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Hybrid Routing using Swarm Intelligence in Wireless Sensor Networks

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ABSTRACT

Hybridrouting is done by usingan energy efficient routing protocol is the majorconcern in the field of wireless sensor networks. In this paper we present hybrid energy efficient hierarchial routing protocol which is developed from previous energy balanced routing protocols. Futuristic advancement in this paper also enlightens some of the issues faced by General Self-Organised Tree-Based Energy-Balanced(GSTEB) protocol.It also explains how these issues are overcomed by extended versions of Hybrid GSTEB. We compare the features and performance issues of energy efficiency through calculating energy consumption, packet delay, network throughput and control overheads.

Keywords: Swarm intelligence, stochastic diffusion, particle swarm, ant colony, hybrid

1. INTRODUCTION

Wireless Routing is the main challenge faced by wireless sensor network.Routing becomes easier when secured paths created for improving the network lifetime, extended battery life, more control overheads and more transmission range of sensor nodes [2], [3], and [4].When the battery life capacity is increased which inturn increases the network lifetime[1],[8].There is an improvement in the quality of service in energy efficient routing protocols when there is avoidance of compressed signals and sensor nodes in the network which transmits the data signals received by base station successfully[7]. Swarm intelligence in wireless routing protocols enables security and improves energy efficiency used in GSTEB is implemented as HGSTEB(Hybrid General Self-Organised Tree-Based Energy Balanced Routing Protocol).

2. SWARM INTELLIGENCE

Swarm Intelligence(SI) is the collective behaviour of decentralized, self-organised systems, natural or artificial. The SI concept work is based on Artificial Intelligence.This SIapproach is widely used in network routing protocols in wireless sensor networks to obtain efficient routing path in networking protocol.Swarm intelligence includes Ant Colony Optimization(ACO), Particle Swarm Optimization(PSO), and Genetic Algorithms(GA).SI consists of a population of simple agents that interacts locally with one another, follows simple rules and exhibits intelligent global behaviour.

2.1. Stochastic Diffusion Search

Stochastic Diffusion Search(SDS) is population-based, naturally inspired search, pattern matching algorithm. This SDSOptimization algorithm belongs to the family of swarmintelligence.SDS is based on modification of physical properties of a simulated environment. There is a direct(one-to-one) communication between the agents in SDS. Leptothoraxacervorum is one of the species of ants employs tandem mechanism which is similar to SDS concept. Agents perform cheap and partial evaluations of hypotheses in SDS. Diffusion

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of information takes place through direct one to one communication process.To provide high-quality solutions, agents make cluster formation to share information with each other.

2.2. PARTICLE SWARM OPTIMIZATION

Particle swarm optimization is a global optimizational method used to improve candidate solution and the movement of the particle is measured bytheir position and velocity in the search-space.

2.3. ANT COLONY OPTIMIZATION

Ant colony optimization is an optimization algorithm and a probabilistic technique used for problems associated with finding the nodes and their routing paths used for sharing the information through graphs.

The optimisation algorithm can be reduced to the problem of finding the minimal length closed round that visits each node once[20]. Wedenote the Eucledian Distance between two nodes i, jis given by the equation

$$d_{ij} = \left[\left(x_i - x_j \right)^2 + \left(y_i - y_j \right)^2 \right]^{1/2} \tag{1}$$

For a selected total number of ants

$$N_{ants} = \sum_{i=1}^{n} A_i(t) \tag{2}$$

where $A_i(t)$ is the total number of ants at node i at any given time t. The various characteristics of ants behaviour is examined since it acts as an agent are,

1. The probability of an ant visiting anode is expressed as

$$v_{ij} = 1/d_{ij} \tag{3}$$

   where v_{ij} is the visiting nodes and dij is the distance between two nodes i, j present on the connecting edge.

2. Migration to already visited nodes isnot allowed until all nodes are visited through association withinone complete round bytime t.

