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Improved Artificial BEE Colony Optimization and Clustering Based GSTEB Routing Protocol

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Abstract—*Wireless Sensor Network(WSN) is a rising technology which is made up of a huge quantity of sensor nodes. Even if WSNs are extensively used in a range of domains, they have a number of limitations such as restricted energy. General Self-Organized Tree-Based Energy-Balance Routing Protocol (GSTEB) is a protocol for WSNs which constructs a routing tree via a procedure in which for every single round, a root node is allocated by base station and transmits root node's choice to every nodes of sensor network. GSTEB has shown quite significant results over the available WSNs protocols, but it has some limitations. : (1)The tree based routing require shortest path between the source and the sink, but shortest path problem is NP-Hard in nature. Therefore the Artificial bee colony (ABC) is required to enhance the GSTEB protocol further to find shortest route. (2)Clustering is also not used in this protocol, so clustering is necessary to reduce the redundant data. (3) GSTEB is used for smaller networks, it is not applied on dense network. In this paper to overcome the limitations of the previous work a new improved technique that is GSTEB routing protocol by using clustering and artificial bee colony optimization is proposed. Performance is also compared with previous GSTEB protocol.*

Keywords*: Artificial Bee Colony, Clustering, Data Aggregation, GSTEB, WSNs.*

1. INTRODUCTION TO WSN

Wireless Sensor Network composed of huge quantity of sensor nodes that are of low price, less energy and light in weight. These nodes are set up in a region to sense different events like pressure, heat, movement etc. A sensor node contains different components that is sensing, processing, communication and power components. An event is sensed by the sensor node, processed and is communicated among the other sensor nodes or Base Station throughout high frequency channel by means of single or multi-hop communication. Sensor nodes have tiny batteries having restricted energy, due to which the life time of sensor network is limited. The major challenge is to enlarge the life span of the network with restricted power of battery.[11]

The remaining part of the paper is structured as: Section 2 gives definition of clustering. Section 3 explains data aggregation. Section 4 explains the GSTEB protocol. Section 5 presents the literature review. Section 6 explains proposed methodology. Section 7 explains experimental setup. Section 8 represents experiment results. Section 9 represents results in tabular form And finally Section 10 presents conclusion and future scope Section 11 consist of references.

2. CLUSTERING

The key intention of cluster based routing is to capably maintain the energy used by sensor nodes by connecting them in multi-hop communication in an exact cluster. The energy resource of sensors and closeness of sensors to the Cluster Head are the two main factors on which construction of cluster is based. Energy utilization, duration of the network and scalability Clustering has main application in more dense networks, since it is greatly easier to deal with a group of cluster heads as compared to handle complete nodes. In wireless sensor network the sensor nodes have restricted energy, transmit power, memory, and calculation capabilities. Power used by the nodes for sending data starting from sensor nodes towards the BS (base station) is the central reason of energy exhaustion within sensor nodes. [12]

3. DATA AGGREGATION

The sensor nodes collect sensory information via monitoring geographical area. Sensory information in sensor network is combined by sink node by using wireless hop-by-hop broadcast. The right aggregation function is used at sink node used for arriving data from in-between sensors nodes and hence it conserves the energy. Aggregation helps to reduce the total amount of network transfer and to condense energy utilization on sensor nodes. In data aggregation technique as shown in Fig. 1 data collected to sensor node by using aggregation methods.

