ENERGY EFFICIENT DIRECTION BASED ROUTING PROTOCOL FOR WSN

Syed Mohd Ali

Research Scholar ECE dept., JNTUH, Kukatpally, Hyderabad, India

Syeda Gauhar Fatima

Professor ECE dept, Deccan College of Engineering and Technology,

Darussalam, Hyderabad, India

Syeda Kausar Fatima

Associate Professor, Shadan College of Engineering and Technology, Hyderabad, India

Dr Syed Abdul Sattar

Principal, Nawab Shah Alam College of Engineering and Technology, Hyderabad, India

ABTRACT

Energy consumption is one of the limitations 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 core cause of more energy consumption and damage the QoS in sensor networks. In WSN, there are several routing protocols which are used to improve the performance of the network. Out of those protocols, Dynamic Source Routing (DSR) protocol is more appropriate in terms of small energy density, but sometimes when the mode of a node changes from active to sleep, the effectiveness decreases as the data packets needs to wait at the initial point where the packet has been sent and this increases the waiting time and end to end interruption of the packets which leads to increase in energy consumption. Our problem is to recognize the dead nodes and to choose another suitable path so that the data transmission becomes smoother and less energy gets preserved. In order to resolve these issues, we propose directional transmission-based energy aware routing protocol named as PDORP. The proposed protocol PDORP has the characteristics of both Power Efficient Gathering Sensor Information System (PEGASIS) and DSR routing protocols. In addition, hybridization of Genetic Algorithm (GA) and Bacterial Foraging Optimization (BFO) 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 ingesting and better throughput which leads to better QoS and prolong the lifetime of

Syed Mohd Ali, Syeda Gauhar Fatima, Syeda Kausar Fatima and Dr Syed Abdul Sattar,

the network. Moreover, the Computation Model is adopted to evaluate and compare the performance of the both routing protocols using soft calculating techniques.

1. INTRODUCTION

In Wireless sensor networks (WSNs), the main source of lifetime for the hubs is the battery. Communicating with different hubs or identifying activities expends a great amount of energy in preparing the information and transferring the collected information to the sink [1-3]. As several cases, it is undesirable to supplant the batteries that are draining or depleted of energy. Many 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 efficiency issues but they have their own assumptions [4].

For the optimization of WSN designs, investigators 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 processes do not take into account the principles, characteristics and requirements of WSN which is application defined. Therefore, in planned 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 enfolded to scale back the data size. Various algorithms such as in-network data handling is actually made to scale back energy consumption when compared to transferring the raw data towards end node. The routing layer as well as MAC layer is usually optimized by simply choosing correct protocols to gain productivity. Node optimization can be achieved by simply strengthening battery utilization as well as applying 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 studies in the routing algorithms. Closely deployed nodes tolerate from many failures due to drained battery power, environmental conditions etc. Dynamic topology of WSN postures 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 classified into two types, dynamic and static:

Dynamic energy consumption can also be computed as:

$$E_{Dynamic} = A.\,C.\,\square^{\square}\,v^2 \tag{1}$$

Where: A= active gates, C= capacitance load, v^2= supply

voltage, f= frequency

Then it can be written as:

$$E_{Dynamic} = \Box\, E_{Dynamic}.\, \Delta\, t \qquad\qquad (2)$$

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

$$E_{Dynamic}\ \Box\ E_{static} \qquad\qquad (3)$$

Thus whole energy consumption computed as:

$$E = {}_{mic} \qquad\qquad (4)$$

It is determined from literature, that extra energy is consumed by the nodes in the role of CH. Therefore the number of cluster heads must be optimum. To balance the burden on the nodes several techniques are working such as: 1) rotate in the role of CH 2) election of CHs according to some formula 3) to improve 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 presentation of proposed routing protocol PDORP is compared with other routing methods such as PEGASIS, DSR, LEACH, and ERP.

Furthermore the calculation Model is adopted to evaluate, compare and validate the performance of the proposed routing protocol.
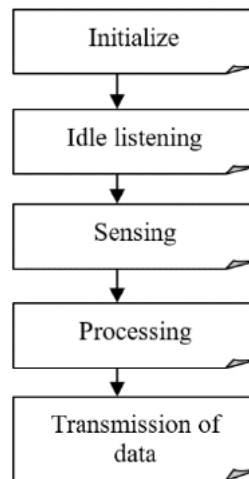
Syed Mohd Ali, Syeda Gauhar Fatima, Syeda Kausar Fatima and Dr Syed Abdul Sattar,

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.

2. RETELATED 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 OnDemand 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.

