A Tri-Classes method for studying the impact of Nodes and Sinks Number on Received Packets Ratio of MANETs routing protocols

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Abstract— **Mobile Ad hoc Networks (MANETs) consist of a set of mobile nodes connected together without any wired or physical infrastructure, which makes nodes independent and simple in deployment. The arbitrary movement of nodes within appropriate range area makes dynamic network and routing between there nodes is difficult. In MANETs the routes are performed by the source nodes (sinks) that establish the network without central access point, so number of sinks is very important in MANETs. When the nodes moving at a variant speed thus making unpredicted network that have unspecific topology. That networks have many limitations such as low energy due to the battery powered of its nodes. Therefore, routing protocols must be used based on the mobility, suitable nodes and sinks numbers, and reducing the energy consumption of the nodes. In this research we proposed a methods consist of three classes (Tri-Classes) to study the impact of changing numbers of nodes and sinks on Received Packets Ratio (RPR) for different MANETs routing protocols, the comparison includes the four major routing protocols, AODV (Ad hoc On Demand Distance Vector), DSDV (Destination Sequenced Distance Vector), DSR(Dynamic Source Routing), and OLSR (Optimized Link State Routing) under various nodes size (50, 100, and 250 nodes) and variant numbers of sinks (5, 10, and 15). We observed that the RPR is completely affected by changing numbers of nodes and sinks. In general we obtain best RPR by increasing nodes and sinks numbers. The protocols were simulated using Network Simulator 3 (NS3).**

Keywords— MANETs, WSNs, routing protocols, AODV, OLSR, DSDV, DSR, Received Packets Ratio (RPR)

I. INTRODUCTION

A Wireless Adhoc network can consider as decentralized kind of wireless network. Mobile Ad-hoc networks (MANETs) is a self-organized and configuration network, which its nodes are connected wirelessly without any infrastructure. Due its characteristics such as, nodes mobility and heterogeneity, It can applied in many fields likes military, smart homes, peer-to-peer communications, road safety, etc. Nodes con join and leave the network automatically at any time and acts as routers or hosts. Its nodes communicate with each other directly with no needed of central point [1][2].

A packets in MANETs may transmitted from a source node to a destination node directly or through some set of intermediate nodes, these nodes changing links to other nodes by its independently moving [3][4]. A strength MANETs is their ability to self-organize the infrastructure of the routing, especially after deployments of nodes [5] [6] .Routing protocol determines the routes between the nodes, then packets can transmitted between nodes on a network[4] [7].network layers [5]. Fortunately, several researchers have launched various surveys that covered WMSNs specifics over the years, with top down surveys covering routing protocols leading the way [6] [7].

II. MANETS ROUTING PROTOCOLS

Managing routing protocols in MANET is an essential challenges due to randomly movements of nodes within the network , in addition to join or leave the network at any time[8], so the optimal route of current time may not work seconds later[9] .

There are three main types of MANETs routing protocols depending on their mechanism of establishing routes between nodes: Proactive Routing Protocols, Reactive Routing Protocols, and Hybrid Protocols[1][4][10][11][12].

1) Proactive Routing Protocols : which known as Table Driven Routing Protocols, its depends on distance vector and link state that works on wireless networks, establishing static links between all pairs of nodes within the network and updating links periodically by sending update packets, all routing data are keeping in table that gives it an advantage of low latency for transmitting packets to destination nodes (due all routes are determined previously and kept in a table, no need to additional routing discovering). While the drawbacks of it is bandwidth overflow (due to sending periodically updating bandwidth even in case of unchanged route). Proactive Protocols suffer of limited resources such as power, needs more storage and link bandwidth overhead, for this reason it is not recommended to use in Ad-hoc Networks. Some examples of this category are: Optimal Link State Routing (OLSR), Destination Sequenced Distance Vector (DSDV), Wireless Routing Protocol (WRP), Multipath Dynamic Address Routing (MDART), and Topology Broadcast Reverse Forwarding TBRF).

2) Reactive Routing Protocols: this known as On-Demand Routing Protocols due to it discover routes between nodes on demand only that reduce routing overhead. Route maintenance executes only on current valid routes from source to destination, reactive routing protocols have many advantages makes it more suitable to large networks spatially that have high traffic. So for MANETs networks

reactive routing protocols is better than proactive routing protocols like scalability, needs less storages, reduce routing overhead. But also requires high latency as a limitation of this kind of routing protocols[3]. Some examples of reactive routing protocols are: Advanced On-Demand Distance Vector (AODV), Dynamics Source Routing (DSR), Temporally Ordered Routing Algorithm (TORA), and Ant-Colony-Based Routing Algorithm (ARA).

