Review On Various LEACH Variants

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Abstract*—*due to limited battery of sensor nodes, energy efficiency becomes weak side of the WSNs. This paper has focused on energy efficient protocols of WSNs. Since no replacement and charging are available for sensor nodes, so utilizing them in optimized manner has open research for sensor researchers. Many energy efficient protocols have been introduced so far and this paper has focused on some well-known energy efficient protocols. The review has shown that the Ant Colony Optimization based energy efficient protocols have proficient results over the existing ones.

Keywords*—*Wireles Sensor Networks(WSN), Ant Colony Optimization(ACO), Cluster Head(CH), Base Station(BS).

Introduction

WSNs have multiple nodes called sensors which are installed and set up in a particular area. A node consists of mainly of these parts: transceiver, processor, sensor, energy unit. The nodes are self-organized, coordinated and work together to collects several kinds of information from the environment and send required data to the base station (BS) for further processing which delivers this data to the sink node.

WSNs applications: vehicle tracking, environmental traffic control, military surveillance, patient monitoring, area monitoring, air pollution monitoring, temperature monitoring, humidity monitoring, event detection, soil makeup, flood detection, drug administrations in hospitals, managing, etc [1] [3]

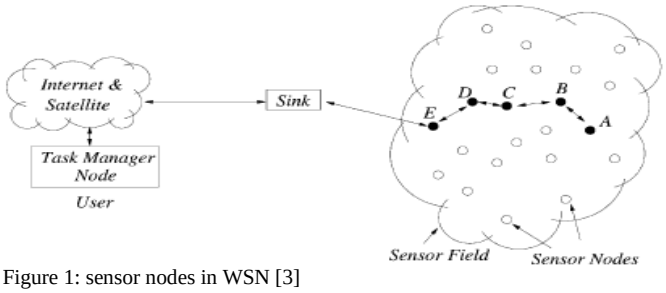


Figure 1: sensor nodes in WSN [3]

WSNs have various limitations like limited power, computation and communication. The battery power of the nodes decides the lifetime of the network. All sensor nodes process and transmit data to the BS (sink) (BS). But the nodes have limited battery power and small life span. So using of this energy in an efficient manner and increasing the lifespan of nodes is the major problem [1]. Latest work in WSNs is regarding energy efficiency as it is the major issue affecting the lifetime of the network. Different energy aware protocols are designed to increase network lifetime.

Energy Efficiency in WSNs

A sensor node is no longer in use when its battery dies. So minimizing energy consumption is considered the major issue to enhance the network lifetime [2]. Every aspect of the node must be designed to be energy efficient. This enhances the overall usefulness of the network.

In multi hop ad hoc networks, each node process data and then route it. So failure of some nodes leads the entire network to re-organize. For these reasons the primary consideration of the researchers is designing power aware protocols for WSNs [3].

For this, the concept of clustering was introduced; in which based on certain criteria few nodes are elected as cluster head (CH). All the sensor nodes are grouped into clusters and the CH manage every other node in the cluster [9]. CH collects data from sensor nodes and delivers it to the sink. These CHs keep on rotating to maintain a stable network [1].

In a WSN, there is a greater load on a CH as compared to other sensor nodes. So there energy depletes at a greater rate and CHs die soon. This make designing of energy efficient clustering techniques critical. For this, various protocols has been introduced.

ENERGY EFFICIENT PROTOCOLS FOR WSNs

LEACH (Low Energy Adaptive Clustering Hierarchy):

It is a hierarchical based protocol that is energy efficient as compared to traditional protocols. It's the first network protocol which adopted hierarchical structure. In LEACH network is divided into clusters based on the signal strength of sensors. CH selection is done randomly and they die quickly. All the nodes in LEACH have same energy level. It operates in two phases: first is setup phase in which CHs are created; second phase is steady phase in which CHs collects data from the sensor nodes in their respective clusters and delivers this data to the sink.

The major drawback of LEACH is that no consideration is given to the energy consumption while selecting a node as a CH. A node with small residual energy can become a CH, which will lead to early death of the CH and shorten the network lifetime. It is not suitable for large size networks [1][4].

