ENHANCED ANT COLONY OPTIMIZATION, CLUSTERING AND COMPRESSION BASED GSTEB PROTOCOL

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ABSTRACT*:*
Wireless sensor networks are widely used for gathering and sending data to the base station. Since sensor nodes in the network are power constrained, it is rather significant for them to minimize the energy consumption so as to enhance the network lifetime. This paper has proposed a new ACO, clustering, compressive sensing and tree based routing protocol for wireless sensor networks. The overall objective of this paper is to improve the GSTEB further by using the compressive sensing based inter cluster data aggregation. The use of clustering will reduce the energy consumed by each node which becomes member node (non CHs) and also adaptive clustering will balance the load of sensor nodes. The compressive sensing will reduce the size of the aggregated packets to reduce the energy consumption further and ACO will reduce the energy consumed by the cluster heads by finding the shortest path to transmit data to the base station. This proposed technique is designed and implemented in MATLAB tool. The comparisons are also drawn among the proposed and existing techniques and it shows that the proposed technique outperforms over the available technique as there is 12.12% improvement in the network stability period, 4.35% improvement in the network lifetime and 7.60% improvement in the throughput.

Keywords*-Energy-balance, wireless sensor network, network lifetime, clustering, ACO, tree construction.*

I. INTRODUCTION

Wireless sensor networks (WSNs) are composed of a larger number of small and low-cost sensor nodes. This network is used for collecting information from environment and communicating with each other via wireless signals [1]. Applications of WSNs include traffic monitoring, home education [2],[3], monitoring environmental or physical properties over a large area, e.g., temperature, pressure, vibration luminosity [4]. They are also widely used to collect information in many applications such as tracking at critical facilities[5], surveillance[6], Vehicle tracking [7],volcano monitoring[8], permafrost monitoring [9] and monitoring animal habitats[10]. In WSNs, the sensor nodes are often deployed in large quantities and are usually battery-powered, so it is not possible to recharge or replace them with thousands of physically embedded nodes in the network. Therefore, conserving the energy of nodes, so as to enhance the network lifetime becomes one of the major issue in the research field of WSNs [11]. Data communication among the sensor nodes in the WSN is one of the foremost reason of energy consumption. So an energy efficient technique ought to be employed. To attain the aim, we need not only to lessen the total energy consumption but also to balance the load in the network [12]. The most extensively employed energy saving technique is the data aggregation. Data aggregation at the sink by the individual nodes results in flooding of the data which causes the maximum energy consumption, thereby degrading the network lifetime. In this paper, we propose a modified approach for General Self-Organized Tree based Energy Balance routing protocol (GSTEB). In existing GSTEB protocol routing tree is constructed where tree based routing is done to transmit data to the base station but in this if the parent node dies the topography needs to be rebuild again which will consume a lot of energy and there can be loss of data also. To prevail over the difficulty of transmission delay and data loss in the network due to the nodes failure in the root to sink, cluster based aggregation method can be used. In large network, proficient transmission of data to the sink requires to find the optimal path as per the number of hops [13], so data can be aggregated at cluster head to be transmitted to the base station. The clustering technique can alleviate data redundancy and reduce the congestive routing traffic in data transmission. After the clustering tree based routing at the cluster-heads require to find the shortest path between the source and the sink, but shortest path problem is NP-Hard in nature. Therefore suitable routing is obligatory for extending the lifespan of low power and super compacted sensor nodes. So artificial intelligence can be applied on the cluster-heads for dynamic routing through Ant Colony Optimization based tree construction to obtain the highest reliable working period. ACO will yield longer lifetime and better scalability [14]. The performance of GSTEB can be increased further by applying compression on the cluster- heads to reduce the amount of data to be transmitted to the base station since it is not suitable to transmit data directly in the network because it will lead to more energy consumption and compressing data before transmission is an effective method to save energy of the nodes. One research has revealed that the energy utilization for executing 3000 instructions is nearly equal to the energy utilization for transmitting 1 bit over a distance of 100 m by radio [15]. Therefore, compressing data before transmitting it to the base station is a proficient way to make good use of nodes' limited battery power, thereby conserving the energy [16]. According to the requirement for completely recovering the compressed numerical data LZW (Lempel-Ziv-Welch) algorithm will be used. Integration of clustering, Compression and ACO with tree based routing is proposed to significantly reduce the energy consumption so that there can be increase in the stability period, network lifetime and scalability related to data collection in wireless sensor network.

The remainder of the paper is organized as follows: Section II presents the related work, Section III presents the proposed scheme, Section IV presents the comparative analysis and simulation results. Finally, Section V concludes the paper and outlines the future research work.