3. Ants deposit pheromone trails of concentration τ_{ij} on each of the visited nodeedges E(i, j). After the completion of one round,

$$\tau_{ij}(t+n) = \sigma.\tau_{ij}(t) + \Delta\tau_{ij} \tag{4}$$

where σ represents the coefficient ofpheromone evaporation between time t and t + n at each edge(i, j)and $\Delta\ \tau_{ij}$ is the accumulated pheromoneconcentration at the node edges and is given by

$$\Delta\tau_{ij} = \sum_{k=1}^{N_{ants}} \Delta\tau_{ij}^{k} \tag{5}$$

where $\Delta\tau_{ij}^{k}$ is the amount of pheromone perunit length left by the k^{th} ant.

$$\Delta\tau_{ij}^{k} = \begin{cases} \dfrac{P}{L_k} & \text{if the } k^{th} \text{ ant at each edge E(i, j)} \\ 0 & \end{cases} \tag{6}$$

between time t and t + n

Otherwise

where P is a constant representing the totalpheromone level possible and L_k is the tourlength covered by the k^{th} ant. The transitionprobability of an agent from one node to anotheris therefore defined in as

$$P_{ij}^{k} = \begin{cases} \dfrac{\left[\tau_{i,j}(t)\right]^{\alpha} . \left[v_{ij}\right]^{\beta}}{\sum k \in allowed\ nodes \left[\tau_{ij}\right](t)^{\alpha} . \left[v_{ij}\right] \beta if j \in allowed\ nodes} \\ 0 \qquad\qquad Otherwise \end{cases} \tag{7}$$

where α and β are constants representing the relative importance of trail concentration versusagent visibility such that if α = 0, the closestnodes are more likely to be selected. Sinceagents are initially randomly distributed overthe nodes, this corresponds to a classicalstochastic greedy algorithm with multiplestarting points. With β = 0, the pheromoneamplification process leads to rapidconvergence of route discovery. This situationis referred to as stagnation, and it is the eventduring which all agents follow the same route cluster-head. Nodes which werenot cluster-head in previous 1/p rounds generate a numberbetween 0 to 1 and if it is less then threshold T(n) the nodes become cluster-head. Threshold value is set through thisformula.

$$T(n) = \begin{cases} \dfrac{P}{1 - P * \left(r \bmod \dfrac{1}{p} \right)} & if\ n \in G \\ 0 & otherwise \end{cases} \tag{8}$$

Where G is set of nodes with no cluster-head in previous 1/p rounds, P is the percentage of cluster-head, r is the current round. The node becomes cluster-headin current round, and also after next 1/p rounds. Thus every node will serve as a cluster-head equally and energy dissipation will be uniform throughout the network. Elected cluster-head broadcasts its status using CSMA MAC protocol. Non-clusterhead node will select its own cluster-head inturn creates TDMA schedule for its associated members in the cluster.In Steady state phase starts when clusters have been created.Probability of solar-driven nodes is higher than battery-driven nodes. Equation 8 is needed to be change to increase the probability of nodes. This is achieved by multiplying a factor s.f (n) to right side of the equation 8.

$$T(n) = s.f(n) \times \frac{p}{1 - \left(\dfrac{cluster\ Heads}{num\ Nodes} \right)} \tag{9}$$

Where s.f (n) is equal to 4 for solar-driven nodes, s.f (n) is equal to 7 for battery driven nodes. P is the percentage of optimal cluster-heads. The clusterHeads is number of cluster-heads since the start of last meta round. The numNodes is total number of nodes.

2. THE PROPOSED TECHNIQUE

2.1. HGSTEB Implementation

The Proposed system is the combination of Stochastic Diffusion Search(SDS), Particle Swarm Optimization (PSO), and Ant Colony Optimization (ACO) for Hybrid General Self-Organized Tree-Based Energy-Balance routing protocol. This combinationexplains how Swarm Intelligence is implemented in GSTEB which makes Hybrid GSTEB.The main key aim of Hybrid GSTEB routing protocol is to reach an extended network lifetime for different applications. The BS allocates a root node and broadcasts its ID and coordinates to all or any sensor nodes in each round [27]. Then network computes the route either by transmitting the routeinformation from BS to sensor nodes is built by each node dynamically and individually[28]. In both cases, HGSTEB may change the basis and reconstructs the routing tree with a short delay and low energy consumption. The architecture of HGSTEB is shown in figure 1.

