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Energy Efficiency Using Particle Swarm Optimization with Adhoc on Demand Distance Vector Routing Protocol over Manet

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ABSTRACT

Mobile Ad-hoc network (MANET) is a collaboration of portable nodes as well as some computing devices which can be placed arbitrarily anywhere in the network to perform a particular task such as data transmission and message passing for various applications. The nodes can transmit data in a particular range and the nodes are capable of changing their location frequently. In previous research, the energy consumption is main issue and hence the overall routing performance is reduced significantly. To overcome the abovementioned issue, in this research, Particle Swarm Optimization-Adhoc On Demand Distance Vector (PSO-AODV) routing protocol is proposed. In this research, the Cluster Head (CH) is selected using PSO algorithm based on the best objective function values. The CH node has capability of rapid packet delivery ratio and better lower energy consumption. The PSO algorithm is used to select the optimal node and increases effective routing procedure. The routing process is done by using AODV protocol in this research. This is used to provide efficient path discovery and provides fast packet transmission and response. Thus the proposed PSO-AODV scheme provides superior performance rather than the existing approaches. The result concludes that the proposed PSO-AODV approach has lower energy consumption, lower end to end delay, higher packet delivery ratio and higher network lifetime than the existing approaches.
Key words: Energy consumption, PSO, AODV, MANET, routing

1. Introduction

MANETs have the imminent to present a best effort system infrastructure for data contribution on such scenarios. MANET is a self-governing group of nodes mobile users that provides infrastructure-freeconstruction for communication over a shared wireless medium [1], [2]. MANET nodes have restricted dispensation speediness and energy, battery, storage space, and communication potential. One of the most demanding problems in MANETs is their energy based routing algorithms.

MANET communications and nodes are normally power-driven via batteries with a restricted energy supply wherein every node stops functioning while the battery drains. Energy efficiency is significant concern in such setting. Since nodes in MANET depends on limited battery control for their energy, energy-saving methods targeted for reducing the total energy consideration of all nodes over the network. As a result of the energy constraints placed on the network's nodes, scheming energy efficient routing protocols is a central concern for MANET, to exploit the life span of its nodes and therefore of the network itself [3].

Clustering is an effectual topology control mechanism in MANET which can maximize network scalability and life span. Node clustering is a vital optimization issue. In order to preserve a definite quantity of service quality and a rational network lifetime, power needs to be optimized in each phase of the system operation [4]. A clustering method can efficiently extend the lifetime of MANET through the limited energy possessions.

Ad-hoc network does not require any fixed network infrastructure and can be easily set up at low cost as required. The routers, participating nodes act as router, are free to move over network at random and manage themselves randomly. Hence, the network's wireless topology may change rapidlyand unpredictably. Each of the mobile nodes is operated via a limited energy battery and usually it is unfeasible to renew or replace the batteries in a distant area. Routing is a development of detecting different routes from source to destination nodes. All the routes are computed and restored in network.

Routing protocols for ad hoc networks can be separated into two types depends on when and how the routes are discovered: proactive (table-driven) [5] and the reactive (on-demand) [6]. For the table driven routing protocols, reliable and up-to-date routing data are preserved in every mobile host. Therefore, for the table-driven protocols every mobile node sustains one or more tables containing routing information data to every other node in the network. When a network topology changes, the mobile hosts broadcast the rationalized messages during the network to uphold the routing information about the entire network.

Ad hoc On-demand Distance Vector Routing (AODV) [7] is an efficient route discovery algorithm. It reduces the amount of broadcasts via generating routes on-demand and maintains a list of all the routes. The Dynamic Source Routing protocol (DSR) [8] and Temporally Ordered Routing Algorithm (TORA) [9] are other on-demand routing protocols. More awareness has been created, due to the restricted battery capability in MANETs energy-aware routing. Energy-aware routing is an effective solution to prolong the lifetime of energy constrained nodes in mobile ad hoc networks [10]. There are generally two kinds of energy-aware routing such as Minimum Energy (ME) routing that chooses the route alongwith least total energy utilization for packet broadcast, and max–min routing that chooses the route which blockage remaining node power is the greatest.