II. RELATED WORK

GSTEB (General Self-Organized Tree-Based Energy-Balance Routing Protocol for Wireless Sensor Network)[12] is a protocol with dynamic routing in which routing tree is constructed where in each round, Base station selects one root node among all the sensor nodes and broadcasts selection of the root node to all sensor nodes in the network. Subsequently, each node selects its own parent by considering itself and its neighbor's information. Simulation results have shown that GSTEB gives improved performance than the other protocols in balancing energy utilization, thereby prolonging the network lifetime. In LEACH [17] operation is divided into two phases : set-up phase and steady phase .In the set-up each node decides whether to become a CH or not. After the selection of CHs, other nodes will join its nearest CH and will join its cluster. Each node will choose the nearest CH. In the steady-state phase, CHs will fuse the received data from their cluster members and send the fused data to BS. Simulation results have shown that LEACH balances the load in the network as a result achieving a factor of 8 times improvement in first node dead time and the last node dies 3 times afterwards than the last node death with direct transmission. HEED [18] is a step up over the LEACH on the way of selection of the cluster heads. This protocol chooses the CH according to the residual energy of each node. HEED protocol ensures that there exists only one CH within a certain range of the network, so there is at all times a uniform distribution of the cluster heads in the network thus ensuring low energy consumption hence enhancing the network lifetime. PEDAP (Power Efficient Data Gathering and Aggregation in Wireless Sensor Networks)[19]is a tree-based routing protocol in which all the sensor nodes in the network form a minimum spanning tree thereby resulting in minimum energy consumption for data transmission. Another version of PEDAP is called PEDAP-PA which slightly increases the energy consumption for data transmission but balances energy consumption per node. Tree-Based Clustering (TBC)[20] is an also a development over LEACH protocol. The cluster creation in TBC is same as the LEACH protocol. In TBC, nodes within a cluster build a routing tree where cluster-head is the root of the tree. The amount of levels and height of the tree is based on the distance of the member nodes to their cluster head.TBC protocol is alike the GSTEB as in TBC also routing tree is build and also each node records the information of all its neighboring nodes and accordingly builds the topography. Lempel-Ziv-Welch (LZW) Algorithm is a universal lossless data compression dictionary algorithm [21]. The principle working of LZW algorithm is similar to the dictionary. This algorithm compresses content character by character, these characters are afterward joined to form a string which is referred by a particular code and these strings are added to the dictionary. So LZW algorithm generates a string table during coding that records all the character strings those have previously appeared and there is no any replication. After that whenever a string is repetitive it can be referred with that code. The LZW decompression algorithm can recreate the dictionary at the same time as processing the compressed data, so it does not need to broadcast the dictionary [22]. This compression algorithm is lossless, simple, representative, quick speed with little complexity and widely used in a diversity of applications such as lossless image compression [23] and text compression [24]. Ant colony Ant colony optimization (ACO) algorithm is based on the natural behavior of the real ants to find the shortest path or trail from a source to the food. It utilizes the performance of the real ants in search of the food. It has been observed that the natural ants deposit some pheromone along the path while traveling from the nest to the food and vice versa. In this way the ants that follow the shorter trail are likely to return earlier and hence pheromone deposition on the shorter path is at a faster rate. ACO can be applied in the network routing problems to find the optimal and shortest path to send data. In a network routing problem, a set of artificial ants are simulated from a source (nodes) to the sink (destination). The forward ants will select the next sensor node arbitrarily by taking the information from the routing table and the ants which are successful in reaching the destination will update the pheromone deposited at the edges visited by them. Ant colony optimization increases the scalability and sensor working period [25]. ACO utilizes the dynamic adaptability and optimization capability of the ant colony to get the optimum route between the sensor nodes [26].

III.PROPOSED APPROACH

In this subsection we introduce the proposed scheme which employs enhanced Ant Colony Optimization, Clustering and Compression based GSTEB protocol to minimize data transfer time thereby enhancing the network lifetime. The proposed technique functions in following stages i.e. Cluster formation (Selection of cluster head), data compression at the cluster heads, applying Ant colony optimization base routing tree construction on cluster-heads to find optimal path to send data to the base station.

A. Steps of the Proposed Methodology are.

Step 1: Initialize the wireless sensor network.

Deploy sensor nodes randomly. Each node will be placed randomly in predefined sensor field with its initial energy.

Step 2: Apply the level wise clustering.

Sensor nodes in the network will form the clusters to balance load in the network. The cluster formation is in the same way as in leach. O.1% of the nodes are randomly selected as the cluster-heads. For this, each node decides whether to become the cluster head or not. The node chooses any random number between 0 and 1, if this selected number is less than the present threshold; the node becomes a cluster-head (CH). The threshold of the node is set as follows:

$$\mathrm{T(n)} = \begin{cases} \dfrac{P}{1 - P * \left(c \bmod \dfrac{1}{P}\right)} & if\ n \in G \\ 0 & otherwise \end{cases} \qquad [1]$$

Where P is the desired percentage of the cluster- heads, c represents the current round and G is representing the set of sensor nodes that have not been the cluster-head in the last 1/P round[17]. After the selection of the CHs, the elected CHs will broadcast an advertisement message to the other nodes in the network. Each non-cluster-head node will decide which CH it wants to join. The nodes will join the nearest CH so that there is minimum energy consumption for transferring the data. Cluster based data aggregation distributes the energy load evenly among all the sensor nodes in the network thereby reducing the energy consumption to enhance the network lifetime.

Step 3: Associated member nodes will send data to their cluster head's.

After the formation of clusters, the elected cluster heads will allocate TDMA schedule to the Cluster members and member nodes will send data to their cluster heads as per TDMA scheduling to avoid collisions.

Step 4: Apply LZW Compression on the Cluster heads.

After the clusters are formed it is not apposite to transmit the data directly to the base station due to nodes limited battery as it will lead to decrease in the network lifetime. Therefore, compressing data before transmitting is an efficient way to make good use of nodes' limited battery power. So to enhance network lifetime lossless Compression will be applied on the CHs to reduce the amount of data to be transmitted to the base station. According to the necessitate for completely recovering the compressed data LZW (Lempel-Ziv-Welch) algorithm will be used by using the formula:

$$CPS = APS \times CR \qquad [2]$$

Where CPS is compressed packets size, APS is actual packet size and CR is the Compression ratio.

