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Review on LEACH-Homogeneous and Heterogeneous Wireless Sensor Network

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ABSTRACT: With the increased adoption of Wireless communication and sensor technology, wireless sensor networks are presently employed in variety of applications from medical to military and from home to industry. The major challenge of WSN is as Sensor nodes are battery operated, energy utilization is the main issue which requires special attention. Previously sensor nodes are considered to be homogeneous in which each node has the same energy, processing capacity and functionality but in order to prolong network lifetime researches has been develop to implant heterogeneity in wireless sensor network in which different energy level is provided to some nodes. This paper enlightens a current survey on basic clustering technique for Homogeneous and Heterogeneous wireless sensor network.

KEYWORDS: Wireless Sensor Networks (WSNs), Low-Energy Adaptive Clustering Hierarchy (LEACH), Heterogeneous WSN , Homogeneous WSN, Multi-hop, Energy consumption.

I. INTRODUCTION

Wireless sensor networks are an active research area and one of the attractive and rapidly growing fields. WSNs are used in many applications, such as area monitoring, health care monitoring, environmental/ earth sensing and industrial monitoring etc. A WSN composed of tiny device called sensor nodes that are densely deployed over a large area and capable of detecting various events. A sensor node consists of sensor, controller, memory, transceiver, A/D converter and battery. Sensing, processing and communication are three main operation of a sensor node. The base station processes and stores the data it receives from the sensor node. The data forwarded by sensor nodes to base station is direct transmission, or through multi-hop communication. The sensor nodes have limited amount of memory, processing, capacity, communication range and above all limited amount of energy because sensor nodes are battery powered [10]. It is difficult to replace and recharge batteries of the sensor nodes as they are deployed in harsh environment. Hierarchical routing is an efficient technique to reduce energy consumption by doing data aggregation and fusion in order to reduce the number of transmission to the base station. The first hierarchal protocol is the low energy adaptive clustering hierarchal (LEACH). The idea of LEACH is to form cluster of sensor nodes based on received signal strength and use cluster head as the router to sink. Many hierarchical protocols were emerged based on the idea of LEACH. The goal of this paper is to provide a current survey on LEACH based protocols.

Paper Organization: The rest of this paper is organized as follows. Section II presents the LEACH protocols architecture .Section III exhibits the details of survey of various LEACH–based homogeneous and heterogeneous WSN. In Section IV, performance of different protocols is concluded.

II. LEACH PROTOCOL ARCHITECTURE

Low energy adaptive cluster hierarchy (LEACH) is an adaptive, self organizing and clustering protocol. In LEACH, the nodes form cluster, with one node in every cluster acts as cluster head. All non-cluster head nodes known as member node transmit their data to the cluster head. Cluster head perform signal processing on the received data (i.e. data aggregation) and transmit data to the BS[1]. Cluster head consume more energy than cluster members. As the cluster head runs out off energy all the nodes that belong to the cluster lose communication ability. To overcome this

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LEACH introduces randomized rotation of cluster head so that energy load is balanced between nodes. LEACH algorithm assures that every node in one cluster would be selected as a cluster head with equal possibility .In LEACH operation is divided into rounds as shown in Fig.1. Each round has two phases: setup phase and steady state phase.

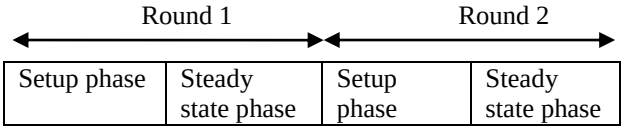

Fig.1 LEACH Phases: Setup and Steady State Phase

In setup phase the cluster head is selected randomly and the nodes closer to cluster head makes a cluster dynamically. In steady state phase the nodes in each cluster would send their data to respective cluster head, and then cluster head would aggregate the data and send it to sink node.

The sub-phases included in the above phases are: advertisement phase, cluster set-up phase, schedule creation phase and data transmission phase [5].

In advertisement phase each node picks random number between 0 and 1 and if the picked number is less than threshold value then it advertise itself as cluster head by broadcasting an advertisement message(ADV) using carrier-sense multiple access (CSMA)MAC protocol. T(n) is computed in eq. (1) [5].

$$T(n) = \begin{cases} \dfrac{P}{\left(1-P\left(r \bmod \left(\frac{1}{p}\right)\right)\right)} & : if\ n \in G \\ 0 & : otherwise \end{cases} \qquad \text{eq. (1)}$$

Where,
n=given number of nodes in the network
P=predefined percentage of CH (P=0.05)
r = r is the current round
G=nodes that have not been cluster head in the last 1/P rounds.

