A Review on Heterogeneous WSNS Protocols

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Abstract- WSNs are very popular in real time applications. Due to the features of the resource-constrained and battery-aware nodes; in WSNs energy utilization has found to be a major interesting subject of research. WSNs compose battery-powered nodes which are connected with the base station to for certain action or task. As sensor nodes are battery-powered i.e. will become dead after the consumption of the battery which is also called lifetime of WSNs. So using the energy in well-organized way may result in prolonging the lifetime of the WSNs. This paper has explained and evaluated the various heterogeneous WSNs protocols to find the short comings of the previous work.

Keywords – WSNs, Energy consumption, SEP, Lifetime, Deterministic, DEEC

I. INTRODUCTION

1. *WIRELESS SENSOR NETWORKS*

Wireless sensor networks are made up of small sensor nodes, computation, and wireless communication capabilities. Many routing protocols have been specifically designed for WSNs where energy responsiveness is an important strategy concern.

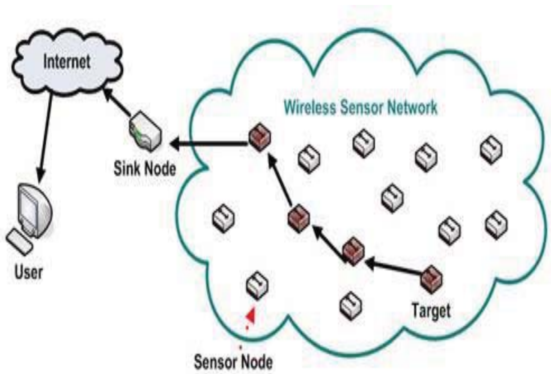

Fig. 1.1 Configuration of Wireless Sensor Network [17]

2 *APPLICATIONS OF WSNs*

A. Health care monitoring

In medical field WSN is used mainly for two purposes: wearable and implanted. Wearable devices are used on the human body surface or just nearby of the human. Implantable devices are used inside human body. Body-area networks can gather all the information i.e. person's health, fitness, and energy expenditure.

B. Air pollution monitoring

Wireless sensor networks are implemented for monitoring the closeness of harmful gases for people. For this applications wireless installations are more beneficial than wired links, which also make them more dynamic for examination readings in different locations.

C. Natural disaster prevention

Wireless sensor networks are successfully used to avoid the significances of natural misadventures, like floods. Wireless nodes have capably been deployed in rivers where changes of the water levels have to be examined in real time.

D. Area monitoring

In area monitoring, the WSN is implemented over an area where some spectacle is to be monitored. A military is the most important example where the sensors detect enemy interruption; a civilian example is the geo-fencing of gas or oil pipelines.

In above figure the configuration of the WSNs is described, in which a sensor network is shown in a cloud that contained the various sensor nodes. These nodes transmit the data to the base station or sink node. Sink node aggregates the data from sensor nodes and transmit to the internet. The user receives data through internet from sink node.

1. CLUSTERING

Wireless sensor network consists of small sensor nodes in which sensor nodes are grouped into clusters. Each cluster is assigned to a leader, which is also known as the cluster head (CH) and definitely performs the tasks such as data aggregation; transmit the data to base station.

The cluster formation method hints to a two-level hierarchy where the CH nodes form the higher level and the cluster-member nodes form the lower level. The sensor nodes intermittently send their data to the corresponding CH nodes. CH nodes aggregate the data (thus decreasing the total number of relayed packets) and transmit them to the base station (BS) either directly or through the intermediate communication with other CH nodes. However, because the CH nodes send all the time data to higher distances than the common (member) nodes, they naturally spend energy at higher rates. A common solution in order balance the energy consumption among all the network nodes is to periodically re-elect new CHs (thus rotating the CH role among all the nodes over time) in each cluster.

