Research Article

Srtsabc Based Self-Regulating Routing Algorithm (Sr3ta(R))

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Abstract: MANETs (Mobile Ad Hoc Networks) are unique types of decentralised wireless networks that do not need any pre-existing communication infrastructure between the nodes. In Mobile Ad Hoc Networks, each node is involved in routing by forwarding data packets to other nodes, and thereby determining the nodes are dynamically forwarded on the basis of network connectivity. The establishment of an efficient routing mechanism for communication between nodes as these nodes move freely with constantly changing topology is one of the important issues in MANETs. In order to keep track of the constantly changing topology of the network, successful optimised techniques are needed. In this paper, hereby propose a SRTSABC Based Self-Regulating Routing Algorithm SR3TA(R) by considering a random set of source and destination nodes and exchanges between them by the Bees. The pheromone tables and data structures are produced during the movement of bees to record the trip time of the nodes. Extensive simulations are conducted to assess the efficacy of the proposed algorithm by manipulating various parameters. The final results obtained are compared with two well known algorithms namely as ZBMRP, DCFP and FF-AOMDV. SR3TA(R) Algorithm with regard to different performance metrics such as the number of data packets sent, Throughput, End-to - End delay and Latency. The final results obtained show that the performance of the proposed SR3TA(R) algorithm is greater than the ZBMRP, DCFP and FF-AOMDV algorithms.

Keywords: MANET, SRTSABC, SR3TA(R), Bees.

1. INTRODUCTION

MANETs are groups of mobile devices that are dynamic, self-configuring, and infrastructureless. They are typically designed for a particular purpose. Every device inside the MANET is known as a node and has to assume a client and a router role. Communication across the network is accomplished by forwarding packets to a destination node; intermediate nodes are used as routers when a direct source-destination connection becomes unavailable. To route messages between distant nodes, MANETs depend on intermediate nodes. Lack of infrastructure for handling the direction packets are routed to their destinations; Instead, MANET routing protocols use routing tables on every node in the network which contain either complete or partial topology information. Reactive protocols including such as Ad hoc On-Demand Distance Vector (AODV) [1], schedule routes when it is necessary to send messages, poll nearby nodes in an effort to find the shortest path to the destination node.

Optimised Link State Routing (OLSR) [2] adopts a proactive approach, flooding the network regularly to produce routing table entries that survive until the next update. Both methods are motion-tolerant and were used in UAV MANETs [3] [4]. Motion tolerance and the characteristics of cooperative communication make those protocols suitable for use in UAVs. Communication by MANET is usually wireless. Any node within the range of the transmitter will trivially intercept wireless communication. It might leave MANETs open to a variety of attacks, such as the attack on Sybil and path manipulation attacks that can compromise network integrity[5].

As there are several solutions to solve routing problem in MANETs are proposed, none of the solutions have considered random source and destination along with the highest pheromone value to explore the best global for the formulation of data structures such as pheromone table, memory, packet and traffic model (explained in the next sections). This work will be the first approach towards this direction.

In this proposed work, a SRTSABC Based Self-Regulating RouTing Algorithm (SR3TA(R)) which considers the random collection of destination nodes and exchanges the bees from source node to destination node. The pheromone table and data structures are generated during the movement of bees, which record the trip time of the nodes from which bees migrate. The efficacy of the proposed method is measured by the selection of various parameters using different scenarios. Test results shows that the proposed scheme is very efficient with respect to the selected parameters when compared to the various other schemes. The rest of the work is organized as follows:

Section 2 describes the system model which includes network model and problem formulation. Section 3 illustrates the phases of Proposed Work – SR3TA(R) in detail. Section 4 provides the simulation results and detailed analysis of proposed work.

2. SYSTEM MODEL

This portion describes the model of the network used in the designing of the proposed algorithm, along with the formulation of problems and the notations involved.

