CHAPTER 4

Performance over Proactive and Reactive Routing Using Soft Computing Approaches
CHAPTER 4

PERFORMANCE OVER PROACTIVE AND REACTIVE ROUTING USING SOFT COMPUTING APPROACHES

4.1 INTRODUCTION

This chapter highlights the optimization of energy in Wireless Sensor Network (WSN) through routing. Energy optimization is used to enhance the lifetime of the WSN, making it energy efficient. For better efficiency, additional data packets suppose to be transmitted with minimum Routing Overhead (RO) and small Bit Error Rate (BER). In the present critique, the performance of proactive and reactive routing algorithm is to be evaluated. Soft computing techniques for routing protocol i.e. Genetic Algorithm (GA) and Bacterial Foraging Optimization (BFO) have been applied individually on Destination Sequence Distance Vector (DSDV) and Dynamic Source Routing (DSR) routing protocols. Moreover, hybridization of GA and BFO is to be applied on both routing protocols. Two CAES’s are to be considered, in CASE-1 (20-60) and in CASE-2 (50-500) nodes are to be considered. Analysis demonstrates that normalized overall DSDV score for GA, BFO and Hybrid are 5.886, 5.845 and 7.716 respectively. Similarly the normalized DSR score for GA, BFO and Hybrid in CASE-1 are 6.434, 6.714 and 7.748 respectively.

In addition in CASE-2 the score of DSDV is 5.571, 5.967 and 11.565 and for DSR with GA, BFO and Hybrid it is 13.155, 13.656 and 16.804. The performance analysis comparison through hybridization approach of proactive and reactive routing protocol gives better result comprising better packet transfer rate with less error, less chances of node failure and prolonging the lifetime of the network. Moreover, the Computation Model is to be adopted to evaluate and also the performance of the two routing techniques are compared using soft computing techniques. The results obtained thereof are encouraging.
4.2 PROPOSED ALGORITHMS

4.2.1 DSDV with GA

In DSDV protocol each node maintains a routing table by adding sequence number attribute for every route. This routing table is updated periodically to keep its information current and fresh. Normal DSDV method is used for transferring data packet towards end if the next link of the source is not active.

1. Initialize

2. \( S = \) Source node, \( D = \) Destination node, \( BL = \) Buffer length

3. If \( (s.\text{Next Hop}() == \text{Does not alive}) \) then

   \{\text{Send the packet from } S \text{ to } D \text{ through DSDV}\}

4. Else if \( (s.BL() == \text{filled}) \) then \{“Reject packet”\}

5. If \( S.BL() == \text{Null} \) then \{“S.received_packet”\}

6. \( S.\text{Broadcast} (\text{Route Request}, 1, D, S); \)

7. If \( (\text{Source.Next Neighbour has route to } D) \) then

   \{\text{S.Receive (Route_ACK); }\}

   \( \text{Max\_no\_of\_Hops} = 0; \)

   \( \text{Min\_no\_of\_Hops} = \infty; \)

   \( \text{Next hop} = 0; \)

   \( \text{Update\_Time} = 1; \)

8. Else (\( S \) has Route_Ack packets)

   \{If \( \text{Route\_Ack.no\_of\_hops} <= \text{Max\_no\_Hops} \)

   \{If \( \text{Route\_Ack.updated\_time} > \text{updated\_time} \)
Host_port_no = Route_Ack.Host_Port;

Updated_time = Route_Ack.Updated_Time; }

9. Else {Max_no_of_Hops = Route_Ack.no_of_Hops

Host_port_no = Route_Ack.Host_Port;

Updated_time = Route_Ack.Updated_time; }

10. Route_Ack.Updated_Time

11. P = Defines path from S to D

12. For each Pi in source routing P

    Pop.Size = P.Elements.Count

13. Fc = current feature set of current element

    Ft = Mutated feature value

14. Fitness function

    1 if f_s < f_t
    0 if f_s > f_t
    1 if f_s==f_t

15. If f == 1

16. Add node to path

17. Else

18. Drop node;

19. Node ++; if (Node == d) then path found;

20. End

21. Evaluate Parameters
22. Stop

4.2.2 DSDV with BFO

Initialize the first step as S denotes Source; D denotes Destination and BL denotes Buffer length. If the nodes are not alive on next node then send the packet from S to D using DSDV. Otherwise the buffer length filled up then rejects the packet. When the buffer length is NULL then receive source packet and broadcast to route and if route got the next destination point through source then the source receive the route acknowledgement and initialize maximum no. of hopes equal to zero, minimum number of hopes infinity and next hop equal to zero. If root acknowledgement less than or equal to maximum number of hopes and if route acknowledgement time greater than update time then maximum number of hopes equals to the root acknowledgement number of hopes and the updated time would be equal to the route acknowledgement update time. BFO has been initialized and bacteria swim length gives the path of elements count. Through GA it got fit value from fitness function for BFO. If iteration is between 1 to number of bacteria’s then it would search the fit value and then sort the same and in the end it will get the destination.