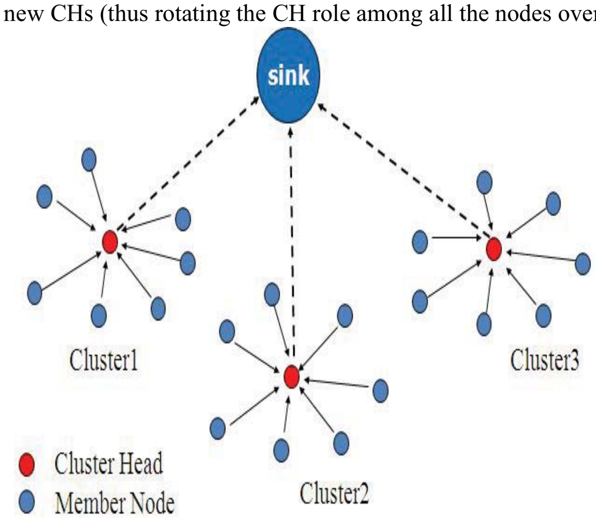

Fig.1.2 Cluster formation of WSNs [18]

Above figure describes the formation of the clusters in WSNs. These clusters contain various sensor nodes and these nodes transmit data to the cluster head which is responsible to forwarding this data to sink node.

A. Homogeneous v/s heterogeneous clusters:

In homogeneous clustering each sensor node has same initial energy but in heterogeneous clustering there are two or more types of sensor nodes. In homogeneous networks all the sensor nodes are same in terms of battery energy and hardware complexity. With purely static clustering (cluster heads once selected, serve for the entire lifetime of the network) in a homogeneous network, it is obvious that the cluster head nodes will be over-loaded with the long range communications to the remote base station, and the extra processing necessary for data aggregation and protocol co-ordination. As a result the cluster head nodes expire before other nodes. in a heterogeneous sensor network, two or more different types of nodes with different battery energy and functionality are used.

The motivation being that the more complex hardware and the extra battery energy can be embedded in few cluster head nodes, thereby reducing the hardware cost of the rest of the network.

B. Clustering Parameters

Before authenticating on the possible categorization options of WSNs clustering algorithms as well as on the algorithms themselves in more details, it is means reporting on some important parameters with regard to the whole clustering techniques in WSNs. These parameters also function as the basic means for further comparison and categorization of the presented clustering protocols throughout this section.

a) *Number of clusters (cluster count):* In most current probabilistic and randomized clustering protocols the CH selection and formation method lead obviously to various clusters. In some published methodologies, however, the set of CHs are predetermined and thus the numbers of clusters are preset. The number of clusters is typically a life-threatening parameter with regard to the efficiency of the total routing protocol.

b) *Intracluster communication:* In some early clustering methodologies the communication between a sensor and its nominated CH is assumed to be direct (one-hop communication). However, multi-hop intracluster communication is often (nowadays) necessary, i.e., when the communication range of the sensor nodes is limited or the number of sensor nodes is very large and the number of CHs is bounded.

c) *Nodes and CH mobility:* If we assume immobile sensor nodes and still CHs we are normally lead to stable clusters with facilitated intracluster and intercluster network organization. On the contrary, if the CHs or the nodes themselves are assumed to be mobile, the cluster membership for each node should energetically change; forcing clusters to evolve over time and probably need to be continuously maintained.

d) **Nodes types and roles:** In some planned network representations (i.e., heterogeneous environments) the CHs are expected to be equipped with meaningfully more computation and communication resources than others. In most usual network models (i.e., homogeneous environments) all nodes have the same proficiencies and just a subset of the deployed sensors is designated as CHs.

e) *Cluster formation methodology:* In most current technologies, when CHs are just consistent sensors nodes and time efficiency is a principal design condition, clustering is being performed in a distributed way without communication. In few earlier methodologies a centralized (or hybrid) approach is monitored; one or more coordinator nodes are used to partition the whole network off-line and control the cluster membership.

f) *Cluster-head selection:* The leader nodes of the clusters (CHs) in some proposed algorithms (mainly for heterogeneous environments) can be preassigned. In most cases however (i.e., in homogeneous environments), the CHs are picked from the deployed set of nodes either in a probabilistic or completely random way or based on other more specific criteria (residual energy, connectivity etc.).

g) Algorithm complexity: In most recent algorithms the fast termination of the executed protocol is one of the primary design goals. Thus, the time complexity or convergence rate of most cluster formation procedures proposed nowadays is constant (or just dependent on the number of CHs or the number of hops). In some earlier protocols, however, the complexity time has been allowed to depend on the total number of sensors in the network, focusing in other criteria first.

