowledge of the distance to its neighbors, it can reach the cluster head over a two-hop path. The protocol is not performing well in term of stability period due to huge amount of energy consumed in neighbors finding.

- **Distributed Energy Efficient Clustering Algorithm for Heterogeneous Wireless Sensor Networks (DEEC)**

Li Qing et al. [8] proposed a distributed multilevel clustering algorithm for heterogeneous WSN. In DEEC the cluster heads are selected by a probability based on the ratio between residual energy of each node and the average energy of the network. The approach of being cluster heads for nodes are different according to their initial and residual energy. The authors have assumed that all the nodes of the sensor network are equipped with different amount of energy. Two levels of heterogeneous nodes are considered in the algorithm and after that a general solution for multi-level heterogeneity is obtained. To avoid that each node needs to know the global knowledge of the networks, DEEC estimates the ideal value of network life-time, which is used to compute the reference energy that each node should expend during a round. Cluster count is variable in this approach lead to uneven clusters.

- **Distributed Energy Balance Clustering Protocol for Heterogeneous Wireless Sensor Networks (DEBC)**

Changmin D et al. [9] proposed a protocol for heterogeneous wireless sensor network. The selection of cluster heads depends on the probability based on radio between residual energy of node to the average energy of network. The high initial and residual energy nodes have more chances to become cluster heads then the nodes have low energy. This protocol improves the LEACH and SEP protocol by considering two level heterogeneity and extends up to multihop heterogeneity.

- **An unequal cluster-based routing protocol in wireless sensor networks (UCR)**

Guihai chen. et al. [11] proposed a protocol for mitigating the hot spot problem in WSNs. It is designed for source driven sensor network applications, such as detection of periodical data from environment. It is a self organized competition based algorithm, where selection of cluster heads based on local information as residual energy of neighboring nodes. The cluster heads closer to base station are expected to have smaller cluster sizes, than those for their from the base station, thus the cluster heads will consume lower energy during the intra cluster data processing and can presume some more energy for the inter cluster relay traffic. The protocol is accomplish the cluster head selection procedure in two phase, which is time consuming and cluster size is uneven due to variable cluster count.

- **Cluster-based Service Discovery for Heterogeneous Wireless Sensor Networks (C4SD)**

R.S. Marin et al. [12] developed a protocol (C4SD) for heterogeneous WSNs that rely on a clustering structure that offers distributed storage of service descriptions. In this protocol, each node is assigned a unique hardware identifier and weight. If any node has higher capability must be selected for cluster head role. These nodes act as a distributed directory of service registrations for the nodes in the cluster. The basic structure ensures low construction and maintenance overhead, reacts rapidly to topological changes of the sensor network by making decisions based only on the 1-hop neighborhood information and avoids the chain reaction problems. A service lookup results in visiting only the directory nodes, which ensures a low discovery cost.

- **An Improved LEACH protocol for application specific wireless sensor network (Improved LEACH)**

Chong Wang et al. [17] suggested a protocol to save energy cost induced due to redundant nodes and balancing the energy consumption among sensor nodes by splitting large cluster into smaller ones. According to author large clusters are split into smaller ones using the mechanism sub cluster head. By using this, the data frame will be smaller, thus the number of frame received by BS will be increasing during the same time. Another make improvement in redundant nodes keeps asleep for most of time. In other words, only one node of them is needed which the others can keep asleep until the first one exhaust with the energy. In such a way the network lifetime is extended. The proposed protocol leads to unequal sized cluster due to variable cluster count.

- **Energy Efficient Heterogeneous Clustered Scheme for Wireless Sensor Networks (EEHC)**

D. Kumar et al. [18] proposed a distributed cluster head election scheme for heterogeneous WSNs. The election of cluster heads is based on different weighted probability. The cluster's member nodes communicate with the elected cluster head and then cluster heads communicate the aggregated information to the base station. The authors have considered three types of nodes. Authors have proposed the different threshold for each type of nodes. This guarantees that each type of node become cluster head according to their weighted probability. The proposed protocol leads to unequal sized cluster due to variable cluster count.