In this research, PSO with AODV scheme is proposed to overcome energy and routing issues. The proposed scheme employs PSO algorithm for optimal cluster head selection in the clustering phase. The energy aware optimized routing is achieved by employing PSOalgorithm. The remainder of this research is organized as follows: section 2 describes the various research methodologies related to this research paper. Section 3 explains the proposed Swarm Optimized Energy and Routing scheme in detail. The experimental results are discussed in section 4 while section 5 makes a conclusion about this research work.

2. Related Work

In [11] Kaur et al (2015) introduced on demand protocols over the MANET for getting a better network performance. It is then shown that, the performance of Reverse Ad hoc On Demand Distance Vector (RAODV) is good with respect to Packet Delivery Ratio (PDR) though in few conditions, because of to link breakage, PDR tends to become low. RAODV can transmit more amounts of packets in comparison with Distance Source Routing Protocol (DSR) and Ad hoc On Demand Distance Vector (AODV). On the basis of the energy consumption, the performance of the

DSR is low in state in comparison with AODV and RAODV. Overhead in DSR is comparatively greater compared to the overhead in AODV and RAODV. RAODV will maximize the network duration although the performance reduces in between due to the more amount of packets that are dropped owing to link failure. Throughput in DSR is low compared to the throughput in AODV and RAODV.

In [12] Johnson et al (2007) used a most widely known routing algorithm, called Dynamic Source Routing (DSR) which is an 'on-demand'algorithm. It contains route discovery and route maintenance phases. Routediscovery contains both route request and route reply messages. In the routediscovery phase, when a node wishes to send a message, it first broadcasts aroute request packet to its neighbors. Every node within network, broadcast range adds their node id to the route request packet and rebroadcasts. Maintaining a route cache in every node reduces the overheadgenerated by a route discovery phase. If a route is found in the route cache, the node will return a route reply message to the source node rather thanforwarding the route request message further.

In [13] Avudainayagam et al (2003) presented a Device and energy-awarerouting (DEAR) for a heterogeneous set of connections. In this work, some nodes are on battery control while other nodes are associated to a continuous supply of energy. The objective of the protocol is to rely on the final type of nodes for general routing functionality, accordingly enlarge the life span of the battery powered nodes. The DEAR protocol calls a node device-aware if it can differentiate among whether it is battery powered or outwardly powered and the cost of using a device of the latter type is zero. During routing, the node evaluates the cost of reachingthe destination versus the cost of attainment a powered node, and if the latter is cheaper, it will forward the packet to a powered node. Hence, the transmission from the powered node is assumed to be of zero charge from an energy utilization perception.

In [14], Younis et al (2006) discussed cluster head selection based on single metric or combination of metrics such as identity, degree, mobility, weight, density, etc. The possibility of clustering technique mainly finds the complexity of CH selection. The CH plays the role of coordinator within its substructure. Every CH acts as a temporary source node within its cluster and communicates with other CHs. A cluster is therefore composed of a cluster head, gateways and members node

In [15], Kadono et al (2010) discussed a new Ant Colony Optimization (ACO) routing algorithm based on robustness of paths for MANETs with global positioning system (GPS. Every ant-like agent estimates robustness of a path via GPS data of visited nodes and decides the amount of pheromone to lie down depends on the robustness. Moreover, this approach, each node forecasts link disconnections from neighbors' GPS information for adjusting in dynamic system change. To maintain paths accessible, when a node predicts a link disconnection, it reorganizes the pheromone on the link to be disconnected thus building of another paths can increase speed. The results demonstrate that the approach achieves superior packet delivery ratio with lesser communication charge. However it has issue with energy consumption for larger networks.

In [16] Cao et al (2008), evaluated PSO routing optimization scheme for multi-hop wireless sensor network. This scheme synthesized the intuitionist compensation of graph theory and optimal search potential of PSO. Cluster heads selection approach is based on maximum residual energy and in revolves and through probabilities independently. The ways to lessen energy utilization and to optimize the network topology can be taken into account to for improving the network lifetime.

In [17], Latiff et al (2007) discussed Particle Swarm Optimization (PSO) algorithm. A problem is optimized by PSO by including dubbed particles,which is the population of candidate solutions here, and moving these particles based onan uncomplicated mathematical formulae over the location and velocity of the particle in the search-space. The movement of every particle is exaggerated via its greatest known local position however it is also concentrating towards the positions that well known in the search-space, which are confirmation and updated as improved positions and discovered by other particles. It is used o move the swarm towards the best solutions. As energy is the major concern in network, PSO provides optimal selection of cluster heads.