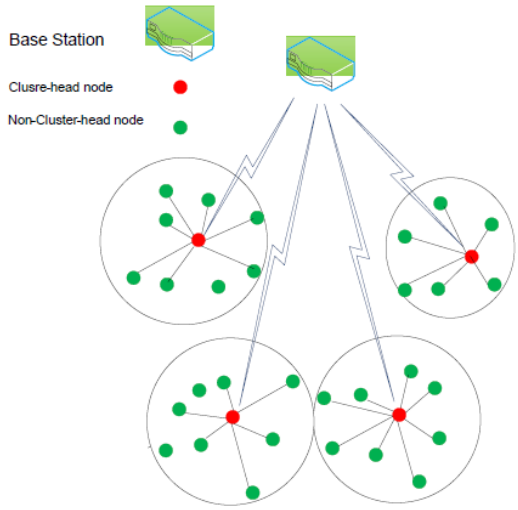


Figure 2: LEACH protocol illustration [12]

LEACH B (Balanced)

This protocol takes into consideration the residual energy of the CH and solves the problem of fluctuation of number of CHs in LEACH. It improves LEACH by introducing a second selection of the CHs based on residual energy every round to keep the number of CHs constant and near-optimal. It leads to balance of energy consumption and minimize the total energy dissipation of the sensors. LEACH B enhances the energy efficiency as compared to LEACH and the network lifetime is increased as well [13].

LEACH C

CHs are chosen randomly based on the energy threshold. Sensor nodes with energy above the average are selected. The information of the nodes location and value of its residual energy are send to the BS at the starting of every iteration. Next the BS broadcast to the network the selected group of CHs using the simulated annealing. If a node receives its own ID, then it becomes the CH. Otherwise this node transfer data to the CH. LEACH C improves the network lifetime as compared to conventional LEACH [4].

EEE LEACH (Energy Efficient Extended)

This is an improvement over LEACH protocol. It is a multiple level clustering technique to decrease communication distance between sensor nodes. Master CHs are introduced along with CHs. It have double layer of cluster formation. First layer consists of cluster construction based on the nodes which transfer data to their respective CHs. CH aggregates this data.

In the second layer master CHs formation takes place. Then CHs examine the nearest MCHs by computing the distance among them and send their aggregate data to the particular MCHs. The MCHs aggregate all received data and delivers it to the BS. As the number of clusters increase, the communication distance decreases. This leads to greater energy efficiency of this protocol and increased network lifetime [14].

MG LEACH (Multi Group based)

This protocol takes the deployed redundant nodes under which major fraction of energy depletion in the network is covered. This is energy efficient routing protocol based on LEACH. Lots of redundant data exists in WSNs because of extensively deployed nodes. This redundancy of sensor nodes is used as a benefit for enhancing network life time. It overtook LEACH as it helps to increase the Network life time.

This approach consist three steps. Two of the steps are same as in LEACH, which are Setup phase and steady state phase. Set building phase is used before set up phase. This is done at the time of deployment and after every "x" rounds by BS. In set building phase, nodes are distributed into Sub Groups depending upon their positions. Every node that is provided with GPS forwards location information to BS directly. BS will utilize this information for each Set building phase. As this is done just once, it does not put away much of the energy [16].

MOD LEACH (Modified)

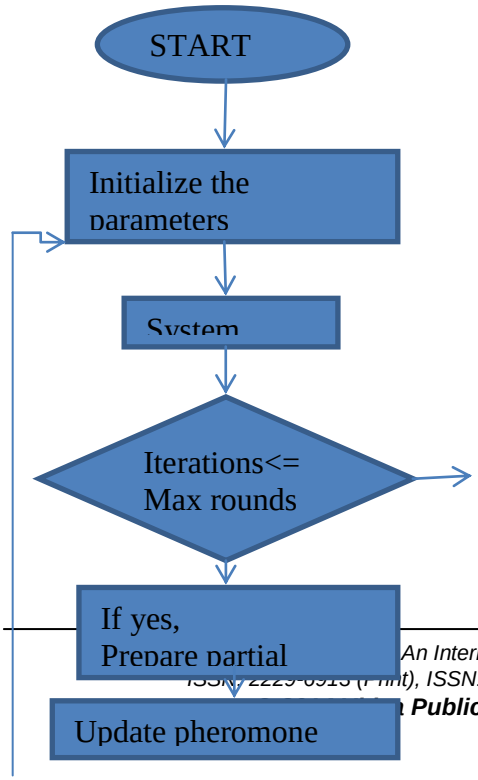
This protocol modifies LEACH, as it introduce an effective CH replacement technique and dual transmitting energy levels. The CH is changed at each round. In each round, CHs are changed and entire cluster formation procedure is repeated. If CH has not used up much power and has more power than the threshold, it will become CH for the following round also. By this method, power lost in routing data for new CH and cluster formation is saved. Otherwise, it will be changed in the same way as in LEACH. Further, soft and hard thresholds are used to enhances the performance even more [15].