- **Stochastic Distributed Energy Efficient Clustering for Heterogeneous Wireless Sensor Networks (SDEEC)**

B. Elbhiri et al. [19] extended the DEEC protocol as the stochastic strategy is the key idea where the number of transmission intra clusters is reduced. This strategy is used when the objective is to collect the maximum or minimum data values like temperature, humidity etc in a region of the network. Thus the cluster head selects pertinent information between those received and send it to the base station. In this case, if the clusters head receives only from nodes with significant information and the others node must be in sleep mode. It is an application specific protocol.

- **Stochastic and Balanced Distributed Energy Efficient Clustering (SBDEEC)**

Elbhiri Brahim et al. [20] proposed a protocol that permits to balance the cluster head selection overall network nodes following their residual energy. So, the advanced nodes are largely solicited to be selected as cluster heads for the first transmission rounds, and when their energy decreases sensibly, these nodes will have the same cluster head selection probability like the normal nodes. The other key idea in of this protocol is to better reduce the intra clusters transmission when the objective is to collect the maximum or minimum data values in a region like temperature humidity etc.

- **Distributed Cluster Head Election Scheme for Improving Lifetime of Heterogeneous Sensor Network and Applications (DCHE)**

Dilip Kumar et al. [21] proposed a distributed cluster head election scheme for heterogeneous WSNs. The election of cluster heads is based on different weighted probability. The cluster's member nodes communicate with the elected cluster head and then cluster heads communicate the aggregated

information to the base station. Authors have considered three different types of nodes and all have different threshold. The weight assigned to each node will decide the selection of cluster head for each type. Simulation results show that the DCHE scheme offers a better performance in terms of lifetime and stability than LEACH, DEEC and Direct Transmission.

- **Energy Efficient Scheme for Clustering Protocol Prolonging Lifetime of Heterogeneous Wireless Sensor Networks (TDEEC)**

Parul Saini et al. [22] proposed an energy efficient cluster head election scheme for heterogeneous WSNs. The author have adjusted the value of the threshold, according to which a node decide to become a cluster head or not, based on the ratio of residual energy and average energy of that round in respect to the optimum number of cluster heads. Two level and three levels of heterogeneous nodes are considered in the algorithm and after that a general solution for multilevel heterogeneity is proposed. It requires the average network energy for cluster head selection, which is more energy consumable.

- **Developed Distributed Energy-Efficient Clustering for Heterogeneous Wireless Sensor Networks (DDEEC)**

Elbhri et al. [23] proposed a developed distributed energy efficient clustering scheme for heterogeneous WSNs. DDEEC is based on DEEC scheme, where all nodes use the initial and residual energy level to define the cluster heads. In this protocol each node needs to have the global knowledge of the networks, DDEEC like DEEC estimate the ideal value of network lifetime, which is used to compute the reference energy that each node should expend during each round. In this scheme, the network is organized into a clustering hierarchy, and the cluster heads collect measurements information from cluster nodes and transmit the aggregated data to the base station directly. Moreover, the authors have supposed that the network topology is fixed and no-varying on time. The difference between DDEEC and DEEC is localized in the expressions which define the probability to be a cluster head for normal and advanced nodes.

- **An Energy Efficient Clustering Scheme for Self-Organizing Distributed Wireless Sensor Networks (EECS)**

Kyung Tae Kim et al. [25] developed an energy efficient clustering scheme based on the concept of weighted probability function for the election of cluster head. In this probability function three parameters are considered. The first parameter is the energy possession rate which is the initial energy Vs current energy. The second one is the individual round which is the time, it takes for the cluster head to be selected and the cluster head aggregate the received data from the member nodes and then transmit the fused information to the base station. Third one is the count that the node had been selected as the cluster head. It mitigates the problem of the decrease in remaining energy of the node as time process by using the above parameters. The proposed protocol take more time for clustering and unequal sized clusters is formed in sensing area.