3. Proposed Methodology

In this research, the Particle Swarm Optimization - Adhoc On Demand Distance Vector (PSO-AODV) routing protocol is proposed to improve energy consumption over MANET. It consist two important steps such as CH selection and routing process in this research.

3.1 System model

In this section, the heterogeneous network is considered that consist of different nodes with different resources. Heterogeneous MANET comprise of mobile devices that have different communications capability such as radio range, battery life, data transmission rate, etc. Recently, some strategies are used to develop routing protocols to accommodate heterogeneous MANETs. In this research, each node is in charge of both detecting events and acting as a router in order to forward packets. It consists of nodes from different manufacturers or service providers. In this case, the malicious nodes may not completely cooperate with each other.

MANET model consists of a set of nodes given by: $N = \{N_1, \ldots N_n\}$, where $|N| = n$. As described. This network does not include centralized source as in wireless MANET networks. The n nodes of the MANET consist of MANETs with added capabilities and/or administrative and control tasks of the network (cluster heads and data aggregation points. The Victim nodes are described as a group of nodes $T = \{T_0, \ldots T_{r-1}\}$, where $T \subset N$, such that, every target node r of set T is a critical node of the network, and $|T| = r \ll n$. The adversary-class is defined as the set of malicious nodes in the network, and are denoted as: $A = \{A_0, A_{1,\ldots} A_{k-1}\}$, where $|A| = k \leq n$. In the MANET communication, the traffic packets originating from a source node can either be forwarded by the nodes through a set of intermediary nodes using a random topology. AODV modeled is preferred in this approach which is used to provide optimal routing path based on the efficient CH node selection using PSO. The Ad hoc On-Demand Distance Vector (AODV) routing protocol is intended for use by mobile nodes in an ad hoc network. It offers quick adaptation to dynamic link conditions, low processing and memory overhead, low network utilization, and determines unicast routes to destinations within the ad hoc network. It uses destination sequence numbers to ensure loop freedom at all times (even in the face of anomalous delivery of routing control messages), avoiding problems (such as "counting to infinity") associated with classical distance vector protocols. The entire proposed technique is shown in the Figure 1.

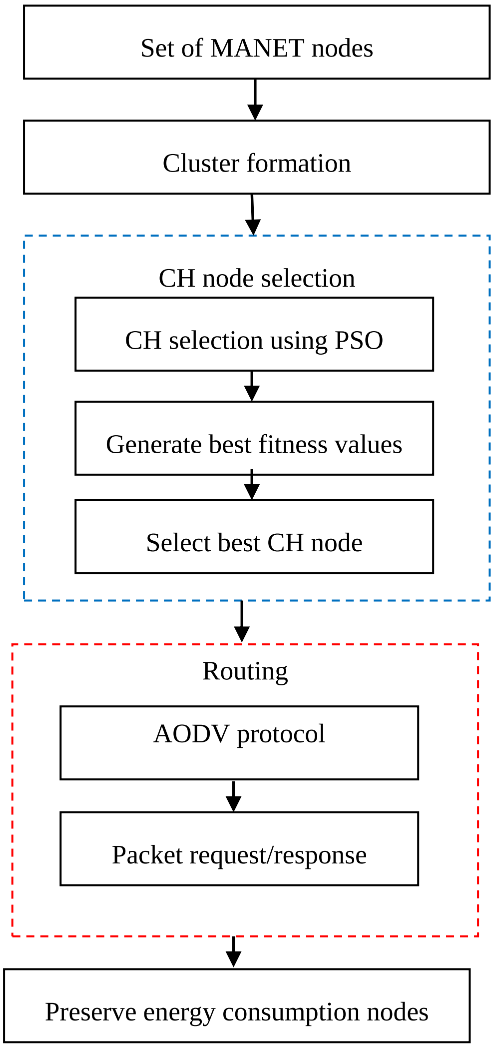

Figure 1 Overall block diagram of the proposed system

3.2 Cluster Head (CH) node selection using Particle Swarm Optimization (PSO) algorithm

In this research, Cluster Head (CH) election is performed by using PSO algorithm optimally. CH is the procedure of selecting a node present within the cluster to act as a leader node. CH keeps a record of the information concerned with its cluster. This information consists of a list containing the nodes existing in the cluster and the path to each node. The CH's responsibility is in communicating with every node in its own cluster. But CH should be capable of communicating with the nodes belonging to other clusters also, which can be reached directly, or by means of the corresponding CH or via gateways. Communication is performed in three stages. In the first stage, all of the cluster heads gets the data transmitted by its members, in the consequent stage, it does the data compression, and at last, it does the transmission of the data to the base station or to the other CH.

