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A Pragmatic Study of Evolutionary Techniques Based Energy Efficient Hierarchical routing protocols - LEACH And PEGASIS

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Abstract- A wireless sensor network (WSN) is a network with wireless transmission medium, where autonomous devices are spatially distributed using micro-sensors to monitor physical or environmental changes. From past few years, WSN has been an area which has fascinated many researchers with their new ideas to increase the life-time of the sensor nodes. The battery power in these sensor nodes plays an important role in increasing the lifespan of the nodes. Hierarchical routing protocols are being proved to be best known protocols to minimize the energy consumption by many researchers. The hierarchical protocols along with their architectural changes also include data aggregation technique at the sensor nodes, before sending the final data to base station. The performance of hierarchical protocols can be improved further by applying evolutionary techniques, since optimization algorithms are sufficiently complex to provide robust and powerful adaptive search mechanisms. In this paper we have surveyed the state-of art of LEACH and PEGASIS hierarchical routing protocols. In addition, importance of applying evolutionary techniques for LEACH and PEGASIS hierarchical routing protocols in WSN has been explored for aggregation by optimizing cluster formation and chain formation respectively.

Keywords: Wireless sensor networks, hierarchical cluster, LEACH, PEGASIS, evolutionary techniques

Introduction

Wireless sensor networks have potential to monitor environments for both military and civil applications. The ability to add remote sensing points, without the cost of running wires, results in numerous benefits including energy and material savings, process improvements, labor savings, and increases productivity [1]. In recent years WSN has been identified as one of the emerging technologies in the field of wireless communication. In general, the WSNs consists of a large number of small and cheap sensor nodes that have very limited, processing power and storage deployed in the monitored area, constituting a network through the way of self organization. The nodes have ability to communicate either directly to the base station (BS) or among each other. Currently, sensors like this are considered for applications with limited power, reliability data transfer, and short range communication and reasonably low cost such sensing applications.

Opposed to traditional ad hoc networks, routing in WSNs is more challenging as a result of their inherent characteristics. Firstly, resources are greatly constrained in terms of power supply, processing capability and transmission bandwidth. Secondly, it is difficult to design a global addressing scheme as Internet Protocol (IP) [2]. Nowadays a cheap wireless sensor nodes having sufficient computation, transmission and receiving powers are available. By this improvement more than hundreds of nodes can be deployed in a network for any application. But the routing and collection of data from this deployed is a challenge as these nodes have limited power. Therefore, designing a WSN routing protocol, enhancing energy efficiency and extending the lifetime of the WSN are the most important challenges for researchers.

The existing WSNs routing protocols can be categorized based on path establishment, network structure and protocol operation. The path establishment are grouped on how network response to sensed data into proactive, reactive and hybrid. The network structure design consists of location based (geographic), hierarchal (clustering) and flat network (data centric). Protocol operation includes negotiation based, multi path based, query based, QOS based and coherent based routing protocol. In a flat topology as shown in Figure 2(a) and (b) shows single hop and multi hop respectively, all nodes perform the same tasks and have the same functionalities in the network (every node transmits data independently to the BS). But in hierarchical topology nodes perform different tasks in WSNs and normally they are organized into clusters according to specific requirements or metrics, only Cluster head (CH) nodes transmits data to BS using single or multihop. Hierarchical clustering protocols with single-hop communication done as in Figure 2(a) and multi-hop communication design as in Figure 2(b) based on data transmission.

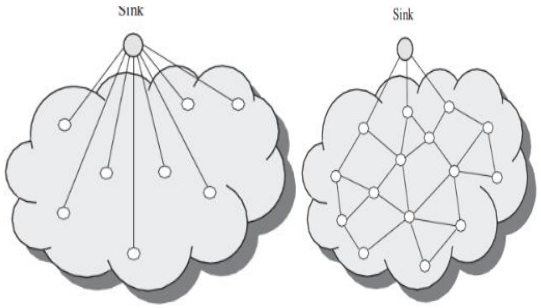

Figure 1(a) Flat single hop Figure 1(b) Flat multi hop

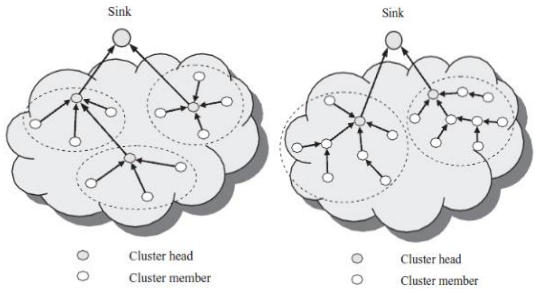

Figure 2(a) Hierarchical single hop Figure 2(b) Hierarchical multi hop

In recent years, clustered routing protocol has gained increasing attention for researchers because of its potential of extending the lifetime of WSN. The clusters will formed among nodes in the networks as shown in the Figure3. The basic idea of clustering routing is to use the information aggregation mechanism in the CH to minimize the number of data transmission from the nodes in the cluster, which reduces the energy dissipation in communication, which ultimately serves main objective of saving energy of the sensor nodes. The design factors that affect clustering are: fault tolerance, scalability, production costs, hardware constraints, sensor network topology ,nodes deployment environment, transmission media and power consumption.

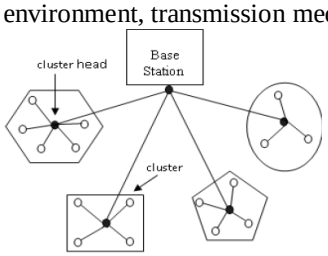

Figure 3 Typical cluster formations in WSN

The networks are still made energy efficient by applying data aggregation, as WSN may suffer the unpredictable heavy traffic[2]. In WSN, data aggregation is an effective way to save the limited resources. The main goal of data aggregation algorithm is to gather and aggregate data by applying functions like sum, average, min, max, etc in an energy efficient manner so, that network lifetime is enhanced. Data aggregation is to eliminate the redundant data from the different sensor nodes which are collected and to be sent to the BS. During the data transmission from sensor nodes to the BS the functionality of each node should be maximized with minimum energy consumption. The same measures are taken in hierarchical protocols like LEACH, PEGASIS, HEED, and others.

