Comparative Study of Routing Protocols for WMN

[1]Meenu Chawla, [2] Amit Taneja, [3] Naunita Bansal
[1]*Department of Computer Science and Engineering*
GZS PTU Campus, Bathinda Punjab
[1]meenuchawla011@gmail.com, [2]amit_t19@yahoo.com, [3]naunitabansal@yahoo.com

Abstract—*Today, Wireless Mesh Networks has been recognized as a new attractive communication paradigm due to their ease of deployment and ability of fault tolerance. WMN is a multi-hop wireless network which builds high performance infrastructure and provides efficient communication using various Routing Protocols. Traditional routing protocols like AODV, DSR and DSDV etc. support Ad-hoc networking in which devices doesn't have capability to provide fault tolerance. To overcome this, several types of Opportunistic based routing protocols have been proposed i.e. EXOR and SOAR etc. which support combination of both Ad-hoc and Mesh networking. All these protocols like EXOR and SOAR exploit the broadcast nature and provide the capability of fault tolerance using multiple alternate paths and redundant copies of data packets. Further, we have shown the comparative performance analysis of EXOR and SOAR using various network parameters i.e. network throughput, robustness (against node/link failure), hop count, bandwidth consumption and traffic congestion for multiple different nodes network.*

Keywords— *WMN; Fault Tolerance; EXOR; SOAR ; ROMER*

I. INTRODUCTION

Nowadays, Wireless Mesh Networks *(WMNs)* has been renowned as a key technology for next-generation wireless networking [1-2], which provides various Real time applications like Internet broadband access, military communication and multimedia networking etc. WMN provides high performance infrastructure [3-5] over multi-hop wireless network.

Traditionally, several Routing Protocols like *AODV* [6-7], *DSR* [8], *DSDV* [9] etc have been proposed that support Ad-hoc networking i.e. all devices can directly communicate to multiple different devices with in its radio ranges but that devices doesn't have capability to provide Fault Tolerance (Capability to Retransmit the data packets on behalf of other devices during failures). To cope well with this drawback, *Opportunistic Routing Protocols* [10] came into existence, which exploits the broadcast nature that chooses multiple alternate paths for transmission and support the combination of both Ad-hoc and Mesh networking. According to Mesh networking, each device acts as a router and achieves the fault tolerance capability.

Several Opportunistic based Routing Protocols have been proposed like *EXOR (Extremely Opportunistic Routing Protocol)* [11] and *SOAR (Simple Opportunistic Routing Protocol)* [12-13]. In *EXOR*, Sender broadcasts the data packets in the form of batches. To maximize the progress, the forwarding nodes transmit data packets in the order of their immediacy to destination node, as measured using *ETX (Extremely Transmission Count)* [14]. But one of the major drawbacks of *EXOR* is that 1) it increases network congestion due to usage of redundant copies of data for resilient packet transmission. 2) Coordination Overhead and diverging problem.

To cope well with these drawbacks, [12-13] have proposed another Routing Protocol i.e. SOAR which is more advantageous than previous approaches. In SOAR, Initially Sender selects shortest path by considering the *ETX* metric and a list of neighbouring nodes. After that it forwards the packets to selected nodes. So it decreases the congestion and load on the network due to selection of only some nodes. 2) Resolves Coordination overhead and diverging problem.

The rest of this paper is organized as follows. Section II presents Comparative Study that describes the execution and drawbacks of previous approaches. Section III describes the comparative performance analysis of approaches using various network parameters [15-17] i.e. network throughput, traffic congestion, hop count, robustness, bandwidth consumption and packet size. Finally, Section IV concludes the paper and discusses the future scope of work.

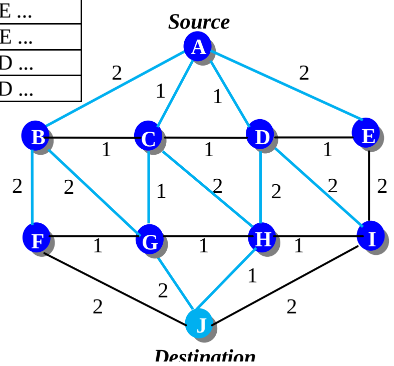
II. COMPARATIVE STUDY OF PREVIOUS APPROACHES

In this section, we have described the execution of Routing approaches *EXOR* [11] and *SOAR* [12-13] and have analyzed their performance in case of failure and without failure. This comparative study also describes the drawbacks of approaches. We have firstly described the execution of *EXOR* [11]. *EXOR* proposed opportunistic based routing protocol in which sender broadcasts the data packets in the form of batches, and provides fault tolerance by transmitting redundant copies of data to multiple nodes. Let us examine this approach using *WMN* as shown in figure1, where A is the source node and J is the destination node. Remaining nodes of the WMN are intermediate nodes. The possible steps to communicate data between $\{A, J\}$ in *WMN* using *EXOR* as follows:

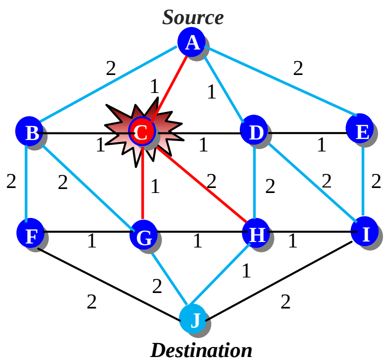
A. Successful packet delivery in case of without failure:

As shown in figure 1(a), source node A has data packets to transmit. It firstly divides the packets into batches with redundant copies of packets according to their forwarding downstream nodes and then broadcast the packets to downstream nodes accordingly. As shown in figure 1(a), source node A broadcasts the packet 1 to node B, D and packet 2 to node B, C and so on. To maximize the progress each downstream node that receives their batch respectively calculates loss probability from its each link to destination node J using *ETX* metric. Suppose that order of their proximity i.e. $ETX(C) < ETX\,(D) < ETX\,(B) < ETX\,(E)$.So node C has highest priority that further broadcast their packets to downstream nodes i.e. G *and* H. With this, the node C maintains the batch map that records the information of acknowledged packets; the neighbouring nodes like B, D *and* E hear the information of acknowledged packets and forward only those packets to their downstream nodes that are not acknowledged according to their proximity. At last, all data packets have successfully delivered to destination node J.

PID	Forwarding List
1	B,D ...
2	B,C ...
3	C,E ...
4	B,D ...
5	C,E ...
6	B,E ...
7	C,E ...
8	D,E ...
9	C,D ...
10	B,D ...



(a)



(b)

Figure 1: Execution of EXOR in WMN:
a) Without failure, b) With failure.

B. Successful Packet Delivery in case of failure:

How EXOR behaves when failure occurs inside the network? Let we describe this case by taking the same example of WMN as shown in figure 1(b).

Suppose In the figure 1(b), node C fails that doesn't have capability to receive the packet. When source node A broadcasts the packets in the form of batches, only nodes B, D *and* E receive their batch of packets and further broadcast it according to their proximity. So there is no loss of packets occur because the packets that are forwarded to node C also have the multiple redundant copies to another neighbouring nodes and that nodes will further broadcast the packets. So it provides fault tolerance by using redundant copies of data packets and provides multiple paths for packet transmission in case of node/link failure because it uses the entire network for packet transmission. But it *increases traffic congestion and load* on the network. With this, many other drawbacks arise using this approach.

a) Coordination Overhead/Hearing Problem occurs due to usage of entire network for packet transmission and all nodes actively hear neighbouring nodes at all time.

b) Diverging and Redundancy Problem occur when any intermediate node is far away from another node and can't hear to each other properly due to low hearing probability. There may be chances that both nodes forward some similar packets. So the paths further diverge and yield many redundant transmissions.

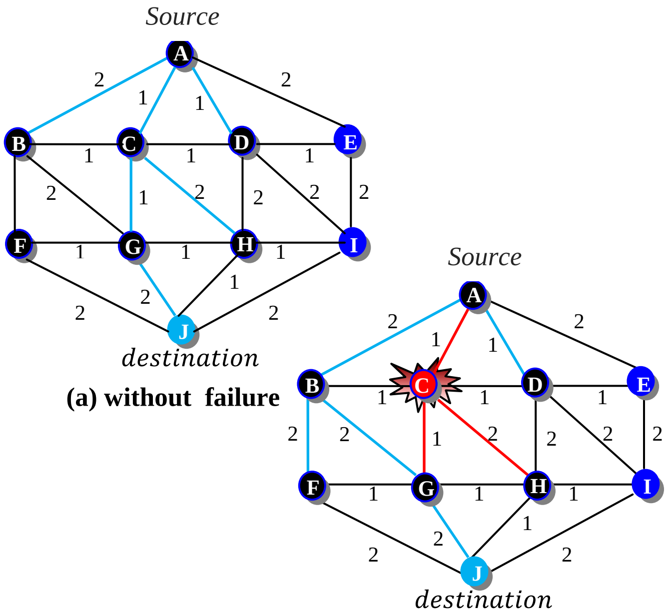
To overcome these problems, another Routing Protocol i.e. *SOAR* came into existence. *SOAR* [12-13] is proactive link state routing protocol in which each node periodically measures and propagates link quality in terms of *ETX*. Based on this information, a Sender initially selects the shortest path by considering the *ETX* metric and a list of neighbouring nodes that are eligible