The cluster members are sent all the data packets which is received in gateway. The proposed method is used to select the CH which has the largest cluster members and it becomes a member of the selected cluster. A compression is used to convert data from an easy-to-use format to one optimized for compactness. Due to compression, the number of data packets can be reduced to maximum extend so that the need of memory and bandwidth are very less. Also, the compressed data resembles a scramble message and an attacker in middle cannot able to understand. Therefore, the data compression not only reduces the size of the original text, but also gives data security. The CH is responsible for its cluster member, whose retransmit can cover all nodes in that cluster. Transmission range, transmission power and transmission packets are considered by the cluster head and through shortest distance the data packets are transmitted to the base station or cluster head node. An appropriate CH node can minimize the energy utilization and improve the network lifetime.

Election of a particular node in the form of a cluster head is of great significance though it is a complex task. Different factors have to be taken into consideration for selecting the best node in the role of a cluster head. Few of these factors are inclusive of the node location with regard to other nodes, mobility, energy, trust, and the throughput of the node. Nodes of MANET possess constrained battery and resources. The election Process leads to an increase in the processing overhead in the network on an overall. Hence the election process should also take the processing and energy limitations of the nodes into consideration. One CH node per cluster has to be chosen during the election process, since multiple cluster heads present within a single cluster can result in reformation of cluster, Quality of Service (QoS), and routing management problems [18].

In this research, CH node selection is performed by using PSO algorithm based on the lower energy consumption, distance and higher packet delivery ratio values as objective function. It is focused to select the optimal cluster head for the resulted clusters.

The PSO is a computational approach that optimizes a problem in continuous, multidimensional search spaces. PSO starts with a swarm of random particles. Each particle is associated with a velocity. Particles' velocities are adjusted in order to the historical behavior of each particle and its neighboursduring they fly through the search space. Thus, the particles have a tendency to move towards the better search space. The version of the utilized PSO algorithm is described mathematically by the following equations:

Each particle updates its own position and velocity according to formula (3) and (4) in every iteration.

$$v_{id}^{k+1} = \omega v_{id}^{k} + c_1 \gamma_{1_1}(p_{id}^{k} - x_{id}^{k}) + c_2 \gamma_{1_2}(p_{gd}^{k} - x_{id}^{k}) + \alpha(\text{rand} - \tfrac{1}{2}) \quad (1)$$

$$x_{id}^{k+1} = \begin{cases} 1 & s(v_{id}^{k+1}) > rand\,(0,1) \\ 0 & \text{else} \end{cases} \quad (2)$$

where the $s(v_{id}^{k+1})$ is the sigmoid function S(vid) = 1/(1 + exp(−v_{id})),i = 1, 2, 3 ... m, m is the number of particles in the swarm, v_{id}^{k} and x_{id}^{k}stand for the velocity and position of the ith particle of the kth iteration, respectively. p_{id}^{k} denotes the previously best position of particle i, p_{gd}^{k} denotes the global best position of the swarm. ω is the inertia weight, c1 and c2 are acceleration constants (the general value of c1 and c2 are in the interval [0 2]), γ1 and γ2 are random numbers in the range [0 1].

Each feature subset can be considered as a point in feature space. The optimal point is the subset with least length and highest classification accuracy. The initial swarm is distributed randomly over the search space, each particle takes one position. The goal of particles is to fly to the best position. By passing the time, their position is changed by communicating with each other, and they search around the local best and global best position. Finally, they should converge on good, possibly optimal, positions since they have exploration ability that equip them to perform FS and discover optimal subsets.

The velocity of each particle is displayed as a positive integer; particle velocities are bounded to a maximum velocity Vmax. It shows how many of features should be changed to be same as the global best point, in other words, the velocity of the particle moving toward the best position. The number of different features (bits) between two particles related to the difference between their positions.

