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REVIEW ARTICLE

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SURVEY ON WIRELESS SENSOR NETWORKS - ENERGY EFFICIENT CLUSTERING PROTOCOLS

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ABSTRACT

A Wireless sensor network is a wireless network made of large number of sensor nodes with at least one base station. The routing protocols save energy of nodes and provide optimal data transmission from sensor node to sink node. Clustering is a mechanism use in WSN to extend lifetime of sensor network by reducing energy consumption. In this paper, include the primary issue energy consumption and network lifetime we represents four cluster based routing protocols; Low Energy Adaptive Clustering Hierarchy (LEACH), Stable Election Protocol (SEP), Enhanced Stable Election Protocol (ESEP),Deterministic energy-efficient clustering (DEC) protocol.

Keywords: WSNs, clustering protocol, energy efficient, network lifetime.

I. INTRODUCTION

WSN is at most improving technology in recent years. It consists of sensor nodes that sense the environment and gather the information from the near field and communicate by wireless links; the information collected is forwarded, through multiple hops relaying to a sink that may use it domestically or connected to alternative networks [1].

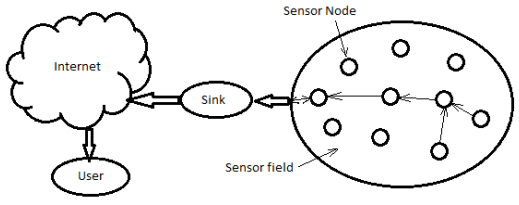

Figure 1: Basic Architecture of WSNs

The applications of WSN which include health care systems, environmental condition monitoring, industrial surveillance, and farm land monitoring, etc. The sensor nodes are scattered in a particular area as per the requirement of the application. Sensor nodes have limited energy. Once the sensor network is chosen, it is difficult to change the network topology and replace the battery of sensor node. Thus the energy utilization of sensor node efficiently to increase stability period and network lifetime are being focused by several authors by developing different protocols [4],[5].

Sensor nodes consume more energy during data transmission than sensing. Different energy efficient routing protocols are designed based on different parameters. In wireless sensor networks, one of the main problem is limited battery power which plays a great influence on the network lifetime [1]. Several routing protocols have been

designed for WSNs to enhance efficiency, scalability and lifetime.

Different energy efficient routing protocols are proposed based on different parameters. In direct transmission, sensor nodes sense data and each sensor node sends data to sink directly [5]. It has a drawback that nodes at long distance from the sink consume their energy more frequently due to involvement of data transmission and it decreases the network lifetime. In multi-hop distance transmission nodes transmit data to their adjacent sensor nodes on the way to sink and hence it involves short distance data transmission [4]. After multi-hop, clustering approach evolved to maximize the network lifetime. Several authors [4]-[6] have used clustering approach. Dividing the sensor networks into small manageable units is called as clustering. In this sensor nodes placed themselves into clusters and each cluster has one node as cluster head and other nodes are the cluster members. The main role of cluster head is to provide data communication between sensor nodes and the base station efficiently [6].A cluster head is selected for each cluster based on the energy level of that node or distance based. Clustering reduce the number of exchanged communications in wireless sensor network which results in low consumption of battery power of sensor nodes. This increases the lifetime of the WSNs [4].

In LEACH and ESEP cluster heads are chosen probabilistically but they do not ensure well distributed election of cluster head over the field.DEC is a heterogeneous residual energy based clustering approach. But it also does not select cluster head uniformly over the field.

