Energy Efficient Data Aggregation using PSO based Mobile Agent approach in Wireless Sensor Network

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Abstract- a significant role is played by Energy efficiency in the design of the wireless sensor networks (WSN). A novel scope on behalf of the effective processing as well as the accumulation of the information is presented by introducing the mobile agent technology within WSN towards the data processing as well as collaborative signal. The relation of the Cluster Heads (CH) as well as the sensor nodes are only considered mostly by the earlier cluster based routing protocols and however, the larger variation prices amid them are ignored. Certain chances are existing within few existing clustering protocols where some of the nodes are remaining exclusive of being a participant of some of the clusters called as the residual nodes. The network lifetime is reduced by the residual nodes. A novel data aggregation technique in which an efficient clustering method using the Intra Mobile Agents (IN-MA) is presented in this paper. Moreover, the introduction of a PSO based location estimation technique is done for finding the optimum location for the sink depending upon the structure of the network. The information out of the members is collected by the Intra Mobile Agents and it is delivered towards the CHs. PSO algorithm is used to estimate the optimum position for the sink. Less duration is required for returning towards the processing components since this method concentrates upon the recognition of the most instructive route with the traversing reduced nodes and therefore, less delay is exhibited. Improved outcomes than the earlier methods is possessed by this method as shown by the experimental outcomes.

Keywords Wireless sensor networks, Mobile agents, Data aggregation, PSO, Energy aware routing, Clustering, Cluster head, optimal selection, ICBM-PSO-WSN.

I. Introduction

Numerous relative smaller nodes are present in a WSN and a sensing device is equipped in every single node. Wireless communication is used by the sensor networks and these nodes are powered by battery. The efficiency must be maintained highly upon the design criteria list [1] as it is demanded by the respective constrained resources, communication abilities in addition to the power consumption. The wireless sensors turns into smaller, cheaper as well as effective due to the developments within the wireless communication in addition to the electronic technologies. Various implementations are highlighted regarding the WSNs, because of the rapid progression of the microprocessor, sensor as well as transceiver. The chances of changing or recharging the faulty or the dead nodes is less due to their implementation in rough as well as inaccessible conditions. Therefore, WSNs remain hypersensitive as well as vulnerable to the energy which is the major variation in it compared to the additional classic wireless networks [2].

The issues of routing within WSN are solved by an ant colony optimization (ACO) algorithm family [4]. Ant colony optimization has come into existence as a significant Meta heuristic technique on behalf of the combinatorial optimization issues from the past few years [3].

The random movements of MS [5, 6] are dealt by various presented methods. Every single SN is visited by MS in a random way and the information out of SNs is gathered in the previous approach and these can be implemented easily. Certain SNs must wait for a longer durations which in turn causes the issues of buffer overflow because of the MS nature of the movement. Moreover, the data delivery latency is increased by it. Therefore, these kind of techniques are unencouraged on behalf of the realistic implementations particularly wherein a larger WSN is involved. The implementation of the controlled mobility approach is done for avoiding such limitations. The techniques on behalf of the MS controlled mobility are upon the basis of the rendezvous points (RPs) [7].

Pollution monitoring area is one of the application of WSN wherein the scattering of WSN is done within various nations or the remote environments for detecting the hazardous gases as well as bacteria. The application of WSN can be done within the healthcare where the elder or the disabled persons with the diseases as well as staying lonely in the houses are assisted. Likewise, it can be applied within agriculture wherein the industrial charges are benefitted by the farmers and the continuous maintenance is excluded by them. The energy-aware as well as tolerant towards the sensor loss or energy exhaustion protocols are considered mainly in the sensor routing issue in the present investigations [8, 9] and therefore, the SN's lifetime is prolonged [10–12]. In order to develop a WSN, the assumption of the quality of service is necessary and the complications are made eminent by the energy limitations [13].