After updating the velocity, a particle's position will be updated by the new velocity. Suppose that the new velocity is V. In this case, V bits of the particle are randomly changed, different from that of Pg. The particles then fly toward the global best while still exploring the search area, instead of simply being same as Pg. The Vmax is used as a constraint to control the global exploration ability of particles. A larger Vmax provides global exploration, while a smaller Vmax increases local exploitation. When Vmax is low, particles have difficulty getting out from locally optimal sections. If Vmax is too high, swarm might fly past good solutions. Objective function is computed as follows

$$(X_i) = \phi.\gamma(S^i)(t) + \phi(n - |S^i(t)| \quad (3)$$

where S^i (t) is the feature subset found by particle i at iteration t, and $|S^i$ (t)|is its length. Fitness is computed in order to both the measure of the classifier performance,$\gamma(Si(t))$, and feature subset length. ϕ and φ are two parameters that control the relative weight of classifier performance and feature subset length, ϕ∈[0,1] and φ = 1 − ϕ. It is used to provide optimal CH node by generating the best fitness values of lower energy consumption, lower end to end delay and higher packet delivery ratio.

Algorithm 1

Initializing a population with N individuals

Initialize the position and velocity of each particle (nodes) in the swarm

While Maximum Iterations is not reached do

Set algorithm factors:

higher packet delivery – H_{PDR}

lower end-to-end delivery – L_{EED}

lower energy consumption - L_{EC}

for each particle $i = 1,2 \ldots.S$ do

Objective function of f(x), where $x = (x_1, \ldots\ldots, x_d)^T$

If f(Pi)<f(Gi)

Construct new CH

Evaluate the fitness of the new particle

If the fitness value is better than its personal best (pBest)

Set current value as the new pBest

End

Choose the particle (node) with the best fitness value of all as gBest

For each particle (node)

Calculate particle velocity and update node position according (1) and (2)

Randomly selecting a $gbest$ for particle i from highest ranked solutions

Update the velocity and position of particle v_{id}^{k+1}

Return most optimal CH

Update the pbest and gbest

Return the optimal CH

End

The above algorithm describes that the N number of nodes are taken for the given network. The objective function is considered as higher packet delivery ratio, lower energy consumption and lower end to end delay metrics. By using PSO technique, the CH node is selected which has the capability of defined objective function. This algorithm generates better fitness function values and it selects the node as CH node which satisfies the threshold values. The PSO position is optimized by using best particle and position as well as velocity values. Thus the PSO provides optimal CH node to improve the packet transmission in the larger network.

3.3 Routing using AODV protocol

In this section, the routing path is performed by Ad-hoc on demand Distance Vector Routing (AODV) routing algorithm. It reduces the amount of transmissions through generating routes on-demand. This protocol checks the route table when source needs to broadcast information. AODV is a loop- free, single path, distance vector protocol based on hop-by-hop routing approach. There are two main procedures in AODV:

- Route discovery
- Route maintenance

Route discovery: The route discovery process is starts when a source needs a route to a destination to transmit information. It checks its routing table to establish if it has a present route to the destination. If it has route, forwards the packet to next hop node otherwise it starts a route detection process. Route discovery starts alongwith the formation of a Route Request (RREQ) packet. Packet contains the following: Source node's IP address, Source node's existing sequence number, Destination IP address, Destination sequence number, Broadcast ID number.

Broadcasting is performed through flooding, and waits for a route reply (RREP). An intermediate node receiving a RREQ packet set a reverse route entry to the source in its rout table. Reverse route entry consists of: Source IP address, Source seq. number, number of hops to source node, IP address of node from which RREQ was received. When the destination node receives a RREQ, it also generates a RREP. The RREP is routed back to the source via the reverse path. As the RREP reaches to source, a forward route to the destination established [19].

Route maintenance: Route maintenance is performed by using route error (REER) packets. A route is "expired" if not used recently. A set of predecessor nodes is maintained for each routing table entry, indicating a set of adjacent nodes that use that entry to route data packets. These nodes are informed with route error (RERR) packets when the next hop link breaks. Each predecessor node, in turn, forwards the RERR to its own group of predecessors, consequently, efficiently erasing all routes using the broken link. Then this RERR is broadcasted to each source routing traffic via the failed link, causing the route discovery process to be reinitiated if routes are still required.

4. Experimental Result

In this section, the performance results of the proposed PSO-AODV scheme is compared with the existing AODV and ACO. The parameters and the simulation settings of the novel technique are tabulated in the given Table 1 [20].