1. Initialize

2. S = Source node, D = Destination node, BL = Buffer length

3. If (S. Next Hop () =
   = Does not alive) then {“Send the packet from S to D through DSDV’’}

4. Else if (S. BL () == filled) then {“Reject packet”}

5. If S. BL () == Null) then {”S. received _packet”}

6. S.Broadcast (Route_Request, 1, D, S);

7. If (Source. Next_Neighbour has route to D) then
   { S.Receive (Route_ACK); }
Max_no_of_Hops = 0; Min_no_of_Hops = \infty;

Next hop = 0;

Update_Time = 1;

8. Else (S has Route_Ack packets)

{If (Route_Ack.no_of_hops <= Max_no_Hops)

{If (Route_Ack.updated_time > updated_time)

{ Host_port_no = Route_Ack.Host_Port;

 Updated_time = Route_Ack.Updated_time; }

9. Else

{Max_no_of_Hops = Route_Ack.no_of_Hops

 Host_port_no = Route_Ack.Host_Port;

 Updated_time = Route_Ack.Updated_time; }

10. Route_Ack.Updated_Time

11. Start BFO

12. Swim.Length = Element Count. Path

 fit_value = fitness fn BFO (x, S));

 itr = Iteration

 fit_value = [ ];

13. For each itr = 1: n

 find fit.value ( );

14. Sk = Sort (fit.value)
15. If Sk == destination
16. End
17. Stop

4.2.3 DSR Algorithm with GA

The population size is the total number of nodes. Fitness function is the function that performs specific task to provide the best possible solution from number of solutions. The path is added with f = 1 and path is not added if the node is dropped. The nodes can be checked for finding the path else the nodes cannot find the destination and then the parameters evaluation is done.

1. Initialize

2. $S = \text{Source}, D = \text{Destination}$.

3. $G(V,E)$ here V denotes for vertex and E denotes for Edge set in between Vi and Vj.

4. $ER = ER$ defines the energy of sensor nodes.

5. $P = \text{Defines the Path from S to D}$.

6. for each Pi in source routing P Pop.Size = P.Elements.Count

7. $Fc = \text{current feature set of current element}$ $Ft = \text{Mutated feature value}$

8. Fitness function

   $1 \text{ if } f_s < f_t$
   $0 \text{ if } f_s > f_t$
   $1 \text{ if } f_s = f_t$

9. If $f == 1$

10. Add node to path

11. Else
12. drop node;

13. Node + +; if (Node == d) then path found;

14. End

15. Evaluate Parameters

16. Stop

4.2.4 DSR with BFO

Network is defined along with the recognitions of source and destination node. Edge set is produced with its neighbor node in the network. Every node is aware about the path length. BFO initializes as soon as the path is defined. Fitness value is defined for every node.

1. Initialize

2. S = Source, D = Destination.

3. G (V, E) Here V defines vertex and E defines the Edge set in between Vi and Vj.

4. E = Defines the energy of the nodes.

5. P = Defines path from S to D

6. for each k in P

7. Start BFO
8. Swim. Length = Element Count. Path  
   fit_value = fitness fn BFO(x,S));  
   itr = Iteration  
   fit_value = [ ];

9. for each itr = 1:n  
   find fit.value( );

10. Sk = Sort(fit.value)  
    .
11. If Sk == destination  
    .
12. End  
    .
13. Stop  
    .

4.2.5 Hybrid Algorithm

This hybrid approach involves GA and bacterial BFO. First BFO technique is applied which includes the chemo taxis process and reproduction process and the fitness function that is called in the BFO for the optimization and then reproduction and elimination process occurred. After implementing BFO output is applied to the GA as a population and the fitness function is computed for GA and then selection, crossover and mutation is performed for the routing optimization. Subsequently evaluation of the performance parameters takes place based on the hybridization technique. The whole process is based on the number of iterations to get the fittest solutions for the optimization so that we can calculate the parameters through which we can compare the performance in terms of network lifetime of the WSN for the energy minimization.

1. Initialize parameter n, N, Nc, Ns, Nre, Ned, Ped, C(i) (i = 1,2, ... N), Øi, Where,
   
n: Dimension of the search space,
N: The number of bacteria in the population,

Nc: Chemotactic steps, Nre: The no. of reproduction steps,

Ned: The number of elimination–dispersal events;

Ped: Elimination–dispersal with probability,

C(i): The step size taken in the arbitrary way precise by the tumble.

