Wireless Ad Hoc Network of MANET, VANET, FANET and SANET: A Review

Sumendra Yogarayan
Multimedia University,Faculty of Information Science and Information,Melaka,Malaysia.
mastersumen@gmail.com

***Abstract*— Over the past few years, technology has progressed and developed rapidly, where ad hoc networks have contributed a significant part to innovative development. There are four varieties of ad hoc networks such as mobile (MANET), vehicular (VANET), flying (FANET), and sea (SANET). Due to the variation of specifications, these four ad hoc networks have to turn into an alternative for providing connectivity in areas where infrastructure-based networks cannot be deployed. Therefore, this paper sets out a review of these four ad hoc networks, particularly focusing on the characteristics such as routing, density, and mobility. In addition, the variances between the four ad hoc networks are discussed with related works. This paper also outlines the challenges to be addressed in the deployments of these ad hoc networks.**

***Index Terms*— Wireless Ad Hoc Network, Routing, Density, Mobility**

I. Introduction

Over the past years, the evolution of wireless networks has enabled them to deliver a wide range of services to users, meeting their requirements in a variety of application areas [1]. The development of new wireless networks that function over various frequency bands and not cluttered is enabled by the advancements in current technology [2] [3]. The Wireless Ad Hoc Network (WANET) is a dedicated network in which all nodes in the network have the same state, and no central control nodes are needed [4] [5]. The WANET is sometimes referred to as a wireless mesh network. The nodes have the ability to join or leave the network at any time. As a result, the failure of a single node will have no effect on the functioning of the whole network, and it is resistant to disruption. These characteristics distinguish the WANET from conventional wired and fixed networks in terms of architecture, network organisation, and protocol design.

Scalability is one of the major issues with WANET due to its unique nature. WANET performance is known to be restricted not only by node capacity (e.g., link or channel), but also by network capacity (e.g., the maximum number of nodes) [6]. There are several elements that affect the capacity measurement, including interference, energy constraints, routing variance (protocol), node size (density), and mobility patterns (models). When considering the scalability of such a network, the number of nodes and the efficiency of a channel capacity (e.g., how many nodes can a channel handle, while maintaining an acceptable quality of service) are taken into consideration [7] [8]. In WANET, there are four categories, namely the Mobile Ad Hoc Network (MANET), the Vehicle Ad Hoc Network (VANET), the Flying Ad Hoc Network (FANET), and the Sea Ad Hoc Network (SANET) [9] [10]. This review aims to study the four ad hoc networks that focus on scalability issues in routing, density, and mobility. The contribution of this review will emphasise to what extent the research community has evolved concerning MANET, VANET, FANET, and SANET. The rest of this paper is organised as follows. In Section II, we outline the four ad hoc networks' differences and prior work. In Section III, we discuss the possible challenges associated with the deployment of these ad hoc networks. Finally, we conclude in Section IV.

II. Literature Review

A. MANET

MANET is a self-structured entity that functions with no static topology. In this network, each node acts as a router and host simultaneously [11]. This allows the network nodes to be equivalent and can quickly join or leave the network. The mobile nodes within each other's radio range can communicate and transfer needed information directly [12]. All network nodes are provided with a wireless interface to communicate with another node within the field. This type of network is fully distributed and can operate anywhere without the assistance of a fixed infrastructure as access points or base stations [13]. Figure 1 gives an example of a MANET architecture.

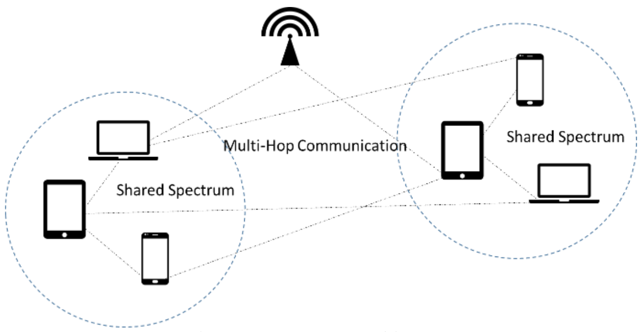

Figure 1: MANET Architecture

In MANET, other participating nodes randomly move within the created wireless ad hoc network. Due to the nature of the communication link between the two devices that are changing from time to time, it is not easy to develop a MANET for devices that move dynamically in the network [14]. Nonetheless, there have been active efforts that focused on routing, density, and mobility.