3) Hybrid Routing Protocols: consist from a combination of previous two kinds of routing protocols. Establishing best route paths to destination nodes by using distance vectors for more precise metrics, then reporting routing information only when there is a change in network topology. An examples of hybrid routing protocols are: Zone-Based Hierarchical Link State Routing Protocol (ZRP), Distributed Spanning Trees Based Routing Protocol (DST), and Distributed Dynamic Routing Protocol (DDR).

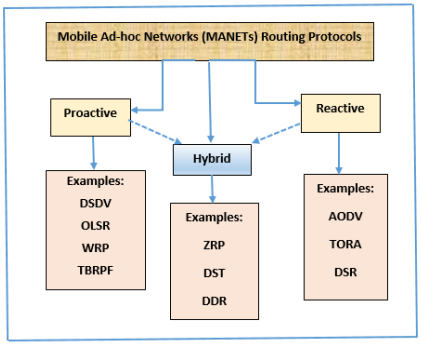


Fig. 1. three major types of MANETs routing protocols.

III. Received Packets Ratio (RPR)

There are many metrics parameters used to determine the efficiency of MANETs networks, such as Received Packets Ratio (RPR), end-to-end delay, energy consumption, throughput, and network life-time. In this research we focus on Received Packets Ratio (RPR) that's also known by some studies as Packets delivery Ratio (PDR) because of its direct impact on network efficiency by keeping packets from loss. Received Packet Ratio (RPR) is computed by equation (1) [3][10]-[12].

RPR%=(total no.of successfully delivered packets)/(total no.of sent packets) *100 …… (1)

IV. Related Works

A lots of previous studies have examined routing protocols in MANETs networks in terms of the suitability of these protocols to the used application and its appropriate environment condition. Some studies have also developed traditional routing protocols, or might suggested new routing protocols suitable to their application by increasing network efficiency.

Network Simulator 2(NS2) was used to studies the impact of network size (100, 150, 200, 250, 300, 350, 400, 450, and 500) nodes on AODV, DSDV, and DSR routing protocols. Results appears that DSR is outperform on AODV and DSDV in terms of Packets Delivery Ratio (PDR), PDR in DSR is increases with the number of nodes until it reaches climax at 250 nodes [13].

Evaluations the performance of MANET Routing Protocols OLSR, AODV, DSR, GRP and TORA on varying network area size using OPNET simulator. Different network area size was used (500*500, 1000*1000, and 2000*2000) on 50 nodes number. The results show that AODV is the best from other in average throughput, while GRP is the best in average end-to-end delay , and TORA was the best in average routing load[14].

Instant runoff Ranked Decision Forests Probit Regression based Connectionist Multilayer Deep Neural Network (IRDFPR-CMDNN) is an efficient, reliable routing protocol used to improving data transmission in MANETs. Proposed efficient data delivery, minimum end-to-end delay, perform delivering data and route maintenance with more than three layers network. Then compare results with traditional DSR routing protocol showing that IRDFPR-CMDNN is outperforms of DSR[7].

Introduced a simulation of hybrid routing protocol for route discovering and links breaking. Compared simulation result with traditional AODV routing protocol showing that hybrid method in general have best performance than AODV [15].

Improving MANET routing protocol using combine of Cat Swarm Optimization (CSO) and Particle Swarm Optimization (PSO), to increase performance by avoiding degraded routing. The results obtained show that the performance of proposed method is better than both CSO and PSO[16].

Analyzes performance of one protocol from proactive routing protocol (OLSR as example), and another one from reactive routing protocol (AODV as example), to specify suitable protocol for TCP and UDP based applications. Results shows that OLSR is more suitable for real-time application due to proactive nature. AODV can used within smaller networks which have minimum available bandwidth [17].

A comparison study of three MANET routing protocols (AODV, DSDV, DSR) in variant simulation times (50, 100, and 200) seconds. Results shows that at increasing nodes number and simulation time the traffics between source and destination increased too. DSR routing protocol have better performance than other protocols in comparison spatially in Packets Delivered Ratio (PDR)[18].

Classifies and compares Ad-hoc network routing protocols through the OPNET simulation tool and focuses on testing two routing protocols performance namely, proactive and reactive routing protocol. The Destination Sequenced Distance Vector (DSDV) used to represents proactive routing protocol, while Ad Hoc On-Demand Distance Vector (AODV), and Dynamic Source Routing (DSR) routing protocols are used as a reactive routing protocols. The performance of these three protocols are simulated with a variety performance metrics. The results obtained from 20 network nodes distributed randomly showed that the DSR protocol is the best option for a Packets Delivery Ratio (PDR) from both DSDV and AODV [19].