II. Related Work

A routing technique for the WSNs with the help of an ant colony optimization in which a comparison of two ant colony-based routing techniques by considering the present amounts of the energy consumption within various situations as well as informed the common parameters for the routing in WSNs is presented by the authors in [14].

An energy aware ant colony algorithm is presented by the authors in [15] in order to route the WSNs where the next node is selected by the ant by considering the sink node distance as well as the remaining energy of the next node and the average energy path is considered by it. The conventional ACA algorithm is used to compare this and the additional enhancement is obtained for balancing the consumption of energy of the nodes and the lifetime of the energy is extended.

Ant colony optimization- based location-aware routing algorithm (ACLR) is introduced by authors in [16] that resembles a flat as well as location perception technique. The residual energy as well as the global & local location data of the nodes is fused by it for defining the probability for selecting the succeeding node for ants.

An energy-efficient ant based routing algorithm (EEABR) is presented by the authors in [17] on behalf of the flat as well as location awareness architectures. The reduced energy consumption path is discovered in this method whereas the ant size within the communication amid the nodes is reduced.

The application of the WSN is done within the implementations including military, healthcare, surveillance and agriculture by means of a powerful technology from the previous years. The application of WSNs are studied by various investigators and the advantages of it are assumed. Higher energy efficiency is maintained by the development of WSNs by most of the investigations in [18, 19] while the data is transmitted from source towards the destination. Certainly by the changing network application, the prices of the network establishment are varying. An even sized cluster constructing technique with the help of the competition range characteristic is referred as an EADC (energy-aware clustering algorithm) in addition to the areas where the distribution of the nodes is not done in a uniform way within the network. Yu et al. [20] introduced this approach.

A cluster-based routing technique is presented by Yu et al. wherein the additional forwarding tasks towards such available nodes are provided by it. Picking the nodes which are having the power or by the less number of neighbors as the succeeding stops is done by this method.

Bagci [21] proposed energy-aware unequal clustering algorithm (EAUCF) to solve the issues of hot spots i.e., bottleneck problem. These problems arise due to the reason that the CHs near the BS are dying rapidly and are with heavy workload compared to others. The major objective of EAUCF technique is prolonging the lifetime of the nodes which are near to the sink or the nodes having less residual energy. Decreasing the workload upon them is the main concept. Authors mostly use the Artificial Bee Colony technique. Application of the energy within the energy effective clustering technique by Karaboga [22] is one of the applications.

III. Proposed system

Node selection phase, setup phase as well as steady state phase are the 3 phases of this method. The distribution of the nodes is done within various clusters is depending upon the distance within this CH selection phase. Every single cluster participant within this phase communicates with one another. The destination on behalf of the data communication is selected by the broadcast of every single node. Every single SN is allocated with a particular ID and after the allocation, the individual IDs are broadcasted by SNs with the help of MAC layer protocol. Primarily with the generation of a random number, a decision is made by a node that wants to be a CH and the threshold value is used to compare. The residual energy as well as the distance are considered for the additional procedure of the CH selection. Particle swarm optimization is used for selecting the sink node within the optimal position of sink phase. The optimal position of the sink requires the evaluation of the fitness function as well as probability of communication of a node. The mobile agent on behalf of the overall CH nodes is determined in this phase. The ICBM-PSO-WSN method for selecting the optimum positions are executed depending upon the chromosomes evaluated by the PSO algorithm.

The cost function C_{ij} is used to select the best candidate for the next hope. The migration cost of MA is represented by Cost function out of the current source node v_i towards the succeeding candidate source node v_j. The trade-off amid the enhancing advantages is possessed by the cost function and the loss is reduced by it. Decreasing the consumption of energy as well as increasing the data gain in addition to the lifetime of the network is the main objective of the cost function. Hence, the probability of the selection of the candidate node is increased by the less cost amongst the overall candidate nodes on behalf of the additional hop migration for MA and it is performed by the cost function. The equation given below is the Cost function P_{ij} for migrating an MA from u_i to u_j:

$$P_{ij} = p\left(1 - \frac{C_j(x,y)}{C_{max}}\right) + q(T_{visit} + 1)\left(\frac{re_j}{re_{max}}\right) + r\frac{E_{ij}}{E_{max}}\ 0 \le a, b, c \le 1, N_{visit} \ge 0..(1)$$

Where,

$C_j(x,y)$: Information gain of candidate node u_j for MA migration.