2. Elimination – dispersal loop \( l = l + 1 \)

3. Reproduction loop \( k = k + 1 \)

4. Chemotaxis loop \( j = j + 1 \)

5. For \( i = 1, 2, \ldots, N \), take a chemotactic step for bacterium \( i \)

6. Compute fitness function, ITSE \((i, j, k, l)\)

7. Let \( \text{ITSE last} = \text{ITSE} \((i, j, k, l)\) \) to save the value

8. Tumble: A random vector is generated i.e. \( \Delta(i) \in \mathbb{R}^n \), with each element \( \Delta m(i, m = 1, 2, \ldots, p) \), a random number on \([-1,1]\).

9. Move: Let \( \phi^x(i + 1, j, k) = \phi^x(i, j, k) + C(i) \frac{\Delta(i)}{\sqrt{\Delta^T(i)\Delta(i)}} \)

10. Compute ITSE \((i, j + 1, k, l)\)

11. Swim; Let \( m = 0 \); While \( m < Ns \); Let \( m = m + 1 \).

12. If ITSE \((i, j + 1, k, l) < \text{ITSE last}\),
    let \( \text{ITSE last} = \text{ITSE} \((i, j + 1, k, l)\) \) and let
    \( \phi^x(i + 1, j, k) = \phi^x(i + 1, j, k) + C(i) \frac{\Delta(i)}{\sqrt{\Delta^T(i)\Delta(i)}} \)

13. Else, let \( m = Ns \), end of while statement If \( j < Nc \), go to step 3
14. Reproduction; For the given k and l, for each \( i = 1, 2, \ldots, N \), let
\[
\text{ITSE}_{\text{health}} = \sum_{j=1}^{N_c+1} \text{ITSE} (i, j, k, l)
\]

15. If \( k < N_{\text{re}} \), go to step 3

16. Eliminate dispersal

17. \((rs, cs) = \text{size of (bfo – input)}\)

18. For each \( Pi \) in source routing \( P \)
\[
\text{Pop. Size} = P.\text{Elements. Count}
\]

\( P \) is the path from source to destination

19. \( F_c = \text{current feature set of current element} \)

20. \( F_t = \text{Mutated feature value} \)

21. Fitness function

\[
1 \text{ if } f_s < f_t \\
0 \text{ if } f_s > f_t \\
1 \text{ if } f_s == f_t
\]

23. If \( f == 1 \)

24. Add node to path

25. Else

26. Drop node;

28. Node ++; if (Node == d) then path found;

29. End

30. Evaluate Parameters

31. Stop
**Internal Working of Hybrid Protocol**

1. Let $n =$ Total no. of nodes.

2. Initialize network DSR/ DSDV, according to the program adjustment.

3. Let $p$ be the path; $S$ be the Source; $D$ be the Destination.

4. Let $cov$ be the coverage set of all nodes

5. **Initial Population**

   $= \sum_{i=1}^{R} Cov_{part}$, where $R$ is the total no. of nodes in the path. / 
   / BFO Application

6. $J_{Health}$ is the health at each bacterial (Node).

   The aim is to find the healthiest node for BFO.

   Here, a paradox would be accomplished i.e. here the rotten bacteria has to be find.

   Hence, the fitness function would be reverse in the nature and termed as $f^*$. 

7. Chromosome=0.5; it is the initial chromosome which has to be considered.

   We can change the value of the chromosome as per requirement

   but the provided value is standard.

8. Let $m$ be the total number of iteration for which the health of each bacteria (node) has to be evaluated.

9. for each $a$ in $m$;

   $J_{Health_{ch}} = \sum_{i=1}^{R} f^*, ch_i$, where $ch_i$ is the chromosome

   End for

   $f^* = \left( \frac{E_{total} - E_0}{E_0} \right)$,

   Where, $E_{total}$ is the total Energy of all nodes and $E_0$ is the current energy of the node.

10. Find least health according to the chemo taxis complexity.
11. Nodes or bacteria with least health would be dropped from path.

12. Let $G = (P, E, E')$, 
   
   where $P =$ remaining path with dropped node using BFO, 
   
   $E$ is the total energy vector at the remaining nodes and $E'$ is all energy of all nodes.

13. Initialize GA for $G$.

   \[
   \text{population} = \text{Total element remaining} \quad \text{Mutation} = 0.5 \quad \text{Chromosome} = 0.8
   \]

   \[
   \text{Chromosome type} = \text{Linear}, \text{Boundary Region type nested}
   \]

   \[
   \text{Iteration} = 1000 \text{ (may be less or more)}
   \]

14. For every for in iteration

   \[
   f'' = \begin{cases} 
   1 & \text{if } \left( \sum_{n=1}^{N} E'_{fn} \right) - E_{fn} > 0, \text{where } n \text{ is the total no. of nodes in that} \\
   0 & \text{otherwise}
   \end{cases}
   \]

15. Remove node with value = 0

4.3 SIMULATION ENVIRONMENT

For the design of our hybrid approach, two well known meta-heuristics: GA and BFO are considered. In order to optimize the energy of WSN, various algorithms and protocols are used and their comparisons are used through routing.

