International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-4, November 2019

Efficient QoS Routing in Manet using Quantum

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***Abstract:** In mobile ad hoc networks, there is always a requirement of transferring real time multimedia information between a source-destination pair through a communication network. To support these communications and emergence of real-time applications, the basic requirement is to determine a feasible path which can join the source node and the destination node with a minimal cost .The paths are subjected to some constraints such as bandwidth, end-to-end delay, jitter and hop count. So, in order to assure an efficient performance, these QoS routing constraints must be properly handled. Therefore, complication of the problem is considered and accessible solution is provided using meta-heuristic algorithm rather than any other methods. To resolve the multi-constrained QoS routing problem in Mobile Ad-hoc Networks (MANETs), an intelligent algorithm has been proposed here to find the feasible path. This paper proposes a QPSO algorithm for solving multimedia routing which is capable of finding the low-cost route with bandwidth, delay and hop count as the constraints. In the proposed algorithm, the feasible path from the source node to the destination node is selected for communication which satisfies the minimum required bandwidth, less end-to-end delay and minimum hop count. The simulation results illustrate that the proposed QPSO algorithm with a novel node selection technique is able to find a better optimal path with multiple QoS constrains such as Bandwidth, hop count and network delay (end-to-end delay). It can meet the real-time requirements in multimedia communication networks.*

***Index Terms:** QoS, Mobile Ad-hoc network, Quantum Particle Swarm Optimization.*

I. INTRODUCTION

Mobile Ad Hoc Networks (MANETs) are categorized as a sort of wireless communication network in which mobile nodes link temporarily and spontaneously. Mobile ad hoc networks have certain distinct features such as, they are infrastructure less and the nodes can organize themselves to form a network without any conventional infrastructure. All the nodes can move randomly and can dynamically make a connection among themselves in a distributive manner and can facilitate peer-to-peer communications. These mobile nodes can be positioned wherever it is needed and they collaborate to facilitate communication using restricted network resources and administration [1]. In MANETs, communication is performed from the source node to the destination node through multiple numbers of intermediary nodes, so each node can act both as a workstation and router at a time. Though MANET is becoming popular, it experiences serious challenges when reliability and quality of service is considered. Due to the widespread use of wireless and mobile devices such as laptop, mobile phones there is a need for adequate resource management to provide quality-of-service (QoS) support for real-time applications in wireless and mobile networking environments. Thus QoS needs a optimal path from source to destination node which can also satisfy multiple QoS parameters [2] i.e. bandwidth, hop count, delay, battery power, packet delivery ratio. QoS metrics can be defined either by any one or by a set of parameters. The multi constrained QoS routing creates more complex problem.

So possibly, some new methods can effectively handle Quality of service routing problem. The routing problem is NP complete if more than one QoS constraints are to be satisfied. To explain the NP-completeness of QoS routing, stochastic methods are to be considered rather than a deterministic method. For resolving the optimization problems, different stochastic methods are used. All through the last span of time, swarm intelligence has been immersed for resolving the global optimization problems.

The QoS metrics can be categorized [3] as additive, concave and multiplicative metric. Additive measure gives the summation of the measure along the link, while minimum value observed in the link gives the concave and multiplicative measure is calculated as the multiplication of values of the measure over the route.

Let L (v_1, v_2) be a metric for link (v_1, v_2). v_1, v_2, v_3..., v_i, v_j symbolize different nodes in a network. Any path L can be given as L = (v_1, v_2,... vi, vj) Where L is the link, v is the node. Metric M is:

Additive : $M(L) = M(v1, v2)+ M(v2, v3) + ... + M(vi, vj)$

Example: Delay, jitter, cost and hop-count are additive metric.

Multiplicative: $M(L) = M(v1, v2) * M(v2, v3) * ... * M(vi, vj)$

Example: Reliability is the multiplicative metric.

Concave: $M(L) = \min \text{ or } \max\{ M(v1, v2), M(v2, v3), ... , M(vi, vj) \}$

Example: Bandwidth and residual node energy is the concave metric.

Among the various QoS metrics bandwidth, delay energy and hop count are the essential services required to be satisfied to enhance the performance of the real time communication by a MANET [4]. In this paper we have proposed a QPSO based technique to reduce the complexity involved in multi constrained QoS routing.

Section 2 of this paper explains the background study on meta-heuristic methods. Section 3 describes the network strategy and proposed QPSO algorithm mapping.

Manuscript published on November 30, 2019.
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The suggested solution with the given constraints, experimental setup and simulation results respectively is describes in section 4 to 6. Analysis of the simulation result and Conclusion obtained are given in Section 7.