The authors of [15] employed network simulator 3 (NS-3) to assess the AODV routing protocol's performance and investigate the effect of mobility speed and node density in MANETs. The performance metrics utilised for the measurement include end-to-end delay, throughput and packet delivery ratio. The simulation results show that mobility speed and node density impact the efficiency of

AODV in MANETs.

In the study [16], the authors conducted a simulation-based study using the QualNet simulator to evaluate the performance of the OLSR, Bellman-Ford, DSR, ZRP, AODV, and DYMO routing protocols in the MANET environment. The authors incorporated a group mobility model to show the realistic environment of the movement of mobile nodes under the varying mobility speed of nodes and CBR traffic patterns. The performance was tested in terms of metrics, namely end-to-end delay, jitter, and throughput. The results of this study have shown that speed has an adverse effect on the performance of routing protocols.

Authors in [17] presented an investigation based on a random waypoint mobility model using the OPNET simulator. The authors emphasise evaluating the performance of OLSR, DSR, and TORA routing protocols under an increase in node density in MANET. The performance was assessed based on throughput, delay, network load, routing traffic sent, and routing traffic received. Based on the results obtained, the authors determined that increasing the density of the nodes affects the efficiency of DSR and TORA in terms of delay and throughput compared to OLSR.

Authors in [18] examined the impacts of different mobility models of DSDV and DSR routing protocols in the MANET environment. For this purpose, the authors incorporated random waypoint, group mobility, freeway, and manhattan models. The execution examination has also included different densities and the number of hops using network simulator 2 (NS-2). The performance was evaluated based on throughput with UDP traffic. The authors describe that the demonstration fluctuates across various mobility models and densities.

Furthermore, in [19], the authors showed the OLSR protocol's performance with two alternative mobility models: random waypoint mobility and random-based mobility. The simulation was carried out using network simulator 2 (NS-2) with various scenarios and nodes. The authors compared the performance of the routing protocol in terms of packet drop ratio, routing overhead normalization, data packet delivered, constant bit ratio, end-to-end delay, packet delivery ratio, and throughput ratio. Based on the results, random waypoint mobility outperformed random-based mobility in every parameter tested.

Readers interested in more works of MANET analysis and evaluation are referred to [20 - 24].

B. VANET

With the involvement of the vehicle node, the network could be built, and it is known as VANET [25]. To keep road users or drivers more comfortable, various applications have been developed. Intelligent Transportation Systems (ITS) is one of those applications that mainly focuses on vehicle communication [26]. These communications are classified into two forms: vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication. Amongst these, V2V requires an on-board unit (OBU), and V2I requires a roadside unit (RSU) to work along with VANET [27]. An example of an applicable VANET architecture is shown in Figure 2.

Although VANET has recently advanced and enabled the V2X ecosystem for deployment in some countries [28], it remains a major challenge. Due to its dynamic nature, the lack of realistic models and the capability to support an increasing number of vehicles has been an imperative topic for many researchers to discover.

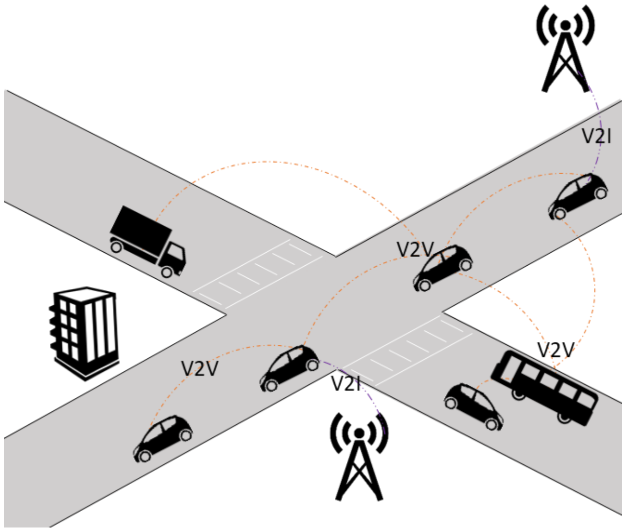

Figure 2: VANET Architecture

The authors of [29] used the GPSR protocol to investigate the mobility features of several VANET mobility models. The mobility models include gauss Markov, reference point group, random waypoint, random direction, and Manhattan grid. Network simulator 2 (NS-2) was used for the simulation, and results were assessed using the following parameters: end-to-end delay, packet delivery ratio, routing overhead, and throughput. The authors determined that the reference point group outperforms the other mobility models in all parameters.

