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QoS Routing enhancement using metaheuristic approach in mobile ad-hoc network

V.V. Mandhare [a,*], V.R. Thool [b], R.R. Manthalkar [c]

[a] Department of Information Technology, India
[b] Department of Instrumentation and Control Engineering, Shri Guru Gobind Singhji Institute of Engineering and Technology, Vishnupuri, Nanded-431606 (MS), India
[c] Department of Electronics and Telecommunication Engineering, Shri Guru Gobind Singhji Institute of Engineering and Technology, Vishnupuri, Nanded-431606 (MS), India

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ABSTRACT

The Quality of Service Routing (QoSR) is always a tricky problem, due to dynamic nature of network, which is always Non-deterministic Polynomial-time (NP) hard. To resolve the problem, multi-constrained QoSR in Mobile Ad-hoc Network (MANET), an intelligent algorithm have been proposed to find the feasible path. This paper focuses on, satisfying the constraint of QoS in MANET inspiring Cuckoo Search(CS) algorithm, based on enhancing conventional CS technique using on-demand protocol. This approach select QoS path based on computation of best fitness value instead of shortest path for Route Replay (RRPLY) packet of Ad-hoc On-Demand Distance Vector (AODV) protocol. The fitness value is computed using three different parameters namely, routing load, residual energy and hop count. The algorithm is applied on AODV protocol for *RRPLY*, where multiple routes are available. The Cuckoo Search Optimization AODV (CSO-AODV) protocol gives better QoS routing metrics, satisfying QoS constraint. The obtained results of proposed CSO-AODV protocol are compared with, Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO) and basic AODV protocol, tested for three different condition i.e. mobility, scalability and congestion. The simulation results of the proposed algorithm is superior compared to ACO, PSO, and AODV algorithms.

1. Introduction

As technology is growing rapidly, it requires many hand-held devices like laptop, palmtop, mobile phones etc. Which are advanced by increasing CPU time, disk space, power consumption and memory size. MANET [1,2], opens the door for these devices. MANET is self-healing, multihop, infrastructure less network free to move from one place to another place. There are several applications of MANET like audio, video, multimedia etc, which requires good communication and QoS [3,4]. Similarly other wireless network CDMA, GSM and Wi-Fi, MANET is unable to provide reliable QoS [5]. Therefore, selecting appropriate protocol is important and challenging task, due to number of protocols presented in the literature, differ from each other and required guarantee of stringent QoS [6]. The main aim of QoS routing [7] is to find relevant path, that must satisfy QoS constraint requirements such as, packet loss, bandwidth, delay, jitter, energy consumption which are transmission characteristics of topology. The routing problem is NP complete if two QoS constraint are satisfied i.e. two additives or combination of additive or multiplicative metrics. QoS routing also satisfies constraint like link, path and tree constraint [8]. Where, bandwidth, jitter-delay and end-to-end delay are main, link and path constraint respectively [9]. Thus, to satisfy the above constraints with multiple objectives, there is need of potentially new approach or technique for solving the QoS routing. Therefore, complication in the problem is considered, and accessible solution is provided using metaheuristic algorithm rather than other methods. To solve QoS routing, past researchers used various metaheuristic algorithms [10,11]. But, there is necessity of enhancing routing protocols in MANETS, to provide stringent QoS enhancement [12].

Section in this paper is organized as follows. Section 2 presents the related work on metaheuristic approaches. Overview of basic AODV algorithm with problem formulation is given in Section 3. Proposed solution with CSO-AODV algorithm, experimental setup and simulation results and discussion are illustrated in Sections 4–6 respectively. Conclusion drawn based on the simulation results is given in Section 7.

* Corresponding author.
E-mail addresses: v_mandhare@yahoo.com (V.V. Mandhare), vrthool@yahoo.com (V.R. Thool).

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2. Related work

To improve the performance of routing protocols using different metahuristic algorithm several methods are proposed and can be found in the literature [13–29]. J. W. Lee et al. [13] proposed ACO algorithm for energy efficiency using three different types of pheromones, to increase the performance in terms of network life time, based on Three Pheromone Ant Colony Optimization (TPACO) algorithm. S. Umamaheswari et al. [14] suggested a framework to improve the security in mobile Ad-hoc network based on AODV. O. Awwad et al. [15] has developed new topology control scheme, implementing PSO to enhance QoS routing in wireless mesh network. To improve QoS routing, J. Sun et al. [16] developed a new algorithm based on QPSO utilizing various QoS metrics. Which provides better solution for the problems related to multicast routing. S. J. Gudakahriz et al. [17] introduced the concept of Honey Bee Mating Optimization (HBMO) principle on routing protocol to upgrade optimization problem. The simulation results obtained has shows that, network life time, end-to-end delay, packet delivery ratio, system life time in HBMO-TORA were better than TORA routing protocol. An efficient routing algorithm for MANETs, “Modified Termite Algorithm (MTA)” was developed by G. Sharvani et al. [18]. To overcome the stagnation problems by fine tuning of pheromone concentration, based on node stability factor. To resolve the dynamic shortest path (SP) routing problem in MANETs, S. Yang et al. [19], presented Genetic Algorithm (GAs) with immigrants and memory schemes. The achieved simulation results with approach [19] shows, immigrants and memory-based GAs quickly adapt changes to the network topology and produce better-quality solutions. Y.T. Chen et al. [20] put forward ACO, Aided Bat Algorithm, in this algorithm measurable frequency and eco time were used for optimization and distance measure from objective and bats respectively. In which direction, movement and correct velocity was computed using echo time. The better search quality was obtained using this algorithm. L. Cobo et al. [23] proposed QoS based model using ACO for multimedia sensor network. The results were compared with different methods, to shows the better performance of proposed method. S. H. Amin et al. [24] proposed SMART data packet routing protocol based on swarm technology. This protocol is combination of ACO and River Formation Dynamics (RFD). Compared to AntHoc net and AODV protocol, results were improved for throughput and reduced for jitter and end to end delay. H. Cheng et al. [25] proposes dynamic load balanced clustering problem in dynamic optimization problem using Genetic Algorithm (GA). In [25] results obtained using GA’s was better compared to conventional GA algorithm. Nancharaiah, et al. [26] developed ACO with fuzzy system. In this approach the path information by the ant was be given to Fuzzy Interface System (FIS), and the optimal path was selected based on path score value. High packet delivery ratio is achieved using [26] approach. P. Venkatkrishna et al. [27] proposed QoS aware multipath ACO protocol for selecting path and forwarding data. The results obtained using [27] shows that proposed protocol is scalable with high traffic network. B Zing et al. [29] introduced energy efficient algorithm based on harmony search algorithm, which gives good result compared to basic harmony algorithm.

QoS constraint fault tolerant and valid route look up algorithm was proposed by S. Surendren et al. [28] in case of route failure, 20% - 30% result improvement was achieved. B. Nancharaiah et al. [21], developed a hybrid routing combining with ACO and PSO algorithm. The hybrid algorithm finds the best solution, which increases various QoS metrics.