II. SOME EXISTING CLUSTERING PROTOCOL

A. Low Energy Adaptive Clustering Hierarchy (LEACH) protocol: It is first hierarchical routing protocol for sensor network to increase the life span. LEACH protocol divides the total WSN into many clusters. The cluster head is selected randomly, every node to become a cluster head is equal to where energy consumption of whole network is averaged. This will extend the network life cycle in WSNs. Leach is a cyclical algorithm that it runs with several rounds. Each round consist two states: cluster setup state and steady state. In setup state it forms cluster within the self-adaptive mode and the information is transferred in steady state. The selection of cluster head depends on decision made 0 and 1 and compares it to the threshold T(n).If the number is less than threshold value, the corresponding node becomes a cluster head for the current round [8].

$$T(n) = \begin{cases} \frac{p}{1-p(r \bmod 1/p)} & \text{if } n \in G \\ 0 & \text{else} \end{cases} \quad (1)$$

Where, P is the desired percentage of cluster heads,r is that the current round, and G is that the set of nodes that haven't been selected as cluster heads within the last 1/p rounds. By considering this threshold, every node has a 1/p probability to be selected as a cluster head in every round. At the end of each round, every normal node that is not a cluster head choose the nearest cluster head and joins that cluster to transmit the information. The cluster heads combine and compress the information and forward it to the base station.

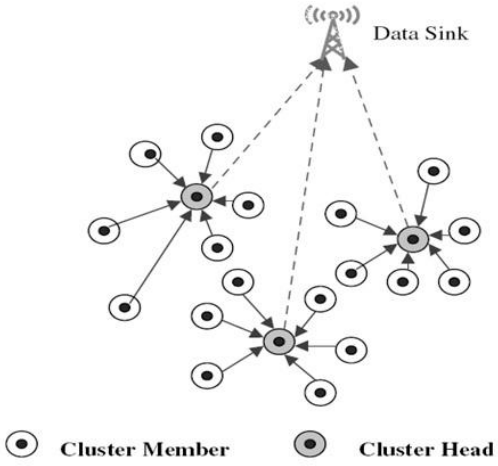

Fig 2: Network Model of LEACH

Limitation in LEACH protocol is as the cluster head is selected randomly. After number of rounds, the node containing greater remaining energy and the node with smaller remaining energy has same probability to be chosen as cluster head. If the node with smaller remaining energy is chosen as cluster head, it will move out the energy quickly and die, due to this network's robustness can be affected and lifetime of the network becomes short [8].

B. SEP Stable Election Protocol (SEP) :It was proposed as an improvement over LEACH protocol.

It is heterogeneous protocol, based on weighted election probabilities of every node to become cluster head according to their specific energy. This protocol assumes that the nodes have different energy and there are two types of nodes: advanced and normal nodes. The advanced nodes get more chances to become a cluster head because of having more amount of energy. Non-cluster-head nodes send their energy information to the cluster head node with the data signal. Here the sink nodes check the heterogeneity and broadcast normal node advanced node probabilities that is nrm P and adv P to the cluster heads [3].

$$T(n_{nrm}) = \begin{cases} \frac{P_{nrm}}{1-P_{nrm}\,[r \bmod (1/P_{nrm})]} & \text{if } n_{nrm} \in G' \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

$$T(n_{adv}) = \begin{cases} \frac{P_{adv}}{1-P_{adv}\,[r \bmod (1/P_{adv})]} & \text{if } n_{adv} \in G'' \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

Where, $T(n_{nrm})$ is threshold value for normal nodes, $T(n_{adv})$ is threshold value for advanced nodes, $1/P_{adv}$ is probability of each advanced node to become a CH in each round,$1/P_{nrm}$ is probability of each normal node to become a CH in each round ,P_{nrm} is percentage of normal nodes to become CH, P_{adv} is percentage of advanced nodes to become CH, G' is set of normal nodes that haven't been selected as CH , $G''$is set of advanced nodes that haven't been selected as CH ,and r is current round. The values for P_{nrm} and P_{adv} are calculated as

$$P_{nrm} = P/(1+m\alpha) \quad (4)$$

$$P_{adv} = (P)(1+\alpha)/(1+m\alpha) \quad (5)$$

Where, m: proportion of the advanced nodes with α times more Energy than the normal nodes.

