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A Review on Clustering in Heterogeneous Wireless Sensor Networks Model

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Abstract – **Heterogeneous Wireless Sensor Network (WSN) comprises of sensor nodes with distinctive capability, for example, diverse computing power and sensing range. Contrasted with homogeneous WSN, arrangement and topology control are more perplexing in heterogeneous WSN. Distinctive energy efficient clustering protocols for wireless sensor networks systems and thinks about these protocols on a few focuses, in the same way as clustering method, location awareness, heterogeneity level and clustering attributes. Though, each protocol is not appropriate for heterogeneous WSNs. In this paper, we review about process of clustering in heterogeneous wireless sensor networks model.**

Keywords–**Wireless Sensor Network, Heterogeneous WSN, Homogeneous WSN.**

I. Introduction

With the advancements in the innovation of micro electro mechanical system (MEMS), improvements in wireless communications and wireless sensor networks have likewise developed [1]. Wireless sensor networks (WSNs) have turned into a standout amongst the most fascinating zones of examination in the recent years. A WSN is comprises of countless sensor nodes which structure a sensor region and a sink. These immense amounts of nodes, having the capacities to sense their surroundings, perform constrained count and impart wirelessly structure the WSNs [2]. Particular capacities, for example, alerting, tracking and sensing as depicted by Shorey [3], might be gotten through participation among these nodes. These parameters make wireless sensors extremely helpful for checking common phenomena, ecological progressions [4], controlling security, assessing activity streams, observing military application [5], and following cordial constrains in the war zones. These undertakings require high trustworthiness of the sensor systems. To make sensor networks more trustworthy, the consideration regarding research on heterogeneous wireless sensor systems has been expanding in later past [6, 7].

A sensor system might be made adaptable by amassing the sensor nodes into gatherings i.e. clusters. Each cluster has a pioneer, regularly alluded to as the cluster head (CH). A CH may be chosen by the sensors in a cluster or pre-assigned by the system planner. The cluster enrolment may be variable or settled. Various clustering calculations have been particularly intended for WSNs for versatility and productive correspondence. The thought of cluster routing is likewise used to perform energy proficient directing in WSNs. In a progressive outline, higher energy nodes (cluster heads) might be utilized to process and send the data while low energy nodes could be utilized to perform the sensing. This part talk about the heterogeneous model for wireless sensor network and clustering calculations.

II. Heterogeneous Model in WSN

This heading characterizes a standard of heterogeneous wireless sensor network and examines the effect of heterogeneous assets [8, 9].

Types of Heterogeneous Resources

There are three common forms of resource heterogeneity in sensor nodes:

- Computational heterogeneity
- Link heterogeneity
- Energy heterogeneity

Computational heterogeneity implies that the heterogeneous node has a more capable chip and more memory than the typical node. With the effective computational means, the heterogeneous nodes can give complex information handling and more term stockpiling.

Link heterogeneity implies that the heterogeneous node has high-data transmission and long-separation system transceiver than the typical node. Link heterogeneity can convey a more trustworthy information transmission. Energy heterogeneity suggests that the heterogeneous node is line powered or its battery is useable.

Among over three sorts of asset heterogeneity, the most critical heterogeneity is the energy heterogeneity on the grounds that both computational heterogeneity and connection heterogeneity will expend more energy asset.

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Impact of Heterogeneity on Wireless Sensor Networks

Benefits of heterogeneous nodes in the sensor network:

- ***Decreasing Latency of Information Transportation:*** Computational heterogeneity can diminish the processing latency in quick nodes and link heterogeneity can diminish the waiting time in the transmitting line. A few number of hops between sensor nodes and sink node likewise mean less forwarding latency.
- ***Prolonging Network Lifetime:*** The normal energy utilization for sending a bundle from the typical nodes to the sink in heterogeneous sensor networks will be considerably short of what the energy expended in homogeneous sensor networks.
- ***Improving Dependability of Information Transmission:*** It is well realized that sensor network connections have a tendency to have low constancy. And each hop significantly brings down the end-to-end transfer rate. With heterogeneous nodes; there will be less hops between ordinary sensor nodes and the sink. So the heterogeneous sensor framework can get much higher end-to-end conveyance rate than the homogeneous sensor network.

Performance Measures

Some execution measures that are used to ascertain the execution of clustering conventions are recorded underneath.