According to the simulation model demonstrated in Figure 4.1, the various simulation parameters used in the research are: Throughput, End to End delay, Congestion, Packet Delivery Ratio, Bit Error Rate, Energy consumption and Routing Overhead. The bits are processing 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 figure represents the hybrid simulation model, in which hybridization of DSDV with DSR has been done in addition with two optimization techniques i.e. GA and BFO. In first panel, DSDV implementation would be considered in which various above mentioned network parameters will be optimized then in second panel DSR implementation will take place in which various above mentioned network parameters will be optimized.

![Simulation Model Diagram]

- **Proactive Protocol (DSDV)**
  - Optimize using GA
  - Optimize using BFO
  - Optimize using Hybrid Algorithm

- **Reactive Protocol (DSR)**
  - Optimize using GA
  - Optimize using BFO
  - Optimize using Hybrid Algorithm

Evaluate results by Throughput, PDR, End to End Delay, Routing Overhead, Congestion, Energy and Bit Error Rate

Compare GA, BFO and Hybrid

- Number of Nodes = 500
- Simulation Time = 200 sec
- Network Length = 1000 m
- Network Width = 1000 m
- Packet Size = 100
- Data rates = 512 bytes/sec

Figure 4.1 Simulation Model
In next step, comparison will be made between GA, BFO and hybrid algorithm. Here, only hybridization of DSDV and DSR is done because DSDV algorithm easily solves the problem of loop routing. In the end, we calculate the performance of the two protocols using the various metrics.

4.4 PERFORMANCE COMPARISON

CASE: 1 for number of nodes (20 – 60)

4.4.1 Comparison of DSDV protocol with respect to GA, BFO and Hybrid Algorithm for CASE 1

The various parameters of GA, BFO and Hybrid in case of DSDV are compared as followed.

1. Packet Delivery Ratio (PDR):

![Comparison of Packet Delivery Ratio](image)

Figure 4.2 Comparison of PDR with varied number of nodes of DSDV with respect to GA, BFO and Hybrid (CASE:1)
Figure 4.2 demonstrates the score of PDR of DSDV routing protocol with GA shows the value from 81 to 96. DSDV with BFO values are from 78 to 95. The values of DSDV with hybrid lie from 84 to 98.

2. Bit Error Rate (BER): In case of BER, the values lies in between 0.2 to 0.4 are the value of DSDV protocol with GA and 0.2 to 1.2 is the value of DSDV with BFO. The value of DSDV with Hybrid lies from 0.1 to 0.2. Below figure 4.3 clearly shows that error rate is very less when hybrid technique is used along with DSDV routing protocol.

![Comparison of Bit Error](image)

Figure 4.3 Comparison of BER with varied number of nodes of DSDV with respect to GA, BFO and Hybrid (CASE:1)

3. Throughput: Figure 4.4 demonstrates the score of all soft computing techniques when implemented along with DSDV routing algorithm. A value with respect to throughput, for DSDV with GA shows the value from 76 to 94. DSDV with BFO values are from 77 to 96. The values of DSR with hybrid lie from 80 to 97.
4. **Congestion:** In case of congestion, DSDV with GA shows the value from 0.4 to 1.7 DSDV with BFO values are from 0.2 to 1.0. The values of DSDV with hybrid lie from 0.1 to 0.1. The value of hybrid in below graph decreases instantly after increasing. Figure 4.5 clearly depict the whole scenario in case of congestion.
5. End to End Delay (E2E Delay): The results of different algorithms for end to end delay are, DSDV with GA show the value as of 0.4 to 0.3. DSDV through BFO values came out to be from 0.3 to 0.7. The values of DSR with hybrid lies from 0.15 to 0.16. Below figure 4.6 present the score of all optimization techniques when used with DSDV routing protocol.

![Comparison of end to end delay](image)

Figure 4.6 Comparison of delay with varied number of nodes of DSDV with respect to GA, BFO and Hybrid (CASE:1)

6. Routing Overhead (RO): Figure 4.7 shows the score of RO with varying number of sensor nodes. The value with respect to RO for DSDV with GA shows the value from 0.6 to 0.16. DSDV with BFO values are from 0.15 to 0.54. The values of DSDV with hybrid came out to be 0.12 to 0.01.
7. Energy Consumption: Figure 4.8 shows the value of Energy consumption when it is implemented on sixty numbers of nodes, for DSDV with GA lies from 0.03 to 0.9, with BFO lies from 0.02 to 0.1 and for Hybrid it is from 0.01 to 0.90.
### 4.4.2 Comparison of DSR protocol with respect to GA, BFO and Hybrid Algorithm for CASE 1

The various parameters of GA, BFO and Hybrid in case of DSR are compared as followed.