PR LEACH (Percentage)

The main idea of this approach is to uniformly distribute the load of network among all the nodes to balance energy dissipation and increase network lifetime. CH is selected on the basis of residual energy. Energy is preserved by inter cluster transmission. Data transmission for members is done at every round randomly [18].

ANT COLONY OPTIMIZATION ALGORITHM (ACO) in WSN

ACO is inspired from the shortest path searching behaviour of the ants. ACO is a construction algorithm. Ants generate the solutions to the problem in every round by examining a construction graph. Every edge of this graph represents the possible steps the ant can take. Each edge has related heuristic information and pheromone trail information to guide the movement of ants.



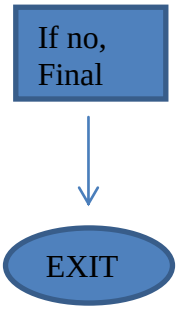


Figure 3: Flowchart of basic ACO [1]

ACO have its various applications in WSNs, which has improved the performance of the sensor networks. Basically, ACO is used in WSNs to enhance energy efficiency of the sensor nodes and increase network lifetime. Different applications of ACO in WSN are listed below:

Ant Based CH Election in WSN

ACO is used in routing data in Wireless Sensor Networks and on this LEACH protocol is applied, to route data in sensor networks to maximize energy efficiency and to increase the network lifetime. It also reduces the work required to send the redundant data sent by the nodes which are at close distance to each other in the sensor network. CHs are chosen randomly as in LEACH but the radius of the cluster is set on the basis of redundancy. Nodes having same data are assigned under same CH and only one of these nodes is allowed to send data to the CH. This technique removes the redundancy of data and improves the energy efficiency and enhance network lifetime as compared to LEACH [1].

Adaptive Clustering Based Dynamic Routing via ACO

Ant Colony Optimization (ACO) is used for clustering based routing. It prolongs the lifetime of sensor nodes and also improves energy limitations. Every node is demonstrated as an ant and dynamic routing is modelled as ant searching. The ant release pheromone when an energy efficient route from the source to sink is found. Every node considers the residual energy and computes

probabilities to choose the best route to increase the network lifespan [9].

ACO Based Sensor Deployment Protocol

This is an ACO based node deployment method which increase the network lifetime and while confirms complete coverage of the area. It increases the quality of monitoring and decrease deployment cost in wireless sensor networks by increasing the coverage area [7]. It eliminates the energy hole problem by changing the communication radius. It also solves the problem of grid based coverage with low cost and connectivity guarantee (GCLC) [6].

A Tree-Growth based Ant Colony Algorithm for QoS Multicast Routing

In multicast routing, multicast routing tree is found to solve the problem. It searches for paths from the source node to the every target node and then integrates this data into a multicast tree. This method is slow and difficult. To remove these difficulties, ACO is used. It adjusts the multicast tree right away. This advances the performance to a great extent [8].

ACO based Unequal Clustering Algorithm for Large Scale WSNs

Unequal means that size of the CHs near the BS is small as compared to the nodes which are farther and the cluster size is based on the distance between CH and the BS. Max-min ACO is used. It balances the node power consumption and it increases the network lifetime as it takes into consideration the inter-cluster traffic. Its main focus is on inter-cluster routing between CHS and BS. It eliminates the hot spot problem [10].

Uneven Clustering Routing Algorithm based on ACO

It is an inter-cluster routing mechanism. This approach uses the ant colony optimization to get the shortest route between the CH. Based on the distance between CHs and sink node it arranges clusters, and clusters close to sink has small size as compared to those far away. So the CHs which are closer can preserve power for the inter-cluster routing [11].

Transmission scheme for WSN using ACO with Unconventional Characteristics

This is a transmission scheme (UMM) which combines MPEE (maximum possible energy efficiency) and MPEB (maximum possible energy balancing). It maximize the lifetime of WSNs. This scheme is based on ant colony optimization (ACO), but in contrast to conventional ACO algorithms it has following two features: each ant needs only one step to finish the complete tour, and it contains no heuristic information [5].

