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Distributed Energy Efficient Dynamic Securing Routing Protocol to Wireless Sensor Network

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Abstract

Wireless sensor network has been employed on variety of applications especially monitoring of environment and patient health has become vital task, hence wireless sensor network has been applied for patient health monitoring and tracking of its health status. Acquired sensed data on the sensing field will be transmitted to base station through mobile sink nodes which in turn increase the high energy consumption and data traffic on route discovery which result in the network degradation. Further to manage the energy , data transmission and security issue, the secure energy efficient routing protocol has been architected on the wireless sensor nodes. In this article, a novel energy secure energy efficient routing protocol to Wireless Sensor Network towards health monitoring and tracking has been proposed. However proposed secure data routing protocol incorporates the trace file for path selection for data transmission to base station using sink node. Trace file has been obtained on processing the cluster heads established in the network. Therefore clustering of node in the network has to be achieved using LEACH protocol which enhances the network scalability and network lifetime by clustering the nodes with Metaheuristics constraints like node energy density comparability. The objective of the proposed model is to enhance the network scalability, energy consumption and security by establishing the multiple node clusters with high density cluster head through Metaheuristics Node Clustering optimization techniques. Metaheuristics based node clustering is been obtained using Incremented Particle Swarm Optimization. Further it is employed to compute the optimal path for sensed data transmission to base station. Node clustering provides high energy consumption among the sensing nodes and to establish the high energy clusters towards sensed information dissemination to base station on dynamically reforming the nodes clusters with respect to Node density and node location against various attacks. Simulation analysis of the proposed energy efficient routing protocol provides high performance in energy utilization, packet delivery ratio, packet loss and Average delay compared against the conventional protocols on propagation of the data through sink nodeto base station.

Keywords: Wireless Sensor Network, Cluster based data Routing, Patient health monitoring, Particle Swarm optimization, Routing protocol

1. Introduction

Wireless Sensor Network is employed as monitoring infrastructure with network topology on fixed deployment and capable of dynamically reconfiguring on basis of the data acquiring and transmission for patient health monitoring. WSM can be projected to numerous applications for military purposes, natural disaster management, medical data acquiring and management etc. Implication of the WNSM is enhances exponentially towards supporting the animal habitat monitoring with nano sensor to avoid multiple

complication of the animals. Due to periodic transmission of sensed information utilizes the network resources such as node power, buffer space and network bandwidth [1].

The vital process for the WSN is to Cluster nodes which collect the sensor information from the node and transmit the sensed information to base station with sink node on ensuring the efficient energy consumption and high transmission rate within defined energy [2]. Data Routing plays another crucial role for resolving the data transmission delay. Key requirement of the incorporating the Met heuristics based clustering protocol is to increase the energy consumption on the heterogeneous sensor nodes towards data dissemination of sensed information of the base station. Especially sensed data routing technique will avoid the utilization of multiple mobile sink for data gathering as cluster head performs the specified operations for data transmission. Furthermore, path selection and coordination of the sensor nodes has been achieved on employing the clustering technique to cluster the nodes on specified strategies with respect to node location and node density [3].

Node clustering against attacks can be carried out using particle swarm optimization on various fitness constraints on the nodes to establish the effective data transmission in the network to base station. Traditionally, path based node clustering is employed to group the nodes on basis of the sink point location and sensor node location which establishes the data communication with reduced transmission delay. Henceforth, nodes will be dynamically updates the clusters and Cluster head according to the node energy and node location [4]. Correspondingly to produce the optimal performance against network degradation, sink trajectory has to be computed for sensed data routing of the wireless sensor network has been included in this article.

The proposed a new secure energy efficient routing technique addresses the sensor network towards patient health monitoring with on data collection by cluster head to disseminate the data to the base station through sink nodes. In addition, the node energy usage can be minimized on efficient sink node trajectory selection mechanism.

The sink trajectory point in the network has been computed on the sink trajectory will minimize the transmission delay on the sensor information. Data communication order is computed by the inter-distance between the nodes and node radius and finally data transmission constraints have been employed for patient monitoring.

The remaining article is segmented as follows, detailed review of conventional approaches on energy efficient cluster based routing protocols has been analysed in the section 2. In depth specification of proposed secure energy efficient routing protocol has been designed using Met heuristics improved particle swarm optimization technique has been represented in the Section 3. The simulation results of the approaches for data transmission to base station along its performance validation against various measures have been highlighted in Section 4. Finally article has been concluded with final summary and future research directions in section 5.