With the above governing equations the SEP protocol improved significantly the network lifetime of WSNs as compared with the LEACH protocol [3]. The limitation of SEP method is that the election of the cluster heads among the two type of nodes is not dynamic, which results that the nodes which are far away from the powerful nodes will die first.

C. Enhanced Stable Election Protocol (ESEP) : This protocol consists of three types of nodes – normal nodes (NRM), intermediate nodes (INT) and advanced nodes (AVD) [7]. The energy of AVD is greater than rest of all other nodes and having energy α times more than energy of 'NRM'. The energy of INT lies between 'NRM' and 'AVD' and are having energy μ times more than energy of 'NRM' Rests of all nodes are called normal nodes, having energy less than both advanced and intermediate nodes [7]. In this protocol each node elect as CH with depending on the type different probability. The probabilities for each type of nodes are given below

$$P_{nrm} = P_{opt}/(1+m\alpha+b\mu) \quad (6)$$

$$P_{int} = P_{opt}(1+\mu)/(1+m\alpha+b\mu) \quad (7)$$

$$P_{adv} = P_{opt}(1+\alpha)/(1+m\alpha+b\mu) \quad (8)$$

Where, P_{nrm} is percentage of normal nodes in network, P_{int} is percentage of intermediate nodes in network, P_{adv} is percentage of advanced nodes in network , m is proportion of the advanced nodes with α times more energy than the normal nodes, b is proportion of the intermediate nodes with μ times more energy than the normal nodes, and P_{opt} is initial probability of a node to become CH in homogenous setup.

The threshold indication functions for normal, intermediate and advanced nodes can be computed as [7]:

$$T(n_{nrm}) = \begin{cases} \frac{P_{nrm}}{1-P_{nrm}\,[r \bmod (1/P_{nrm})]} & \text{if } n_{nrm} \in G' \\ 0 & \text{otherwise} \end{cases} \quad (9)$$

In above equations, we have n(1-m-b) normal nodes, where G' is the set of all normal nodes that have not become CH in the past $\frac{1}{P_{nrm}}$ round r. The same analogy follows for the intermediate and advanced nodes.

$$T(n_{int}) = \begin{cases} \frac{P_{int}}{1-P_{int}\,[r \bmod (1/P_{int})]} & \text{if } n_{int} \in G'' \\ 0 & \text{otherwise} \end{cases} \quad (10)$$

We have nb intermediate nodes, with G''the set of intermediate nodes that have not become CH in the past $\frac{1}{P_{int}}$ round r.

$$T(n_{adv}) = \begin{cases} \frac{P_{adv}}{1-P_{adv}\,[r \bmod (1/P_{adv})]} & \text{if } n_{adv} \in G''' \\ 0 & \text{otherwise} \end{cases} \quad (11)$$

We have nm advanced nodes, with G''' as the set of advanced nodes that have not become CH in the past $\frac{1}{P_{adv}}$ round r. Hence, the average total number of cluster-heads per round will be :

$$n(1-m-b)P_{nrm} + nbP_{int} + nmP_{adv} = nP_{opt} \quad (12)$$

To sum-up, ESEP is designed to exploit different levels of heterogeneity in the network, Enhanced SEP has more network life time and resource sharing as compared to SEP due to the addition of intermediate nodes(INT).