Step 5: Apply Ant Colony Optimization based GSTEB tree construction on cluster heads to send data to base station.

To send data from the CHs to the base station Ant Colony Optimization based Routing Tree Construction will be applied on CHs to send data to the base station as simple tree based routing in GSTEB is NP-Hard in nature. Therefore appropriate routing is mandatory for extending the lifespan of the sensor nodes. So artificial intelligence will be applied on the cluster-heads for dynamic routing via Ant Colony Optimization based tree construction for better scalability and longer lifetime. Each CH will act as an artificial ant and dynamic routing as ant foraging. The pheromone of the ant is released after an energy efficient channel from the CH to base station will be secured. When Route will be discovered there will be pheromone diffusion, data aggregation will lead to accumulation and when there will be information loss it will lead to evaporation of the pheromone. The first step in ACO is the selection of the trail between neighboring clusters. The probability that the ant will move to cluster head j from cluster head i is given by the following formula:

$$P_{i,j} = \frac{(\tau_{i,j})^{\alpha}(\eta_{i,j})^{\beta}}{\Sigma\left((\tau_{i,j})^{\alpha}(\eta_{i,j})^{\beta}\right)} \qquad [3]$$

Where $\tau_{i,j}$ represents the amount of pheromone deposit from CHi to CHj, $\eta_{i,j}$ is the pheromone on each edge which joins the CH i and j and $\eta_{i,j} = 1/E_{DIST(i,j)}$, where $E_{DIS(i,j)}$ is the distance between the CH i and j, α and β are two parameters that determines the relative influence of the pheromone and heuristic information.

The main characteristic of the ACO is that the pheromone value is updated by all the ants that have reached the base station successfully. However, before the pheromone value is updated evaporation also occurs. Pheromone evaporation (ρ) on the edge between CH i and CH j is given by the formula:

$$\tau_{ij} \leftarrow (1-\rho)\tau_{ij} \qquad [4]$$

So, every moment of time, t={1,2,3,4,5...n} represent one iteration in which all the ants will perform one move towards the selected cluster head and deposit the pheromone calculated by the following formula

$$\tau_{ij}(t+n) = \rho.\tau_{ij}(t) + \Delta\tau_{ij} \qquad [5]$$

Where $\Delta\tau_{ij}$is the amount of pheromone being deposited. The amount of pheromone deposited by ant k is 0, if it has not passed some edge. Otherwise, if the ant k has passed all the way through some edge between the cluster heads, it will deposit the amount of pheromone that is inversely proportional to the total cost or of all the edges ant k has passed on its path from the starting cluster head to the base station. The following formula presents this procedure:

$$\tau_{ij} \leftarrow \tau_{ij} + \sum_{K=1}^{m} \Delta\tau_{ij}^{K}, \ \forall (i,j) \in L \qquad [6]$$

$\Delta\tau ij^k$ is the amount of pheromone deposited by ant K on the edges visited. It is calculated by the following formula

$$\Delta\tau_{ij}^{K} = \begin{cases} 1/C^K \\ 0 \end{cases} \qquad [7]$$

Where C^k is the total length of all the edges that ant k has passed from the starting cluster head to the base station. GSTEB routing tree will be constructed on the cluster heads by using the shortest path found by ACO. One advantage of using ACO in network routing is that when the there is increase in the number of cluster heads, it can be applied for controlling congestion in the network. One more advantage of using ACO is that if there is link failure and disconnection between two cluster heads on the route of the shortest path, the ACO will rapidly follow some other path and congregate with it.

Step 6: Evaluate and update energy consumption.

Energy of the sensor nodes will be evaluated and updated by using the following formulas

i. $W(i).E = W(i).E - \left(\left(Tx_{energy} + EDA\right) * (K) + efs * K * (d^2)\right) : if d < d_o$ [8]

ii. $W(i).E = W(i).E\left(\left(Tx_{energy} + EDA\right) * (K) + amp * K * (d^4)\right) : if\ d > d_0$ [9]

Where W(i).E is the energy of i^{th} node, EDA is effective data aggregation, Tx_{energy} is the Transmitter energy, K is the packet size, efs is the free space, amp is the multipath and $d_o$is the minimum allowed distance.

Step 7: Check whether the nodes are dead or not.

The nodes which are not dead will start sending the data again by forming the clusters again**.**

Step 8: Count the dead nodes.

If the nodes are dead, count them. If all the nodes are dead then the network lifetime is end and if some nodes are alive they will again start sending their data again.

B. Comparison Methodology of the Existing GSTEB Protocol and the Proposed Approach.

Fig. 1 shows the comparison methodology of the existing work (GSTEB) protocol and the proposed approach (GSTEB with clustering, compression and ACO based routing).

IV. COMPARATIVE ANALYSIS AND SIMULATION RESULTS

A MATLAB simulation of the proposed scheme (GSTEB with clustering and compression and ACO) is done to evaluate the performance. In this section we have evaluated the performance of the proposed scheme and compared it with the GSTEB on the basis of stability period, network lifetime, residual energy (average remaining energy), throughput at different energy levels from 0.05J to 0.5 J by taking 100 sensor nodes and on the basis of scalability by taking 100 to 550 nodes in the network. The sensor nodes are distributed randomly in a 100×100 region with base station at (175m, 175m). Table I shows the parameters used in the simulation.