Considering above facts, it is clear that metaheuristic algorithm plays vital role in improving efficiency of routing in MANET. The algorithms presented in the literature, to solve the problem of routing, using bio-inspired algorithms, has some limitations [22]. Therefore, energy efficiency of routing protocols using these algorithms may not be consider for routing in MANET. Hence, to enhance routing and provide QoS for different applications, CS algorithm is applied on reactive protocol and is presented in this paper. In this work QoS routing is enhanced by modifying AODV protocols RRPLY packet using Cuckoo Search (CS) algorithm by computing fitness value instead of shortest path computation. The enhanced QoS metrics using proposed CSO-AODV, is effective and has achieved better results compared to ACO, PSO and AODV protocol. The CS algorithm have been used by many researchers in science and engineering for optimization, that provides better results. Presently CS algorithm is used in various domains and areas for engineering optimization, scheduling, feature selection, function optimization, forecasting, planning, image processing and real-world applications.

3. Ad-hoc on-demand distance vector routing protocol

The routing protocol is divided into different types [30–33]. Among these AODV is reactive, self starting, dynamic, loop freedom, efficient routing protocol based on Bellmen Ford algorithm [34]. The main difference of AODV protocol is, it use sequence number. The sequence number is created by destination or multicast group leader. The route discovery and route maintenance are phases of AODV protocol [35]. The three message types, defined by AODV are Route Request (RREQ), RRPLY and Multicast Activation (MCAST). The ‘hello message’ is send to its neighbors to get nodes existence. Then RREQ packet is send to destination via shortest path. The RRPLY is send through multiple paths. The format of *RRPLEY* packet is given in Fig. 1, where ‘R’ presents repair flag used for multicast and ‘A’ indicate acknowledgment required. The *RRPLY* packet is send back to source node by computing hop count, which produce enormous drawback. Firstly, congestion is occur on specified path and packet drop rate is high. Secondly, time require to reach the packets to source node is high, due to extra overhead high energy is require. Thus for real time applications AODV protocol fails and reduce QoS. Therefore, it is essential to enhance QoS constraint of AODV protocol, which has been focused in this paper. The problem formulation based on AODV protocol with QoS is given in 3.1.

3.1. Problem formulation

Modeling of QoS routing problem can solve optimization problem using different practical constraint for reactive protocols. The objective function of QoS routing is formulated using Eq. (1).

$$\text{Minimize} M(I(x,S)) = M_c + \delta_1 M_b + \delta_2 M_d + +\delta_3 M_{dj} + +\delta_4 M_{pl} \quad (1)$$

where M_c=cost function component of objective function,
M_b= cost related to bandwidth requirement,
M_d= cost related to delay requirement,
M_{dj}= cost related to delay jitter requirement,
M_{pl}= cost related to packet loss requirement.
$M(I(x, S))$= Total cost function.

Additionally, δ_1, δ_2, δ_3 and δ_4 are penalty constant of bandwidth, delay, delay-jitter and packet loss respectively. The following are the reasons for coupling multi-constraint and cost optimization.

- For each source and destination pairs feasible paths are expected for practical QoS routing.
- For perfection of users and network engineer’s significance minimize the network resources.

It can be represented in summation, as Eq. (2),

$$M(I(x,S)) = \sum_{e\in I(x,S)} M(x) + \sum_{e\in I(x,S)} M(y) \quad (2)$$

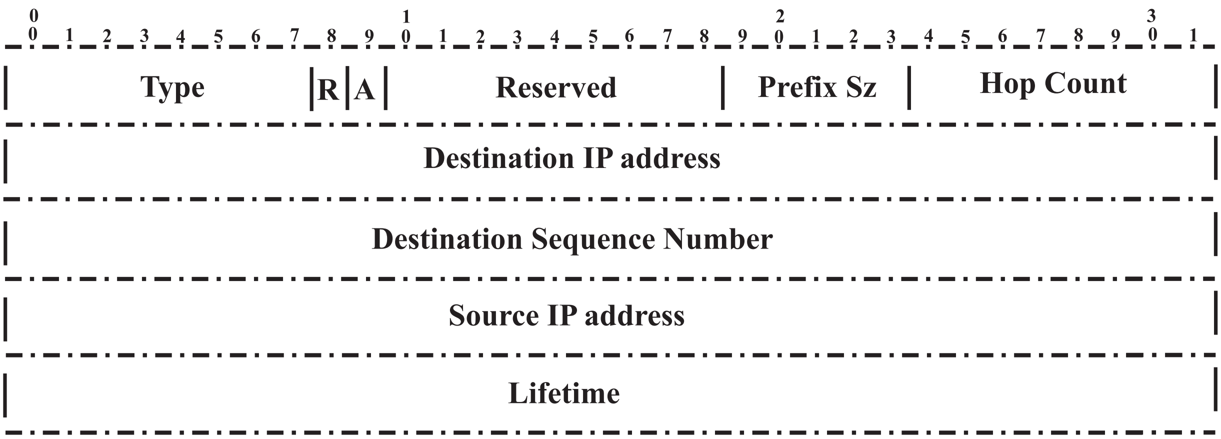

Fig. 1. Message format for route replay in AODV.

where, $M(x)$= Cost function of source node x,
$M(y)$= Cost function of destination node y,
e=Link present between nodes.

The objective of QoS is subject to fulfilled the constraints like delay, packet loss, throughput, jitter, packet delivery ratio. AODV is the On-demand topology based reactive routing protocol in MANET communication. As AODV establishes route in on-demand manner, overhead involved in reactive routing protocols is reduced, due to the periodic route discovery. It identifies most recent route using sequence number feature in *RREQ* and *RRPLY* packets and also shortest path through the comparison of hop count mentioned in every *RRPLY* packet. Route information of every data flow is maintained in routing table of source and intermediate router. If energy present in the router is below threshold then nodes tends to be dead node, because wireless devices used in MANET are battery limited. Thus, it is unable to forward/transmit data. It also fails when the selected path in the router involves multiple data flows. In such condition, currently transmitted data will be delayed, due to transmission of data that belongs to different flows and it will be lost if Time To Live (TTL) is expired. This leads to degrade the QoS in real time applications.

4. Proposed system methodology

The detail schematic representation of proposed architecture is shown in Fig. 2. In conventional AODV protocol, route discovery phase, *RREQ* packet is broadcast to neighboring node. After that *RRPLY* packet is send from destination. Therefore, multiple paths are available to send the packet to source node. Thus, shortest path is chosen to deliver the packet to the destination based on hop count. In this work, we have modified the existing approach for *RRPLY* packet. The proposed approach is based on CS algorithm, where packet is send to source node via best fitness value computation. Here, instead of hop count, path is calculated using residual energy, hop count and routing load. Therefore, from the multiple paths, one path is selected using best fitness value satisfying the QoS constraint. The following subsection represents the details of basic CS algorithm.

4.1. Overview of original cuckoo search algorithm

Yang and Deb [36], developed metaheuristic CS algorithm, inspiring cuckoo bird reproduction system. In other host bird's nest, cuckoo female fertilized her eggs. Host bird in this way unwittingly raises her brood. Host bird discover the cuckoo eggs in her nest, the host bird will throw it out or abandon her nest and start her own brood elsewhere. The CS algorithm consider each egg in nest of host bird represent solution and cuckoo egg represents potentially new solution. If new solution is good then previous solution, then worst solution is replaced by new one. Yang and Deb, [36] discover that random walk using levy flight is performing best then simple random walk. The formulation of CS in terms of mathematics, i.e. in each nest only one egg (solution), generates new optimal solution using levy flight walk [37]. The evolutionary produced eggs developed by cuckoo bird is flash same to the local host birds. Thus, for an optimization three important points are guide, as given below.