2. Related Work

There are conventional approaches to the address the issues of the energy consumption and location aware routing Wireless Sensor Network with respect to cluster based routing architectures. The architectures are as follows

2.1 Low Energy Adaptive Clustering Hierarchy for Wireless Sensor Network

In this model, the number of low power and low cost sensor has been deployment as self adaptive and traffic dependent network protocol on the traffic of the network. The node data transmissions of the sensed data are adaptively changes to the traffic pattern. Power changes occur based on traffic [4]. The node will be time-synchronized for path negotiation and data contention on basis of node density. Path Allocation model of the protocol enhances the transmission capabilities on the less utilized nodes to prevent network degradation. Further linear programming architecture has been employed to Dynamic node hopping sequence. The routing architecture provides optimal stability among the node transmission time with respect to node availability and energy consumed on the effective path within specified delay along throughput constraints to solve energy hole problem.

2.2 Metaheuristics model for Energy Optimized Clustering

In this architecture, the number of node is deployed in the environment to provide a scalable and adaptive data transmission path on specified time against sensed data of the network. It eliminates the energy hole problem in the network by eliminating the nodes with low node density for data transmission to base station. It is effectively used to maximize the lifetime of the network by employing the metaheuristics principles on the nodes in the specified cluster. The idea of clustering is based on energy density among neighbouring nodes for data transmission. Optimal path allocation is subject to deliver the sensed data on available node density probability and throughput constraints of the transmitting nodes in the cluster. Further protocol manages the nods and node data transmission dynamically on its available energy density of the sensor nodes.

3. Proposed Model

In this section, a novel secure energy efficient routing protocol to Wireless Sensor Network towards patient health monitoring and tracking has been designed on composition of optimal node clustering strategies, trajectory point of the sink node and energy defined path prediction against attacks. Sensor node deployed to acquire, transform and transmit the animal habitat information to the base station through sink nodes.

3.1 Network Architecture –WSN

Wireless Sensor Network is established with provision to sense and transmitting the data sensed through sink node to base station. In these cases, sensing node is employed to sense the habitat of animals to monitor their behaviour from distinct location. Each sensor node in a network transmits the data among the nodes on the deployed network with node changing topology employing routing technique. Data transmission range of the node is similar among the network and its node link established in bi directional manner.

Architecture of WSN is depicted as undirected graph. The routing technique of WSN are modelled as Cluster based data routing to periodically control the node information which is essential to establish the path to route sensed data. Cluster head is established to eliminate frequent data loses and network failure. WSN is considered as

Let represent Network as Unidirectedgraph G

UG= (P, I) Eq.1

Where

P-collection of Sensor nodes & I-collection of the Sensor node edges

3.2 Node Clustering

According the topology of WSN, clustering of the nodes has to be carry out in order to reduce the energy hole problem. Clustering of the node represents a cluster containing cluster head which acquires the continuous monitoring information of specific node in the node cluster along node energy and sensor information. Each node's energy and sensed information has been updated to its cluster head to alleviate the network overhead and energy degradation on path selection. On data clustering, the cluster topology changes inside a cluster on basis of the nodes density but it will not influence the network as effective queue management strategies have been modelled to cluster head.

The data clustering of nodes minimizes energy depletion of the sensor node on providing stable data transmission performance to base station with minimized hop and queue length. Furthermore cluster head determination among the collection of sensor node is computed in the specified location of the network with particular network density and node distance. Clustering of node is established along the location similarity and node density similarity constraints towards habitat monitoring.

3.2.1 Clustering of Node on basis of Location Similarity

Collection of sensor node has been grouped as cluster on basis of its location uniqueness and its nearest location with least distance. The clustering establishing constraints of node forms the cluster which acts as quickest neighbour with optimal area radius to the selected node considered as cluster head. Table 1 provides the wireless sensor network parameter for cluster generation.

Table 1: Clustering parameter

Clustering Parameter	Description
N	No. of sensor nodes on dynamic topology
R	Node Radius
N_d	Node Density
N_H	Node Hop distance

Clustering of the node is projected on basis of node scheduling and sensed data routing on basis of Wireless Sensor network parameters. The partitions of the sensor node are Cluster Head, transmitting node and intermediate node. It is established to increase the network transmission rate. In this node clustering on specified location, Determination of the energy for data transmission is computed on basis of following equation 2

$$\text{Clustering of Node C} = \lambda \sum_{k=0}^{n} (\mathrm{r} * \mathrm{d})^2 L^R \quad \text{..... Equation 2}$$

Where

R – Network Area with radius between nodes,

L – Node length between nodes,

N_D- Node density of each node

3.2.2 Clustering of Node Collection on basis of Node density

Collections of nodes have been clustered with respect to its node density. Clustering constraint son the nodes to determine the cluster head among the collection of nodes is based on node density and node radius

with one hop neighbour. Node clustering regularly gathers the node energy as transmitting cost of the node respectively. Cluster head is computed using Algorithm 1

Algorithm 1: Cluster and Cluster Head Formation

N_i Represents the collection of the sensor node

Calculate Node Density N^d

For (Node i=0 to N)

Fix N^d Maximum = Threshold

If (N_i^d >= N^dMaximum)

Choose N_i^d as Cluster head among the nodes

Else

Identify the another node with high node density

Compute Node Degree N^r

For (Node i=0 to N)

Fix N^r Maximum = Threshold

If (N_i^r >= N^r Maximum)

Choos N_i^r as Node degree of the nodes

Else

Compute other nodes as node degree

Compute Cluster head

If (Node haslarge energy density)

Establish particular nodes as Cluster Head

Else

Compute the another nodeson basis of energy condition of the node

The Figure 1 depicts the cluster head formation architecture on the available sensor node for monitoring and transmission.