h) Multiple levels: In several published approaches the concept of a multi-level cluster hierarchy is introduced to achieve even better energy distribution and total energy consumption (instead of using only one cluster level). The improvements offered by multi-level clustering are to be further studied, especially when we have very large networks and inter-CH communication efficiency is of high importance.

i) *Overlapping:* Several protocols give also high importance on the concept of node overlapping within different clusters (either for better routing efficiency or for faster cluster formation protocol execution or for other reasons). Most of the known protocols, however, still try to have minimum overlap only or do not support overlapping at all.

2. *WIRELESS SENSOR NETWORK PROPERTIES*

WSNs are used in a vast variety of scenarios. This kind of range of requirements is not necessarily applicable for all the scenarios. Therefore many types of the sensor networks are came into scenario like classical sensor networks, mobile sensor networks, wireless sensor and actuator networks, wireless multimedia sensor networks and many others.

This division cannot be treated as a classification of sensor networks. It illustrates only some emerging trends which enhance diversity in WSNs. The taxonomy that characterizes different properties of sensor networks can be found in Mottola and Picco survey described in Fig. 1. 3

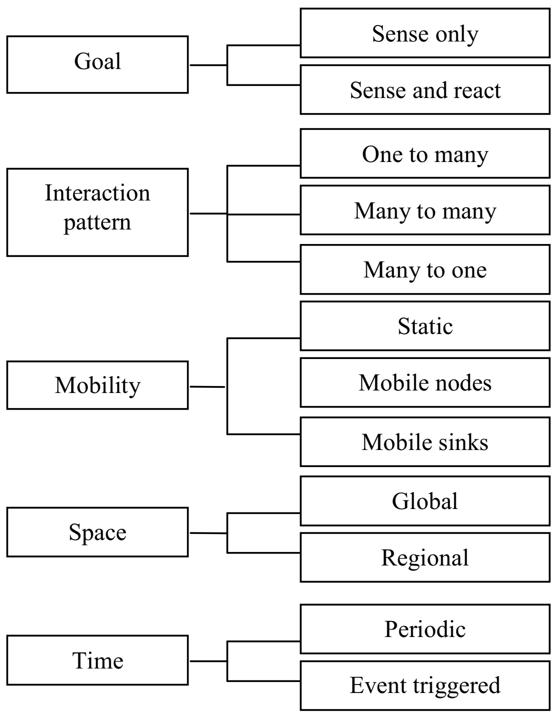

Fig. 1.3 Taxonomy of WSN applications [16].

1.4.1 Goal

In early researches the goal of the WSN applications is to collect environmental data for analysis this is called sense only. This can be performed by a field of sensor-equipped nodes which sends their data, possibly along multiple hops, to a single base station that centrally collects the data but now applications are also required to perform some actions based on the sensed data this phenomenon called sense and react, now the nodes are equipped with actuators.

1.4.2 Interaction pattern

The next key property is interaction pattern. This property describes the methods in which sensor nodes exchange the information with each other. This phenomenon somehow based on the goal that nodes are trying to achieve. The interaction pattern many-to-one, where data is send from all nodes in the network to a central collection point. One-to-many in which one node transmit data to all or more than node. And in many-to-many interactions many nodes transmits data many other nodes.

1.4.3 Mobility

This is the most important property. Sensor nodes may change their location after initial deployment. Mobility may apply to all nodes within a network or only to subsets of nodes. There are three classes of mobility static, mobile nodes and mobile sinks. Also there are some other aspects of mobility shown in Fig.1.4

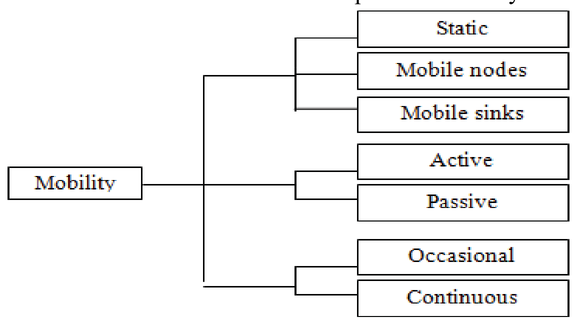

Fig.1.4 Extended mobility taxonomy[16]

Mobility can result from environmental influences such as wind or water; sensor nodes may be attached to or carried by mobile entities – passive mobility. Sensor nodes may possess automotive capabilities – active mobility. The degree of mobility may also vary from occasional movement with long periods of immobility in between, to constant travel.