ISSN: 2229-6913 (Print), ISSN: 2320-0332 (Online) -, Web Presence: http://www.ijoes.vidyapublications.com

for forwarding the data. After that the Sender broadcast data packets that include an ordered list of forwarding nodes. Let us examine this approach using same example of WMN as shown in figure 2 in which A is source node and J is destination node. The possible cases to communicate data between $\{A, J\}$ in WMN using SOAR as follows:

C. Successful Packet Delivery in case of without failure:

As shown in figure 2(a), Suppose Source node A has data packets to transmit to destination node J, it initially selects Shortest Path i.e. $A \rightarrow C \rightarrow G \rightarrow J$ by considering its ETX values. With this, it consider a list of neighbouring nodes i.e. B, F, D, H for providing the redundant copies of data which is helpful for forwarding the data packets successfully to destination node J.



(a) without failure

(b) with failure

Figure2: Execution of SOAR in WMN: a) without failure b) with failure.

After that Source node A broadcast data packets to their selected downstream nodes B, C *and* D. After receiving the packets by B, C *and* D they further broadcast the packets according to their priority calculated by ETX. So this approach is also based on priority based forwarding scheme.

D. Successful Packet Delivery in case of Failure:

Suppose in figure 2(b), node C fails, when source node A broadcast the data packets to selected nodes i.e. B, C *and* D but only node B *and* D successfully receive it and participate in further forwarding by calculating their proximities using *ETX* metric. So this approach uses some selected nodes for successful packet delivery. The major advantage of using *SOAR* [12-13] is that it decreases traffic congestion and network load because it sends the data to some nodes. It also minimizes the coordination overhead. It resolves the diverging problem properly because it uses the closest nodes for packet transmission.

Table I show the brief comparative study of both approaches *EXOR* [11] and *SOAR* [12-13].

TABLE I. COMPARATIVE STUDY OF PREVIOUS APPROACHES

S.NO	EXOR [11]	SOAR [12-13]
1.	Proposed opportunistic based routing in which sender broadcasts the packets into batches to all downstream nodes.	Proposed proactive link state routing in which sender initially selects some alternate paths for transmission.
2.	Coordination overhead occurs due to usage of all nodes for transmission.	Minimizes the coordination overhead because it uses some selected nodes.
3.	Divergence and redundancy problem occurs due to far distance between nodes and can't hear properly.	Resolve the divergence problem and minimizes the redundancy problem.
4.	Network congestion occurs due to broadcast of redundant copies of data.	Less Network congestion occurs due transmission of less no. of copies of data.

III. PERFORMANCE ANALYSIS

In this section, we have analyzed the performance of *FTR* (Table III) over previous proposed approaches *EXOR* and *SOAR* in terms of network performance parameters i.e. network throughput, robustness against node/link failure, network congestion, hop count and bandwidth consumption. These parameters are defined as:

(a) Network Throughput: is defined as how fast we can actually send data through a network.

(b) Robustness against node/link failures: is defined in terms of fault tolerance (i.e. possible number of paths exist in case of failure).

(c) Network Congestion: how much traffic exists during transmission of data between source and destination?

(d) Hop Count: is defined as how many number of intermediate nodes used for reliable packet transmission.

ISSN: 2229-6913 (Print), ISSN: 2320-0332 (Online) -, Web Presence: http://www.ijoes.vidyapublications.com

(e) Bandwidth Consumption: is measurement of bit rate of consumed data communication resources.

Since *EXOR* [11] exploit broadcasting and use multiple paths for efficient packet transmission which really increase the traffic congestion on the network due to transmission of redundant copies of data and throughput decrease due to increase in transmission cost. But in *SOAR* [12-13], it chooses some selected nodes for successful packet delivery. So network throughput increases in case of *SOAR* due to decreease in transmission cost. Here with, *SOAR* avoids the broadcast nature i.e. network congestion also decreases. [11] also consume high bandwidth due to use of large number of intermediate nodes for successful packet transmission from source to destination. But *SOAR* provides the

TABLE II. Comparative Performance Analysis of Approaches

Approaches / Parameters	EXOR	SOAR
Network Throughput	decreases	Increases
Traffic Congestion	increases	decreases
Bandwidth Consumption	high	proper
Hop Count	increases	decreases
Robustness(against node/link failure)	provides	provides

proper utilization of bandwidth and uses less number of intermediate nodes for packet transmission. If any failure occurs during transmission then both protocols provide different paths for successful packet delivery from source to destination.Table III shows the comparative analysis of both approches.