TABLE 1. Literature Review

Author	Technique	Merits	Problem
[19] Aarti Jain et.al	Fuzzy logic and ACO based OD-PPRP routing	OD-PRRP 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	Newton divided the results show that there is a significant	AODVLP can be further Yadav et.al difference reduction in packet drops and end-to-end improved by limiting overhead	interpolation for link delay parameters and improvement in data of unnecessary control messages prediction method packet delivery ratio for AODV with link prediction

To solve the above discussed problems in the table 1, [1925], 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.

3. 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:

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

(5)

Here, P_i is the received signal power at the distance *dist* from a transmitter and α is the path loss exponent that varies in 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.

4. 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.

4.1. Algorithm1. Network creation

1. Network. height=1000
2. Network.Width=1000; N=Total_Nodes.
3. For each **n'** in **N**

$$counter = 1;$$
$$xloc(n') = 1000 * Random.$$
$$yloc(n') = 1000 * Random.$$
$$Node.\,name(n') = conuter;\ counter = counter + 1;$$

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

$$d = \sqrt{((x(i) - x(j))^2 + y(i) - y(j))^2};$$
$$= \frac{Network.width*20}{100};\qquad (6)$$

$$if\ (d \le th)\ cov\_set(i, 1) = i;$$
$$cov\_set(i, cov\_count) = j;$$
$$cov\_count = cov\_count + 1:$$
end if end for end for

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.

4.2. 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[possiblenoedcount] = all n; Possiblenodecount+=1;

Endif

9. Selection=possiblenodecount*Random;
10. Selected_node=Possible_nodes[selection];
11. Possible_Nodes=[   ];   Path(Path   element)   = selected_Node
12. END

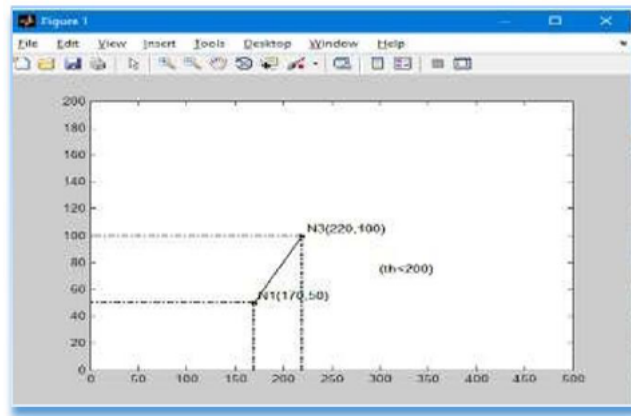Syed Mohd Ali, Syeda Gauhar Fatima, Syeda Kausar Fatima and Dr Syed Abdul Sattar,

Figure 2 Network Creation

(X axis=Number of rounds and Y axis=Number of Nodes)

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.
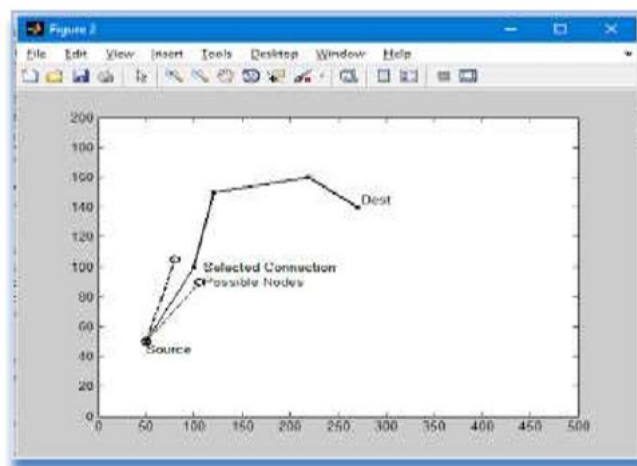

Figure 3 Path Finding

((X axis=Number of rounds and Y axis=Number of Nodes)

4.3. 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 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.

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.

4.4. Algorithm 3. Routing Cache DSR Integration (PDORP)

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

$$\Delta H = \frac{\sum^{N}_{j=1} EA + ET + ER}{N} \tag{7}$$

3. If(($E_{Ai} + E_{Ti} + E_{Ri}$)> 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)==Routingdistortionpossible Nodes)
10. if(isempty(d))
11. Accept Packet;
12. Else
13. Reject Packet;
14. End ;

4.5. Algorithm 4. Hybrid Algorithm (Action of GA and BFO)

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.

$$1.\ f = (1 - \frac{ET_i + ER_i}{N} * rand) \tag{8}$$

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. $g = 1 - (ET_k - (\sum^{N}_{l=1} E_T)/N)$
    (9)

12. If g>0, New_trust=Rand

13. $t_r = t_r + 1$;

