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Energy Efficient Secure Cluster Head Selection in Clustering for Internet of Things by using Nature Inspired Computing (NIC) Techniques

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ABSTRACT

Internet of Things(IoT) is a promising technologies to connect virtually various objects to the Internet through sensors. All these virtually connected objects connect, monitor and collected the information by sensors and finally processed these information in internet that is visible by the end user. The terminology 'Things' are the smart devices are grouped as clusters for energy efficient routing are organized by clustering algorithms in the wireless sensor network for IoT context. But their applications are efficiently enhance challenges in Internet of Things(IoT). The energy efficient and secure cluster head selection optimization by newly nature inspired computing algorithms i.e. Biogeography-Based Optimization(BBO) for solving optimization problems. The cluster head selection plays a prominent role to enhance network life time by transferring data packets to the base station in IoT concept. In the proposed paper, the selection of secure cluster head optimized by Biogeography Based Optimization(BBO) to improve the energy based sensor nodes, network lifetime, stable and secure network and quality of network better simulation results by MATLAB are compared with Stable Election Protocol(SEP), Evolutionary Routing Protocol(ERP), Intelligent Hierarchical Clustering Routing Protocol(IHCR).

Keywords - Optimization, Biogeography Based Optimization, Cluster Head, Wireless Sensor Network, Internet of Things (IoT).

I. INTRODUCTION

Internet of Things(IoT) is an umbrella of technologies that can sense the objects by sensors and gather the information ultimately send to the internet, this information can view by end users[1]. The applications of internet of things are smart whether forecasting, smart agriculture, smart irrigation, smart building, smart robotics for the development smartness every time and everywhere. IoT devices are less powered for limited battery resources for that quickly loss its battery life. All these IoT devices gathered to form a cluster and communicate and transfer message information from one node to another node. The clustering is the Wireless sensor network concept and its a process of grouping of similar nodes or objects to form a group. These clustering concept consists of three main types of nodes i.e. cluster heads, normal nodes, gateway nodes. Every cluster having one cluster head(CH) that balance the load in the network thereby reducing energy consumption and enhance the life time.

Therefore, to finding nearest network path for huge-scale-network becomes Np-hard[9]. To solving this, better to optimize small size network to large size network. The complexity of routing can be ranged from minimum sized network to heavy size network. The complexity of choosing a network-route grows as

per the network size. For that reason, meta-heuristic algorithms better optimization solution for this type of NP Hard problems whereas compare to heuristics approaches[10,11,12]. The new optimization algorithms Biogeography-based optimization(BBO) proposed by Simon D,2008 for solving complex problems for clustering related problems.[13].

BBO has certain similarities with existing well known bio-inspired algorithms are Genetic Algorithm(GA) and Particle Swarm Optimization(PSO). In Genetic Algorithm(GA), whether the parent is not fittest(not a capable), according to this, its child couldn't survive for upcoming next generation because having low-probability, but whereas in Particle Swarm Optimization(PSO) and Biogeography Based Optimization(BBO) solutions are capable to surviving for upcoming generations. In PSO, solutions are form in to same groups, whereas in BBO and GA, the solutions not into group in the cluster. The Solution of PSO is updated by velocity, whereas BBO solution is updated by directly. So BBO has provide most performance results than GA and PSO for that results[13]. The authors optimize BBO for secure cluster selection in WSN. Biogeography Based Optimization(BBO) is a nature inspired computing algorithm for designed to solve complex and real world problems for solve cluster head selection in IoT related problems. In proposed work, Biogeography Based Optimization(BBO) apply for energy efficient secure cluster head selection in the area of heterogeneous networks.

In this paper, we use the modified Bio-geographic based optimization algorithm to attain the novel approach for CH election in heterogeneous network[14]. BBO algorithm is idea of implementation by two methods i.e. immigration and emigration of species as per their habitats. In proposed work, improve the migration phase of BBO and then applied that modified BBO to WSN. The experimental results show that it performs better among others in terms of cluster head selection, lifespan, stability, energy consumption, quality of network and throughput etc. In this proposed research objective, for efficient and energetic cluster head selection approach in the area of heterogeneous network, apply nature inspired computing algorithm i.e. Bio-geographic based optimization algorithm(BBO). The main idea of implementing of this BBO is immigration and emigration of species according to their habitats. Research proposed work, modified and improve migration strategy for better cluster head selection in IoT approach. According to this proposed approach it seems that there seems improvement in efficient cluster head selection, improve life span of network, minimize energy consumption, maximize throughput and in all aspects improve the quality of service(QoS).