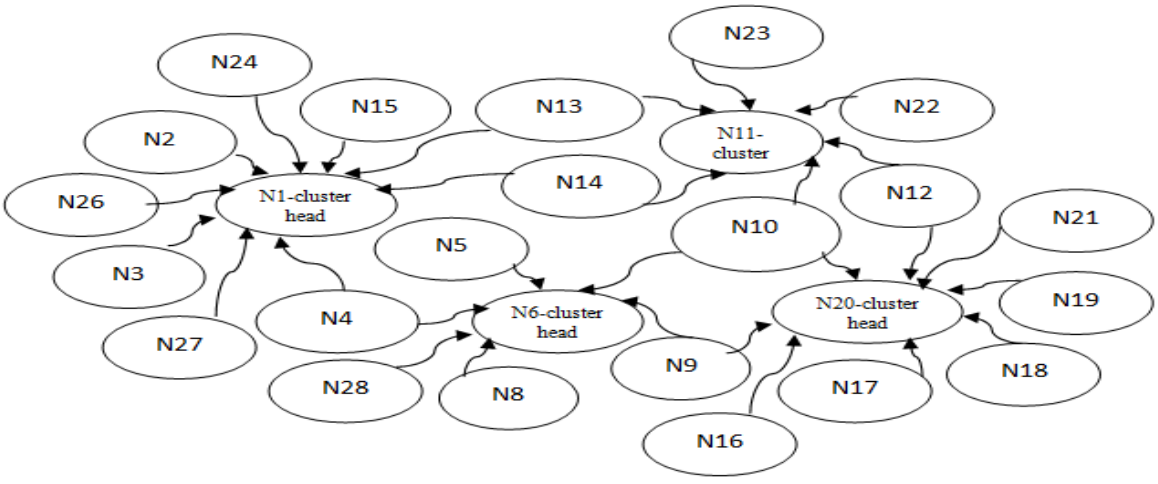

Figure 1: Cluster head Formation

3.2.3 Trace File generation using Channel Sensing

The Node information is collected as Trace file to form path selection information using cluster head of the network. Further trace information is sharedamong thegenerated cluster heads. Trace files contains the nodeinformation gathered from the clustered nodes on parameter such as node energy density, node queue length, node bandwidth etc. Trace file considered as log file of each node and it is processed for log aggregator in the cluster heads. Trace File support for effective data transmission to base station.

3.3 Metaheuristics Clustering

Objective of the Metaheuristics clustering is to enhance the node scalability on establishing the multiple cluster head. Each Cluster heads has been considered asdecision making nodes which transmit the sensed information to the specified sink trajectory point designating to the base station. Particular Network has segmented into various paths for effective data communication with respect to node queue length and node energy density. Clustering which facilitates the path selection towards data transmission on basis of node density and node location. Further sink trajectory for data collection has been computed on basis of the node queue length.

The Metaheuristics based node and data clustering is established using spatial information of nodes to enhance the optimal transmission performance. Effective path composing the nodes computed using clustering mechanism such as energy based node clustering and location based node clustering to reduce the usage of high energy on the nodes for data transmission.

Cluster head manages trace data of the nodes in the clusters for path allocation. For Path allocation for data transmission, Cluster head determine the node degree of the specified cluster node for data communication with other clusters node. Data communication between the two clusters is as represented as

Node degree changes between the clusters can be computed for intra cluster data communication as

$\Delta_V = |d_V - \delta\ |$ ..... (Equation.3)

Summation of node distance among the node neighbours is calculated as

$$D_v = \sum_{v' \in N(v)} \{dist(R, v')\} \text{....Equation 4}$$

Sensor node's energy and location will acts as primary constraint for Metaheuristics clustering. During large data transmission Traffic in the network, employment of Metaheuristics algorithms reduce the congestion and network degradation for data transmission to base station, it is given by

$$Path\,\text{Pr}edictio = \frac{n_c}{\sum_i (x_i - \mu)^2} \quad \text{..... Equation 5}$$

Where n_c -Total cluster heads in the WSN,

x_i -Total Energy of the particular cluster in WSN

μ - Average number of neighbor's nodes in the cluster head

The periodic node upgradation has been acquired by the cluster heads in order to minimize the data transmission time, cost and delay as possible.