14. Node_trust$(t_r) = Node\_trust(t_r) + New\_trust.$
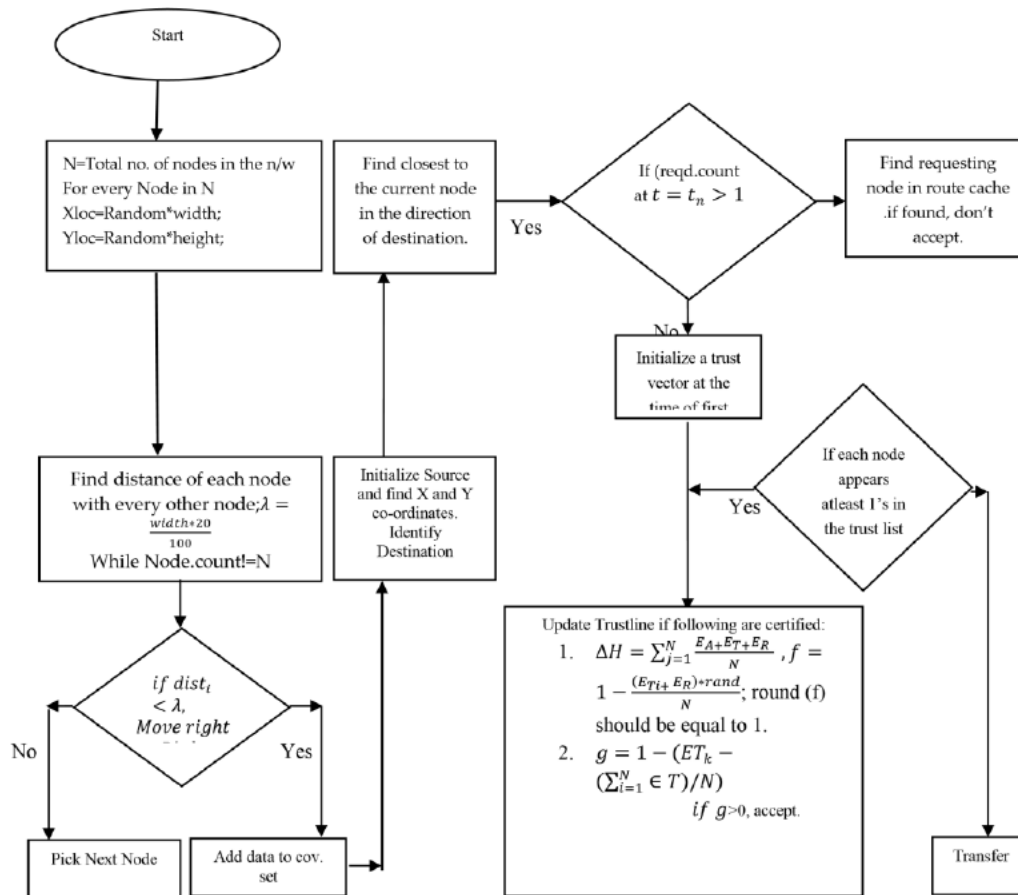

Figure 4 Flow chart of PDORP

15. Endforeach.

5. PERFORMANCE EALUATION

This segment 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 = Aggregation Energy of the nodes 4. E_T = Energy consumption at transfer of packet;
5. E_R = Energy consumption at receiving packets.
6. Network Type: GPS
7. Nodes: 100 to 500