2.1 NETWORK MODEL

Let assume that MANET has been defined by G = (V, E) will have n wireless nodes with a finite non-empty set of nodes V (V_1,V_2, ... ,V_n) and a non-empty set of links (L) comprising two end points that can communicate among each other. Routing from source node to destination using routing protocol involves generating message on source node and then sending them to randomly selected nodes from neighborhood list N. Assume that in a MANET setting A, B , C , D, E, F and G represent seven wireless nodes. Suppose Node A needs to connect with node G. Three separate routes exist from which packets can be routed. Routing is the method of routing the packets from source to destination. In terms of quality of service (QoS), an efficient routing protocol finds the optimal route. Proposed routing algorithm determines the optimal path based on different parameters, such as Throughput, latency, total number of routed packets and End-to-End delay.

2.2 PROBLEM FORMULATION

A new ABC based algorithm (SRTS-ABC**)** [6] [9] for MANETs is utilized in the present research work. Through implementing reinforcement learning in particular, the risk of a packet being stuck in a loop is assumed to be small. The aim of routing is to define the optimal path between sender and receiver. Based on the above definition the goals of the proposed solution are as follows:

- Random collection of end nodes is taken resulting in a reduction of the overheads in the process of route discovery.
- Global pheromone update is taken which increases the probability with the most promising routes being chosen.
- Minimizing the end-to-end delay which ensures the packets are delivered as quickly as possible.

3. PHASES IN SR3TA(R)

SR3TA(R) consists of FOUR phase that is Route Setup Phase, Route Maintenance Phase, Route Recovery Phase and Special Phase for Detecting Malicious nodes.

PHASES AND PROCEDURE OF SR2TA	
Phase 1	Route Setup Phase in SR3TA(R)
Phase 2	Route Maintenance Phase in SR3TA(R)
Phase 3	Route Recovery Phase in SR3TA(R)

Table 1 Pheromone table.

Target nodes	**Neighbor Nodes**			
	nen_1	**nen_2**	....	**nen_m**
tno_1	ɷ (1,1)	ɷ (1,2)	....	ɷ (1,m)
tno_2	ɷ (2,1)	ɷ (2,2)	....	ɷ (2,m)
⋮	⋮	⋮	⋮	⋮
tno_n	ɷ (n,1)	ɷ (n,1)	....	ɷ (n,m)

PHASE 1: Route setup phase in SR3TA(R)

Initially any source node wants to send data to a particular destination node; the SRTSABC creates Employed Bees (EB) starts at the source node (HIVE) and send the EB towards the destination node. Afterward, source nodes are selected randomly from the set of nodes and sent to the destinations which were randomly selected. It will allow the active nodes within the network to participate in global knowledge of the overall topology in the form of a pheromone table, as seen in Table 1. Only the destination node is randomly selected in the previous available Routing based algorithms, which can cover only a subset of the overall network since the route is often discovered early and choosing the random destination which cannot cover the overall topology until that time. Here ABC algorithm is chosen to solve some problems in previous Routing Algorithms.
The following point shows the process of route setup phase. The following procedure are followed, when EBs are started from the source node towards the destination node.

Point Number: 1

Once any intermediate node h receives the EB then it checks destination node address of EB. Unless node h is not the particular destination node then

- Specific node h adds its own unique address and time when EB arrived to h.
- After reach particular destination, Specific node h (destination node) adds the source node address as the destination address for routing back using OB (**Trace Back Approach**).

Specific node h broadcast EB to its neighbors again if it did not have a valid route to the destination node.

Point Number: 2

- If the EB identified, the node h receives duplicate node, i.e, with same sequence number and source address or either the sequence number is less than or equal to max sequence number and route record of EB includes address of present node, then that EB is dropped. Else particular node updates the max sequence number by new value (by using newly arrived node) and executes the step as described in point 1. In the proposed algorithm, the movement of Bees is described in point 3.