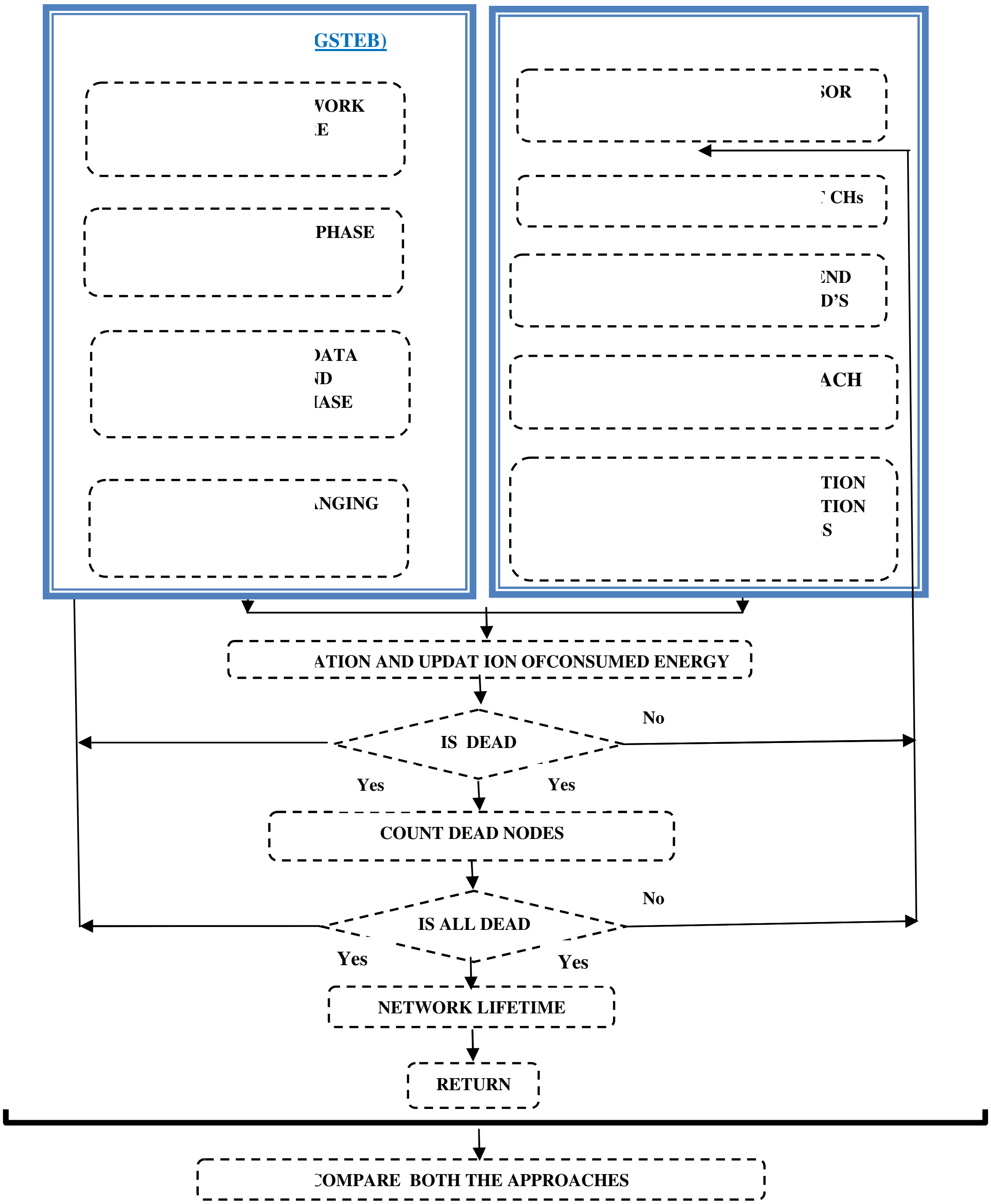

Fig .1 Comparison between the existing GSTEB and proposed methodology

TABLE I
PARAMETERS USED IN THE SIMULATION

Parameter	Value
Size of target area	100 × 100
Location of BS	(175, 175)
Number of nodes	100 to 550
Initial energy	0.05 J to 0.5 J
Probability(p) of the CHs	0.1
Transmitter Energy	$50 * 10^{-9}$J/bit
Receiver Energy	$50 * 10^{-9}$J/bit
Free space(amplifier)	$10 * 10^{-13}$J/bit/m^2
Multipath(amplifier)	$0.0013 * 10^{-13}$ J/bit/m^2
Effective Data aggregation	$5 * 10^{-9}$J/bit/signal
Maximum lifetime	3000 rounds
Data packet Size	2200 KB
LZW compression	0.75

A. Working of the GSTEB and the Proposed Scheme

Fig. 2 shows the working of GSTEB protocol. Green circled nodes are representing the sensor nodes. Base is located at (175 m, 175m) along x-axis and along y-axis. Black lines between the sensor nodes and base station are representing communication of the sensor nodes with the base station and the lines between the sensor nodes are representing the communication between the leaf nodes and the parent nodes.