C_{max}: Maximum information gain of nodes.

E_{ij}: Amount of energy consumed in migration of MA from v_i to v_j.

E_{max}: Maximum energy required for the mitigation of MA from one node to another. re_j: remaining energy level of the nodeu_j.

re_{max}: Maximum initial energy level of nodes during deployment.

T_{visit}: Number of visits of node v_j by MA.

Due to the continuous selection of node v_j, the visiting of the node is constrained by MA since the node might possess additional energy loss for a node and therefore, the lifetime of the network is reduced. The constant weighing factors provided for the factors such as the information gain, residual gain as well as the migration energy are presented by p, q, r.

This paper considers the steady state phase, compares the resulting chromosomes with respect to distance, (received signal strength) and CH nodes data. The data out of the member nodes is collected by MA and is delivered towards the CH. The data is sent to the SINK by CH. The ICBM-PSO based algorithm is described in this paper using the initialization of the particle, multi-objective fitness function derivation, PSO, QoS parameters, selection of guides in addition to the pseudo code.

An incorporation of the PSO algorithm is used to determine the optimum position for the SINK node afterwards the distribution of the network within 'n' number of clusters in addition to the selection of CH. A fitness function equation (2) is used to calculate the nodes fitness values. The population of final particle for PSO is done upon the basis of the fitness values.

$$fitness(i) = \frac{1}{M}\sum_{j=1}^{M}[\sqrt{(x_j - x_i)^2 + (y_j - y_i)^2}) - d_j \quad \text{---- (2)}$$

Where, fitness (i) represents a fitness value of particle I; (xi, yi) represents position coordinates of the particles i, the distance is represented by d (j).

Upon the basis of fitness values of the nodes by the P_{best}, G_{best} values at every single iteration round. The comparison of the overall P_{best} is done and the G_{best} value is resolved. In accordance with the Equations (3) and (4), every single particles velocity as well as the position for the 'i'th iteration is updated.

$$V_i(t+1) = V_i + c_1r_1\left(P_{best} - x_i(t)\right) + c_2r_2(G_{best} - x_i(t)) \quad \text{---- (3)}$$

$$x_i(t+1) = x_i(t) + v_i(t+1) \quad \text{---- (4)}$$

The selection of the final particles on behalf of the genetic technique is done after the 'n' number of iterations and the population of the final chromosomes is done. The selection of the mutation point is done and the manipulation is done in a random way.

Selection of optimal selection:

N= total number of nodes

LCH = List of cluster heads

LCM = List of cluster members

P = percentage of CH

Coordinates N_i= {N_1, N_2, N_3 …}

Total number of possible nodes = m

Maximum iterations = i_{max}

Particle best fitness = P_{best}

Best of P_{best} = G_{best}

For I = 1: N

Compute and transmit residual energy, distance

End

Elects cluster head based on distance with high energy

For J = 1: N

Transmit the status of each node

If (CH==true)

Informs about its CH election for current round

LCH=node (j)

Else

Informs the cluster membership details to the nodes

LCM=node (j);

Initialize particles P (i),   1<=j<=m

For each particle P (i)

{

Calculate fitness (p (i))

Pbest = particle fitness (p(i))

}

End for

Gbest = best particle fitness (p(i)), where 1<=i<=m

While (iteration < imax) do

For each particle P(i)

Update Particle_Velocity

Update Particle_Position

Compute fitness(p(i))

If fitness(p(i)) < Pbest(i) then

Pbest = fitness(p(i))

End If

If Gbest < Pbest(i) then

Gbest = Pbest(i)