Evolutionary Techniques [ET] often perform well approximating solutions to all types of problems as they based on generality. This generality as shown successes in many diverse fields like engineering, art, biology, economics, marketing, genetics, operations research, robotics, social sciences, physics, politics and chemistry. The routing algorithms uses evolutionary techniques such as optimization based, genetic based, swarm intelligence based to optimize the data transmission between nodes and CH and finally to BS. In the last few years, a relatively large number of routing protocols which are based on ET have been developed for WSNs.

These papers is a sincere attempt to include comprehensive review and critical discussions regarding most prominent hierarchal routing algorithms based on evolutionary techniques that have been developed for WSNs. Section II briefs about the basic hierarchical routing algorithm in terms of its working and problems associated with them. Section III discusses about the various improved protocols based on ET for LEACH and PEGASIS, followed by conclusions in Section IV.

Basic Hierarchical Clustering Protocols

A. LEACH

The LEACH (Low Energy Adaptive Clustering Hierarchy), a clustering based protocol that exploits randomized rotation of local cluster based station (cluster-heads) to evenly distribute the energy load among the sensors in the network. LEACH is a hierarchical clustering–based protocol that utilizes randomized rotation of local CHs [CH] to evenly distribute the energy load among sensors in the network. It uses localized co ordination between nearby nodes to enable scalability and robustness for dynamic networks and incorporate data fusion into the routing protocols to reduce the amount of information by aggregation of data at CH thatis to be finally transmitted to the BS [3].

LEACH Algorithm: The operation of LEACH is broken up into rounds, each round incorporates 2 phases: Set-up phase and steady phase. To minimize the overhead, the steady phase is longer than set-up phase.

In setup phase, nodes decide whether to become a CH or not for current round based on the suggested percentage of CH for the network. Nodes choose the number between 0 and 1. If selected number is less than T(n) as in equation 1, the node becomes CH.

$$T(n) = \frac{p}{1 - p * (r \bmod {}^{1}/_{p})} \quad if\ n\ \epsilon\ G \qquad (1)$$

Where, *p* the desired percentage of CHs, *r* the current round, and G is the set of nodes hat have not been cluster-heads in the last 1/p rounds. The node selected as a CH broadcast advertisement message to rest of the nodes. Non CH decides to join the cluster based on the signal strength received from the CH. Nodes inform the CH by transmitting the join request to the CH. CH receives all the messages from the nodes and schedules a TDMA for each of the nodes in its cluster.

In steady state the sensed information will be transmitted to the CH during its scheduled time using TDMA. CH collects frames from all the nodes in the cluster. Once the cluster head

receives all the data, it performs data aggregation to enhance the common signal and reduce the uncorrelated noise among the data. Further, data will be transmitted to the BS using CDMA code.

Some of the problems with the LEACH protocol are:

i. It assumes that nodes always have data to send and all the nodes including CH are have same initial energy.
ii. It requires the user to specify probability for use with the threshold function.
iii. Number of clusters is predefined.
iv. The CHS are randomly selected rotationally and residual energy of the node is not considered for cluster formation
v. CHs send aggregated data to BS in single hop manner, so, that it cannot cover for large geographical areas.
vi. It does not guarantee good CH distribution and it involves the assumption of uniform energy consumption for the CHs
vii. The operations are carried out in rounds; all nodes in the network are considered while reconstructing new clusters, hence consumes lot of energy.
viii. It may be unstable during the setup phase which depends on the density of sensors.
ix. The CH used in the LEACH consumes a large amount of energy if they are located far away from BS.
x. LEACH uses dynamic clustering which results in extra overhead such as the CH changes, advertisement that reduces the energy consumption gain
xi. Leach is not able to cover large geographical areas of some square miles or more, because it requires more energy to reach the CHs with longer distance.

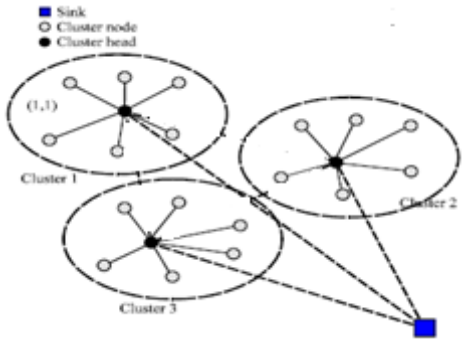

Figure 4 Cluster formations in Leach

In order to overcome these problems of LEACH many researchers have proposed variants of LEACH based protocols. A survey on variants of LEACH algorithm is described in [4]. To mitigate some of the above mentioned limitations authors have implemented improved LEACH as VLEACH and MODLEACH for selection of cluster head [5].

B. PEGASIS

Power-Efficient Gathering in Sensor Information Systems (PEGASIS) [6] is a data-gathering and near-optimal chain-based algorithm. The energy conservation is done within the network by creating a chain structure comprised of all nodes and continually data aggregation across the chain but, not directly by forming clusters. In this protocol only one node in any given transmission time-frame allotted by BS will send the data by forming a chain from source to BS. Data-fusion/Data aggregation occurs at every node in the sensor network allowing for all relevant information to pervade across the network. In order to increase network life time, nodes need only to communicate with
their closest neighbors and they take turns in communicating with the BS as in figure 5 using data aggregation technique.

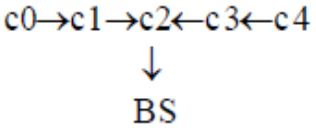

Figure 5 Token passing approaches (6)

Data aggregation is achieved along the chain by initially chain leader issuing a token to the last node in the right end of the chain. The end node after receiving the token transmits its data to its downstream neighbor in the chain toward the chain leader. The neighboring node aggregates the data and transmits them to its next downstream neighbor. This process continues until the aggregated data reach the chain leader. Once chain leader receives aggregated data from right stream, it an issues token to the left end of the chain, and the same aggregation process is repeated until the data reach the chain leader from the left stream. Then, the chain leader aggregates the data of left and right stream and transmits data to the BS.Hence, PEGASIS achieves energy conservation in two ways: by head node receiving only two data to transmit and further conserves energy by reducing the number of data messages gathering at head node. Each node sends and receives packet from only one closest neighbor node. So, the energy consumption is adjusted. A node collects the data and forwards it to the node in the chain that communicates with the BS. Major problems faced by PEGASIS are

i) In each round, a node in the chain will be selected to communicate with the BS. This again leads to the large energy consumption thus reducing the network life time.

ii) On the other hand, the biggest disadvantage is the excessive delay for distant nodes and distance between two neighboring nodes may be more.

iii) Each node in a network should have a global information regarding network.

