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# Energy Efficient Direction-Based PDORP Routing Protocol for WSN

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**ABSTRACT** Energy consumption is one of the constraints in wireless sensor networks (WSNs). The routing protocols are the hot areas to address quality-of-service (QoS) related issues, viz., energy consumption, network lifetime, network scalability, and packet overhead. The key issue in WSN is that these networks suffer from the packet overhead, which is the root cause of more energy consumption and degrade the QoS in sensor networks. In WSN, there are several routing protocols, which are used to enhance the performance of the network. Out of those protocols, dynamic source routing (DSR) protocol is more suitable in terms of small energy density, but sometimes when the mode of a node changes from active to sleep, the efficiency decreases as the data packets need to wait at the initial point, where the packet has been sent and this increases the waiting time and end-to-end delay of the packets, which leads to increase in energy consumption. Our problem is to identify the dead nodes and to choose another suitable path so that the data transmission becomes smoother and less energy gets conserved. In order to resolve these issues, we propose directional transmission-based energy aware routing protocol named PDORP. The proposed protocol PDORP has the characteristics of both power efficient gathering sensor information system and DSR routing protocols. In addition, hybridization of genetic algorithm and bacterial foraging optimization is applied to proposed routing protocol to identify energy efficient optimal paths. The performance analysis, comparison through a hybridization approach of the proposed routing protocol, gives better result comprising less bit error rate, less delay, less energy consumption, and better throughput, which leads to better QoS and prolong the lifetime of the network. Moreover, the computation model is adopted to evaluate and compare the performance of the both routing protocols using soft computing techniques.

**INDEX TERMS** Wireless sensor networks, DSR, PEGASIS, PDORP, OD-PRRP, LEACH, optimization, hybridization, computation model.

## I. INTRODUCTION

In Wireless sensor networks (WSNs), the main source of lifetime for the hubs is the battery. Communicating with different hubs or sensing activities expends a great amount of energy in preparing the information and transmitting the gathered information to the sink [1]–[3]. As several cases, it is undesirable to supplant the batteries that are draining or depleted of energy. Numerous scientists are in this field attempting to discover power-aware protocols for wireless sensor networks, keeping in mind the end goal to overcome such energy effectiveness issues but they have their own assumptions [4].

For the optimization of WSN designs, researchers have proposed various approaches [5]. To meet different design criteria, related researches into the optimization of wireless sensor network design can be grouped into three categories: 1) Optimization in the communication layers; 2) Node hardware optimization and 3) Cross-layer optimization [6]–[8]. However, most of the optimization procedures do not take into account the principles, characteristics and requirements of WSN which is application defined. Therefore, in proposed approach energy optimization is done using hybrid algorithms i.e. GA and BFO method in DSR protocol.

Within the application layer, the traffic load is usually squeezed to scale back the data size. Various algorithms such as in-network data processing is actually produced to scale back energy consumption when compared to transmitting the raw data towards end node. The routing layer as well as MAC layer is usually optimized by simply choosing appropriate protocols to gain productivity. Node optimization can be achieved by simply strengthening battery utilization as well as implementing power-aware equipment layout. Three different types of optimizations are labeled: optimization of the communication layers; the actual node optimization; as well as cross-layer optimization.

Performance of any routing protocol mainly depends on the energy consumed while travelling from source to destination [9]–[11]. Random deployment of nodes leads many researches in the routing algorithms. Densely deployed nodes endure from many failures due to drained battery power, environmental conditions etc. Dynamic topology of WSN poses another constraint as nodes require changing the information regularly. These features of WSN construct scalability, reliability, energy efficiency and resource management are great challenges in the design process of routing protocols. Energy consumption can be categorized into two types, dynamic and static:

Dynamic energy consumption can also be computed as:

$$E_{Dynamic} = A.C.f.v^2. \quad (1)$$

Where: A = active gates, C = capacitance load,  $v^2$  = supply voltage, f = frequency

Then it can be written as:

$$\sum E_{Dynamic} = E_{Dynamic} \cdot \Delta t \quad (2)$$

Where:  $E_{Dynamic}$  = dynamic energy,  $\Delta t$  = dynamic time  
As:

$$E_{Dynamic} \Rightarrow E_{static} \quad (3)$$

Thus whole energy consumption computed as:

$$E = E_{Dynamic} \quad (4)$$

It is concluded from literature, that extra energy is consumed by the nodes in the role of CH. Therefore the number of cluster heads must be optimal. To balance the burden on the nodes several techniques are employed such as: 1) rotate in the role of CH 2) election of CHs according to some formula 3) to develop a routing scheme in which load over single CH is not increased and so on. A very popular routing protocol, LEACH was developed in 2000, used the adaptive cluster approach to maximize the energy efficiency. But in this work PEGASIS will be utilized [12], [13]. To consume nodes efficiently and wisely is one of the important features of sensor networks. As wireless sensor nodes are prepared with non-chargeable batteries with inadequate energy supply, a sensor network cannot work well after a fraction of the nodes run out of energy. Another challenge in front of WSN is to receive the data from trustworthy nodes so that are hidden or malicious nodes could not disrupt the route.

In order to deal with above mentioned issues viz. Reliability, energy efficiency, shortest route, delay, communication overhead and resource management, we have proposed a PDORP routing protocol that ensures reliability of the network by creating a trust list of transmitting nodes. The proposed method smartly utilizes the characteristics of both proactive (PEGASIS) and reactive (DSR) routing protocol. The concept of directional transmission ensures marginal decrease in communication distance among the nodes, results in less energy gets conserved. In addition, the concept of cache memory is beneficial when a node becomes more aggressive at the time of transfer and previously it was not in the cache memory, the other node is bound to receive a packet from it and in such a way it can cause damage to existing routes. In order to cope with this situation proposed routing protocol creates a trust for the first time in each round on the basis of the parameters allocated to the nodes.