- ***Network Lifetime:*** It is the interval (time) from beginning of operation (of the sensor network) until the passing of the first alive node.
- ***Number of Cluster Heads for Every Round:*** On the spot measure reflects the amount of nodes which would send straightforwardly to the base station, data totalled from their cluster members.
- ***Number of Dynamic Nodes for Every Round:*** This prompt measure reflects the aggregate number of nodes and that of each one sort that has not yet consumed the majority of their energy.
- ***Throughput:*** This incorporates the aggregate rate of information sent over the network, the rate of information exchange from cluster heads to the base station and also the rate of information sent from the nodes to their cluster heads. Figure 1 demonstrates the heterogeneous framework for wireless sensor network.

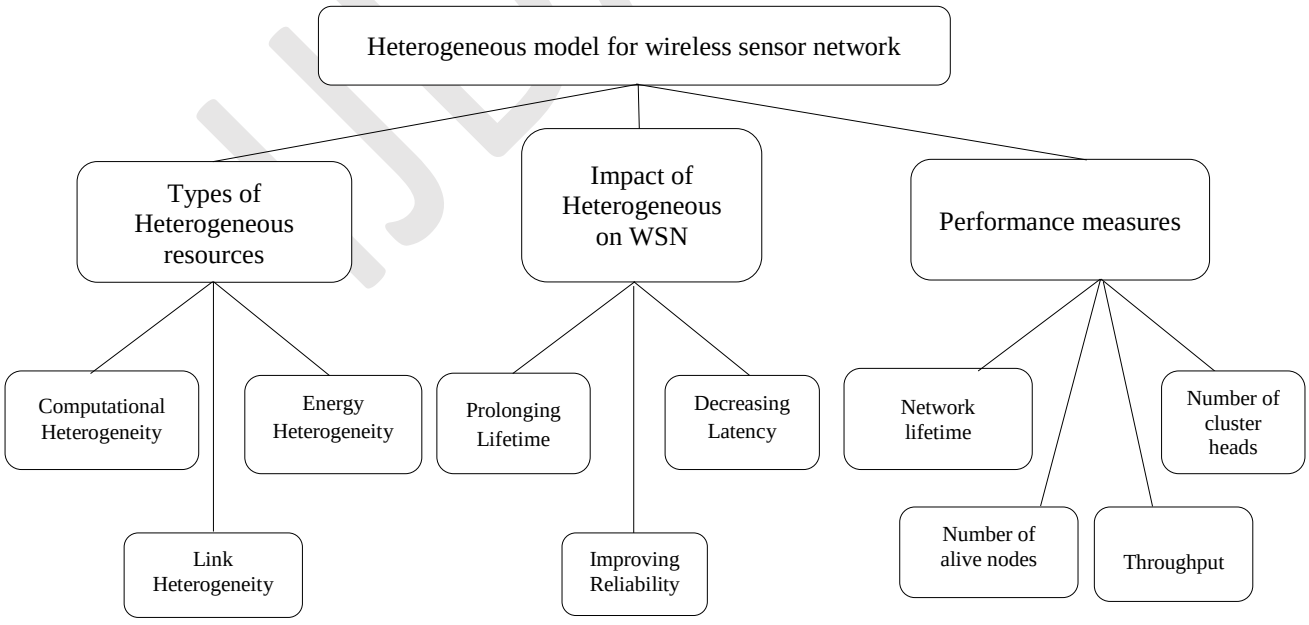

Figure 1: Heterogeneous model for Wireless Sensor Network

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III. CLUSTERING

Network design parameters like in system information handling, node organization and competencies are best depicted in [10]. Clustering destinations like reduced delay, fault tolerance, maximal network longevity, minimum cluster count, increased connectivity and load balancing are additionally portrayed with reference to the homogeneous wireless sensor networks. Abbasi et al. in [10] exhibited an order of clustering characteristics as clustering properties, cluster head proficiencies and clustering procedure. Our review of heterogeneous clustering is likewise focused around a percentage of the properties depicted in [10].