Improved Leach & Pegasis algorithm Based On Evolutionary Techniques

Evolutionary techniques are generic population-based meta-heuristic optimization algorithms. Evolutionary methods are based on principles derived from natural evolution processes like mutation, reproduction, recombination, and selection. This process is iterated with the goal of deriving a better population of candidate solutions. In course of time, many new methods have been developed. Evolutionary techniques are applied nowadays in many fields like WSNs, cloud computing, grid computing, image processing, etc. Some of evolutionary techniques which have received greater prominence in the field of WSN evolutionary strategies like PSO, Ant colony, Bat optimization, cuckoo optimization, Artificial Bee colony (ABC) and many more.

Genetic algorithm is a subset of evolutionary computation. It is a generic population-based on metaheuristic optimization algorithm

A. LEACH protocol optimization based on evolutionary techniques

LEACH is energy efficient, single hop clustering protocol. The selection CH is done randomly. Likewise, the formation of the cluster is done only based on message received signal strength by the nodes. To overcome some of these major problems, many researchers have proposed quite a number of techniques to optimize the performance of LEACH in terms of cluster formation and selection of optimal CH using both evolutionary and non-evolutionary algorithms. In this section we brief some of the improved LEACH protocols based on evolutionary techniques.

i. Energy-aware clustering for WSNs using particle swarm optimization [ECWPSO][7]

In this paper authors [7] have defined a new cost function for particle swarm optimization(PSO), with the objective of simultaneously minimizing the intra-cluster distance and optimizing the energy consumption of the network. In this protocol the operation completely is based on a centralized control algorithm that is implemented at the BS. The proposed protocol operates in rounds, where each round begins with a setup phase in which clusters are formed. This is followed by a steady state phase which works in similar approach as in LEACH. At the starting of each setup phase, all nodes send information about their current energy status and locations to the BS. Based on this information, the BS computes the average energy level of all nodes. Nodes with a sufficient energy are selected as CHs; the nodes with an energy level above the average are eligible to be a CH candidate for this round. Next, the BS runs the PSO algorithm to determine the best *K* CHs that can minimize the cost function based on distance between nodes in a cluster to CH. The cost function forms compact clusters with the optimum set of nodes that have sufficient energy to perform the CH tasks. For a sensor network with *N* nodes and *K* predetermined number of clusters. The clusters are formed by initializing*S* particles to contain *K* randomly selected CHs among the eligible CH candidates. For each node cost function is applied and later on distance between a particle and CH is computer for all the particles in the network.The personal and global best for each particle is found. Regularly particles are updated based on particle velocity and distance from the CH. The same steps are repeated until the maximum number of iterations reached. The selection of CH and their member's information will be sent to BS; it in turns transfers a cluster id to CHs. Once the CH finishes receiving data from its entire members at the end of each frame, the CH performs data fusion and sends the fused data to the BS.

ii. WSN clustering using particles swarm optimization for reducing energy consumption [WCPSO][8]

In this paper [8] authors have introduced an approach for clustering sensor networks based on Particle Swarm Optimization (PSO) algorithm using the optimal fitness function with an aim to extend network lifetime. The parameters used in this algorithm are residual energy density, the distance from the BS, intra-cluster distance from the CH. In clustering phase, the particles are generated randomly. Then the best points are selected as the CHs and other nodes which are located near each CH becomes the member of the cluster and then fitness function is calculated for every CH. If the fitness function is better than global best it is substituted. Then each node prepares a control message that contains identity and value of its residual energy and sends it directly to the BS. The BS which receives the information performs clustering operation. Assigns the nodes into cluster based on the distances according to the validity index. Once the clusters are formed then further operations are performed similar to LEACH.

iii. Intercluster ant colony optimization algorithm for WSN in dense environment based on ant-colony optimization [IACOW][9]

In this paper [9], Inter cluster Ant Colony Optimization algorithm (IC-ACO) has been proposed that relies upon ACO algorithm for routing of data packets in the network with an aim to minimize the efforts wasted in transferring the redundant data sent by the sensors which lie in the close proximity of each other in a densely deployed network. In this approach, LEACH algorithm is used as the basis for the randomized selection of CHs. The protocol works in two phases. In the first phase, the CHs have been selected and nodes classify themselves into clusters. In the second phase, minimization of redundant data transmission and routing of data based on ant colony optimization are performed with in the cluster. Selection of CHs, minimization of redundancy and IC-ACO to route the data packets within the cluster are applied until all the nodes are dead in the sensor network. Improvement can be done in selection of the CH.

iv. An Energy-Efficient Ant-Based Routing Algorithm for WSNs [AEARW][10]

In this paper [10] presents a routing algorithm based on the Ant Colony Optimization meta-heuristic with an aim to minimize communication load and maximize energy savings. The authors concentrate on two problems. Firstly, the older method of storing the route details in a routing table. Secondly, on quality of the path established from source node to BS node. The memory Mk of each ant is reduced to just two records, the last two visited nodes. Since the path followed by the ants is no more in their memories, a memory must be created at each node that keeps record of each ant that was received and sent. If no record is found, the node saves the required information, restarts a timer, and forwards the ant to the next node. If a record containing the ant identification is found, the ant is eliminated and backward ant searches its memory to find the next node to where the ant must be sent. The vector *Ek* was erased from the forward ant's *k* then only carry the average energy till the current node *(EAvgk)*, and the minimum energy level registered *(EMink)*. These values are updated by each node that receives the forward ants. When the forward ant reaches the BS-node these values are used to calculate the amount of pheromone trail used by the corresponding backward ant. To lose part of the pheromone strength during its way to the source node. So, those nodes near the BS-node will have more pheromone levels than remote nodes to find better paths. Maintenance of two BSs is a problem in this protocol.

v. Improved low energy adaptive hierarchy protocol based on local centroid bat algorithm [ILEHP][11]