EndIf

Endfor

Imax=imax+1

Endwhile

Populate chromosomes from particles p(i)

Mutate the chromosomes

For each chromosome chrom(i)

Calculate distance dist (chrom(i))

If Dist(best) < dist (chrom(i)) then

Dist(best) = dist (chrom(i))

If RSSI(chrom(i)) == min then

Best(chrome) = chrom(i)

EndIf

EndIf

Endfor

End

IV. Results and Discussion

The performance analysis of this method is presented in this method with the help of comprehensive investigations. The simulation setup depending upon the investigations is presented in this section. The comparative study of the outcomes attained through the method is concluded using the respective contemporaries as well as statistical analysis. Table 1 presents the parameters of simulation implemented in the network process.

Tabel1: Simulation Table

Parameter	Value
Application traffic	CBR
Transmission rate	1000 bytes / 0.5ms
Radio range	250m
Packet size	1000 bytes
Simulation time	50 secs
Number of nodes	44
Area	1500 x 1000m

Routing methods	ICBM-PSO, DMADA,ACO
Routing protocol	AODV

The ICBM-PSO performance with the implementation of the comparative simulations is measured in this method. Network simulator-2 is used to simulate the proposed methods such as ACO and DMADA. The ACO & DMADA protocols as well as ICBM-PSO are similar in the energy model. The deployment of 44 sensor nodes is done in a random way in this simulation within a 1500 m x 1000 m dimension of topographical area A. Table 1 presents the essential parameters of the simulation.

The parameters of the system implemented in this simulation is shown in Table 1. The data collected by the sensor nodes which is the deferral tolerant data is accepted here for simplifying the mobile sink scheduling which means they are waiting for the mobile sink for lifting them up.

The following parameters are considered by the analysis as well as comparison of the performance of this method using the existing protocols.

1) Network performance: the number of transmitted packets evaluated Megabits per sec.
2) Propagation Delay: average time for one packet for propagating out of the source node towards destination node.
3) Energy consumption: overall energy of nodes within the network.

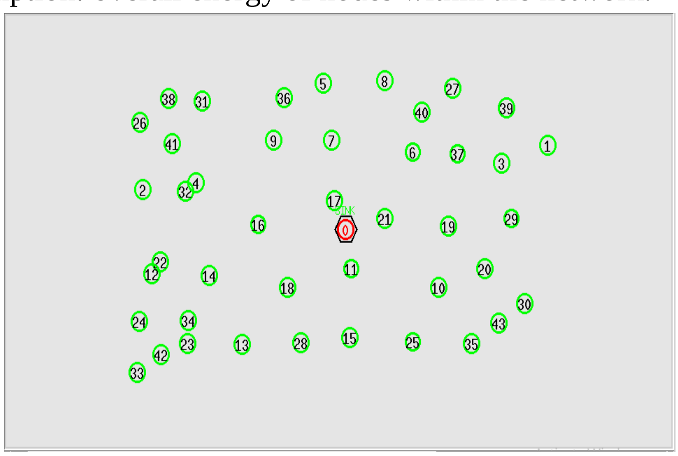

Fig. 1: Network deployment

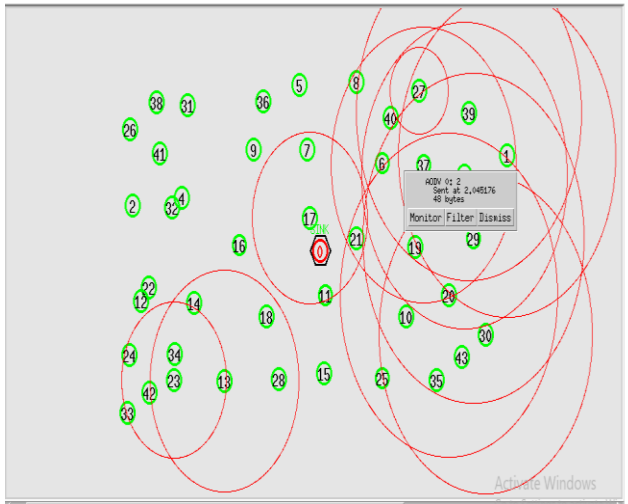

Fig. 2: Broadcasting process in network

Fig 1 demonstrates that all nodes are placed in the network and the nodes deployment is properly done in the network. At this point, the entire nodes that are represented are on the basis of random topology values and it should mention the overall properties of NAM window.