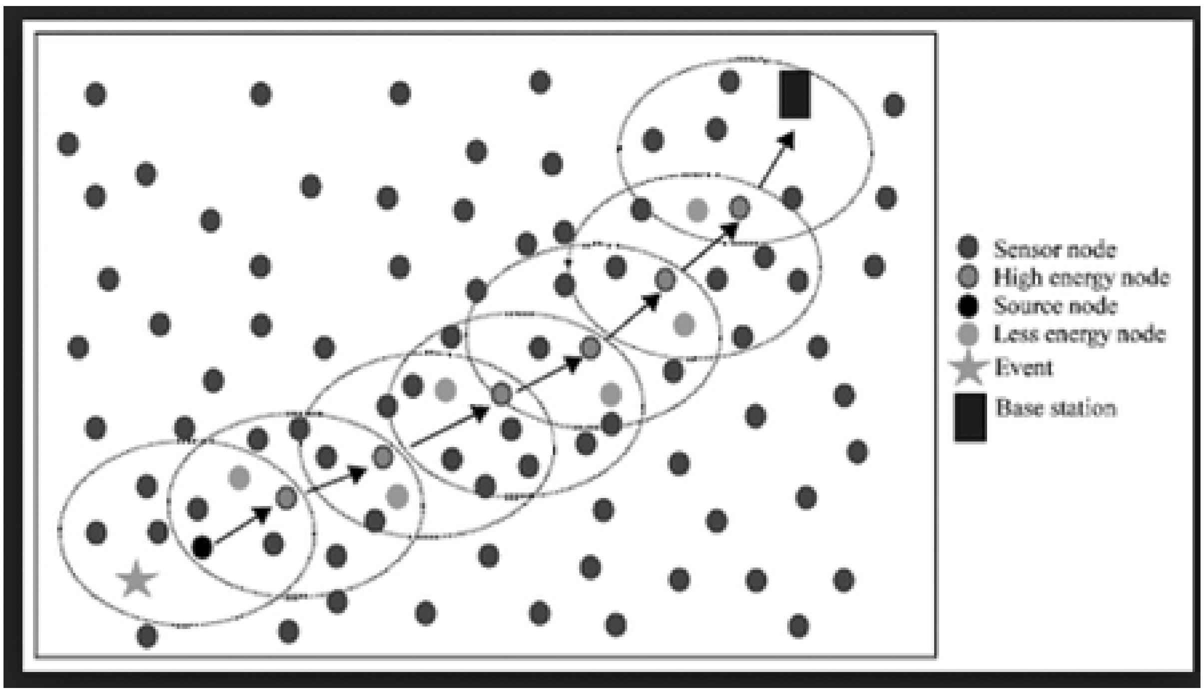

Figure 1: Architecture of HGSTEB

The operation of HGSTEB is divided as Initialisation, Tree Construction, Data Collection and Transmission, and Exchange of Information.

2.1.1. Initialisation

When Initial Phase begins, base station broadcasts a packet to all or some of the nodes to share with them of creation time. Each node sends its packet in a group with a particular radius during a unique time slot. Each node sends a packet which contains all its neighbours information during a unique time slot. Then its neighbours can receive this packet and record the info in memory. Initial Phase has been just a significant preparation for other phases. After Initialisation, HGSTEB operates in rounds where the routing tree is rebuilt.Each sensor node generates data packet which is provided to base station. The complete round takes place when all the information is received from the sensor nodes to the base station.

2.1.2. Tree Construction

The root and broadcast rootID is assigned to a node with high residual energy by the base station. Each node is allowed to choose a parent in its neighbours using vitality. The energy level is calculated by the nodes using,

$$EL = \frac{\text{Re}\,sidual\ Energy(i)}{\alpha} \tag{10}$$

In the equation 10, where ‘i’ may be the ID of every node, and á is a constant which reflects the minimum energy unit and may be changed predicated on our demands. The length between a parent node and the primary root needs to be shorter because every node selects the parent from its neighbours and their information in the table. Each node is fully aware of all its neighbours parent and child nodes.In case a node does not have any child node, it defines itself as a leaf node from that data transmission begins.

2.1.3. Data Collection and Transmission

Data packet is the collection of gathered information done by each sensor node which is transmitted in the base station. After having a node receivesevery piece of information from its child nodes, this nodeitself functions as a leaf node and tries to send the fuseddata in the next time slot. The initial segment is required toexamine if you have communication interference for aparent node. In this segment, at the same time each leaf node sends abeacon that contains its ID to its parent node.So considering the energy consumption, each node chooses its parent.

