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Enhancement of Network-Lifetime through Clustering in Heterogeneous Wireless Sensor Network: A Survey

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Abstract: Energy is one of the scarcest resources in the wireless sensor networks. Most important fact about the energy conservation is deployment of sensor nodes with in network area, so energy which used in network remains balanced throughout the whole network. Clustering algorithm is a kind of key technology used to increase energy efficiency. It can be used to enhance the lifetime and stability period (death of first node) of network by consuming minimum amount of energy. Energy efficient protocol used to characterize the heterogeneous wireless sensor network. It is observed that energy imbalance in wireless sensor networks occurs due to relaying of data from different parts of network towards the sink node, so for improved energy balance instead of using only sensor nodes it is necessary to deploy node with some extra energy with normal sensor nodes to manage such imbalance. In this paper we have survey the previous techniques used for enhancement of energy consumption.

Keywords: wireless sensor networks, connectivity, coverage, node deployment, stability period, energy balance, network lifetime.

I. INTRODUCTION

In recent research advancement in wireless sensor and micro-controllers enable a new wide area monitoring paradigm commonly known as wireless sensor network. In wireless sensor network hardware enabled to have deployment of small sensor nodes having limited signal processing , low power and wireless communication capacities. Wireless sensor networks uses sensor nodes in various environmental conditions to sense the event that occurred around the sensing field [2]. Such as environment monitoring, smart offices, military surveillance and transportation traffic monitoring to perform in efficient way. In order to achieve high performance, low fault tolerant and low energy consumption nodes are deployed randomly in interested area or very close to it. In wireless sensors networks power consumption can be a crucial task [7], low power consumption mainly required to enhance the network lifetime. In wireless sensor networks, the hierarchical routing tree is maintained to when each node selects its parent (CH node) and children (non-CH node).Wireless sensor networks can be used in many applications such as health monitoring, Environment, habitat monitoring and in the military application to inform troops about the dangerous areas in military surveillance range. Communication in wireless can be explained in the three ways. These are Time Driven, Query Driven, and Event Driven. Time driven approach is used to transfer and receive data on timely basis.

Event Driven approach is used to inform the sink node or CH node about an event occurred in the sensing field. Query driven is used to make a request about the required information from CH or sink node.

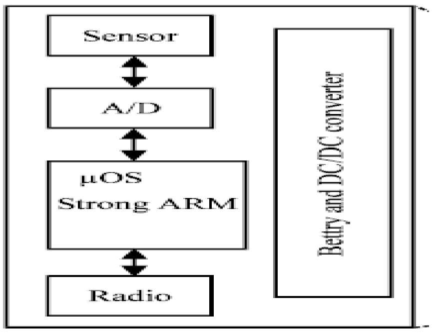

Fig.1:Sensor Node Architecture

In wireless sensors networks clustering techniques are used to enhance the lifetime of the sensor network. In clustered network sensors node can take their own decision to perform sensing task [8], constructing new topology and routing data toward a particular area. In clustering nodes assembles themselves in form of clusters and in which one node acted as CH, all other nodes called non-Ch nodes have to sense data and transmit data to CH and then CH aggregate data and transmit the aggregated data to sink node.

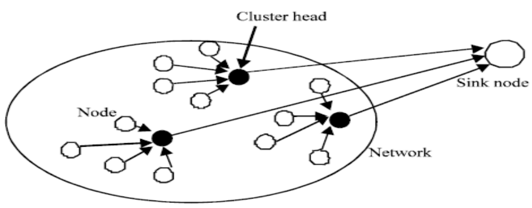

Fig.2: Example of Node Clustering in WSN

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Clustering has numerous advantages which explained as follows:

1. Clustering reduces the size of routing table stored at the individual nodes by localizing the route set up within the cluster.
2. Clustering helpful in removing redundant exchange of messages among sensor nodes.
3. CH can prolong battery life by using energy efficient techniques.
4. A CH can perform data aggregation in its cluster and decrease the number of redundant packets.
5. A CH can reduce the rate of energy consumption by scheduling activities in the cluster.