The research paper is organized as follows. In Section 2, includes the literature review In Section 3, describes about existing work. In Section 4, described about Biogeography Based Optimization. In Section 5, describes about proposed work. In section 6, describes about simulation results and discussion. In Section 7, includes the conclusion of this research paper

II. LITERATURE REVIEW

In clustering of Internet of Things(IoT) there are two types of nodes are present. They are cluster head(CH) nodes and non-cluster nodes. The nodes are formed in to a group and become a cluster. In that cluster, one special node i.e. cluster head(CH) perform collect data &information from sensor nodes in a network and send to sink. Cluster head performs efficiency of network and maximize the sensor node battery energy. The literature describes major information about performance of various homogeneous protocols and heterogeneous protocols of wireless sensor networks that perform IoT related clustering problems in a clustering technology. These protocols are Low-energy adaptive clustering hierarchy(LEACH)[15], Stable Election Protocol (SEP)[16], Evolutionary Routing Protocol (ERP)[17] and Intelligent HCR(IHCR)[18].

Low Energy Adaptive Clustering Hierarchy(LEACH) protocol is a clustering protocol to enhance the lifespan of wireless sensor networks by minimize the energy consumption and to create Cluster Heads[19]. The LEACH protocol perform several rounds with two phases i.e. Set-up- Phase and Steady-Phase[20,21]. In setup-phase the goal of LEACH protocol group every sensor node to a cluster and select the cluster head. In steady phase the cluster head collects all the data from the nodes in a cluster and send these collected data to the base station(sink). LEACH elects the CH via probabilistic model. This means a random value is assigned to each node between 0 to 1. If the value assigned is lesser than the threshold, this node becomes a CH else not a CH. The authors in[22] proposed an enhance version of LEACH. The stable election protocol(SEP) is a heterogeneous protocol that prolong the time interval before the death of first node i.e. stability period. SEP based on weighted election capability of each node to become cluster head i.e. according to remaining energy of a particular node in a cluster, that node select as a cluster head. Obviously SEP is heterogeneous clustering protocol that provides longer stability period and higher average throughput than current clustering protocols[23].

IHCR(Intelligent Hierarchical Clustered Routing protocol) was introduced by A. W. Matin,S. Hussain,2006 [24]. IHCR apply Genetic algorithm to select energy efficient cluster head selection in sensor network. By applying selection, crossover and mutation Genetic algorithm initialize the population in binary form. By generating values by GA each chromosome has some values 0,-1 and 1. 0 bit shows normal nodes, -1 shows inactive nodes and 1 shows cluster heads. According to the node density and energy consumption the fitness is evaluated. According to parameters are like standard deviation(SD) in between cluster distance, number of transmissions between nodes (T), energy consumption of nodes in data transmission(E), sum of all present cluster head nodes distance from sink(C) and sum of all present sensor node distance to sink(D) are mentioned.

III. EXISTING WORK

In 2006, Matin et al.[25] proposed intelligent HCR protocol by applying nature inspired computing algorithm i.e. genetic algorithm(GA) to generate energy efficient CHs. For every generation of Genetic Algorithm(GA), based on fitness of chromosome, the initial population is optimized. The objective of the fitness is to minimize the energy consumption and prolonging the lifetime of the network. The fitness function is given in following Eq(1).

$$F = \Sigma\, i\alpha(wi, f\, i)\ \forall fi \in \{SD, T, E, C, D\} \quad (1)$$

In above function α is a random number, wi represent arbitrary weights at iteration i, assigned initially to each parameter. However, the fitness function is not efficient and shows poor stability period of sensor network.

In 2012, Baraa et al.[26] proposed evolutionary-based routing protocol (ERP) that enhanced the fitness function of GA based HCR by considering the compactness and separation error of cluster along with number of CH in each round. ERP outperforms the LEACH and intelligent Hierarchical Clustering Routing(IHCR). In the literature survey, as per applying stochastic approaches, not capability to provide quality of solutions due un-avail of suitable parameters in fitness function[27]. In the existing work there no effective chosen of cluster head and network route for suitability of large scale networks. The existing research work proved to be Np-hard problem. But in proposed research work BBO algorithm and as per objective function proves better performance than SEP, ERP and IHCR algorithms. The proposed BBO algorithm improves the stability of network, network life time, quality of network, improves total number of alive nodes per round and improves number of data packets received from cluster head to base station.