Authors [30] presented a simulation study on the GPSR and AODV routing protocols in a VANET environment using OMNET++ with SUMO. The focus of the study was to involve a varying number of nodes with realistic simulation scenarios. The simulation performances were observed based on packet delivery ratio, end-to-end delay, packet drop ratio, and throughput. In comparison to AODV, the results showed that the performance of GPSR is less vulnerable when there is an increase in the number of nodes and speed, demonstrating its strength for scalability and mobility.

In the study [31], the AODV protocol has been taken as the routing protocol to create a scenario for the VANET environment using network simulator 2 (NS-2) and SUMO and MOVE. The authors aim to assess various performance parameters against different node densities. The parameters involved in this study are throughput, average throughput, simulation time, and packet drop. According to the observations, increasing the node density impacts AODV efficiency in both throughput and delay.

The authors in [32] discussed the purpose of infrastructure in an urban setting and compared the performance of the OLSR, AODV, AOMDV, DSR, ZRP, GPSR, and MDART routing protocols where mobility was a restriction. In order to compare different routing protocols in an urban environment, network simulator 2 (NS-2) was used along with the other kinds of traffic. The authors assessed the performance in terms of end-to-end delay, routing cost, jitter, packet delivery ratio, and efficiency. According to the authors, the demonstration varies depending on the use of routing protocol and the kind of traffic involved.

Furthermore, authors in [33] explored DSR, DSDV, and AODV routing protocols in the VANET environment using network simulator 2 (NS-2) and SUMO. The authors defined an increasing number of vehicles in a realistic movement scenario using the two-ray ground mobility model. The performance of the simulation is considered in terms of end-to-end delay, packet delivery ratio, and throughput. The authors determined that the AODV routing protocol is more appropriate for movement with increasing vehicles than DSR and DSDV.

Readers interested in further publications on VANET analysis and assessment are directed to [34-38].

C. FANET

FANET is a special class of MANET that resembles VANET [39]. In other words, there is also the commonality of mobility in FANET, as it is in MANET and VANET [40]. FANET is a type of network that consists of mobile agents called micro aerial vehicles (MAVs) [41]. These flying agents make up a group of small MAVs connected on an ad hoc basis to communicate for the required purposes. The existence of these flying agents typically results in the frequent changes of FANET's network topology [42]. Figure 3 depicts a FANET architecture.

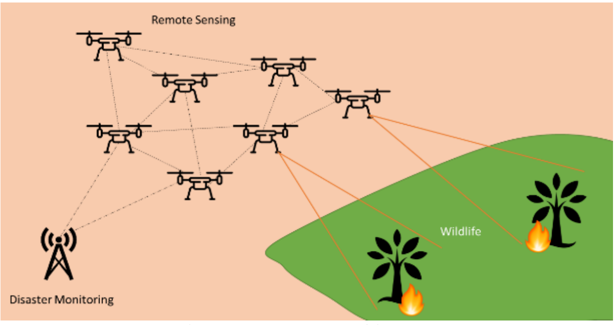

Figure 3: FANET Architecture

FANET is also known as a swarm or fleet of Unmanned Aerial Vehicles (UAVs), a group of aerial robots or drones that collaborates to accomplish a common purpose [43]. Each drone in a swarm may be assigned a specific data gathering and processing assignment, and these tasks can be carried out in real-time. Despite this, researchers have been exploring the creation of UAV swarm systems since communication is one of the utmost challenging subjects to address.

The authors of [44] used OPNET to create a realistic FANET simulation environment in which they compared OLSR, DSR, AODV, and GRP routing protocols on a random waypoint mobility model. To compare the performance of the protocols, parameters such as end-to-end delay, throughput, received data, and dropped data were measured. The experimental findings show that various routing may be adapted to diverse UAV communication network scenarios. Consequently, the quantitative findings may serve as a useful reference for selecting the appropriate routing protocol in various cases.