Secure Path Selection –Incremental Particle Swarm Optimization

Transmission path selection for sensed information is to identify the nodesfrom different cluster head which capable for effective data dissemination to base station using Incremental Particle Swarm Optimization (IPSO). The fitnesscriteria for selecting the transmitting node among different cluster are computed using the total available energy of the nodes in cluster head along security analysis. The sensed information incorporatesIPSO approach to generate dynamic strategies for effective path for data dissemination to base station through sink nodes.

Due to the variations in received signal strengths in various locations,effective path radius for data dissemination can be represented as

$PR_{i,j} = \gamma_{i,j} N_j$ ..... (6)

Where N_j depicts the radius between the transmitting nodes

$\gamma_{i,j}$ - Node energy efficiency factor

During multiple data communication to base station, the totalenergyconsumed for daya communication on particularpath can be computed as

$MR_{i,j} = NE_{i,j}\ \gamma_{i,j} N_j\ /(f_j+1)$.....(7)

Where $NE_{i,j}$denotes nodeenergy loss Factor

f_j denotes fitness function

Path selection strategy for data dissemination computed using IPSO for node indexing in the cluster and among the cluster for data transmission. The multiple strategy of the nodein the cluster provides the route outcome to transmit the sensor information acquired in specified location or specified time period. Strategies can be energy efficiency factors, energy utilization constraints and location specification with respect to fitness function. The incremental PSO optimization computes better path for effective data dissemination of the base station through sink on the particular location and secure against multiple attacks. In this sink trajectory computed using fitness function.

Path selection is given by velocity factors

$$P = N^d = P + V_1 * \text{random variable} * (pBest - N_d) + V_2 * \text{random} * (gBest - N_d)$$

Where P is the data acquired on the Path for data dissemination

P is the particle represents the acquired node information on the respective cluster

V_1 is the total node information in the particular cluster

V_2: Totalnode information in the entire network

pBest: AppropraiteNode location in particularcluster

gBest: Appropriate Node position in entire cluster head.

random: random variable

Fitness function = $\sum_{m=k}^{n-1} \mathrm{Sim}(\boldsymbol{\delta}_i^j(x_k) - \boldsymbol{\delta}_i^j(y_{m+1})) + F(y_n)$

Optimal data communicating path O(p)

As an outcome, optimal path for data transmission has been selected efficiently. It is represented to be efficient for data transmission to base station.

4. Simulation Analysis

In this part, secure energy efficient routing protocol to Wireless Sensor Network towards patient health monitoring and tracking model has stimulated by employingNS2 Simulator. On experimental validation of the approach, the WSN properties and its network performance measures has been validated with respect to node density, energy utilization, Packet delivery ratio, Average delay and packet loss. Proposed Metaheuristics defined clustering based secure routing protocol performs better compared to the conventional cluster based routing protocols such as LEACH protocol and PSO based node clustering techniques using fitness constraints. The proposed clustering protocol employed to enhance the performance of the network through node density coordination among various clusters. Simulation set up of the proposed network architecture has been described in the table 2

Table 2-WSN Simulation Parameters

Simulation Parameter	Value
Network Simulator	MATLAB 2018b
Network Size	500m *500m
Node deployed	50
Node Power	0.5mW/Hz
Data Traffic	CBR
Data Packet size	1028 bytes
Buffer size	150 packets
Simulation period	, 45 minutes

In detailed simulation of the node containing sensed information has been transmitted has using network properties represented in the table 2. Further it is node transmits the sensed information cluster head. Cluster heads determines the appropriate path for data dissemination to base station through sink. The desired path is computed by cluster head on optimal selection of energy density and location of the nodes with reference to intermediate node on the cluster head. Figure 2 represents the no of transmission capabilities of the operational nodes