1.4.4 Space

Different applications may require the distributed processing spreading different portions of the physical space. The space can be global where the processing involves in principle the whole network, most likely because the phenomena of interest span the whole geographical area where the WSN is deployed or regional where the majority of the processing occurs only within some limited area of interest.

1.4.5 Time

In WSNs usually the term time is associated with the network lifetime, which has a high impact on the required degree of communication and energy efficiency. However the term time can also characterize the way how the distributed processing is done. If the network is used to monitor some considered area, the application can perform periodic tasks to gather sensor readings. This solution is maybe not energy efficient, but collected data may be used in further analysis. Another way to monitor the same area is event triggered solution – the application is characterized by two phases:

– during event detection, the system is largely quiescent, with each node monitoring the values it samples from the environment with little or no communication involved;

– if and when the event condition is met (e.g., a sensor value raises above a threshold), the WSN begins its distributed processing

3. *SENSOR DEPLOYMENT*

In a sensor network positioning of nodes is noticeable factor. The localization and deployment of nodes are the major issues in research. They have distinguished four primary objectives for sensor deployment, such as: area coverage, network connectivity, and network longevity and data fidelity.

A. Coverage

The coverage problem is the objective that has been widely discussed in the literature. Typically considered problems are area coverage, point/target coverage, energy-efficient coverage and k-coverage problem. Assessing the coverage varies based on the underlying model of each sensor's field of view and the metric used to measure the collective coverage of deployed sensors. The most commonly used sensor coverage model is a sensing disk model. All points within a disk cantered at sensor are considered to be covered by the sensor. In the literature of WSNs, however, many papers assume a fixed sensing range and an isotropic detection capability of sensor. The detection ability within coverage of a sensor can be classified as the 0/1 coverage model (binary model), the probabilistic coverage model, and the information coverage model.

B. Differentiated Detection Levels

Differentiated sensor network deployment, which considers the satisfaction of detection levels in different geographical characteristics, is also an important issue. In many real world WSN applications, such as underwater sensor deployment or surveillance applications, the supervised area may require extremely high detection probabilities at certain sensitive areas. However, for some not so sensitive areas, relatively low detection probabilities are required to reduce the number of sensors deployed so as to decrease the cost. In this case, different areas require different densities of deployed nodes. Therefore, the sensing requirements are not uniformly distributed within the area. As a result, the deployment strategy of WSN should take into consideration the geographical characteristics of the monitored events.

C. Network Connectivity

Network connectivity is another important issue in design of WSN. The network is connected if any active node can communicate with any other active node. Network connectivity is necessary to ensure that messages are propagated to the appropriate base station and the loss of connectivity if often treated as the end of network life. This property is strongly connected with coverage and energy efficiency (the value of transmission range may vary according to transmission power). The relationship between coverage and connectivity results from sensing and transmission ranges. If the transmission range of a node is much longer than its sensing range then connectivity is not an issue, because the coverage ensures there is a way to communicate. Situation is different if the communication range is less than sensing range.

D. Network Lifetime

One of the major challenges in the design of WSNs is the fact that energy resources are very limited. Recharging or replacing the battery of the sensors in the network may be difficult or impossible, causing severe limitations in the communication and processing time between all sensors in the network. Note that failure of regular sensors may not harm the overall functioning of a WSN, since neighbouring sensors can take over, provided that their density is high. Therefore, the key parameter to optimize for is network lifetime – the time until the network gets partitioned in a way that is impossible to collect the data from a part of the network.