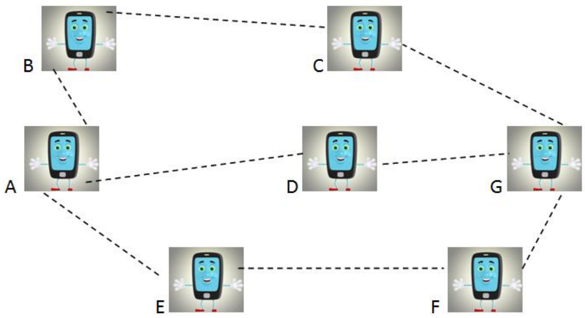

Figure 1 Network Topology (General)

Point Number : 3

Movements of Bees

Here Bees are the primary component which monitor and control the various operations in the proposed algorithm. Therefore, the following steps are worked out for the movement of Bees in the proposed algorithm:

- **Step 1:** In the proposed SR3TA(R) algorithm, the two Bees are used as follows: Employed Bees (EB) and Onlooker Bees (OB).
  - First, Employed Bees (EB) which is starts from the source node (SN) after a fix amount of time and moves towards the destination node (DN) by passing number of intermediate nodes.
  - Second, Onlooker Bees (OB) which is starts from the source node to transfer the data, only after getting information (Routing information) from EB. After reached particular destination node, OB starts from destination node and follows the path traveled in reverse order to updates the route table in the network. The EB which is travelling towards the destination node D, currently available at node h, follows the path through node K by probability value ($₡_{hk(dn)}$) calculated as follows:

$$₡_{hk(dn)} = \frac{\mu_{hk(dn)} + \ddot{\theta}\sigma_{hk}}{\ddot{\theta}|N_h| + (1-\ddot{\theta})} \qquad (1)$$

- **Step 2:** If the node selected is not among the nodes previously selected, then the new node selected is added to the memory of the bee as described in Table 5. If the picked node is one of the nodes already chosen then a loop is identified and the nodes involved in the process are removed from the memory of bee.
- **Step 3:** Once a Bee enters the destination node, the correctness of the chosen route can be calculated later. The accuracy of the route can be specified as per the necessity of an application. This algorithm uses trip time from the bees and local statistical model parameters to measure the path's goodness.
  The destination node produces OB (i.e, EB becomes OB only after reaches particular destination node) for quantifying the value of goodness. OB is created with high priority because it carries the route searched by EB. Thus, high probability is allocated to these types of packets as these will be accountable for the propagation of the explored network path.
- **Step 4:** OB follows the same path through the corresponding bees, but in the opposite direction, and deposits some quantity of pheromone μ(h) on the reverse path to the node. This number is proportionate to the process which is responsible for the path's integrity. The equations for the pheromone modification are as follows:

If (node was on bee's path), then

$\mu(h) = \mu(h) + r^* (1 - \mu(h) + r^{2*} \mu_{high} / C$ (2)

else

$\mu(h) = \mu(h) - r^* \mu(h) - r^{2*} \mu_{high} / (C^* (|N_h| - 1)$ (3)

After retrieving relevant information, EB is discarded and OB is forwarded to the path followed by EB. As already explained by Eqs (2) and (3), the pheromone table is revised by OBs. When OB enters source S all tables of pheromone are updated.

If node I receive EB and node I already have pathway to destination in its cache then it adds its address to the EB's memory and generates OB and sends it back to source after adding the destination's path details.

PHASE 2: Route Maintenance Phase in SR3TA(R)

A source node regularly dispatches bees in a constructive manner at a lower rate than the rate of sending data packets in order to preserve the existing paths and find different or alternate pathways. If no network error occurs then EB will select the next hop to explore an existing path. It also collects up-to - date information on the defined path, and updates the pheromone values on the path accordingly. When a node receives an EB but has no routing details to the target, the EB is transmitted.

Moreover, the total number of transmissions permitted across the route towards the destination is limited to control the overhead. Once congestion arises at any intermediate node, it will reconstruct EB's path to notify source S for route change. The pheromone value is modified from source and the same value is revised in the routing table, so the congested route is not overloaded any further. This knowledge can be obtained as determined in from the heuristic function value σ_{hk}, which will drop its value as the queue length increases. If all alternate routes fail, the source node will then re-initiate new request for route. If there is error occurs in the node's connection, mainly due to changing mobile node position.

