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A New BBBC based LEACH Algorithm for Energy Efficient Routing in WSN

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Abstract: *The competing objectives of wireless sensor network for optimizing the scarce battery utilization with sending large amount of data to base station, constantly suggest for identifying energy efficient routing algorithm. To achieve this objective, in this paper a Big Bang Big Crunch (BBBC) based metaheuristic algorithm is proposed for the selection of Cluster Head in such a way so that its energy is used uniformly with delayed disintegration of network. For this purpose, the LEACH algorithm random clustering approach has been replaced by BBBC clustering. To evaluate the performance of our proposed BBBC based LEACH protocol we have compared it with random LEACH, Max Energy LEACH and k-means LEACH. Results showed improvement in energy conservation.*

I INTRODUCTION

In wireless sensor networks the primary objective is to maximizing network life as it is impractical to change or replace exhausted small batteries [Demirkol2006] to which every node is configured with. In fact, there are two competing objectives in the design of WSNs. The first objective is the capability to exchange large amount of data between the nodes and the base station. The second constraining objective is minimizing the energy consumption. The two competing objectives reveal the importance of efficient routing protocol in WSNs. Therefore, many routing algorithms have been proposed due to the challenges in designing an energy efficient network.

There are three types of network structure: flat routing [1], location-based routing [2] and hierarchical routing [3]. In flat routing protocols, nodes play the same role and have similar functionality in transmitting and receiving data while location-based protocols utilize the position information to relay the data to the desired regions rather than the whole network. Hierarchical routing protocols, also known as cluster-based routing, is mainly considered as a two layer architecture where one layer is engaged in cluster head selection and the other layer is responsible for routing. Among all the proposed methods, hierarchical routing protocols greatly satisfy the limitations and constraints in WSNs [4]. The main goal of all the hierarchical routing protocols is to appropriately create clusters and choose cluster heads in order to reserve energy in the network. LEACH (Low Energy Adaptive Clustering Hierarchy) algorithm first proposed by Heinzelman [5] of MIT is one of the most known algorithms in this category. It utilizes randomized rotation of local cluster base station (CH) to evenly distribute the energy load among the sensors in the network and rearranges the network's clustering dynamically and periodically, making it difficult for us to rely on long lasting node-to-node trust relationships to make the protocol secure. This works in two phases: setup and steady phase. In the setup phase CHs are selected and in the second phase data distribution is done. The random election strategy of cluster head in LEACH may misdistribute cluster head leading to unbalanced energy distribution and early network disintegration. In this method, the cluster head consumes more energy for receiving, processing and directly sending this data to the BS node. Various new improvements such as LEACH-F, LEACH-C, H-LEACH, E-LEACH, V-LEACH have been proposed in LEACH for network life elongation. In all these algorithms various new strategies of clustering scheme were employed to increase the WSN life. This paper proposed a BBBC based clustering scheme to elongate the WSN lifetime.

II LITERATURE REVIEW

The WSN clustering protocols can be classified into two categories: probabilistic and deterministic. In probabilistic clustering protocols, a node becomes a CH with a certain probability, which requires an exchange of overhead messages for the CH's election. LEACH is one of the most recognized protocol in this. The Power-Efficient Gathering in Sensor Information Systems (PEGASIS) proposed in [6] is an improvement over the LEACH protocol. It is a near optimal chain-based protocol. The idea of cluster formation and cluster head is discarded in PEGASIS. Instead of multiple nodes, a single node in the chain communicates with the base-station. Energy-Efficient Hierarchical Clustering (EEHC) [7] is also a probabilistic clustering algorithm. The basic operation of the EEHC algorithm consists of electing CHs with probability p and each CH announces its election to the k-hop away neighboring nodes. Any node that receives such a CH election announcement, if it is not itself a CH, becomes a member of the closest cluster. In addition, if the election announcement does not reach a node within a specific time interval, the node becomes a forced CH. Bandyopadhyay et al [7] proposed Energy-Efficient Clustering Scheme (EECS) protocol. In this protocol, CH candidates compete for the ability to elevate to a CH with a certain probability.