H. Redwan et al. (2018) in their research paper [103] they analysis the performance of four MANETs routing protocols (AODV, DSR , GRP , and OLSR) for UAVs communication based on scenarios with varying data rates supported IEEE 802.11p. Their simulation results shown that varying data rates has an impact in the delay performance of all protocols.

In terms of load, AODV shown a least load followed by DSR and GRP while in terms of routing overhead OLSR has a highest routing overhead traffic followed by GRP and AODV. The lowest delay observed for OLSR followed by AODV and GRP. However their study and simulation works not considered the high mobility and scalability, they used mobility speed 20m/s and node density 50 nodes.

V. Proposed Method

In this research we proposed Tri-Classes method for studying the impact of nodes and sink numbers in performance of different MANETs routing protocols. Figure 4. Shows the flowchart of proposed methods.

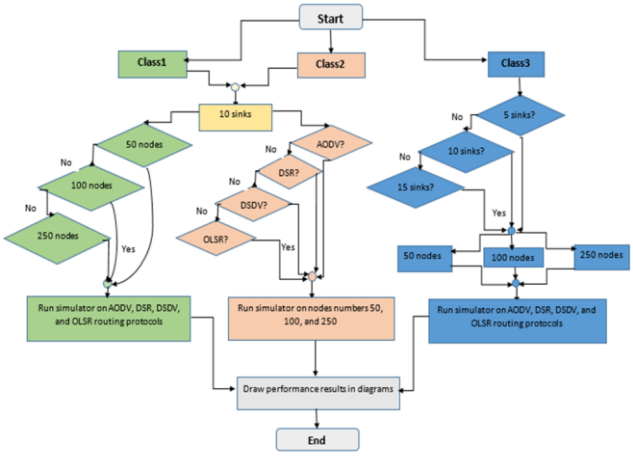


Fig. 2. Flowchart of Tri-Classes methods for studying impact nodes and sinks numbers on performance of MANETs routing protocols

II. Simulation and Results

Many simulators can used to simulate MANETs routing protocols, Network Simulator 3 (NS3) was used in this study to simulate various routing protocols such as AODV, DSDV, OLSR, and DSR. It's applying on different numbers of network nodes and sinks (source nodes) to compare Received Packet Ratio (RPR) as a following details:

Table 1. Simulation parameters used in the study

Simulation Parameters	Value
Operating System	Linux Ubuntu 20.4
Mobility model	Random Waypoint Model [20]
No. of wireless nodes	50, 100, and 250
No. of sink nodes (sources)	5, 10, and 15
Sink (source) type	UDP
Simulation time in seconds	100
Simulation area size in meters	300*1500 m^2
Mobile node speed	20 m/s
Transmit power	7.5 dBm
Physical layer protocol	802.11b
Data rate	2 mb/s
MANETs routing protocols	AODV, DSDV, DSR, and OLSR

Three numbers of network nodes are used (50, 100, and 250) nodes, and three numbers of sinks are used (5, 10, and 15) nodes, to compare the ratio of received packets. Depending on flowchart in figure 4. We used three classifications classes in comparison, first according to number of nodes, and second is according of each used protocol, finally according to number of sinks used in MANET.

Figures 3,4, and 5 represent the Received Packet Ratio in case of nodes equal 50, 100, and 250 respectively, in all this figures x-axis represent the simulation time in seconds while y-axis is representing the received packets ratio. And sinks number determined in 10 sinks.

