Qualitative-based QoS performance study using hybrid ACO and PSO algorithm routing in MANET

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Abstract. In today's accelerated growth of mobile device technology, resource utilization in access network will continue to draw more attention to the increasing mobile user devices and applications. The main objective is to address the issue of QoS resource utilization efficiency. This paper combines the Ant Colony Optimization (ACO) algorithm and the Particle Swarm Optimization (PSO) algorithm to provide the optimum routing and to improve the QoS resource utilization efficiency. This proposed hybrid ACO-PSO algorithm uses the IEEE 802.11 DCF standard with multi-antenna scheme (MIMO) of Mobile Ad-hoc Network (MANET) to apply into integrated wireless (MANET) optical (PON network) based in Software Defined Network (SDN) with cloud computing. IEEE 802.11 Wireless Local Area Network (WLAN) gives the opportunity to its users to practice the wireless environment and full functionality of "anything, anytime, anywhere" concept. The proposed work is implemented using the OMNeT++ software where it investigates the QoS performance. These metrics include all nodes throughput, bandwidth, and load balance, routing and control overhead improvement with reduction. They also comprise of RSSI, end to end delay, Packet Delivery Ratio, network capacity, packet loss probability, as well as power consumption in all wireless nodes and energy consumption from wireless domain to wired domain.

1. Introduction

MANET is one of the confidential wireless networking approaches where a group of wireless devices can establish communication among themselves without any infrastructure [1]. MANET allows direct communication between the senders and receivers nodes for exchanging packet data through wireless and base station in a network structure. In WLAN, defined network base is used to provide service to the senders and receivers of the data packets through wireless medium [2]. To select optimum path in routing, the ACO algorithm is used which is based on reliable path under dual channel condition (DSAR). Dual channel communication mode improves the networks bandwidth. The hierarchical model is used to optimize the dual layer network. Reliable path is selected using ACO algorithm ahead of time to reduce the probability of routing restart [3]. ACO algorithm is used by many investigators for

developing new solutions for multipath routing in MANET. Ant based Ad-hoc On Multipath Demand routing protocol with Controlled Broadcast (A-AOMDV-CB) is an innovative algorithm inspired by the swarm intelligence. It uses the method adopted by the ACO algorithms with the features of multipath routing in ad-hoc environment [4]. Communication is one of the main resources of energy consumption in MANET. To select the optimized path in routing, the PSO algorithm is used. PSO algorithm selects the path by considering the energy parameters. PSO algorithm consists of three phases that are route setup phase, route discovery phase and maintenance phase [5]. Forwarding Search Space (FSS) heuristic technique is used to overcome the problems in the meta-heuristic algorithms. Forwarding Zone (FZ) is selected between the source and destination node. The Adaptive PSO (APSO) algorithm is applied for effective routing in FZ areas. A hybrid FZ-APSO is introduced for routing in dense network with minimum delay and energy consumption in order to increase the lifetime of the network [5]. MANET communication performance is easily degraded by even single local congestion on the path. To avoid this problem, detour paths are selected between the source and destination which can avoid the congested areas. When a packet meets congestion, it is assumed that the next hop node along the shortest path to the destination is the center of congestion and the packet is forwarded to its destination without visiting the node neighboring with the congestion central node [7].

In order to increase the network capacity, a delay sensitive multicast protocol is introduced which can minimize the sum of total transmission time of forwarders and the total blocking time of the blocked hosts. This protocol taking the neighboring information of the forwarders into account and properly adjusting the data rates of the forwarders. While routing, packet loss is the one of the significant issues in the MANET. Packet consists of unit of information which is steered amongst source and destination in a system. Packet loss happens when at least one packet crosswise over systems in a network drop before achieving the destination node. Packet loss strategy is introduced to ease the packet loss issue to an amount of degree. Energy efficient clustering formation is one of the major issues in the MANET. To overcome this problem, Clustering Based Energy Efficient Algorithm (CEERA) is introduced. This method is implemented based on the new weightage and dispersed flexibility exploration weighted clustering algorithm with the local clustering head. The CEERA algorithm selection technique reduces the routing overhead and increases the network life time.