In this paper[11] authors have applied a bat algorithm technique to solve some disadvantage in LEACH like random selection of CH, taking no account of the remaining energy and position of nodes, along with an aim to improve the poor local search capability of the algorithm. The improved protocol divides the CH selection process into optimization of temporary CH and formal CH selection. In this protocol, they will generate temporary CHs by following traditional LEACH protocol at the first. Later on, optimizes these CHs based on LCBA and select formal CHs according to the remaining energy of nodes.

vi. A New BBC based LEACH Algorithm for Energy Efficient Routing in WSN [ANBLE][12]

In this paper [12] traditional LEACH algorithm's cluster formation is improved using big bang crunch based metaheuristic algorithm with an objective to optimize the scare battery utilization. The proposed protocol applies the fitness function on nodes and selects the CH. Then, cluster member are joined around the center of the mass by adding or subtracting a normal random number whose value decreases as the iterations elapse

vii. Hybrid Approach for Energy Optimization in WSNs[HAEOW][13]

In this paper [13] a hybrid clustering approach is proposed to minimize the energy of the network so as toincrease the life time of WSN. The cluster based firefly and artificial bee colony (ABC) algorithm are implemented.Two problems are concentrated like selection of CH and cluster formation. Initially the selection of CH and CH formation of cluster remains same as LEACH for first round. From the existing CH are checked for residual energy if CH is eligible to continue as CH for next round, if it as with firefly technique, it will continue as CH for next round, else the selection of next CH is done with highest residual energy in the cluster. This process is repeated for all clusters in the network. Then, selection of CH done based on optimization of ABC using residual energy of the current CH; then top required *n* nodes with highest residual energy are set as CHs. The steady phase remains same as LEACH.

viii. Clustering approach for WSNs based on Cuckoo Search Strategy[CWCSS][14]

This paper [14] proposes a clustering protocol based on the brood parasitism of few cuckoo bird spices with an aim to increase the lifetime of the network. The CHs are computed randomly as in LEACH. Once the CHs are selected, they will broadcast the message.Non-CH nodes in the network treat CHs as the nest, then, tries to choose a best CH based on residual energy of CH, distance between CH and BS, and distance between CH and non-CH. The non-CH will send JOIN_REQ for the chosen CH. JOIN_REQ is treated as the cuckoo egg. CHs on the reception of the request generates a random probability of whether to accept or reject the request based on the threshold value, which changes from round to round and whether the rejection probability cross the threshold or not. This phenomenon is mapped to the rejection or acceptance of cuckoo eggs by the host bird with some probability. In this proposed work, a JOIN_REQ is considered only if non-CH nodes threshold probability is more than threshold probability in CH; else a node is rejected by CH. The entire nodes in the plot, splits itself into formation of clusters and enter the steady-phase communication, where actually the transmission of sensed information happens between the nodes and the BS.

ix. Flower Pollination Optimization Algorithm for WSN Lifetime Global Optimization[FPOAW][15]

The flower pollination optimization algorithm [15] is used to propose WSN energy aware clustering formation model based on the intra-cluster distances with an objective to achieve the global optimization for WSN lifetime. A candidate CH is to be selected for every cluster from the flower pollination clustering. The CHis selected as the node inside the clusterwith the most remaining energy. It searches for optimal distribution of nodes on clusters. The objective; fitness function are employed to minimize the intra-cluster compactness with minimum distance between nodes in same cluster. using flower pollination optimization the number of cluster are done based on distance between CH and nodes in a cluster with a goal to find the number of cluster centers that minimize the intra-cluster distance. The steady phase of the protocol remains unchanged[18].

x. Cluster Formation of Wireless Sensor Nodes using Adaptive Particle Swarm Optimization[CFWAPSO][16]

In this paper [16] adaptive particle swarm optimization is applied in the selection of the CH with an aim to reduce the energy efficiency. The selection of the CH is done at BS using PSO.CHs selection is based on particles velocity and position. Each particle calculates the fitness value of each particle, and then updates position and velocitybased on the calculated results. The same steps are repeated, until all the particles have gone through these steps. BS loaded with PSO algorithm broadcasts the calculated CHs ID to the network. The process of cluster forming is similar to the LEACH protocol.

xi. Fire-LEACH: A Novel Clustering Protocol for WSNs based on Firefly Algorithm[FL][17]

In this paper [17] a clustering algorithm based on firefly algorithm approach used for improving the LEACH protocol for reducing in steady state energy consumption**.** The BS broadcasts the percentage of CHs requirements for the entire network. Based on this randomly CHs are selected as in LEACH. All the CHs learn about the ordinary nodes and other CHs in the plot. Then they broadcast the packet of interest by introducing the intensity value that is calculated based on, intensity value of all nodes in network for that round. The firefly algorithm is applied to compute this value using distance of HC and non-CH nodes, which serves to be an objective function for all sensor nodes. All the CHs store the maximum of the intensity values calculated with all the other non-CH nodes in the network belonging to a particular round. The non-CH nodes now compare their intensity values with all the other CHs intensity values and attach to a CH that is having more intensity value than their values, by sending a

join request packet. This process leads to a cluster formation. After the formation of the clusters, the network enters to the steady state phase; further steps are same as in LEACH.

xii. Achieving energy efficiency in WSN using GSA[AEEWG][18]

The problem[18] of selecting CH in a cluster is once again concentrated in this paper using the technique of Gravitational Search algorithm (GSA). GSA is based on Newtonion law of gravity and the law of motion. Here agents are considered as objects and their performance based on its masses. All objects are attached to one another by a gravitational force which causes the movement of objects globally. While forming clusters GSA clustering method is used. CH for each cluster is selected based on the nodes distance from BS in the cluster, node beingin central position in cluster and remaining energy.

xiii. Genetic Algorithm Based Energy Efficient Clusters (GABEEC) in Wireless Sensor Networks [19]

In this paper [19], a genetic algorithm based method(GABEEC) is proposed to optimize the lifetime of wireless sensor networks. The proposed method is a cluster based approach like LEACH. The method has 2 phases which are Set-up and Steady-state phase. In the set-up phase, the clusters are created and are not changed throughout the network. The clusters are not recreated for each round. In each round, here are static clusters with dynamically changing cluster-heads. The fitness function employed is based on distance between node to CH and from CH to BS. Selection is based on Roulette-Wheel selection method. Then crossover and mutation function is employed to choose the best in local optimum. The steady phase and selection of CH remains same as LEACH.

xiv. An Improved LEACH Multi-hop Routing Protocol Based on Genetic Algorithms for Heterogeneous Wireless Sensor Networks [ILMGHW] [20]

In this paper [20], a multi-hop routing algorithm LEACH-Genetic Algorithm is proposed to improve single-hop system in the LEACH.