Fig 2 shows the occurrence of broadcasting all over the network which is meant for the purpose of communication. In this process, entire nodes ought to be involved.

Figure 3 represents the cluster formation. Here clusters are divided based on area division and for select the cluster head, different parameters considered.

Figure 4 shows and represents the communication between hop node and sink node.

In figure 5, data transmission process occurs at sink node and all network data collected from Mobile agents.

Figure 6 represents the cluster file. Here all cluster heads formed based on distance and residual energy parameters.

Figure 7 represents the trace file of network. In this all individual data and different energy values of nodes represented.

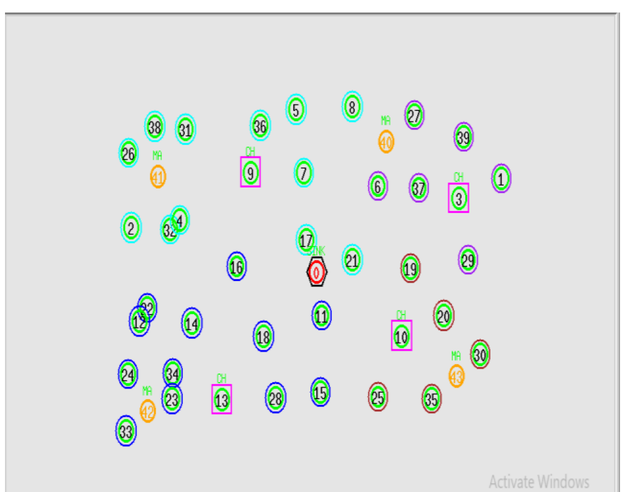

Fig. 3: Cluster formation

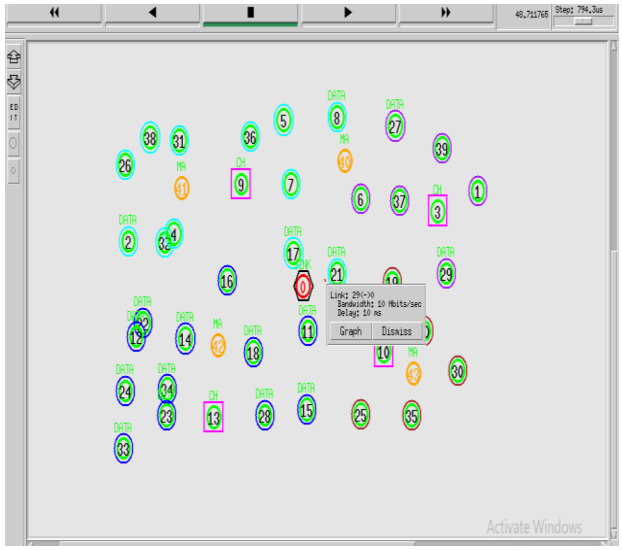

Fig. 4: Link between node 29 to sink node

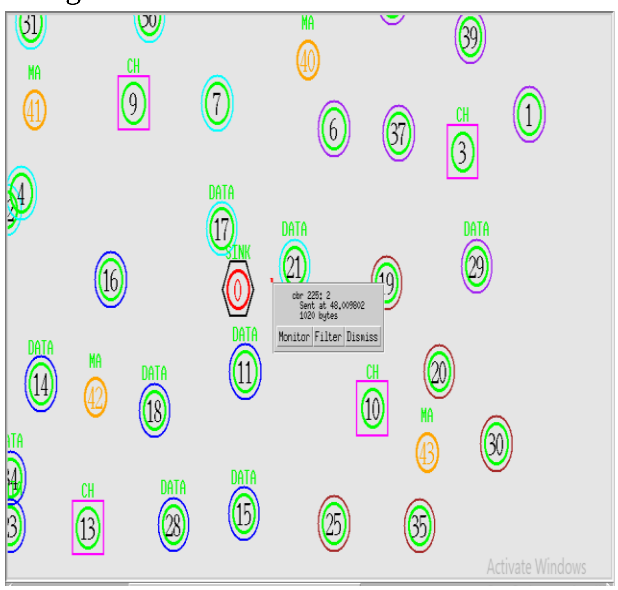

Fig. 5: Data processing at SINK node

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Cluster - 1 : 11 12 13 14 15 16 18 22 23 24 28 33 34 42
Cluster - 2 : 10 19 20 25 30 35 43
Cluster - 3 : 2 4 5 7 8 9 17 21 26 31 32 36 38 41
Cluster - 4 : 1 3 6 27 29 37 39 40

^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^

=======================================================
Energy of node 11 98.572178
=======================================================
Distance from node 11 to its neighbour  11  12  13  14  15  16  18  22
23  24  28  33  34  42
 0.000000  391.081833  246.333108  278.179798  111.018017  196.654519
127.577427  375.191951  342.696659  424.595101  154.159009  451.983407
330.588869  205.973299
Energy of node 12 98.685132
=======================================================
Distance from node 12 to its neighbour  11  12  13  14  15  16  18  22
23  24  28  33  34  42
 391.081833  0.000000  210.535033  113.017698  402.405268  222.854212
267.904834  25.612497  132.075736  80.956779  313.320922  161.623018
103.276328  186.386695
Energy of node 13 98.545933
=======================================================
Distance from node 13 to its neighbour  11  12  13  14  15  16  18  22
23  24  28  33  34  42
 246.333108  210.535033  0.000000  128.996124  212.285186  196.461192
128.701204  209.468375  107.018690  205.360658  116.038787  210.857772
112.946890  102.396289
Energy of node 14 98.645153
=======================================================
```

Fig. 6: Cluster file in network