II. NODE-CLUSTERING ALGORITHM

Recently, researchers have devoted considerable attention to node-clustering algorithms because of their ability to prolong the lifetime of WSNs. All the necessary terms involved in designing node-clustering algorithms are explained in this section.

Homogeneous vs. heterogeneous: In a homogeneous network, all nodes in the WSN have the same storage, computation, communication, sensing and energy capabilities. The communication links between the sensor nodes are symmetric. As a result, in such a network, a pair of neighboring sensors can communicate directly; otherwise, the network is the heterogeneous. The combination of both is called a hybrid network. The heterogeneous network is a fair assumption for practical implementations.

Optimum number of clusters: The number of clusters required in a network is closely related to achieving optimal energy consumption. In some published approaches, the set of CHs is predetermined and thus the number of clusters is preset. Randomly picking CHs from the deployed sensors usually yields a variable number of clusters. Typically, use of at least 10 clusters is recommended [3].

Stability: Stability is influenced by how the numbers of clusters in the network are counted. If the cluster counts vary and a node's membership evolves over time, this is called an adaptive scheme. Otherwise, the clustering scheme is called fixed because the number of clusters does not change and sensor nodes do not switch from one cluster to another in the network [1].

Cluster head (CH): The CH acts as a router that receives sensing data from all members of the cluster and transmits data to the sink node using single- or multi-hop data transmission. Multi-hop data transmission is the appropriate technique for sink nodes located far away from the sensing area. Otherwise, single-hop data transmission is better. Sometimes the CH can be designated as a mobile or immobile node [1].

Non-cluster head node: Each node can become the CH in any round. A node that is not selected as the CH becomes a non-CH node which then selects its corresponding cluster based on its signal strength with the current CH.

Transmission range: This term refers to a disk of a given radius, including its boundary and center. Transmission range is usually the threshold that differentiates two kinds of communication schemes in the network, namely free space and multi-path fading models.

Single-hop vs multi-hop: In contrast to multi-hop transmission, data in single-hop mode are transmitted from one node to another without using a third node as a router.

Mobile vs. immobile nodes: A node can either move within the network (mobile node) or be stationary (immobile node).

Figure 3 illustrates all the terminological definitions given above.

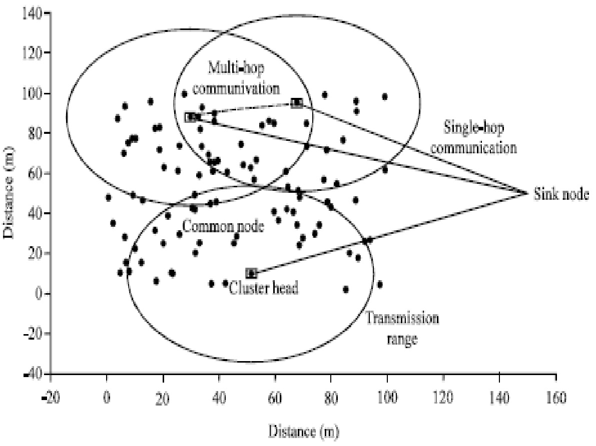

Fig.3: Architecture of a wireless sensor network

III. HETEROGENEOUS WIRELESS SENSOR NETWORKS (HWSNs)

Types of heterogeneous resources: [5] list three types of resource heterogeneity in sensor nodes. The first, computational heterogeneity, means that at least one node contains a more powerful microprocessor and larger memory than a normal node. The second type is known as link heterogeneity and means that at least one heterogeneous node has higher bandwidth and a longer-distance network receiver than a normal node. The third type, energy heterogeneity, means that at least one heterogeneous node is line-powered or that its battery is replaceable. For the most part, energy heterogeneity is the most vital type of resource heterogeneity. A sensor network generally suffers a negative impact when both computational and link heterogeneity have consumed large quantities of energy resources. Therefore, energy heterogeneity must be given top priority when creating a heterogeneous environment in a WSN.