IV. INTRODUCTION TO BIOGEOGRAPHY BASED OPTIMIZATION(BBO)

Biogeography Based Optimization(BBO) is a bio-inspired algorithm. BBO is a metaheuristic type of optimization algorithm for finding optimum and global results of a problem. Metaheuristic optimization proposed by Fred Glover [28]. In the past, those algorithms with stochastic approach are referred as heuristic. The word heuristic approach means to find or discover by trail and error. But whereas 'meta' meaning is higher level and metaheuristic algorithms perform better results than heuristics. But there is not guarantee of optimum solutions can be reached by applying these algorithms. All metaheuristic algorithms applicable for global optimization. The importance of metaheuristic algorithms are the nearby quality solution can be found in reasonable amount of time. The components of metaheuristic approach are intensification and diversification or exploitation and exploration[29]. Diversification means to generate diverse solutions so as to explore the search space on a global scale, while intensification means to focus the search in a local region knowing that a current good solution is found in this region. The good combination of these two components applicable for global optimal solutions reached in reasonable amount of time.

Biogeography Based Optimization(BBO) is famous for experimental and also research oriented algorithm for geographically located of biological organisms for solving global optimization problems. BBO specially of bio-inspired and it describes the movement of species from one island to other island. Elitism operator, migration and mutation operators are the parameters of BBO. In BBO having some habitats and each habitat having some value i.e. Habitat Suitability Index(HSI) and having some parameter called Suitability Index Variable(SVI). The migration uses the immigration and emigration rate to improve the HSI value of habitat. The mutation operator update the solution to explore the island. The elitism operator select the best optimal solutions from available possible solutions for better results.

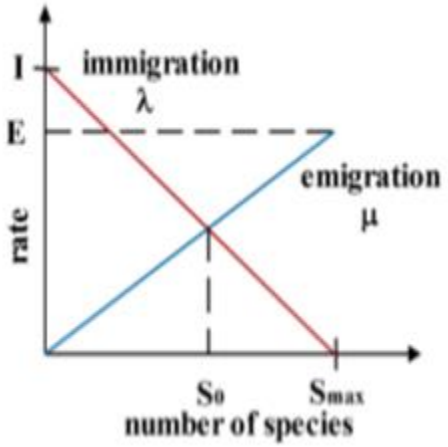

Fig1 – Biogeography Based Optimization

Fig1 shows the relation between no. of species, immigration rate and emigration rate functions of the number of species in the habitat. See in figure about immigration curve. The maximum point of the habitat is I, it occurs when zero species in habitat. If number of species increases, then automatically habitat becomes crowded more, then more species are try to survive for immigration to the habitat, then immigration rate decreases. The more number of species this habitat can able to support Smax at this point immigration rate becomes zero. Now consider the emigration curve. If there are no species in the habitat then the emigration rate must be zero. As the number of species increases, the habitat becomes more crowded, more species are able to leave the habitat to explore other possible residences, and the emigration rate increases. The maximum emigration rate is, which occurs when the habitat contains the largest number of species that it can support Now consider the emigration curve. If there are no species in the habitat then the emigration rate must be zero. As the number of species increases, the habitat becomes more crowded, more species are able to leave the habitat to explore other possible residences, and the emigration rate increases. The maximum emigration rate is , which occurs when the habitat contains the largest number of species that it can support In emigration curve, if there is not any species in the habitat then automatically emigration

rate becomes zero. If number of species increases, the habitat becomes crowded, then more species are leave the habitat for possible residences for that reason emigration rate increases. The maximum emigration rate E which occurs when habitat contains largest species that it will support. Here S0 is the equilibrium position of an island, at which immigration and emigration rate coincide. Smax denotes the maximum no. of species. If the no. Of species in the habitat is greater than S0 then it is said to be high HSI habitat. If the no. of species in the habitat is less than S0 then it is said to be low HSI habitat.