PHASE 3: Route Recovery Phase in SR3TA(R)

Due to node movement or a connection being broken a route can be invalidated. If a node does not receive the buddy packet for a certain amount of time as part of the beaconing from its neighbours, the connection is considered broken. In such a case, the node changes the related pheromone entries in its routing table to zero, and transmits the connection failure message. All the neighbors update their routing table only after receiving the notification message. The broken connection will conduct a local repair process and will attempt to find an alternate route to the destination. Within mean time all the packets it receives are buffered. When the node discovers a new path to the destination, then the newly discovered route must send all the buffered packets to the destination.

At the same time, the source receives a notification from bees to notify the source node about the changes in path. Bees update their routing table to make appropriate route changes on all nodes on their path that receives the notification. In the notification bee, the source will replace the relevant path with the path value.

If an alternate path could not be identified after the local repair then an error message is sent to the source node. Particularly, after receiving the error message, a new path finding process will be initiated by the source node by sending new bees in search of destination.SR3TA(R) has various paths but for communications only the path with the best pheromone value is used. When the optimal path fails, then the next optimal path is selected. Therefore, the proposed algorithm does not break even on optimal path failure. Following steps illustrates the proposed scheme for the route maintenance and path recovery process. SR3TA(R) algorithm uses pheromone value μ_{high} in Eq(2) and (3) which will help in converging better routes quickly.

3.1 Pheromone table Updating Process

In this Illustration Node A is regarded as the source node, and node F as the destination node. If source A has wants to communicate with destination F, BEEs will be created at node A and will be sent to node F.

Sample Pheromone Table 1: Node A			
Destination	**Neighbors**		
	B	**D**	**F**
B	0.8	0.1	0.1
C	0.6	0.3	0.1
D	0.8	0.1	0.1
E	0.8	0.1	0.1
F	0.1	0.3	0.6

Sample Pheromone Table 2: Node B		
Destination	**Neighbors**	
	A	**C**
A	0.8	0.2
C	0.8	0.2
D	0.6	0.4
E	0.6	0.4
F	0.5	0.5

Since there is no direct connection between nodes A and F, bees are therefore transmitted to all outgoing links, i.e. to nodes B, C, D and E. Now the FANTs are sent to C, E and F nodes. In the end, first EB reaches destination node F by collecting all the intermediate node information. OB is generated over the destination node and sent in the reverse order of nodes stored in EB stack to the source node A.

Let's examine the pheromone table for better explanation on few topology nodes. In the pheromone table, pheromone values are considered by giving the shorter and closer paths more weight which can be easily seen from the topology example. The number of each table row is maintained as 1.0. above Tables explain how the pheromone values are stored in the tables retained within each node

4. SIMULATION ENVIRONMENT

The propose Self-Regulating Secured RouTing Algorithm (SR3TA(R)) will be evaluated using simulation on ns-2 , using the topology of the network with 100 nodes. Here the new bee agents are enforced and new packet format is developed as well. Activities for all the 100 nodes are established in different directions, here bidirectional communication (TCP packets) between 10 pairs of nodes is generated, i.e. 20 nodes have been initialised to communicate with one another. The simulations run for particular 160s. No conversation had begun for the first 10 s. After 10 s, the first pair began conversation, the second pair began conversation after 20 s and so on the tenth pair started conversation after performing for 100 s. After that, the network got crowded with lots of traffic as 20 nodes began their communication. The communication was halted at 150s, i.e. after 150s no new TCP packet was produced but only the packets that started early floated on the network before reaching their destination.

4.1 Simulation Parameters

Table 1 explains the names of parameters used in simulations, and their values.

Table 1 Parameters Setup

Parameter Name	Value	Parameter Name	Value
Network type	Wireless	**Dimension of topology**	1400 ~ 1400 (X ~ Y)
Number of nodes	Maximum 200	**Speed of nodes**	Varies between 12 and 38 m/s
Simulation start time	11.0 s	**Pause time**	50–330 s
Simulation stop time	100 – 1000 s	**Mobility model**	Random
Propagation delay	145 ms	**Channel**	Wireless
No. of simultaneously opened connections	12 TCP connections (i.e. 24 nodes	**Propagation**	Two way
		Packet size	50 Bytes

To assess the efficacy of the proposed algorithm, the following parameters are evaluated.