The authors of [45] developed a unique mobility model based on spiral line (SLMM) using DSDV and AODV routing protocols in the FANET environment using network simulator 2. (NS-2). The simulation's performance was assessed based on end-to-end delay, routing overhead, throughput and packet loss. The results showed that the AODV routing protocol performs better with SLMM than the DSDV routing protocol. The authors believe that SLMM effectively supplements the mobility model that can provide better performance support in the FANET environment.

The study [46] used the DSR, DSDV, and AODV routing protocols in the FANET environment using the network simulator 2. (NS-2). The authors combined the random waypoint and Gauss-Markov mobility models to create a new random-gauss integrated model designed to work with the routing protocols. The simulation contains a range of node densities and speeds. The performance was evaluated in terms of end-to-end delay, packet delivery ratio, jitter, and throughput. The authors find that the random-gauss integrated model is superior to the other two models in terms of performance.

Authors in [47] examined the feasibility of the 3D mobility model in the FANET environment using network simulator 2 (NS-2). The simulation comprises the routing protocols OLSR, DSDV, AODV, and GPSR with CBR traffic. In addition, the simulation incorporates different numbers of nodes and speeds. The performance was assessed using parameters such as packet delivery ratio and end-to-end delay. The simulation results reveal that the AODV routing protocol outperforms the other three protocols.

Furthermore, using network simulator 2 (NS-2), the authors of [48] investigated OLSR, AODV, DSDV, DSR, FSR, and TORA routing protocols in the FANET environment. The authors include the random waypoint mobility model and CBR traffic. The simulation was evaluated in terms of end-to-end delay, packet loss, and throughput. According to the results, FSR had promising performance when compared to the other routing protocols.

More research on FANET analysis and assessment may be found at [49-53].

D. SANET

SANET consists of nodes such as boats, ships, submarines, vessels, or unmanned surface vehicles (USV) linked together to form an extensive network [54]. The network is focused on improving aquatic connectivity. Typically, the nodes that exist within a specific area are determined by the node density [55]. As the nodes are dispersed throughout the oceans, the density of nodes is moderate. Under conditions of high USV mobility in SANET, topology can have frequent changes in topology compared to MANET. However, compared to VANET and FANET, changes in topology are significantly slower [56] [57]. An example of a SANET architecture is illustrated in Figure 4.

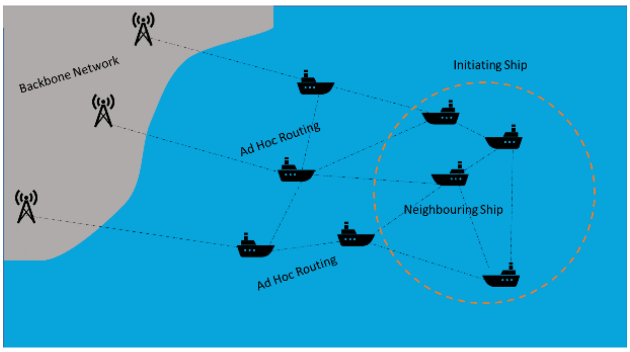

Figure 4: SANET Architecture

According to [58], existing sea communication systems provide low-data-rate services such as ship identification or positioning via an automatic identification system (AIS). Although communication between ships is possible, it requires a significant amount compared to a conventional communication system. Nonetheless, research into ship networking has led many researchers to investigate a resistant SANET environment.

The author of [59] demonstrated the AIS-aided AODV routing protocol in a SANET environment. The author emphasized the need to employ ship position information to reduce the amount of flooding during the route discovery process. The technique was tested on a testbed that was created using Linux as the operating system. The performance was assessed based on routing overhead metrics. The experimental results demonstrate that the proposed A-AODV routing protocol can support multi-hop data transfer while incurring a lower routing overhead than existing protocols.

The author [60] presented an improved GPSR routing protocol in a SANET environment implemented using MATLAB. The authors tested two different scenarios in order to see how the results differed from one another. The routing void rate, packet delivery rate, and route hop count are some of the parameters used to evaluate the network's performance. When comparing the improved routing protocol to the traditional routing protocol, the results demonstrated that the improved routing protocol has better routing void and packet delivery rates.