GA uses mechanisms similar to biological evolution, such as reproduction, mutation, recombination, and selection. The distance between CHs and BS is tried to be shortest path. The CHs which lies far away from BS communicates with it through the transit CHs and nodes which are nearer to BS can communicate with it directly. During set-up phase the clusters are formed as in LEACH then, BS-centered multi-hop path between CH's to BS is obtained by applying GA method. Selection is done by applying Roulette selection method and fitness function is based on length of the links in the network. The steady phase remains same as LEACH.

xv. New Clustering Protocol for Wireless Sensor Networks Using Genetic Algorithm Approach [NCWG] [21]

In this paper [21]GA is used to optimize lifetime and energy consumption of network. The algorithm improves by considering coverage metric. The designed algorithm is centralized and runs in BS. The fitness value will be assigned for each node during the set-up phase. The value depends on total energy of the network and distance of each node to BS. Further selection of the CH will be based on assigned fitness value itself. Cluster formation and steady phase remains same as LEACH.

xvi. A novel genetic algorithm in LEACH-C routing protocol for sensor networks [NLRS] [22]

In this paper [22] genetic algorithm based centralized protocol is proposed. The nodes above the average energy are chosen randomly for initial generation. In next rounds the selection of nodes is based on two fitness values, first value depends on distance between node to CH and second value depends on distance between CH and BS and first fitness value.

B.PEGASIS protocol optimization based on evolutionary techniques

In recent years, researchers have proposed many improved algorithms based on PEGASIS such as PEG-Ant, PDCH and EEPB. When constructing chain in order to decrease the formation of long sized link, leader is selected by considering both the residual energy of nodes and the distance between node and BS, and adjusts the reselection frequency of leader according to remaining nodes in the network. Still, PEGASIS has deficiencies; some of which are readdressed by using evolutionary computations. Some of the PEGASIS protocols based on evolutionary techniques are briefed below.

i. Energy Efficient Data Gathering Schemes in WSNs Using Ant Colony Optimization[EDGWACO][23]

This paper[23] proposes an energy efficient protocols which enhance the performance of LEACH and PEGASIS by applying Ant Colony Optimization algorithm (ACO). The individual nodes being deployed randomly in the play field the BS is located at variable distances from them. The proposed schemes try to nullify the differences occurring due to inter-nodal distance and unequal energy dissipation of the nodes, by employing ACO for chain construction instead of the greedy algorithm to enhance the network performance. For tackling first problem scheme 1 is designed, in which instead making all nodes transmitting to BS the same number times, a nodes are made to transmit unequal number of time to the BS depending on their distance from it. In the second scheme the chain formation is done using ACO, which takes care on distances not becoming extremely large. The best choice of route in each decision process is based on both pheromone and visibility factors. Reconstruction of the chain is done by bypassing the dead nodes. Data gathering phase starts after chain formation. For each data collecting round CH is selected among all nodes in the network. Token passing method is retained. CH initiates to start data transmission from the ends of the chain.

ii. Cuckoo based Energy Effective Routing in WSN[CERW][24]

This work[24] is carried out to improve the network throughput as well as the network lifetimeusing cuckoo search algorithm. An opportunistic routing is proposed to identify the effective path based on the energy analysis, load

analysis and the delay analysis to minimize congestion in the network in turn it minimizes the energy consumption. Here opportunistic routing performs network optimization on the basis of Cuckoo Search. The cuckoo search technique is used for optimization purpose and the original PEGASIS is modified before optimizing using Fuzzy system. The results show that this enhanced protocol save more energy and improve the network lifetime by getting a significant difference of 16 percent.

iii. A Kind of Energy-efficient Routing Algorithm for WSN Based on HQEA [AKERWH] [25]

This paper [25] proposes a new hierarchical routing algorithm for WSNs called hybrid quantum evolutionary algorithm based energy-efficient routing algorithm (HERA), which is based on LEACH and PEGASIS algorithms based on hybrid quantum evolutionary algorithm. In order to reduce the data transmission distance. This algorithm uses the HQEA to establish the best cluster-based multi-chain topology for the sake of balancing energy dissipation, node's residual energy and its distance from the target are considered as criterions of CH election, and each CH relays the sensed data of other clusters to the BS. This protocol improves the election method of CH, comprehensively considers node own residual energy and the distance to target node, rather than just according to the length of distance to choose CH. This breaks invariable pattern about the election of CH according to the father CH, makes CH tend to change, and balances the energy consumption of CH. During the selection of CH at first, in the network, selection of father CH with the largest ratio that residual energy to BS distance is identified. Then it is added into the CH link. Then taking the end nodes in CH chain as destination node periodically, searching for the nodes with the maximum right values as the CH from clusters which are still not joined in CH chain, adding them into the CH chain, and eventually form a CH link. The multiple jump communication link, and hybrid quantum evolutionary algorithm is used to get the optimal clustering group chain method, which makes the total distance of link shortest. In order to reduce energy consumption during communication the method of comparing node residual energy and target distance to select CH, via multiple-jumps through other CH to transfer the collected data to BS is included.

iv. An Improved Energy-Efficient BBO-Based PEGASIS Protocol in Wireless Sensors Network[AIEBBO] [26]

This protocol [26] is designed based on BBO (Biogeography-based optimization) along PEGASIS to get a shortest chain as well as balance of energy consumption between nodes. Since BBO is study of population immigration and emigration. The original BBO, immigration partial BBO method is used to optimize chain formation between nodes to BS. The initial round is based on PEGASIS itself, later on immigration and emigration factors are set based on nodes energy levels. Based on this factor the shortest chain is formed between nodes.

v. Balancing energy dissipation in data gathering WSNs using ant colonyoptimization[BEDGACO] [27]