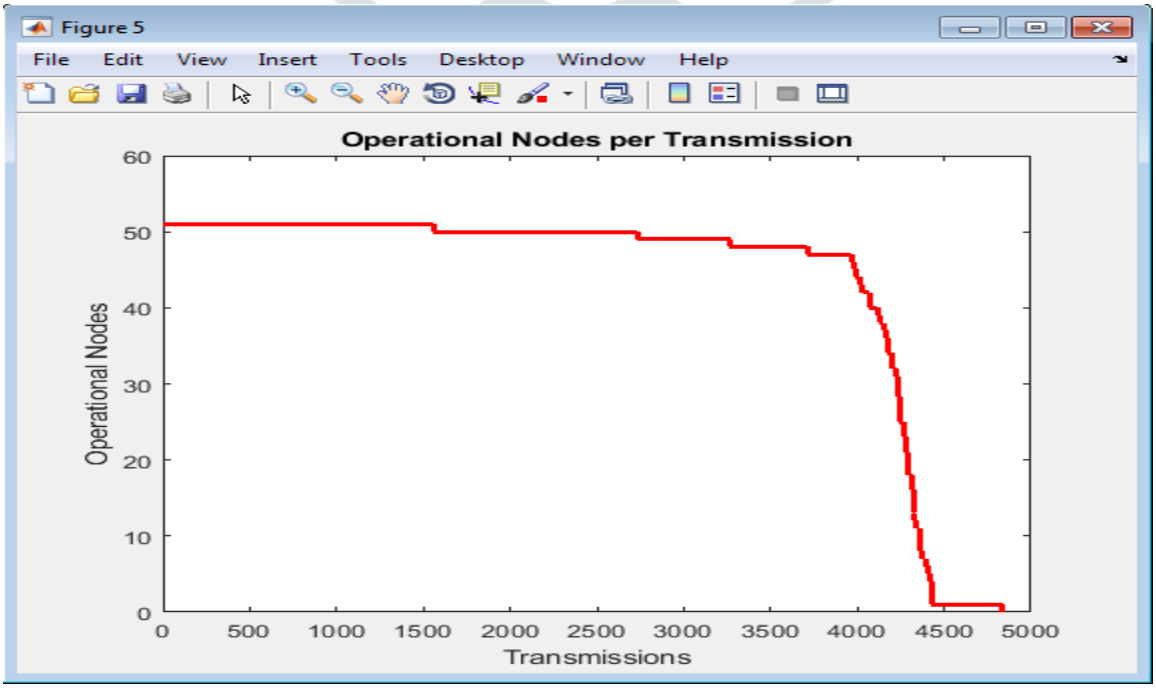

Figure 2: Transmission capability of operation nodes

Cluster based data routing protocol is been synchronized in term of time and location. The proposed IPSO algorithm determines the optimal data transferpath for data disseminationto base station on communicating with multiple cluster head in the total network. IPSO algorithm calculates the shortest data transmission path for sensed data routing to base station through sink node [15]. Total node energy consumed at several intervals has been evaluated and represented in the figure 3.

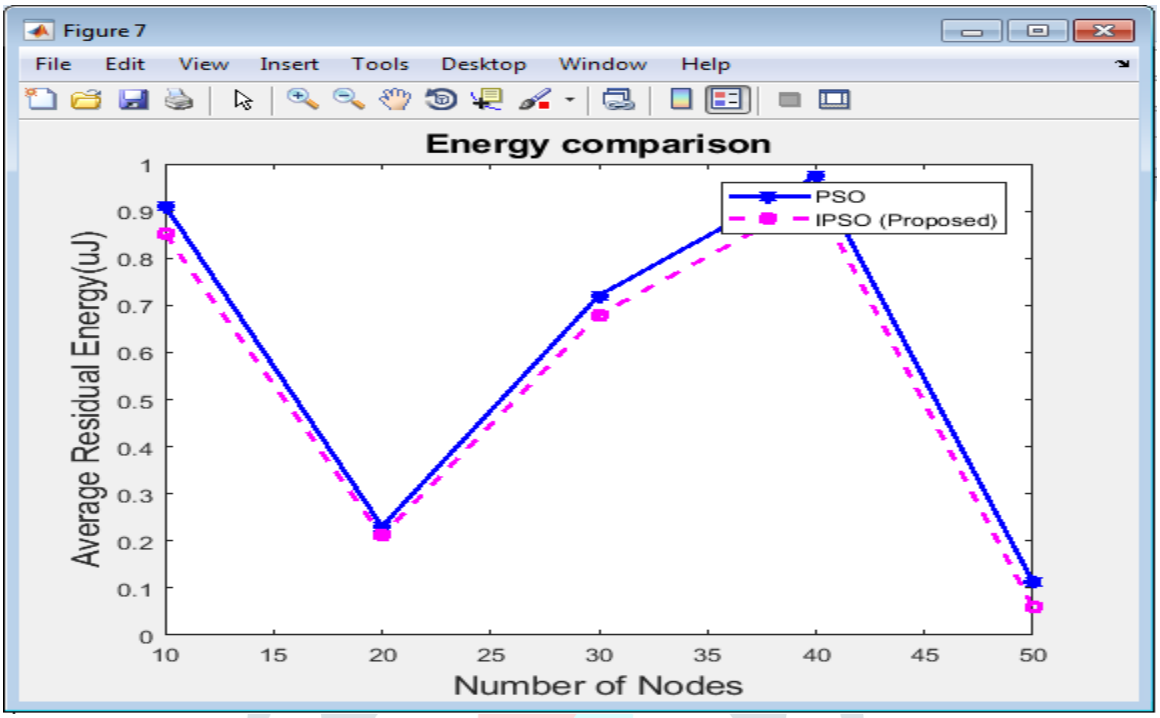

Figure 3: Performance Analysis of Energy Consumption

The optimal path for sensed information dissemination to base station against node failure is computed and its energy consumption has been calculated. Those computations prove that proposed model operates with less energy consumption and less data losses.Data transmission on the data traffic is been controlled using Metaheuristics based node clustering mechanism. TheMetaheuristics clustering technique is capable of establishing the cluster head with effective data transmission rate and reduced energy utilization on the computed paths.