- **Mobile Nodes Based Clustering Protocol for Life Time Optimization in Wireless Sensor Network: (MNCP)**

Babar Nazir et al. [26] proposed an algorithm that uses mobile nodes to fill the gap formed by any energy hole or hot spot. The mobile nodes can move any where if any cluster is suffering from the cluster head selection problem due to low residual energy. Any cluster that has the problem of cluster head selection send a message for mobile node in the nearly area. Any nearest mobile node of maximum energy will be activated and move to that reignited cluster. In that way we can use the energy in a balanced way through the network and increase the lifetime of the sensor network.

- **Improved and Balanced LEACH for Heterogeneous Wireless Sensor Networks (IBLEACH)**

Ben Alla Said et al. [27] proposed an improved and balanced LEACH which is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network. In the scheme, some high energy nodes called NCG nodes (normal node/cluster head/gateway) become cluster heads to aggregate the data to their cluster members and transmit it to the chosen gateways that requires the minimum communication energy to reduce the energy consumption of cluster head and decrease probability of failure nodes.

- **Energy Consumption and Lifetime analysis in Clustered Multi-hop Wireless Sensor Networks Using the Probabilistic Cluster-Head Selection Method (ECLCM)**

J. Choi et al. [30] developed an energy model to estimate the energy consumed in a multihop WSN clustered with probabilistic cluster head selection. Each sensor node selects itself as a cluster-head with a predefined probability without any information exchange with other nodes. Each cluster-head advertises itself as a cluster-head to other nodes within its radio range. Each node receives advertisements during a certain period from the arrival of the first received advertisement, and then chooses a cluster-head with the smallest number of hops from it and advertises its cluster-head to other nodes within its radio range. If cluster heads with the smallest number of hops from a sensor node are more than two, then the node randomly selects one of them. This repeats until each node selects its cluster-head or become a cluster-head. All nodes communicate according to TDMA schedules organized by the cluster-heads or the sink node. Thus, data collision can be prevented. The proposed protocol leads to unequal sized cluster due to variable cluster count. Multi hopping lead to network holes near to base station.

- **Weighted Election Protocol for Heterogeneous Wireless Sensor Networks (WEP)**

Md. G. Rashed et al. [31] developed an energy efficient protocol (WEP) to enhance the stability period of sensor network. Author introduces a clustering scheme with a chain routing algorithm to enhance the energy and stable period constraints. In this a weight is assigned to the optimal probability for each node. This weight must be equal to the ratio between initial energy of each node to the initial energy of the normal node. After assigning weighted probability, the cluster heads and cluster number are selected in the same way as in LEACH protocol. By using the algorithm a chain among the selected cluster heads have been constructed. After this from the selected cluster heads, a chain leader is selected randomly. All non cluster head nodes send their data to their respective cluster head nodes. The cluster head nodes in each cluster then fused the data and send it to base station.

- **Energy Efficient Cluster Based Data Aggregation for Wireless Sensor Networks (ECBDA)**

Siva R. et al. [33] propose a data aggregation method to enhance the network lifetime. In ECBDA cluster formation phase is used to split the network into set of cluster. *K* clusters are formed in each layer then each layer is divided into a set of clusters. In Cluster Head election process, one node is selected as cluster head from each cluster by using its residual energy and the communication cost factor. Once a node is elected as a cluster head, it broadcasts the cluster head message to its cluster members, other cluster heads and base station. Data forwarding is performed in the third phase. In the Data aggregation phase, all cluster members send its sensed data during its allotted time slot. The cluster head waits until its TDMA frame ends. After receiving its data from its entire cluster member, cluster head starts the aggregation process. Each cluster head eliminates the duplicates and forwards the packet to BS via the forwarding nodes. Maintenance phase checks the cluster head's residual energy at each round. If the residual energy is less than the required threshold value, a new cluster head is elected from the same cluster. Re-clustering is also performed in the maintenance phase. The proposed protocol leads to small sized cluster which lead to more amount of data transfer form cluster head to base station it is energy consumable.