- Initial Solution: Set of solution is represented by cuckoo eggs and its dimensions are placed randomly at different nest.
- Next Generation: For next generation only part of the eggs (the best eggs) with acceptable solution is allowed.
- Acceptance Rule: The intended solution is removed when any of the eggs are identified as strange and replace this alien in a new nest.

Initially, CS algorithms starts with n host population of nest and meet monotonously. In original document, jth component of ith nest values is found using Eq. (3),

$$X_{ij}(0) = R.(U_{ij} - L_{ij}) + L_{ij}, \tag{3}$$

where, U_{ij} represent upper bound of jth component, L_{ji} represents lower bound of jth component and R represents uniform random standard number on the interval from 0 to 1. This choice ensures that initial values are with in the search space domain, which is the boundary condition control for each iteration.

In basic CS algorithm each nest contain one egg. The algorithm can be extended to more complicated case if multiple eggs are present i.e. set of solution. The CS algorithm has control parameters, for this one boundary condition is very essential for number of iteration. Therefore when the values of attributes overflows, the allowed search space limits.

Using levy flight algorithm [38], for each iteration h, cuckoo egg i is selected randomly to produce a new solution $X_i(h+1)$. This is kind of random walk algorithm, where steps are defined in terms of step lengths, having certain probability distribution with order of the steps being random or isotropic. Investigating levy flight with traditional methods levy flight is invoked over other random walk, due to better performance of CS. The generic equation of levy flight is given by Eq. (4),

$$x_i(h+1) = x_i(h) + \alpha \oplus \text{levy}(\lambda) \tag{4}$$

$\text{Levy}\ (\lambda) \backsim h$
where, h indicates the number of current generation and λ indicates step size, which should be problem oriented as scale factor,

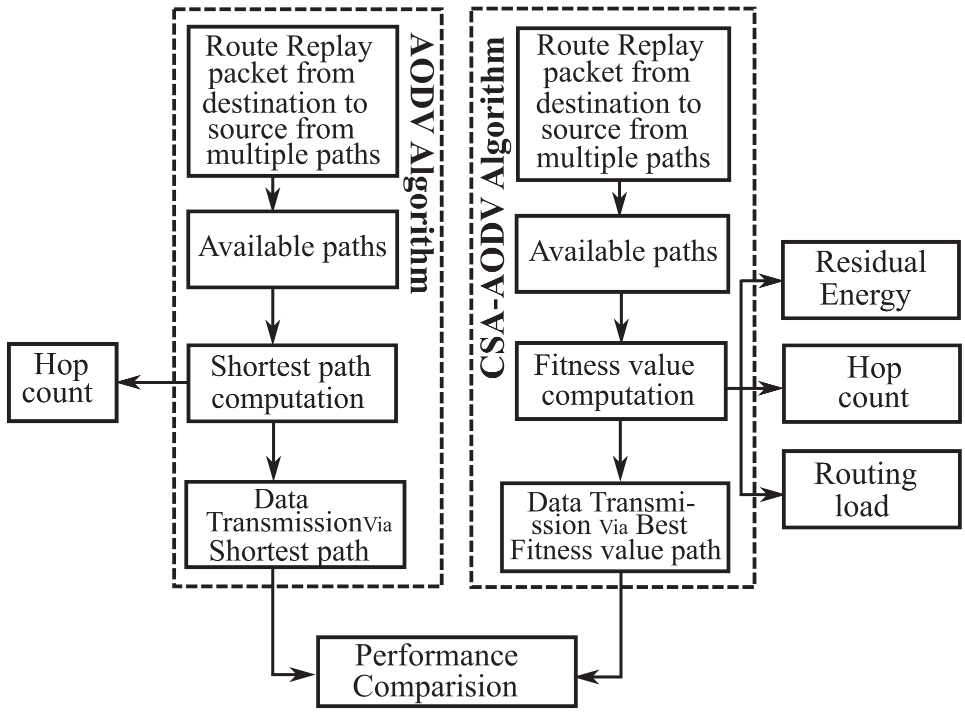

Fig. 2. Schematic representation of proposed system .

$\oplus$ represents entry wise multiplication for levy flight. Eq. (5) represents the Markova chain with probability distribution. The neighborhood location $h+1$ depends on current location h, first and second transition probability respectively. The probability of transition of levy flight is given by Eq. (5),

$$-\lambda, (1 < \lambda \leqslant 3) \quad (5)$$

The infinite variance with infinite mean is considered. Generation of random number with levy comprised, with uniform distribution, random direction is chosen. Positive and negative approach is consider using symmetric approach is given by Eqs. (6) and (7).

$$\phi = (\hat{\Gamma}(1+\hat{\beta}) sin((\pi.\beta)/\hat{2}) \quad (6)$$

$$\Gamma(((1+\beta)/2)\hat{\ }\beta.\hat{2}(\beta-1)/\hat{2}))1/\beta, \quad (7)$$

where, Γ denotes Gamma function and $\beta = 3/\hat{2}$ in the original implementation by Yang and Deb [36]. Test function for levy flight is given by Eq. (8),

$$f(x, y) = sin^2(3\pi x) + (x-1)^2(1+sin^2(3\pi y)) \quad (8)$$

$F(1, 1) = 0$.

The simplicity is the significant aspect of this heuristics. Therefore, low complexity in new algorithm and power to deal with complex and challenging problems. However in comparison with other metaheuristic techniques such as PSO and ACO, CS approach has only single parameter under consideration. The flowchart of conventional algorithm is presented in Fig. 3, where Q_i and Q_j are previous and current fitness value computation respectively. The new solution is replaced by the current one. The step-wise evaluation of CS is present in Algorithm 1.

Algorithm 1 Basic cuckoo search algorithm.

```
procedure OBJECTIVE FUNCTION(f(v), v = (v_1, ..., v_d)P)
    Generate initial population of n host nests v_i  i = 1, 2, ..., n
    While p < MaxGeneration or stop criterion
    By Levy flights get a cuckoo randomly
    Evaluate its fitness / quality Q_i
    Choose a nest among n (say, j) randomly
    If (Q_i > Q_j)
    Replace j by the new solution;
    End
    A fraction Q_a of worse nests is abandoned and new ones are built
    The best solution is chosen or kept (Quality solutions nests);
    The current best is rank to find the solutions
    End while
    Post process results and visualization
    End
```

4.2. CSO-AODV algorithm

The CSO-AODV algorithm is used for Optimized path selection, for reliable data delivery. If the routers identified through the AODV are not energy efficient and overloaded due to high traffic, data delivery to the destination is affected. Hence, CS algorithm based routing optimization solution is proposed for AODV as presented in Fig. 2. It selects the optimized routing path to deliver the data in reliable manner. When the route reply is issued from destination, it is transmitted to the source through multiple paths. Each router attach its residual energy, hop count and routing load in the reply packet. Source processes the received reply packets from multiple paths and calculates fitness function for every path. It selects the path that has best fitness value than all other paths and carries out the data transmission over it.