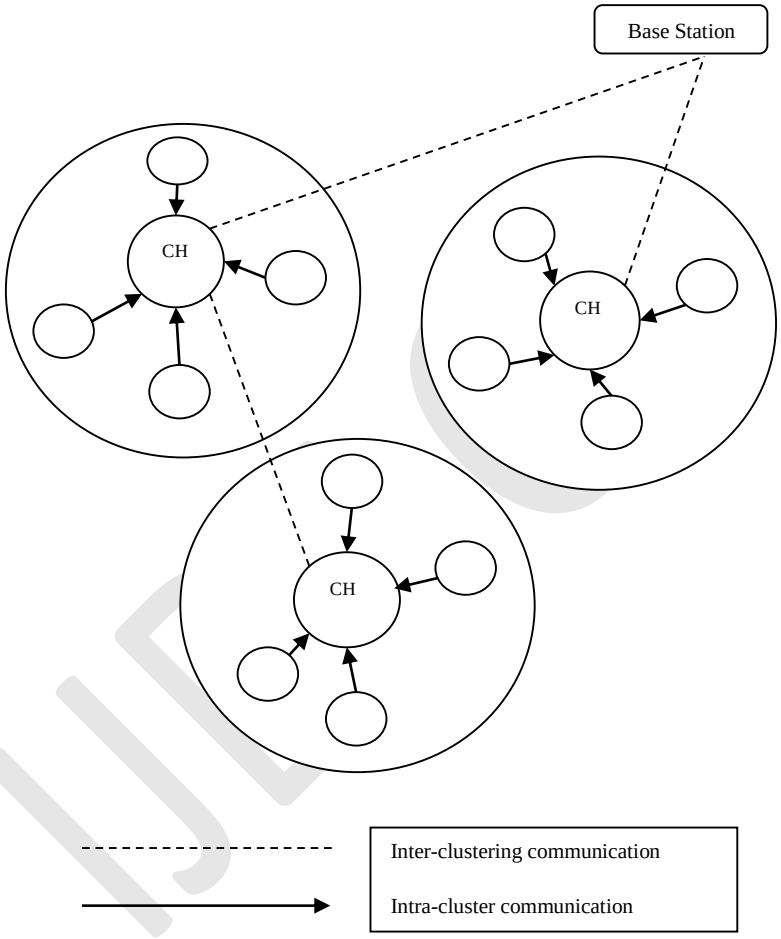

Figure 2: Data communication in a clustering network

Clustering Challenges and Objectives

WSNs likewise exhibit a few specific difficulties as far as outline and usage. Comparable difficulties and outline objectives have additionally been confronted prior in the field of mobile ad hoc networks (MANETs), and commonly a lot of related thoughts (considering clustering protocols and so forth.) have been obtained from that field. In WSNs, however (in which the backing of portability regardless of the possibility that its material, it's not discriminating), the restricted competencies (battery power, transmission reach, handling fittings and memory utilized, and so on.) of the sensor nodes joined with the extraordinary area based conditions met (not effectively got to in place energize the batteries or supplant the whole sensors) make the energy efficiency and the scalability factors considerably more urgent. In addition, the test of prolonging network lifetime under the above confinements is hard to be met by utilizing only conventional methods. Thus, it gets unavoidable to take after option procedures prompting more proficient

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conventions with a lot of contrasts contrasted with the ones intended for MANETs.

Beyond the typical (however essential) difficulties said above (constrained energy, restricted proficiencies, and network lifetime) some extra critical contemplations in the design procedure of clustering algorithms for WSNs ought to be the accompanying:

- ***Cluster Establishment:*** The CH determination and cluster creation techniques ought to create the best conceivable clusters (decently adjusted, and so forth.). Then again they ought to additionally protect the amount of exchanged messages low and the aggregate time unpredictability ought to (if conceivable) stay consistent and free to the development of the system. This yields an extremely difficult trade-off.
- ***Application Dependency:*** When planning clustering and directing conventions for WSNs, application robustness must be of high necessity and the planned protocols ought to have the capacity to adjust to an assortment of use prerequisites. Secure correspondence: As in conventional networks, the security of information is characteristically of equivalent significance in WSNs as well. The capability of a WSN clustering plan to save secure communication is regularly paramount when considering these networks for military applications.
- ***Synchronization:*** Slotted transmission methods, for example, TDMA permit nodes to regularly schedule sleep intervals to minimize energy utilized. Such plans oblige comparing synchronization instruments and the viability of this systems must be considered.
- ***Data Aggregation:*** Because this methodology makes energy improvement conceivable it remains a principal configuration challenge in numerous sensor network schemes these days. Be that as it may its successful execution in numerous applications is not a direct system and must be further advanced as indicated by particular application prerequisites.