- Throughput
- Packet drop and delivery ratio
- Data packets send

- Path length
- End-to-End Delay

4.2 Results and discussion

4.2.1 Effect of Throughput

Throughput in communication networks is the sum of digital data per unit of time supplied over a physical or logical connection. It is measured in bits per second (bits / s or bps), sometimes in packets of data per second, or packets of data per timeslot.

Throughput = Effective number of packets send successfully / overall time

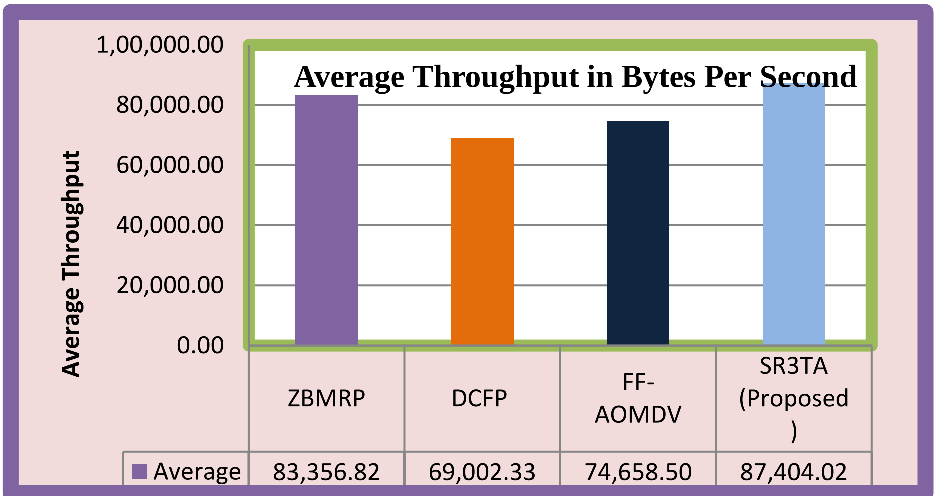

Figure 2 Average Throughput in Bytes Per Second

4.2.2 Packet drop and delivery ratio

It is the estimate of the percentage of successfully transmitted packets to the target nodes.

Delivery ratio = (No. of packets send-packets lost) * 100 / No. of packets send

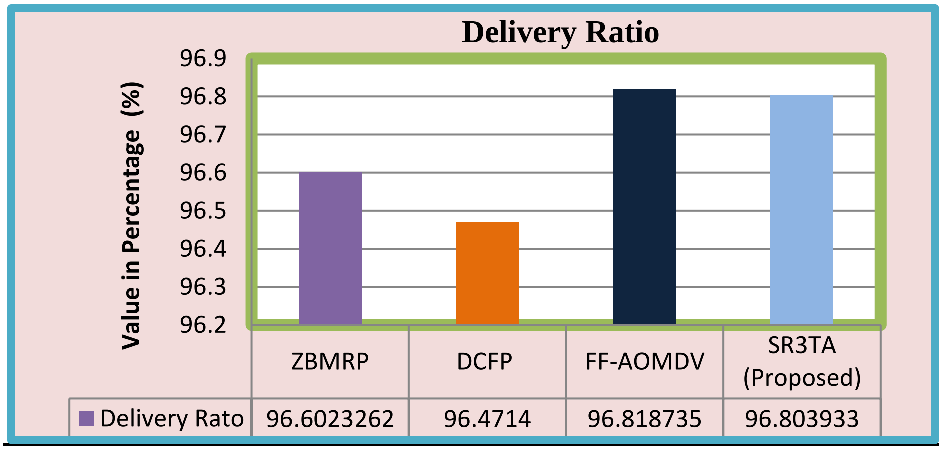

Figure 3 Packet Delivery Ration (Proposed Scheme)

Table Relative analysis of all the schemes with different criteria.