The authors of [61] investigated existing OLSR, AODV, and DSR routing protocols in the SANET environment using a network simulator (NS-3) and ocean-net topology. In addition, the authors used the random waypoint, random walk, and constant mobility models. The performance was assessed based on end-to-end delay, packet delivery ratio, and throughput metrics. Based on the authors, the demonstration fluctuates across different routing protocols and with different mobility models.

The authors in [62] developed a novel routing technique, opportunistic void avoidance routing (OVAR), to overcome the void issue and improve energy dependability in the SANET environment. The proposed routing protocol was tested against HHVBF, VAPR, and VBF in a single-sink architecture using a network simulator (NS-2) and an aqua-sim simulation software package. The performance was evaluated in terms of energy tax, propagation deviation factor, average hop count, packet delivery ratio, and end-to-end delay. The findings of the thorough simulation analysis reveal that the proposed routing protocol outperforms all existing protocols.

Furthermore, authors in [63] presented a stateless opportunistic routing protocol (SORP) to handle trapped and void nodes locally discovered using a passive participation technique. The proposed routing protocol was evaluated in a multi-sink architecture against DBR and WDFAD-DBR utilising a network simulator (NS-2) and aqua-sim. The simulation was evaluated in terms of the energy tax, distance covered, number of forwardings, end-to-end delay, and packet delivery ratio. The simulation findings reveal that SORP outperforms other protocols in terms of routing performance parameters.

Readers interested in more works of SANET analysis and evaluation are referred to [64-68].

Table 1 shows the characteristics of MANET, VANET, FANET, and SANET. According to the deliberations of all four ad hoc networks' most recent published work, most researchers are interested in the particular subject because of the tremendous potential it holds. However, the majority of the work done so far does not provide an extended explanation for a suitable routing protocol that takes into account node density and mobility in addition to the increase. Perhaps it is intended to be extremely simple and restricted in nature. Furthermore, utilizing a testbed for real-world demonstration is considered an innovative process, given that there has been limited study into this area to date.

Table 1
Characteristics of MANET, VANET, FANET and SANET

Characteristics	MANET	VANET	FANET	SANET
Node Type	Laptop, Tablet, Smartphone	Vehicle, Bus, Truck, Motorcycle, Traffic Light	Aircraft, Helicopter, Drone	Boat, Ship, Vessel
Node Setup	Positioning	Road or Infrastructure	Airfields	Water
Topology Change	Slow	Fast	Fast	Slow
Node Density	Low	High	Very High	Medium
Node Speed	Low to Medium	Medium to High	Medium to High	Medium to High
Routing Protocol	Proactive, Reactive, and Hybrid	Proactive, Reactive, and Hybrid	Proactive, Reactive, and Hybrid	Proactive, Reactive, and Hybrid
Node Mobility	Low	High	Very High	Medium
Mobility Model	Random	Regular	Regular or Random	Random
Computational Power	Low	High	High	High
Frequency Band	2.4 GHz / 5.0 GHz	5.9 GHz	2.4 GHz / 5.0 GHz	5.0 GHz

III. Discussion

A. Routing

Routing protocols differ in MANET, VANET, FANET, and SANET. Due to the difference in deployments, it is challenging to ensure that the routing protocol can update the routing tables. Besides, it is also uncertain where these routing protocols may have been developed to be reliable on either low or high mobility nodes. On a separate note, there has been minimal research on medium mobility nodes, leading to further examination of the routing protocols' deployments. Based on the literature, developing a routing protocol for effective data transmission includes mobility and density. Therefore, adopting modified versions or new protocols with the potential to apply new techniques in different contexts is critical.

B. Density

The number of nodes within the network and their motion significantly affect network performance. Establishing a route within a dispersed network is generally difficult because of contentious communication distances, whereas in a dense network, the network nodes may be affected by increased interference. In the circumstance of high mobility, it may cause frequent route disruptions, causing delays in the spread and loss of packets in the route establishments. Large mobile networks lack consistent node settings, and nodes' availability can be dispersed in an actual scenario. Hence, network connectivity and routing have a significant impact on node density. This could be illustrated in a network environment in terms of mobile, vehicle, drone, or vessel communication. The determination of network connectivity depends upon the density of the neighbouring nodes. In addition, node density is a crucial factor in terms of selecting and repairing routes. A higher density of nodes may provide opportunities for route selection and route repair. If the network nodes are saturated, the transitions between nodes increase the overhead costs of the network, which would result in an imbalance of load. Thus, the use of appropriate node density in a realistic context leads to network performance improvements.