This advertisement message includes node's ID and a header that discriminate this message as an announcement message [1]. During this phase non-cluster head nodes must keep their receivers on. Each non-cluster head node determines their respective cluster head based on received signal strength of the advertisement message. After each node has decided to which cluster it belongs each node transmit a join request message (join-REQ) back to the selected CH. This message is also a shot message consisting of the node's ID and cluster head's ID. This is included in cluster set-up phase. After receiving all (join-REQ) messages TDMA schedule is created and this schedule is transmitted to all the nodes in the cluster. This ensure that there are no collisions among data messages and also allow the radio components of each non-cluster head node to be turned off at all times except their transmit time and thus reduces the energy consumption. This phase is known as schedule creation phase. After TDMA schedule the set-up phase is complete and steady state operation begins. Steady state phase is data transmission phase in which nodes send their data to the cluster head in a given time slot directly or through intra-cluster communication. Power control must be set to reduce energy dissipation [1].The CH nodes must keep its receiver on to receive all the data from the nodes. When all the data is received CH nodes performs aggregation to compress the data and then this data is sent to base station directly or through inter-cluster communication .After a certain time a new round begin [5].

A. *Homogeneous and Heterogeneous model for wireless sensor network:*

In homogeneous wireless sensor network all nodes in the network are equipped with equal amount of energy. While in case of heterogeneous there is super, normal and advance node are uniformly distributed in space .The initial energy of normal node is E0 same as initial energy of all nodes in homogeneous WSN. The energy of super node is β time's

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more than normal node and the energy of advance node is α times more than the normal node. In the heterogeneous scenario there are different weighted probabilities for normal, advance and super node shown in [3].

B. *Sensor Nodes Communication:*

Multi-hop inter-cluster communication: Each cluster head selects the nearest cluster head in one hop range as its next hop. Multi-hop intra-cluster communication: Intra-cluster routing refers to the routing that occurs between sensors belonging to the same cluster. Direct diffusion: Direct diffusion (DD) constructs the route between sensor nodes and the BS [6].

III. CLUSTERING ALGORITHMS BASED ON HOMOGENEOUS AND HETEROGENEOUS WSN

A. *Stable election protocols***:**

Smaragdakis G.et al [2] proposed SEP, a two-level heterogeneous-aware protocol to prolong the stability period and also describe the instability of some protocols in the presence of heterogeneity, once some nodes die. It consists of two types of node: normal node and advance node. To balance energy consumption advance nodes become cluster heads more than normal nodes [2].Stable election protocol is energy aware and is based on weighted elections probabilities of each node to become cluster head according to the remaining energy in each node. To balance energy consumption advance nodes become cluster heads more often than normal nodes [2].This prolongs the stability period (i.e. start of network operation until the death of first sensor node) and throughput.

B. *EEHC: Energy efficient Heterogeneous clustered scheme for WSNs:*

Kumar D. et al [3] introduce an energy efficient three-level heterogeneous clustered scheme based on weighted probabilities for the election of cluster heads. EEHC protocol compares its performance with LEACH in presence of heterogeneity. EECH has three types of nodes, super node, advance node, and normal node. Different nodes are having different weighted probabilities. According to these probabilities the threshold is obtained that is used to elect the cluster heads in each round. EECH takes full advantage of heterogeneity by introducing extra energy of advance and super node therefore increases the stable region and decreasing the unstable region.

C. *EHE-LEACH: Enhanced Heterogeneous LAECH Protocol for Lifetime Enhancement of Wireless SNs:*

Tyagi S. et al [6] proposed an enhanced two-level heterogeneous LEACH (EHE-LEACH) protocol for lifetime enhancement of SNs and also overcome the major drawback of SEP protocol (i.e. poor stability). There are two levels of node: normal and advance node. Cluster heads are selected on the bases of weighted probabilities. Based on these weighted probabilities respective threshold are suggested. This protocol is using the combination of direct diffusion (DD) and LEACH. In EHE-LEACH fixed distance threshold is used to, separate DD and clustering. The proposed model consider two parameters: minimize the execution and maximize the life time and stability by using combination of two techniques simultaneously direct diffusion and clustering. The Half node alive and last node alive is the two key parameters used for the measurement of lifetime and stability of the system. Simulation results show that the lifetime and stability of network field is significantly enhanced as compared to LEACH and SEP.