	ZBMRP	SR3TA(R) (Proposed)	DCFP	FF-AOMDV
Packet drop	34	10	42	8
TCP packet send	12,111	12,845	10,002	11,112
Delivery ratio	96.6023262	96.8039330	96.4714	96.818735

Throughput (bytes/s)	83,356.82	87,404.02	69,002.331	74,658.5
Total End-to-End delay	3853.32	3704.74	3687.4465	3266.1776
Total Jitter	964.86	801.14	902.3914	874.79414
Average End-to-End delay	0.22379466	0.19331211	0.2765332	0.2002020
Average path length	2.47712	2.16433	3.3660720	2.0063303
Average Jitter	0.06974836	0.08968911	0.0897994	0.0788167
Average window size	8.88673361	11.1411105	09.6420	8.5563064

4.2.3 Data Packets Send

The number of packets sends during the simulation cycle also measured to verify the algorithm can send more data at the specified time interval.

Data Packets Send = Number of Packets Successfully Send + Total Number Of Packets Lost

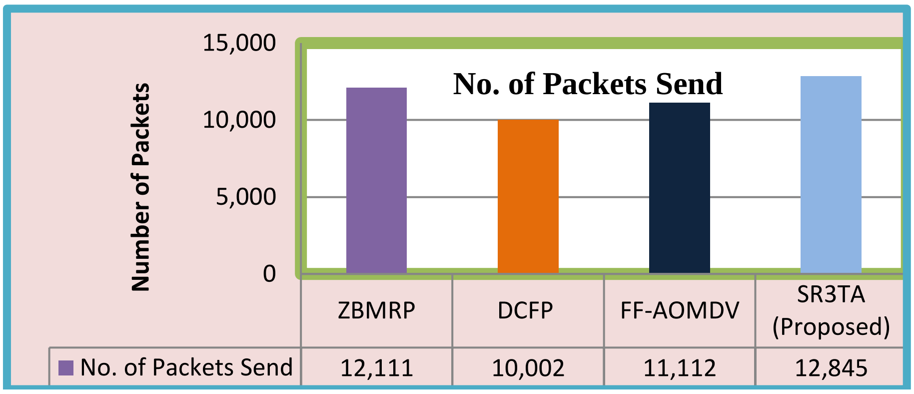

Figure 4 Total TCP Packet Sent by each Protocol

4.2.4 Path Length

It is the route length depending on the number of hops.

Path length = Number of hops the packet routed to reach its destination

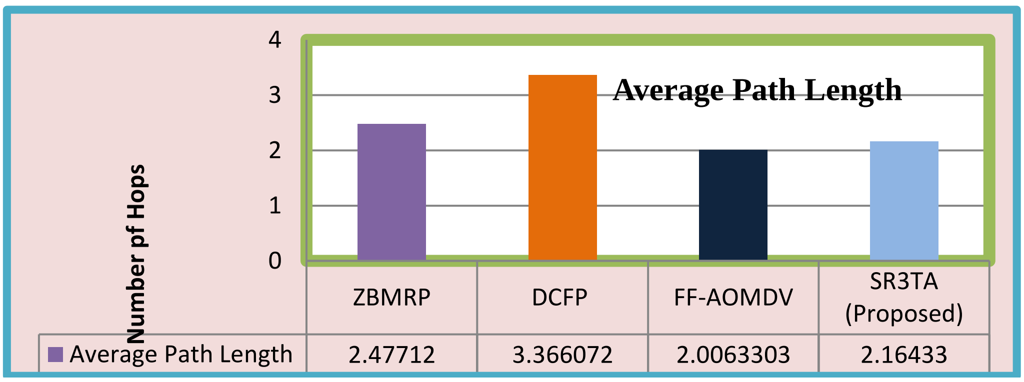

Figure 5 Average Path Length (number of hops between Source node and destination node)

4.2.5 End-to-End Delay

End-to - End delay refers to the time taken to send a packet from source to destination over a network. In certain cases, data transmission occurs only between two adjacent nodes, but through a path that may involve several intermediate nodes. End-to - end delay is the amount of the delays encountered from the source to the destination at each hop.