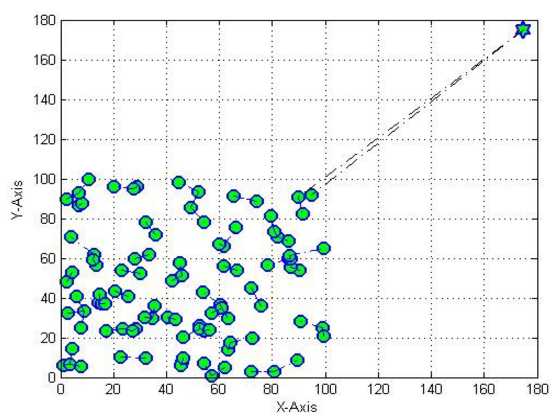

Fig 2: Working of the GSSTEB Protocol

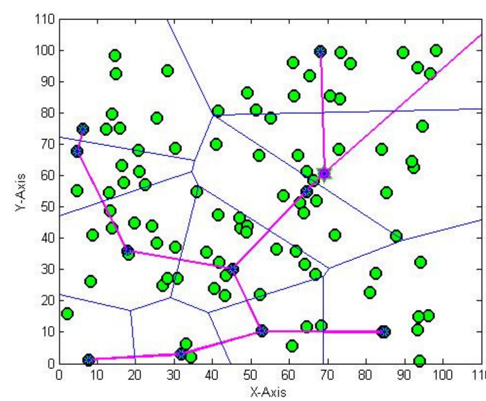

Fig 3: Working of the Proposed Scheme

Fig.3 shows the working of the proposed scheme when all the nodes are alive. Green circled nodes represent the normal sensor nodes means the non-cluster head nodes whereas nodes with blue color are representing cluster heads. Magenta star represents the cluster head means the root node that will directly communicate with the base station; all other cluster heads will transmit their data to this cluster head through ACO based tree construction routing. The blue lines, forming hexagonal shape is cluster head area also called cluster field. Each cluster field has a single cluster head. Magenta lines are representing communication among the cluster heads and communication of the root cluster head with base station by forming the ACO based tree construction. The base station is residing outside the sensor field.

B . Comparison of the Existing GSTEB Protocol with the Proposed Scheme on the basis of Initial Energy

1) Comparison on the basis of Network Stability: Stability period of a network is the time when first node dies in the network. Table II shows the comparison between GSTEB and proposed scheme when the first node dies at different energy levels from 0.05J to 0.5J.

TABLE II
COMPARISON TABLE OF THE NETWORK STABILITY

Initial Energy	Network stability of GSTEB	Network stability of the proposed scheme
0.05	71	147
0.1	136	303
0.15	208	430
0.2	253	610
0.25	343	687
0.3	379	701
0.35	438	961
0.4	560	1086
0.45	654	1171
0.5	644	1255

TABLE III
COMPARISON TABLE OF THE NETWORK LIFETIME

Initial Energy	Network lifetime of GSTEB	Network lifetime of the proposed scheme
0.05	157	189
0.1	303	355
0.15	469	529
0.2	584	690
0.25	755	866
0.3	904	1064
0.35	1084	1207
0.4	1186	1419
0.45	1374	1550
0.5	1477	1729

Fig. 4 shows the comparison graph where x-axis is representing the initial energy and y-axis is representing the number of rounds. Blue bar in the graph represents stability achieved by the GSTEB and magenta bar is representing the proposed scheme. From the results we can see that in the proposed scheme first node dies much latter than the first node death in GSTEB. So we can find that by using clustering, compression and ACO with GSTEB load is balanced more efficiently.

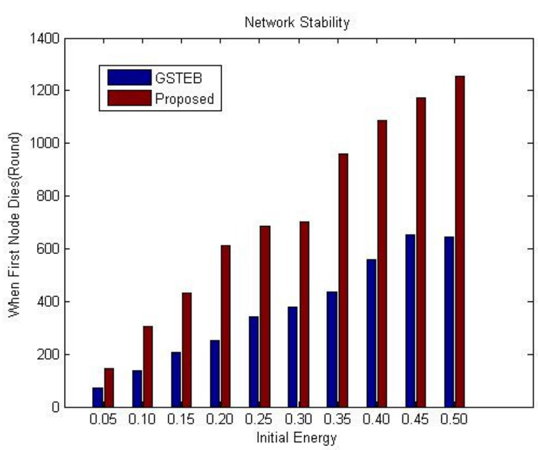

Fig. 4: Comparison graph of the Network Stability of the existing GSTEB and the proposed scheme

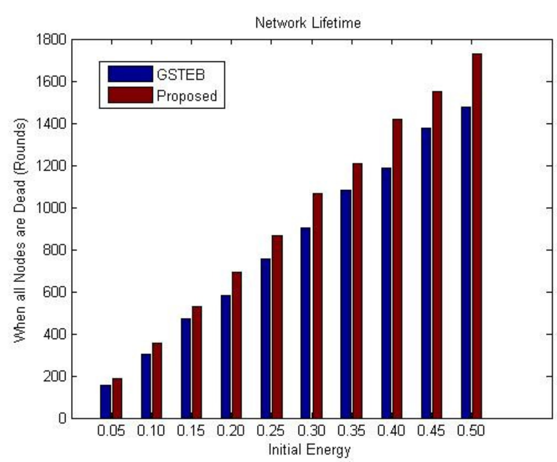

Fig. 5: Comparison graph of the Network Lifetime of the existing GSTEB and the proposed scheme

2) Comparison on the basis of Network Lifetime: Network lifetime of a network is the time when all the nodes are dead in the network. Table III show the comparison between GSTEB and proposed scheme when all the sensor nodes are dead in the network at different energy levels from 0.05 J to 0.5 J.