Fig. 4 demonstrate the flowchart of proposed CSO-AODV algorithm, where Q_i and Q_j are the previous and current fitness value computation respectively. Among these best fitness value is consider. Fitness is computed with energy, shortest path and delay metric. The steps of proposed algorithm is illustrated in Algorithm 2. The assumption for proposed approach are mentioned below,

Cuckoo - Source node,

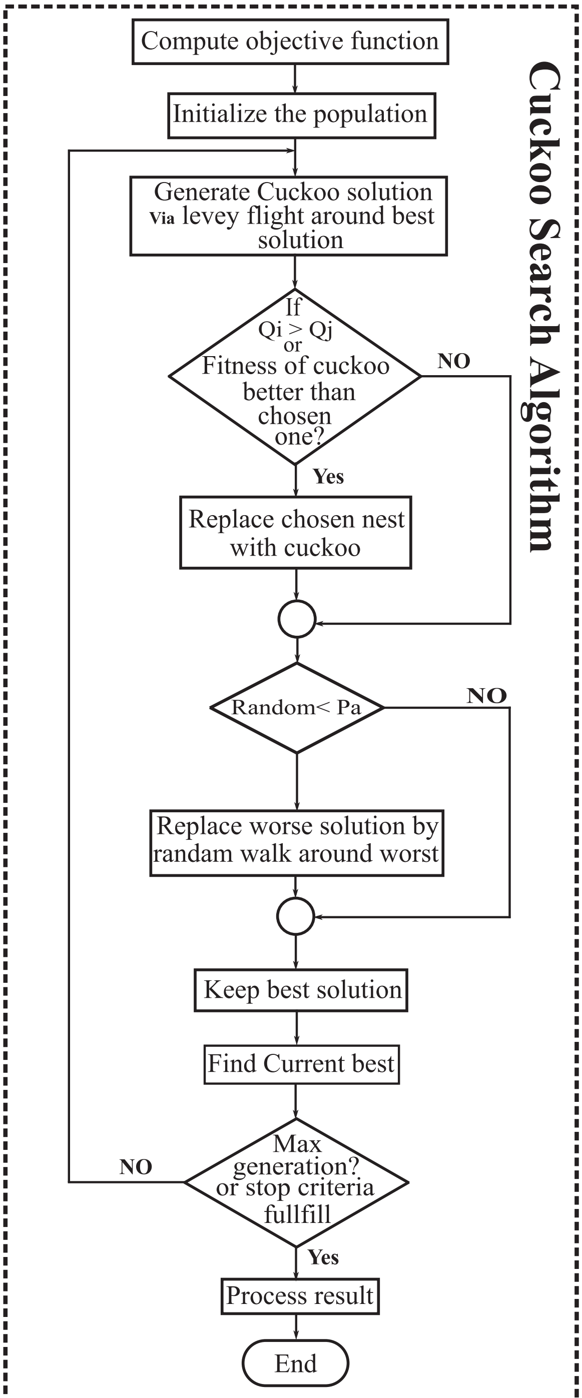

Fig. 3. Flow chart of basic cuckoo search algorithm.

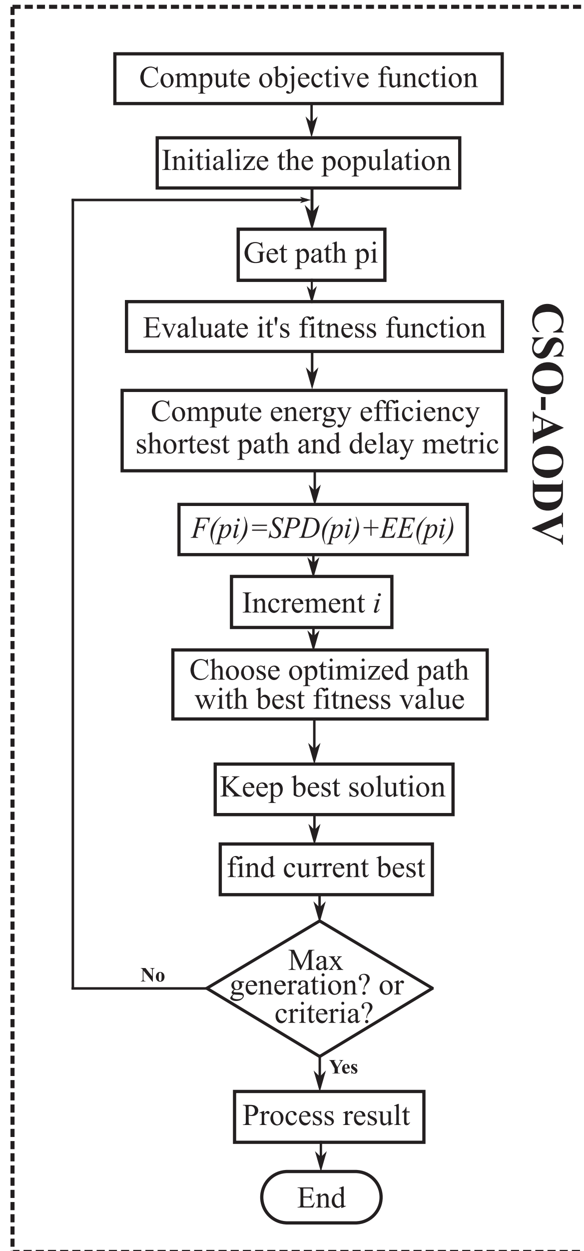

Fig. 4. Flow Chart of CSO-AODV algorithm.

Egg - Data packet of the source,
Nest - Path available from source to destination.

- Initial Solution: The data packets from the source is sent via the identified path using AODV.
- Next Generation: Only the data which is transmitted through the optimal path is delivered to the destination.
- Acceptance Rule: Data transmitted over the energy inefficient or high traffic route is dropped or delivered with certain delay.

5. Experimental setup

Original AODV protocol is modified and new protocol CSO-AODV is designed by modifying *aodv.cc* and *aodv.h* files according to the proposed method and ns2 is rebuilt with newly added protocol with the files $cso - aodv.h$, $cso - aodv.cc$, $cso - aodv\_packet.h$, $cso - aodv - rtable.cc$, $cso - aodv - rtable.h$, $cso - aodv - rqueue.cc$, $cso - aodv - rqueue.h$, and $cso - aodv - logs.cc$. The performance of proposed CSO-AODV is evaluated for the simulation settings as per the following simulation model and compared with PSO, ACO and original AODV. Evaluation is done for the scenarios of varying number of data flows. Metrics such as energy efficiency, packet delivery ratio, end-to-end delay, throughput, jitter, number of packet send and receive rate are measured using AWK script by analyzing trace file. The graphs are plotted using MATLAB software R2012@a for measured metrics.