```
M 0.0 nn 44 x 1500 y 1000 rp
M 0.0 prop Propagation/TwoRayGround ant Antenna/OmniAntenna
s 0.000000000 _0_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei
0.000 es 0.000 et 0.000 er 0.000] ------- [0:255 -1:255 1 0] [0x1 1 [0 2]
32.000000] (HELLO)
s 0.000000000 _1_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei
0.000 es 0.000 et 0.000 er 0.000] ------- [1:255 -1:255 1 0] [0x1 1 [1 2]
32.000000] (HELLO)
s 0.000000000 _2_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei
0.000 es 0.000 et 0.000 er 0.000] ------- [2:255 -1:255 1 0] [0x1 1 [2 2]
32.000000] (HELLO)
s 0.000000000 _3_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei
0.000 es 0.000 et 0.000 er 0.000] ------- [3:255 -1:255 1 0] [0x1 1 [3 2]
32.000000] (HELLO)
s 0.000000000 _4_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei
0.000 es 0.000 et 0.000 er 0.000] ------- [4:255 -1:255 1 0] [0x1 1 [4 2]
32.000000] (HELLO)
s 0.000000000 _5_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei
0.000 es 0.000 et 0.000 er 0.000] ------- [5:255 -1:255 1 0] [0x1 1 [5 2]
32.000000] (HELLO)
s 0.000000000 _6_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei
0.000 es 0.000 et 0.000 er 0.000] ------- [6:255 -1:255 1 0] [0x1 1 [6 2]
32.000000] (HELLO)
s 0.000000000 _7_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei
0.000 es 0.000 et 0.000 er 0.000] ------- [7:255 -1:255 1 0] [0x1 1 [7 2]
32.000000] (HELLO)