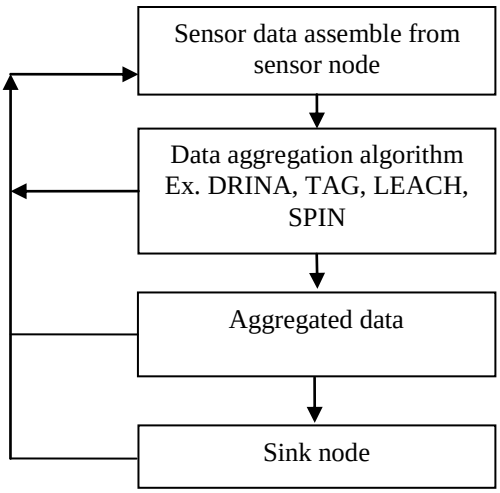

Fig. 1: General structure of the Data Aggregation Algorithm

4. GSTEB PROTOCOL

General Self-Organized Tree-Based Energy-Balance Routing Protocol (GSTEB) [7] constructs a routing tree via a procedure in which for every single round, BS (base station) allocates a root node and transmits root node's selection to every sensor nodes. Then, every one node chooses its parent by taking into consideration simply itself as well as its neighbours information, as a result making GSTEB a powerful protocol.

Data fusion has two cases:

Case(1):The data among any nodes can be completely combined or fused. Each one node broadcasts the identical quantity of data despite what amount of data it obtains from its children.

Case(2):The data cannot be combined. The message's length broadcasted by every sensor node be the total of its individual sensed data plus obtained data from its children.

The chief plan of this protocol is to achieve a longer network life span for diverse applications. The operation of GSTEB is divided into following phases:

a) Initial Phase

In this Phase ,the factors of network are initialized. It is split into following steps.

Step 1: When this Phase starts, base station transmits a packet to every of the nodes to notify about starting moment.

Step 2: Every node transmits its within a circle through a definite radius. Every other node will observe the channel, and if a few of these nodes are the neighbours of that node i, they can obtain that package and store the information about node i within own memory.

Step 3: Every node transmits a package that consists of everyone of its neighbours' information. After that its neighbours can obtain that package as well as store the relevant data in memory storage.

b) Tree Constructing Phase

GSTEB carry out the various steps to construct a routing tree:

Step 1: Base station allocates a sensor node as the root and transmits its ID and coordinates to every node.

Step 2: Everyone node seeks to pick a parent in its neighbours by using energy level (EL).

Step 3: Since all nodes picks the parent as of its neighbours and each node stores its neighbours' neighbours' information within Table II, every one node can recognize the entire of its child nodes.

c) Self-Organized Data Collecting and Transmitting Phase

When the routing tree is created, every node gathers information to produce a DATA_PKT that is broadcasted towards base station.

d) Information Exchanging Phase

For Case1 the nodes that be going away to expire have to notify others nodes .

For Case2 when base station built the routing tree, then the base station compute the energy utilized by every node in that round.

5. LITERATURE REVIEW

Li et al. [1] planned a novel technique - Adaptive Data Aggregation Mechanism (ADAM). From the reproduction, proved the efficiency of ADAM in realized data combination through significant compression proportion and as a result expanded the lift-time of the networks.

F. Nawaz et al. [2] proposed a data aggregation & routing protocol for Wireless Sensor Network (WSN) that was appropriate to mostly deployed networks. This protocol reduced load of data and enhanced the life span.

D.Mantri et al. [3] proposed and evaluated the group based data aggregation technique. Simulation result showed, proposed algorithm provided an enhancement of 14.94% in energy utilization as compared to main cluster based protocol LEACH.

J.Peng et al. [4] planned algorithm that was created from LEACH,. The overlap of detect regions was examined and a nodes-adaptive program was planned to reduced the quantity of data with LEACH protocol.

B. S. Mathapati et al. [5] proposed a novel protocol called An Energy Efficient Reliable Routing Protocol for WSN which be cluster based. This protocol make sure reliability as well as balanced power utilization.

D. Kumar [6] proposed and evaluated two protocols which are clustering based which were called S-EECP (single-hop energy-efficient clustering protocol) and M-EECP (multi-hop energy-efficient clustering protocol). This protocols prolonged network life, and achieved load equilibrium amongst the cluster heads.

Z.Han et al.[7] proposed a General Self-Organized Tree-Based Energy Balance routing protocol (GSTEB) which enhanced performance as compared to other protocols in balancing power utilization, thus prolonged the duration of wireless sensor network.

S. Rani et al. [8] proposed Energy Efficient Inter Cluster Co-ordination Protocol(EEICCP) which is based on a layered technique designed for the clusters.