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The impact of heterogeneous resources: The main benefit of a heterogeneous network is extended network lifetime. Average energy consumption can be decreased by forwarding packets from normal nodes to the sink node[6]. In addition, if each hop in the network can significantly reduce its end-to-end delivery time, this can improve the reliability of data transmission because there will be fewer hops between the normal sensor nodes and the sink. Consequently, use of computational or link heterogeneity can decrease the latency of data transfer in the network.

(A) OBJECTIVES OF HETEROGENEOUS CLUSTERING

Nodes are formed into clusters to attain certain objectives, as explained below:

Enhanced network lifetime: The lifetime of the network can be extended by re-energizing the sensor nodes. This will create heterogeneity because some of these nodes are equipped with more energy than the normal nodes already in use. Consequently, all the normal nodes can transmit sensed data to the sink node through the nearest heterogeneous node. This will make the average energy consumption for forwarding data to the sink node much less than in the homogeneous sensor network.

Load balancing: LEACH guarantees, in the homogeneous case, that any unstable region in the network will be of limited size. No such guarantee exists for heterogeneous networks. As a solution, a weighted probability has been introduced to increase the stable region in a network which is implemented as a heterogeneous [7].

Decreasing the latency of data transfer: HWSNs with computational heterogeneity may decrease the processing latency for immediately adjacent nodes. Moreover, if link heterogeneity is implemented in the HWSNs, this will reduce the waiting time in the transmission queue.

Improving the reliability of data transmission: In a heterogeneous network, the number of hops to transmit data from sensor nodes to the sink node is less than in a homogeneous network[6]. For this reason, HWSNs can achieve much higher end-to-end delivery speeds.

(B) CLUSTERING ATTRIBUTES

Clustering attributes are a vital part of categorizing and differentiating the various clustering algorithms which have been proposed for HWSNs. There are three types of attributes of clustering algorithms [1].

Cluster properties: Important cluster attributes include the optimal number of clusters, the stability of the network and the data transmission technique used for intra-cluster or inter-cluster connectivity. Normally, direct communication is selected for nearby data communication and multi-hop data communication for long-distance communication.

Cluster head capabilities and selection: The CH is a particularly powerful node in a clustering algorithm. It can be either mobile or immobile. When a CH is mobile, its cluster's sensor membership changes dynamically and clusters will need to be continually maintained. If the CH is immobile, a good choice of CH yields a stable cluster which facilitates intra- and inter-cluster network management. Each proposed algorithm has its own types of node heterogeneity, as was explained in the previous section. Furthermore, sometimes the CH acts as a data aggregation or relay node. All these tasks vary depending on the network implementation. Finally, the CH selection scheme varies depending on many factors such as the initial, residual and average energy of all the nodes in the network.

Clustering process: The methodology, the objective of node clustering and the cluster-head selection method are important factors that must be considered during the clustering process. For HWSNs, various methodologies can be selected, including adaptive clustering, energy multi-level clustering and stability-oriented clustering. Consequently, the objectives of clustering must be considered with respect to load balancing, network connectivity and similar tasks. Furthermore, a cluster-head selection method is needed to determine the CH using stochastic or deterministic methods or a combination of both.