2. Proposed Work

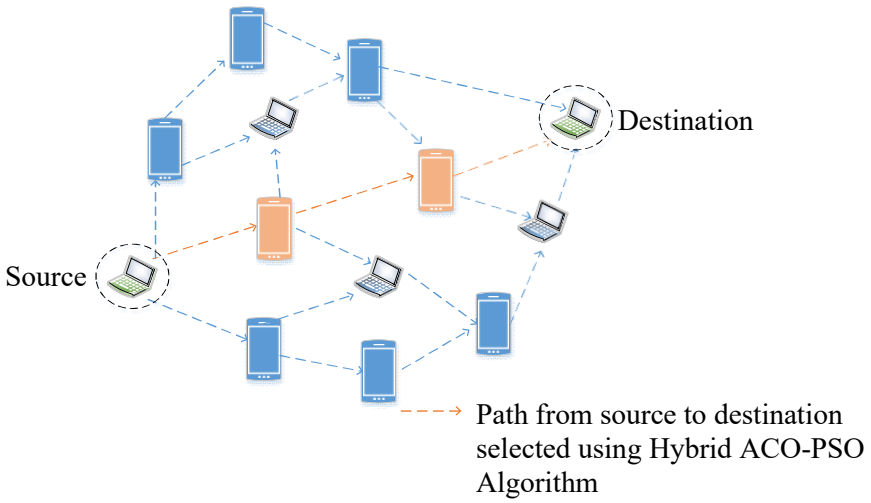

Figure 1. Architecture for proposed routing

2.1. System Overview

Figure 1 shows the architecture of the proposed routing in which the hybrid algorithm is applied to select the optimum path. In the proposed work, two popular swarm inspired methods are used in computational intelligence areas, which are the ACO and PSO techniques. The Hybrid combination of ACO and PSO algorithm is chosen to select the best route in MANET routing. This work aims to utilize the benefits of ACO and PSO algorithms for solving multi metric QoS routing problem in MANET routing. The proposed algorithm uses ACO to find the possible paths based on the concave metrics bandwidth and residual node energy. They originated from any source node to destination node for the network topology. Because of its foraging and self-organizing nature, it is more suitable for path exploration in a dynamic topology. Once the set of possible routes are found based on the pheromone concentration by the artificial ants, the resulting set of routes forms the initial population for the PSO phase. Based on the fitness function, the computation optimum paths are identified.

The metrics considered for the fitness function computation in PSO algorithm are position, velocity, delay and hop-hop count between the source and destination nodes. The PSO cycle is continued until the predefined number of generations are reached.

2.2. Proposed Routing

In the proposed work, the ACO and PSO algorithms are combined to select the optimum routes in the MANET routing. The ACO and PSO algorithm is the most efficient and intelligent algorithms in the swarm intelligence. The proposed algorithm uses all the parameters of both ACO and PSO algorithms. In the proposed algorithm, the made use of PSO is applied to enhance the attributes of the ACO algorithm. The utilization of the ACO algorithm is also enhanced to find the shortest path or route. The proposed algorithm not only reduces the number of paths in the ACO, but also finds the shortest path among largest path. The hybrid of ACO and PSO algorithm gives better result than the standalone ACO and standalone PSO algorithm.

In Figure 2, the proposed algorithm is illustrated, where the algorithm steps of the proposed hybrid ACO-PSO are described below:

Step 1: Parameters of the ACO technique are initialized.
Step 2: Ant solutions using pheromone trial based on bandwidth and residual node energy are constructed.
Step 3: The amount of pheromones is updated
Step 4: If maximum number of iterations reached, then proceed to Step 5 or else proceed to Step 2.
Step 5: Set of paths which are identified by the Ant agents are created.
Step 6: The initial particles for PSO algorithms are generated.
Step 7: If the fitness values are satisfied, then process is completed or else proceed to Step 8.
Step 8: The local best and global best values of each particle are evaluated using delay and hop count metrics.
Step 9: The velocity for each particle is computed.
Step 10: The position of each particle is updated.
Step 11: If the stopping criteria is reached, then proceed to Step 12 or else proceed to Step 7.
Step 12: The best set of particles are returned and process is finally completed.

The above steps are performed in the proposed algorithm to find the optimum route in the MANET routing. In the proposed algorithm for this work, the PSO algorithm is used to find the best path among the paths which are given by the ACO algorithm.