Xu Long-long et al, in [19] introduces the wireless sensor network, and analysis the problems existed in LEACH routing protocol. Put forward the improved algorithm based on LEACH cluster head multi-hops algorithm, and under considering the premise of node energy, consider the optimum number of cluster head and selecting cluster node, and through the use of limiter the number of nodes in each cluster to balance the energy depletion of each node. It could balance energy consumption and prolong the lifetime of sensor network through the use of algorithm. Emulation result indicates it is effective.

According to Xufei Mao et al [18], Opportunistic routing has been shown to improve the network throughput, by allowing nodes that overhear the transmission and closer to the destination to participate in forwarding packets, i.e., in forwarder list. The nodes in forwarder list are prioritized and the lower priority forwarder will discard the packet if the packet has been forwarded by a higher priority forwarder. One challenging problem is to select and prioritize forwarder list such that a certain network performance is optimized. In this paper, we focus on selecting and prioritizing forwarder list to minimize energy consumption by all nodes.

A new class of algorithms, inspired by swarm intelligence, is currently being developed that can potentially solve numerous problems of modern WSNs requirement. These algorithms rely on the communication of a massive amount of simultaneously interacting agents. Ant based, bee based and slim based and particle swarm optimization algorithms are few of such in this category. The ant colony optimization (ACO) based routing scheme has been motivated by functioning principles of ants foraging behavior, allowing an ant colony to perform complex tasks such as nest building and foraging [9]. Energy efficient ant-based routing algorithm (EEABR) is developed by Camilo in 2006 [10]. In every node, a data structure, stores ant information, whereas the routing table stores the previous node, the forward node, the ant identification and a timeout value. Ant colony optimization-based location-aware routing (ACLR) is another are developed by Xiaoming Wang in 2008 as a new communication protocol [9] for WSNs called ant colony optimization-based location-aware routing (ACLR), which is based on the ant colony optimization (ACO). There are another set of protocols which are inspired from honeybees foraging behaviors. The routing in computer networks has several resemblances with honeybee's behavior [11]. Honeybees in particular have mechanisms for WSNs such as self-organization and division of labor. There are a few routing protocols for WSNs, inspired from bees behavior. Saleem and Farooq in 2007 [11], implemented bee-hive routing protocol for wireless sensor networks which are developed originally for wired networks [12] Beehive is developed by an inspiration of the scout-recruit system of honeybees [13]. Slime mold term is used for heterotrophic organism. There is a strong resemblance between such unicellular organisms, at colonies and wireless sensor networks. As already mentioned before, a wireless sensor network can be viewed as a "colony" of sensor nodes. These nodes are simple, with limited capacity and scarce resources, and can react autonomously. As such, they are able to perform simple tasks [14]. Nonetheless, there are some works based on the slime mold behaviors. Xu in Ji in [15] proposed a PSO based strategy for clustering in LEACH.

III PROPOSED METHODOLOGY

We propose to make efficient clustering of WSN nodes with the help of BBBC in such a way so that transmission energy of nodes used to send data to cluster head (CH) is minimized. Before proceeding further we need to understand BBBC. The Big Bang and Big Crunch theory is introduced by Erol and Eksin [17], which is based upon the analogy of universe evolution where two phase of evolution is represented by expansion (Big Bang) & contraction (Big crunch). This algorithm has a low computational time and high convergence speed. In fact, the Big Bang phase dissipates energy and produces disorder and randomness. In the Big Crunch phase, randomly distributed particles (which form the solution when represented in a problem) are arranged into an order by way of a convergence operator "center of mass". The Big Bang–Big Crunch phases are followed alternatively until randomness within the search space during the Big Bang becomes smaller and smaller and finally leading to a solution. Below in figure is given the algorithm for the BBBC algorithm in steps.