II. RELATED WORK

With the expansion of ad hoc networks, the need of QOS requirement has been increased for real time and multimedia applications in a MANET and hence, it becomes a research hotspot. Various researchers have contributed in Ad Hoc networks for resolving QoS routing problem and thus, researchers have used various metaheuristic algorithms. Several approaches have proposed and can be found in literature [5-12]. V.V Mandhare [1] proposed CSO-AODV protocol to find the relevant path instead of shortest path satisfying different QoS constraints. Incorporating two diverse heuristic approaches CSA and DE, a technically guaranteed computational intelligent hybrid algorithm is derived to explain a multi-objectives in mobile Ad Hoc Networks (MANETs) by S. Rajalakshmi et.al. [2]. In a multi objective optimization approach has been proposed by S.K.Nivetha et.al [6], which aims at finding the route while considering different parameters in a hybrid ACO-PSO based model .Ahmed Younes et al. [7] have suggested an efficient GA to obtain an optimized multicast routing with bandwidth and delay constraints. In the proposed algorithm from k different paths, the best possible path can be chosen. Energy efficient multi constrained optimization implemented by hybrid ACO and GA in MANET routing [8] proposed by S.K.Nivetha et al. is another approach which combines the benefits of both the algorithms to reduce the complexities in routing. A hybrid routing approach has been proposed by B.Nancharaiah et al. using Simulated Annealing (SA) and a different QoS routing algorithm is suggested in [5]. Considering different routing structures and policies [9-15], several researchers have offered different contributions. Routing in different random topologies adopting the firefly swarm with the shortest path search technique has been proposed by D Jinil Peris et al. to find a better solution in a larger network. Depending on ants foraging behavior, an effective load balancing algorithm [12] has been proposed to enhance the network output considering throughput, delay an RO as network performance metrics.

III. PARTICLE SWARM OPTIMIZATION

Particle swarm optimization (PSO) algorithm is a population based computational technique based on the behavior such as bird flocking and fish schooling was introduced by Kennedy et al. [16] in 1995. In PSO, each individual is a possible solution which is known as a particle in the multidimensional search space. A particle starts with an initial position and velocity and it keeps on updating its own and neighbors' experiences or the experience of the whole swarm.
The particle updates its position and velocity by the following equations:

$$v_{new} = w^* v_{current} + c_1 rand\,()(p_{best} - x_{current}) + c_2 rand\,()(g_{best} - x_{current}) \quad (1)$$

$$x_{new} = x_{current} + v_{new} \quad (2)$$

Where c_1 and c_2 are called acceleration coefficients. Parameter w is the inertia weight which helps to balance the exploration and exploitation of PSO. P_{best} and $V_{current}$ are the current position and velocity of particle respectively. g_{best} is the global best position of the best particle among all the particles in the population.

IV. QUANTUM BEHAVED PARTICLE SWARM OPTIMIZATION (QPSO)

PSO algorithm has a disadvantage that it does not give assurance for a global convergence as it may be trapped into the local optima because it converges at a very fast rate for which the quality of the solution cannot improve. During the trap the pbest and gbest of a neighboring particles are very adjacent to each, so during the particle's position updation, the value of $(p_{best} - x_{current})$ and $(g_{best} - x_{current})$ does not change hence this particle mislays its search capability. To overcome the limitations of PSO, a quantum behaved PSO (QPSO) was introduced. In (QPSO), the position of the particle is defined by wave function instead of velocity. The probability of the particle's lactation in position x is defined from probability density function $(\Psi(x,t))^2$, and the particle position is updated according to the following equations,

$$x_{new} = P_{attractor} - \beta^*(M_{best} - x_{current})^* \ln\left(\frac{1}{u}\right) \quad \text{if } r \geq 0.5 \quad (3)$$

$$x_{new} = P_{attractor} + \beta^*(M_{best} - x_{current})^* \ln\left(\frac{1}{u}\right) \quad \text{if } r < 0.5 \quad (4)$$

$$P_{attractor} = \theta^* P_{best} + (1-\theta)^* g_{best} \quad (5)$$

$$M_{best} = \frac{1}{N}\sum_{i=1}^{N} P_{attractor} \quad (6)$$

where P_i is the local attractor, g_{best} and P_{best} is the global best position and current position the of particles in the population respectively. M_{best} is the mean best position of all the best positions of the population in current generation, r, u, θ are random number distributed uniformly on [0,1]. The parameter β contraction expansion (CE) in the equation 5 and 6, helps for the convergence speed of the particle

$$\beta = \beta_{max} - (((\beta_{max} - \beta_{min})/t_{max})^* t) \quad (7)$$

Where β_{max} is the initial contraction expansion factor value, β_{min} is the final contraction expansion factor value where , 't' is the current iteration number and t_{max} is the maximum number of iterations[15].