1. **Packet Delivery Ratio (PDR):** Figure 4.9 demonstrates the score of PDR of DSR routing protocol. In packet delivery ratio parameter, DSR with GA shows the value from 70 to 90. DSR with BFO values are from 60 to 80. The values of DSR with hybrid lie from 80 to 95. Better results are shown in Hybridization.

![Comparison of Packet Delivery Ratio](image)

2. **Bit Error Rate (BER):** In case of bit error rate parameter, DSR with GA shows the value from 0.2 to 0.35. DSR with BFO values are from 0.1 to 0.3. The values of DSR with hybrid lie from 0.08 to 0.25. Below figure 4.10 clearly shows that error rate is very less when hybrid technique is used along with DSR routing protocol.
3. Throughput: Figure 4.11 demonstrates the score of all soft computing techniques when implemented along with DSR routing algorithm. A value with respect to throughput, for DSR with GA shows the value from 75 to 95. DSR with BFO values are from 75 to 95.
The values of DSR with hybrid lie from 79 to 96 and shows that the result of Hybrid algorithm is better than the comparison with GA and BFO.

4. Congestion: The values of congestion of BFO, GA and Hybrid algorithms with respect to number of nodes are DSR with GA shows the value from 0.7 to 0.2. DSR with BFO values are from 0.5 to 0.2. The values of DSR with hybrid lie from 0.4 to 0.14. The value of hybrid in below graph decreases instantly after increasing. Figure 4.12 clearly depict the whole scenario in case of congestion.

![Comparison of congestion with varied number of nodes of DSR with respect to GA, BFO and Hybrid (CASE:1)](image)

Figure 4.12 Comparison of congestion with varied number of nodes of DSR with respect to GA, BFO and Hybrid (CASE:1)

5. End to End Delay (E2E Delay): The results of different algorithms for end to end delay are, DSR with GA shows the value from 0.3 to 0.5. The value of BFO declined after inclining. DSR with BFO values are from 0.25 to 0.5. The values of DSR with hybrid lie from 0.2 to 0.25. Below figure 4.13 present the score of all optimization techniques when used with DSR routing protocol.
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Figure 4.13 Comparison of delay with varied number of nodes of DSR with respect to GA, BFO and Hybrid (CASE:1)

6. Routing Overhead (RO): Figure 4.14 shows the score of routing overhead with respect to nodes. The values of routing overhead of different algorithms with respect to number of nodes are, DSR with GA shows the value from 0.55 to 1. DSR with BFO values are from 0.4 to 0.5. The values of DSR with hybrid lie from 0.17 to 0.05.

Figure 4.14 Comparison of routing overhead with varied number of nodes of DSR with respect to GA, BFO and Hybrid (CASE:1)
7. Energy Consumption: Figure 4.15 shows the value of Energy consumption when it is performed on 60 nodes, for DSR with GA lies from 0.04 and going towards 1, with BFO lies from 0.04 to 0.1 and for Hybrid it is from 0.01 to 0.05, which is quite low as compared to GA and BFO. It is one of the critical parameter in order to achieve better life time of the wireless sensor network.

![Comparison between energy consumption](image)

Figure 4.15 Comparison of energy consumption with varied number of nodes of DSR with respect to GA, BFO and Hybrid (CASE:1)
Table 4.1: Comparison of various algorithms with respect to DSR and DSDV for CASE: 1

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<tr>
<th>Parameters</th>
<th>Protocols</th>
<th>DSR</th>
<th>DSDV</th>
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<tr>
<td></td>
<td>Genetic Algorithm</td>
<td>Bacterial Forging Optimization</td>
<td>Hybrid</td>
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<td>BIT ERROR RATE</td>
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The above table is converted into average score.
Table 4.2: Average score of various algorithms for CASE: 1

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<th>Routing Protocols</th>
<th>Algorithms</th>
<th>BIT ERROR RATE</th>
<th>CONGESTION</th>
<th>END TO END DELAY</th>
<th>ROUTING OVERHEAD</th>
<th>PACKET DELIVERY RATIO</th>
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<th>ENERGY</th>
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<td>91.56</td>
<td>89.06</td>
<td>0.261</td>
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An evaluation model is applied on the above table and gets a metric Q as follows.
Q = \begin{bmatrix}
0.204 & 0.496 & 0.362 & 0.67 & 80 & 85.42 & 0.429 \\
0.256 & 0.438 & 0.518 & 0.384 & 70 & 85 & 0.38 \\
0.128 & 0.324 & 0.268 & 0.122 & 88.9 & 87.66 & 0.328 \\
0.297 & 1.02 & 0.618 & 0.364 & 89.3 & 86.5 & 0.487 \\
0.64 & 0.66 & 0.52 & 0.36 & 86.8 & 87.52 & 0.464 \\
0.108 & 0.34 & 0.214 & 0.07 & 91.56 & 89.06 & 0.261 
\end{bmatrix}