Energy computation is computed using following representation

Energy Consumption = Energy consumed during designing- Energy consumed during data transmission
Energy consumed during data transmission= Initial energy of the node before transmission - energy of the node after

The evaluation of the model on the node energy consumption is depicted in the figure 3. Throughput of the network considered as total energy density of the clustered nodes in the network. Network energy depletion can be eliminated on employing the dynamic strategies for path selection.

Average delay of the network is computed as ration of number of the sensor information to the total number of sensor information transmitted to the base station in specified time interval. In this IPSO strategies has been employed to identify the optimal path for data dissemination on basis of location and energy based

fitness constraints. The average delay evaluation of the cluster based routing architectures is represented in the figure 4

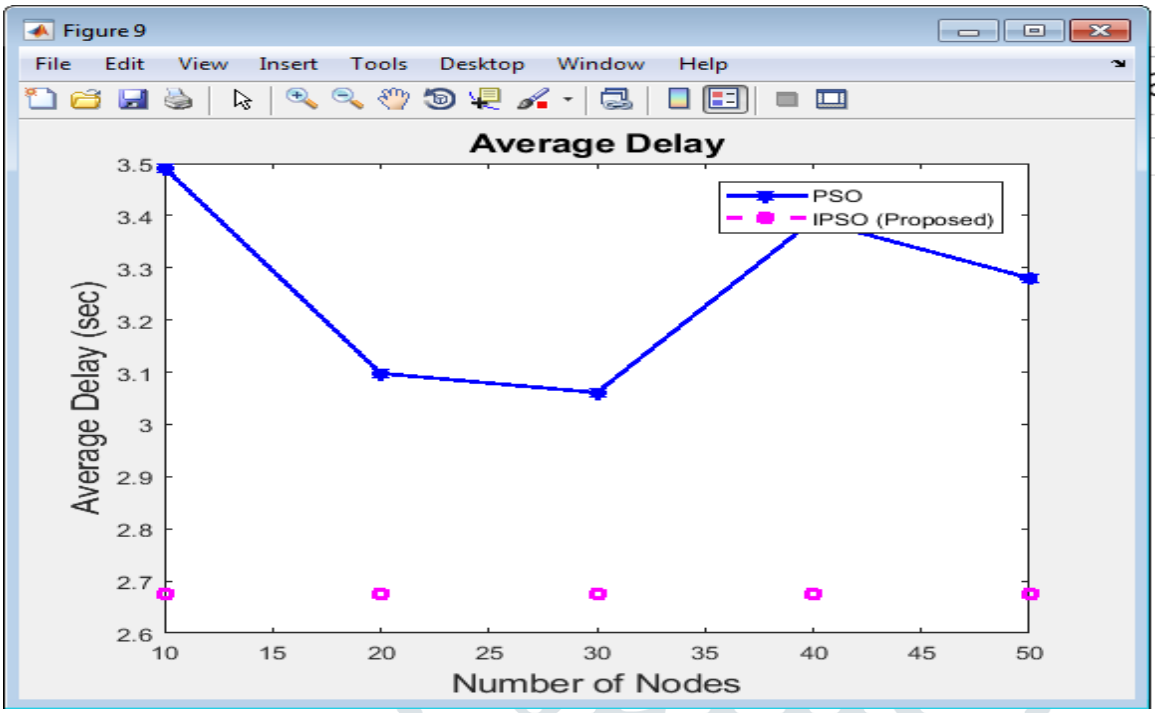

Figure 4: Performance Analysis of average delay

Average delay = 100% * $\frac{\text{nd}-\text{ne}}{nd}$

The average delay is computed as nodes in the network against the sensed data transmission to base station on the specified time and specified location to fixed data sizes. Table 3provides the performance comparison of the different cluster based routing technique for WSN for data transmission and energy consumption.

Table 3 – Performance Comparison of Cluster based data Routing mechanism for WSN

Technique	Average delay in mbps	Energy Consumption in joules	Packet Delivery Ratio	Network life timein ms
Secure Data Routing and path selection using PSO-Existing	85.58	12.23	96.78	**23**
Secure Data Routing and path selection using Incremental PSO Proposed	89.26	22.59	99.95	**47**

Packet delivery ratio is determined as ratio containing the number of sensed data information in the particular time to the particular node's transmitting data to base station in the particular time in specified path and energy conditions. Figure 5 describes the performance evaluation of the packer deliver ratio.