Moreover, in PDORP, Hybridization of GA and BFO optimization is to be applied to proposed routing protocol to identify energy efficient optimal paths. In fig. 1. the energy consumed by sensor nodes at various stages are demonstrated. Bit error rate, delay, energy consumption and throughput metrics are used to compute and evaluate the performance of the candidate routing protocols in wireless sensor network. By using MATLAB simulations the performance of proposed routing protocol PDORP is compared with other routing methods such as PEGASIS, DSR, LEACH, and ERP. Furthermore the computation Model is adopted to evaluate, compare and validate the performance of the proposed routing protocol.

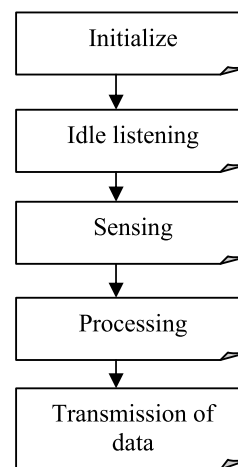


FIGURE 1. Energy processing in sensor nodes.

The main contributions of this paper are as follows:

- It has decreased the communication distance between the nodes so that less energy gets consumed and it is ensured by using directional transmission.
- The advantages of both the PEGASIS routing and DSR routing methodology i.e. shortest path, less overhead, fast response and the connectivity of the nodes

are achieved by combining the use of both of these methodologies.

- When a node becomes more aggressive at the time of transfer and previously it was not in the cache memory, the other node is bound to receive a packet from it and in such a way it can cause damage to existing routes. A solution to this problem could be checking of any node at the time of receiving a data packet but this would cause unessential delay. Hence, the proposed solution creates a trust for the first time in each round on the basis of the parameters allocated to the nodes. After every round, the trust list is updated and after a certain number of rounds, the trust would not be checked to avoid time delays.
- Hybridization of GA and BFO optimization is applied to proposed routing protocol to identify energy efficient optimal paths.
- The performance of PDORP has been analyzed by comparing the performance with PEGASIS Routing Protocol (PRP) by using MATLAB simulations.
- The performance comparison through a hybridization approach of the proposed routing protocol shows better results comprising less bit error rate, less delay, less energy consumption and better throughput which further leads to better QoS and prolong the lifetime of the network.

The rest of the paper is organized as follows. Section 2 presents related work. Section 3 elaborates the system model. In Section 4, detailed description of the proposed method PDORP is given. In Section 5 simulation results are presented and effectiveness of our work is evaluated. Conclusions are given in Section 6.

## II. RELATED WORK

As wireless sensor nodes are prepared with non-chargeable batteries with inadequate energy supply, a sensor network cannot work well after a fraction of the nodes run out of energy. As the energy conservation is one of the main issues in wireless sensor network; hence for efficient working of the network, energy consumption should be less. High energy consumption is one of the main reasons of the node failure. Below literature survey presents the various routing protocols in WSN. The basic parameter that has considered in literature survey is energy [14], [15]. Various advantages as well as disadvantages about routing protocols have also been discussed.

Routing protocols are used to find a path and for sending data between sensor nodes and the base stations. There are number of routing protocols that are proposed for WSNs.

These protocols are classified according to the way they're functioning, based on parameters and the type of target applications. It can be categorized as flat routing; hierarchical routing and geographical position supported routing. The flat routing approach is further classified as proactive or table driven, reactive or source initiated and hybrid routing protocol (combine the characteristics of both). In a proactive protocol the nodes transmit the data to a BS through the predefined route. The Destination-Sequenced Distance Vector (DSDV),

Optimized Link State Routing (OLSR), Low Energy Adaptive Clustering hierarchy protocol (LEACH) and Power efficient Gathering Sensor Information System (PEGASIS) utilizes this type of protocol. In reactive or on-demand routing protocols, routing information acquired by a node when it is needed, some reactive routing protocols are such as DSR, Adaptive On-Demand Distance Vector (AODV), On-Demand Multicast Routing Protocol (ODMRP) and Cluster Based Routing Protocol (CBRP) [15]–[18]. Table 1, presents the recent literature of energy efficient protocols.

To solve the above discussed problems in the table 1, [19]–[25], we have proposed a novel approach based on hybrid technique. Like [29]–[31] our work is also multi-objective i.e. it has shown improvement not only in the parameter of energy but also bit error rate and end to end delay.

Our proposed routing protocol has characterized with proactive and reactive phenomenon and used directional transmission in order to choose the shortest path towards the destination and cache memory ensures reliability and less delay by creating a trust list of nodes which results in less energy gets conserved by nodes. Finally, hybrid optimization is used to select optimal path.

## III. SYSTEM ASSUMPTIONS

We have assumed a network with limited number of sensor nodes, which are randomly deployed on a 2 - dimension area. All the nodes are homogeneous and they have initial energy  $e_i$ , where  $e_i > 0$ . All the nodes have one hop communication and hence they use short range radio transmission. Transmission between two nodes is possible only when the remaining energy of nodes is greater or equal to the threshold level of the energy. We have used the path loss model described in [26], which is most popular for theoretical analysis and network simulations. We have used the same equation as used in [19] for computation of power reception by the distant node for distance of  $dist$  meters described as under:

$$P_r(dist) = P_i * \left(\frac{dist_i}{dist}\right)^\alpha \quad (5)$$

Here,  $P_i$  is the received signal power at the distance  $dist$  from a transmitter and  $\alpha$  is the path loss exponent that varies between 2 - 6.

We have made some other assumptions about our model which are as follows:

- Transmission power of node is adjusted by the node themselves and received signal strength (RSS) can be computed easily.
- Transmission and reception of packets are accomplished with the help of directional antennas.
- Nodes are naïve about their location.
- Nodes have the knowledge of their neighbors to transmit and receive the packets.
- Every sensor node is aware of the direction as per reference to local north.

TABLE 1. Literature review.