Table 1: Simulation Parameters

Parameter	values
No. of Nodes	100
Area Size	1100 X 1100

	m
Mac	802.11
Radio Range	250m
Simulation Time	60 sec
Traffic Source	CBR
Packet Size	80 bytes

Performance Metrics

The below metrics are utilized in the simulation for the purpose of validating the performance of this new approach.

Energy Consumption

Energy consumption is the average energy required for sending, receiving or forward operations of a packet to a node in the network during the period of time.

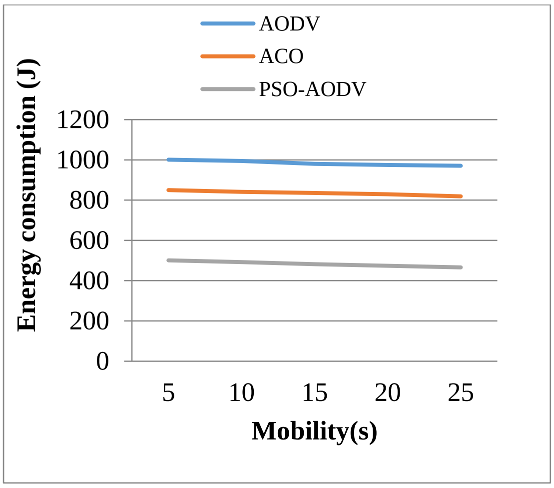

Figure 2 Number of nodes Vs Packet Delivery Ratio

From the Figure 2, it can be observed that the comparison of energy consumption using existing AODV, ACO and proposed PSO-AODV approaches. The mobility is varied from 10 to 50 (s). Mobility is plotted on x axis and the energy consumption is plotted on the y axis. It shows that the existing AODV and ACO methods provide higher energy consumption whereas the proposed PSO-AODV provides lower energy consumption. Thus the result proves that the proposed system has better performance in terms of optimized energy consumption based routing using PSO-AODV scheme over given network.

4.2 End to end delay

The average time which is incurred by a packet to be transmitted from source to destination through the network is known as the End to End delay.

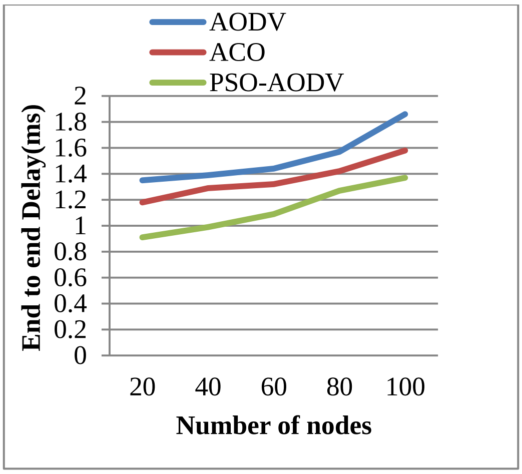

Figure 3 Number of nodes Vs End to End Delay

Figure 3 illustrates the comparison between the AODV, ACO and PSO-AODV techniques of the end to end delay performance. The nodes are varied from 20 to 100 and the end to end delay is plotted graphically for these nodes in nano seconds (ns). In the x axis, the number of nodes is considered and the end to end delay is taken in the y axis. The experimentation result shows that the proposed PSO-AODV algorithm yields a lesser end to end delay than the existing AODV and ACO techniques. Thus the result proves that the proposed system has better performance in terms of optimized energy consumption based routing using PSO-AODV scheme over given network.

4.3 Throughput

The rate with which the data packets get transmitted successfully over the network or communication links is defined as the throughput. It is measured in bits per second (bit/s or bps). It is also indicated by the units of information that are processed over a particular time slot.

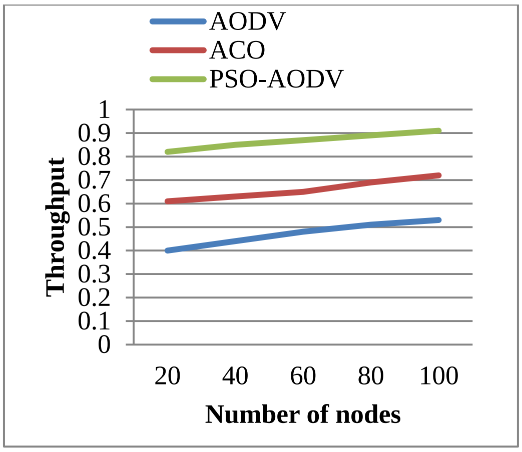

Figure 4 Number of nodes Vs Throughput

From the Figure 4, it can be observed that the comparison of throughput using existing AODV, ACO and proposed PSO-AODV approaches. The number of nodes is plotted on the x axis and the throughput is plotted on the y axis. The nodes are varied between to 100 nodes for the existing and proposed system. It shows that the existing AODV and ACO methods provide lower throughput whereas the proposed PSO-AODV provides higher throughput. Thus the result proves that the proposed system has better performance in terms of optimized energy consumption based routing using PSO-AODV scheme over given network.

