TBOR: Tree Based Opportunistic Routing for Mobile Ad Hoc Networks

Y. Harold Robinson, M. Rajaram, E. Golden Julie, S. Balaji

Abstract**—**A mobile ad hoc network (MANET) is a wireless communication network where nodes that are not within direct transmission range establish their communication via the help of other nodes to forward data. Routing protocols in MANETs are usually categorized as proactive. Tree Based Opportunistic Routing (TBOR) finds a multipath link based on maximum probability of the throughput. The simulation results show that the presented method is performed very well compared to the existing methods in terms of throughput, delay and routing overhead.

Keywords**—**Mobile ad hoc networks, opportunistic data forwarding, proactive Source routing, BFS.

I. Introduction

A MANET is a combination of mobile network and Ad Hoc network [1]. The Opportunistic Data Forwarding represents the multihop wireless links for a multiple data pockets [7]. Initially IP forwarding has to be used for multiple data transfer. The Medium Access Control (MAC) can identify the actual next hop forwarder for an overall transmission [5]. The operation identifies the next node by the protocols as link state routing (LS) or source routing (SR).

MANET is a wireless network where the nodes move arbitrarily. It is an autonomous system in which mobile hosts connected by wireless links are free to move randomly and often act as routers at the same time [6]. Because MANETs are mobile, in early form they use wireless connections to connect to various networks [3]. The major drawbacks of using this algorithm are that DSDV requires a regular update of its routing tables, which uses up battery power and a small amount of bandwidth even when the network is idle. Whenever the topology of the network changes, a new sequence number is necessary before the network reconverted; thus, DSDV is not suitable for highly dynamic networks. Since no formal specification of this algorithm is present, there is no commercial implementation of this algorithm [4]. Energy Efficient Particle Swarm Optimization method is used to improve the Energy Efficiency in Multipath Routing [11]. The memory aided fuzzy classification method is used to improve the broadcasting nodes in the MANET [8]. Link failure can be reduced using the Trustworthy Link Failure Algorithm [2]. The overall optimal path identification has to be done in every process of base station. So, there may be possibility for collusion [9]. The optimal path information is also not a stored one; so, every communication needs the process of shortest path finding. Security is provided using Pairwise key Predistribution methodology [12].

The presented method used PSR to handle the forwarder data in MANETs. The PSR is used to identify all the possible paths for all the nodes and the information to be distributed to every node [10].

Harold Robinson Y. is an Associate Professor with the Department of Computer Science and Engineering, SCAD College of Engineering and Technology, India (e-mail: yhrobinphd@gmail.com).
Prof. Dr. M. Rajaram is the Vice-Chancellor, Anna University Chennai, India (e-mail: rajaramgct@rediffmail.com)
Golden Julie is an Assistant Professor, Department of Computer Science and Engineering, Anna University, Chennai, India (e-mail: goldenjuliephd@gmail.com).
Balaji S. is an Associate Professor with the Department of Computer Science and Engineering, Francis Xavier Engineering College, India (e-mail: sbalajiphd@gmail.com).

II. Design of PSR

A. PSR

PSR protocol provides nodes with more network structure information than distance-vector based protocols. The value of the source routing protocol includes:

1) Better control of path selection by the source nodes
2) IP forwarding to improving at intermediate nodes,
3) Support for opportunistic data forwarding. PSR complements DSR as a proactive counterpart to provide responsive data transportation services

In the PSR, each node maintains one single optimized tree for the identification of shortest path. The information of every node has to be transferred to all other nodes.

The major challenges handled by PSR are:

a) Overhead Reduction: Every node has the information to all other nodes. So there is no possibility for collusion.
b) Loop prevention: PSR allows the intermediate node to modify the path. So the flexibility improves the communication efficiency.

B. Breadth First Spanning Tree (BFST)

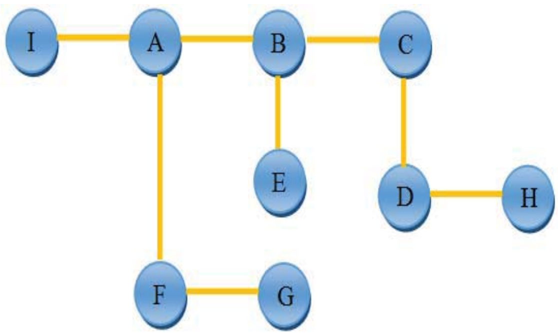

Fig. 1 Network Construction

The network enumeration with all possible state of values could be enrolled to identify most unique shortest path based on the search done as breadth basis.