Author	Technique	Merits	Problem
[19] Aarti Jain et.al	Fuzzy logic and ACO based OD-PPRP routing	OD-PPRP has better network lifetime, less transmission delay, high packet delivery ratio and decrease in overhead than other routing protocols like EARQ, EEABR and EAODV.	It is applicable only on WSN network, so can be applied to MANET or wireless network.
[20] Xin Guan et.al	Load balance data gathering algorithm	Provides more uniform energy consumption in sensor nodes and also increase the lifetime of sensor networks.	Further extension of this protocol and make it adapt to the three-dimensional Environment.
[21] Yasuhiro et.al	Route Construction Method	Can construct effective communication routes in terms of both power consumption and the quality of communication.	Some metrics other than the packet delivery ratio seem to be needed to further improve the quality of communication.
[22] Young Duk et.al	A cross-Layer Channel Access and Routing Protocol	The proposed protocol can more efficiently support QoS packets, even the network is highly loaded.	Need to investigate more detailed QoS requirements of medical information systems.
[23] Minwoo et.al	Integration platform based on WBAN	Optimized the WBAN and the TCP as a sampling rate control.	Usage of Zigbee protocols because it has a slower power consumption rate.
[24] Kwnagcheol Shin et.al	Milestone-based predictive routing	The proposed routing protocol reduces energy consumption and packet delivery ratios in comparison to previous routing protocols such as ALURP and Elastic.	Improve the predictive protocol by managing QoS in sink mobility WSNs.
[25] Anita Yadav et.al	Newton divided difference interpolation for link prediction method	The results show that there is a significant reduction in packet drops and end-to-end delay parameters and improvement in data packet delivery ratio for AODV with link prediction.	AODVLP can be further improved by limiting overhead of unnecessary control messages

IV. PROPOSED METHOD

In this section we discuss the network modeling and the proposed routing method PDORP in detail. By using algorithm 1, (Network creation) we have created a network with randomly deployed nodes N (500). We have taken the area of 1000 square meters. In the fourth step of this algorithm we have computed the distance *d* of all the nodes from their neighbors and we have compared their distance with the threshold *th* value of distance, so that they could be connected only when their distance is less than or equals to the threshold value. We have used this algorithm to make it sure that all the nodes are connected with a minimum distant value.

Above algorithm describes the node deployment in the whole network. In proposed network 1000\*1000 network development takes place with coverage set = 1. Fig. 2 shows snapshot of network creation.

A route for data transmission is established by using the algorithm 2 (Path finding) to find the optimal route in the large coverage set of nodes. If source node and destination nodes come under coverage set, then transmission will take place, otherwise again path searching will done. Fig. 3. shows the selected connection between a source node and possible nodes towards the destination.

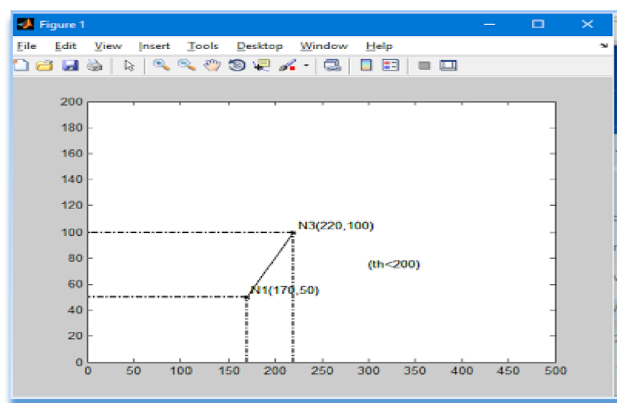


FIGURE 2. Network Creation. (X axis=Number of rounds and Y axis=Number of Nodes).

Proposed Routing Protocol “PDORP”: PEGASIS-DSR Optimized Routing Protocol (PDORP), optimally utilizes the characteristics of both the proactive and reactive routing model.

If a node becomes more aggressive at the time of transfer and previously it was not in the cache memory, the other node

**Algorithm 1** Network Creation

```

1. Network.height=1000
2. Network.Width=1000; N=Total_Nodes.
3. For each n in N
    counter = 1;
    xloc(n)= 1000 * Random.
    yloc(n)= 1000 * Random.
    Node.name(n)= counter; counter = counter + 1;
    Endforeach
4. Cov_set = [ ]; //it would contain the limited area node.
    for i=1 to N
        cov_count=2;
        for j=1:N
            if(i!=j) // A node cannot compute distance to itself
                d = sqrt(((x(i) -x(j))^2 + y(i) -y(j))^2);
                th = (Network.width * 20) / 100;
                if (d <= th) cov_set(i, 1) = i;
                    cov_set(i, cov_count) = j;
                    cov_count = cov_count + 1 ;
                end if end for end for

```

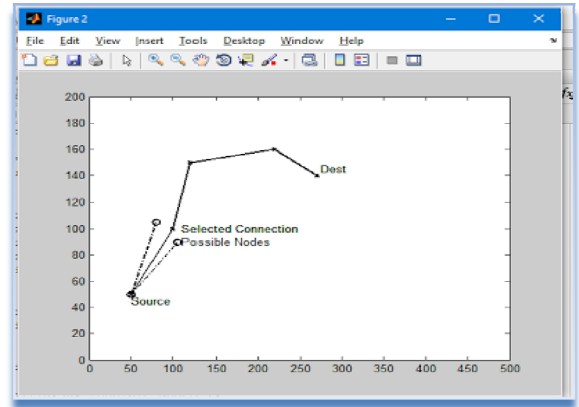
**Algorithm 2** Path Finding

```

1. For i=1 : Network.Simulation.Rounds
2. Source=Initialize.Source;
3. Source.Id=Node.name(source); Path=[ ]; Pathelement =2; Path[1]=Source;
4. Source.Packet.count=1000;
5. Destination.Id=Node.name(Destination);
6. Current_cov_set_source=cov_set (source.Id,:);
   dest_found=0; possible_nodes=[ ];
7. While(dest_found!=1)
8. For each all n in current_cov_set
   If(x(all n)>xloc(Source.Id) && (x(all n)-
   xloc(Destination.Id) < 0
       Possible_nodes[possiblecount] = all n;
       Possiblecount+=1;
   Endif
9. Selection=possiblecount*Random;
10. Selected_node=Possible_nodes[selection];
11. Possible_Nodes=[ ]; Path(Path element) =
    selected_Node
12. End

```

is bound to receive a packet from it and in such a way it can cause damage to existing routes. A solution to this problem could be checking of any node at the time of receiving a data packet but this would cause unessential delay. Hence, the proposed solution creates a trustiest for the first time in each round on the basis of the parameters allocated to the nodes. After every round, the trust list is updated and after a certain number of rounds, the trust would not be checked to avoid time delays.