2.1.4. Exchange of Information

Each node must generate and transmit a data packet ineach round, before it drains its energy and dies. The dyingof any sensor node can persuade the topography. So thenodes that are likely to die need to share with other nodes.The process contains splittedtime slots and in eachtime slot, the energy dissipated makes random delayed nodes and helps to makeonly one node broadcast in a new slot. Once the delay isended, these nodes will make an effort to broadcast apackage to the complete network. While all the nodes aremonitoring the channel, they’ll receive this packet and perform an ID check. So, the cluster head is selected on the basis of the degree of energy in order that information may be transferred securely.

```
Stochastic Diffusion Search Algorithm in HGSTEB
Initialize agents and calculate their fitness
Repeat
/* Test-phase */
for each agent, x_i
randomly choose an agent, x_j,
from the population
if f(x_i) ≤ f(x_j) then
active_i = true
else
active_i = false
endif
endfor
/* Diffusion-phase */
for each agent, x_i
ifactive_i == false then
randomly choose an agent, x_j, from
the population
ifactive_j == true then
set x_i to a solution randomly chosen from the neighborhood of x_j
else
reinitialize x_i to a solution in an uncharted region
endif
endif
end for
Until a stopping criterion is met.
Let x_g be the agent with the best (i.e. minimum) fitness function
Improve x_g using a local search method
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Advantages of HGSTEB protocol:

1. HGSTEB is a balanced self organized energy consumption protocol.
2. It provides longer network lifetime for different applications.
3. In HGSTEB, transmission delay is short as all the leaf nodes transmit data in the same slot.
4. It reduces routing overhead as compared to anyother hierarchical routing protocols.