5.1. System model

In MANET, nodes M are moving in the network area of $X \times Y$. X is the network width and Y is the network height. Number of communication flow (nf) of source $S \in M$ and destination $D \in M$ pair

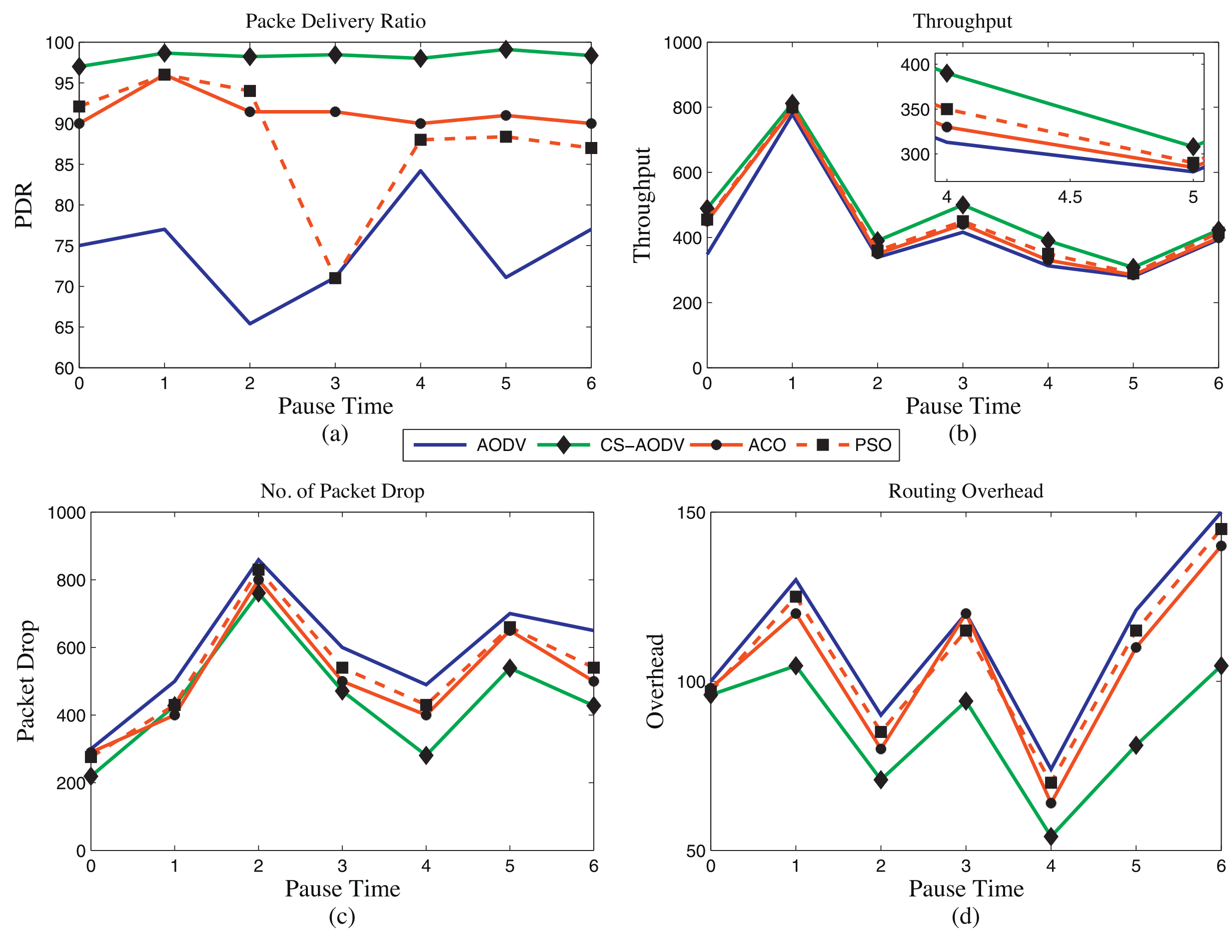

Fig. 5. Simulation results for mobility, (a) packet delivery ratio, (b) throughput, (c) number of packets drop, (d) routing overhead.

Algorithm 2 Proposed cuckoo search optimization AODV algorithm.

procedure OBJECTIVE FUNCTION($f(p), v = (p_1, \ldots, p_d)N$)
  Get available population of N paths p_i $i = 1, 2, \ldots, n$ for source and destination
  While $i \le N$ or (stop criterion)
  Get path p_i
  Evaluate its fitness function $F(p_i)$
  Energy Efficiency Metric
  $EE(p_i)$ = 1;
  If $ResE(p_i) > \text{ThE}$, $p_i \in p_n = 0$
   Otherwise
  Shortest Path and Delay Metric
  SPD(p_i)= 1/hop count (p_i)+ 1/routing load, (p_i) $p_i \in p_n$
  Fitness $F(p_i)$= SPD(p_i)+EE(p_i)
  Increment i
  End while
  Choose Optimized path = Path with best fitness value
  End
  The best solution is chosen or kept (Quality solutions nests);
  The current best is rank to find the solutions
  End while
  Post process results and visualization
  End

is established dynamically. Router $R \in M$ can be involved in $\le nf$ i.e. number of flows. Each flow has n number of paths p_1, p_2, ..., p_n. Routing load (RL) on each R is equivalent to number of data flows it involved. Energy model is applied on every node with initial energy, transmission power, reception power, sleep power and idle power. Hop count (H) is the path length of each flow. Fitness $F(p_i)$ of each path p_i is the function of residual energy, RL and H.

5.2. Parameters used

- Packet Delivery Ratio (PDR):
  The ratio of number of data packet sends to the number of data packet received to the destination is termed as packet delivery ratio. This parameter specifies how effectively protocol deliver the packet to the destination. The large value of PDR indicates superiority of proposed algorithm performance.

$$PDR = \sum_i \frac{PD}{PS} \times 100 \tag{9}$$

  where, PD = packet delivery, and PS = packet send, ith packet.
- End-to-End delay(Delay):
  The performance of the network in delivering packet from source node to the destination node indicates delay in packet transmission. Average end-to-end delay indicate total delay occur in entire network to the average packet send to the network. Lower value of end-to-end delay indicates that MANET is performing better using proposed algorithm.

$$Delay = \sum PA_i - PS_i \tag{10}$$

  where, PA_i = packet arrival, and PS_i = packet start, ith packet.
- Routing Overhead:

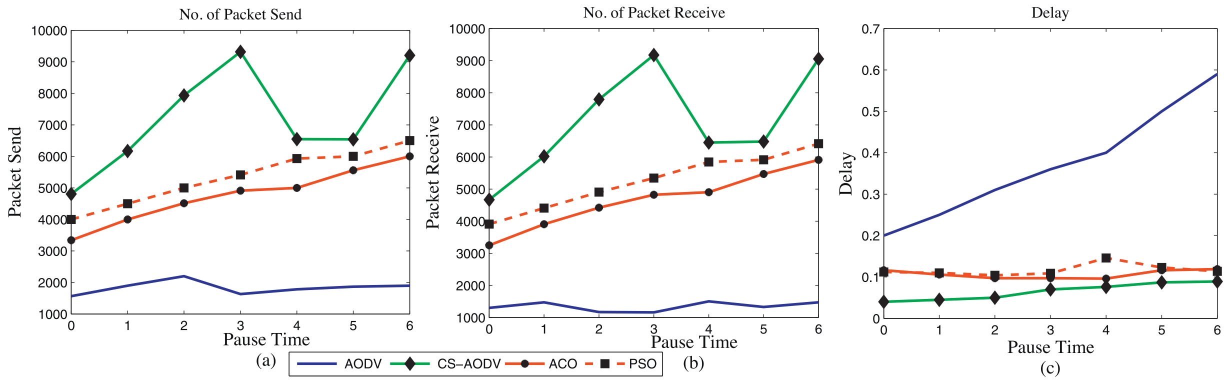

Fig. 6. Simulation results for mobility, (a) number of packets send, (b) number of packets receive (c) end-to-end delay.