End-to-End Delay = Passing time on Hop1 + Passing time on Hop2 +…………. + Passing time on Hopn

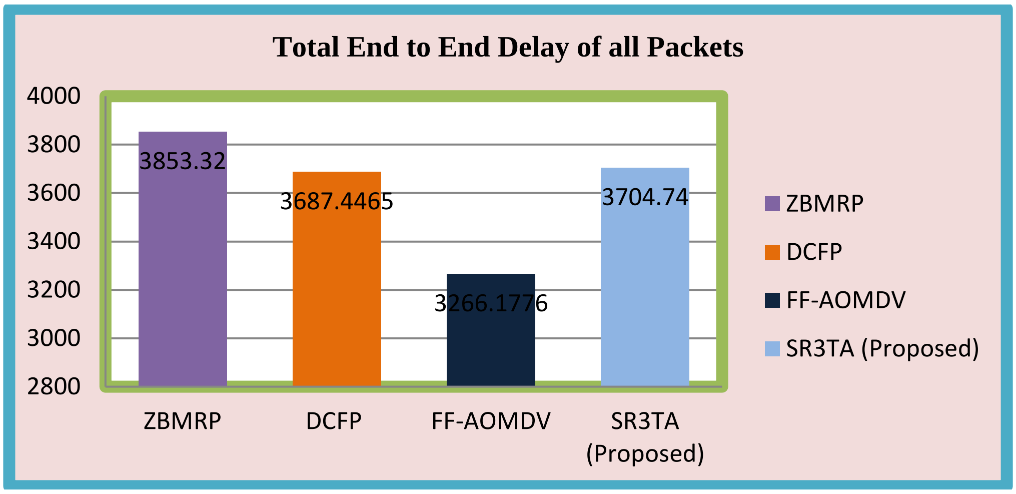

Figure 6 Total End to End Delay between Source node and destination node

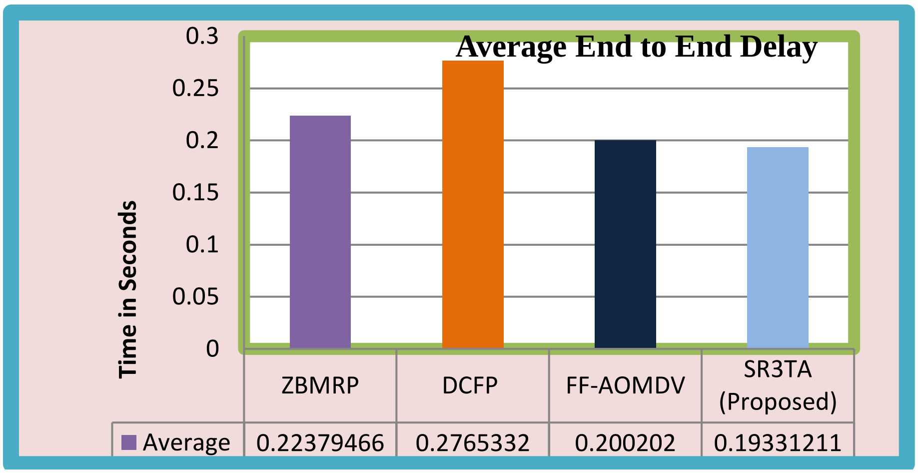

Figure 7 Average End to End Delay between Source node and destination node

5. CONCLUSION

In wide areas of applications such as emergency management, video transfers, safe communication etc., MANETs have been used. It is a difficult job to route the packets to their final destination in MANETs due to the frequent topological changes. This work proposed a new SRTSABC Based Self-Regulating Routing Algorithm (SR3TA(R)) in view of the same, which considered the random collection of source and destination nodes and exchanges between them the bees. Some of the special features of Bees that contribute to the routing issue have been considered in this work. The flow of packets and Bee's through the network; alters stochastically the routing strategy and routes that are used by future packets. In contrast to ZBMRP, DCFP and FF-AOMDV protocols, the result is that the SR3TA(R) has better efficiency, as seen in the results section using different performance assessment metrics.

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