C. Mobility

The ultimate purpose of mobility models is to demonstrate the direction, acceleration, and speed of a node. Therefore, it is vital to decide on a suitable mobility model to analyze respective routing protocols. Modelling ad-hoc mobility nodes is a controlled concept, as only a few ad-hoc networks can be compared. There are various types of mobility models that have been classified according to their specific mobility characteristics, such as temporal, spatial, and geographic. The movement history impacts the movement of a moving node in temporal models. Whereas in spatial models, the moving nodes tend to move correspondingly. In the geographic model, the constraint of a moving node is due to obstacles, roads, or highways. In most simulations, the random mobility model is used to determine the performance of the relevant protocols. Although the movement affects the network's topology over time, it is also conflictual and impractical as nodes' movement is uncontrolled and uncertain in real-world scenarios. Therefore, it is crucial to identify a specific mobility model to ensure real-world deployment.

IV. Conclusion and Future Works

The core component of an ad hoc network is the fundamental application of providing services to end-users. The behaviour of the nodes in MANET, VANET, FANET, and SANET is dynamic due to different types of topology and network nature. These ad hoc networks are directly connected to the end-users in various deployments, an essential milestone in a vigorous environment. This paper has discussed ad hoc networks based on mobile, vehicle, flying, and sea systems, their characteristics, related works, and potential challenges. A comprehensive study will be carried out in future work to identify the specific deployments in terms of routing, density, and mobility.

References

[1] M, Ilyas, "*The handbook of ad hoc wireless networks*," CRC Press, 2017.

[2] A. N. Uwaechia, and N. M. Mahyuddin, "*A comprehensive survey on millimeter wave communications for fifth-generation wireless networks: Feasibility and challenges*," vol. 8, pp. 62367-62414, 2020.

[3] J. Wu, and P. Fan, "*A survey on high mobility wireless communications: Challenges, opportunities and solutions*,". vol. 4, pp. 450-476, 2016.

[4] S. Ghalib, A. Kasem, and A. Ali, "*Analytical study of wireless ad-hoc networks: types, characteristics, differences, applications, protocols*," In International Conference on Futuristic Trends in Networks and Computing Technologies, pp. 22-40, 2019.

[5] B. Yousefi, F. Ghassemi, and R. Khosravi, "*Modeling and efficient verification of wireless ad hoc networks*," Formal Aspects of Computing, vol. 29, no. 6, pp. 1051-1086, 2017.

[6] S. Sharmila, and T. Shanthi, "*A survey on wireless ad hoc network: Issues and implementation*," In 2016 International Conference on Emerging Trends in Engineering, Technology and Science (ICETETS), pp. 1-6, 2016.

[7] J. R. Diaz, J. Lloret, J. M. Jimenez, S. Sendra, and J. J. Rodrigues, "*Fault tolerant mechanism for multimedia flows in wireless ad hoc networks based on fast switching paths*," Mathematical Problems in Engineering, vol. 2014, pp. 1–12, 2014.

[8] R. Basomingera and Y.-J. Choi, "*Learning from routing information for detecting routing misbehavior in ad hoc networks*," Sensors, vol. 20, no. 21, pp. 6275, 2020.

[9] A. R. Ragab, "*A new classification for ad-hoc network*," International Journal of Interactive Mobile Technologies (iJIM), vol. 14, no. 14, p. 214, 2020.

[10] M. Sharma, M. Singh, K. Walia, and K. Kaur, "*A comprehensive study of performance parameters for MANET, VANET and FANET*," 2019 IEEE 10th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), pp. 0643-0646, 2019.

[11] P. Chitra, and T. Ranganayaki, "*A Study on Manet: Applications, Challenges and Issues*," International Journal of Engineering Research & Technology (IJERT), vol. 8, no. 3, pp. 1-4, 2020.

[12] N. A. M. Saudi, M. A. Arshad, A. G. Buja, A. F. A. Fadzil, and R. M. Saidi, "*Mobile ad-hoc network (MANET) routing protocols: A performance assessment*," In Proceedings of the Third International Conference on Computing, Mathematics and Statistics (iCMS2017) pp. 53-59, 2019.