**FIGURE 3.** Path Finding. (X axis=Number of rounds and Y axis=Number of Nodes).

In fig. 4. we have shown the flow chart of our proposed scheme. When a source node wants to transmit data to destination node, it calculate the distance from all the neighbors and forward the data to the node whose distance is less than or equals to the threshold distance and only in the direction of destination nodes and it also ensures that the minimum distance neighbor node should be in the direction of the destination node. After this process all the nodes in the direction of the destination are added into the trust list only in the first round of simulation. Whenever a new data transmission is required, then the trust list will be updated in the first round of simulation and the data will be transferred via only those nodes which are found in the trust vector. As the vector list is created only in the starting phase of the simulation so to continue the transmission thereafter vector list is stored in the cache which is created using the algorithm 3.

**Algorithm 3** Routing Cache DSR Integration (PDORP)

```

1. PC=1;
2. For i=1 to N

```

$$\Delta H = \frac{\sum_{j=1}^N E_A + E_T + E_R}{N} \tag{7}$$

```

3. If((EAi + ETi + ERi) > ΔH)
4. RoutingdistortionpossibleNodes(PC) = i;
5. PC = PC + 1
6. endif;
7. endfor;
8. Initialize transfer;Packet.count=1000;
9. d=find(Packet.sender.Id)==RoutingdistortionpossibleNodes)
10. if(isempty(d))
11. Accept Packet;
12. Else
13. Reject Packet;
14. End ;

```

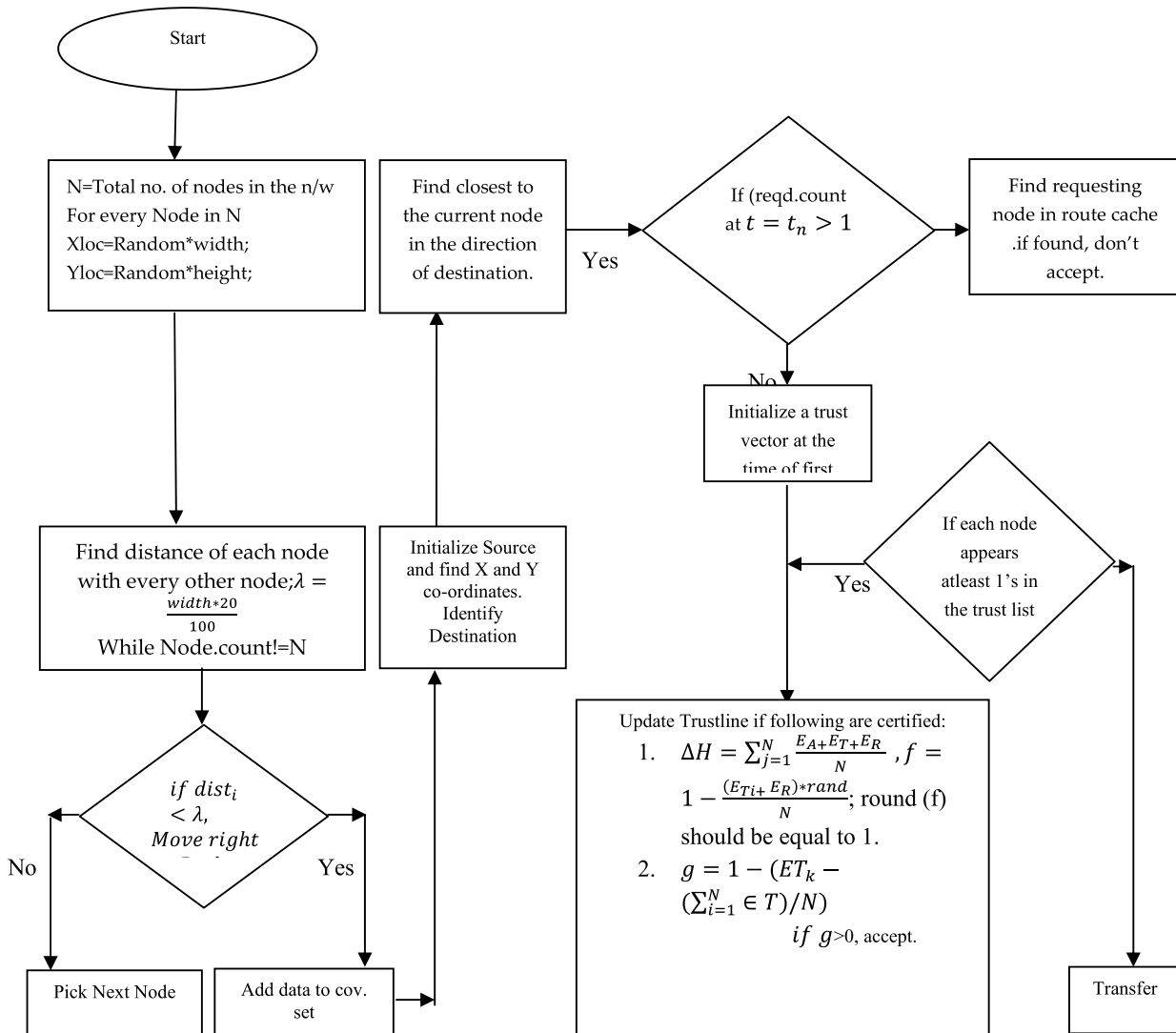


FIGURE 4. Flow chart of PDORP.

It has been considered that each node occurs once in the trust list. To create the fitness value of trust, a hybrid algorithm, which consists of GA and BFO has been proposed via algorithm4. GA would be optimizing the node consistency based on the  $E_R$  &  $E_T$ .

Each node will have to pass a fitness function given in step 1 of algorithm 4.

**V. PERFORMANCE EVALUATION**

This section demonstrates simulation results. The performance of various routing protocols viz. PRP, DSR, LEACH, OD-PRRP and proposed routing protocol PDORP are compared using delay, bit error rate, and throughput metrics. The bits are processed at a rate of 512bytes/Sec. The sizes of the packets are 100. The packets are taking 200 sec to deliver the packets to the destination that is the simulation time for each simulation scenario. The numbers of nodes used are 500. Below Fig. 5. represents the simulation model,

in which hybridization of PEGASIS with DSR has been done by considering the direction concept of PEGASIS and cache concept of DSR, in addition with two optimization techniques i.e. GA and BFO.