s 0.000000000 _8_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei
0.000 es 0.000 et 0.000 er 0.000] ------- [8:255 -1:255 1 0] [0x1 1 [8 2]
32.000000] (HELLO)
s 0.000000000 _9_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei
0.000 es 0.000 et 0.000 er 0.000] ------- [9:255 -1:255 1 0] [0x1 1 [9 2]
32.000000] (HELLO)
```

Fig. 7: Trace file of Network

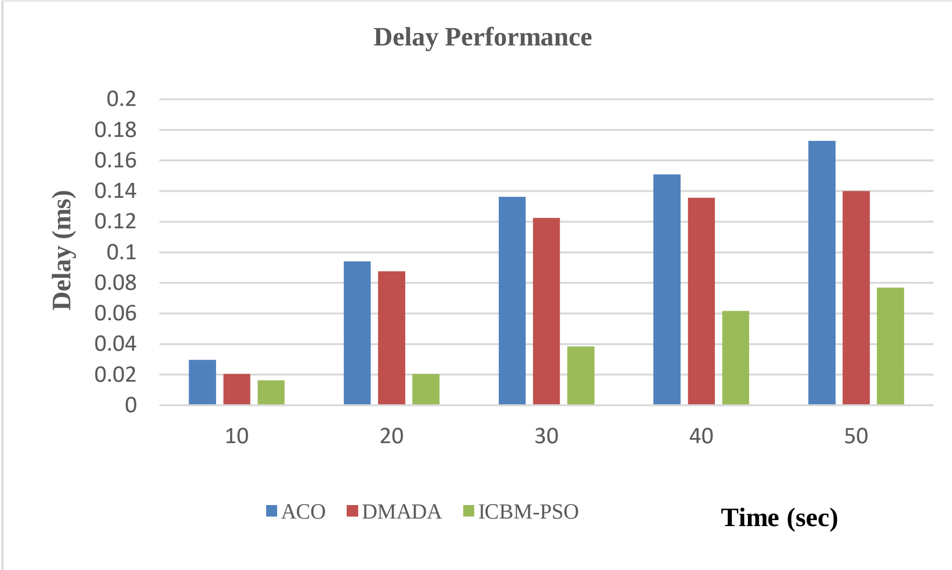

Fig 8: Network Delay

The comparative analysis of end-to-end delay is shown in Figure 8. The simulation period within the network is enhanced with the increasing end-to-end delay. Low delay is possessed by this method compared to ACO and DMADA. Finding the appropriate informative route with the transverse of the comparatively less period is the objective of this increment and reduced time duration is considered by MA for returning towards the SINK.

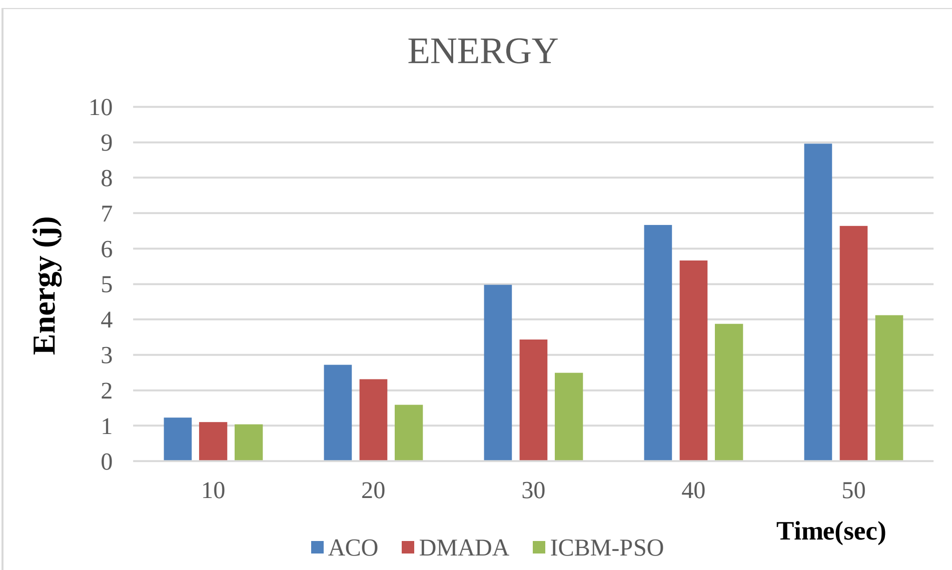

Fig 9: Energy Consumption

The comparative analysis of energy consumption is shown in Figure 9. The comparison of this method and the existing methods such as ACO and DMADA is done in the succeeding phase. The simulation is varied from 10 to 50 sec in this simulation. The optimum position of the SINK that is consuming the less power to transmit MA is selected in this method. Hence, the consumption of energy amongst the source nodes is balanced in this method.

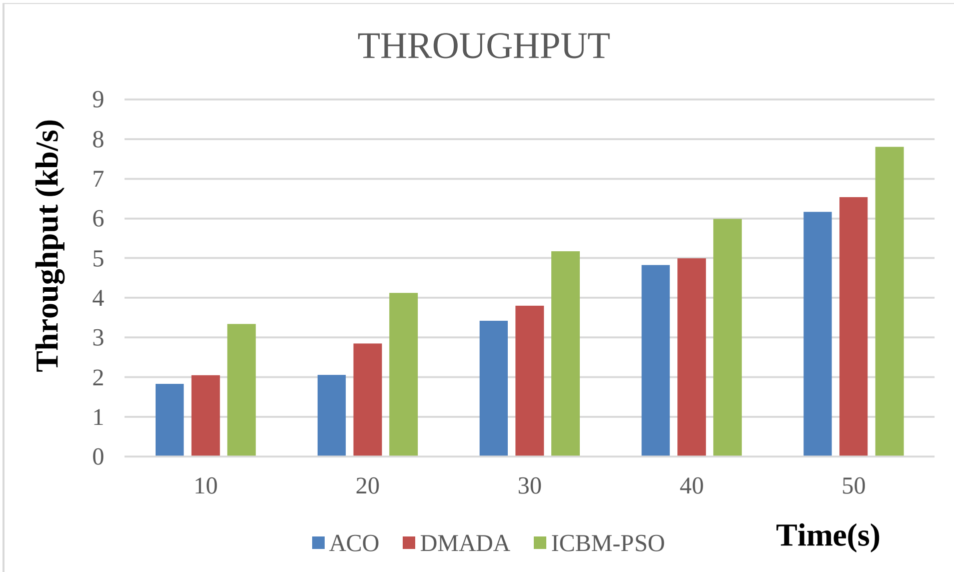

Fig 10: Throughput

The network performance of ACO, DMADA and ICBM-PSO is analyzed in this method. The mode of varying the simulation with the evolvement of the network is examined here. It is because of the ICBM-PSO route selection depending upon the maximum-minimum signal strength standard that leads to the extension of the route lifetime in addition to the proposed link failure technique wherein the link failure is predicted within the previous duration earlier to the data packet dropping. A higher throughput of the proposed ICBM-PSO is caused by this. The throughput is represented in Figure 10.

Conclusion:

This paper introduces an ICBM-PSO optimal path design technique on behalf of the SINK within WSN using a trade-off amid transmission distance as well as congestion at the SINK surroundings. The deployment of SINK is done at the optimum location and the additional traffic at the nodes which are the 2 contradictory goals is reduced. The rigorous simulations are used to endorse the method and the performance of the ACO, DMADA, and PSO with respect to various performance parameters is presented in the simulation outcomes. NS2 tool is used to validate the statistical significance of the simulation outcomes. The designing of an energy effective optimum path for the SINK node within WSN is done here. The optimization algorithm technique using energy effective for the multiple sink nodes will be developed in future.

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