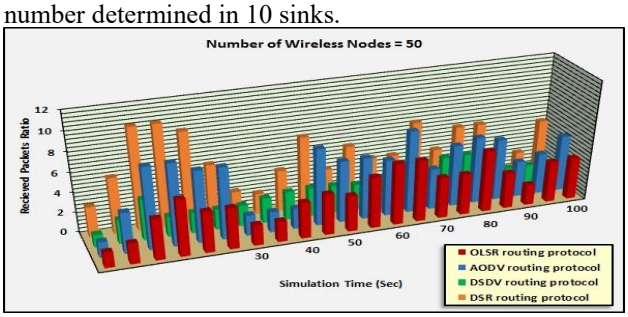


Fig. 3. Received Packets Ratio at nodes number= 50

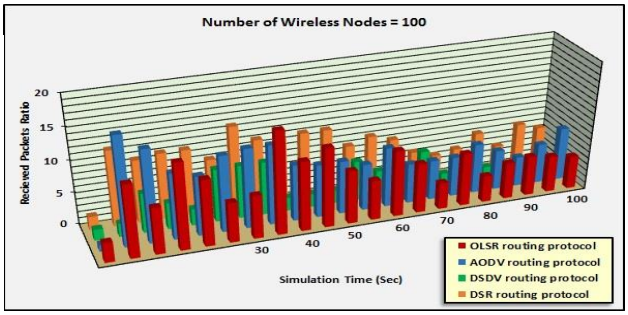


Fig. 4. Received Packets Ratio at nodes number= 100

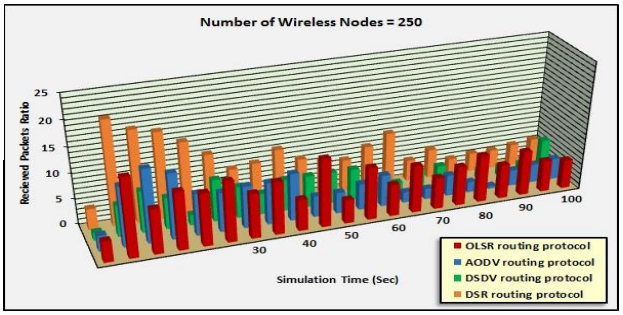


Fig. 5. Received Packets Ratio at nodes number= 250

Fig. 3. Show the ratio of received packets of all compared MANETs routing protocol in determined nodes number to 50, DSR is highest RPR while OLSR is lowest one. In addition to the received packet ratio do not exceeds 20 unless in case of DSR. While fig. 4. Appears that received packet ratio is proportional increased than the previous one. AODV have the best RPR in nodes=100, the rest of protocols are coming after him gradually. Fig. 5. represent RPR of MANET routing protocols at nodes number= 250, results shows that increasing in RPR than two previous figures, DSR protocol is highest at the beginning of the simulation time and continues to decrease almost gradually over the simulation time, DSR is the best RPR while DSDV is the worst. So we conclude from this that the increase in nodes number is directly proportional to RPR.

Figures 6, 7, 8, and 9 are explained Received Packet Ratio depends of MANETs routing protocols used in simulation AODV, DSDV, DSR, and OLSR respectively, in all this figures x-axis represent the simulation time in seconds while y-axis is representing the Received Packets Ratio.