[13] S. Kumar, M. Goyal, D. Goyal, and R. C. Poonia, "*Routing protocols and security issues in MANET*," 2017 International Conference on Infocom Technologies and Unmanned Systems (Trends and Future Directions) (ICTUS), pp. 818-824, 2017.

[14] A. K. S. Ali, and U. Kulkarni, "*Characteristics, applications and challenges in mobile Ad-Hoc networks (MANET): overview*," Wireless Networks, vol. 3, no. 12, pp. 6-12, 2015.

[15] T. W. Ching, A. H. Aman, W. M. Azamuddin, and Z. S. Attarbashi, "*Performance evaluation of AODV routing protocol in MANET using NS-3 simulator*," 2021 3rd International Cyber Resilience Conference (CRC), 2021.

[16] R. K. Upadhyay, S. Kumar and J. Wasim, "*Performance of MANET Routing Protocols with Varying Mobility Speed and Group Mobility Model*," Vidyabharati International Interdisciplinary Research Journal, pp. 28-32, 2021.

[17] N. Raza, A. Amin, H. Ur, and M. Tariq, "*Effect of node density over the performance of DSR, TORA, and OLSR routing protocols of MANET*," International Journal of Computer Applications, vol. 177, no. 39, pp. 34–41, 2020.

[18] K. Divya and B. Srinivasan, "*Impact of Node Mobility on MANET Routing Protocols Models,*" International Journal of Research in Engineering and Science (IJRES), vol. 9, no. 7, pp. 24-33, 2021.

[19] T. Hussain, "*An investigation of the performance optimized Link State Routing Protocol on the basis of mobility models*," Journal of Mechanics of Continua and Mathematical Sciences, vol. 15, no. 9, 2020.

[20] S. Taterh, Y. Meena, and G. Paliwal, "*Performance analysis of ad hoc on-demand distance vector routing protocol for mobile ad hoc networks*," Asset Analytics, pp. 235–245, 2019.

[21] I. Ahmad, F. Masood, and A. W. Khan, "*Performance assessment of QoS using AODV, TORA and ZRP routing protocol in MANET*," Mehran University Research Journal of Engineering and Technology, vol. 39, no. 4, pp. 744–750, 2020.

[22] A. Kurniawan, P. Kristalina, and M. Z. Hadi, "*Performance analysis of routing protocols AODV, OLSR and DSDV on MANET using NS3*," 2020 International Electronics Symposium (IES), pp. 199-206, 2020.

[23] M. A. Fadhil, N. N. Kamiss, and A. D. Jasim, "*Performance Evaluation of Reactive and Proactive Routing Protocols based on Mobility and Offered Load*," International Journal of Computer Science & Engineering Technology (IJCSET), vol. 9, pp. 34-38, 2019.

[24] A. A. Hashim, M. M. Farhan, and S. Alshybani, "*Performance evaluation of OLSR and AODV routing protocols over mobile ad-hoc networks*," 2019 First International Conference of Intelligent Computing and Engineering (ICOICE), pp. 1-8, 2019.

[25] M. Fotros, J. Rezazadeh, and O. Ameri Sianaki, "*A survey on VANETs routing protocols for IoT Intelligent Transportation Systems*," Advances in Intelligent Systems and Computing, pp. 1097–1115, 2020.

[26] C. Ksouri, I. Jemili, M. Mosbah, and A. Belghith, "*VANETs routing protocols survey: Classifications, Optimization Methods and new trends*," Communications in Computer and Information Science, pp. 3–22, 2020.

[27] S. Baras, I. Saeed, H. A. Tabaza, and M. Elhadef, "*Vanets-based Intelligent Transportation Systems: An overview*," Advances in Computer Science and Ubiquitous Computing, pp. 265–273, 2017.

[28] M. S. Sheikh and J. Liang, "*A comprehensive survey on VANET security services in Traffic Management System*," Wireless Communications and Mobile Computing, vol. 2019, pp. 1–23, 2019.

[29] K. Raheja, M. Mahajan, and A. Goel, "*Implementation of GPSR protocol with various mobility models in VANET scenario*," Journal of Physics: Conference Series, vol. 1950, no. 1, p. 012080, 2021.