(Number of parameters) \( n = 7 \)

(Number of algorithms) \( m = 6 \)

The value of N-Matrix corresponding to m qualities

\[ N = \{n_1, n_2, \ldots, n_7\} \]

\[ N = \{0, 0, 0, 0, 1, 1, 0\} \]

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

\[ C = \{1, 2, 1, 1, 100, 100, 1\} \]
Performance over Proactive and Reactive Routing using Soft Computing Approaches

\[
V = \begin{pmatrix}
1 & 1.101 & 1 & 0.49 & 0.947 & 0.983 & 0.912 \\
1 & 1.24 & 0.80 & 0.85 & 0.829 & 0.978 & 1 \\
1 & 1.686 & 1 & 1 & 1.052 & 1 & 1 \\
0.916 & 0.535 & 0.674 & 0.90 & 1.057 & 0.996 & 0.803 \\
0.425 & 0.827 & 0.801 & 0.91 & 1.02 & 1 & 0.84 \\
1 & 1.606 & 1 & 1 & 1.08 & 1.02 & 1 \\
\end{pmatrix}
\begin{pmatrix}
6.434 \\
6.714 \\
7.748 \\
5.886 \\
5.845 \\
7.716 \\
\end{pmatrix}
\]

The aggregate score for CASE-1 are:

1) The score for algorithm-1 (DSR-GA) is = 6.434
2) The score for algorithm-2 (DSR-BFO) is = 6.714
3) The score for algorithm-3 (DSR-Hybrid) is = 7.748
4) The score for algorithm-4 (DSDV-GA) is = 5.886
5) The score for algorithm-5 (DSDV - BFO) is = 5.845
6) The score for algorithm-6 (DSDV - Hybrid) is = 7.716

CASE: 2 when number of nodes are (50 – 500)

4.4.3 Comparison of DSDV protocol with respect to GA, BFO and Hybrid Algorithm for CASE 2

1. Packet Delivery Ratio (PDR): The score of PDR of DSDV with GA shows the value from 9.99 to 81. DSDV with BFO values are from 5 to 83. The values of DSDV with hybrid lie from 10 to 85. Below Figure 4.16 shows the comparison of PDR with varied number of nodes of DSDV with respect to GA, BFO and Hybrid.
2. Bit Error Rate (BER): DSDV with GA shows the value of BER from 0.60 to 0.98. DSDV with BFO values are from 0.63 to 0.88. The values of DSDV with hybrid lie from 0.50 to 0.98. Below figure 4.17 clearly shows that error rate is very less when hybrid technique is used along with DSDV routing protocol.
3. Throughput: Values of various algorithms i.e. GA, BFO and Hybrid are shown in the below Figure 4.18 with respect to Throughput. DSDV with GA shows the value from 44 to 97. DSDV with BFO values are from 69 to 98. The values of DSDV with hybrid lie from 90 to 99.

Figure 4.18 Comparison of throughput with varied number of nodes of DSDV with respect to GA, BFO and Hybrid (CASE: 2)

4. Congestion: Below Figure 4.19 shows the values of various algorithms and their comparison with respect to congestion. The values lies in between 9.57 to 98.06 are the value of DSDV with GA and 7.92 to 96 is the value of DSDV with BFO. The value of DSDV with Hybrid lies from 5.92 to 80.
5. **End to End Delay (E2E):** In case of this parameter, DSDV with GA show the value as of 0.48 to 27. DSDV through BFO values came out to be from 0.2 to 23. The values of DSDV with hybrid lie from 0.21 to 0.46. Figure 4.2 demonstrates the comparison of E2E delay with varied number of nodes of DSDV with respect to GA, BFO and Hybrid.

![Comparison of congestion with varied number of nodes of DSDV with respect to GA, BFO and Hybrid (CASE:2)](image)
6. Routing Overhead (RO): Figure 4.21 shows the score of Routing Overhead, DSDV with GA shows the value from 18 to 100. DSDV with BFO values are from 14 to 99. The values of DSDV with hybrid came out to be 13 to 22.
7. Energy Consumption: The energy consumption rate for sensors in a WSN mainly depends on the protocols the sensors use for communications and it is performed on up to 500 nodes. Figure 4.22 clearly shows the score of Energy consumption for DSDV with GA lies from 0.01 to 0.8, with BFO lies from 0.02 to 0.91 and for Hybrid it is from 0.01 to 0.69.