- **A Density Control Energy Balanced Clustering Technique for Randomly Deployed Wireless Sensor Network (DCEBC)**

Sanjeev Kumar Gupta et al. [34] developed a protocol to enhance the life time of heterogeneous wireless sensor networks. In this paper authors select cluster heads based on probability threshold and current energy level. Authors also work on redundant node identification and deactivation. DCEBC achieves longer lifetime and stability period.

3.4. Popular Non Probabilistic Clustering Protocols

- **Designing Efficient Routing Protocol for Heterogeneous Sensor Network (HSR)**

Xiaojiang Du et al. [7] Considers heterogeneous sensor networks by deploying a small number of powerful high end sensors with large number of low end sensors. In this each sensor node is static and aware of its own location. As both types of sensors are uniformly and randomly distributed in the network. In cluster formation process nodes select the cluster heads based on the signal strength. The cluster heads send the data to the sink via multi hop transmission over cluster heads. The proposed approach is static which will not suitable for many applications.

- **Traffic Based Clustering in Wireless Sensor Network (TBC)**

Vijay Kr. Chaurasiya et al. [13] proposed an approach to create a system which will adopt a topology (size of cluster and number of hierarchal level) in accordance with the traffic patterns and density of sensor nodes deployed in a given area of interest. In multi hopped network load on the cluster head near the base station will be more as compared to farther cluster heads as the proximity cluster head have to do the dual work of collecting data from its own cluster and also to forward data from distant cluster heads. Therefore this situation may result in dying out of nearest cluster heads sooner than distant cluster heads. It will result in failure of sensor network as a whole. Therefore, authors have suggested that to construct a network topology based on the node density in different regions of the overall area covered by the network. This will avoid bottleneck problem and may result in long life of the network by proper load balancing. The proposed protocol degrades the energy of long distance sensor nodes early than nearer sensor nodes.

- **A probability Driven Unequal Clustering Mechanism for WSNs (PRODUCE)**

Jung-Hwan et al. [14] proposed a distributed and randomized clustering algorithm that organizes the network with unequal sized clustering. It determined with localized probabilities and multihop routing based on stochastic geometry. In this algorithm, distance clusters which are far from the BS have larger cluster sizes and closer cluster have smaller cluster sizes. For the selection of cluster head in cluster a different probability assigned on each level. The proposed protocol leads to unequal sized cluster due to variable cluster count.

- **Energy and Distance Based Clustering: An Energy Efficient Clustering Method for WSN (EDBC)**

Mehdi Saeidmanesh et al. [15] proposed a protocol which considers the residual energy and distance from the base station of each node in the cluster head selection process. If all sensor nodes are distributed in large area some clusters are far from the base station and others are close to base station. This can lead a great difference in transmission energy dissipations that the nodes use transmits data to base station. In this author has divided the whole of the network terrain into concentric circular segments around the base station. The number of cluster heads in each segment is different from the other segments in terms of distance from the base station. The cluster head election probability in closer segments is more than distant segments and the number of cluster heads in these segments is more.

- **Distributed Clustering Algorithms with Load Balancing in Wireless Sensor Network (DCLB)**

Farruh Ishmanov et al. [16] evaluated distributed clustering with load balancing for forming cluster efficiently and balancing load in inter cluster communication cluster. Size (range) is important in terms of energy efficiency and balancing load in multi hop communication of cluster heads. Since it determine data volume in every step of clustering to avoid energy inefficiency and balanced load of cluster. It forms cluster with different sizes in each step. The proposed protocol leads to unequal sized cluster due to variable cluster count.

- **A Density and Distance Based Cluster Head Selection Algorithms in Sensor Networks (DDCHS)**

Kyounghwa Lee et al. [24] proposed an algorithm to elect the cluster head based on density and distance of sensor nodes in the sensor network. In this the cluster area is divided into two perpendicular diameters to get four quadrant, then in each quadrant, select following cluster head by group's node density and distance from the cluster head. Author have compared with LEACH and HEED protocols by calculating the energy consumption for communication of once between whole nodes and cluster head by position of cluster. This protocol shows better performance than LEACH and HEED. It is centralized approach and need location of each node.