1. Create random population of solution.
2. Evaluate Solutions.
3. The fittest individual can be selected as the center of mass.
4. Calculate new candidates around the center of mass by adding or subtracting a normal random number whose value decreases as the iterations elapse.

5. The algorithm continues until predefined stopping criteria has been met.

Fig 1. BBBC Search Algorithm Workflow

$$x_i^d(t+1) = C^d(t) + rand * 0.5 * \frac{F_u^d - F_l^d}{1+\frac{t}{s}} \text{ ………(1)}$$

Where C^d is a central point in d dimension

- $x_i^d(t+1)$ position vector at t+1 iteration for i particle in $\boldsymbol{d}$ dimension
- $\boldsymbol{rand}()$ is random number generator.
- F_u^d upper limit of x variable in d dimension
- F_l^d lower limit of x variable in d dimension
- $\boldsymbol{s}$ is a smooth function to control exploration

In our simulation, we have used MATLAB programming. MATLAB is a software package that makes it easier for you to enter matrices and vectors, and manipulate them. To simulate LEACH, we have used random 100-node networks for our simulations with similar parameters used in [5]. We placed the BS at a far distance from all other nodes. For a 100m x 100m plot, our BS is located at (50, 200) so that the BS is at least 100m from the closest sensor node. We have used a base paper [16] in our simulation where k-means is used for clustering and then cluster heads are chosen from each cluster on the basis of node's distance from BS, node's central position in cluster and remaining energy. We have replaced BBBC with k-means and the following section shows that a significant improvement of performance has been achieved due to this. The following are the parameters used for our simulation.

Table 1 Simulation Parameters

max_Round	No. of Max Round	9999
ctrPacketLength	Length of packet that sent for nodes to CH	200 bits
PacketLength	Length of packet that sent for CH to BS	6400 bits
initEnergy	Initial energy of each node	0.5nJ
transEnergy	Energy for transferring of each bit (ETX)	50 nJ/bit
recEnergy	Energy for receiving of each bit (ETX)	50 nJ/bit
fsEnergy	Energy of free space model	10e-12 J/bit
mpEnergy	Energy of multi path model	1.3e-15 J/bit
aggrEnergy	Data aggregation energy	5e-9 J/bit

IV RESULT ANALYSIS

Table 2 shows the results obtained from the experimentations done as per the setup explained in the previous section. Six algorithms have been implemented in this thesis. In first algorithm i.e. Random LEACH algorithm is implemented where CHs are selected randomly based on a probability function. We have taken this probability as 10%. It is further improved by using a fair distribution of energy by selecting maximum energy nodes to be CHs. In this method a fix number of CHs are selected based on the number of nodes that are living. Another modification is made in third algorithm where nodes are clustered based on inter distance by using a standard algorithm such as K-means. Other three algorithm are based on BBBC and its variants. We measure algorithms' efficiency by assessing total no. of rounds up to which network survives. A network is assumed to be live if more than 30% nodes are alive with total energy greater than zero.

Table 2 Experimentation Results

WSN Routing Algorithm	Network Life (in rounds)	Rounds in which first Node Dead	Rounds in which 50% Node Dead	No of packets sent in total rounds	Remaining Energy after 80% node is dead (Joules)
Random LEACH	718	100	410	12165	2.383
Max Energy LEACH	1249	1209	1242	12383	1.267
K-means LEACH	1756	72	814	9319	8.155
BBBC LEACH	1848	545	1283	12220	1.328

In table 2, it is clearly shown that BBBC clustering based LEACH algorithms perform far better as compared to other methods if we consider the no of rounds covered by the algorithms. The BBBC algorithm performs nearly three times better than random LEACH and nearly 50% better than max energy LEACH. If we consider a network, dead if 50% nodes are dead then Max Energy LEACH is performing better than K-means based LEACH and nearly equal to BBBC variants LEACH. Random LEACH has performed worst in every situation. If we consider 80% node criterion for network life then the BBBC algorithm performs better.