E. Data Fidelity

Ensuring the credibility of the gathered data is obviously an important design goal of WSNs. A sensor network basically provides a collective assessment of the detected phenomena by fusing the readings of multiple independent (and sometimes heterogeneous) sensors. Data fusion boosts the fidelity of the reported incidents by lowering the probability of false alarms and of missing a detectable object. Increasing the number of sensors reporting in a particular region will surely boost the accuracy of the fused data. However, redundancy in coverage would require an increased node density, which can be undesirable due to increased cost or decreased survivability (the potential of detecting the sensors in a combat field).

F. Energy Efficiency

This criterion is often used interchangeably with lifetime. Due to the limited energy resource in each sensor node, we need to utilize the sensors in an efficient manner so as to increase the lifetime of the network. There are at least two approaches to the problem of conserving energy in sensor networks connected with optimal placement. The first approach is to plan a schedule of active sensors that enables other sensors to go into a sleep mode utilizing overlaps among sensing ranges. The second approach is adjusting the sensing range of sensors for energy conservation.

G. Number of Nodes

This criterion is obvious. The more sensors are used the higher is cost. Therefore optimal node deployment is considered to achieve the specified goals with minimum cost.

H. Fault Tolerance and Load Balancing

Fault tolerant design is required to prevent individual failures from shortening network lifetime. Many authors focus on forming k-connected WSNs. K-connectivity implies that there are k independent paths among every pair of nodes. For $k >= 2$, the network can tolerate some node and link failures. Due to many-to-one interaction pattern k-connectivity is especially important design factor in the neighbourhood of base stations and guarantees certain communication capacity among nodes.

4. EDDEEC

In this paper protocol implements the thought of probabilities for CH choice based on initial, remaining energy level of the nodes and average energy of network. This protocol protects the super and advance nodes from over penalized, because after some rounds some super and advance nodes have same residual energy level as normal nodes due to repeatedly CH selection. EDDEEC estimates probabilities of normal, advance and super nodes. These changes are focused on absolute residual energy level $T_{absolute}$, which is the value in which advance and super nodes containing similar energy level as that of normal nodes. The thought states that under $Tabsolute$ all normal, advance and super nodes have equal probability for CH selection.

The probability for three types of nodes given by EDEEC is specified below

$$p_i = \begin{cases} \dfrac{p_{opt} E_i(r)}{(1 + m(a + m_o b))\bar{E}(r)} & \textit{if } s_i \textit{ is the normal node} \\ \dfrac{(1 + a) p_{opt} E_i(r)}{(1 + m(a + m_o b))\bar{E}(r)} & \textit{if } s_i \textit{ is the advance node} \\ \dfrac{(1 + b) p_{opt} E_i(r)}{(1 + m(a + m_o b))\bar{E}(r)} & \textit{if } s_i \textit{ is the super node} \end{cases} \quad (25)$$

A.

Our suggested probabilities for CH selection in EDDEEC are given as follows:

$$p_i = \begin{cases} \dfrac{p_{opt} E_i(r)}{\left(1 + m(a + m_o b)\right)\bar{E}(r)} & \textit{for } N_{ml} \textit{ nodes} \\ & \textit{if } E_i(r) > T_{absolute} \\ \dfrac{(1 + a) p_{opt} E_i(r)}{\left(1 + m(a + m_o b)\right)\bar{E}(r)} & \textit{for Adv nodes} \\ & \textit{if } E_i(r) > T_{absolute} \\ \dfrac{(1 + b) p_{opt} E_i(r)}{\left(1 + m(a + m_o b)\right)\bar{E}(r)} & \textit{ifor Sup nodes} \\ & \textit{if } E_i(r) > T_{absolute} \\ c\dfrac{(1 + b) p_{opt} E_i(r)}{\left(1 + m(a + m_o b)\right)\bar{E}(r)} & \textit{for Nml, Adv, Sup nodes} \\ & \textit{if } E_i(r) \leq T_{absolute} \end{cases} \quad (26)$$

B. The value of absolute residual energy level, $Tabsolute$, is written as:

$$T_{absolute} = ZE_o \quad (27)$$

where, *z*ϙ(0, 1). If *z* = 0 then we have conventional EDEEC. In reality, advanced and super nodes may have not been a CH in rounds *r*, it is also probable that some of them become CH and similar is the case with the normal nodes. So, exact value of *z* is not certain.