V. PROBLEM FORMULATION

A. Defining the network

A network is defined as a connection between the nodes through different links. Here we have presented it as a weighted graph G = (V, L), where V signifies the set of nodes and L symbolizes the set of communication links in the Network. |V| and |L| is the numbers of nodes and links in the network respectively.

The range of communication between nodes represented as 'r' and the distance between the nearby nodes as 'd'. To establish a communication the $d \leq r$ must be satisfied. From source to destination 'L' is the set of all paths.

B. Representation of the particle and encoding system

The proposed algorithm has been simulated using a network of 50 nodes scattered over a100m x100 m region.

For the solution representation of the problem, two criteria are considered for choosing a node. In the first criterion, the entire area is divided horizontally into different segments by a transmission range. By second criteria from the source node the next node will be chosen from the set of available nodes by a real number encoding system in the segmental area of transmission. A real number encoding system represents the position of the particle. The numbers of the particle in the swarm is equivalent to the number of nodes. Real numbers between [-1, 1] are generated for each node and a particular node will be chosen from each segmental area by the smallest position value of the particle from the respective segmental area. For an example, assume that we have 20 numbers of nodes spread over an area of 100m x 100 m. Let the transmission range be 10m, so the entire area is divided into 10 segmental area. The encoding scheme is given in Fig.1

In the 1st segment, the available nodes are Node 1, Node 2 and Node 3. So from the source node, the data can be transferred to any of these 3 nodes. The particle position for Node 1, Node 2 and Node 3 are generated as 0.67, 0.129, and 0.863 respectively. The node 2 will be selected because its corresponding particle position is smallest. Similarly in the 2nd segmental area, node 4 will be selected. In the similar process, a path can be generated i.e. S-2-4-7-8-11-14-16-18-20-D.

Our approached QPSO based algorithm tries to fetch a feasible path along the network which can satisfy all the

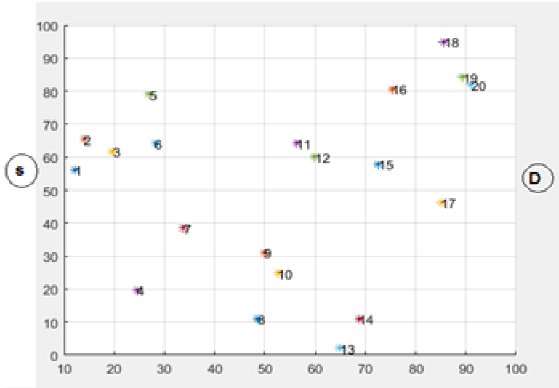

Fig. 1: A 50 Node Scenario

Segmental Area	1			2			3	4	5				6		7		8			9
Available Nodes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Particle Position	0.67	0.129	0.863	0.041	0.283	0.235	0.857	0.403	0.982	0.567	0.252	0.683	0.501	0.352	0.489	0.183	0.464	0.213	0.954	0.315
Node chosen	2			4			7	8	11				14		16		18			20

Fig. 2: Particle Representation Model

three constraints. It may be applied in the network scenario where varied parameters are in use. Here, we have emphasized on finding a path having maximum available bandwidth, lesser total stringent delay and also having the minimum hop count as three parameters in order to determine a optimized path amongst various feasible paths between a source node a destination node. Our proposed approach is more scalable and can give better result when there is a growth in the number of network nodes. For an example the fig 3 and fig 4 represents a 50 nodes and 500 nodes scenario where the blue line shows the possible communicating links between the nodes. By using the proposed algorithm we obtained the optimal path from source (node 1) to destination (last node), is represented by red line.