The various simulation parameters used in the research are shown below.

1. Width of the network: 1000 m
2. Height of the network: 1000 m
3.  $E_A$  = AggregationEnergyofthenodes
4.  $E_T$  = Energyconsumptionattransferofpacket;
5.  $E_R$  = Energyconsumptionatreceivingpackets.
6. Network Type: GPS
7. Nodes: 100 to 500
8. Network.Allocation: Random
9. Network.Coverage:  $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
10. Network.Caching: DSR cache
11. Network.Routing: PEGASIS Inspired.

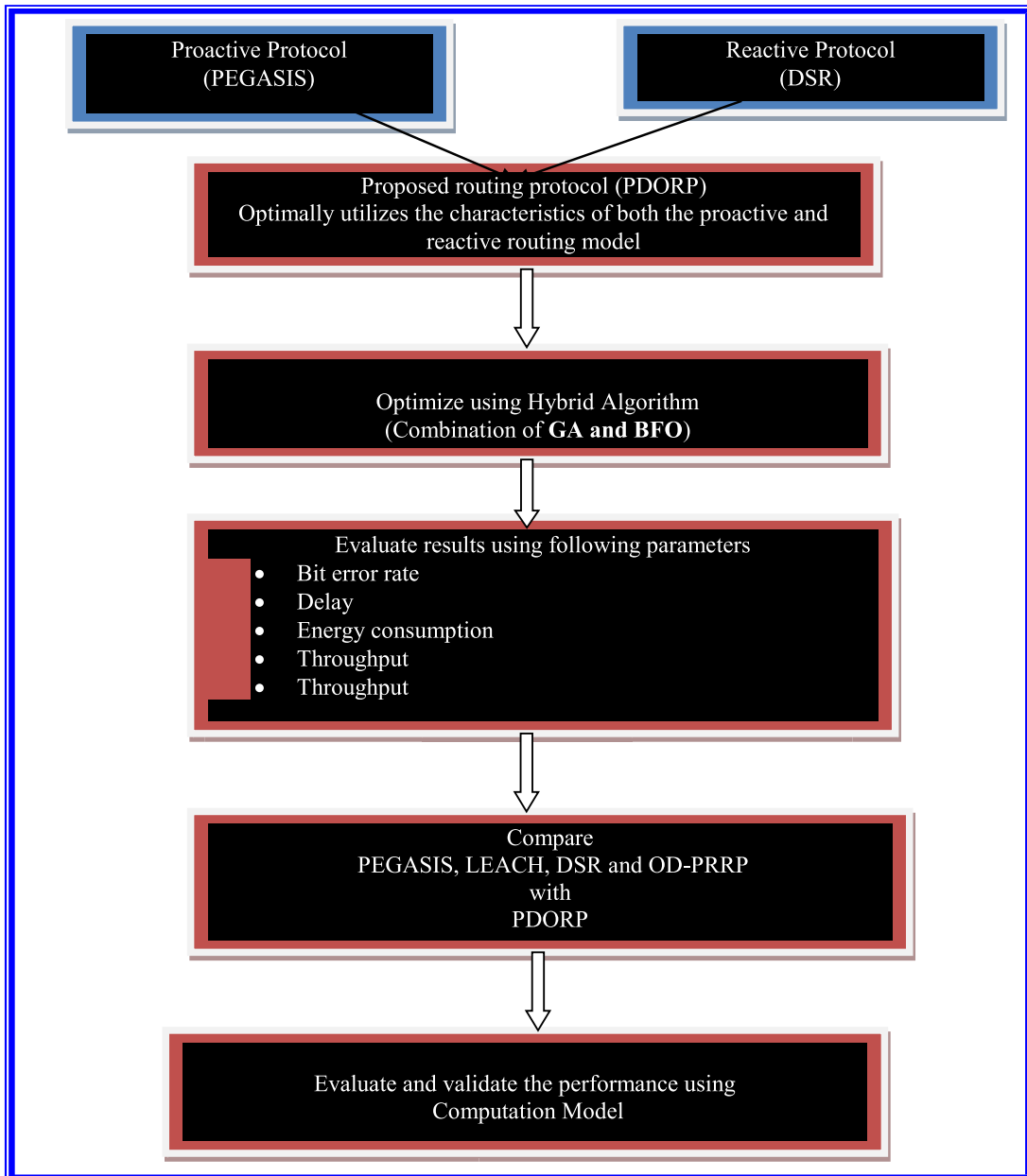


FIGURE 5. Simulation model.

#### A. COMPARISON BASED ON VARIOUS PARAMETERS WITH VARYING NUMBER OF SENSOR NODES

##### 1) END TO END TRANSMISSION DELAY

This parameter signifies the total amount of time taken by a packet from source to destination including transmission delay, queuing delay, propagation delay and processing delay. However an increase in the numbers of nodes also increases the difference of delay. The delay in transmission of a data packet is the amount of time between sending data packet by source node and receipt of same at the destination node. Fig. 6. demonstrates the results for end-to-end delay with varying number of sensor nodes. It has been observed that

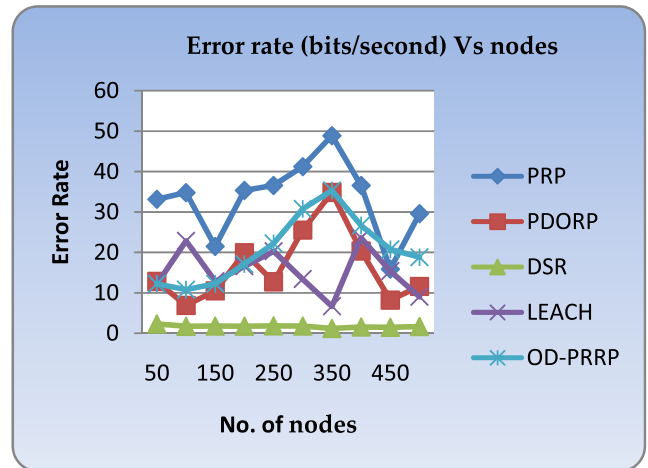
end to end delay for OD-PRRP increases with increase in the number of nodes. In addition, results show that proposed routing protocol PDORP marginally outperforms than LEACH, DSR, PEGASIS and even from OD-PRRP while considering low packet delivery delay.