Goals of Clustering

Eventually a goal ought to be fixed straightforwardly to the particular application that is, no doubt explained by the WSN:

- ***Load Balancing:*** Having an even dispersion of nodes over the cluster group is imperative for enhancing the life of the WSN. Considering the CH's extra impart obligations and the ensuing battery channel, moving the CH obligation around the cluster is an unquestionable requirement. In the event that the measure of the cluster group gets disproportionate, then the life of the little cluster group is bargained. Contingent upon the format of the WSN, losing a cluster may have negative impacts on the whole WSN. An alternate attention is the point at which now is the ideal time for the CH to gather and total the information to show up for the base station, a bigger than normal cluster will take more time to perform this undertaking. Contingent upon the specifics of the application and the subtle elements of the measure of information being gathered and reported will focus exactly how much of an effect this has to the usefulness of the WSN.
- ***Fault-Tolerance:*** Many WSNs applications happen in the outside after a helicopter has dropped hundreds to many sensors to the ground. The danger of physical harm is a reality and glitch ought to be considered into the configuration of the WSN. Consider the pulverizing outcomes if a CH fizzled ahead of schedule in the organization and there was no configuration to supplant the CH's obligations. In view of the truth of unplanned disappointments, there must be a method for observing the strength of every CH and a plan to supplant a broke down CH.
- ***Energy Efficiency:*** Expanding the life of the WSN is a key destination for any WSN application. Battery life is decreased by a sensor node in every task performed and if the set of assignments set earlier these nodes is not completely enhanced for energy, then the life of the WSN will be altogether reduced. The estimation of WSN is kind of connected to the future of the WSN. Obviously there are costs included in passing on sensors and depending upon the application, there could be timing conditions (i.e. Combat surveillance) that prevents the fast redeployment from claiming a WSN that has ended. Expanding the life of the WSN is a key to the achievement of the estimation of WSN.
- ***Clustering Process:*** Eventually, this procedure should effectively arrange the whole

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WSN into groups of clusters that are ready to convey inside their clusters, additionally equipped to total data and report to the base station. Likewise, an approach for selecting a CH is required alongside a procedure to turn this obligation among the sensor nodes. There are diverse methodologies, for example, pre-determined CH, or an election process. What number of nodes ought to go into each one cluster? Clearly, the more confounded the methodology, the more cycles utilized with the sensor itself and the more energy devoured. Additionally, there is an impediment on the measure of capacity, so these algorithms should run productively, as well as have a little footprint impression.

Classification of Clustering Attributes

- ***Cluster Properties:*** Quite regularly, clustering techniques strive to accomplish a few qualities for the produced clusters. Such qualities could be identified with the interior structure of the cluster or how it identifies with others. The accompanying are the significant traits:
- ***Cluster Count:*** CHs are decided ahead of time in a portion of the distributed methodologies like [11], [12], and [13], in this manner, the amount of clusters is reset. CH selection algorithms by and large pick haphazardly CHs from the sent sensors consequently yields variable number of clusters.
- ***Intracluster Topology:*** Certain clustering schemes are focused around immediate correspondence between a sensor and its assigned CH, yet here and there Multihop sensor to CH integration is needed.
- ***Connectivity of CH to BS:*** CHs send the collected information to the BS specifically or by implication with help of other CH nodes. That is to say, there exists an immediate connection or a Multihop.

Cluster Head

- ***Capabilities:*** The accompanying properties of the CH hub are separating components among grouping plans:
- ***Mobility:*** CH may be stationary or versatile. As a rule, they are stationary. Be that as it may here and there, CHs can move inside a restricted area to reposition themselves for better execution of network.
- ***Types of Node:*** Generally sensor nodes among the conveyed sensors are assigned as CHs, however now and again sensor nodes outfitted with essentially more processing and correspondence assets are chosen as CHs.
- ***Role:*** Some of the principle parts of the CHs are relaying the traffic, aggregation or combination of the sensed data.

CH Selection Based on:

- ***Initial Energy:*** This is a vital parameter to choose the CH. At the point when any algorithm begins it for the most part considers the initial energy.
- ***Residual Energy:*** After a portion of the rounds are finished, the cluster head choice ought to be focused around the energy staying in the sensors.
- ***Rate of Energy Consumption:*** This is an alternate vital parameter that considers the energy utilization rate $V_i(t)$ focused around emulating formula:

$$V_i(t) = \frac{E_{initial} - E_i(t)}{r-1} \quad (1)$$

Where $E_i(t)$ and $E_{initial}$ are the residual energy and initial energy of every node separately and r is the existing round.