V. PROPOSED WORK

Biogeography Based Optimization Based Energy Efficient Clustering Protocol(BBOEECP). BBO follows single feature of migration property i.e. every SIV operate individually and limited are updated. For this reason in proposed research algorithm, migration operator modified as follows. According to the proposed paper, migration operator have been modified in two ways. In original BBO only limited features modified but not all features possible to modified In proposed, first it generates a new island by modifying all features of immigration island. Second modification is, the original BBO algorithm the island not selected for migration. But in proposed one, uses best individual along with other islands as emerging islands. In proposed algorithm, every island have d number of SIVs for that d number of random numbers will generated. When these random numbers less than immigration rate(λ) then SIV of immigrating island is replaced by SIV of emigrating island. If not, selected SIV posses its value from related best island SIV. As the process, all the features of immigration island are modified properly.

A) Algorithm - Improved Migration Operator

```
begin
  for iland_i = 1 to Number_of_Population
  select counter_iland with probability based
  on λ_imigration
       if randam_no(0,1)< λ_imigration then
       for solution=1 to dimension_d
      replace dimension_d with μ_emigration
  select λ_imigration with probability based on
  μ_emigration.
      H_imigration(λ) (SIV) ← (replace with) H_emigration(μ) (SIV)
        else
      H_imigration(λ) (SIV) ← (replace with) H_best SIV)
            end if
       end for
      end if
end for
end
```

In proposed research(EEBBOCP), improve migration operator. If SIV not selected, the value will change seems best suitable SIV. Every SIV in island must change using improved migration. NP shows the number population of number of islands present. NP i.e. possible solutions. Each island having d number SIV for that d number of possible random numbers will be generated. These random numbers less than immigration rate(λ) according to this SIV of immigration island is replaced by SIV of emigrating island. If not possible, SIV takes value from suitable best island SIV. As per this process, all the features of immigration island will be changed or modified. In this way optimal results will be generated for better best solutions.

Fig2 – Flow chart

The proposed EEBBOCP is for energy efficient cluster head selection in wireless sensor networks that related to internet of things concept. In every communication network, the network lift time and stability is important characteristics. Stability here means, when first node in the network dies means first node deletes overall energy and battery capacity. So improve the energy efficiency of a node, battery capacity to improve, enhance the stability of a network. For that reason there must be algorithm for efficient cluster head selection for prolong life period, stable of network. EEBBOCP algorithmic protocol used to improve network life time, more stable of a cluster-network in heterogeneous type of network.

A) Fitness function

In proposed work, to implement above factors, the formula for fitness function as follows.

f_n = *weight1 * (energy_Non_Cluster_Head + energy_Cluster_Head) + weight2 * compaction /separation + weight3 * non_cluster_head*

In above formula weight1, weight2, weight3 are weights. An empirical analysis is performed on different values of these weights and it is observed that for weight1 = 0.4, weight2 = 0.5, and weight3 = 0.1. The parameters of the proposed fitness function is energy_Non_Cluster_Head i.e. energy taken from non-cluster-head-node to cluster-head-node. Compactness i.e. to minimize the distance between cluster nodes to cluster head separation i.e. maximize the distance between one cluster head to the cluster head. Minimize cluster-head count. In proposed research work consider single objective function for that it generates only one value to measure the quality of solutions in a prescribed time period.

C) Simulation Results

The proposed protocol EEBBOCP compare network matrices like network stability, network lifetime, total number alive-nodes per round, received data packets to base station etc. [30,31] with heterogeneous protocols like SET, ERP, IHCR.

D) Simulation settings

Simulation parameter settings available in the Table-I [32]. The protocols implemented using intel core™ i3 7020U processor with 4.00 GB RAM and simulation software MATLAB R2014a with 100 node randomly deployed in 100×100 m2 WSN.

TABLE1- Parameter settings

Sr. No.	Description	Parameters	Value
1	Network area	N X N	100x100m^0
2.	Base station position	BS	(50.50)
3.	Total sensor nodes	n	100
4.	Sensor node's initial energy	E_0	0.5 J
5.	Advanced nodes percentage	m_0	0.1
6.	Energy factor for advanced nodes	α	1
7.	Dissipated energy per bit	E_{elec}	50 nJ/bit
8.	Energy by transmitter in free space model	E_{fs}	10_pJ/bit/m^2
9.	Energy by transmitter in multipath model	E_{mp}	0.0013_pJ/bit/m^4
10.	Energy of aggregation by CH	E_{DA}	5 nJ/bit/message
11.	Size of data packet	...	4000 bits
12.	Population size	Popsize	100
13.	Number of iterations	MaxGen	1000
14.	Mutation probability	P_m	0.1
15.	Crossover probability	P_c	1