8. Network.Allocation: Random
9. Network.Coverage: $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
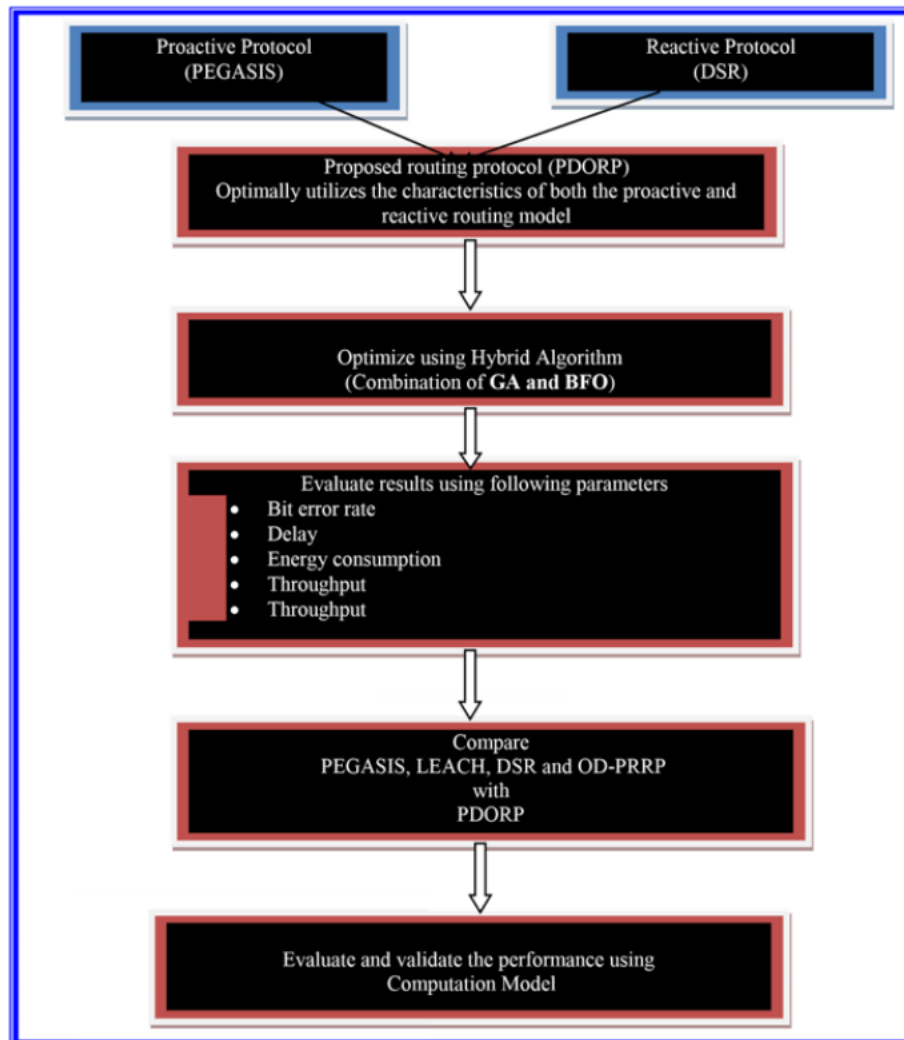10. Network.Caching: DSR cache
11. Network.Routing: PEGASIS Inspired

Figure 5 Simulation Model

5.1. Comparison based on various parameters with varying number of sensor nodes

5.1.1. End to End Transmission Delay

This parameter signifies the total amount of time taken by a packet from source to terminus including transmission delay, line up delay, transmission 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

Syed Mohd Ali, Syeda Gauhar Fatima, Syeda Kausar Fatima and Dr Syed Abdul Sattar,

PDORP marginally outperforms than LEACH, DSR, PEGASIS and even from OD-PRRP while considering low packet delivery delay.
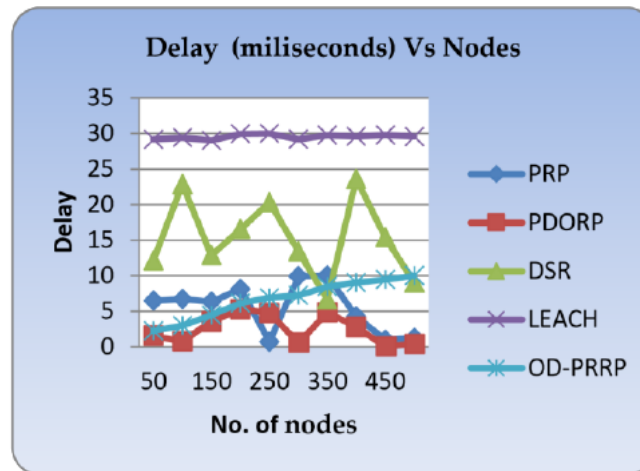

Figure 6 Comparison of end to end delay with varying number of sensor nodes

5.1.2. 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 improved in the attack. Fig. 7. clearly shows that DSR protocol has a less error rate as compared to the entire candidate routing protocols. Moreover the proposed algorithm PDORP performs better than PRP, OD-PRRP and sometimes from LEACH as well. When a node becomes more violent 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 assigned to the nodes which results in less chance of attack and less bit error rate.
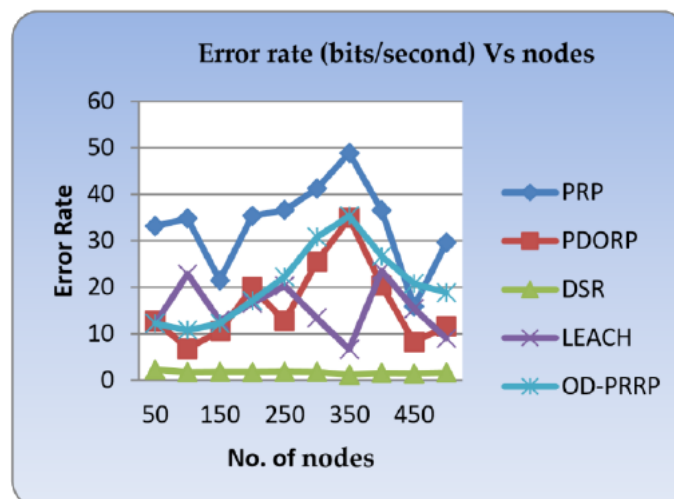