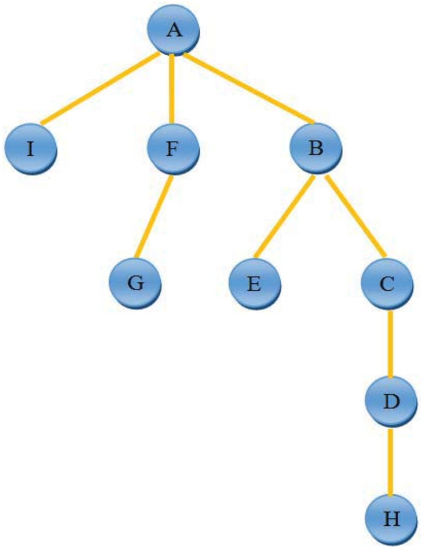

Fig. 2 BFST construction from network

C. Route Optimized Quality of Service

Legend based transformation of service curve and active curve can be used to create the independent cross traffic which can be achieved the quality of service network Traffic based Routing. Transforming the conservation to the legend domain (- , +). The service based legend transformation has performed the provided service curve in the traffic T_r to path $Path_x$.

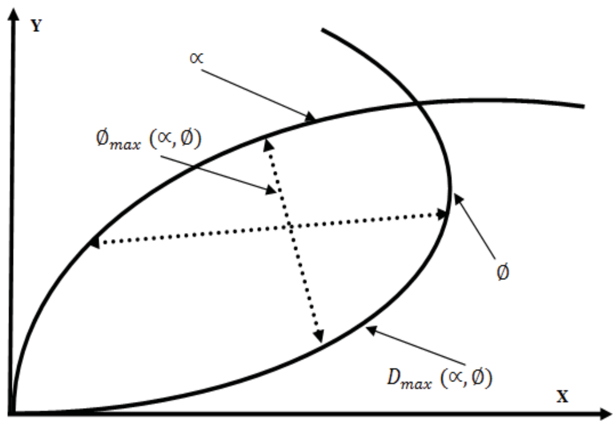

Fig. 3 Delay Bound Representation

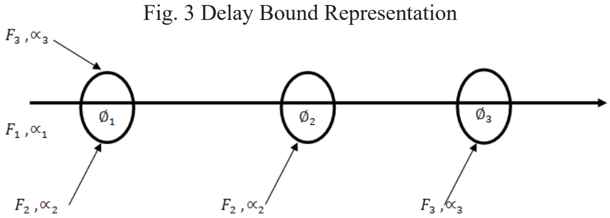

Fig. 4 Traffic Flow in the Network

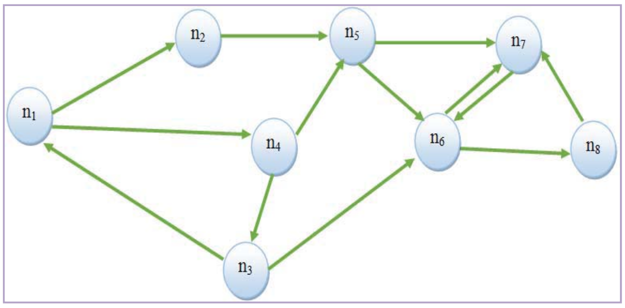

Fig. 5 Network Topology

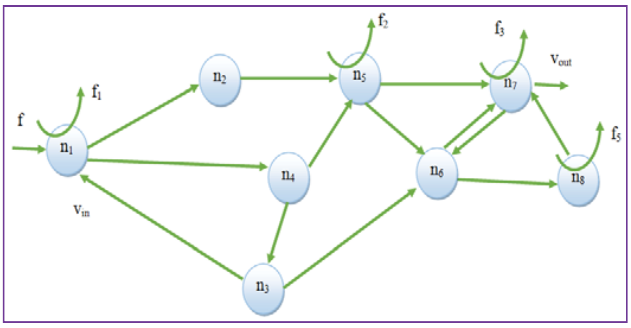

Fig. 6 Quality of Service of Legend based Transformation

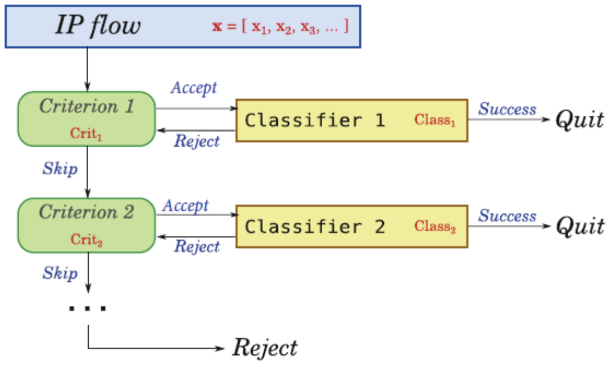

Fig. 7 Initial Process of Traffic Path Classifier

The Traffic T_r by the path $Path_x$ can be calculated as