Fig. 5 shows the comparison graph. In the graph x-axis represents the initial energy and y-axis represents the number of rounds. Blue color in the graph is representing the GSTEB and magenta color in the graph represents the network lifetime of the proposed scheme. The network lifetime of the proposed scheme is more than the existing GSTEB protocol.

From the results we can see that in the proposed scheme network lifetime is increased as in the proposed scheme all the nodes in the network die much later than in GSTEB. So the performance of GSTEB has improves after using clustering, compression and ACO based routing.

3) Comparison on the basis of Throughput: Throughput is the number of packets transferred to the base station. Table IV shows the comparison between GSTEB and proposed scheme on the basis of the throughput at different energy levels from 0.05J to 0.5J.

TABLE IV
COMPARISON TABLE OF THROUGHPUT

Initial Energy	Throughput of existing GSTEB	Throughput of the proposed scheme
0.05	474	593
0.1	1555	2102
0.15	3752	4661
0.2	5544	7942
0.25	9060	12496
0.3	12656	18840
0.35	18428	24282
0.4	21780	33518
0.45	28854	40032
0.5	33971	49825

TABLE V
COMPARISON TABLE OF THE RESIDUAL ENERGY

Initial Energy	Residual energy of existing GSTEB	Residual energy of the proposed scheme
0.05	0.0015	0.0225
0.1	0.0061	0.0479
0.15	0.0141	0.0721
0.2	0.0237	0.0976
0.25	0.0391	0.1216
0.3	0.0536	0.1456
0.35	0.0749	0.1718
0.4	0.0969	0.1952
0.45	0.1244	0.2206
0.5	0.1502	0.2469

From the results we can find that that the throughput obtained by the proposed scheme (modified GSTEB) is more than the existing GSTEB protocol. Fig. 6 shows the comparison graph of the throughput obtained by the GSTEB and the proposed scheme. X-axis is representing initial energy given and y-axis is representing the number of packets transmitted to the base station. Blue color bar in the graph represents the throughput obtained from GSTEB and magenta color bar represents the throughput obtained from proposed scheme.

4) Comparison on the basis of Residual Energy: Residual energy is the average remaining energy of the nodes. Table V shows the comparison table between GSTEB and the proposed scheme on the basis of residual energy obtained at different energy levels from 0.05J to 0.5J. We can see that residual energy obtained in the proposed scheme by using clustering, compression and ACO with GSTEB is more than the residual energy obtained in existing GSTEB and Fig. 7 shows the comparison graph of the residual energy obtained by the GSTEB and the proposed scheme. X-axis is representing initial energy given to the sensor nodes and y-axis represents the average remaining energy of the node after sending data to the base station. Blue color bar in the graph represents the

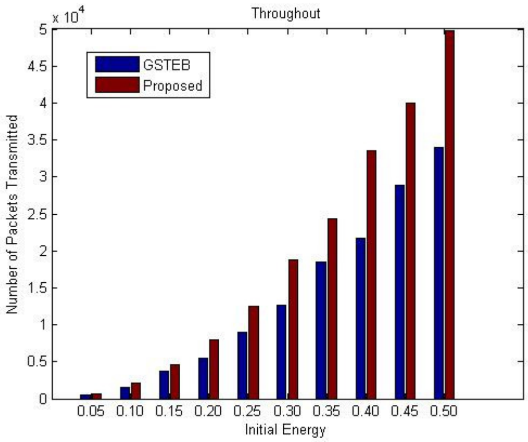

Fig. 6 Comparison graph of the throughput of the existing GSTEB and the proposed scheme

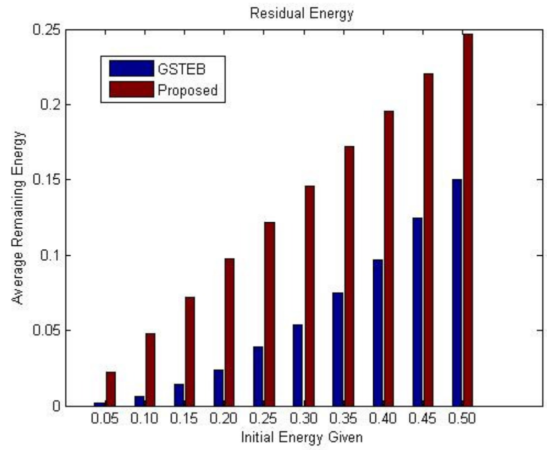

Fig. 7 Comparison graph of the residual energy of the existing GSTEB and the proposed scheme

residual energy obtained from GSTEB and magenta color bar represents the residual energy obtained from proposed scheme.

C. Comparison on the basis of Scalability between existing GSTEB and the Proposed Scheme

We have checked the scalability of the GSTEB and the proposed scheme (GSTEB with clustering, compression and ACO) by taking the different number of nodes from 100 to 550 at energy level 0.1J and checked the stability period, network lifetime, throughput and residual energy obtained.