5. It provides improved and efficient packet delivery ratio.
6. It gives a secured routing path for connecting all the sensor nodes effectively.
7. It avoids compressed signals therefore providing a continuous transmission network.

3. SIMULATION RESULTS

The simulation is done using Network Simulator(NS-2) for load balancing the energy and also less energy consumption of power.

3.1. Packet Delivery Ratio

PDR can be derived from the ratio of the number of received packets by the number of transmitted packets to bereceived and sent from/to the server andthe PDR is calculated by:

$$PDR = \frac{N(rp)}{N(tp)} \qquad (11)$$

Where PDR is Packet Delivery Ratio, N(rp) is number of received packets and N(tp) is number of transmitted packets.

Fig 2 shows the graphical representation of Packet Delivery Ratio with respect to number of nodes. The Packet Delivery Ratio is high in the simulation result.

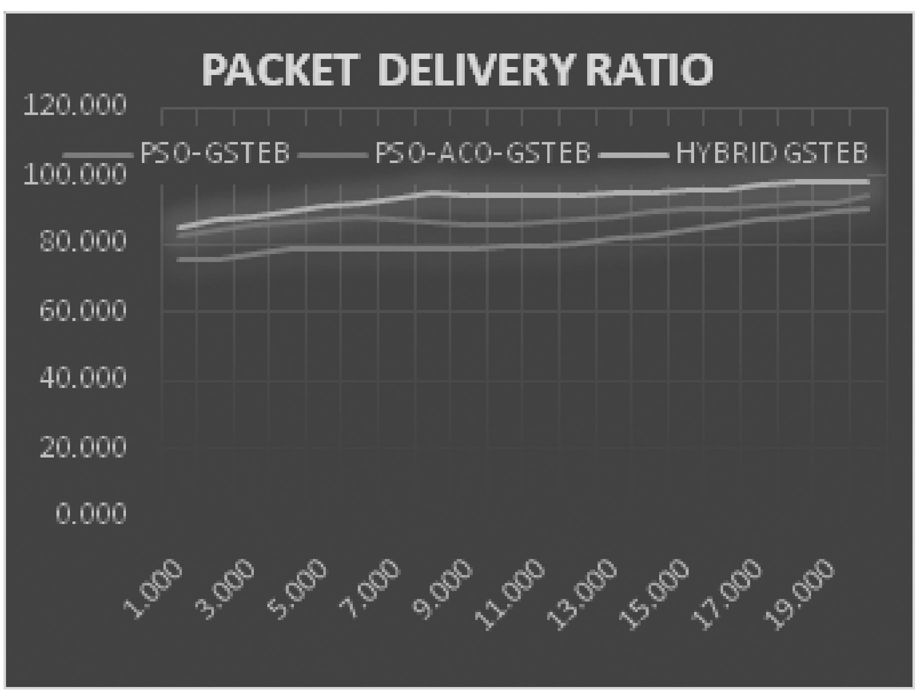

Figure 2: Packet Delivery Ratio

3.2. Energy used by the cluster heads

The metric is measured as the percent of energy consumed by a node with respect to its initial energy. The initial energy "ie" and the final energy "fe" left in the node, at the end of the simulation run are measured. The percent energy consumed by a node is calculated as the energy consumed to the initial energy. And finally the percent energy consumed by all the nodes in a scenario is calculated as the average of their individual energy consumption of the nodes.

Energy used by the nodes are calculated by

$$EC = \frac{ie - fe}{ie} \tag{12}$$

$$AEC = \sum_{i}^{k} EC / N_i \tag{13}$$

Where Ecis thepercentage of energy consumed, ie is the Initial energy, fe is the final energy, AEC is the Average energy consumed by the WSN's and N_i is the number of nodes.Energy consumed by the cluster heads decreases when the nodes increases.