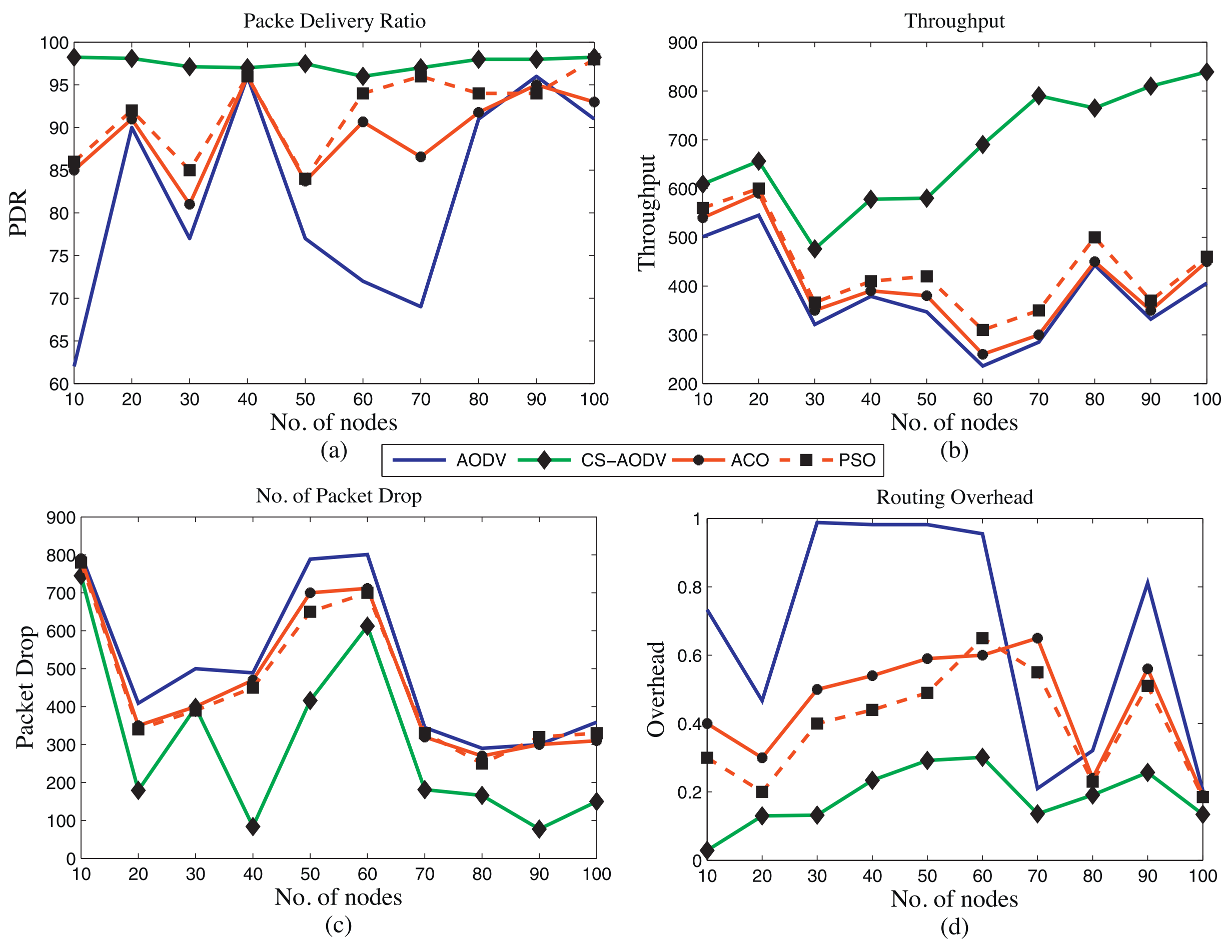

Fig. 7. Simulation results for scalability, (a) packet delivery ratio, (b) throughput, (c) number of packets drop, (d) routing overhead.

The number of control packets produced in the network is shown using control overhead. Less the value of control overhead, better is the performance evaluation in MANET.

$$NRL = \frac{N_C}{N_D} \tag{11}$$

where, N_C = number of routing control packet sent, and N_D = number of data packet received.

- Jitter:
  Jitter is very important metrics for QoS routing. It is delay occur to reach the packet to destination in expected time. It is often refereed to reference clock source. Jitter may be observed in characteristics such as the signal amplitude, phase of periodic signals, frequency of successive pulses. It is almost present in all communication link.

$$Jitter = \sum_{i=0}^{1} square(Delay_i - \overline{Delay})/N \tag{12}$$

where, N = Number of node, ith packet

- Throughput:
  The amount of data successfully transfer from one place to another place is measured in terms of throughput.

$$Thoughput = \sum_i \frac{P_d}{P_a - P_s} \tag{13}$$

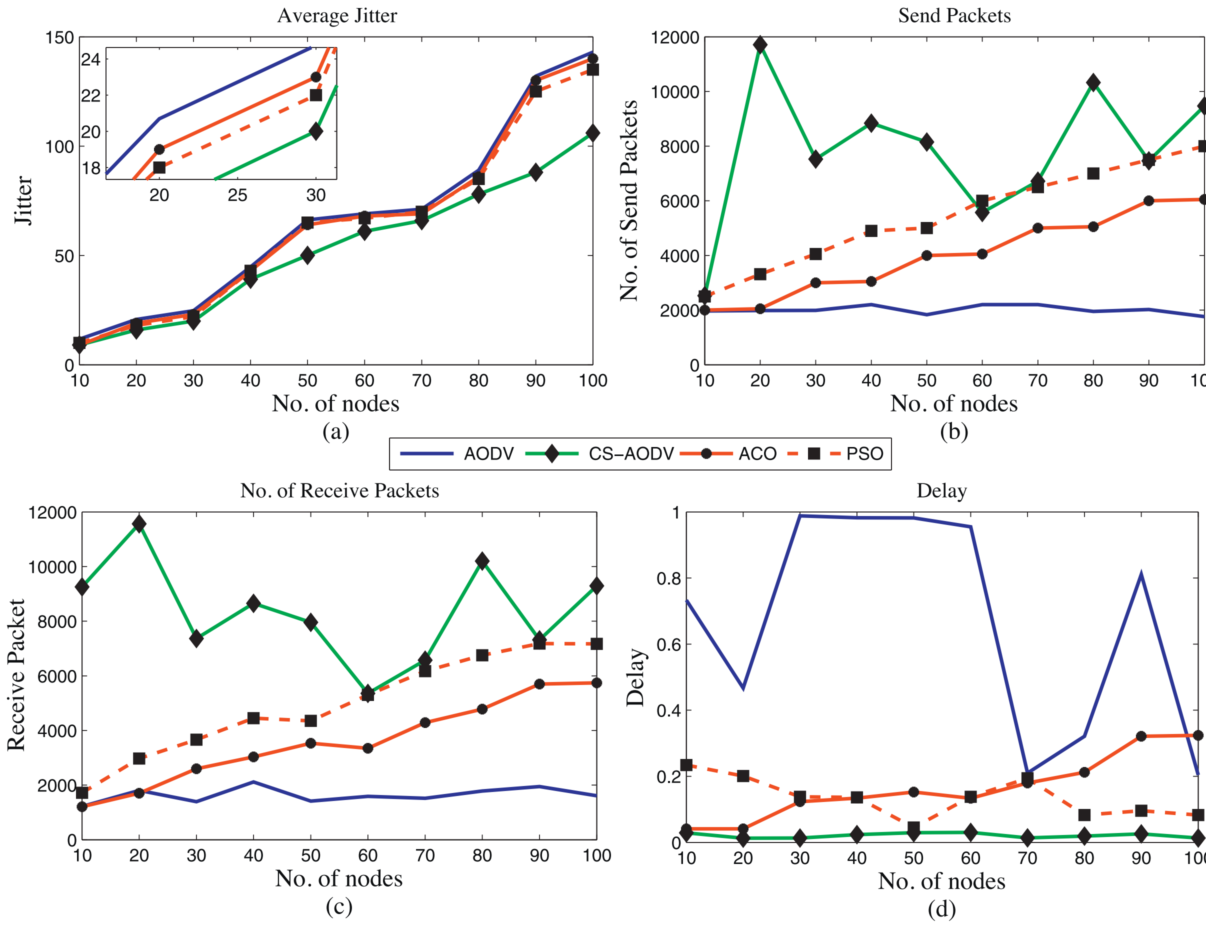

Fig. 8. Simulation results for scalability, (a) average jitter, (b) send packets, (c) number of receive packets, (d) end-to-end delay.

where, P_d = packet delivered, P_a = packet arrival, and P_s = packet start time, *i*th Packet.