TABLE VI
COMPARISON TABLE OF THE SCALABILTY ACHIEVED ON THE BASIS OF NETWORK STABILITY

No of Nodes	Network Stability of existing GSTEB	Network Stability of the proposed scheme
100	136	303
150	131	333
200	115	373
250	105	426
300	99	441
350	98	450
400	77	466
450	61	470
500	48	478
550	39	481

TABLE VII
COMPARISON TABLE OF THE SCALABILTY ON THE BASIS OF NETWORK LIFETIME

No of Nodes	Network Lifetime of existing GSTEB	Network Lifetime of the proposed scheme
100	303	355
150	272	420
200	269	440
250	260	462
300	256	492
350	225	504
400	212	519
450	211	521
500	190	527
550	181	543

1) On the basis of Network Stability: Table VI shows the results obtained by checking the scalability on the basis of network lifetime. The stability period achieved by the GSTEB decreases with the increase with the number of nodes, so we can say that GSTEB is not scalable. On the other hand the stability period of the proposed scheme increases with the increase in the number of nodes.

Fig. 8 shows the comparison graph of the scalability on the basis of network stability between the existing GSTEB and the proposed scheme when initial energy 0.1J is given. Green line in the graph is representing the proposed scheme and blue line in the graph is representing the existing GSTEB. In the graph the stability period of the proposed scheme increases with the increase in the number of nodes and the graph of the existing GSTEB stability period decreases with the increase in the number of nodes.

2) On the basis of Network Lifetime: Table VII shows the results obtained by checking the scalability on the basis of network lifetime.

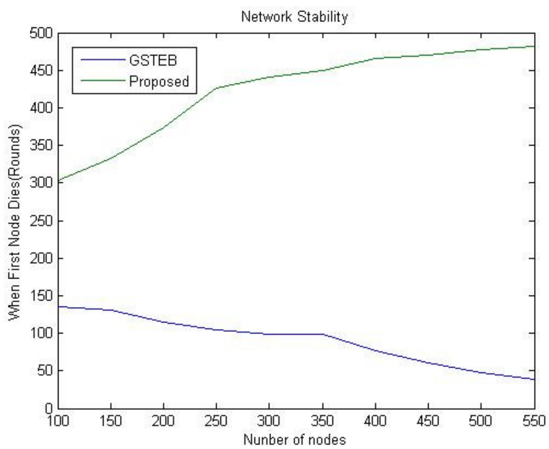

Fig. 8 Comparison graph of the Network Stability

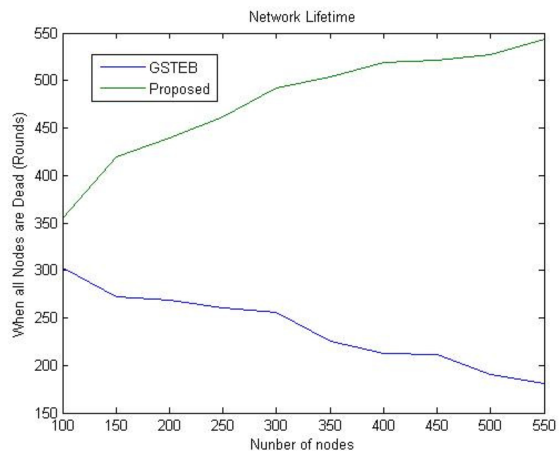

Fig. 9 Comparison graph of the Network Lifetime

Fig. 9 shows the comparison graph of the scalability on the basis of network lifetime between the existing GSTEB and the proposed scheme when initial energy 0.1J is given. Green line in the graph is representing the proposed scheme and blue line in the graph is representing the GSTEB. The network lifetime of the existing GSTEB decreases with the increase in the number of nodes but on the other hand the network lifetime of the proposed scheme increases continuously with the increase in the number of nodes so proposed scheme is scalable.

3) On the basis of Throughput: Table VIII shows the results obtained by checking the scalability on the basis of throughput. The throughput of the existing GSTEB does not increase with the increase in the number of nodes but the throughput of the proposed scheme increases continuously with the increase in the number of nodes so proposed scheme is scalable than the GSTEB.

Fig. 10 shows the comparison graph of the scalability on the basis of throughput between the existing GSTEB and proposed scheme when initial energy 0.1J is given. Green line in the graph is representing the proposed scheme and blue line in the graph is representing the GSTEB. So we can say that by using clustering, compression and ACO based routing the proposed scheme has become scalable.

TABLE VIII
COMPARISON TABLE OF THE SCLABILTY ACHIEVED ON THE BASIS OF THROUGHPUT

No of Nodes	Throughput of existing GSTEB	Throughput of the proposed scheme
100	1555	2102
150	2992	4408
200	2930	6460
250	2800	10340
300	2816	12110
350	2760	14992
400	2756	17954
450	2743	20371
500	2470	23158
550	2353	26994

TABLE IX
COMPARISON TABLE OF THE SCLABILTY ACHIEVED ON THE BASIS OF RESIDUAL ENERGY

No of Nodes	Residual Energy of existing GSTEB	Residual Energy of the proposed scheme
100	0.0061	0.0479
150	0.0056	0.0480
200	0.0051	0.0480
250	0.0049	0.0481
300	0.0046	0.0482
350	0.0045	0.0483
400	0.0043	0.0484
450	0.0041	0.0485
500	0.0036	0.0486
550	0.0032	0.0487

4) On the basis of Residual Energy: Table IX shows the results obtained by checking the scalability on the basis of residual energy. The residual energy of the GSTEB decreases with the increase in the number of nodes but the residual energy of the proposed scheme increases continuously with the increase in the number of nodes so proposed scheme is scalable than the GSTEB. So by using clustering for data aggregation, compression for reducing the data to be transmitted to the base station and ACO based routing tree construction for finding the shortest and optimal path to send data to the base station, the proposed scheme has become scalable.