II. RELATED WORK

A Routing protocol is used to transmitting information from sensor node to sink. These routing techniques are works on two networks homogenous and heterogeneous. In homogeneous network nodes all nodes are of one kind and in heterogeneous networks there are more than two types of nodes are available. Various routing protocols have been proposed in the literature to reducing the consumption of energy and increasing the lifetime of the network. A brief summary of the literature is given below:

The reactive networks [1] are those who instantly react to the any alterations in the parameters like power availability, position (in case of sensor nodes are mobile), reach ability, type of task. TEEN [1] has found to be more

suitable for real time applications as it has provided immediate response. TEEN [1] protocol is not well suited for applications where data required frequently.
SEP (Stable Election Protocol) [2], a heterogeneous protocol to extend the time interval before the death of the first node (referred as *stability period*), which is crucial for many applications where the feedback from the sensor network must be reliable. SEP is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node. In this work two types of sensor nodes are considered normal nodes and advanced nodes. Normal nodes have less energy than advanced nodes. In SEP [2]; it is not required to have any global knowledge of energy at every election round. SEP is dynamic in that there is no need to assume any prior distribution of the different levels of energy in the sensor nodes.

In DEEC [3], the election of cluster-heads is done by a probability based on the ratio between residual energy of each node and the average energy of the network. The epochs of being cluster-heads for nodes are different according to their initial and residual energy. The nodes with maximum initial and residual energy will have greater chances to be the cluster-heads than the nodes with minimum energy. 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 use to compute the reference energy that each node should expend during a round. To maximize the DEEC protocol performances, the DDEEC [4] implemented a balanced and dynamic way to distribute the spent energy more equitably between nodes. These alterations introduced enlarge better the performances of DDEEC protocol than the others. DDEEC takes some advantage than DEEC in terms of first node dies and prolong of the stable time. It is due to the fusion between DEEC techniques and the balanced way in term of cluster head election introduced by the DDEEC.

E-DEEC (Enhanced Distributed Energy Efficient Clustering) scheme [5] is based on DEEC with addition of super nodes. Cluster head selection algorithm is broken into rounds. At each round node decides whether to become a cluster head based on threshold calculated by the suggested percentage of cluster heads for the network and the number of times the node has been a cluster-head so far. This decision is made by the nodes by choosing the random number between 0 and 1. If the number is less than a threshold T(s) the node becomes a clusterhead for the current round.

The back-up node [6] is the node that takes the responsibility of cluster head in case of any failure. This technique will also help to make the wireless sensor network more energy efficient. Enhanced Reliable Distributed Energy Efficient Protocol (ERDEEP) provides more energy efficient network and reliability. The protocol solves the problem of the reliability by choosing a Back-up Node for every cluster head. The Back-up Node will remain in the sleep mode and if cluster head gets down; a signal is send to back-up node along with data and responsibilities by cluster head to back-up node and it (Back-up node) starts its working by taking all the responsibility of the cluster head. Now this back-up node will aggregate the data and forward to the base station.

Energy Efficient Clustering Routing Protocol Based on Weight (ECRPW) [7] has prolonged the lifetime of networks. ECRPW takes into consideration the nodes' residual energy during the election process of cluster heads. The constraint of distance threshold is used to optimize cluster scheme. It effectively prolongs the network lifetime by taking advantage of the characteristic of different energy in heterogeneous nodes.

The QoS [8] of an energy-efficient cluster-based routing protocol called Energy-Aware routing Protocol (EAP) in terms of lifetime, delay, loss percentage, and throughput, and proposed some modifications on it to enhance its performance. The modified version of EAP is called LLEAP (Low Loss Energy-Aware routing Protocol). LLEAP has the same three phases of EAP except some modifications in each phase. LLEAP modifies EAP in terms of some QoS parameters by modifying the weights equations, adding a second iteration for tree construction, using schedule technique for nodes sleep and awakening to save nodes energy, and using an aggregation method decreases delay and packet losses.