![Comparison of Energy Consumption](image)

Figure 4.22 Comparison of Energy Consumption with varied number of nodes of DSDV with respect to GA, BFO and Hybrid (CASE:2)

4.4.4 Comparison of DSR protocol with respect to GA, BFO and Hybrid Algorithm

Below figures demonstrates the comparison of various metrics with varied number of nodes of DSR with respect to GA, BFO and Hybrid, when implementation is done on 50-500 nodes.

1. Packet Delivery Ratio (PDR): The score of PDR of DSR with GA shows the value from 8.99 to 80. DSR with BFO values are from 4 to 80. The values of DSR with hybrid lie from 10 to 94. Below
Figure 4.23 shows the comparison of PDR with varied number of nodes of DSR with respect to GA, BFO and Hybrid.

Figure 4.23 Comparison of PDR with varied number of nodes of DSR with respect to GA, BFO and Hybrid (CASE:2)

2. Bit Error Rate (BER): DSR with GA shows the value of Bit Error Rate from 0.62 to 1.23. DSDV with BFO values are from 0.69 to 0.96. The values of DSR with hybrid lie from 1.51 to 0.88. Below figure 4.24 clearly shows that error rate is very less when hybrid technique is used along with DSR routing protocol.
3. **Throughput**: Values of various algorithms i.e. GA, BFO and Hybrid are shown in the below Figure 4.25 with respect to Throughput. DSR with GA shows the value from 84 to 97. DSR with BFO values are from 44 to 97. The values of DSR with hybrid lie from 85 to 99.
4. Congestion: With respect to congestion, the values lies in between 9.7 to 98.07 are the value of DSR with GA and 7.6 to 96 is the value of DSR with BFO. The value of DSR with Hybrid lies from 6.8 to 80.20. Below Figure 4.26 shows the values of various algorithms and their comparison with respect to congestion.

![Comparison of congestion with varied number of nodes of DSR with respect to GA, BFO and Hybrid (CASE:2)](image)

5. End to End Delay (E2E): In case of E2E delay parameter, DSR with GA show the value as of 0.84 to 1. DSR through BFO values came out to be from 0.81 to 0.85. The values of DSR with hybrid lie from 0.36 to 0.1. Figure 4.27 demonstrates the comparison of E2E delay with varied number of nodes of DSR with respect to GA, BFO and Hybrid.
6. Routing Overhead (RO): Figure 4.28 clearly shows the score of Routing Overhead, DSR with GA shows the value from 15 to 99. DSR with BFO values are from 12 to 98. The values of DSR with hybrid came out to be 9 to 79.

Figure 4.27 Comparison of E2E delay with varied number of nodes of DSR with respect to GA, BFO and Hybrid (CASE:2)

Figure 4.28 Comparison of RO with varied number of nodes of DSR with respect to GA, BFO and Hybrid (CASE:2)
7. Energy Consumption: The network consists in reducing energy consumption to a minimum in such a way as to maximize a network lifetime. Figure 4.29 shows the value of DSR for GA lies from 0.02 to 0.1, for BFO, it lies from 0.02 to 0.13 and for Hybrid, it is from 0.02 to 1.0 and been tested on 500 nodes.

Figure 4.29 Comparison of Energy Consumption with varied number of nodes of DSR with respect to GA, BFO and Hybrid (CASE:2)
Table 4.3 Comparison of various algorithms with respect to DSR and DSDV for CASE: 2

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### Performance over Proactive and Reactive Routing using Soft Computing Approaches

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</table>
Table 4.4 shows the average score of table 4.3.

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<td>0.05</td>
<td>0.7</td>
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<td>0.03</td>
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<td>0.65</td>
<td>0.68</td>
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<td>0.06</td>
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<td>0.74</td>
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<td>1.0</td>
<td>0.8</td>
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<td>0.69</td>
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</table>
Table 4.4 Average score of various algorithms for CASE: 2