Figure 7 Comparison of bit error rate with varying number of sensor nodes

5.1.3. 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:

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

5.1.4. 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 leaning applications. The performance of PRP, PORP and OD-PRRP is almost similar in case of throughput.
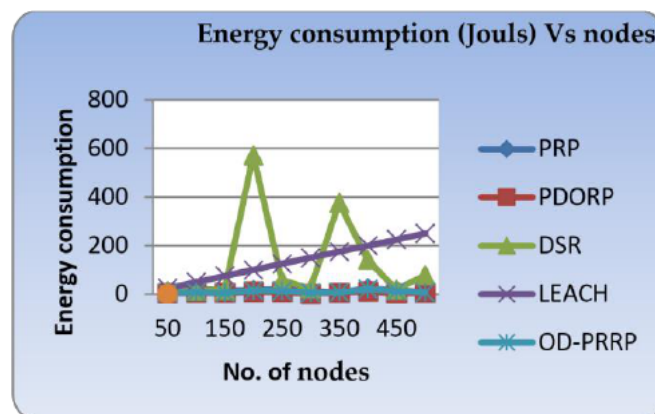

Figure 8 Comparison of energy consumption with varying number of sensor nodes

5.2. 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. In case of throughput metric LEACH is better than all other candidate routing protocols, on the other hand LEACH is inappropriate for the applications where energy consumption is a key constraint. . The energy consumption of proposed 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 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 outdoes than LEACH, DSR, PEGASIS and even from OD-PRRP while considering low packet delivery delay.

6. EVALUATION MODEL

Assume a set of *n* candidate algorithms, *A1, A2, A3……* and suppose *m* parameters are selected to evaluate these algorithms, we can achieve the following matrix.

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

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

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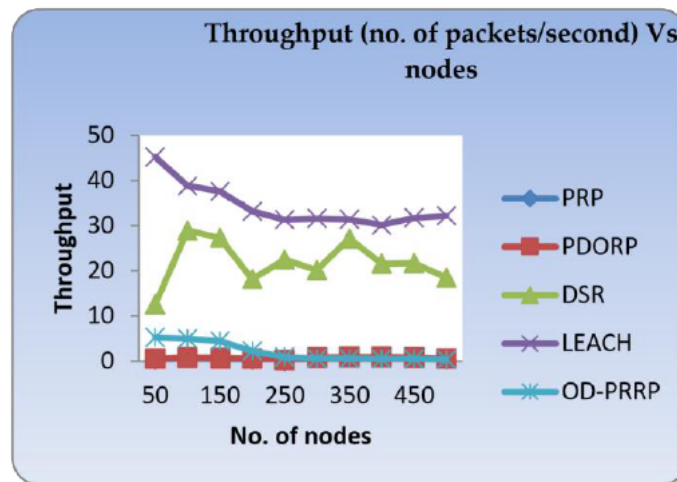- Result remains independent of units

Figure 9 Comparison of throughput with varying number of sensor nodes

6.1. Normalization Procedure

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

The principal cluster is N = {n1, n2, nj nm} with 1≤ j≤ m. Here the estimation of njj can be either 0 or 1.The estimation of nj will be 1 for the situation where the expansion of qi, j advantages the algorithm and nj=0 is the place the decrease of qi, j advantages the algorithm.

The second cluster is C= {c1, c2, cj… .cm}. Here cj 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) $\sum$ qi, j is the normal estimation of parameter qj over n algorithms.