##### 2) BIT ERROR RATE

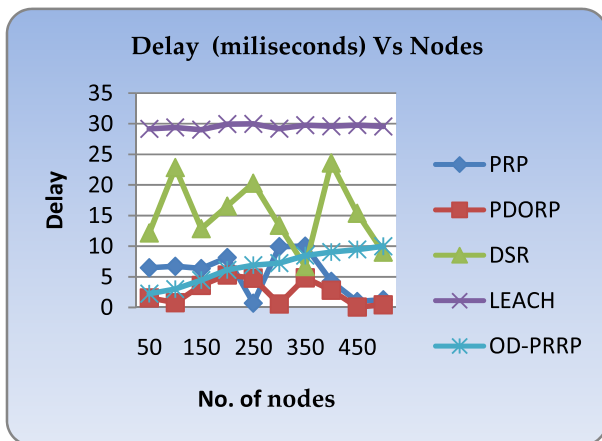
The metric defines the measure of the number of errors found in the network during packets sending. It has been seen that value of error rates has been enhanced in the attack. Fig. 7. clearly shows that DSR protocol has a less error rate as compared to the entire candidate routing protocols.

**Algorithm 4** Hybrid Algorithm (Action of GA and BFO)

1.  $f = (1 - \frac{ET_i + ER_i}{N} * rand)$  (8)
2. For  $i=1:N$
3. If round (f)==1
4. Node is accepted for BFO fitness check;
5.  $GAlist(Gaa)=I$ ;  $Gaa=Gaa+1$ ;
6.  $Trust\_value=0$ ;
7. Endif
8. End for;
9.  $t_r=0$ ;
10. For each K in GA list
11.  $g = 1 - (\frac{ET_k - (\sum_{l=1}^N ET_l)}{N})$  (9)
12. If  $g>0$ ,  $New\_trust=Rand$
13.  $t_r = t_r + 1$ ;
14.  $Node\_trust(t_r) = Node\_trust(t_r) + New\_trust$ .
15. Endforeach.



**FIGURE 7.** Comparison of bit error rate with varying number of sensor nodes.



**FIGURE 6.** Comparison of end to end delay with varying number of sensor nodes.

Moreover the proposed algorithm PDORP performs better than PRP, OD-PRRP and sometimes from LEACH as well. When a node becomes more aggressive at the time of transfer and previously it was not in the cache memory, the other node is bound to receive a packet from it and in such a way it can cause damage to existing routes. So the proposed solution creates trusties for the first time in each round on the basis of the parameters allocated to the nodes which results in less chance of attack and less bit error rate.

**3) ENERGY CONSUMPTION**

This generates lowering of the number of transmissions for the forwarded messages to all the group members. It is defined as the sum of units required for the key transmission throughout the duration of the simulation. The energy consumption formula for transmitting the data is:

$$E_{Tx}(k, d) = E_{elec} * k + Camp * k * d^2, d > 1$$

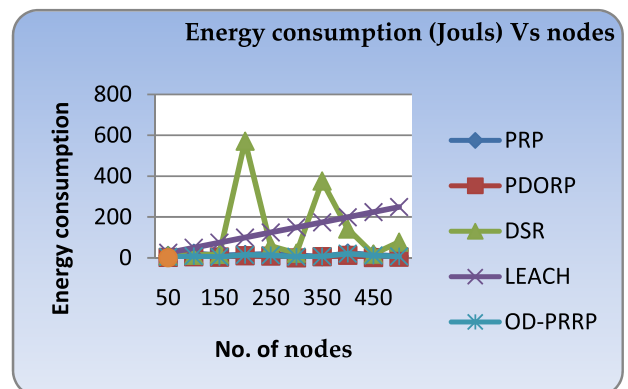
Energy consumption formula of receiving data:

$$E_{Rx}(k) = E_{elec} * k$$

Where k is the data volume to be transmitted, d is the distance among the two sensors.  $E_{elec}$  is the energy consumption to take out the data transmission in terms of nJ/bit.

Therefore, the total energy consumed =  $\sum E_{Rx} + \sum E_{Tx}$ , i.e. the total consumed energy of data receiving + total consumed energy of data transmitting.

From the below Fig. 8. it has been observed that PRP and new routing protocol PDORP outperforms than DSR, LEECH and OD-PRRP. The energy consumption of proposed algorithm is almost stable even with increase in number of nodes. In terms of energy consumption parameter PDORP will act as optimal routing protocol.



**FIGURE 8.** Comparison of energy consumption with varying number of sensor nodes.



TABLE 2. Comparison values of various parameters with varying number of nodes.

Algorithms Metrics	No. of nodes	DSR	LEACH	PEGASIS	OD-PRRP	PDORP
BER	100	1.739	22.858	34.792	10.789	6.878
	200	1.766	16.563	35.329	17.112	19.932
	300	1.793	13.415	41.220	30.776	25.521
	400	1.570	23.592	36.560	26.663	20.351
	500	1.668	9.029	29.590	18.825	11.595
Delay	100	21.585	29.391	6.709	2.989	0.766
	200	17.631	29.941	8.131	6.123	5.287
	300	14.415	29.185	9.915	7.234	0.538
	400	22.299	29.589	4.258	9.023	2.803
	500	10.902	29.556	1.253	9.989	0.420
Energy consumption	100	13.454	49.921	20.518	7.996	5.969
	200	571.604	99.847	17.656	14.927	10.660
	300	23.295	149.799	13.415	5.786	0.235
	400	141.511	199.699	24.492	20.892	12.488
	500	77.456	249.653	8.102	7.341	4.128
Throughput	100	28.912	38.824	0.723	4.987	0.785
	200	18.175	33.190	0.342	2.221	0.509
	300	20.139	31.589	0.773	0.559	0.831
	400	21.584	30.132	0.889	0.500	0.944
	500	18.469	32.177	0.376	0.355	0.452