$$\emptyset(Path_x) = \emptyset_1 \; x \; \emptyset_4 x \; \emptyset_7 \quad (1)$$

Figs. 3-6 demonstrate the quality of service based on legend transformation in the network.

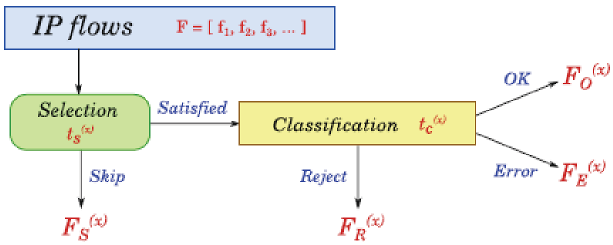

Fig. 8 Final Process of Traffic Path Classifier

D.Network Connectivity

Network connectivity is the ratio between all of the suitable routes in MANET. The average for the lifetime has been calculated. Let a be the number of nodes in MANET, to calculate Z_t, the highest suitable number of routes at the period of t as

$$Z_t = \frac{a\,(a+1)}{2} \tag{2}$$

With discovery of D_t, the set of divisions at period t and $|D_t|$ is the number of divisions at period t.

The active number of routes at period t as

$$A_t = \sum_{\{D_t\}} \frac{|D_t|(|D_t|+1)}{2} \tag{3}$$

The network connectivity for a period t is

$$N_t = \frac{A_t}{Z_t} \tag{4}$$

The connectivity percentage for the period of simulation is calculated as

$$\text{ConnectivityPercent} = \frac{1}{t} \times \sum_{t=1}^{\text{Maximum}} N_t \tag{5}$$