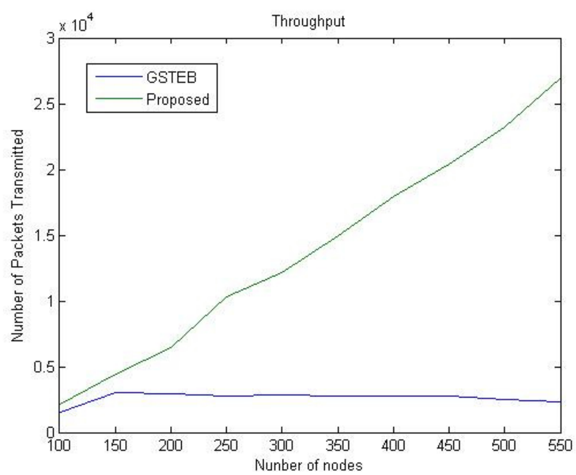

Fig. 10 Comparison graph of the Throughput

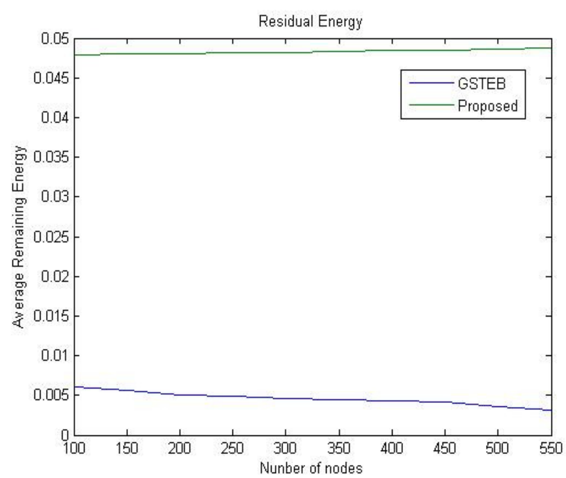

Fig.11 Comparison graph of the Residual Energy

Fig. 11 shows the comparison graph of the scalability on the basis of residual energy between the existing GSTEB and the proposed scheme when initial energy 0.1J is given. Green line in the graph is representing the proposed scheme and blue line in the graph is representing the existing GSTEB protocol. The graph of the residual energy of the existing GSTEB decreases with the increase in the number of nodes and graph of the residual energy of the proposed scheme increases with the increase in the number of nodes.

So by using clustering for data aggregation, compression to reduce the amount of data to be transferred and ACO to find the shortest path to send data to the base station with GSTEB, the performance is increased significantly as there is increase in the stability period and network lifetime, residual energy, and throughput of the proposed scheme. The previous GSTEB approach was not scalable as the stability period, network lifetime, throughput and residual energy of GSTEB decreases by increasing the number of nodes but by using clustering, compression and ACO based tree construction routing with GSTEB, it has become scalable.

D. Comparison of the Proposed Scheme with other Existing Protocols

Table X shows the comparison of the proposed scheme with the other existing protocols in wireless sensor network on the basis of first node dead time and last node dead time in the network. In this Table, the simulation results are taken from [12] except the proposed results. We can find that there is improvement offered by the proposed scheme over the existing LEACH, PEGASIS, TREEPSI, TBC and GSTEB protocols when initial energy 0.25 Joule and 5 Joule is given to the nodes. In the proposed scheme the there is improvement in the first node dead time and the last node dead time as compared to the other existing protocols. So we can say that in the proposed approach the network stability period and network lifetime is more than all the other existing protocols in the wireless sensor network.

TABLE IX
NETWORK LIFETIMES OF DIFFERENT SCHEMES

Initial Energy	Protocol	The round a node begins to die	The round all the nodes are dead
0.25	LEACH	118	243
	PEGASIS	246	568
	TREEPSI	267	611
	TBC	328	629
	GSTEB	389	677
	PROPOSED	687	866
0.5	LEACH	209	435
	PEGASIS	485	1067
	TREEPSI	532	1123
	TBC	589	1165
	GSTEB	730	1330
	PROPOSED	1255	1729

V. CONCLUSION AND FUTURE WORK

This paper has proposed, a new ACO, clustering, compressive sensing and tree based routing protocol for wireless sensor networks. The overall objective of the proposed work is to improve the GSTEB protocol further by using the compression based inter cluster data aggregation for transmitting data to the base station. By using clustering there will be reduction in the energy consumption of each node which becomes member node (non CHs), also adaptive clustering will balance the load of sensor nodes in the network there will be no transmission delay and data loss in the network due to the nodes failure in the root to sink.. The LZW compression has been used due to its lossless compression to reduce the size of the aggregated packets to be transmitted to the base station so as to reduce the energy consumption further and ACO will reduce the energy consumption of the cluster heads by finding the shortest and best path that is not NP hard to send data to the base station. This proposed technique is designed and implemented in MATLAB tool. The comparisons are also drawn among the proposed and existing techniques on the basis of stability, lifetime, throughput, residual energy and scalability of the network. The comparison results have clearly shown that the proposed technique outperforms over the available techniques.

This work has not considered the use of the node deployment techniques, so in near future to enhance the results further efficient multi-objective optimization based node deployment can be used. Also this work has not used the effect of the mobility of the sink and also of nodes. Therefore in near future the mobile sink and nodes based WSNs can also be considered to evaluate the efficiency of the proposed technique.

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