(Number of parameters)  $n = 4$

(Number of algorithms)  $m = 5$

The value of N-Matrix corresponding to  $m$  qualities  $N = \{n_1, n_2, \dots, n_4\}$

$N = \{0, 0, 0, 1\}$

The maximum normalized values in  $c$ -matrix corresponding to  $m$  qualities are

$C = \{50, 50, 1000, 50\}$

4) THROUGHPUT

This metric describes the average rate of successful messages delivered over the network in a given time. As shown in Fig. 9. LEACH protocol is better than all other candidate algorithms. DSR is also better than PRP, PDORP and OD-PRRP protocols. It is clearly indicated by the results that LEACH outperforms in throughput oriented applications. The performance of PRP, PORP and OD-PRRP is almost similar in case of throughput.

B. COMPARISON BASED ON VARIOUS PARAMETERS WITH VARYING NUMBER OF ROUNDS

It has been observed from Fig. 10. that proposed method outperforms than OD-PRRP, LEACH, DSR and PEGASIS while considering bit error rate, end to end transmission delay and energy consumption metrics with varying number of nodes with varying number of nodes (Table 2 and Table 3). In case of throughput metric LEACH is better than all other candidate routing protocols, on the other hand LEACH is unsuitable for the applications where energy consumption is a key constraint. The energy consumption of proposed

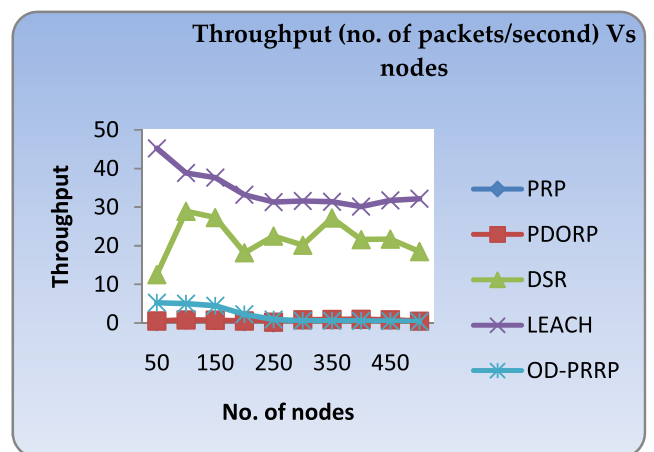


FIGURE 9. Comparison of throughput with varying number of sensor nodes.

algorithm is almost stable even with the increase in number of rounds. In terms of energy consumption parameter PDORP will act as optimal routing protocol. It has been observed

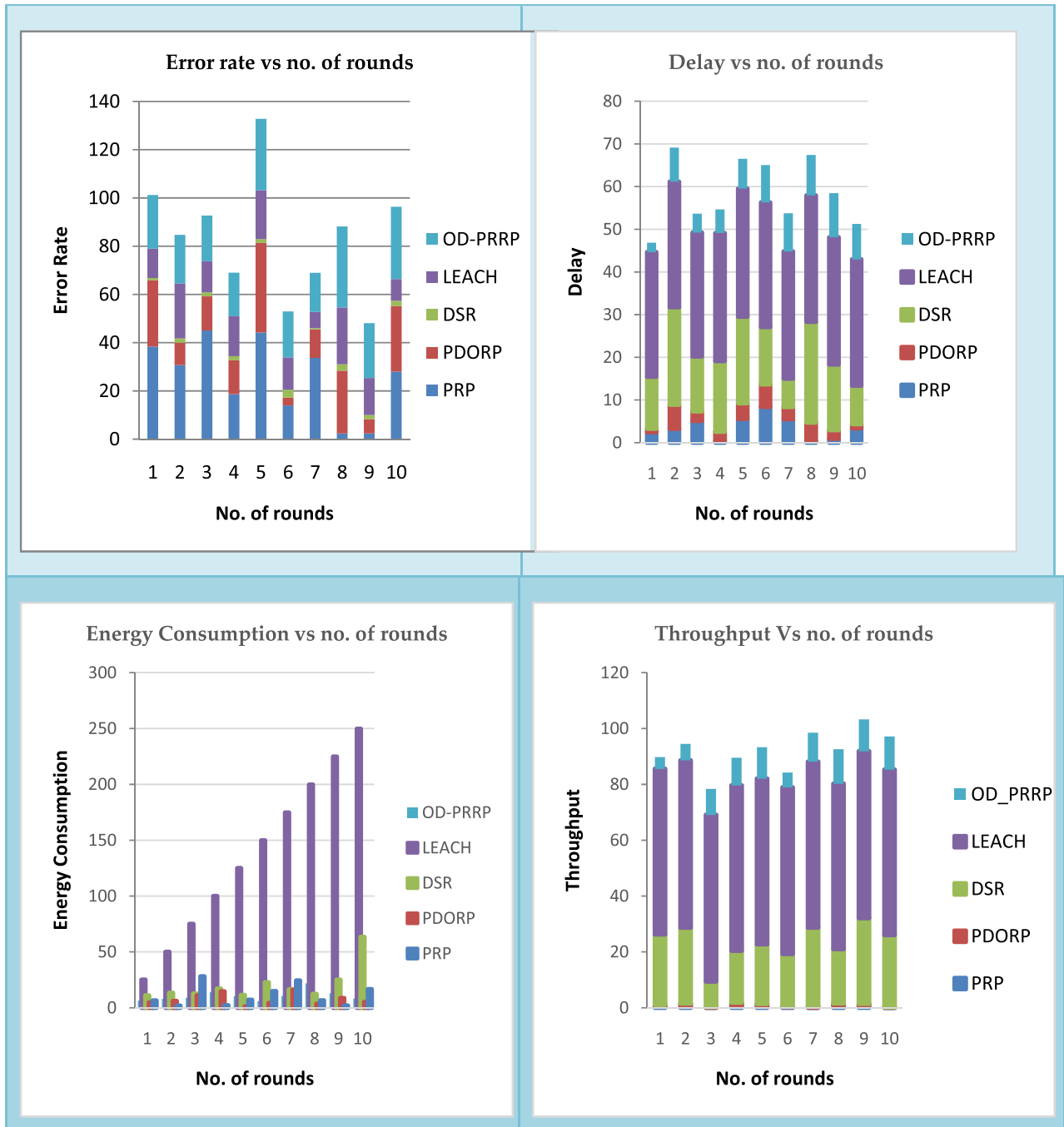


FIGURE 10. Comparison of various parameters with varying number of rounds.

that end to end delay for OD-PRRP increases with increase in number of rounds. In addition, results show that proposed routing protocol PDORP marginally outperforms than LEACH, DSR, PEGASIS and even from OD-PRRP while considering low packet delivery delay.