E) Evaluations

The network life time and stability period of proposed protocol EBBOCP shows better performance results than heterogeneous protocol SEP, ERP and IHCR. The following table -2 provide information about comparative results of total number of rounds in network vs dead nodes. The better performance shows by proposed EEBBOCP shows 1% of dead nodes in wireless sensor network at 1305th round and the last sensor node died at 3500th round. It means stability about network is very high than that of SEP, ERP, IHCR. The remaining energy of network is essential factor for good performance of network. In figure 3(a) total residual energy, figure 3(b) number of packets to base station, figure 3(c) number of active nodes are analyzed. The table –iv shows the performance results of EEBBOCP residual energy better than that of SEP, ERP, IHCR. This shows the efficiency of EEBBOCP for selection of energy efficient CH selection in the network.

TABLE2- Dead nodes comparison

% of dead nodes-►	Number_Of _rounds				
	1%	50%	70%	90%	100%
SEP	863	1296	1396	1487	2265
IHCR	885	1312	1451	1925	3336
ERP	1070	1391	1566	1925	3200
EEBBOCP	1120	1451	1571	2025	3557

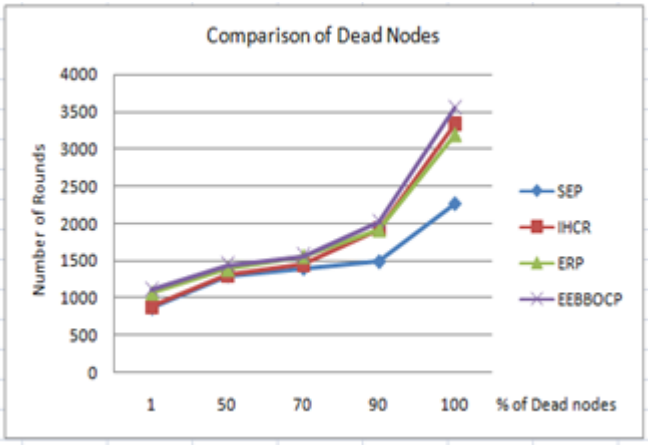

Fig3 - Dead nodes comparison

Fig3, many no. of advance sensor-nodes are selected as CHs. According to this reason network becomes having quality of more residual energy and having quality of network stability for longer duration when compare with mentioned protocols in this research paper are SEP,IHCR,ERP. In this figure while comparison of dead nodes of SEP,IHCR and ERP with EEBBOCP. In proposed protocol having stability in 3557th round %0 dead nodes are there.

TABLE3- Comparison of remaining energy

Remaining Energy	**Number of rounds**			
	1	**200**	**1000**	**2000**
SEP	54.96	46.53	12.91	0
IHCR	54.96	47.28	16.5	1.81
ERP	54.96	47.84	19.19	2.41
EEBBOCP	55.96	48.2	20.07	3.3

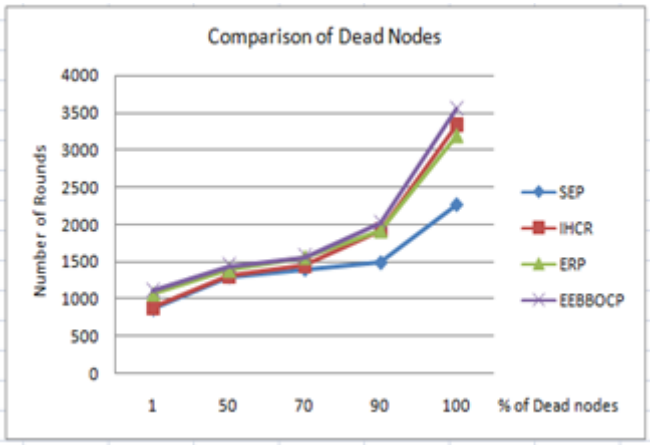

Fig4- Comparison of remaining energy

In above fig4 shows comparison of remaining energy in 1 round to 2000 rounds for mentioned protocols SEP,IHCR,ERP with EEBBOCP. In this figure while comparison of remaining energy (residual energy) of SEP,IHCR,ERP with BBOEECP. The proposed protocol EEBBOCP even in 2000th round having highest remaining energy (3.3).

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