4.4. Packet delivery ratio

The ratio of packets that are successfully delivered to a destination compared to the number of packets that have been sent.

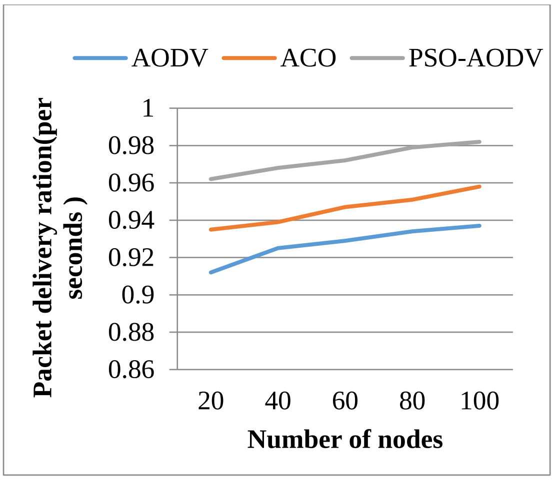

Figure 5 Number of nodes Vs Packet Delivery Ratio

Figure 5 shows the comparison between the existing and new techniques for packet delivery ratio. It is a measure of the number of packets that are received against the number of packets which were originally sent. It is evident from the simulation that the ACO-MGA proposed yields a greater packet delivery ration compared to the other existing AODV and ACO techniques. Thus the result proves that the proposed system has better performance in terms of optimized energy consumption based routing using PSO-AODV scheme over given network.

4.5 Network lifetime

The system is called better, when the algorithm provides higher network lifetime.

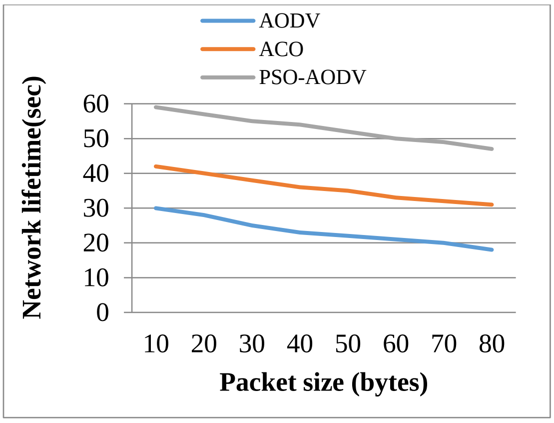

Figure 6 Network lifetime vs Packet size

From the Figure 6, it can be observed that the comparison of network lifetime using existing AODV, ACO and proposed PSO-AODV approaches. The packet size is varied from 10 to 80 (bytes). Packet size is plotted on x axis and the network lifetime is plotted on the y axis. It shows that the existing AODV and ACO methods provide lower network lifetime whereas the proposed PSO-AODV provides higher network lifetime. Thus the result proves that the proposed system has better performance in terms of optimized energy consumption based routing using PSO-AODV scheme over given network.

5. Conclusion

In MANET, it is significant that enhancing energy efficiency based routing performances. In this research, optimal CH election and routing is considered as important factors. Previous research has issue with higher energy consideration hence the overall performance gets degraded due to large number of groups. To address the above issues, optimal based CH selection is proposed. Optimal CH selection is done with PSO algorithm and it improves the energy consumption, end to end delay and transmission range. The routing process is performed using AODV protocol which gives optimal path discovery. It improves packet transmission and response higher for the given network. The overall performance is progressed in the terms of higher throughput, lower energy consumption, lower end-to-end delay, higher packet delivery rate compared with existing methods. In this research, node failure detection is not dealt and the data which has lost due to node failure is not recovered. It may incur some security concerns to the networks, so secure data transfer with recovery mechanism can be further developed.

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