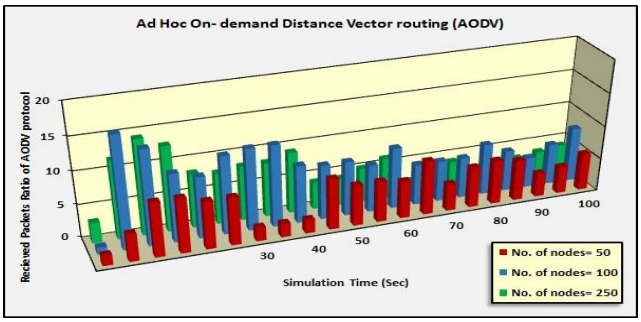


Fig. 6. Received Packets Ratio at AODV protocol for variant nodes numbers

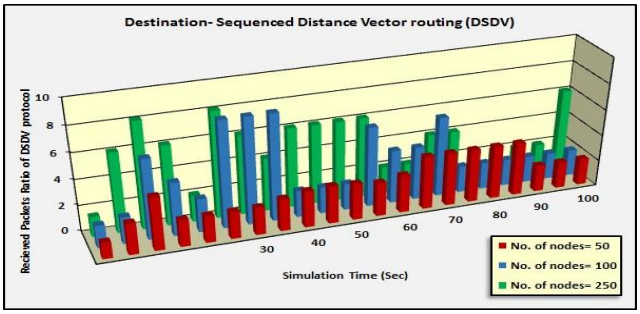


Fig. 7. Received Packets Ratio at DSDV protocol for variant nodes numbers

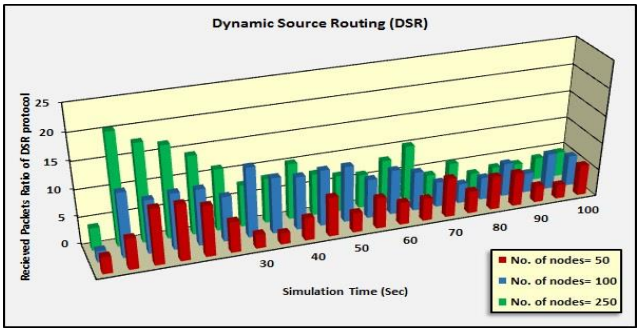


Fig. 8. Received Packets Ratio at DSR protocol for variant nodes numbers

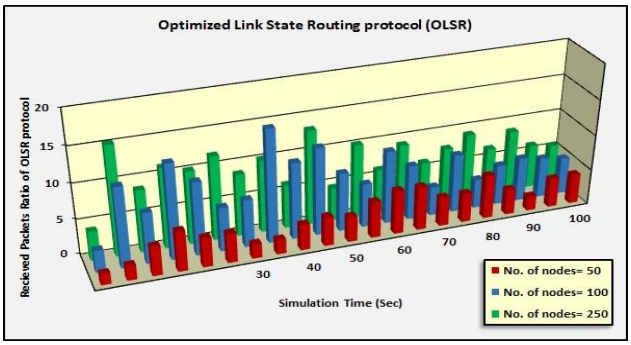
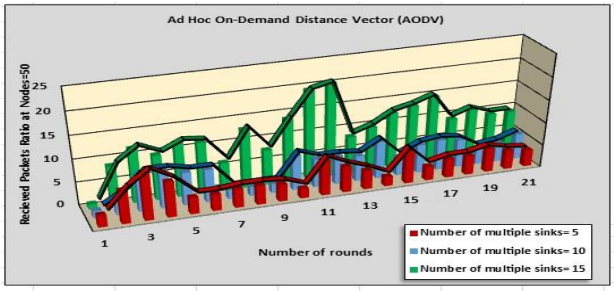


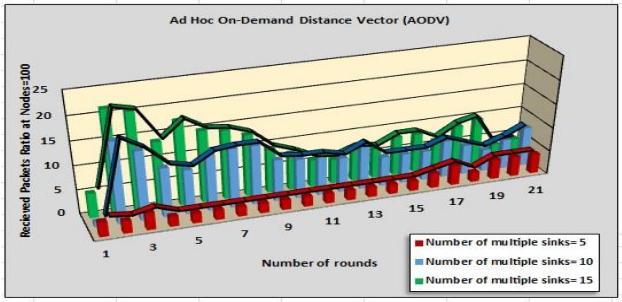
Fig. 9. Received Packets Ratio at OLSR protocol for variant nodes numbers

At fig. 6. Shows that at almost simulation time packets received ratio in AODV spatially at nodes=100 is greater than that is in nodes=50 and 250, so the best nodes number for AODV protocol is 100 nodes. While in fig. 7. Represent received packets ratio of DSDV protocol. Fig. 8. DSR protocol received packets ratio is relatively decreased with the time of simulations. Finally fig. 9. Explain packets received ratio of OLSR protocols. We observed that packets received ratio is increased with increasing of number of nodes (proportional increasing).

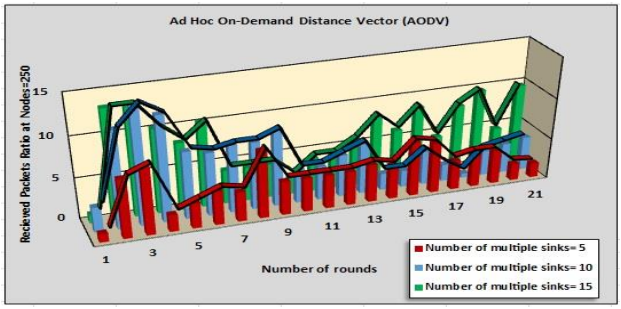
Figures 10, 11, 12, and 13 represents impact of changing sinks number on Received Packets Ratio for AODV, DSDV, DSR, and OLSR respectively, at various nodes size (a) 50 nodes, (b) 100 nodes, and (c)250 nodes, at each figure.



(a) AODV Received Packets Ratio at Nodes=50



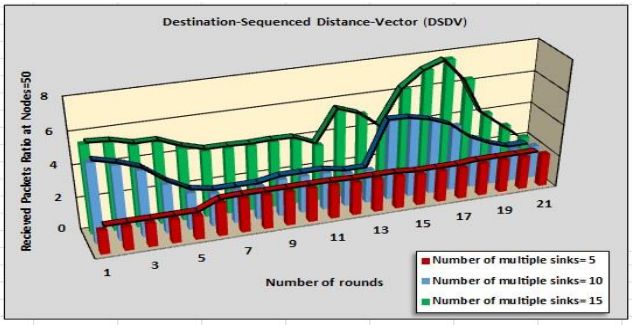
(b) AODV Received Packets Ratio at Nodes=100



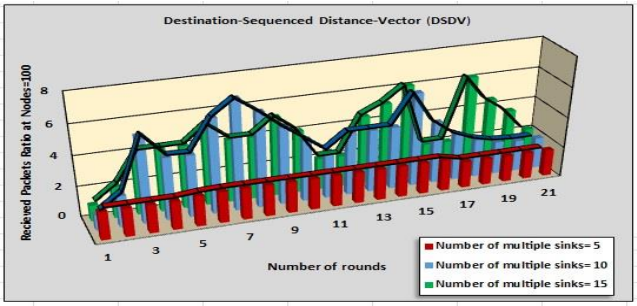
(c) AODV Received Packets Ratio at Nodes=250