A. Jain et al. [9] aimed to define a novel centrality metric "cluster optimal degree centrality". Finally based on the definite centrality metric, a Fuzzy Inference method based cluster head(CH) selection technique had been proposed that prolonged the network lifetime.

M. Saxena et al. [10] proposed an energy aware algorithm based on clustering for longer time of MANET (Mobile Adhoc Network).

6. PROPOSED METHODOLOGY

The new proposed technique is designed and implemented in the MATLAB tool. Two metrics are used to evaluate the proposed technique:

a) First Node Dead Time i.e. Stable Period

b) Half Node Dead

The proposed methodology works as:

Step 1: Initialize network

Step 2: Deploy network randomly in predefined sensor field.

Step 3: Apply GSTEB to evaluate levels

Initial Phase: while every node obtain the packet, they will calculate their individual energy-lev/el (EL) using function:

$$EL(i)=\lceil \text{Residual Energy}(i)/\alpha \rceil \quad (1)$$

EL is parameter for load balance, and it is predictable energy value rather than a accurate one. Here i denote the ID of every node and α is the constant which reflects the minimum energy unit .

Tree Constructing Phase: GSTEB performs various steps to build a tree.

Self-Organized Data Collecting and Transmitting Phase:

once the routing tree be constructed, every sensor node collects information to produce a DATA_PKT which wants to be transmitted to BS.

Information Exchanging Phase:

For Case1 the nodes that be going away to expire need to notify others .

For Case2 once the routing tree be built, the energy expenditure of every node within this round can be planned by BS .

Step 4: Apply clustering to develop cluster heads.

A node turned into a CH for the present rotation round if the number is less than the following given threshold

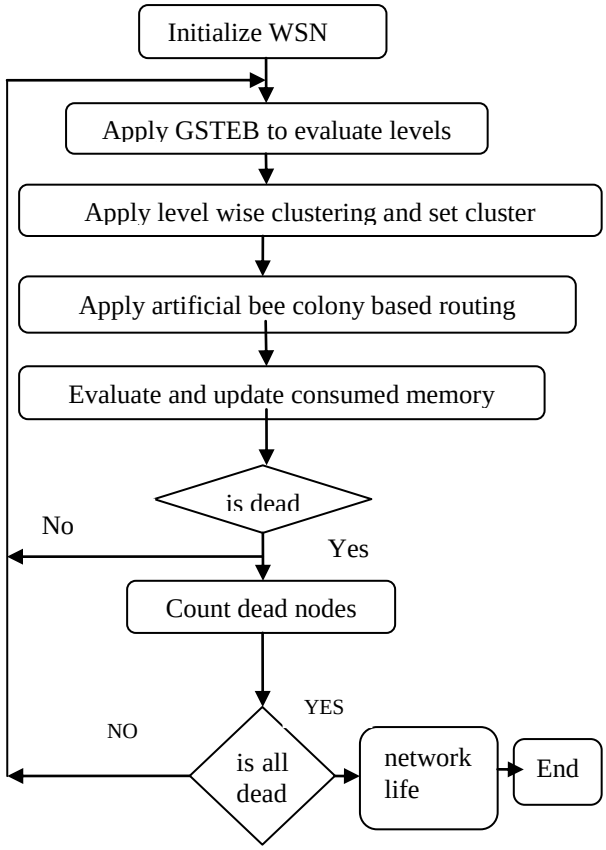

Fig. 2: Flowchart of Proposed Methodology

$$T(i)\begin{cases}\frac{p}{1-p(r \bmod \left(\frac{1}{p}\right))} * E_{con} & i \in G \\ 0 \text{ otherwise}\end{cases} \quad (2)$$

Where p is optimal percentage of CHs in each round. r is current node and i represent any node that wants to become the CH in that round. G is the group of nodes that has not been chosen as CHs in previous 1/p rounds

Step 5: Apply artificial bee colony on clusters to find the best route among CHs to sink.

a) Employed bees are assigned to food sources by using following equation:

$$x'(i) = x_j(i) \pm r(x_j(i) - x_k(i)) \quad (3)$$

b) Movement of the Onlookers is completed by using given equations:

Probability of Selection of a nectar source:

$$P_i = \frac{F(\theta_i)}{\sum_{k=1}^{S} F(\theta_k)} \quad (4)$$

P_i : probability of selecting the i^{th} employed bee

S : The numbers of employed bees

θ_i : The location of the i^{th} employed bee

$F(\theta_i)$: fitness value

Computation of novel position:

$$x_{ij}(t+1) = \theta_{ij}(t) + \emptyset(\theta_{ij}(t) - \theta_{kj}(t)) \quad (5)$$

x_i is the place of the onlooker bee

t is the iteration number

θ_k is the at random chosen employed bee

j is the measurement of the solution

$\emptyset(\theta_{ij}(t) - \theta_{kj}(t))$ is a series of arbitrary variable inside range.

c) Movement of the Scout bee

The movement of the scout bee is completed by means of the following equations:

$$\theta_{ij} = \theta_{jmin} + r.(\theta_{jmax} - \theta_{jmin}) \quad (6)$$

r : A random number and $r \in [0,1]$

Step 6: Evaluate and update energy consumption.

$$d_{toCH} = \frac{M}{\sqrt{2\pi k}}, d_{toBS} = 0.765\frac{M}{2} \quad (7)$$

$$E_{Tx}(1,d) = 1\,E_{elec} + l\varepsilon_{fs}d^2, d < d_0 \quad (8)$$

$$E_{Tx}(1,d) = 1E_{elec} + l\varepsilon_{mp}d^4, d \geq d_0 \quad (9)$$

Where $d_0 = \sqrt{\frac{E_{fs}}{E_{mp}}}$,

M is area of WSN

E_{fs} is amplification energy of free space

E_{mp} is amplification energy when area is more.

Step 7: Check whether all nodes become dead, if yes then show network life time and Return else continue to step 3.

$$\text{Dead} = \begin{cases} 1 \text{ if } s(i).\text{Energy} \leq 0 \\ 0 \text{ otherwise} \end{cases} \quad (10)$$

$$\text{Termination} = \begin{cases} 1 \text{ if countdead} == n \\ 0 \text{ otherwise} \end{cases} \quad (11)$$

7. EXPERIMENTAL SET-UP

Table 1. has shown a variety of constants and variables required to simulate this work. These parameters are standard values used as benchmark for WSNs.

Table 1: Experimental Setup

Parameter	Value
Area(x,y)	100,100
Base station(x,y)	100,100
Nodes(n)	300
Probability(p)	0.1
Initial Energy(Eo)	0.11
transmiter_energy	50nJ/bit
receiver_energy	50nJ/bit
Maximum lifetime	100
Message size	4000 bits

8. EXPERIMENT RESULTS

On applying clustering and artificial bee colony optimization, following results are achieved.

8.1) WSN in active stage

Fig. 3. is showing the active environment of ABC based GSTEB. Magenta diamond is representing the base station. Magenta stars are representing the normal sensor nodes.

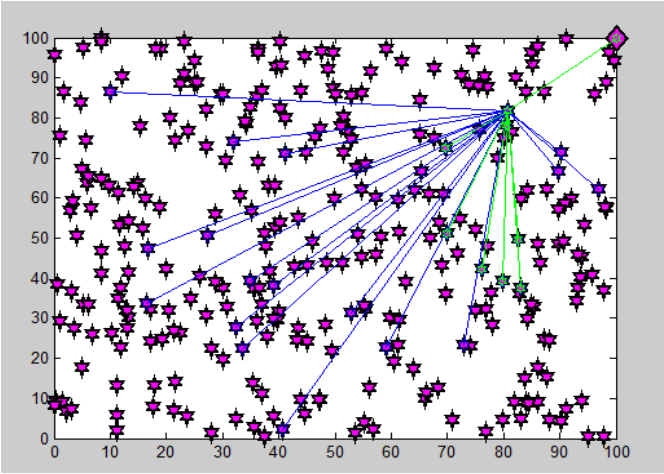

Fig. 3: When all the sensor nodes are alive

8.2) First node dead

Fig. 4 is showing the environment of ABC based GSTEB in which one node is dead. Dead node is represented by red star.