(C) ENERGY-EFFICIENT NODE-CLUSTERING ALGORITHM FOR HWSNs

Energy consumption model: Energy consumption by the sensor nodes in WSNs can be calculated using the energy model proposed by [3]. The energy consumption for sending k bits of data over a distance d can be calculated using Eq. 1. The distance threshold d_0 will differentiate the type of data communication. The first equation is the free-space model, in which the transmission power is attenuated to d^2 for $d<d_0$. The second equation is the multi-path fading model, in which the transmission power is attenuated to d^4 for $d>d_0$:

$$E_{Tx}(k,d) = \begin{cases} kE_{elec} + k\varepsilon_{friss-amp} d^2 & : d < d_0 \\ kE_{elec} + k\varepsilon_{two-ray-amp} d^4 & : d > d_0 \end{cases} \quad (1)$$

where, $\varepsilon_{friss-amp}$ and $\varepsilon_{two-ray-amp}$ are the two-channel model parameters for the energy needed for power amplification. Consequently, the energy consumed when receiving k bits of data can be calculated using Eq. 2:

$$E_{rx}(k) = E_{Rx-elec}(k) = kE_{elec} \quad (2)$$

where E_{elec} represents the energy consumed in transmitting or receiving a bit of data.

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IV. NODE-CLUSTERING ALGORITHM FOR HWSNs

Node-clustering algorithms are a well-known technique for reducing energy consumption in a sensor network as well as increasing the lifetime of the network. Currently, several types of node-clustering algorithm exist each with different clustering attributes as explained earlier. The following section will discuss some of these techniques.

Energy-efficient stability-oriented clustering: The first design for a heterogeneous WSN was reported by [7]. This study examined the effect of a heterogeneous network with a cluster-based clustering implementation scheme. Furthermore, it reported a simulation of the LEACH routing protocol for heterogeneous WSNs. The LEACH routing protocol was developed for homogeneous network implementation.

According to [7], when the node population starts to decrease, the number of cluster heads chosen per round becomes unstable (fewer than intended) and therefore there is no guarantee that a constant number of cluster heads (equal to nxP_{opt}) will be selected per round per epoch. Consequently, a new clustering algorithm was proposed to increase the stable region and thereby decrease the unstable region and improve the feedback quality of the wireless clustered sensors in the presence of a heterogeneous network. Some percentage of the population of sensor nodes is equipped with additional energy resources; this is a source of heterogeneity which may result from initialization. Hence, two types of nodes, called normal and advanced nodes, were designed. The selection of each cluster head depends on a threshold calculation as shown in Eq. 3 for a normal node and Eq. 4 for an advanced node:

$$T(S_{nrm}) = \begin{cases} \dfrac{Pnrm}{1 - pnrm(rmod\dfrac{1}{pnrm})} & \text{if } S_{nrm} \in G' \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

$$T(Sadv) = \begin{cases} \dfrac{Padv}{1 - padv(rmod\dfrac{1}{padv}} & \text{if } S_{adv} \in G' \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

where, P_{nrm} and P_{adv} are the weighted probabilities for normal and advanced nodes, r is the current round identifier and G' (G") is the set of normal (advanced) nodes that have not become the cluster head. In the clustering process, a normal node (S_{nrm}) or an advanced node (S_{adv}) will choose a random number between zero and one. If the number selected is less than a threshold value T(S), the node becomes a CH for the current round. Otherwise, the node is not selected as a CH, but possibly in the next round it will have a chance to become the new CH. The simulation revealed that network stability was achieved and that the lifetime of the network could have been increased.

Energy-efficient adaptive clustering: In an energy-efficient adaptive clustering algorithm, sensor nodes organize themselves into local clusters, with one node in each cluster acting as the cluster head node. Certain factors must be considered in selecting which node will become the cluster head. Careful selection can prolong the lifetime of the Heterogeneous Wireless Sensor Network(HWSN). [4], and [2] revealed that consideration of the residual and average energy of the network during cluster-head selection can increase the lifetime of the HWSN. Moreover, distance and communication cost attributes can be added to the clustering algorithm to enhance the lifetime of the HWSN.