This paper[27] presents a better try to equalize the energy dissipation of the nodes by taking into account of two issues like, distance of nodes from nodes to BS and varying inter distance between nodes. While constructing the chain Ant Colony Optimization algorithm is used, instead of greedy approach. To apply ant algorithm, ants are placed arbitrarily on the nodes. Each ant is a simple agent with certain memory attributed. According to a probability, an ant chooses the next node by accessing into taboo table into which it has to move into. This probability is a function of inter-nodal distance and pheromone deposited upon the link. At the end of travelling an ant deposits pheromone on the paths it has travelled through. Based on the information collected an ant determines an ant's choice of a node from its neighborhood. The chain is reconstructed using ACO when a node dies, but by bypassing it.

vi. Reducing Chain Complexity using Honey Bee Optimization in WSN[RCCHBO] [28]

In this authors have concentrated on design of an energy efficient chain with in the network. The protocol [28] designed is a chain based hierarchical routing protocol that is optimal in terms of network life time and energy efficient. Honey bee technique is used to find optimal chain. Honey bee algorithm randomly search for neighborhood search for both functional and combinatorial optimization along its way. Here, various parameters are required in general i.e. scout bees (n), selected sites in visited sites (m), stopping criteria, best sites in selected sites(e), initial patch size that includes the size of the network and its neighborhood, bees for selected sites, bees for (m-e) sites. Bees are randomly placed in a space and then the evaluation of bee's fitness is done. Next, the bees with highest fitness are the selected bees and the bees that visit the sites are selected for the neighborhood search. The major phases in this protocol is divided into different phases as, at the first the initialization of the parameter, field initialization, random deployment of sensor nodes, deployment of BS, chain formation using greedy algorithm optimization of distance parameters using HBO, data transmission of all rounds, computation of number of rounds of communication. Honey bee algorithm performs random search along with the neighborhood search for both functional and combinational optimization.

vii. Performance Improvement in a WSN by Reduction Chain Complexity using Honey Bee Optimization[PIWRH] [29]

In this paper [29], a new protocol, O-PEGASIS (Optimized PEGASIS) has been presented to reduce the chain complexity in PEGASIS. A new methodology has been designed to overcome the problem of PEGASIS by using the Artificial Bee Colony (ABC) optimization technique. Artificial Bees Colony algorithm performs both local plus global search by utilizing it exploration and exploitation methodologies, respectively. The main purpose of Honey Bee's algorithm is to find out an optimized solution by using the bee's natural foraging behavior for searching food.

viii. Many-to-One Improved Ant Routing [MOIAR] [30]

In this paper ant colony optimization based protocol is discussed. This proposed algorithm [30] works in two phases. The first phase using the ant agents establishes the shortest path. Each node launches a sequence of n forward ants. Each ant is unicast to a neighbor node selected from n according to rule. At node 1, a backward ant coming from neighbor j updates the pheromone tables. The second phase provides the procedure for actual data routing. For minimizing the packet loss, proactive congestion control mechanism is adopted by the second phase. It is presumed that the neighboring nodes as well as the destination are already known to the sensor.

ix. Energy efficient data gathering in wireless sensor network using genetic algorithm [EDWG] [31]

In this paper [31] PEGASIS is implemented using genetic algorithm to construct data routing chain. The selection of best parents,generation, crossover, and mutation operators are employed. The fitness function is based on the distance between two nodes. At initial rounds greedy chains are built based on energy level of nodes, in later rounds genetic algorithm are employed to form an optimized routing path for data gathering is done.

Comparison of different hierarchical routing protocols namely LEACH, PEGASIS, HEED, TEEN, APTEEN are provided in Table 1 in terms of parameters like power management, network lifetime, scalability, load balancing, cluster stability, algorithm complexity, design model and aggregation.

Comparisons of improved LEACH protocols based on evolutionary techniques are included in Table 2 with the parameters like path establishment, network node management, best effort or QOS, load balancing, fault tolerant, network control, optimization technique applied, and optimization task applied for purpose. Comparisons of improved PEGASIS based on evolutionary techniques are included in Table 3.

Conclusion

One of the main challenges in the design of routing protocols for WSNs is energy efficiency due to the scarce energy resources of sensors. The extension of sensor networks lifetime is the ultimate objective behind design of routing protocols in WSN. This paper briefs about LEACH and PEGASIS hierarchical protocol along with improvements proposed on these protocols using evolutionary techniques by researchers. Among the various evolutionary algorithm, the survey reveals that Artificial bee colony optimization and ant colony optimization algorithms have been widely applied for increasing network life time of PEGASIS, whereas particle swarm optimization, ant colony optimization and genetic algorithms protocol have been applied for is improving LEACH protocols. The study reveals that evolutionary algorithms have been applied on LEACH protocol to optimize the tasks of cluster head selection and formation of cluster respectively for aggregation of data which increases the life span of the WSN. Likewise, PEGASIS optimize the chain formation for aggregation of data within the network in turn to extend the overall network life time. By this survey we conclude that for energy-efficient and prolonged WSNs, there is still a need to explore much more efficient, scalable and robust hierarchical routing schemes by applying bio-inspired algorithms for better performance in terms of extending the life time of network.

References

[1] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “A Surveyon Sensor Networks,” IEEE Communications Magazine, Vol. 40, No. 8,PP. 102–114, Aug 2002.

[2] Sushruta Mishra, HirenThakkar ,Features of WSN and Data Aggregation techniques in WSN: A Survey ISSN: 2277-3754 International Journal of Engineering and Innovative Technology (IJEIT) Volume 1, Issue 4, April 2012

[3] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, Energy Efficient Communication Protocols for Wireless Sensor Networks In Proceedings of the 33rd Annual Hawaii International Conference on System Sciences (HICSS), PP. 3005-3014, Big Island, Hawaii, USA, Jan 2000.

[4] Devika G, AshaGowdaKaregowda, “A pragmatic study of LEACH and its descendant routing protocols in WSN”, National conference on research issues in image analysis and mining intelligence, Erode Arts & Science college, Erode, Tamil Nadu, India, Feb 2015.(Accepted for publication in International Journal of Computation Intelligence and Informatics for upcoming issue.

[5] Devika G, AshaGowda Karegowda,” Performance enhancement of LEACH, V-LEACH and MOD-LEACH clustering routing protocols for wireless sensor networks”, International Conference on Research in Business management & Information Technology(ICRBIT - 2015), Vol.1, No.1, PP.119-126, April 29- 30, 2015, RNSIT, Bangalore.(Accepted for publication in International Journal of Computer Science Engineering and Information Technology Research).