- Number of Packet Send:
  The number of packets are send from source node to destination node is specified using this parameter.
- Number of Packet Receive:
  The number of packet received from source node to destination is indicated using this parameter.

6. Results and discussion

This section investigates the performance of proposed protocol. The impact of mobility, scalability and congestion is analyzed using different QoS parameters. To show the strength of our proposed protocol, results of CSO-AODV algorithm are compared with ACO, PSO, along with basic AODV algorithm. The ACO and PSO algorithms were applied on the basic AODV protocol and results were computed. Following observation has been made for various QoS metrics.

6.1. Impact of mobility on performance of CSO-AODV algorithm

Mobility model used here is random way point model, in which pause time is changed from 0 *ns* to 6 *ns*, considering number of node, pause time constant. Table. 1 shows detail simulation environment of proposed simulation study. The number of flow consider here is fixed at 5, due to dynamic nature of the network, there is diverse impact on mobility of node using proposed algorithm for different QoS metrics.

Table 1
Test data using following parameters.

Simulator	Network simulator
Number of nodes	10,20,30,40,50,60,70,80,90,100
Area	500 m × 500 m
Communication range	250 m
Interface type	Phy/WirelessPhy
MAC type	802.11
Queue type	Drop tail/Priority Queue
Queue length	50 Packets
Pause times	3,6,9,12,15
Antenna type	Omni Antenna
Propagation type	TwoRayGround
Routing protocols	AODV,CS-AODV,PSO,ACO
Mobility model	Random Way Point
Transport agent	UDP
Application agent	CBR
Simulation envrionment	50 s
Initial energy	50 Joules
Transmission power	1.0 watts
Reception power	0.5 watts
Sleep power	0.3 watts
Ideal power	0.01 watts
Simulation time	50 s
Number of flows	4,5,6,7,8

Figs. 5 and 6 depicts the different QoS metrics. The Fig. 5 (a) presents the comparison of PDR for AODV, ACO, PSO and proposed CSO-AODV scheme. The PDR with proposed approach is higher than above mentioned protocols. As mobility increases it remains steady using proposed approach. The proposed scheme support

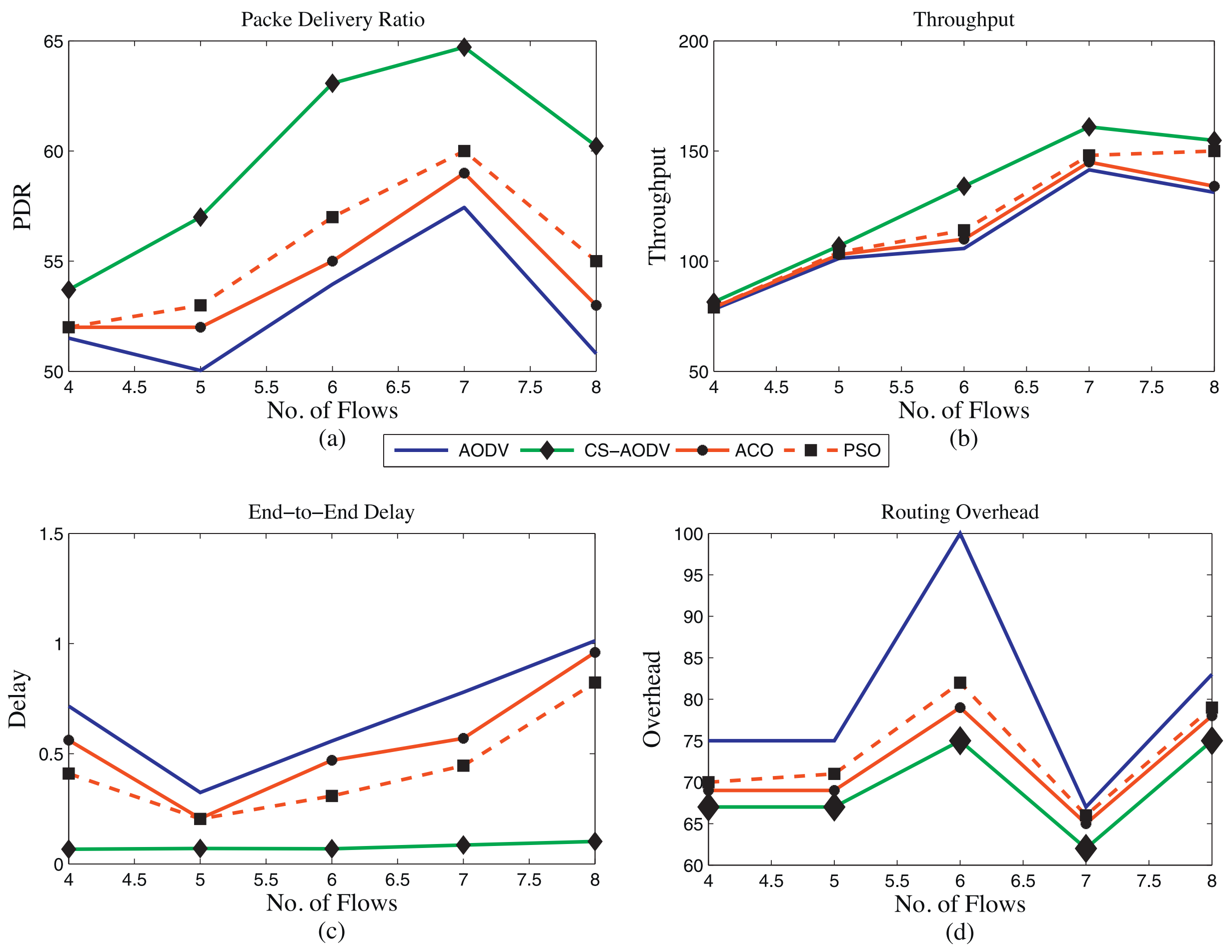

Fig. 9. Simulation results for congestion, (a) packet delivery ratio, (b) throughput, (c) end-to-end delay, (d) routing overhead.

high mobility condition referring PDR. Improvement is achieved from 12% to 35%. Reason behind high PDR in CSO-AODV is that *RRPLY* packets travels through best fitness value. This value is computed using routing load, hop count and residual energy. Whereas, Fig. 5 (b), presents high throughput with proposed approach. As mobility increases throughput changes randomly because of dynamic nature of the node. Throughput achieved is 1% - 10% using CSO-AODV protocol compared to ACO and PSO algorithm on AODV protocol. The number of packet drop rate and routing overhead are reduced as shown in Fig. 5 (c and d). 10%–50% of reduction in packets drop rate takes place with new protocol. The reason behind it is that RRPLY's best path is selected by computing the fitness value, whereas in traditional approach path is selected using shortest path. Thus, congestion is occur on shortest path and packet may be drop and result in reduce performance. Fig. 6 (a and b) illustrates the send and receive rate of mentioned protocols. The CSO-AODV algorithm provides high packet send and receive rate with variation because of dynamic nature of the network. Fig. 6 (c) depicts the delay occurred in CS-AODV, ACO, PSO and AODV. The CS-AODV have less delay due to congestion free path available using RRPLY packet. Thus, from obtained result and discussion in this section, it is clear that proposed protocol supports for varied mobility condition in an Ad-hoc network.