D. *EEM-LEACH: energy efficient multi–hop LEACH routing protocols for clustered WSNs:*

Antoo A. et al [4] proposed an energy efficient homogeneous routing protocol EEM-LEACH that discovers a multi-hop path with minimum communication cost from each node to base station. Cluster head selection is based on maximum residual energy and average energy consumption of nodes. In the proposed protocol the threshold T(n) is adjusted by incorporating residual energy and average energy consumed .EEM–LEACH include a multi-hop inter cluster communication and direct communication. Multi-hop path from each cluster head to base station depends upon communication cost metric shown by equation and is chosen in set-up phase [4]. This protocol is centralized i.e. base

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station at the centre sends message. EEM –LEACH shows better lifetime, minimized energy consumption and good packet delivery than existing protocols.

E. *Heterogeneous multi-hop LEACH routing protocols:*

Sharma S. et al [5] introduced a heterogeneous multilevel clustering approach to increase the energy efficiency by keeping the radio communication distance as minimum as possible. There are three types of nodes: normal node, intermediate node and advance node. It allows inter-cluster communication. In this protocol cluster-head sends the aggregated data to an advance node which is closer to the BS or to BS directly depending upon the smaller distance. The protocol provides better results and is more energy-efficient as compared to LEACH.

F. *DEEC: Design of distributed energy–efficient clustering algorithms for heterogeneous wireless sensor network:*

Qing L. et al [7] purposed an energy–aware algorithm fit for multilevel heterogeneous wireless sensor networks. In this algorithm cluster heads are elected in which the ratio of the average energy of the network and nodes residual energy will be considered. Selection of cluster-head is based on initial and residual energy level of nodes. The authors assumed that all the nodes of the sensor network contain different amount of energy, which is a source of heterogeneity. DEEC assure that all the nodes in the network die almost at the same time. DEEC protocol is centralized, as base station broadcast the total energy and estimate life time of all nodes. At the start of processing nodes should have kept the prior knowledge of total energy and lifetime of the network. Simulation shows that DEEC perform more efficiently than other protocols (LEACH, SEP, LEACH-F).

G. *Improved LEACH protocol for wireless sensor network:*

Kumar N. et al [8] proposed an improved LEACH (I-LEACH) a homogeneous wireless sensor network to overcome two shortcoming of LEACH protocol i.e. cluster head selection is based on probability and location of cluster head is not certain which result CHs to be concentrated in one part of network. I-LEACH include two main changes, residual energy is used to select the cluster head instead of probability and coordinates are used to form cluster so that their must remain a CH close to every sensor node. I-LEACH also uses first order energy dissipation radio model. Simulation result shows that I-LEACH solves the issue of node heterogeneity as it works on the residual energy concept. I-LEACH improves the network lifespan over LEACH protocol.

H. *U-LEACH: A novel routing protocol for heterogeneous wireless sensor network***:**

Kumar N. et al [9] suggested a universal–low energy adaptive cluster hierarchy (U-LEACH) protocol showing significant reduction in residual energy of the nodes. U-LEACH is a chain–formation based hierarchical clustering protocol for heterogeneous WSNs. The selection of cluster head is based on residual energy and initial energy of the nodes. The process used for transferring data from node to cluster head is done by chain formation .U-leach combines' features of I-LEACH and PEGASIS (chain formation) protocol along with the concept of heterogeneity. The simulation result shows that the stability period has been enhanced and the concept of introducing MCH has reduced the consumption of energy and hence increases the lifespan of network.

I. *Cluster head election for energy and delay constraints applications of wireless sensor network:*

Thakkar A. et al [10] illustrated a homogeneous routing algorithm by introducing Energy Delay index for Trade-off (EDIT) to optimize both energy and delay. Energy consumption is directly proportional to the distance but it increases delay. Proposed approach is derived using two types of distances named Euclidean distance and hop-count to measure distance from the sink. EDIT is centralized, as the algorithm is initiated by the sink by sending message. In this each node waits for energy message before it broadcast its energy level. Cluster head is elected on the bases of remaining energy. If two or more nodes are having equal energy EDIT is calculated from equation [10]. Each probable CH will wait for 1/EDIT times before doing announcement that it is a CH. Results shows that delay felt by packets are small

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when Euclidean distance is used compared to hop count. And also shows that energy consumption per node is more when Euclidean distance is used.