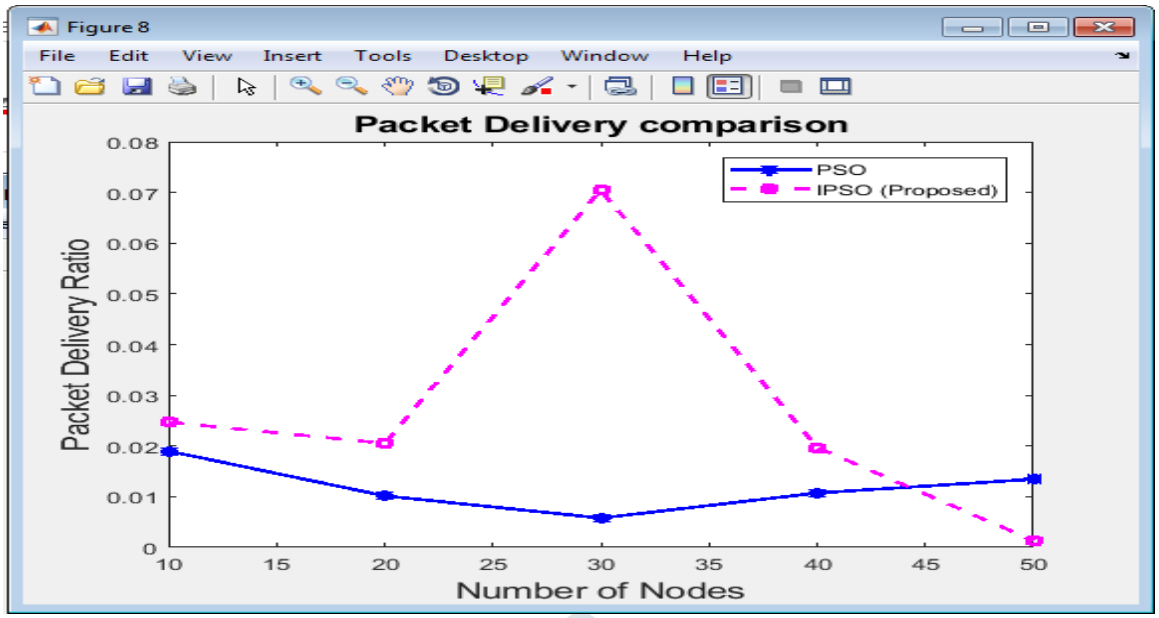

Figure 5: Performance Analysis of Packet Delivery Ratio

The packet loss is computed on basis of energy loss of the network in parallel lead to data transmission loss. In this work, an energy management strategy of the node has been controlled using IPSO. The energy controlling reduces the node failure while transmitting data to base station via sink node

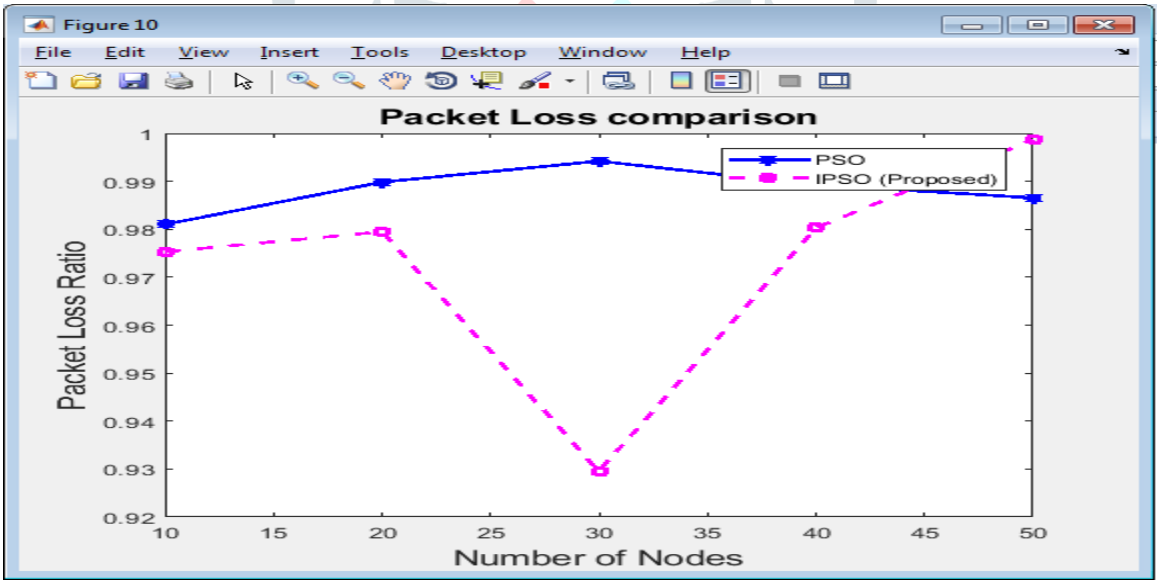

Figure 6: Performance Analysis of Packet loss

In addition, cluster based data routing mechanism is capable of handling the network complication effectively. The figure 6 depicts the performance evaluation of the packet loss against energy and location of the nodes. Network lifetime of the nodes depends on the scheduling of the nodes in the cluster for data transmission to base station with assistance of the sink nodes.