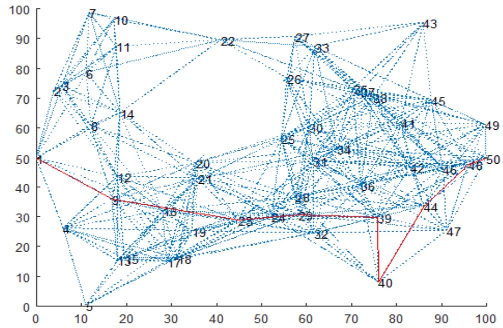

Fig. 3: A possible path in 50 Node Scenario

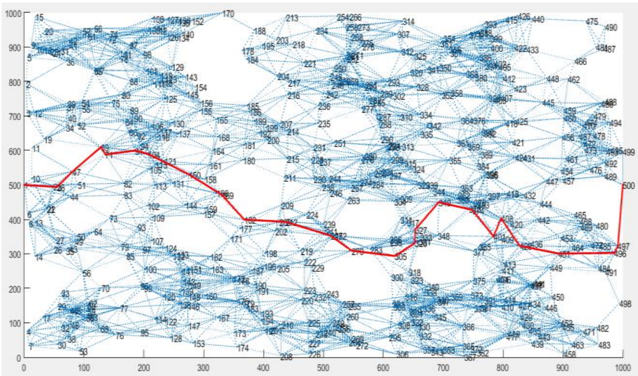

Fig. 4: A possible path in 500 Node Scenario

C. Fitness function:

We have considered the routing challenge along with multiple constraints to find an optimized path. To formulate a feasible path between a source-destination pair, the constraints attached with the link and node must be handled and shared properly. Considering different constraints we have defined the fitness function as follows.

$$F(x) = w_1 \times (F_1) + w_2 \times (F_2) + w_3 \times (F_3)$$

Here w_1, w_2 *and* w3 are the priority weightage and F_1 is the primary objective i.e. Bandwidth and F_2 and F_3 are the secondary objectives i.e. Delay and Hop-count.

Routing Metrics:

Delay: The amount of delay is represented as the time elapsed through the edges and in the queue of the hops during the transmission of the messages from source to destination.

$Delay(L) = Delay(E) + Delay(H)$

Hop count: The total number of hop count indicates the number of nodes visited by the message from the source to the destination. H (L) = |L (v)|

Bandwidth: The available bandwidth of the path from S to T is maximum amount of bandwidth available on all the links along the path.

Bandwidth B (L) = max {band (e), e ∈ E (l)}, $Bandwidth(e) \geq B$

VI. SIMULATION RESULT

The algorithm was coded in Matlab and Random way point model is the mobility model considered. The delay, transmission capacity (bandwidth) of the channel is set randomly from 1s to 30s and 2 to 10 mbps respectively. From the source node, the link with highest bandwidth and lowest delay will be selected as per the transmission requirement. The path that does not satisfy the bandwidth requirements is filtered. To analyze the simulation results, we have placed 50 to 100 nodes randomly in an area of 1000x1000 square meters. The nodes can communicate within a range of 150m. The nodes can move with a speed of 10m/s. As the network has a dynamic behavior, it has various impacts on different QoS metrics. So, seven different pause time from 0s to 120s have been considered to analyze the effect of the algorithm

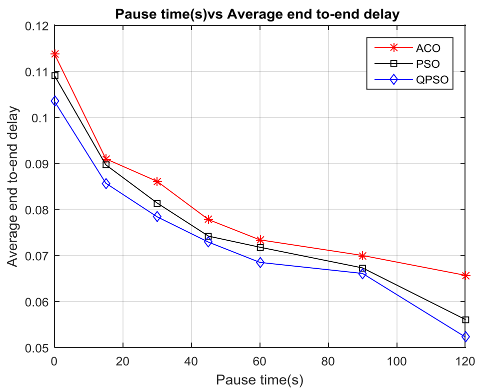

Fig. 5: Pause time vs Average end to end delay

Fig.5 shows that with the increase in the pause time, the delay experienced by the QPSO algorithm decreases remarkably. As the topology is static for some time, the data can be transferred in the defined optimized path with less computed delay. It is shown in the graph that our proposed algorithm QPSO gives better result than PSO, and ACO.

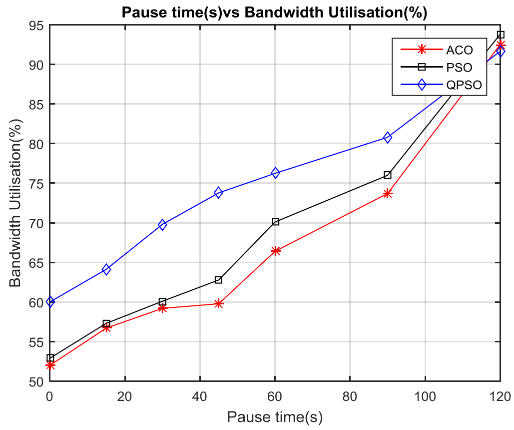

Fig. 6: Pause time vs Bandwidth utilization

Fig 6 shows the effect of changing pause time on bandwidth consumption in a network. The above graph shows QPSO shows rather better utilization of bandwidth than ACO and PSO. As the pause time increases, the optimized path in the network gives better bandwidth utilization.