If we closely look the figures from 2 to 4 and table 1 then we can easily say that the BBBC based algorithms are much better than random LEACH and K-means LEACH. Nearly 300% network life improvement is recorded for over simple LEACH and 50% over max Energy LEACH and K-means. If we compare the no of dead nodes as per our simulation results Max energy LEACH seems to perform better, but there nodes once start dying accelerates network decay very fast. On one front random LEACH and k-means LEACH algorithms are lacking i.e. network disintegration in this front. In these algorithms, first node is dead very. Even BBBC are not performing well if we consider this parameter. This is the grey area which needs to be addressed in future research.

If we consider no of packets sent to BS then Max Energy LEACH and BBBC LEACH is clearly winner. Both have sent highest no of packets to BS but if we consider the ratio between packet sent and no. of rounds performed by the algorithm then Max Energy LEACH is clear winner in this. The following figures show these statistics.

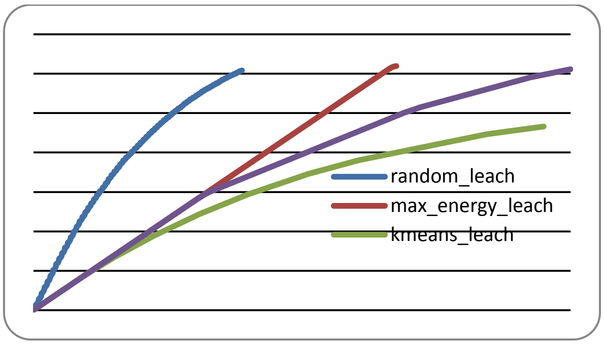

Figure 2 Nodes Remaining Energy pattern in WSN

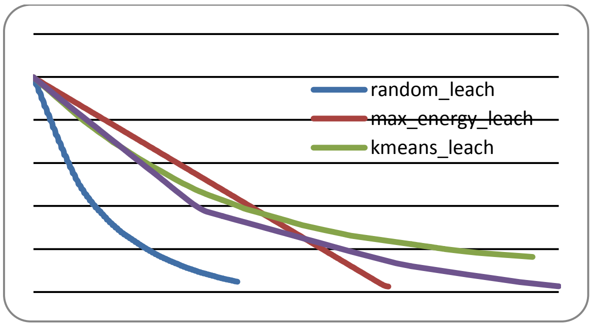

Figure 3 No of Packets Sent to BS by CHs

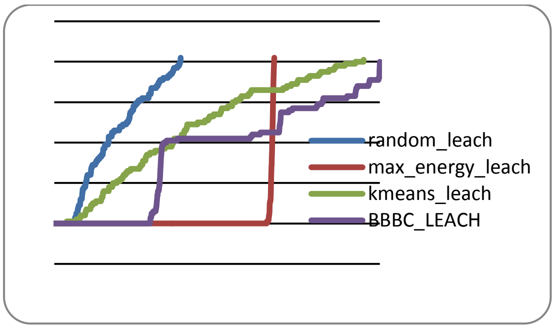

Figure 4. No of dead nodes per round

VI CONCLUSION

We have measured performance of four algorithms in these experiments. Parameters for performance measurements are Residual Energy, Dead Nodes, Packets sent to BS. These parameters are shown in above figures and are plotted against number of rounds. If we consider residual energy and total number of rounds then BBBC-LEACH and its variants perform better than kmeans-LEACH, Max Energy LEACH and random LEACH. But residual energy at the end of total number of round shows that Max Energy LEACH most uniformly distributed energy dissipation among nodes and then BBBC based LEACH performs. For network integration or dead nodes criterion Max Energy LEACH performs far better than other algorithms. For number of packets sent to BS criterion BBBC and Max Energy LEACH performs better than other algorithms.

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