- **An Energy Efficient Clustering Scheme with Self-organized ID Assignment for Wireless Sensor Networks (EECSIA)**

Qingehao Zheng et al. [28] proposed a distributed clustering scheme that considers both energy and topological features of a WSN. EESCIA enables an efficient solution to handling large-scale networks in assigning unique IDs to sensor nodes, reducing communication expenses and extending the network lifetime. EECSIA is fast and locally scalable, and it achieves a good distribution of cluster heads within the networks. Further-more, as nodes are energy constrained, frequently receiving data from common nodes and forwarding them to base station will consume a large amount of energy on cluster heads. EECSIA has avoided this problem, and it can achieve re-clustering within constant time in a local manner. Message communication is very large for cluster head selection which is more energy consumable.

- **Fault Tolerant Energy Efficient Distributed Clustering for WSN (FEED)**M. Mehrani et al. [29] proposed an energy efficient clustering method, which select suitable cluster heads by using energy, density, centrality and the distance between nodes for making cluster. Authors have taken a supervisor node for every cluster head which is to be its replacement when the cluster head fails. This property causes an increase in network lifetime and also helps the network to be fault tolerant. It requires the global position of sensor nodes and message communication is very large in cluster head selection, which is costly and energy consumable respectively.

- **A location Based Clustering Algorithm for Wireless Sensor Networks (LBS)**

Ashok Kumar et al. [32] proposed a protocol to prolong the lifetime of sensor network. The clusters are formed only once during the lifetime of sensor network. Cluster heads rotation depends on the residual energy of a cluster heads. The rotation frequency timing of cluster head is based on energy consumption of sensor nodes for various tasks performed by them during the lifetime of sensor network. This ensures balanced energy consumption of all sensor nodes present in a cluster, resulting in prolonged network lifetime. The proposed protocol is static in nature, cluster head selection procedure is not well in term of energy consumption. Load balancing is unevenly distributed, so all these lead to poor stability period.

- **Node degree based clustering for WSN.**

Sanjeev Kumar Gupta et al. [35] propose Node Degree Based Clustering (NDBC) for enhancing life time of heterogeneous WSNs. In this paper, authors use two types of sensor nodes, i.e., advanced and normal nodes. Advance nodes are having more energy than normal nodes. The advanced nodes are selected as cluster head based on its energy and node degree in the network. Using NDBC authors have reduced communication cost among sensor nodes used for transmitting and receiving the messages for cluster head selection.

4. CONCLUSION

Clustering is a technique to reduce energy consumption and to provide stability in wireless sensor networks. For heterogeneous wireless sensor networks, several clustering protocols are proposed. Most of the recent energy efficient clustering protocols designed for sensor networks are based on residual energy, average energy, location, density etc. which are effective in energy saving. We surveyed energy efficient clustering protocols based on cluster head selection techniques, i.e. probability based and nonprobability based. We observe that many probabilistic clustering approach lead to variable cluster count and variable cluster size. In this type of clustering approaches network hole is created. In the nonprobability clustering approach cluster count and cluster size is optimum but it require more number of message transmission for cluster head selection, which is very energy consumable. Table 1 shows the comparison between various clustering protocols used in wireless sensor networks.