Energy consumption of a node after time t is calculated using the following equation

$$E_{cons}(t) = N_t * C_1 + N_r * C_2 \tag{14}$$

WhereE_{cons}(t) is energy consumed by a node after time t.N_t is no. of packets transmitted by the node after time t.N_r is no. of packets received by the node after time t.

Fig 3 shows when number of nodes increases the energy consumption is lower in proposed system when comparedto the existing system.

3.3. Throughput

It is a measure of the amount of data transmitted from the source to the destination in second, a unit period of time and total number of bits received per second. It measures the totaldata throughput over the network

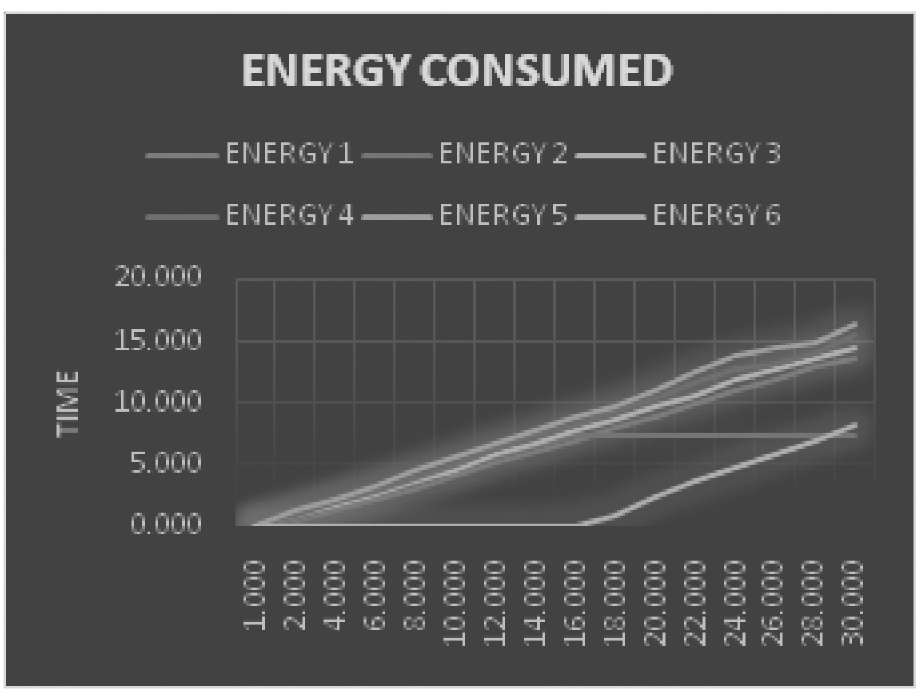

Figure 3: Energy Consumed

by not considering other overhead.[12] It is calculated bythe total number of data packets successfully received at the node, and the number of bits received, by the total simulation runtime. Hence the throughput of the network is defined as the average of thethroughput of all nodes involved in data transmission.

Throughput is calculated by

$$Through\ put = \sum \frac{t(nodes)}{N} \tag{14}$$

Where t (nodes) is throughput of nodes involved in data transmission and N is the number of nodes.

Fig 4 shows the graphical representation of Throughput withrespect to number of nodes. Throughput is increasing whenthe network size is increased.

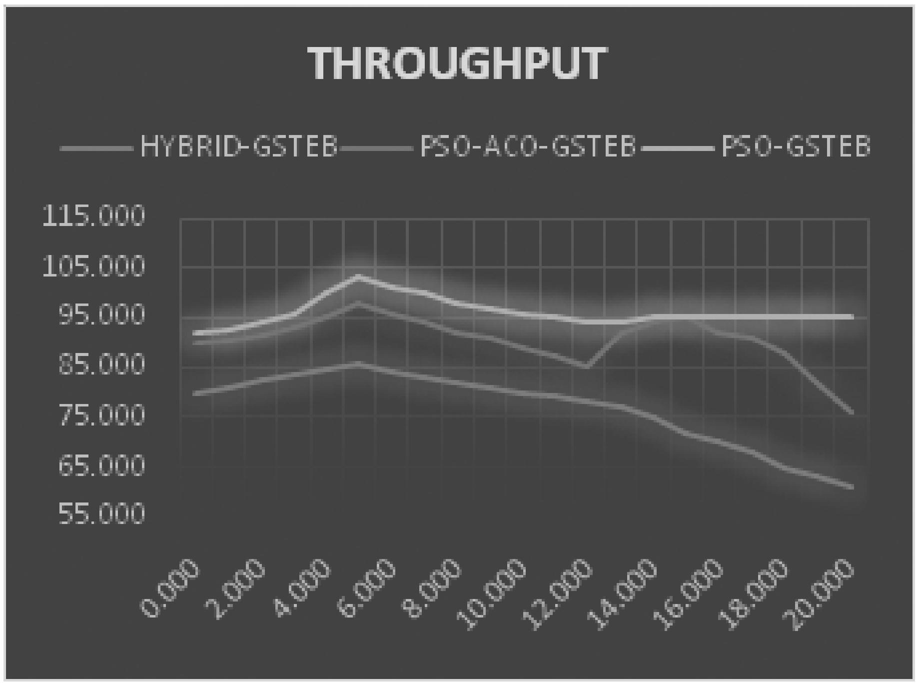

Figure 4: Throughput

3.4. Control Overhead

Control Overhead is the number/size of routing control packets sent by the protocol.It is calculated using counters while simulating with test flows[13]. Sometimes it is expressed as a ratio of control to data. High control overheads may adversely affect packet delivery ratio and latency under higher loads.