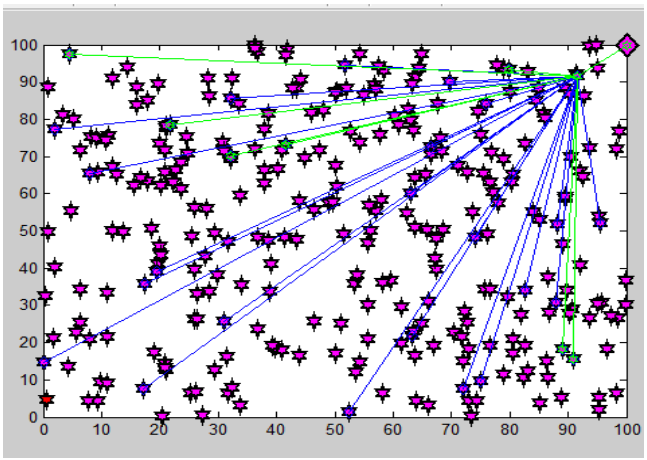

Fig. 4: When first node is dead

8.3) Half nodes dead

Fig. 5. is showing ABC based GSTEB in which half nodes are dead. Dead nodes are represented by red star.

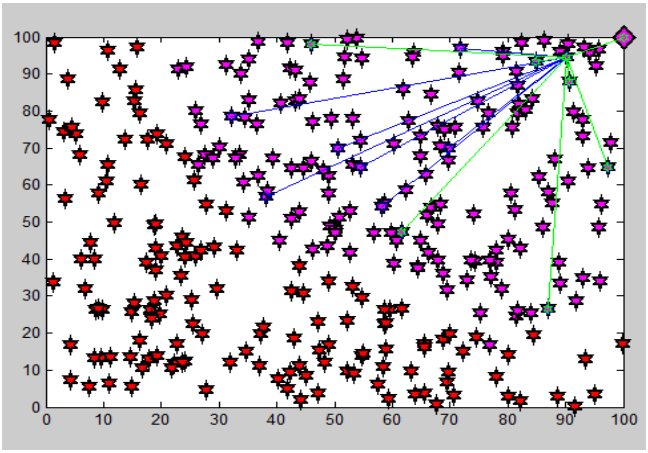

Fig. 5: When half nodes are dead

8.4) Alive nodes

Fig. 6 is showing alive nodes.

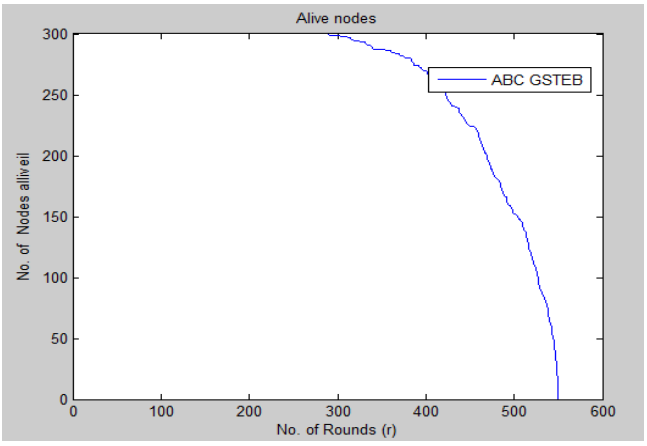

Fig. 6: Alive nodes versus number of rounds

8.5) Dead nodes

Fig. 7 is showing dead nodes.