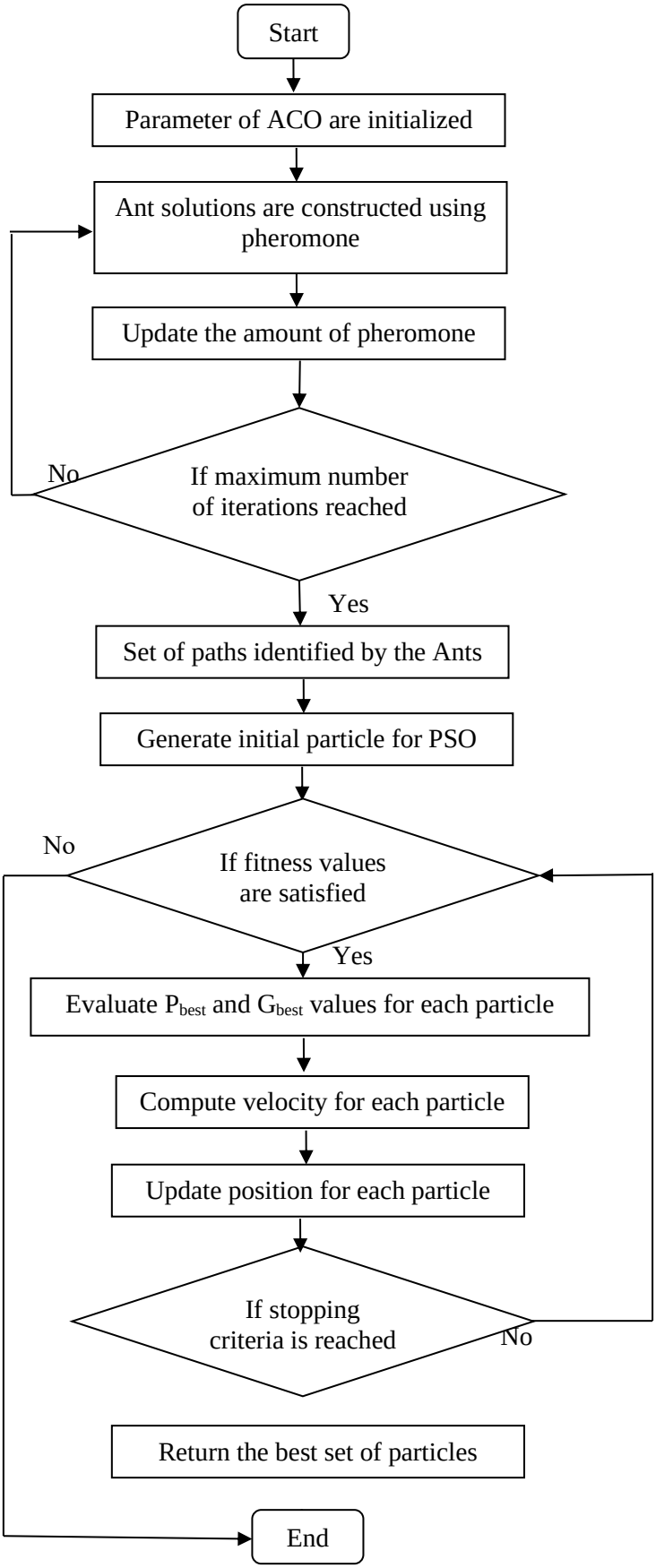

Figure 2. Flowchart for hybrid ACO-PSO algorithm

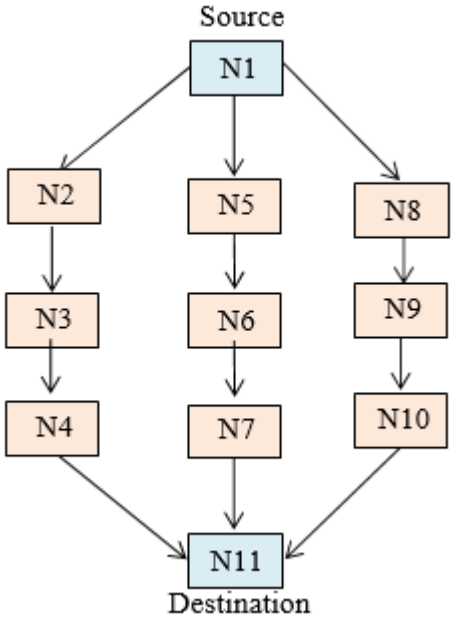

Figure 3. Possible paths from the source to destination

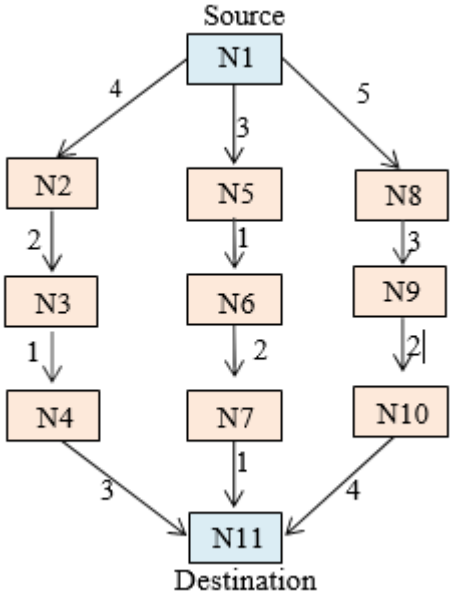

Figure 4. Delay in each node from source to destination

Figure 3 shows the example topology with N1 as the source node and N13 as the destination node. It describes the possible path selected using the ACO algorithm. Using these paths, initial populations are generated for PSO algorithm. Figure 4 shows the delay in each node between source and destination. These delays are computed in the PSO algorithm to select the minimum delay path between the source and the destination. PSO algorithm selects the optimum path using the fitness function calculation which have the metrics such as delay between source and destination and hop count between the source and destination nodes.

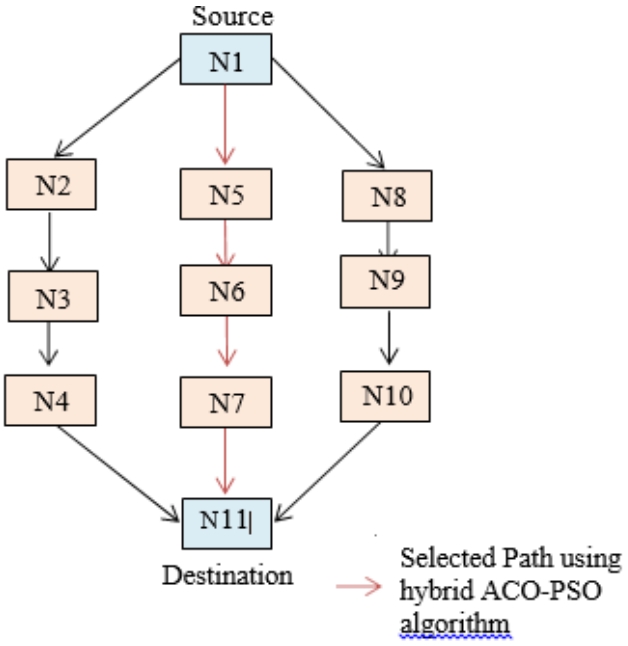

Figure 5. Selected path from source node to destination node

In Figure 5, the N1 sends the data using N5, N6 and N7 paths to the destination node N11. From N1 node to N11 nodes, the paths are selected using the ACO algorithm. Selected path from the ACO algorithm is given to the PSO algorithm as particles. The selected paths have the same hop count between the source node and destination node. To tackle this situation, the PSO algorithm computes the delay between the hop node and the destination node. The PSO algorithm computes fitness function using delay and hop count as metrics, as well as provide updates on the position and velocity of the node. The lowest delay between the source and destination node is selected for routing using the PSO algorithm.

3. Experimental Results and Discussion

In this section, the simulation results and comparison between the proposed hybrid algorithm and conventional ACO and PSO algorithm are furtherly discussed in detail.

3.1. Simulation Environment

The simulation has been performed in MANET routing which consists of 50 wireless nodes with 1500m x 1000m simulation areas. The simulation setup configurations are shown in Table 1.

Table 1. Simulation setup configuration

Simulation Area	1500 m x 1000 m
Number of nodes	50
Nodes Communication range	250 m
Nodes initial placement	Random
IEEE standard	IEEE 802.11n
Mobility Model	Random waypoint
Radio transmitter	2.5 mW
Radio Bi-Rate	40 Mbps
Packet Size	520 Bytes
Simulation Style	Cmdenv-express-mode
Simulation time	800 s

3.2. Performance Metrics

For this work, the proposed method performance metrics are compared with the conventional ACO and PSO algorithms which are shown in Table 2.