D. Deterministic Energy Efficient Clustering protocol (DEC) : DEC outperforms the probabilistic-based models (LEACH, SEP and SEP-E) by guaranteeing that a fixed number of cluster-heads are elected per round. The CH is chosen by using only the residual energy (RE) of sensor nodes. The nodes to become CH have maximum residual energy than others [2]. There are two phases of DEC: Setup and Steady Phase. The formation of clusters is done in setup phase [2], [4]. Base Station select N, total no. of clusters required at any round m for network. Base Station selects N cluster heads in round 1 only. Once the Cluster Heads are selected, they send advertisement (ADV) message to all surrounding sensor nodes by using Carrier Sense multiple access (CSMA MAC) protocol. The nodes send patch-request message using CSMA MAC protocol to Cluster Head .This message includes CM-ID(ID of cluster members), CH-ID(ID of cluster head) and residual energy of cluster members. After receiving patch-request message from CMs, CH come to know RE of all its cluster members. Each CH transmits a TDMA schedule to its all CMs. After setup phase, the steady phase begins. But before beginning of next phase, CH finds out CM-RE's information received. If it finds any other sensor node with more residual energy, it makes that node as new cluster head for next round and if it does not finds then it will remain as CH for next round too. Steady phase of DEC protocol is same as that of LEACH. It involves data transmission from CM to CH using CDMA or TDMA schedule sent by CH to avoid collision. CH sends aggregated data received from its CMs to sink using TDMA schedule sent by sink. This ends the current round r = m. The following round r = m+1 begins. Because new CHs for new round are already elected in previous round so it does not need global information and thus decreases the overhead. This process continues till the last node dies. DEC is a routing protocol which guarantees the election of determined numeral of CHs but it is a reactive protocol and draws energy more frequently for reactive applications. Even when we change the number of cluster heads per round, DEC is more robust and more stable than the probabilistic-based models [4]. Overall, DEC improves the lifetime of WSNs by an order of magnitude which is significant when compared with LEACH, SEP and SEP-E.

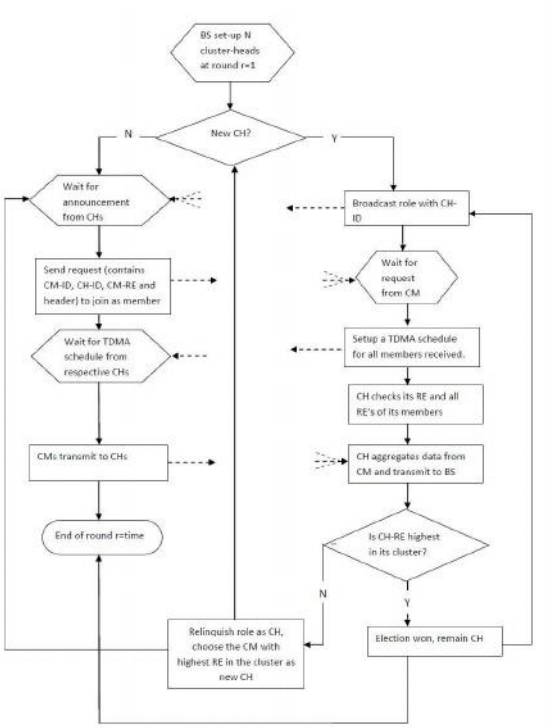

Figure 3. DEC algorithm flow chart

III. CONCLUSION

The major objective of every routing protocol is to decrease the energy consumption and raise up the lifetime of the network Therefore, the protocols designed for WSNs should be energy efficient so that it can extend the lifespan of each sensor node. Clustering is best technique to reduce energy to be consumed and to provide resistant in wireless sensor networks.

LEACH and ESEP protocols are the probabilistic model to manage the energy consumption of WSN has very low network stability. DEC has local information that the residual energy of each node to optimize the energy consumption in both homogeneous and heterogeneous scenarios we have considered, regardless of the level of energy hierarchies in the network. Further, a DEC

protocol has better utilizes of energy in WSN than the LEACH and ESEP protocols but it is difficult to balance network lifetime with network stability in DEC.

IV. Future scope

In our future work, we can implement the proposed protocol in real world application setting such as in environmental monitoring, agricultural monitoring, and medical monitoring. These networks can connect the physical world with the digital world, with the ability to more accurately control and understanding of our surroundings. An enhanced protocol can be implemented by increasing energy heterogeneity of the network which has increased the stability and network lifetime .The simulation is done by using MATLAB software.

However, there are many challenges that must be addressed before the full potential of these networks are realized. WSNs must be reliable and scalable to support large numbers of unattended wireless sensors.

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