RELATED WORK

Heinzelman et al. (2000) [17] has proposed a protocol for homogeneous WSN. It is Low-Energy Adaptive Clustering Hierarchy (LEACH). Homogeneous WSN is the one which has all nodes at same energy level. In LEACH every node depends on its individual probability to become a CH. It equally assigns the energy load among the sensor nodes by the use of randomized alternation of cluster-heads. M.Tong and M.Tang (2010) [13] has introduced an improvement over conventional LEACH protocol. It balance of energy consumption and minimize the total energy dissipation of the sensors, so it is named as LEACH B. it takes into account the residual energy of the nodes. S.Shi et al. (2012) [4] proposed another protocol called LEACH C to overcome the drawbacks of LEACH. CHs are chosen randomly based on the energy threshold. Sensor nodes with energy above the average are selected. This approach prolongs the network lifetime. M.Sharma and K.Sharma (2012) [14] has proposed an energy efficient extended (EEE) LEACH which is an improvement over LEACH. It is a multilevel clustering approach to reduce communication distance within sensor nodes. Master CHs are introduced along with CHs and arranged in two layers. This leads to greater energy efficiency of this protocol and increased network lifetime. M.Haneef et al. (2012) [16] takes the redundancy of the deployed nodes as an advantage to prolong network lifetime. It has an extra step as compared to LEACH, set building phase which is used before set up phase. It does not put away much of the network energy. This approach is called MG LEACH. D.Mahmood et al. (2013) [15] introduce an effective CH replacement technique and dual transmitting energy levels which modifies LEACH and it is named MOD LEACH. CH changes at each round. If CH has not used up much power and has more power than the threshold, it will become CH for the following round also. Energy wasted in routing data for new CH and cluster formation can be saved. Then soft and hard thresholds are applied on MODLEACH. This enhances the performance of this protocol. M.Salim et al. (2014) [18] proposed a scheme called percentage LEACH that

improves cluster-head selection approach oh LEACH. It uniformly distributes load among nodes and balances energy dissipation by considering the nodes residual energy and this increase network lifetime.

W.Liao et al. (2011) [7] introduces an ACO based sensor deployment in which deployment problem is modelled as the multiple knapsack problem. This deployment approach increase network lifetime and ensuring complete coverage of the service area. H.Wang et al. (2011) [8] introduces a scheme to directly optimizes the multicast routing tree by using ACO to overcome the shortcomings of the conventional approach, which was slow and complex. This approach is a tree based optimization. X.Liu and D.He (2014) [6] proposed a mechanism for node deployment in WSN based on ACO and Greedy migration method. It also solves the problem of grid based coverage with low cost and connectivity guarantee (GCLC). ACO-Greedy adjusts the communication radius to lessen the energy hole problem and extend the network lifetime. M.Song and Z.Cheng-lin (2011) [10] introduced a scheme in which the CHs near the BS is small as compared to the nodes which are farther and the cluster size is based on the distance between CH and the BS. This is done by using max-min ACO which helps in eliminating hotspot problem. J.Du and L.Wang (2011) [11] proposed an uneven clustering routing algorithm for inter cluster routing based on ant colony optimization to get the shortest route between the CH. Clusters close to sink has small size as compared to those far away. So the CHs which are closer preserve more power. X.Liu (2014) [5] proposed a transmission scheme named UMM based on ACO, which combines MPEE (maximum possible energy efficiency) and MPEB (maximum possible energy balancing) to enhance network lifetime. It uses unconventional characteristics of ACO to make performance of this scheme superior to existing ones. Z.Ye and H.Mohamadian (2014) [9] ACO is applied to the dynamic clustering based routing via adaptive algorithms in which every node considers the residual energy and calculates probabilities to select an optimal route to increase the network lifespan. T.Sharma et al. (2014) [1] introduces an approach to improve energy efficiency and maximize lifetime of the network as compared to LEACH by using Ant Colony Optimization. It is based on the behavior of ants to select the shortest path from source to the sink node. It also removes the redundancy in the data send between the nodes by grouping the nodes with same data under one CH.

GAPS IN LITERATURE

The review has shown that existing technology has many limitations. Some of them are:

1. The use of improved CH selection has been ignored in ACO based routing protocols.
2. Use of effective data aggregation has been neglected in majority of LEACH variants.
3. The hybridization of clustering and tree based data aggregation has also been ignored in majority of existing researches.

CONCLUSIONS AND FUTURE WORK

WSNs have limited battery of sensor nodes; no replacement and charging are available for sensor nodes, so utilizing them in optimized manner has open research for sensor researchers. This paper has discussed on some well-known energy efficient protocols. From this review we can conclude that the ACO based energy efficient protocols have improved results over the existing techniques.

This work has not considered any improvement over the available protocols. So in future we will propose an improved ACO based protocol which has enhanced CH selection and data aggregation based upon ACO.

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