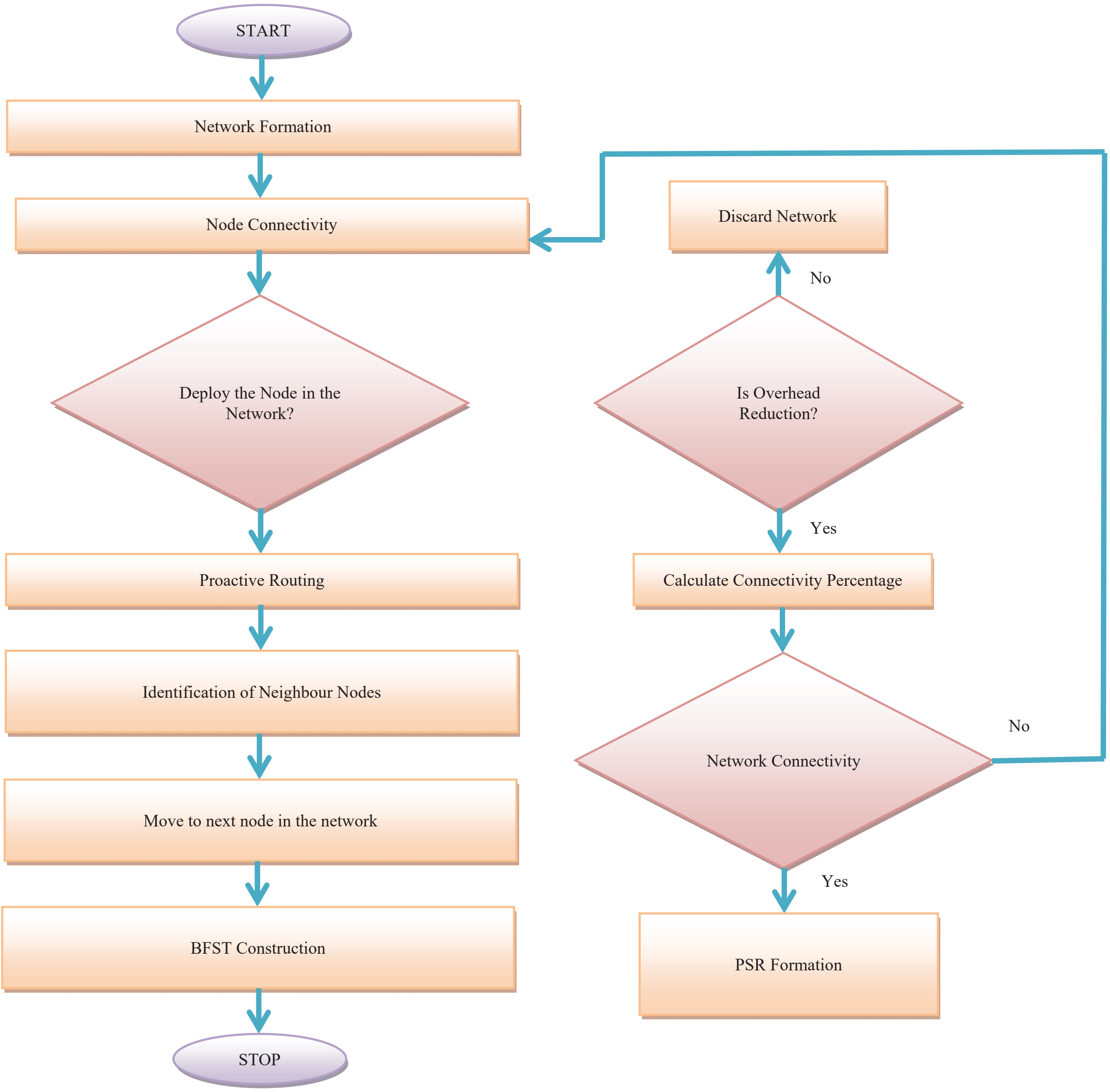

Fig. 7 Flowchart for Proposed system

E. Implementation

The first major advantage is to reduce the time links. Second, PSR always maintains a breadth-first spanning tree at each node, to provide responsive data transportation services. Third, we utilize both full dump and differential updates to strike the balance between efficient and robust network operations. Last, we use source routing to forward data rather than IP forwarding. Then, we serialize the binary tree using a bit sequence of 34s bits. Particularly, we scan the binary tree layer by layer. When processing a node, we initially include its IP address in the sequence.

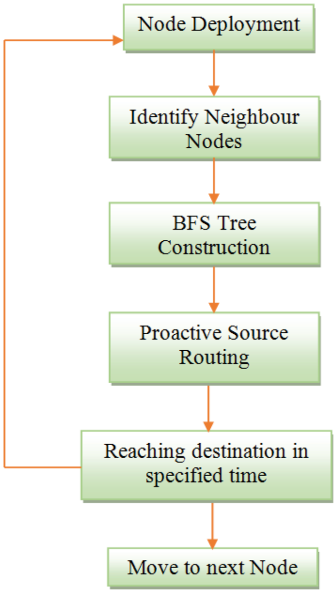

Fig. 8 System Design

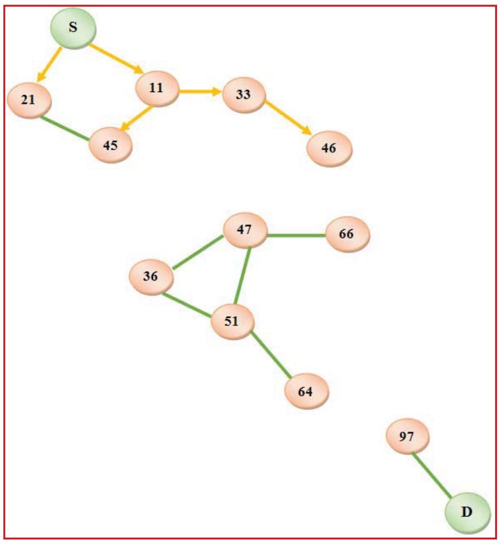

Fig. 9 PSR Node Formation

By using PSR, the information of all nodes has to be exchanged to all other nodes. The maximum sharing path has to be taken as the shortest path, so the interference between the nodes are avoided. Figs. 10-13 demonstrate the PSR construction from source node to destination node containing discovery node and neighboring nodes.