[4] proposed a clustering algorithm for two-level HWSNs called Distributed Energy-efficient Clustering (DEEC). The first-level nodes are designated as the advanced nodes and the second level consists of the normal nodes. The total initial energy of the HWSN is given by Eq. 5:

$$E_{total} = N(1-m)E_0 + NmE_0(1+a) = NE_0\,(1+am) \quad (5)$$

where, N is the number of nodes, E_0 is the initial energy of the normal nodes and m is the proportion of advanced nodes which possess a times more energy than normal nodes. In addition, a multi-level HWSN was considered and its total initial energy was calculated using Eq. 6:

$$E_{total} = \sum_{i=1}^{N} E_O\,(1 + a_i) = E_O\left(N + \sum_{i=1}^{N} a_i\right) \quad (6)$$

where, a_i is times more energy for node i.

In the clustering algorithm sequence, the nodes were distributed uniformly and one node in each cluster was selected as the cluster head node. The selection of the cluster head was based on the initial and residual energy left in the node at each round. The nodes with high residual energy become cluster heads more often than lower-energy ones. To organize the nodes into an HWSN, a weighted probability equation has been defined for normal and advanced nodes and is stated as Eq. 7 for a two-level HWSN:

$$P_i = \begin{cases} \dfrac{P_{opt}\,E_i\,(r)}{(1+am)\overline{E(r)}} & \text{if } s_i \text{ is a normal node} \\ \dfrac{P_{opt}\,(1+a)E_i(r)}{(1+am)\overline{E(r)}} & \text{if } s_i \text{ is an advanced node} \end{cases} \quad (7)$$

where, p_{opt} is the average probability of becoming a cluster head, $E_i(r)$ is the residual energy of node s_i in round r and $\overline{E(r)}$ is the average energy in round r. The weighted probabilities for multi-level HWSNs are given by Eq. 8:

$$p(S_i) = \frac{p_{opt}N(1 + a_i)E_i(r)}{(N + \sum_{i=1}^{N} a_i)\overline{E(r)}} \quad (8)$$

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The $\overline{E(r)}$ value was estimated to make sure that the DEEC protocol can guarantee that all nodes die at approximately the same time. Each non-cluster head node sends L bits of data per round to the cluster head.
Authors have implemented a similar clustering algorithm concept as a DEEC protocol. Their work showed that consideration of the ratio between remaining energy and the average energy of the network can extend the lifetime of the wireless network.
Incorporation of energy into cluster-head selection has been studied by [2] for two-level HWSNs. Their work was based on a DEEC scheme with certain improvements involving the use of a threshold residual energy value, as shown in Eq. 9. This equation is intended to ensure that advanced and normal nodes have the same probability to become a cluster head. As a result, cluster-head selection will be more balanced and more equitable:

$$Th_{REV} = E_0\left(1 + \frac{\alpha E_{disNN}}{E_{disNN} - E_{disAN}}\right) \qquad (9)$$

where, E_{disNN} is the energy dissipated by a normal node in each round and E_{disAN} is the energy dissipated by an advanced node. Finally, the weighted probability that each node will be selected as a cluster head is given by Eq. 10:

$$p_i = \begin{cases} \dfrac{p_{opt} E_i(r)}{(1+am)\overline{E(r)}} & \text{for nml nodes}, E_i(r) > Th_{REV} \\ \dfrac{(1+a)p_{opt} E_i(r)}{(1+am)\overline{E(r)}} & \text{for adv nodes}, E_i(r) > Th_{REV} \\ \dfrac{(1+a)p_{opt} E_i(r)}{(1+am)\overline{E(r)}} & \text{for adv, nml nodes}, E_i(r) \le Th_{REV} \end{cases} \qquad (10)$$

where, c is a real positive variable which directly controls the number of cluster heads. Implemented algorithm similar to the SGCH algorithm but in a heterogeneous environment. In this algorithm, every node is divided into several clusters according to the distances between nodes. There are three types of nodes, referred to as normal, moderately advanced and highly advanced nodes. In the clustering process, the node in each cluster with the maximum energy remaining will be selected as the cluster head. Subsequently, each node forwards its sensed data to the nearest cluster head. The cluster head will then transmit the data to the sink node.
This network performs an environmental monitoring task and its sensor nodes monitor a variety of objects. A recent study involved nodes distributed randomly with mobile or stationary properties. They assumed that the node communication links are symmetric and that nodes do not have any location information, but can calculate the distance between nodes according to the signal strength received. The distance between nodes i and j was calculated using Eq. 11:

$$d_{i,j} = \alpha\sqrt{\frac{K \times E_i^{tran}}{E_{j,i}^{rec}}} \qquad (11)$$

where, α is a distance-energy gradient with a value varying from 1-6 according to the physical environment in which the sensor networks operate; E_i^{tran} is the transmission energy for broadcasting and $E_{j,i}^{rec}$ is the received signal strength (received energy). In the clustering algorithm, the node establishes a routing table of neighboring nodes based on received data and saves all relevant information for all nodes within its communication range. The nodes with more residual energy should be given greater opportunity to become cluster heads and all nodes take turns at being cluster head nodes. The threshold equation for the probability of selecting sensor nodes as a cluster head is given here as Eq. 12:

$$T(i) = \begin{cases} \dfrac{p_i}{1 - p_i\left(r \bmod \dfrac{1}{p_i}\right)}[(\alpha\overline{\omega}(E)_i + \beta\overline{\omega}(C_i)) + \left(r_s \operatorname{div} \dfrac{1}{p_I}\right)(1 - (\alpha\overline{\omega}(E)_i + \beta\overline{\omega}(C)_i) & \text{if } i \in G \\ 0 & \text{otherwise} \end{cases} \qquad (12)$$

where, α and β are coefficients, r is the round identifier, $\overline{\omega}(E)_i$ is an energy factor and $\overline{\omega}(C)_i$ is a communication factor. The algorithm operates in an iterative fashion. After completion of one round, a new node must be selected as the cluster head for the next round. To reduce the energy consumed when broadcasting and the communication cost, an energy consumption prediction mechanism for Regular Data Acquisition (RDA) nodes has been developed. Each node will determine whether its current residual energy is close to the residual energy predicted in the last round using Eq. 13:

$$\gamma = \left|1 - \frac{E_{jr\_predicted}}{E_{jr}}\right| \qquad (13)$$

where, the value of γ is less than the amplifier energy, $E_{jr,predicted}$ is the predicted residual energy of node j at the beginning of round r and E_{jr} is the current energy of node j.

Energy-efficient multi-level clustering: Multi-level clustering is achieved by multi-level cluster head node selection during clustering algorithm execution. Use of this technique can reduce and balance energy consumption and hence prolong the lifetime of a WSN. This can also be achieved using multi-hop data transmission, in which each cluster head acts as a relay node during data transmission. In addition, the network can be divided into two or more zones or tiers to prolong its lifetime.
Hasnaoui et al. (2010) carried out studies in a two-level HWSN of a multi-level clustering algorithm known as the Oriented Cluster Formation (OCFLE) algorithm. OCFLE is an oriented cluster formation algorithm based on the position of the CHs in the sensing area and on the minimum distance between a non-cluster head node and the sink node using a suitable intermediate CH.

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In the clustering process, the cluster head node was selected based on the ratio between the residual energy of each node and the average energy of the network. A two-level hierarchical design was introduced in which suitable intermediate CHs for data transmission were developed. The CH with the most energy, called MaxCH, is the most likely to be chosen as the intermediate CH used to transmit aggregate data to the Base Station (BS). MaxCH collects all data coming from all CHs, compresses them into a single signal and sends them directly to the base station. The multi-level clustering network concept is illustrated in Fig. 4.
Recently a clustering algorithm for two-level HWSNs which introduces the concept of Minimum Reachability Power (MRP). This concept takes into consideration the transmission range among the nodes in the network. Eq. 14expresses the probability of cluster head node selection during the clustering process:

$$P_1^n(u) = N_{CH1}^{opt}\left[\phi \frac{E_u(t)}{\sum_{v\in S(t)} E_v(t)} + (1-\phi)\left(\frac{\frac{1}{P_u}}{\sum_{v\in S(t)} \frac{1}{P_v}}\right)\right]$$

$$P_1^a(u) = N_{CH1}^{opt}\left[\phi \frac{E_u(t) * \gamma}{\sum_{v\in S(t)} E_v(t)} + (1-\phi)\left(\frac{\frac{1}{P_u}}{\sum_{v\in S(t)} \frac{1}{P_v}}\right)\right] \quad (14)$$

where, P_1^n is the probability of becoming CH for a normal node and $P_1^a(u)$ the probability of becoming CH for an advanced node, φ is a parameter which determines the weighting of energy and distance factors, N_{CH1}^{opt} is the optimal number of CHs for level 1, $E_u(t)$ is the energy of the nodes, γ is the energy multiplier for advanced nodes compared to normal nodes, $\Sigma_{v\in S} E_v(t)$ is the total remaining energy of the network and P_u and P_v are the MRP values. Eq. 15 shows the probability calculation for level-2 cluster-head selection:

$$P_2^n(u) = \sqrt{N_1}\left[\phi \frac{E_u(t)}{\sum_{v\in S(t)} E_v(t)} + (1-\phi)\left(\frac{\frac{1}{P_u}}{\sum_{v\in S(t)} \frac{1}{P_v}}\right)\right]$$

$$P_2^a(u) = \sqrt{N_1}\left[\phi \frac{E_u(t) * \gamma}{\sum_{v\in S(t)} E_v(t)} + (1-\phi)\left(\frac{\frac{1}{P_u}}{\sum_{v\in S(t)} \frac{1}{P_v}}\right)\right] \quad (15)$$

where, N_1 is the cardinality of the active set.

After a level-T clustering topology has been formed, the regular nodes start transmitting their sensed data to their CHs. Level-T CHs aggregate the sensed data and send them to level-(T-1) CHs and so forth. Finally, all level-1 CHs transmit the aggregated data to the sink node. Author extended the clustering algorithm to include inter-cluster transmission considerations. Their research is an extension of their previous work on the EEHC algorithm. A new mechanism was added to the clustering algorithm, as shown in Fig. 5.

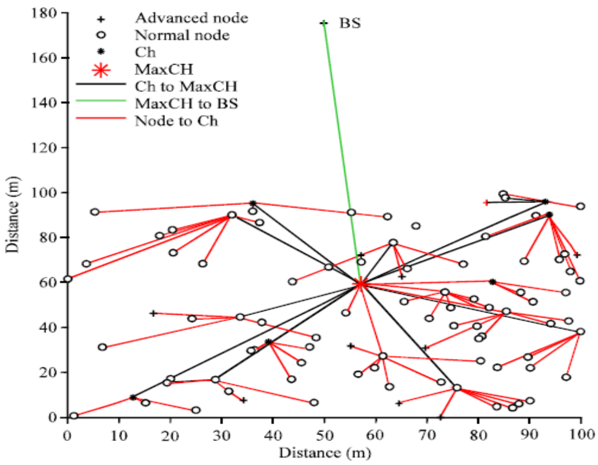

Fig:4 Dynamic oriented cluster formation using OCFLE

The diagram shows that the sensed data were transmitted to the sink node using multi-hop data transmission. The path metrics and their route costs were formed into an array matrix called an "adjacency matrix." In each cluster, the cluster head receives the messages and then aggregates the received messages with its own message. The aggregated message is then forwarded to the next-hop receiver (sink or CH), based on the routing information calculated using the optimal path approach.

Han (2010) examined multiple-hop routing in a clustering algorithm for HWSNs and proposed a three-level heterogeneous network. The nodes organize themselves into local clusters, with one node acting as the cluster head in each cluster.