Figure 10. Received Packets Ratio of AODV at variants Nodes and Sinks numbers

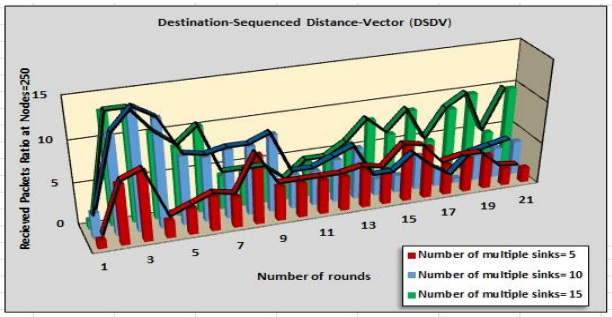
At figure 10. Shows influence of sinks & nodes number on RPR of AODV routing protocol, we observed that as the number of sinks increases the RPR will increase in all nodes number. In AODV the best RPR is obtained when the number of nodes is 100 and sinks number is 15.



(a) DSDV Received Packets Ratio at Nodes=50



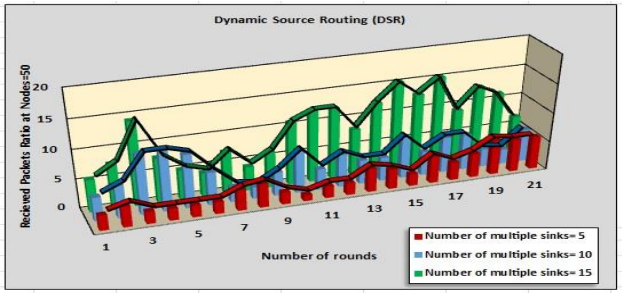
(b) DSDV Received Packets Ratio at Nodes=100



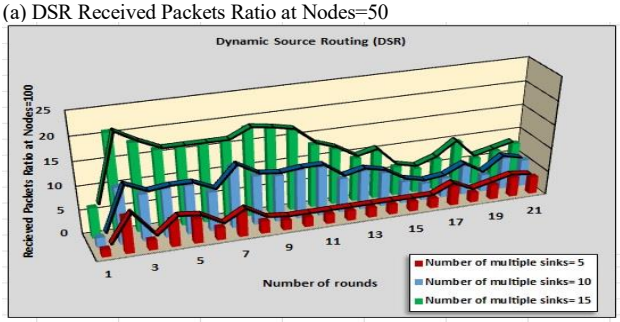
(a) DSDV Received Packets Ratio at Nodes=250

Fig. 11. DSDV Received Packets Ratio at variant Nodes and Sinks numbers

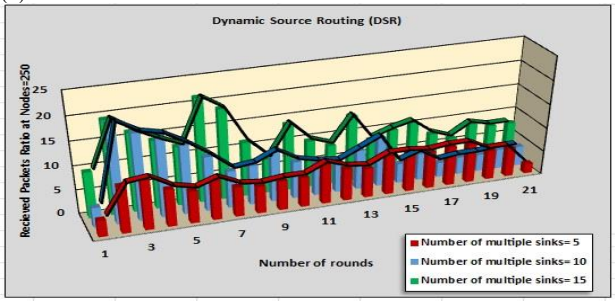
In DSDV routing protocol, RPR is increased when nodes and sinks number is increased, so the best RPR is obtain in nodes equal 250 and sinks is 15. That clear in fig. 11.



(a) DSR Received Packets Ratio at Nodes=50



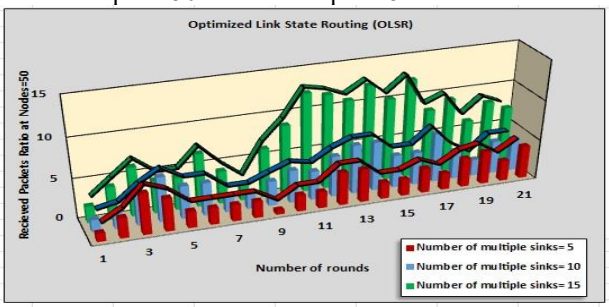
(b) DSR Received Packets Ratio at Nodes=100



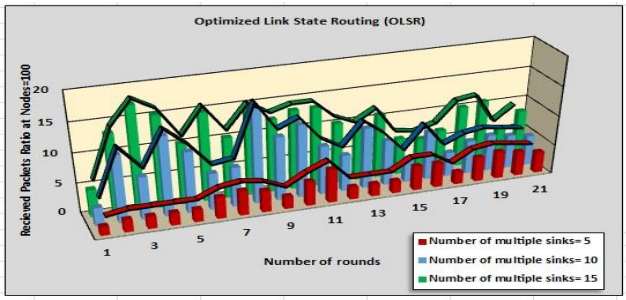
(c) DSR Received Packets Ratio at Nodes=250