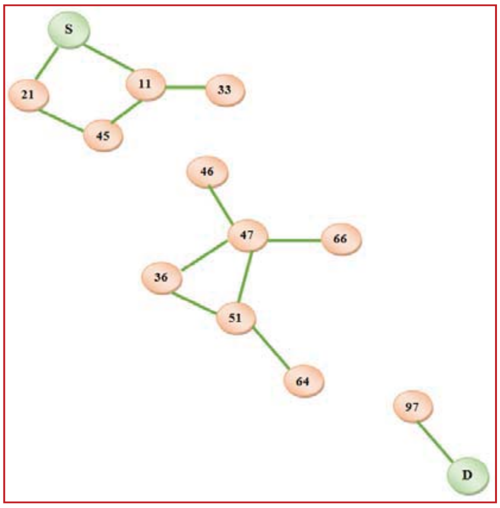

Fig. 10 Data Indication

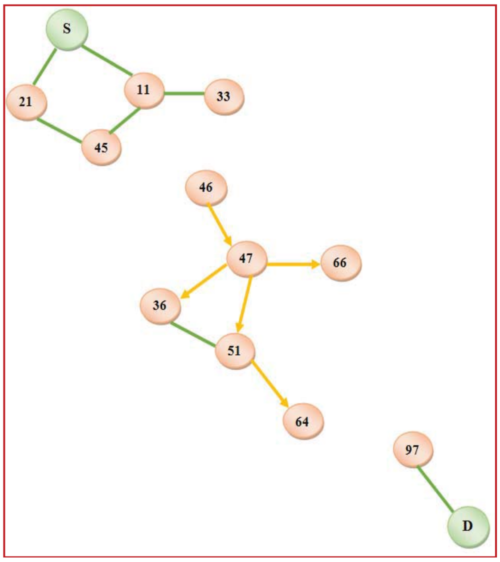

Fig. 11 Source node initiates discovery

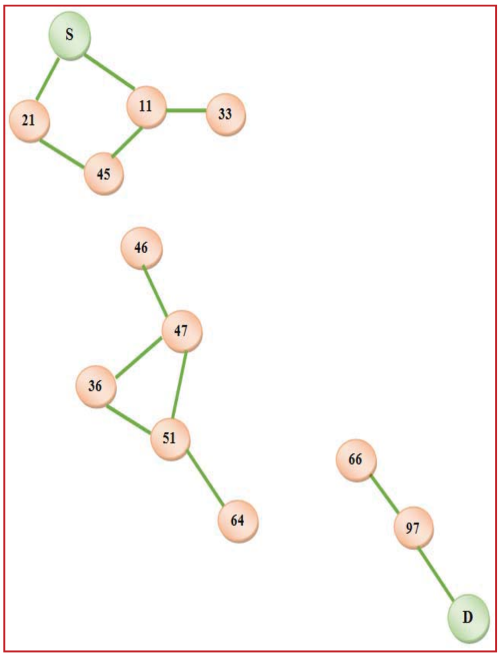

Fig. 12 Source selects the Proxy Node

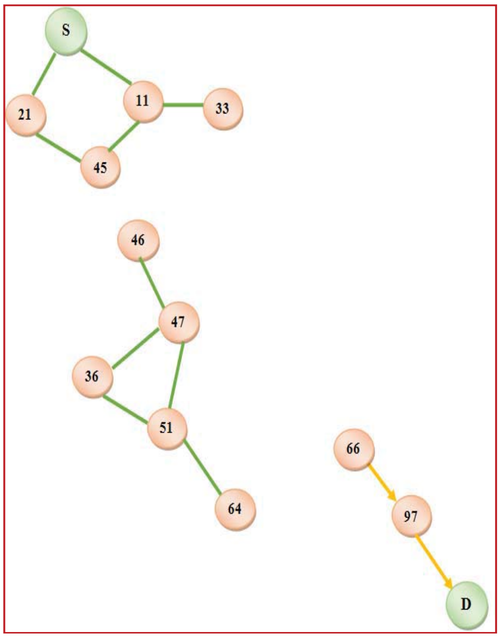

Fig. 13 Destination Proxy

III. Tree Based Opportunistic Routing Algorithm

A. TBOR – Multipath Routing

MultiPath_TBOR(source, destination, x, N)
$c_1 \leftarrow c$
$x_1 \leftarrow x$
for i ← 0 to N do
  $S\_Tree_i \leftarrow$ TBOR(x_i, source)
  $Path_i \leftarrow$ Get_Path(S_Tree_i, destination)
    for every edge e in $\sum$
      if e is in $Path_i$ or Rev (e) is in $Path_i$ then
        $c_{i+1}(e) \leftarrow g_{Path}(c_i(e))$
      else if all the vertex_Head(e) is in Pathi then
        $c_{i+1}(e) \leftarrow g_e(c_i(e))$
      else
        $c_{i+1}(e) \leftarrow c_i(e)$
      end if
  end for
    $x_{i+1} \leftarrow (\gamma, x, c_{i+1})$
end for
return ($Path_1, Path_2, \ldots\ldots, Path_N$)

B. TBOR – Rounds Selection

A' := A
B' := φ
while |A'| > 0
  if |B'| = 0 then B' = B
    for x ∈ B'
      $A_x := \{a \in A' \mid x < a\}$
  end
  $x^* := \min(A_x)$
  $A_n :=$ choose (A_{x^*})
  $G_n := x^*$
  $A' = A' \setminus G_n$
end

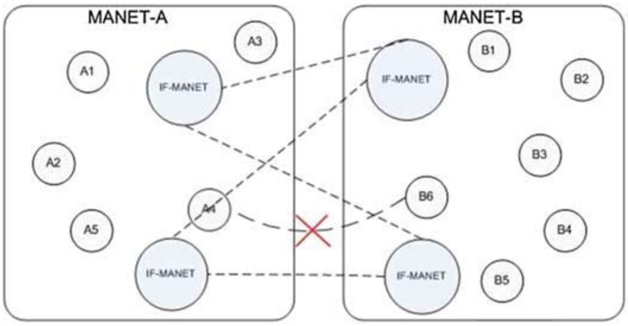

Fig. 14 Communication Model

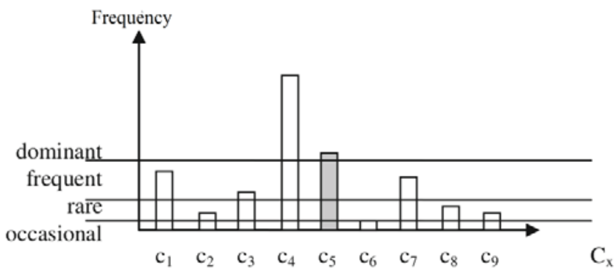

Fig. 15 Frequency Distribution

IV. Performance Evaluation