[6] Lindsey S., Raghavendra C. “PEGASIS: Power-Efficient Gathering in Sensor Information Systems”, Aerospace Conference Proceedings, IEEE, LosAngeles, CA, USA, Vol. 3, No.3, PP.1125-1130, 2003.

[7] Latiff, Tsimenidis, C.C., Sharif, B.S, “Energy-Aware Clustering for Wireless Sensor Networks using Particle Swarm Optimization”,IEEE, PP.1 - 5 , Sept. 2007. E-ISBN :978-1-4244-1144-3.

[8] Amin Rostami and Mohammad Hossin Mottar,”Wireless sensor network clustering using particles swarm optimization for reducingEnergy Consumption”, International Journal of Managing Information Technology (IJMIT) Vol.6, No.4, Nov 2014.

[9] Jung-Yoon Kim, Tripti Sharma, Brijesh Kumar, G. S. Tomar,Karan Berry, and Won-Hyung Lee, "Intercluster Ant Colony Optimization Algorithm for Wireless Sensor Network in Dense Environment",Hindawi Publishing Corporation International Journal of Distributed Sensor Networks, Vol. 2014, PP.1-10, April 2014, Article ID 457402.

[10] Tiago Camilo, Carlos Carreto, Jorge Sá Silva and Fernando Boavida,"An Energy-Efficient Ant-Based Routing Algorithm for Wireless Sensor Networks ", ANTS, LNCS 4150,PP.49-59, 2006.

[11] Cao, Yang Cui, Zhihua; Li, Feixiang Dai, Chaohua Chen, Weirong Improved Low Energy Adaptive Clustering Hierarchy Protocol Based on Local Centroid Bat Algorithm", Sensor Letters, Vol.12, No. 9, PP. 1372-1377, Sept 2014.

[12] Archana, Sukhjinderkaur,"A New BBC based LEACH Algorithm for Energy Efficient Routing in WSN", International Journal of Engineering and Computer Science, ISSN: 2319 -7242, Vol.3, No.2, PP.3914-3918, Feb 2014.

[13] P.Leela, K.Yogitha,"Hybrid Approach for Energy Optimization in Wireless Sensor Networks", International Journal of Innovative Research in Science, Engineering and Technology, Vol.3, Special Issue 3, PP.959-964, March 2014, SSN (Online): 2319 - 8753ISSN (Print): 2347 -6710.

[14] Sandeep Kumar E, G.P. Mohanraj, Raghuchandra R. Gouda,"Clustering approach for Wireless Sensor Networks based on Cuckoo Search Strategy", International Journal of Advanced Research in Computer and Communication Engineering, Vol. 3, Issue 6, PP. 6966-6970,June 2014.

[15] Marwa Sharawi, E. Emary, Imane Aly Saroit, Hesham El-Mahdy,"Flower Pollination optimization Algorithm for Wireless Sensor Network Lifetime Global Optimization",International Journal of Soft Computing and Engineering (IJSCE),ISSN: 2231-2307,Vol.4, No.3, PP.54-59,July 2014.

[16] Zhan Wei Siew, Awang Bono, Hou Pin Yoong, Kiam Beng Yeo, Kenneth Tze Kin Teo, "Cluster Formation of Wireless Sensor Nodes using Adaptive Particle Swarm Optimization ", IJSSST, Vol.13,No.3B, PP.38-44, Oct 2013.

[17] E Sandeep Kumar, "Fire-LEACH: A Novel Clustering Protocol for Wireless Sensor Networks based on Fire fly Algorithm",International Journal of Computer Science: Theory and Application, ISSN: 2336-0984, Vol. 1, No. 1.PP. 12-17, 2014.

[18] Priyank Garg, Reena Rani and Gurpreet Singh, "Achieving Energy Efficiency in WSN using GSA", International Journal of Advanced Research in Computer Science and Software Engineering Vol.4, No.4, PP.168-174, April 2014, ISSN: 277 28.

[19] Selim Bayrakl and Senol Zafer Erdogan," Genetic Algorithm Based Energy Efficient Clusters (GABEEC) in Wireless Sensor Networks", Published by Elsevie, Vol. 10, PP. 247 – 25, Aug 2012.

[20] Chengzhi Long, Xiaoming Zhou, Sha Liao, and Na Zhang, "An Improved LEACH Multi-hop Routing Protocol Based on Genetic Algorithms for Heterogeneous Wireless Sensor Networks", Journal of Information & Computational Science, Vol-11, No.2, PP.415–424, Jan 2014.

[21] Ali Norouzi, Faezeh Sadat Babamir and Abdul Halim Zaim," A New Clustering Protocol for Wireless Sensor Networks Using Genetic Algorithm Approach", Scientific research, Wireless Sensor Network, Vol.3, PP.362-370, Nov 2011.

[22] A Rahmanian, H Omranpour, M Akbari and K Raahemifar,"A novel genetic algortim in LEACH-C routing protocol for sensor networks", IEEE, CCECE, PP. 001096 – 001100, ISSN :0840-7789, May 2011.

[23] AnandSeetharam, AyanAcharya, Abhishek Bhattacharyya, Mrinal.K.Naska,"Energy Efficient Data Gathering Schemes in Wireless Sensor Networks Using Ant Colony Optimization", Journal of Applied Computer Science & Mathematics, Vol.5, No.6, PP. 1-13, Jan2009.

[24] Gurpreet Kaur Bhatti, Jatinder Pal Singh Raina,"Cuckoo based Energy Effective Routing in Wireless Sensor Network", ISSN 2319-7080 International Journal of Computer Science and Communication Engineering, Vol.3, No.1, PP.92-95,Feb2014.

[25] Lingxia Liu and Qiang Song, "A Kind of Energy-efficient Routing Algorithm for WSN Based on HQEA ", International Journal of Hybrid Information Technology Vol. 6, No. 4, July 2013.

[26] Bipandeep Singh, Simranjit Kaur, Bipandeep Singh et al, "An Improved Energy-Efficient BBO-Based PEGASIS Protocol in Wireless Sensors Network", Int. Journal of Engineering Research and Applications www.ijera.com ISSN : 2248-9622, Vol. 4, Issue 3(Version 1), PP.470-474, Mar 2014.