Fig. 12. DSR Received Packets Ratio at variant Nodes and Sinks numbers

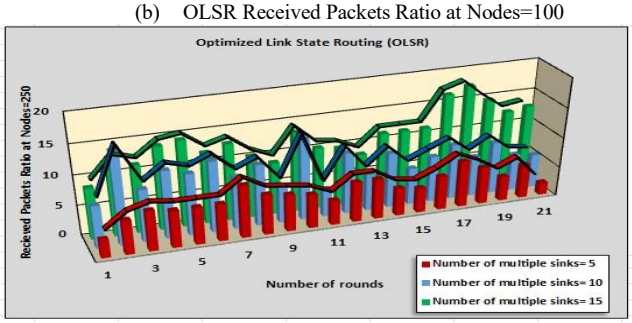
Received Packets Ratio of DSR routing protocol is affected by changing nodes and sinks numbers, fig. 12 show that RPR is increased by increasing numbers of nodes and sinks, so the better RPR in DSR routing protocol is achieved at nodes equal 250 and sinks equal 15.



(a) OLSR Received Packets Ratio at Nodes=50



(b) OLSR Received Packets Ratio at Nodes=100



(c) OLSR Received Packets Ratio at Nodes=250

Fig. 13.. OLSR Received Packets Ratio at variant Nodes sinks numbers

Fig. 13. Explain the influence of increasing nodes and sinks numbers on received packets ratio of OLSR routing protocol, at fig. 13.(a) when nodes equal 50 we observed that RPR is relatively increased with increasing round number and sinks number. At fig. 13. (b) And (c) the RPR is increased due to nodes and sinks increasing. Best RPR in OLSR is obtain in nodes is 250 and sinks is 15.

VI. CONCLUSION

General observations of simulations results refers to Received Packets Ratio of MANETs routing protocols is improved by increasing nodes and sinks numbers. We can summarize many interesting points that help researcher to choose the suitable MANETs routing protocols and the best number of nodes and sinks used to in their applications as the following:

- Best Received Packets Ratio is in nodes=250, we conclude that the ratio of receiving packets is increased with the increasing nodes number, but sometimes the simulator have limitations about maximum nodes number.

- Best protocol in case of Received Packets Ratio is DSR along all nodes number, But in case of nodes=100 the best protocol was AODV. While the worst among protocols is DSDV in all nodes number.
- When using small nodes number, probability of loss packets increase, we show that at OLSR and DSDV protocols.
- Increasing sinks nodes number is actively contributes to increasing RPR for all MANETs routing protocols.
- Best RPR for DSDV, DSR, and OLSR routing protocols is obtained in nodes number is 250 and sinks number is 15, while in AODV best RPR is obtains in nodes number 100 and sinks number is 15.

As a future works we can simulates hybrid routing protocols or other MANETs routing protocols and VANET, also may consider the effective of variant nodes number on other performance metrics such as throughput, end-to-end delay.

References

[1] C. Sandhiya and E. Bhuvaneswari, "An Overview on Wireless Sensor Networks (WSN) and Mobile ADHOC Networks (MANET)," *Int. J. Eng. Sci. Invent.*, pp. 10–14, 2018.

[2] A. I. Ameur, A. Lakas, Y. M. Bachir, and O. S. Oubbati, "Peer-to-peer overlay techniques for vehicular ad hoc networks: Survey and challenges," *Veh. Commun.*, p. 100455, 2022.

[3] M. J. Abbas, H. M. Turki Alhilfi, and T. Sutikno, "Performance evaluation of two models in the reactive routing protocol in manets," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 21, no. 1, pp. 391–397, 2021, doi: 10.11591/ijeecs.v21.i1.pp391-397.

[4] S. Lalar and A. Yadav, "Comparative Study of Routing Protocols in MANET," *Orient. J. Comput. Sci. Technol.*, vol. 10, no. 1, pp. 174–179, 2017, doi: 10.13005/ojcst/10.01.23.

[5] P. Pandey and R. Singh, "Efficient route selection scheme in manet using enhanced aodv protocol," *Wirel. Pers. Commun.*, vol. 123, no. 1, pp. 959–974, 2022.

[6] S. M. Shaymrao, P. S. Krishnaraju, T. Mahalingappa, and M. T. Narayanappa, "Design and development of anonymous location based routing for mobile ad-hoc network," *Int. J. Electr. Comput. Eng.*, vol. 12, no. 3, p. 2743, 2022.