The reasons that we select PSR with that of OLSR, DSDV, and DSR baseline protocols that are different in nature are as follows. On one hand, OLSR and DSDV are both proactive routing protocols, and PSR is also in this category. Furthermore, DSR is a well-accepted reactive source routing scheme, and as with PSR, it supports source routing, which does not require other nodes to maintain forwarding lookup tables. All three baseline protocols are implemented and tested. This experimental result shows that the overhead of PSR (20 to 30) is just a fraction of that of OLSR and DSDV (140 to 260) and more than an order of magnitude smaller than DSR (420 to 830). The routing overhead of PSR, OLSR, and DSDV goes up gradually as the node density increases. This is a typical behavior of proactive routing protocols in MANETs. These protocols usually use a fixed-time interval to schedule route exchanges. While the number of routing messages transmitted in the network is always constant for a given network, the size of such message is determined by the node density. That is, a node periodically transmits a message to summarize changes as nodes have come into or gone out of its range. As a result, when the node density is higher, a longer update message is transmitted even if the rate of node motion velocity is the same. Note that when the node density is really high, e.g., around 10 and 12, the overhead of OLSR flattens out or even slightly decreases. This is a feature of OLSR when its multipoint relaying mechanism becomes more effective in removing duplicate broadcasts, which is the most important improvement of OLSR over conventional LS routing protocols. PSR uses a highly concise design of messaging, allowing it to have much smaller overhead than the baseline protocols.