Table 2 illustrates the performance metrics comparison between the ACO and PCO algorithm with hybrid ACO-PSO algorithm. The proposed algorithm achieves all the QoS performance metrics whereas the conventional ACO and PSO algorithm does not fulfil the proper QoS metrics performance. The following section described the QoS performance metrics which are achieved through the proposed hybrid ACO and PSO algorithm.

Table 2. Performance comparison between hybrid and conventional algorithms

Performance Metrics	ACO Algorithm	PSP Algorithm	Hybrid ACO-PSO Algorithm
Throughput	*X*	⁄	⁄
Bandwidth	⁄	⁄	⁄
RSSI	*X*	⁄	⁄
End To End Delay	*X*	*X*	⁄
Packet Delivery Ratio	*X*	*X*	⁄
Network Capacity	*X*	⁄	⁄
Packet Loss Probability	*X*	⁄	⁄
Energy Consumption	*X*	*X*	⁄
Power Consumption	*X*	*X*	⁄
Scalability	*X*	*X*	⁄
Reliability	*X*	*X*	⁄

Throughput
The throughput is defined as the amount of data that is successfully delivered from source to destination within the given time. Throughput (*T*) can be expressed as:

$$T = \frac{U_S}{\mathrm{t}} \tag{1}$$

where U_S represents the number of data that is transmitted successfully and *t* is the time taken to transmit data.

Bandwidth
The bandwidth is defined as the maximum amount of data that can be travelled through the link or network.

$$Bandwidth\ (p) = \min\big(Bandwidth(e), e \in E(p)\big) p \geq B \tag{2}$$

where *B* represents the minimum bandwidth required.

RSSI
The RSSI is the Received Signal Strength Indicator which is the measurement of the power received in the signal. It is represented as *P*, which is given by:

$$P = \mathrm{VAL} + \mathrm{OFFSET} \tag{3}$$

where *VAL* represents the power, *p* in the RF and *OFFSET* is formed during the system development from the front end repeatedly.

End to End Delay
The End to End Delay is defined as the amount of time required to deliver the packet from the source node to the destination node. Delay is represented as *D*, which is given by:

$$D = \frac{\sum(arrival\ time\ of\ packet - forwarded\ time\ of\ packet)}{\sum number\ of\ nodes\ in\ connection} \tag{4}$$

Packet Delivery Ratio
The Packet Delivery Ratio is defined as the ratio of successfully delivered packet to the total data packets sent from the source to destination nodes. The packet delivery ratio P_r is represented as below:

$$P_r = \frac{N_d}{N_t} \tag{5}$$

where N_d is the successfully delivered packet and N_t is the total data packet sent from the source node to the destination node.

Power Consumption
The Power Consumption is defined as the amount of power consumed during the routing process.

Energy Consumption
The Energy Consumption is defined as the amount of energy consumed during the routing process. It is represented as *E* which is expressed as below:

$$E = \rho_C \times t \tag{6}$$

where ρ_C is the power consumed during the process and *t* is the time required for the process.

4. Conclusions
In earlier works, MANET routing and satisfying QoS performance metrics are challenging task need to be drawn. This drawback is overcame by the proposed algorithm in this paper. The proposed work presented a swarm agent based intelligent hybrid algorithm using the ACO and PSO algorithms. These two Meta heuristic algorithms are combined to achieve optimum routing and perfect QoS metrics performance. In the first stage, the ACO algorithm is used to find the possible paths between the source and destination based on the metrics energy and bandwidth. The results form the initial population for PSO algorithm using good pheromone values. In the second stage, the PSO algorithm finds the better path using fitness function computation values which considers the metrics such as end to end delay and hop count between the source and destination nodes. The simulation result of the proposed hybrid algorithm provides better results than the conventional ACO and PSO algorithms. The proposed algorithm also provides better QoS performance metrics compared to the standalone ACO and PSO algorithm, respectively. In future work, the authors plan to increase the number of nodes in the MANET network. In addition, they plan to mitigate the Byzantine Attack and Wormhole attack in the MANET routing.

5. Acknowledgement
The authors would like to thank the Centre for Research and Innovation Management of Universiti Teknikal Malaysia Melaka (UTeM) for sponsoring this work under the PJP/2019/FTKEE (5A)/S01658.

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