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

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

$$0 \qquad \left\{ \begin{array}{l} j \qquad c \qquad\qquad if \; (1/n) \sum q_{i,} = \\[2em] n_j = 1 \; or \; q_{i,}/(1/n) \sum q_{i,j} \\ \qquad\qquad\qquad\qquad \geq c_j \\[1em] V_{i,} = \quad (1/n) \end{array} \right.$$
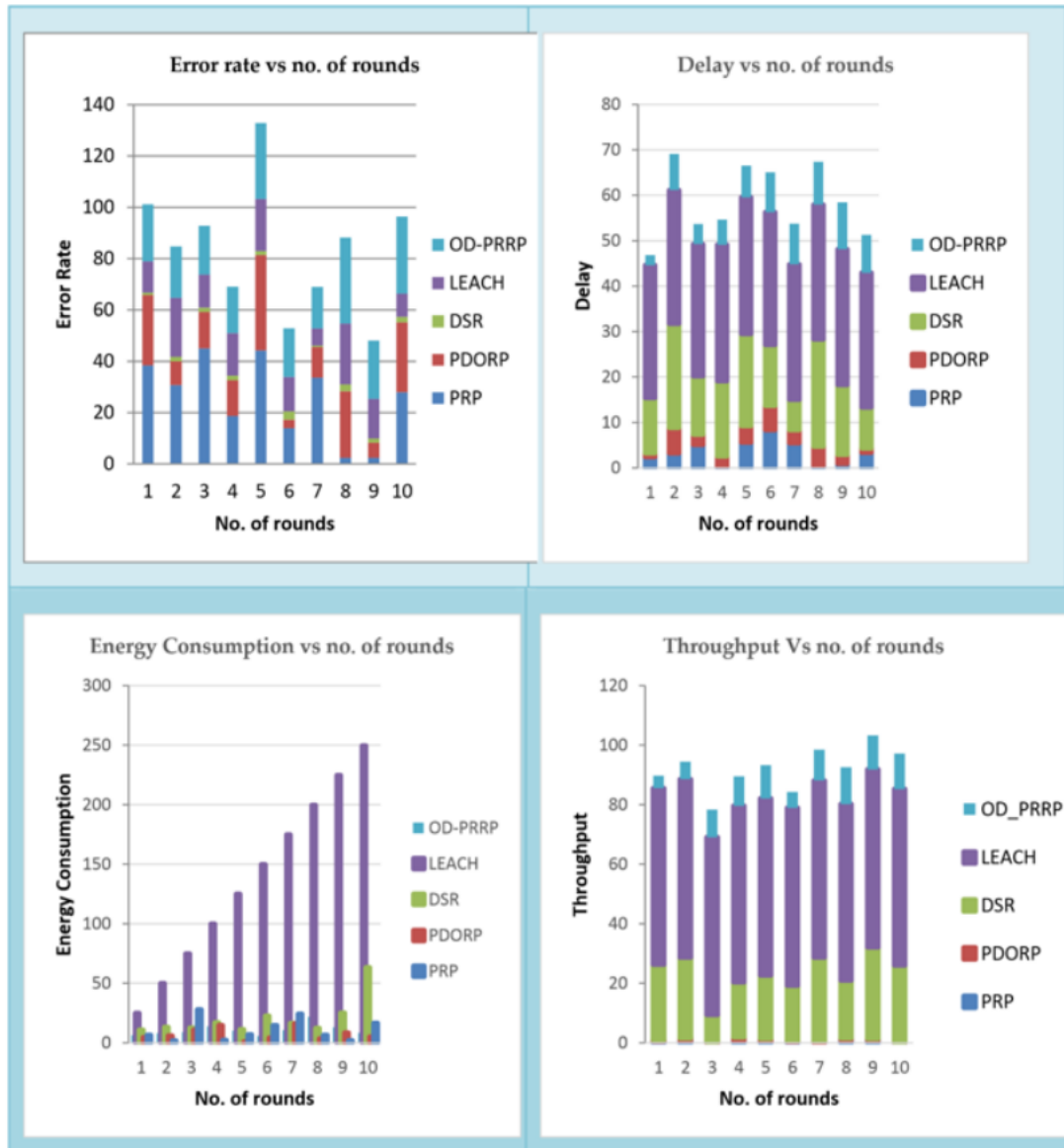

Figure 10 Comparison of various parameters with varying number of rounds

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

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

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

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

$$v1,1 \qquad v1,2 \ldots \ldots \ldots \qquad v1,m$$

$$Q' = [v2,1 \qquad v2,2 \ldots \ldots \ldots \qquad v2^{,m}\ldots]$$

$$vn,1 \qquad vn,2 \ldots \ldots \ldots \qquad vn,m$$

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, ..., n_4} N = {0, 0, 0, 1}

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

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

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

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

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

7. CONCLUSION

In this paper, we presented hybrid optimization based PEGASIS-DSR optimized routing protocol (PDORP), which has used cache and directional communication 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.

PDORP	16.85	1.962	6.69	0.70

PEGASIS, LEACH, DSR and OD-PRRP and the results indicated that it performs better in most important parameters viz Bit error rate, end to end transmission delay, energy ingesting and throughput. The method can be applied for the design of several types of sensor networks that require dependability, 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 authenticated using the calculation model and validated the proposed scheme. In future the proposed work will be extended to perform in dynamic environments.

ACKNOWLEDGMENT

REFERENCES

[1]   M. Merck."The icecube detector: A large sensor network at the south pole". *IEEE Pervasive Computing*, 2010, vol. (4), pp 43-47.

[2]   Y.-C. Wang; W.-C.Peng ; Y.-C.Tseng. "Energy-balanced dispatch of mobile sensors in a hybrid wireless sensor network". *IEEE Transactions on Parallel Distributed Systems.* 2010, vol-21, pp 1836-1850.