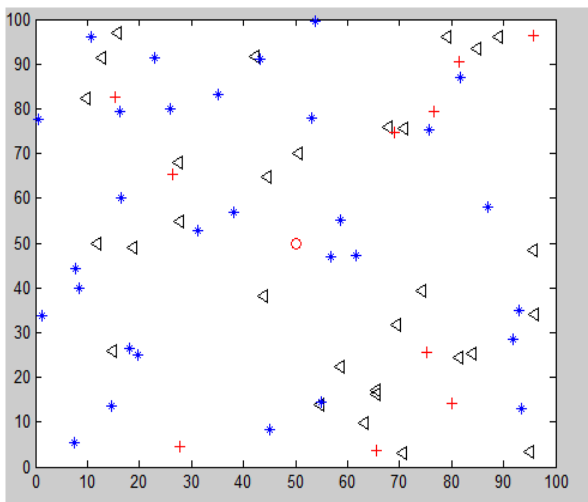

Fig 5: Normal, advanced and super nodes are shown by, star, triangle and the plus respectively.

The node with the most remaining energy will be selected as the cluster head. The CH node sets up a TDMA schedule and transmits it to the nodes in the cluster. Non-cluster head nodes will join a CH based on the distance calculation.

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V. PERFORMANCE EVALUATION METRICS

Some of the parameters that can be used to evaluate the performance of node-clustering algorithms are:

Average energy dissipated: The average energy usage by a sensor node in the network over time for various purposes such as transmitting, receiving and aggregating data.

Network lifetime: The time interval from initial node activation until network death.

Number of cluster heads per round: The number of cluster heads chosen in each round which represents the number of nodes which will send data directly to the sink node.

Total number of nodes alive: The number of nodes that remain alive in each round.

Number of data messages/throughput: The number of data messages received by the sink node. If the volume of data messages received is too big for the sink node, it will make the sink node die and energy consumption will decrease.

Clustering approach	Type of heterogeneity	Level of heterogeneity	Hierarchy network	Location awareness	Energy efficiency	Balanced clustering
SEP						
Smaragdakis *et al.* (2004)	Energy	Two	No	Not required	Moderate	Yes
DEEC						
Qing *et al.* (2006)	Energy	Two/multi-level	No	Not required	High	-
DEBC						
Changmin and Hong (2007)	Energy	Two/multi-level	No	Not required	Moderate	-
DDEEC						
Elbhiri *et al.* (2010)	Energy	Two	No	Not required	Moderate	-
Based on SGCH						
Jiun-Jian *et al.* (2009)	Energy	Three	Yes	Yes	Moderate	
EEPCA						
Liu *et al.* (2011)	Energy and data-acquisition-regularity	Multi level	no	yes	moderate	-
OCFLE						
Hasnaoui *et al.* (2010)	Energy	Two	Yes	Yes	High	-
PAMC						
Soni and Katiyar (2011)	Energy	Two	Yes	Yes	Moderate	-
EEMCP						
Kumar *et al.* (2010)	Energy	Three	Yes	Yes	High	-
LEACH-HPR						
Han (2010)	Energy	Three	Yes	Yes	Moderate	-
ZREECR						
Li *et al.* (2007a)	Energy	Two	Yes	Yes	Low	-
NSEEAR						
Mehrotra and Leong (2009)	Energy	Two	Yes	Yes	Moderate	-

VI. CONCLUSION

In this paper, we provided a survey of all techniques used in the heterogeneous wireless sensor networks. All the existing techniques used the nodes energy and number of clusters technique to increase the network life time. In this paper we studied the stability period of network (time of death of first node in network). Bystable energy techniques only nodes with high energy selected as CH and other nodes are elected as cluster members. Nodes distribute their energy between clusters to enhance network lifetime. In addition to previous studies we have also observed that with the help of hierarchical routing used in wireless sensor networks helpful in increasing lifetime of the network and minimizes energy consumption.

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