- ***Average Energy of the Network:*** The average energy is utilized as the reference energy for every node. It is the ideal energy that every node ought to possess in existing round to retain the network alive.

IV. Energy Efficient Clustering Protocols for Heterogeneous Wireless Sensor Networks

Katiyar et al. [8] overviewed clustering calculations for heterogeneous wireless sensor networks. They grouped clustering algorithms focused around two fundamental paradigms: as indicated by the strength and vitality proficiency. They likewise overviewed a few energy-efficient clustering protocols for heterogeneous WSNs. In this segment, we need to overview and look at other energy proficient conventions for clustering in heterogeneous wireless sensor networks.

Energy Efficient Heterogeneous Clustered Scheme (EEHC)

Dilip and Patel [9] proposed an energy effective heterogeneous clustered method (EEHC), for choosing cluster heads in a conveyed manner in various levelled wireless sensor networks. The election probabilities of cluster heads are weighted by the leftover energy of a node with respect to that of different nodes in the system. The algorithm is

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focused around LEACH and takes a shot at the decision methodologies of the cluster head in vicinity of heterogeneity of nodes. Reproductions results demonstrate that EEHC is more viable in drawing out the system lifetime contrasted and LEACH.

Distributed Energy Balance Clustering (DEBC) Protocol

Changmin Duan and Hong Fan [14] proposed a distributed energy balance clustering DEBC) protocol for heterogeneous wireless sensor networks. Cluster heads are chosen by a likelihood relying upon the degree between residual energy of node and the average energy of network. The high initial and residual energy nodes have a bigger number of opportunities to be the cluster heads than the low energy nodes. This protocol additionally considers two-level heterogeneity and afterward it expands the results for multi-level heterogeneity. DEBC is not the same as LEACH, which verify every node might be cluster head in every ni=1/p rounds. This paper finds the DEBC is better than LEACH and SEP.

Weighted Election Protocol (WEP)

Rashed et al. [15] proposed a routing protocol with a specific end goal to upgrade the stability period of wireless sensor networks. This protocol is called weighted election protocol (WEP). It acquaints a plan with join together clustering methodology with chain routing algorithm for fulfil both energy and stable period compels under heterogeneous environment in WSN.

In this method, the authors have considered the accompanying suspicions:

- Every sensor node has power control and the capability to transmit information to any possible sensor node or specifically to the base station.
- In the prototype, two sorts of nodes are utilized, for example, normal node and advanced node where advanced node have more energy as compared to normal node.
- Advanced nodes need to wind up cluster heads more frequently as compared to normal nodes by distinct threshold for each one sort of node
- There is no mobility.

WEP allocates a weight to the optimal probability for every node. This weight must be equivalent to the initial energy of every node partitioned by the initial energy of the ordinary node. In the wake of doling out weighted likelihood of each one sort nodes, this convention can choose cluster head and their related non-cluster head as the same path as it done in LEACH protocol. At that point that can utilize greedy algorithm to make a chain among the chose cluster heads. In the wake of building chain among cluster head nodes, a chain pioneer is chosen arbitrarily. Utilizing TDMA scheme, all non-cluster head nodes send their information to their particular cluster head nodes. The cluster head nodes in each one cluster then fused those information lastly send to the base station.

Distributed Energy Efficient Clustering (DEEC) Algorithm

Distributed energy efficient clustering algorithm is proposed by Qing et al. [16]. In DEEC, the cluster heads are picked by a probability centered on the degree between leftover energy of each node and the average energy of the network. The epochs of being cluster heads out to nodes are diverse as per their residual and initial energy.

The authors have expected that all the nodes of the sensor network are furnished with distinctive measure of energy, which is a wellspring of heterogeneity. DEEC is likewise focused around LEACH; it pivots the cluster head part among all nodes to use energy consistency.

Two levels of heterogeneous nodes are considered in the algorithm and after that a general answer for multi-level heterogeneity is acquired. To keep away from that every node needs to know the worldwide information of the network, DEEC gauges the perfect estimation of network life-time, which is utilized to process the reference energy that every node ought to exhaust throughout a round.

Developed Distributed Energy-efficient Clustering (DDEEC)

Elbhiri et al. [17] proposed a created distributed energy efficient clustering scheme for heterogeneous WSNs. This method is focused around changing rapidly and with more proficiency the cluster head election probability.