[3]   B.K. Panigrahi, V. Ravikumar Pandi, "Bacterial foraging optimisation: Nelder–Mead hybrid algorithm for economic load dispatch", *IET Generation Transmission Distribution*, 2008, vol. 2, no. 4, pp. 556-565,

[4]   T. H. Feiroz Khan and D. Sivakumar, "Performance of AODV, DSDV and DSR protocols in mobile wireless mesh networks," Second International Conference on Current Trends In Engineering and Technology - ICCTET 2014, Coimbatore, 2014, pp. 397-399.

[5]   Mesh Networks", *IEEE 2nd International Conference on Current Trends in Engineering and Technology*,2014, Coiambtore, pp 397-399.

[6]   Chen Han-ning, Zhu Yun-long, Hu Kun-yuan, "Cooperative bacterial foraging algorithm for global optimization", *IEEE Chinese control and decision conference,* Guilin, China, 2009, vol. 6, pp 3896-3901.

[7]   D. Johnson, Y. Hu, and D. Maltz, "The Dynamic Source Routing Protocol for Nodes Ad Hoc Networks (DSR) for IPv4", *IETF RFC 4728*, 2007, vol. 15, pp. 153-181.

[8]   Dong Hwa Kim, Ajith Abraham, and Jae Hoon Cho, "A hybrid genetic algorithm and bacterial foraging approach for global optimization", *Informmation Sciences*, 2007, vol.-177, issue-18, pp. 3918-3937.

[9]   Chang Wook Ahn, R. S. Ramakrishna, "A Genetic Algorithm for Shortest Path Routing Problem and the Sizing of Populations", *IEEE transactions on evolutionary computation,* Dec. 2002, vol. 6, no. 6, pp 566-579.

[10]   J. Carretero, F.Xhafa, & A.Abraham. "Genetic algorithm-based schedulers for grid computing systems". *International Journal of Innovative Computing, Information and Control*, 2007, vol 3(7), pp. 247-272.

[11]   L.G. Quesada. "A Routing Protocol for MANETs", *In Master of Science in Communication Technology thesis*, 2007,(http://brage.bibsys.no/xmlui/handle/11250/261916)

[12]   H. AlAamri, M. Abolhasan, and T. Wysocki, On Optimising "Route Discovery in Absence of Previous Route Information in MANETs", Proc. *IEEE Vehicular Technology Conference (VTC), Barcelona, 2009,*pp. 1-5.

[13]   H. Shen, Y. L. Zhu, X. M. Zhou, H. F. Guo, C. G. Chang, "Bacterial foraging optimization algorithm with particle swarm optimization strategy for global numerical optimization", *World Summit on Genetic and Evolutionary Computation,* 2009, Shanghai, China, pp. 497-504.

[14]   Kou Pan-gao, Zhou Jian-zhong, "Optimal PID Governor Tuning of Hydraulic Turbine Generators with Bacterial Foraging Particle Swarm Optimization Algorithm". In *Proceedings of the CSEE*, 2009, Vol. 29(26), pp 101-106.

[15]   Kevin M.Passino, "Biomimicry of bacterial foraging", *IEEE Control System Magazine,*2002, vol. 22, pp. 52–67.

[16]   W.B.Heinzelman. "Application-Specific Protocol Architectures for Wireless Networks" *PhD. thesis, Massachusetts Institute of Technology. Cambridge,* MA, USA, June 2000.

[17]   Q.F.Jiang, D. Manivannan. "Routing protocols for sensor networks". *In proceedings of Conference on Consumer Communications and Networking,* Las Vegas, NV, USA, 2004, pp. 93-98.

[18]   S. Lindsey, C.S. Raghavendra. PEGASIS: "Power Efficient gathering in sensor information systems". *In Proceedings of IEEE Aerospace Conference,* Big Sky, MT, USA, March 2002, pp 1125-1130.

[19]   Shalli Rani, Jyoteesh Malhotra, Rajneesh Talwar, "Energy efficient chain based cooperative routing protocol for WSN", *Applied Soft Computing*. July (2015), vol-35, pp 386-397.

[20]   Aarti Jain and B. V. Ramana Reddy."A Novel Method of Modeling Wireless Sensor Network Using Fuzzy Graph and Energy Efficient Fuzzy Based k-Hop Clustering Algorithm". *Wireless Personal Communications.* 2015, vol 82(1), pp. 157-181.