[7] S. Arumugam and R. Thangavel, "IRDFPR-CMDNN: An energy efficient and reliable routing protocol for improved data transmission in MANET," *Sci. Tech. J. Inf. Technol. Mech. Opt.*, vol. 22, no. 2, pp. 364–375, 2022, doi: 10.17586/2226-1494-2022-22-2-364-375.

[8] M. Achparaki *et al.*, "We are IntechOpen , the world ' s leading publisher of Open Access books Built by scientists , for scientists TOP 1 %," *Intech*, p. 13, 2012, [Online]. Available: http://dx.doi.org/10.1039/C7RA00172J%0Ahttps://www.intechopen.com/books/advanced-biometric-technologies/liveness-detection-in-biometrics%0Ahttp://dx.doi.org/10.1016/j.colsurfa.2011.12.014

[9] A. Sharma, R. Kumar, and V. Mansotra, "Proposed Stemming Algorithm for Hindi Information Retrieval," *Int. J. Innov. Res. Comput. Commun. Eng. (An ISO Certif. Organ.*, vol. 3297, no. 6, pp. 11449–11455, 2016, doi: 10.15680/IJIRCCE.2016.

[10] F. T. Al-Dhief, N. Sabri, M. S. Salim, S. Fouad, and S. A. Aljunid, "MANET Routing Protocols Evaluation: AODV, DSR and DSDV Perspective," *MATEC Web Conf.*, vol. 150, pp. 1–6, 2018, doi: 10.1051/matecconf/201815006024.

[11] K. L. Arega, G. Raga, and R. Bareto, "Survey on Performance Analysis of AODV, DSR and DSDV in MANET," *Comput. Eng. Intell. Syst.*, vol. 11, no. 3, pp. 23–32, 2020, doi: 10.7176/ceis/11-3-03.

[12] A. Mishra, S. Singh, and A. K. Tripathi, "Comparison of MANET routing protocols," *Int. J. Comput. Sci. Mob. Comput*, no. March, 2019, [Online]. Available: https://www.researchgate.net/profile/Shweta-Singh-35/publication/331980713_Comparison_of_Manet_Routing_Protocols/links/5c98a669299bf11169457ef3/Comparison-of-Manet-Routing-Protocols.pdf

[13] S. El Khediri, N. Nasri, A. Benfradj, A. Kachouri, and A. Wei, "Routing protocols in MANET: Performance comparison of AODV, DSR and DSDV protocols using NS2," *2014 Int. Symp. Networks, Comput. Commun. ISNCC 2014*, no. March 2018, 2014, doi: 10.1109/SNCC.2014.6866519.

[14] G. M. Patil, A. Kumar, and A. D. Shaligram, "Performance Comparison of MANET Routing Protocols (OLSR, AODV, DSR, GRP and TORA) Considering Different Network Area Size," *Int. J. Eng. Manag. Res.*, vol. 6, no. 3, pp. 475–484, 2016, [Online]. Available: www.ijemr.net

[15] A. M. Soomro, M. F. Bin Fudzee, M. Hussain, and H. M. Saim, "A Hybrid Routing Approach Comparison with AODV Protocol Regarding Speed for Disaster Management in MANET," *J. Comput. Sci.*, vol. 18, no. 3, pp. 204–213, 2022, doi: 10.3844/jcssp.2022.204.213.

[16] A. A. Hadi and S. V. AL-Din Makki, "Improved MANET Routing Protocols Performance by Using Hybrid Cat and Particle Swarm Optimization (CPSO)," *Webology*, vol. 19, no. 1, pp. 2182–2195, 2022, doi: 10.14704/web/v19i1/web19148.

[17] W. A. Imtiaz, M. Afaq, and M. Faheem, "TCP and UDP Based Comparison of MANET Routing Protocols Using OPNET," pp. 1–7.

[18] B. RHanji and R. Shettar, "Simulation based Comparative Study of MANET Routing Protocols," *Int. J. Comput. Appl.*, vol. 92, no. 16, pp. 35–41, 2014, doi: 10.5120/16096-5412.

[19] S. T. Yousif, "Simulation and Comparison of Ad Hoc Networks Routing Protocols Based on Opnet," *Iraqi J. Inf. Commun. Technol.*, vol. 5, no. 1, pp. 42–49, 2022, doi: 10.31987/ijict.5.1.190.

[20] T. Camp, J. Boleng, and V. Davies, "A survey of mobility models for ad hoc network research," *Wirel. Commun. Mob. Comput.*, vol. 2, no. 5, pp. 483–502, 2002, doi: 10.1002/wcm.72.