Fig 5 shows the graphical representation of Control Overhead withrespect to number of nodes.

3.5. End to End Delay

The end-to-end delay is the time taken for a data packet to reach the destination node [15]. The packet delay is the time taken for it to reach the destination. The average delay is calculated by taking the average of delays for everydata packet transmitted. The parameter acts when the data transmission is done successfully.

$$pd = rt(dest) - tt(source) \tag{15}$$

$$d = \sum \frac{pd}{n(rp)} \tag{16}$$

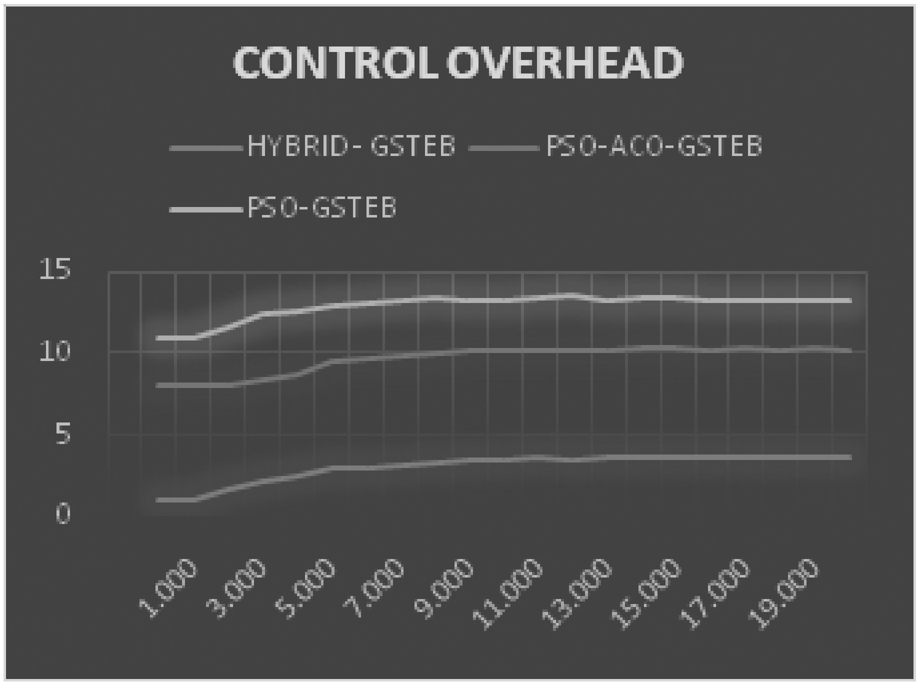

Figure 5: Control Overhead

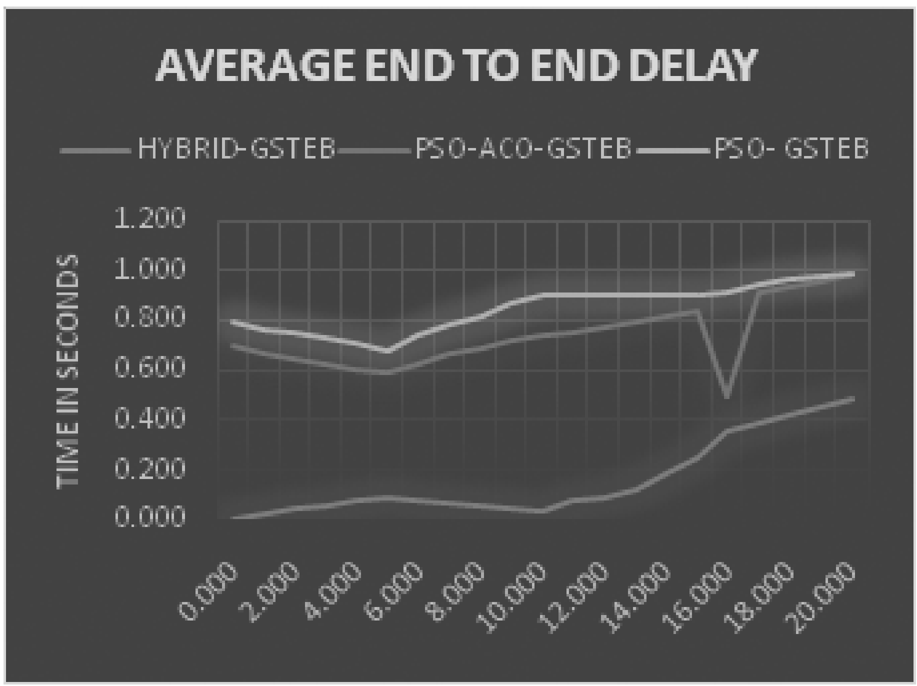

Figure 6: Average End to End Delay

Where pd is packet delay, rt(dest) is receive time at destination, tt(source) is transmit time at source, d is average delay and n(rp) is total number of received packets.

Fig 6 shows the graphical representation of AverageEnd to End Delay of nodes.

4. CONCLUSIONS

WSN is an emerging technology which helps and experiences revolutionary method in routing approach.In this paper we have done the research work for hybrid clustering and tree based routing protocol for wireless sensor networks.The proposed GSTEB uses hybrid secured clustering-based algorithms, swarm intelligence for better performance to consume energy less, secured routing path, avoidance of compressed signals and packet delivery loss.

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In thispaperwe proposed Hybrid GSTEB based on advanced swarm intelligence networks for providing security to the routing protocols with wireless sensor networks which has the remarkable future inwireless sensor networks.I solemnly thank and show gratitude tomy guide and our university for their beloved and esteemed support in bringing out this research paper.

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