J. *A clustering based hybrid routing protocol for enhancing network lifetime of wireless sensor network:*

Gnanambigai J. et al [11] proposed a new hybrid routing protocol called quadrant based low energy adaptive clustering hierarchy (QB-LEACH). This protocol integrates the advantage of two different protocols: quadrant based directional routing (Q-dir) and LEACH. This protocol fuses the clustering approach and restricted flooding. In QB-LEACH cluster formation is based on LEACH procedure and data transmission is based on Q-DIR. CH communicate to BS through intermediate gateway node IGN. Three performance metrics are considered: routing overhead, average energy consumption for data transmission and lifetime of network. Simulation shows that QB-LEACH prolongs the network lifetime by using limited number of nodes for data transmission. Also by using IGN large communication distance between the CH and BS is reduced.

K. *Improved energy efficiency semi static routing algorithm using sink mobility for WSN:*

Deepali et al [12] propose an improved energy efficiency semi-static clustering protocol which is based on sink mobility. In IEESSC clustering is based on remaining energy. IEESSC is an improved version of EESSC using sink mobility to reduce communication cost. EESSC is energy aware hierarchal based clustering protocol. In this protocol CH creates list of nodes in cluster (LNC) and distance list to other cluster (DLOC). According to LNC CHs are selected in each round. In IEESSC sink moves randomly by changing its position after each round. Simulation shows that stability period (FND), network lifetime (LND) and MND of IEESSC is better than EESSC and LEACH.

L. *A cluster-based routing protocol for wireless sensor networks with adjustable cluster size:*

Kuang lai W. et al [13] proposed a cluster-based routing protocol for wireless sensor network named as Adjustable cluster-based routing protocol (ACRP) in which cluster size is adjusted such that communication loads can be evenly shared by individual node and therefore extend the lifetime of an entire sensor network. LEACH has a drawback that it has unequal clusters sizes. To deal with the problem ARCP tries to balance the cluster sizes after each round. In ACRP after receiving the join message CH will send this message to BS by flooding. BS send a path creation message for route establishment. The CH in ARCP transmits data by using multi-hop transmission. The simulation shows the advantage of ACRP over LEACH.

M. *An extended Vice-cluster selection approach to improve V LEACH protocol in WSN:*

Ahlawat A. et al [14] proposed a new version of LEACH protocol called improved VLEACH which increase network life time by selecting vice- cluster head. Vice cluster head is alternate head that work only when the cluster head will die. The process of vice cluster head selection is based on minimum distance, maximum residual energy and minimum energy. Conclusion shows that the new version of improved V-LEACH outperforms the original LEACH protocol by increasing the life time of network.

IV. CONCLUSION

While talking about wireless sensor network the main challenge in designing is how to efficiently utilize energy because sensor nodes are battery powered. Our main objective is to increase the network life time as long as possible and to increase network stability .This paper reviewed various homogeneous and heterogeneous wireless sensor network and concluded that heterogeneous wireless network shows better energy utilization, stability and are more familiar to real life application. Moreover heterogeneous WSN overcome the disadvantages of Homogeneous WSN by introducing inter-clustering and intra-clustering techniques.

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BIOGRAPHY

Supriya Dhauta completed her B-Tech in Electronic and Communication from ACET baru sahib.She is currently pursuing her M-tech in Electronics and Communication Engineering from Bahra University, waknaghat. She participated in International Conference on "re-newable energy" held on 5^{th}-6^{th} may 2012 at eternal university and national conference on "innovation in engineering, pharmaceutical, legal and management sciences held on 30^{th} may 2014 at Bahra university. Her current research interest includes wireless sensor networks.

Ripul Rishi completed his B-Tech in Electronic and Communication engineering from DAV Institute of Engineering and Technology in year 2010. He received his M-Tech degree from C-DAC in Embedded system in year 2013. He has published papers in International journals and computer applications. He is currently working as assistant professor in School of Electronics and Communication Engineering, Bahra University, Waknaghat. His current research interest includes embedded system and wireless sensor network.