**VI. EVALUATION MODEL**

Assume a set of  $n$  candidate algorithms,  $A1, A2, A3, \dots$  and suppose  $m$  parameters are selected to evaluate these

algorithms, we can achieve the following matrix.

$$Q = \begin{bmatrix} q_{1,1} & q_{1,2} & \dots & \dots & \dots & q_{1,m} \\ q_{2,1} & q_{2,2} & \dots & \dots & \dots & q_{2,m} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ q_{n,1} & q_{n,2} & \dots & \dots & \dots & q_{n,m} \end{bmatrix}$$

To compare  $n$  algorithms, the grid  $Q$  should be standardizing [27]–[28]. The reasons of standardization are:

- Consistent evaluation of all the parameters

TABLE 3. Average score of various algorithms.

Metrics Algorithms	BER	Delay	Energy consumption	Throughput
DSR	1.707	17.36	165.4	21.45
LEACH	17.09	29.53	149.7	33.18
PEGASIS	35.49	6.05	16.83	0.62
OD-PRRP	20.83	7.07	11.38	1.72
PDORP	16.85	1.962	6.69	0.70

- Uniform index to represent algorithm parameters
- Setting a maximum normal value for each parameter
- Result remains independent of units.

A. NORMALIZATION PROCEDURE

With a specific end goal to standardize framework Q, First we have to depict two clusters.

- The principal cluster is  $N = \{n_1, n_2, n_j \dots n_m\}$  with  $1 \leq j \leq m$ . Here the estimation of  $n_j$  can be either 0 or 1. The estimation of  $n_j$  will be 1 for the situation where the expansion of  $q_i, j$  advantages the algorithm and  $n_j=0$  is the place the decrease of  $q_i, j$  advantages the algorithm.

The second cluster is  $C = \{c_1, c_2, c_j \dots c_m\}$ . Here  $c_j$  is a steady that sets the most extreme standardized quality comparing to the parameter. Every

- component in framework Q will be standardized utilizing the accompanying mathematical statement.

Here  $(1/n) \sum q_i, j$  is the normal estimation of parameter  $q_j$  over n algorithms.

The summation  $\sum$  is over  $i = 1$  to  $n$ .

$$\begin{cases} q_{i,j}/(1/n) \sum q_{i,j} < c_j \text{ and } n_j = 1 \\ c_j \text{ if } (1/n) \sum q_{i,j} = 0 \text{ and} \\ n_j = 1 \text{ or } q_{i,j}/(1/n) \sum q_{i,j} \geq c_j \\ V_{i,j} = (1/n) \end{cases}$$

$$\sum q_{i,j}/q_{i,j} \text{ if } q_{i,j} \neq 0 \text{ and}$$

$$(1/n) \sum q_{i,j}/q_{i,j} < c_j \text{ and } n_j = 0$$

$$c_j \text{ if } q_{i,j} = 0 \text{ and } n_j = 0$$

$$\text{or } (1/n) \sum q_{i,j}/q_{i,j} \geq c_j$$

Applying this equation to Q, we get matrix Q' as follows:

$$Q' = \begin{bmatrix} v_{1,1} & v_{1,2} & \dots & \dots & \dots & v_{1,m} \\ v_{2,1} & v_{2,2} & \dots & \dots & \dots & v_{2,m} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ v_{n,1} & v_{n,2} & \dots & \dots & \dots & v_{n,m} \end{bmatrix}$$

$$V = \begin{pmatrix} 10.77 & 0.71 & 0.42 & 1.85 \\ 1.07 & 0.41 & 0.46 & 2.87 \\ 0.51 & 2.04 & 4.15 & 0.05 \\ 0.88 & 1.75 & 6.15 & 0.14 \\ 1.09 & 6.31 & 10.46 & 0.06 \end{pmatrix} = \begin{pmatrix} 13.77 \\ 4.84 \\ 6.77 \\ 8.93 \\ 17.93 \end{pmatrix}$$

The aggregate score of candidate algorithms are:

- The score for algorithm-1 (DSR) is =13.77
- The score for algorithm-2 (LEACH) is = 4.84
- The score for algorithm-3 (PEGASIS) is = 6.77
- The score for algorithm-4 (OD\_PRRP) is = 8.93
- **The score for algorithm-5 (PDORP) is = 17.93.**

VII. CONCLUSION

In this paper, we presented hybrid optimization based PEGASIS-DSR optimized routing protocol (PDORP), which has used cache and directional transmission concept of both proactive and reactive routing protocols. The simulation results of our proposed protocol show reduction in end to end transmission delay and bit error rate without compromising with energy efficiency. In PDORP, both the proactive routing and reactive routing methodology have been used in order to obtain fast and non-damaged path along with lower transmission delay. The performance of PDORP has been evaluated by comparing with existing available methods viz. PEGASIS, LEACH, DSR and OD-PRRP and the results indicated that it performs better in most significant parameters viz Bit error rate, end to end transmission delay, energy consumption and throughput. The method can be applied for the design of several types of sensor networks that require reliability, energy efficiency, scalability, prolonged network lifetime, and low end to end transmission delay without requiring location information e.g. During secured battlefield surveillance, habitat monitoring and underwater monitoring. The performance of the proposed method has also been evaluated and validated using the computation model and validated the proposed scheme. In future the proposed work will be extended to perform in dynamic environments.

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