[21]   Jing Liu, Xing-Guo Luo, Xing-Ming Zhang, Fan Zhang and Bai-Nan Li, "Job Scheduling Model for Cloud Computing Based on Multi-Objective Genetic Algorithm*", IJCSI International Journal of Computer Science Issues,* Vol. 10, Issue 1, No 3, January 2013, pp 134-139

[22]   Akimitsu Kanzaki, Yasuhiro Nose, Takahiro Hara, & Shojiro Nishio, "Dynamic Route Construction Based on Measured Characteristics of Radio Propagation in Wireless Sensor Networks", *International Journal of Advanced Computer Science*, vol. 2, No. 3, Pp. 85-98, Mar. 2012.

[23] Young-Duk Kim, Kook-Rae Cho, Hui-Sup Cho, and Dongkyun Kim. 2014. "A Cross-Layer Channel Access and Routing Protocol for Medical-Grade QoS Support in Wireless Sensor Networks". *Wireless Personal Communications,*2014, vol. 77 (1), pp 309-328.

[24] Minwoo Jung, Kabsu Han, Jeonghun Cho, "Advanced verification on WBAN and cloud computing for u-health environment", *Multimedia Tools,* August 2015, Vol. 74, Issue 16, pp 6151-6168

[25] Kwnagcheol Shin, Soontae Kim, "Predictive routing for mobile sinks in wireless sensor networks: a milestonebased approach", *The Journal of Supercomputing,* Dec 2012, Volume 62, Issue 3, pp 1519-1536

[26] Anita Yadav, Y. N. Singh, SMIEEE and Raghuraj Singh, "Cross Layer Design for Power Control and Link Availability in Mobile Adhoc Networks", *International Journal of Computer Networks & Communications (IJCNC)* Vol.7, No.3, May 2015

[27] T.S. Rappaport. *Wireless communications: Principles and practice*, 1996, (Vol. 2). New Jersey: Prentice Hall PTR.

[28] G. S. Brar, R. Singh, "A Quality Computation Model for Software Artifacts", *International Journal of Computer Applications*, Vol. 25(6), 2011, pp 38-42.

[29] Liang Z. Zeng. "QoS computation and policing in dynamic web service selection", *Proceedings of the 13th international World Wide Web conference on Alternate track papers & posters - WWW Alt*, ACM, New York, NY, USA, *2004* pp 66-73. Doi:10.1145/1013367.1013379.

[30] Shallli Rani, Rajneesh Talwar, Jyoteesh Malhotra,S.H. Ahmed, M.Sarkar, & Houbing Song. "A Novel Scheme for an Energy Efficient Internet of Things Based on Wireless Sensor Networks". *Sensors,* 15(11), (2015). pp.28603-28626.

[31] Kumar. R & Kumar, D. Multi-objective fractional artificial bee colony algorithm to energy aware routing protocol in wireless sensor network. Wireless Networks, pp 1-14.

[32] Kumar, R., & Kumar, D. Hybrid Swarm Intelligence Energy Efficient Clustered Routing Algorithm for Wireless Sensor Networks. *Journal of Sensors,* 501, (2016). Paper ID 5836913.

[33] Kirankumar Y. Bendigeri and Jayashree D. Mallapur. Advanced Remote Monitoring of a Crop in Agriculture using Wireless Sensor Network Topologies, International Journal of Electronics and Communication Engineering & Technology, 6(9), 2015, pp. 30-38

[34] K. Raghava Rao, Monika Vallabhaneni, Srikanth Narayanaraju, Rajendra Kumar Jonnalagadda and Sunilkumar kanaparthi, Air Pollution Monitoring Using Zigbee Based Wireless Sensor Networks, International Journal of Electronics and Communication Engineering & Technology (IJECET), Volume 5, Issue 5, May (2014), pp. 56-63

[35] Shobha Biradar and Mallikarjuna Shastry P.M., An Efficient Approach for Providing Full Connectivity in Wireless Sensor Network. International Journal of Computer Engineering & Technology, 9(6), 2018, pp. 140–154.

[36] Rashid M. Awadi, Rawya Y. Rizk, Mohamed I. Habib and Amira A. M. Elsonbaty, An Efficient Cluster Head Selection Scheme for Dynamic Sleep Time in Wireless Sensor Network, International Journal of Electronics and Communication Engineering & Technology (IJECET), Volume 4, Issue 6, November-December, 2013, pp. 01-13

[37] R.S. Raghav, Sujatha Pothula, Dhavachelvan Ponnurangam, An Enriched Artificial Bee Colony (EABC) Algorithm for Detection of Sinkhole Attacks in Wireless Sensor Network, International Journal of Mechanical Engineering and Technology (IJMET), 8(8), 2017, pp. 193-202

[38] S.V.Annlin Jeba and Dr.B. Paramasivan, An Evaluation of En-Route Filtering Schemes on Wireless Sensor Networks, International Journal of Computer Engineering and Technology (IJCET), Volume 3, Issue 2, July- September (2012). Pp. 62-73.