DDEEC is focused around DEEC technique, where all nodes utilize the beginning and residual energy level to characterize the cluster heads. To sidestep that every node needs to have the worldwide information of the networks, DDEEC like DEEC assessment the perfect estimation of network lifetime, which is utilized to process the reference energy that every node ought to exhaust throughout each one round.

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In the technique, the network is sorted out into a clustering hierarchy, and the cluster heads gather estimations data from cluster nodes and transmit the collected information to the base station straightforwardly. Additionally, the authors have assumed that the network topology is settled and no-changing on time. The contrast in the middle of DDEEC and DEEC is restricted in the articulation which characterize the likelihood to be a cluster head for normal and advanced nodes. Simulation results demonstrate that the protocol performs superior to the SEP and DEEC regarding network lifetime and first node passes on.

Stochastic Distributed Energy Efficient Clustering (SDEEC)

An enhancement of DEEC is proposed as stochastic DEEC by Elbhiri et al. [18]. SDEEC is a self-organized network with dynamic clustering. This algorithm presents an element strategy where the cluster head selection probability is more proficient. In this protocol, the cluster head choice in general system is focused around nodes' remaining energy.

As per the protocol, all non-cluster head nodes send information to particular cluster heads in their distributed transmission time. The cluster head node must keep its beneficiary on, to get all the information from the nodes in the cluster. Certain signal processing is performed by cluster head to layer the information into a solitary signal when all the information is gotten. After this stage, each one cluster head sends the totalled information to its prime cluster head. Every non-cluster head can turn off to the sleep mode to save the energy. The disservice in the protocol is that if non-cluster head nodes turn off to the sleep mode when cluster head is performing collection, how they will come to think about the following round of cluster head choice. Simulation results demonstrate that SDEEC performs superior to SEP and DEEC regarding network lifetime.

Threshold Distributed Energy Efficient Clustering (TDEEC) Protocol

Saini and K. Sharma [19] proposed an energy efficient cluster head scheme for heterogeneous wireless sensor networks, which is called Threshold Distributed Energy Efficient Clustering protocol.

In this technique, the authors have considered the accompanying suppositions:

- Sensor nodes are consistently arbitrarily conveyed in the network.
- Nodes are position-unaware, i.e. not outfitted with GPS competent antennas.
- Nodes have comparable preparing and correspondence capacities and equivalent consequence.
- Sensor nodes have heterogeneity as far as energy i.e., distinctive energy levels. All nodes have diverse initial energy; a few nodes are outfitted with more energy than the ordinary nodes.

In TDEEC, the authors have balanced the estimation of the threshold, as per which a node chooses to be a cluster head or not, in view of degree of average energy and residual energy of that adjust in admiration to the ideal number of cluster heads. Simulation results demonstrate that TDEEC performs better as contrasted with SEP and DEEC in heterogeneous environment for WSN.

Enhanced Distributed Energy Efficient Clustering (E-DEEC)

Heinzelman, et al. [20] proposed LEACH centralized (LEACH-C), a convention that utilizes a centralized clustering algorithm and the same steady state protocol as LEACH. SEP (Stable Election Protocol) [21] is proposed in which each sensor node in a heterogeneous two-level progressive system freely chooses itself as a cluster head focused around its initial energy in respect to that of different nodes. Li Qing et al. proposed DEEC [16] (Distributed energy efficient Clustering) algorithm in which cluster head is chosen on the premise of probability of proportion of remaining energy and average energy of the system. Simulations demonstrate that its execution is superior to different protocols. B. Elbhiri et al. proposed SBDEEC (Stochastic and Balanced Developed Distributed Energy-Efficient Clustering) [18]. SBDEEC presents an adjusted and element system where the cluster head election probability is more effective. Besides, it utilizes a stochastic scheme recognition to enlarge the network lifetime. Simulation results demonstrate that this protocol is superior to the Stable Election Protocol (SEP) and the Distributed Energy- Efficient Clustering (DEEC) as far as network lifetime. The E-DEEC (Enhanced Distributed Energy Efficient Clustering) scheme is based on DEEC with addition of super nodes.

V. CONCLUSION

Carrying out literature review is very significant in any research project. It clearly establishes the need of the work and the background development. It generates related queries regarding improvements in the study already done and allows unsolved problems to emerge and thus clearly define all

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boundaries regarding the development of the research project. This paper reviews the process of clustering in heterogeneous wireless sensor networks model.

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