In this work, network life time will be increased on basis of operating the nodes on the fixed threshold to avoid the node failure and degradation of the network performance. Figure 7 represents the performance analysis of the network lifetime against the node deployed.

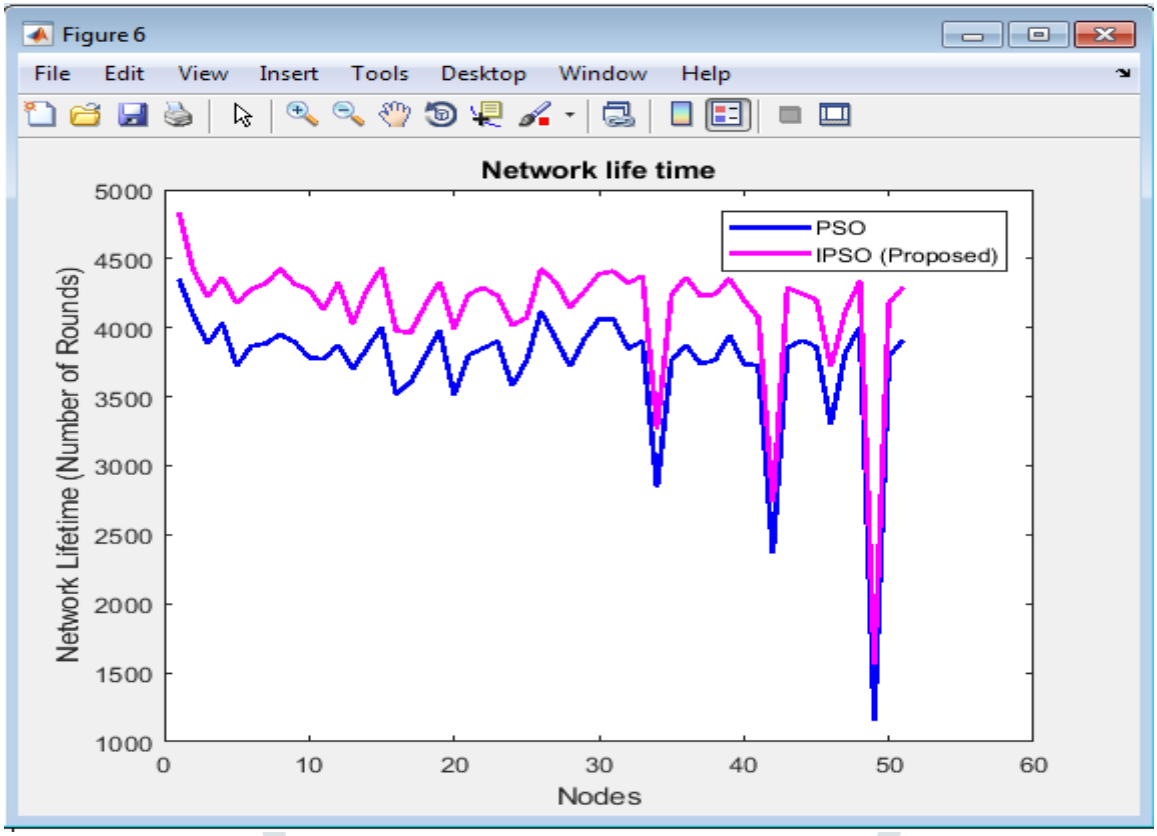

Figure 7: Performance Analysis of Proposed Framework against Existing Technique through Network lifetime.

In this analysis it has been proven that energy conservation of the node on the specified location maximizes the number of data transmission on optimal path selection for animal habitat monitoring and tracking using improved PSO technique. It has been evaluated against conventional cluster based data routing protocol evaluate the amount on the energy utilized.

5. Conclusion

We design and simulated a secure energy efficient routing protocol to Wireless Sensor Network towards patient health monitoring and tracking has considered as effective path selection solution towards information dissemination to base station by sensor node. Further it reduces the data losses, average delay and energy consumption to more extent. Metaheuristics based clustering approach provides optimal condition during node failure with reduced energy consumption for secure data communication. The Proposed data routing model increases the energy consumption operational nodes by imposing effective strategies of the improved PSO.

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