<table>
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<tr>
<th>Routing Protocols</th>
<th>Algorithms</th>
<th>BIT ERROR RATE</th>
<th>CONGESTION</th>
<th>END TO END DELAY</th>
<th>ROUTING OVERHEAD</th>
<th>PACKET DELIVERY RATIO</th>
<th>THROUGHPUT</th>
<th>ENERGY CONSUMPTION</th>
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<tr>
<td>DSR</td>
<td>GA</td>
<td>0.91</td>
<td>49.06</td>
<td>0.67</td>
<td>76.16</td>
<td>44.90</td>
<td>92.23</td>
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<td></td>
<td>BFO</td>
<td>0.88</td>
<td>45.86</td>
<td>0.63</td>
<td>69.64</td>
<td>40.75</td>
<td>74.45</td>
<td>0.38</td>
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<tr>
<td></td>
<td>Hybrid</td>
<td>0.86</td>
<td>36.06</td>
<td>0.50</td>
<td>52.96</td>
<td>53.86</td>
<td>96.37</td>
<td>0.32</td>
</tr>
<tr>
<td>DSDV</td>
<td>GA</td>
<td>0.97</td>
<td>53.76</td>
<td>13.56</td>
<td>79.06</td>
<td>46.70</td>
<td>74.45</td>
<td>0.48</td>
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<tr>
<td></td>
<td>BFO</td>
<td>0.78</td>
<td>51.10</td>
<td>10.89</td>
<td>73.96</td>
<td>43.15</td>
<td>88.73</td>
<td>0.46</td>
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<tr>
<td></td>
<td>Hybrid</td>
<td>0.89</td>
<td>43.40</td>
<td>4.12</td>
<td>12.11</td>
<td>54.14</td>
<td>9.84</td>
<td>0.26</td>
</tr>
</tbody>
</table>

After applying an evaluation on above table we get a matrix Q as follows.
Performance over Proactive and Reactive Routing using Soft Computing Approaches

\[ Q = \begin{pmatrix}
0.91 & 49.06 & 0.67 & 76.16 & 44.90 & 92.23 & 0.42 \\
0.88 & 45.86 & 0.63 & 69.64 & 40.75 & 74.45 & 0.38 \\
0.86 & 36.06 & 0.50 & 52.96 & 53.86 & 96.37 & 0.32 \\
0.97 & 53.76 & 13.56 & 79.06 & 46.70 & 74.45 & 0.48 \\
0.78 & 51.10 & 10.89 & 73.96 & 43.15 & 88.73 & 0.46 \\
0.89 & 43.40 & 4.12 & 12.11 & 54.14 & 96.84 & 0.26
\end{pmatrix} \]

(Number of parameters) \( n = 7 \)

(Number of algorithms) \( m = 6 \)

The value of N-Matrix corresponding to m qualities \( N = \{ n_1, n_2, \ldots, n_7 \} \)

\[ N = \{0, 0, 0, 0, 1, 1, 0\} \]

The maximum normalized values in c -matrix corresponding to m qualities are \( C = \{1, 70, 25, 100, 70, 100, 1\} \)

\[ V = \begin{pmatrix}
0.927 & 0.948 & 7.55 & 0.796 & 0.95 & 1.05 & 0.92 \\
1 & 1.014 & 8.03 & 0.87 & 0.86 & 0.853 & 1 \\
1.291 & 1.29 & 10.12 & 1.145 & 1.13 & 1.1 & 1 \\
0.91 & 0.865 & 0.37 & 0.767 & 0.98 & 0.853 & 0.805 \\
1 & 0.91 & 0.46 & 0.82 & 0.91 & 1.01 & 0.84 \\
1 & 1.07 & 1.22 & 5.00 & 1.14 & 1.11 & 1
\end{pmatrix} = \begin{pmatrix}
13.155 \\
13.636 \\
16.804 \\
5.571 \\
5.967 \\
11.565
\end{pmatrix} \]
The aggregate score for CASE-2 are:

1) The score for algorithm-1 (DSR-GA) is = 13.155  
2) The score for algorithm-2 (DSR-BFO) is = 13.636  
3) The score for algorithm-3 (DSR-Hybrid) is = 16.804  
4) The score for algorithm-4 (DSDV-GA) is = 5.571  
5) The score for algorithm-5 (DSDV-BFO) is = 5.967  
6) The score for algorithm-6 (DSDV-Hybrid) is = 11.565  

4.5 CONCLUSION

The comparative study of the proactive and reactive routing protocols (in both CASES) shows that the normalized overall scores of DSDV for GA, BFO and Hybrid in CASE-1 are 5.886, 5.845 and 7.716 respectively. Similarly the normalized overall score of DSR for GA, BFO and Hybrid are 6.434, 6.714 and 7.748 respectively. Moreover in CASE-2 the score of DSDV for GA, BFO and Hybrid are 5.571, 5.967 and 11.565 and for DSR it is 13.155, 13.656 and 16.804. In both CASE’s and both protocols the scores of GA and BFO are significantly lower than Hybrid algorithm and if we compare Hybrid algorithm in the contrast of DSDV and DSR, the score of DSR is little higher than that of DSDV. We find that the hybridization of both the optimization techniques performs better than applying individually on both proactive and reactive routing algorithm.

Wireless Sensor Networks is quite a rising and hot idea in wireless communication that is a lot of research is undergoing and numbers of issues are subjected to be investigated in this area. While, there are a lot of extra routing protocols that are need to be examine yet. Number of design issues like node deployment, heterogeneity, localization and synchronization that require being evaluating further and the
protocols security that need to be explored by means of attacks nature to which wireless communication is taken as an appealing target.