[27] Ayan Acharya, Anand Seetharam, Abhishek Bhattacharyya, and Mrinal Kanti Naskar," Balancing energy dissipation in data gathering wireless sensor networks using ant colony optimization", Spinger, LNCS 5408, PP. 437–443, 2009.

[28] Richa Mehta, O.S. Khanna,"Reducing Chain Complexity using Honey Bee Optimization in Wireless

sensor network", International Journal of Computer Trends and Technology (IJCTT) –Vol.4, No.4, 683-687, April 2013.

[29] Parul Mittal, Paramjeet Singh,"Performance Improvement in a Wireless Sensor Network by Reduction Chain Complexity using Honey Bee Optimization", International Journal of Science and Research (IJSR),Vol. 3,No.8, PP.721-724, Aug 2014.

[30] Ru Huang, Shanghai Jiao Tong, Jie Zhu,Xutao Yu,Guanghui Xu,"The Ant-Based Algorithm for the Optimal Many-to-one Routing in Sensor Networks ", IEEE Communications, Circuits and Systems Proceedings, 2006 International Conference,Vol.3,PP.25-28, June 2006.

[31] Manpreet Bath, Jyoti Saxena and Ravneet Kaur," Energy efficient data gathering in wireless sensor network using genetic algorithm", International Journal on Recent and Innovation Trends in Computing and Communication, Vol. 3,No. 7, PP.165-169, July 2015.

TABLE 1: Comparison of hierarchical routing protocol

Protocol	**Power management**	**Network lifetime**	**Scalability**	**Load balancing**	**Cluster stability**	**Algorithm complexity**	**Delivery delay**	**QOS**	**overhead**	**Data aggregation**	**Design model**
LEACH	Very low	Good	Very low	Moderate	Moderate	Low	Very low	No	High	Yes	Cluster based
HEED	Moderate	Very good	Moderate	Moderate	High	Moderate	Moderate	No	High	Yes	Cluster model
PEGASIS	Very High	Very good	Low	Moderate	Low	High	Very high	No	Low	Yes	Chain based
TEEN	Moderate	Very good	Low	Good	Very low	High	Low	Yes	High	Yes	Active Threshold
APTEEN	Low	Very good	Low	Moderate	Low	Very high	Low	Yes	high	Yes	Active threshold with cluster

TABLE 2: Comparison of evolutionary algorithm based LEACH protocol

Reference	Protocol	Optimization method	Optimized task	Single/(S)/ multipath(M)	Reactive(R)/pro active(P)/Hybrid	QOS(Y/N)	Load balancing	Fault tolerant	Distributed/ Centralized
Latiff et.al 2007[7]	ECWPSO	Particle swarm optimization	Selection of CH	S	P	N	Y	N	C
Amin et.al.2014[8]	WCPSO	Particle swarm optimization	Selection of CH	S	P	Y	Y	N	D
Jung-yoon et.al.2014[9]	IACOW	Ant colony optimization	Minimization of redundant data	S	P	N	Y	N	D
Tiago et.al 2006[10]	AEARW	Ant colony optimization	Cluster formation	S	P	N	Y	N	D
Cao et.al.2014[11]	ILEHP	Local centroid bat algorithm	Cluster formation	S	R	Y	Y	Y	D
Archna et.al 2014[12]	ANBLE	Big bang crunch based meta heuristic algorithm	Selection of CH	S	R	N	Y	N	D
Leela et.al 2014[13]	HAEOW	Artificial bee colony	Cluster formation	S	P	N	Y	N	C
Sandeep et.al 2014[14]	CWCSS	Cuckoo search strategy	Selection of CH	S	P	Y	Y	Y	D
Marwa et.al 2014[15]	FPOAW	Flower pollination optimization	Cluster formation	S	P	N	N	N	C
Zhan et.al 2013[16]	CFWAPSO	Adaptive Particle swarm optimization	Selection of CH	S	P	N	N	N	C
Sandeep et.al 2014[17]	FL	Firefly, artificial bee colony	ABC- Selection of CH	S	P	N	Y	N	D
Priyanka et.al 2014[18]	AEEWG	Gravitational Search algorithm	Cluster formation	S	P	Y	N	N	D
Seliam.et.al 2012[19]	GABEEC	Genetic Algorithm	Selection of CH	S	P	N	N	N	D
Chengzhi.et.al 2014[20]	ILMGHW	Genetic Algorithm	Formation of multi-hop path	M	P	N	N	Y	D
Ali.et.al 2011[21]	NCWG	Genetic algorithm	selection of CH	S	P	N	Y	N	C
Rahmanian.et.al 2011[22]	NLRS	Genetic algorithm	Selection of CH	S	P	N	Y	N	C

TABLE 3: Comparison of evolutionary algorithm based PEGASIS protocol

Reference	Protocol	Optimization method	Optimized task	Single(S)/ multipath(M)	Reactive/proactive/Hybrid	Congestion QOS(Y/N)	Load balancing	Fault tolerant	Distributed/ Centralized
Anand et.al 2009[23]	EDGWACO	Ant colony optimization	chain formation with in cluster	M	P	N	N	Y	N	D
Gurupreet et.al 2014[24]	CERW	Cuckoo search	To optimize the chain	S	P	Y	Y	Y	N	D
Lingxia et.al 2013[25]	AKERWH	Hybrid quantum evolutionary	Chain between CH to master CH	S	P	Y	Y	Y	N	D
Bipendeep et.al 2014[26]	AIEBBO	Biogeography-based	To optimize chain formation	S	P	N	N	Y	N	D
Ayan et.al 2009[27]	BEDGACO	Ant colony optimization	Distance to BS, distance between nodes	S	P	N	Y	Y	Y	D
Richa et.al 2013[28]	RCCHBO	Honey bee technique	To optimize chain formation	S	P	N	N	Y	N	D
Parual et.al 2014[29]	PIWRH	Honey bee technique	To optimize chain formation	S	P	N	N	Y	N	D
Huang et.al 2006[30]	MOIAR	Ant colony optimization	To optimize chain formation	S	P	Y	Y	Y	N	D