6.2. Impact of scalability on performance of CSO-AODV algorithm

Testing of CSO-AODV algorithm under scalability, are consider for nodes from 10 to 100. Figs. 7 and 8 shows the performance evaluation of proposed approach for different QoS metrics. The Fig. 7 (a) represents PDR of proposed protocol, which is 5% – 38% high, as compare to traditional AODV protocol, 2% – 12% high using PSO and 1% – 10% high using ACO algorithm. Fig. 7 (b) represents throughput of new protocol which is 10% – 40% higher compare to AODV protocol. The PSO and ACO is also lower compared to CSO-AODV protocol. Fig. 7 (c) demonstrate packet drop rate reduction of proposed protocol. When the number of nodes varies, drop rate changes randomly because of dynamic nature of the network. In Fig. 7 (d) it is observe that, 10%–80% reduction in routing overhead takes place using proposed protocol, due to modified RREPLY in traditional AODV protocol. However ACO and PSO also have higher overhead compared to CSO-AODV protocol. When number of nodes increases routing overhead also increases in ACO and PSO scheme. Fig. 8 (a) shows CSO-AODV has lowest jitter compared to ACO, PSO and basic AODV protocol. Number of packet send and receive rate is presented in Fig. 8 (b and c) respectively. The Fig. 8 (d) represent the delay for above mentioned protocols. The end-to-end delay of CSO-AODV protocol is lowest, compared to ACO, PSO and AODV protocol. The result analysis shows that for scalability condition of CSO-AODV protocol works better and provides high performance then ACO, PSO and traditional protocol, Which is very important factor for increasing topology. Hence, proposed protocol can be very useful in large network, which can provide QoS routing for different types of application.

6.3. Impact of congestion on performance of CSO-AODV algorithm

To analyze the effect of congestion on performance of new protocol number of flows were consider from 4 to 8 for different QoS

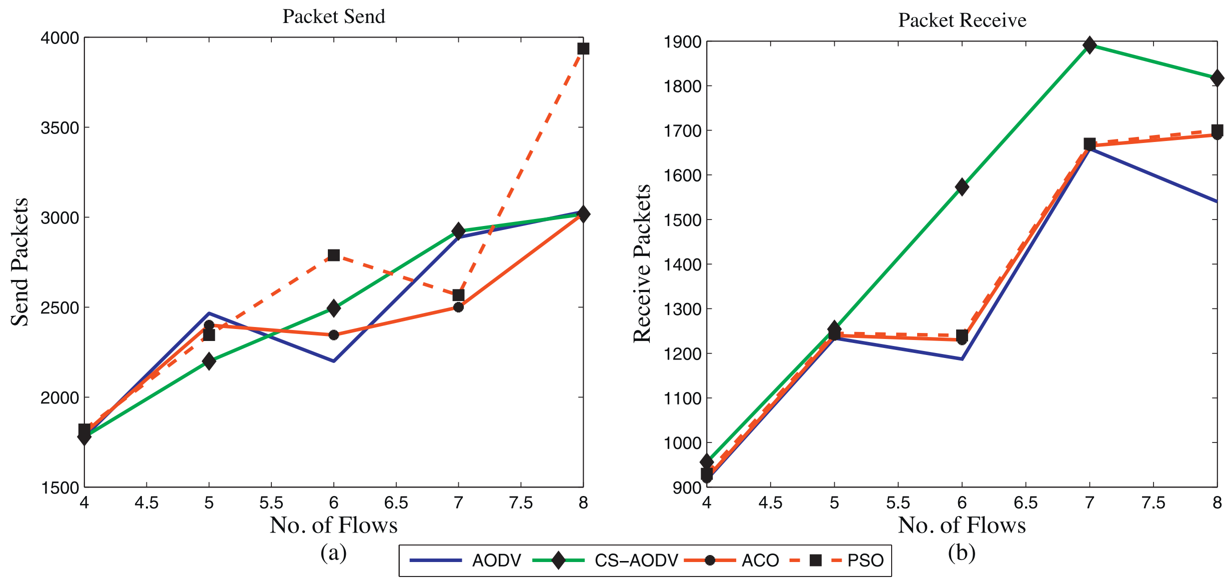

Fig. 10. Simulation results for congestion, (a) packets send, (b) packets receive.

metrics. For the Simulation mobility level and number of nodes are kept constant. Fig. 9 (a) demonstrate the performance in terms of PDR is high and is 2% – 10% compared to traditional approach. However, ACO and PSO is lower as shown in Fig. 9 (a). Because of high congestion occur in shortest path, when RRPLY is takes place, resulting in packet drop, delay to reach the packet to destination. Proposed approach is based on best fitness value, results in increasing PDR and throughput which is demonstrated in Fig. 9 (b). Fig. 9 (c and d) presents delay and overhead reduction, which gives good QoS in MANET topology. Fig. 10, presents number of packets send and receive rate of proposed protocol. Thus, from the discussion and analyzing performance of proposed protocol works superior compare to ACO, PSO and basic AODV protocol in congestion condition.

7. Conclusion

This paper deals with performance evaluation of QoS in MANET using proposed CSO-AODV protocol. The CSO-AODV protocol achieves QoS by jointly finding *RRPLY* from multiple paths using best fitness value computation is carried out. Thus, it satisfies QoS constraint during route discovery process. The performance evaluation of proposed protocol is carried out using network simulation and the results are compared with ACO, PSO and basic AODV protocol. After simulation, results are analyzed using three different conditions i.e. mobility, scalability and congestion. The result analysis shows that proposed protocol is effective for mobility, scalability and congestion network condition and can provides stringent QoS to numerous applications. In future work we want to provide robustness to our proposed system by modifying cuckoo search algorithm.

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Vaishali V. Mandhare received B.E. in Information Technology in 2005. She is completing her M.Tech in computer engineering department in 2009 from Dr. B.A.T.U. Lonere, India. She is working as Associate Professor in Information Technology department in P.R.E.C. Loni, India. Currently she is pursuing her PhD in SGGS,IE&T, Nanded, India. Her research interest includes routing in wireless network and IoT.

Vijaya R. Thool is an Associate Professor in Instrumentation and Control Engineering in SGGS,IE&T, Nanded, India. She is completing her PhD. from S.R.T.M.U.N. University, Nanded. Her research interest include wireless sensor network, agriculture etc. She is guiding number of M.Tech and PhD students. She is publishing various conference and journal papers. She is Life member of Indian Society for Technical Education, Instrument Society of India and Member of American Society of Agricultural and Biological Engineers. She is co-coordinating different responsibilities at college level.