Table 1. Comparison of the Clustering Protocols for Wireless Sensor Networks

Clustering Approach	Node Deployment Uniform / Random	Heterogeneity (Y/N)	Heterogeneity Level	Clustering Method Distributed (D)/ Centralized (C) /Hybrid (H)	Location Awareness (Y/N)	Cluster Head Mobility Fixed (F)/ Mobile (M)	Clustering Properties						CH Selection based On				
													Probability Based		Non Probability Based		
							Cluster Count Variable (V) /Fixed (F)	Cluster Size Variable (V) /Fixed (F)	Cluster Density Variable (V) /Fixed (F)	Message Count Yes (Y) /NO (N)	Intra-cluster Topology	Connectivity of CH to BS	Pure Probability (Y/N)	Weighted Probability(Y/N)	Neighbor (Y/N)	Distance (Y/N)	Location (Y/N)
LEACH [1]	Random	N	-	D	N	F	V	V	V	N	Single Hop	Direct Link	Y	-	-	-	-
LEACH-C [2]	Random	N	-	C	N	F	V	V	V	N	Single Hop	Direct Link	Y	-	-	-	-

SEP [4]	Random	Y	Two	D	N	F	V	V	V	N	Single Hop	Direct Link	-	Y	-	-	-
HEED [5]	Random	N	-	D	N	F	V	V	V	N	Single Hop	Direct Link	Y	-	-	-	-
DWEHC [6]	Random	N	-	D	N	F	V	V	V	N	Single Hop	Direct link	-	Y	-	-	-
HSR [7]	Random	Y	Two	D	Y	F	V	V	V	Y	Multi Hop	Multi Hop	-	-	-	Y	-
DEEC [8]	Random	Y	Two/ Multi	D	N	F	V	V	V	N	Single Hop	Direct Link	-	Y	-	-	-
DEBC [9]	Random	Y	Two/ Multi	D	N	F	V	V	V	N	Single Hop	Direct Link	-	Y	-	-	-
UCR [11]	Random	N	-	D	N	F	V	V	V	N	Single Hop	Multi Hop	Y	Y	-	-	-
C4SD [12]	Random	Y	Multi	D	Y	M	V	V	V	N	Multi Hop	Multi Hop	-	Y	-	-	-
TBC [13]	Random	N	-	D	Y	F	V	V	V	Y	Multi Hop	Multi Hop	-	-	Y	Y	
PRODUCE [14]	Random	N	-	D	Y	F	V	V	V	Y	Single Hop	Direct Link	-	-	-	Y	-
EDBC [15]	Random	N	-	D	Y	F	V	V	V	Y	Single Hop	Direct Link	-	-	-	Y	-
DCLB [16]	Random	N	-	C	Y	F	V	V	V	Y	Single hop	Multi Hop	-	-	Y	-	Y
Improved LEACH [17]	Random	N	-	D	N	F	V	V	V	N	Single Hop	Direct Link	Y	-	-	-	-
EEHC [18]	Random	Y	Three	D	N	F	V	V	V	N	Single Hop	Direct Link	-	Y	-	-	-
SDEEC [19]	Random	Y	Two	D	N	F	V	V	V	N	Single hop	Direct Link	-	Y	-	-	-
SBDEEC [20]	Random	Y	Two	D	N	F	V	V	V	N	Single Hop	Direct Link	-	Y	-	-	-
DCHE [21]	Uniform	Y	Three	D	N	F	V	V	F	N	Single Hop	Direct Link	-	Y	-	-	-
TDEEC [22]	Random	Y	Two/ Multi	D	N	F	V	V	V	N	Single Hop	Direct Link	-	Y	-	-	-
DDEEC [23]	Random	Y	Two	D	N	F	V	V	V	N	Single Hop	Direct Link	-	Y	-	-	-
DDCHS [24]	Random	N	-	D	Y	F	V	V	V	Y	Single Hop	Direct Link	-	-	Y	Y	-
EECS [25]	Random	N	-	D	N	F	V	V	V	N	Single Hop	Direct Link	-	Y	-	-	-
MNCP [26]	Random	N	-	D	N	M	V	V	V	N	Single Hop	Direct Link	-	Y	-	-	-
IB-LEACH [27]	Random	N	-	D	N	F	V	V	V	N	Single hop	Direct Link	Y	-	-	-	
EECSIA [28]	Random	N	-	D	N	F	V	V	V	Y	Single Hop	Direct Link	-	-	Y	-	-
FEED [29]	Random	N	-	D	N	F	V	V	V	Y	Single Hop	Direct Link	-	-	Y	-	-
ECLCM [30]	Random	N	-	D	N	F	V	V	V	N	Multi Hop	Multi Hop	Y	-	-	-	-
WEP [31]	Random	Y	Two	D	N	F	V	V	V	N	Single Hop	Direct Link	-	Y	-	-	-
LBC [32]	Random	N	-	C	Y	F	F	F	V	Y	Single Hop	Direct Link	-	Y	-	-	Y
ECBDA [33]	Random	N	-	H	N	F	V	V	V	N	Single Hop	Multi Hop	-	Y	-	-	-
DCEBC [34]	Random	Y	Two	D	N	F	V	V	V	N	Single Hop	Single Hop	-	Y	Y	-	-
NDBC [35]	Random	Y	Two	D	N	F	F	V	V	Y	Multi Hop	Single Hop	-	-	Y	-	-