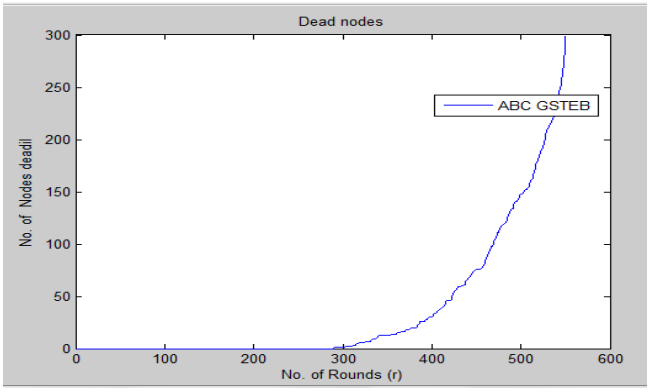

Fig. 7: Dead nodes versus number of rounds

8.6) Remaining energy

Fig. 8. shows that as the no. of rounds increases , the energy decreases. It becomes zero when all the nodes are dead.

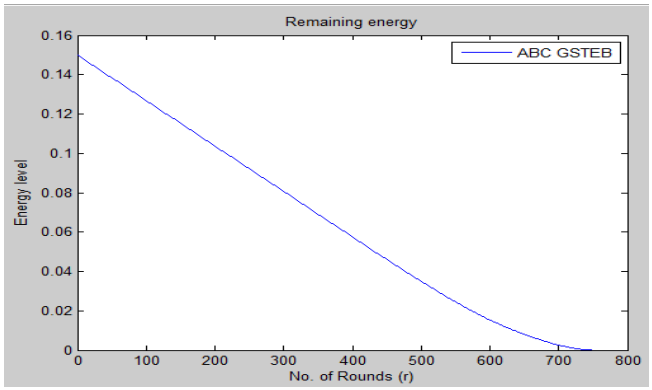

Fig. 8: Remaining energy versus number of rounds

8.7) Packets sent to BS

Fig. 9 is showing total number of packet sent to base station.

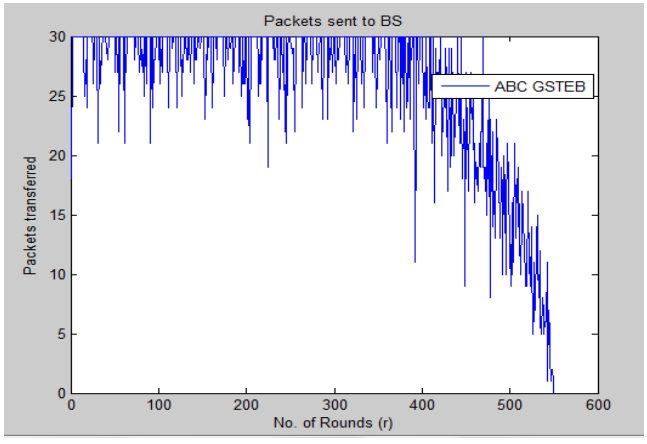

Fig. 9: Packets sent to BS versus number of rounds

9. RESULTS IN TABULAR FORM

Table 2: First node dead

Initial Energy	Existing	Proposed
0.11	154	289
0.12	166	321
0.13	179	343
0.14	193	368
0.15	207	383
0.16	220	439
0.17	235	465
0.18	249	483
0.19	266	495
0.20	275	545

Table 2 shows that the number of rounds for first node dead in proposed are more than the existing GSTEB.

Table 3: Half node dead

Initial Energy	Existing GSTEB	Proposed GSTEB
0.11	291	503
0.12	318	540
0.13	348	594
0.14	372	633
0.15	398	678
0.16	422	729
0.17	452	764
0.18	478	829
0.19	506	851
0.20	539	911

Table 3 shows that the number of rounds for half nodes dead in proposed are more than the existing GSTEB.

10. CONCLUSION AND FUTURE WORK

The proposed technique has the ability to overcome the limitations of the GSTEB routing protocol by using the clustering and artificial bee colony optimization based optimized path selection. The comparisons has clearly revealed that the number of rounds for first node dead and half node dead are more in proposed GSTEB as compared to available GSTEB. Thus network life time is greater in proposed GSTEB protocol.

This work considers only two parameters for comparison. Further we will use more parameters to evaluate performance of proposed GSTEB as compared to existing.

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