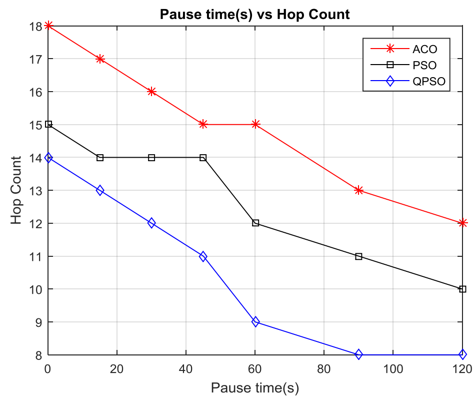

Fig. 7: Pause time vs No. of hop Count

Fig 7 shows the total number of hops navigated during different simulations. The proposed algorithm takes less number of hops than PSO and ACO. Here, the total number of hops navigated on an average is 8 to 14 for reaching the destination.

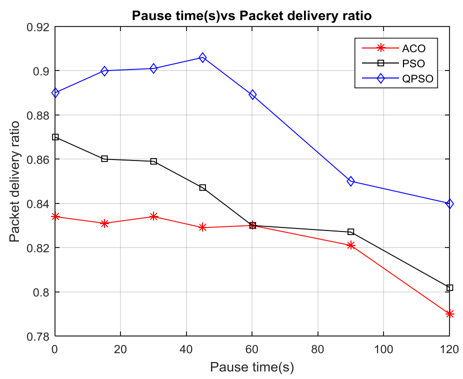

Fig. 8: Pause time vs Packet Delivery Ratio

Retrieval Number: D8600118419/2019©BEIESP
DOI:10.35940/ijrte.D8600.118419
Journal Website: www.ijrte.org

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Blue Eyes Intelligence Engineering
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Figure 8 illustrates that the Packet Delivery Ratio increases in our algorithm than in PSO and ACO. The proposed algorithm gives improved packet delivery result as other algorithms under 45s pause time. But, when the pause time becomes more, there is packet drop as the broken paths cannot be recovered and it has to search for next best path for communication.

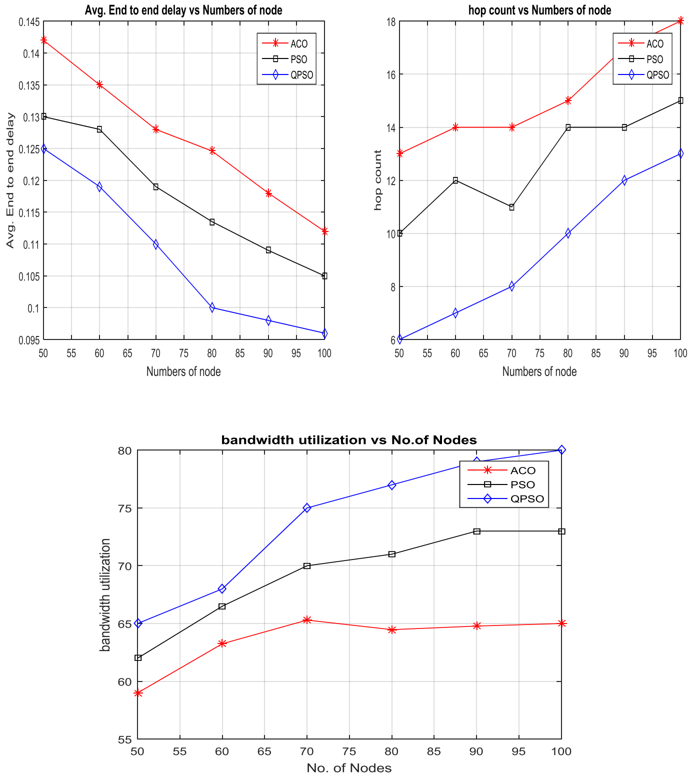

Fig. 9: scenario under varied number of nodes condition

The simulation scenario is also tested under varied number of nodes condition which is illustrated in fig.9.As we move from one node to another using the path preference probability, it is found that QPSO shows better performance than PSO and ACO.As the no. of node increases the delay decreases . When the nodes available will be more in a particular scenario the probability of link break and packet drop will be less hence decrease in end to end delay. Here we have selected the link having highest available bandwidth and less number of hop count as a preferred path so QPSO has given an optimized path with a better result as shown in the graph.

VII. CONCLUSION

The purpose of the new mechanism presented in the QPSO algorithm is to find a path satisfying multiple constraints in a MANET. The dynamic constraints used in this approach can find the most suitable path for a specific scenario. We have got a fault tolerant system by using the concept of multipath routing. The service performance is determined by using each of the QoS parameters. Effective data delivery accomplishment signifies that the path attained by the QPSO algorithm gives a better multimedia data transmission, with maximum utilization of bandwidth and minimum delay and hop count.

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