IV. CONCLUSION AND FUTURE WORK

In this paper we have discussed various routing protocols for WMN. The *EXOR* Protocol exploits the broadcast nature and provides the capability of fault tolerance using multiple alternate paths and redundant copies of data packets. But *SOAR* provides us the reliable packet transmission with the reduction of number of links that ensures effectual communication in *WMN*. This approach also resolves the coordination overhead, hearing problem and provides effective utilization of bandwidth. Further we have analyzed the performance of both approaches i.e. *EXOR* and *SOAR* using various network parameters i.e. network throughput, robustness (against node/link failure), hop count, bandwidth consumption and network congestion which analyzes that *SOAR* is more efficient and provides more reliable communication. In future, practical implementation of *SOAR* approach for wireless mesh network is to be analyzed for accurate and absolute results.

REFERENCES

[1]. Ahmeda, S. Shubat, and Eman A. Essied. "Routing Protocols for Wireless Mesh Networks." Lecture Notes on Software Engineering 1.1 (2013)

[2]. Sichitiu, L. Mihail "Wireless mesh networks: opportunities and challenges."Proceedings of World Wireless Congress. 2005

[3]. Akyildiz, F. Ian, and Xudong Wang. "A survey on wireless mesh networks."Communications Magazine, IEEE 43.9 (2005): S23-S30.

[4]. Rohilla, Yashpal, and Preeti Gulia. "A comparative study of wireless mesh and ad-hoc network." International Journal on Computer Science and Engineering 4.6 (2012) p1181-1184.

[5]. Nitin Rakesh and Vipin Tyagi, “Failure Recovery in XOR’ed Networks”, Proceeding of the 2012 IEEE International Conference Signal Processing, Computing and Control (ISPCC), Waknaghat, India, 2012, pp. 1–6.

[6]. Perkins, E. Charles, and Elizabeth M. Royer. "Ad-hoc on-demand distance vector routing." Mobile Computing Systems and Applications, 1999. Proceedings. WMCSA'99. Second IEEE Workshop on. IEEE, 1999.

[7]. Kinjal Shah, Gagan Dua, Dharmendar Sharma, Priyanka Mishra and Nitin Rakesh “Transmission of Successful Route Error Message(RERR) in Routing Aware Multiple Description Video Coding Over Mobile Adhoc Network”, Procceding of the International Journal of Multimedia & Its Applications, vol. 3, no. 3, 2011, pp. 51–59.

[8]. Johnson, B. David, A. Maltz David, and Josh Broch. "DSR: The dynamic source routing protocol for multi-hop wireless ad hoc networks." Ad hoc networking 5 (2001): p139-172.

[9]. Perkins, E. Charles, and Pravin Bhagwat. "Highly dynamic destination-sequenced distance-vector routing (DSDV) for mobile computers." ACM SIGCOMM Computer Communication Review. Vol. 24. No. 4. ACM, 1994.

[10]. Biswas, Sanjit, and Robert Morris. "Opportunistic routing in multi-hop wireless networks." ACM SIGCOMM Computer Communication Review 34, no. 1 (2004): 69-74.

[11]. Biswas, Sanjit, and Robert Morris. "ExOR: opportunistic multi-hop routing for wireless

networks." ACM SIGCOMM Computer Communication Review. Vol. 35. No. 4. ACM, 2005.

[12]. Rozner, Eric, et al. "Simple opportunistic routing protocol for wireless mesh networks." Wireless Mesh Networks, 2006.2nd IEEE Workshop on. IEEE, 2006.

[13]. Rozner, Eric, et al. "SOAR: Simple opportunistic adaptive routing protocol for wireless mesh networks." Mobile Computing, IEEE Transactions on 8.12 (2009): 1622-1635

[14]. De Couto, Douglas SJ, et al. "A high-throughput path metric for multi-hop wireless routing." Wireless Networks 11.4 (2005): 419-434

[15]. Campista, Miguel Elias M., et al. "Routing metrics and protocols for wireless mesh networks." Network, IEEE 22.1 (2008): 6-12.

[16]. Leiserson, E. Charles, Ronald L. Rivest, and Clifford Stein. Introduction to algorithms. Edited by Thomas H. Cormen. The MIT press, 2001.