5. REFERENCES

[1] W. Rabiner Heinzelman and H. Balakrishnan, 2000. Energy-Efficient communication Protocol for Wireless microsensor networks, IEEE, Proceeding of the 3rd Hawali International Conference on System Science.

[2] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, 2002. An application specific protocol architecture for wireless microsensor networks, IEEE Transactions on Wireless Communications.

[3] I.F. Akyildiz et al. 2002. Wireless sensor networks: a survey, Computer Network.

[4] Georgios Smaragdakis and Ibrahim Matta, 2004. SEP: A Stable Election Protocol for Clustered Heterogeneous Wireless Sensor Networks.

[5] O. Younis, S. Fahmy, 2004. HEED: A Hybrid, Energy-Efficient, Distributed clustering approach for Ad Hoc sensor networks, IEEE Transactions on Mobile Computing.

[6] P. Ding, J. Holliday, 2005. A. Celik, Distributed energy efficient hierarchical clustering for wireless sensor networks, In: Proceedings of the IEEE International Conference on Distributed Computing in Sensor Systems (DCOSS'05).

[7] Xiaojiang Du and Fenging Lin, 2005. Designing Efficient Routing Protocol for Heterogeneous Sensor Network, IEEE, Performance, Computing and Communication conference.

[8] L. Qing, Q. Zhu, M. Wang, 2006. Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks, In ELSEVIER, Computer Communications.

[9] Changmin Duan, 2007. A Distributed Energy Balance Clustering Protocol for Heterogeneous Wireless Sensor Networks, IEEE WiCon,

[10] A.A. Abbasi and M. Younis, 2007. A survey on clustering algorithms for wireless sensor network, Computer Communication.

[11] Guihai Chen · Chengfa Li, 2007. An unequal cluster-based routing protocol in wireless sensor networks, Springer Science Business Media, LLC.

[12] R.S. Marin-Perianu and J. Scholten, 2007. Cluster-based service discovery for heterogeneous wireless sensor networks, International Journal of Parallel, Emergent and Distributed Systems.

[13] Vijay Kr. Chaurasiya and S. Rahul Kumar, 2008. Traffic Based Clustering in Wireless Sensor Network, IEEE WCSN.

[14] Jung-Hwan Kim and Chauhdary Sajjad Hussain, 2008. PRODUCE: A Probability-Driven Unequal Clustering Mechanism for Wireless Sensor Networks, IEEE, 22nd International Conference on Advanced Information Networking and Applications – Workshops, WAINA.

[15] Mehdi Saeidmanesh and Mojtaba Hajimohammadi, 2009. Energy and Distance Based Clustering: An Energy Efficient Clustering Method for Wireless Sensor Networks, World Academy of Science, Engineering and Technology.

[16] Farruh Ishmanov and Sung Won Kim,2009. Distributed Clustering Algorithm with Load Balancing in Wireless Sensor Network, IEEE World Congress on Computer Science and Information Engineening.

[17] Chong Wang and Jiakang Liu, 2009. An Improved LEACH Protocol for Application Specific Wireless Sensor Networks, IEEE: WiCOM 09 Proceedings of the 5th International Conference on Wireless Communication Networking and Mobile Computing.