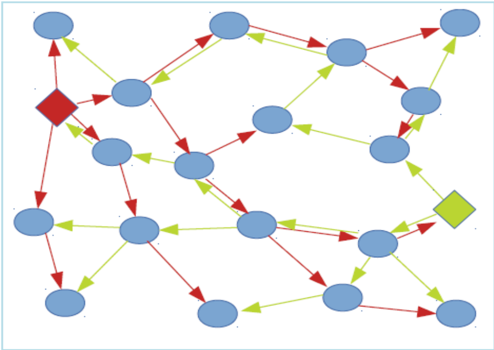

Fig. 16 Network Connectivity

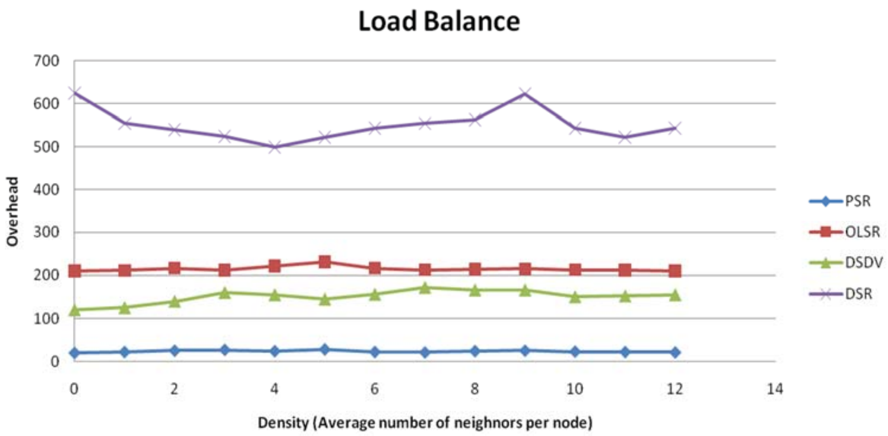

Fig. 17 Performance analyses Density vs. Overhead

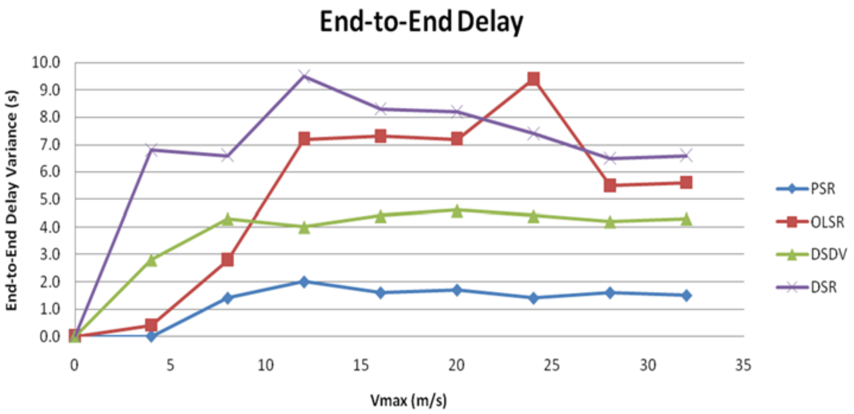

Fig. 18 Performance Analysis Maximum possible node vs. Delay

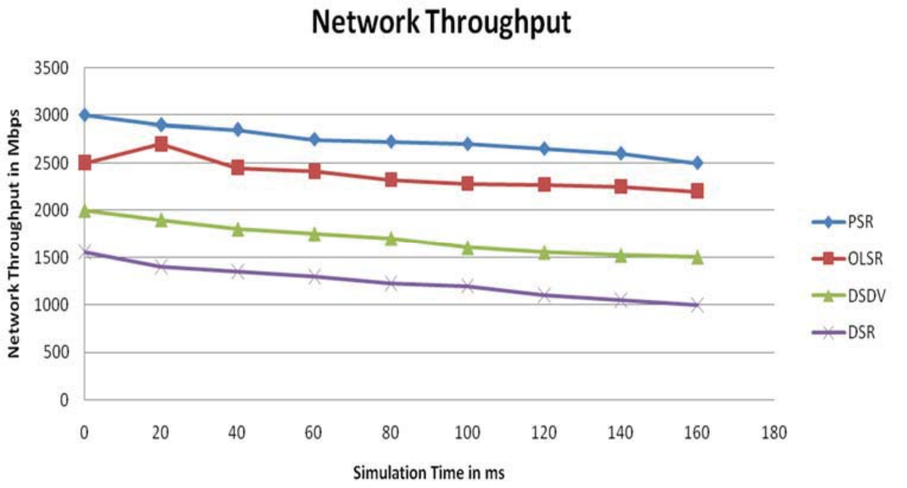

Fig. 19 Throughput

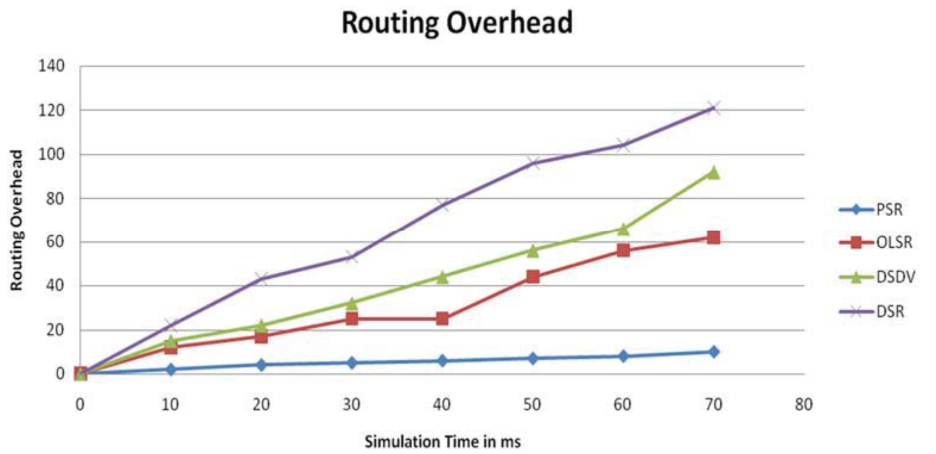

Fig. 20 Routing Overhead

The end-to-end delay presents a rather distinct landscape. In particular, the number for DSR is significantly higher than the other protocols, except in low-mobility networks with $v_{max} = 0$ or 4 m/s. In all cases, the delay for PSR is much smaller compared with OLSR and DSDV. On the other hand, the measured delay indicates that all protocols become less consistent when nodes move faster. Relatively speaking, however, the variance of PSR is much smaller than the other three.

Figs. 17-20 demonstrate the performance evaluation of the proposed work compared to existing methods.

V. Conclusion

This paper has investigated the challenges of Mobile Ad Hoc Network Tree Based Routing and Proposed TBOR for MANET to provide the Quality of Service in Routing. TBOR has addressed four key areas of Routing Overhead, Throughput, Load Balancing and End to End Delay.

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Y. Harold Robinson is currently working as an Associate Professor, dept of CSE in SCAD College of engineering and Technology, Tirunelveli. He finished ME degree in Anna University, Chennai. He is Pursuing his Ph.D. from Anna University Chennai. His research interests are Wireless Networks Mobile Computing, Wireless Sensor Networks. He has published several Research papers in International Journals. He has presented many papers in National and International conferences in Network security, Mobile Computing and Cloud Computing.