Heterogeneity-aware Hierarchical Stable Election Protocol (HSEP) [9] has reduced transmission cost from Cluster Head to Base Station. This proposed protocol is heterogeneous-aware in the sense that election probabilities are weighted by the initial energy of a node relative to that of other nodes in the network. This technique enhances time interval before death of first node is refereed as stability period. HSEP uses two type of CHs, primary CHs and secondary CHs.

A three-tier clustered heterogeneous network has been considered in ESEP [10]; where the moderate and advanced nodes elect themselves as cluster heads for the increasing number of rounds based on their higher initial energy relative to other nodes. A cluster head election process is considered based on the battery power and residual energy of the node. In the approach, moderate and advanced nodes have higher probabilities to become a cluster head in a particular round than the normal nodes. As the energy drain rate is less in moderate and advanced nodes, it extends the lifetime of the network.

The reactive networks [11] are those who respond immediately response to any change in the network, therefore this protocol is very much suitable to the real time applications. TSEP is a three level heterogeneous network protocol in which the sensor nodes are with different energy levels like normal nodes, intermediate nodes and advanced nodes. Advanced nodes are having energy greater than all other nodes. TSEP has increased the stability time period than all other protocols.

The unequal distribution of wireless sensor nodes [12] and unbalanced energy consumption has become a major problem for Wireless Sensor Networks (WSNs). Traditional clustered networks with fixed sink nodes always suffer from high energy burden during multi hop transmission. Thus mobile sink(s) are introduced to networks with benefits of low latency, low energy consumption, and long lifetime, etc.

In order to guide the process of cluster head election for a given multi-level heterogeneous network, EDCS [13] determines the probability of node to be a cluster head through average network residual energy estimation in next round by average energy consumption forecast in ideal state and reference value of historical energy consumption simultaneously. It solves the drawback that the general routing protocols in homogeneous networks cannot be directly applied to heterogeneous multi-level environment. The EDCS protocol focuses on energy heterogeneity.

Cluster Heads (CHs) are elected on the bases of residual energy level of nodes. BEENISH [14] has implemented the concept of selecting CH which is based on residual energy level of the nodes with respect to average energy of network. BEENISH uses the concept of four types of nodes; normal, advance, super and ultra-super nodes. In BEENISH ultra-super nodes are largely elected as CH as compare to super, advance and normal nodes, and so, on. In this way energy consumed by all nodes is equally distributed. Election of CH based on residual and average energy of the network. So, nodes with high energy have more chances to get selected as CH, as compare to the low energy nodes.

After some rounds, some super and advance nodes have same residual energy level as normal nodes due to repeatedly CH selection. Although EDEEC [15] continues to punish advance and super nodes, same is the problem with DEEC, it continues to punish just advance nodes and DDEEC is only effective for two-level heterogeneous network as mentioned previously in related work. To avoid this unbalanced case in three-level heterogeneous network and to save super and advance nodes from over penalized, we propose changes in function which defined by EDEEC for calculating probabilities of normal, advance and super nodes. These changes are based on absolute residual energy level *Tabsolute*, which is the value in which advance and super nodes have same energy level as that of normal nodes. The idea specifies that under *Tabsolute* all normal, advance and super nodes have same probability for CH selection.

A SHORT COMINGS OF EARLIER WORK

1. SEP, ESEP and TSEP continues to punish advance and intermediate nodes i.e. no special protection for over utilization of advance and intermediate nodes.
2. DEEC variants has neglected the use of distance between two CHs may cause too small cluster heads.
3. It has been found that the most of the existing researchers have neglected the use of absolute residual energy level (ARL) value to avoid this unbalanced case in three-level heterogeneous network and to save intermediate and advance nodes from over penalized.
4. The use of node waiting time to become CHs is also ignored in the most of existing research.

III.CONCLUSION

Although EDDEEC has shown quite significant results over existing WSNs protocols but it has neglected the use of waiting time of node to become CHs. So may some nodes will not become CHs for a long time even they have more confidence to become CHs.

So to overcome this problem in near future we will use minimum allowed distance (MDCH) between two CHs to cover the sensor field in the most efficient way. MDCH will have ability to overcome the problem of the too small and too high cluster heads. No implementation is considered in this paper so in near future we will use suitable simulation tool to implement the modified EDDEEC protocol.

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