[18] D. Kumar, 2009. Energy Efficient Heterogeneous Clustered Scheme for Wireless Sensor Networks, In Elsevier Computer Communications.

[19] B. Elbhiri and R. Saadane, 2009. Stochastic Distributed Energy-Efficent Clustering (SDEEC) for heterogeneous wireless sensor networks.

[20] Elbhiri Brahim and Saadane Rachid,2009. Stochastic and Balanced Distributed Energy-Efficient Clustering (SBDEEC) for heterogeneous wireless sensor networks**,** Signal Processing and communications group UPC.

[21] Dilip Kumar and Trilok C.,2010. Distributed Cluster Head Election (DCHE) Scheme for Improving Lifetime of Heterogeneous Sensor Networks, Tamkang Journal of Science and Engineering.

[22] Parul Saini, Ajay K Sharma, 2010. Energy Efficient Scheme for Clustering Protocol Prolonging the Lifetime of Heterogeneous Wireless Sensor Networks, International Journal of Computer Applications.

[23] Elbhiri B. and R. Saadane, 2010. Developed Distributed Energy-Efficient Clustering (DDEEC) for heterogeneous wireless sensor networks, In IEEE I/V Communications and Mobile Network (ISVC).

[24] Kyounghwa Lee and Hyeopgeon Lee, 2010. A Density and Distance based Cluster Head Selection Algorithm in Sensor Networks, IEEE, ICACT.

[25] Kyung Tae Kim and Han Ku Yoo, 2010. EECS: An Energy Efficient Cluster Scheme In Wireless Sensor Networks, IEEE International Conference on Computer and Information Technology.

[26] Babar Nazir and Halabi Hasbullah, 2010. Mobile Nodes based Clustering Protocol for Lifetime Optimization in Wireless Sensor Network, In: International Conference on Intelligent and Information Technology.

[27] Ben Alla Said and EZZATI Abdellah, 2010. Improved and Balanced LEACH for Heterogeneous Wireless Sensor Networks.

[28] Qingchao Zheng, 2010. An Energy Efficient Clustering Scheme with Self-Organized ID Assignment for Wireless Sensor Networks, Parallel and Distributed Systems (ICPADS), 2010 IEEE 16th International Conference.

[29] Mehrani, M., 2010. FEED: Fault tolerant, energy efficient, distributed Clustering for WSN, IEEE, Advanced Communication Technology (ICACT).

[30] Jinchul Choi and Chaewoo Lee, 2011. Energy consumption and lifetime analysis in clustered multi-hop wireless sensor networks using the probabilistic cluster-head selection method, EURASIP Journal on Wireless Communications and Networking.

[31] Md. Golam Rashed and M. Hasnat Kabir, 2011. WEP: an Energy Efficient Protocol for Cluster Based Heterogeneous Wireless Sensor Networ, International Journal of Distributed and Parallel Systems (IJDPS).

[32] Ashok Kumar and Narottam Chand, 2011. Location Based Clustering in Wireless Sensor Network, World Academy of Science, Engineering and Technology.

[33] Siva Ranjani. S and Radha Krishnan.S, 2012. Energy-Efficient Cluster Based Data Aggregation for Wireless Sensor Networks, IEEE Recent Advances in Computing and Software Systems (RACSS).

[34] Sanjeev Kumar Gupta, Neeraj Jain and Poonam Sinha, 2012. A Density Control Energy Balanced Clustering Technique for Randomly Deployed Wireless Sensor Network, IEEE WOCN 2012 Conference.

[35] Sanjeev Kumar Gupta, Neeraj Jain and Poonam Sinha, 2012. Node Degree Based Clustering for WSN, International Journal of Computer Applications (IJCA).

[36] Yan Zhang, Laurence T. Yang & Jiming Chen, 2010, RFID and Sensor Networks, auerbach publication, International Standard Book Number:978-1-4200-7777-3