Prof. Dr. M. Rajaram M.E., Ph.D. is the Vice-Chancellor of Anna University, Chennai. As a research guide, Dr. M. Rajaram produced 30 Ph.D.'s and four M.S. scholars in various fields. At present, 10 research scholars are pursuing their Ph.D. under his direct supervision. He has contributed to the areas of Computer Networks, High Voltage Engineering, Measurement and Instrumentation, Adaptive Controller, Electro-Magnetic Theory, and Intelligent Computing with his 157 publications in renowned research journals, 111 research publications in International Conferences, 73 research publications in National Conferences, more than 100 technical reports and six technical books some of which he has co-authored

E. Golden Julie received her B.E degree in Computer Science and Engg in 2005 from Anna University Chennai and ME degree in Computer Science and Engineering in 2008 from Anna University Chennai. Currently she is Pursuing her Ph.D. from Anna University Chennai. Presently she is working as assistant professor in Regional centre Anna University, Tirunelveli, India She has published many research papers in various fields. Her research area includes Wireless Sensor Adhoc Networks and Image Processing. She is a member of ISTE.

S. Balaji, M.E, MISTE doing his Ph.D. in Anna University, Chennai and currently working as a HOD in dept of CSE at SCAD College of engineering and Technology, Tirunelveli. His research interests are Wireless Networks Mobile Computing, Network Security with apps, Wireless Sensor Networks, Cloud Computing. He has presented many papers in National and International conferences in network security, Mobile Computing, network security, and Cloud Computing. He has organized and conducted various national and international conferences, International Seminars and National Workshops. And also his methodology of teaching about TCP & UDP is hosted on Wipro Mission 10x portal. He is a life time member of ISTE.