[30] I. Aljabry and G. Al-Suhail, "*A simulation of AODV and GPSR routing protocols in VANET based on multimetrices*," Iraqi Journal for Electrical and Electronic Engineering, vol. 17, no. 2, pp. 66–72, 2021.

[31] S. Kumar, A. Kumar, V. Tyagi, and A. Kumar, "*Impact of network density on AODV protocol in VANET*," 2020 IEEE 5th International Conference on Computing Communication and Automation (ICCCA), 2020.

[32] S. Smiri, A. Boushaba, R. Ben Abbou, and A. Zahi, "*Performance analysis of routing protocols with roadside unit infrastructure in a vehicular ad hoc network*," International Journal of Computer Networks & Communications, vol. 12, no. 4, pp. 19–39, 2020.

[33] S. Pande, R. Sadakale and N. V. K. Ramesh, "*Performance Analysis of AODV Routing Protocol in VANET Using NS-2 and SUMO*," WCNC-2021: Workshop on Computer Networks & Communications, 2021.

[34] C. M. Raut and S. R. Devane, "*Performance evaluation of vehicular ad hoc networks in case of road side unit failure*," Cognitive Informatics and Soft Computing, pp. 295–305, 2020.

[35] D. Soumaya, S. Dardouri, and B. Ridha, "*Performance evaluation of routing protocols for vehicular ad-hoc networks using NS2/Sumo*," Advances in Intelligent Systems and Computing, pp. 352–365, 2020.

[36] M. S. Hossain, J. Sen, M. A. Hossain, M. M. Rahman, and M. I. Abdullah, "*Performance Evaluation of Ad Hoc Network over Moving Vehicles in a City*," Global Journal of Computer Science and Technology, vol. 20, no.2, pp. 21-25, 2020.

[37] C. Tolba, "*Investigating fading impact on AODV, OLSR and DSDV protocols in NS3*," In Third International Conference on Computing and Wireless Communication Systems, ICCWCS 2019. European Alliance for Innovation (EAI), 2019.

[38] Z. Naim and M. I. Hossain, "*Performance analysis of AODV, DSDV and DSR in Vehicular Adhoc Network (VANET)*," 2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), pp. 17-22, 2019.

[39] A. Mukherjee, V. Keshary, K. Pandya, N. Dey, and S. C. Satapathy, "*Flying ad hoc networks: A comprehensive survey*," Advances in Intelligent Systems and Computing, pp. 569–580, 2018.

[40] A. Chriki, H. Touati, H. Snoussi, and F. Kamoun, "*FANET: Communication, Mobility Models and security issues*," Computer Networks, vol. 163, p. 106877, 2019.

[41] A. Bujari, C. E. Palazzi, and D. Ronzani, "*FANET application scenarios and Mobility Models*," Proceedings of the 3rd Workshop on Micro Aerial Vehicle Networks, Systems, and Applications - DroNet '17, pp. 43-46, 2017.

[42] M. Itallo B. Azevedo, C. Coutinho, E. Martins Toda, T. Costa Carvalho, and J. Jailton, "*Wireless communications challenges to flying ad hoc networks (FANET)*," Mobile Computing, 2020.

[43] A. Guillen-Perez and M.-D. Cano, "*Flying ad hoc networks: A new domain for network communications*," Sensors, vol. 18, no. 10, p. 3571, 2018.

[44] X. Tan, Z. Zuo, S. Su, X. Guo, X. Sun, and D. Jiang, "*Performance analysis of routing protocols for UAV Communication Networks*," IEEE Access, pp. 1–1, 2020.

[45] D. He, W. Sun, and L. Shi, "*The novel mobility models based on Spiral Line for aerial backbone networks*," IEEE Access, vol. 8, pp. 11297–11314, 2020.

[46] P. Kaur, A. Singh, and S. S. Gill, "*RGIM: An integrated approach to improve QoS in AODV, DSR and DSDV routing protocols for FANETS using the chain mobility model*," The Computer Journal, vol. 63, no. 10, pp. 1500–1512, 2020.

[47] N. Lin, F. Gao, L. Zhao, A. Al-Dubai, and Z. Tan, "*A 3D smooth random walk mobility model for FANETs*," 2019 IEEE 21st International Conference on High Performance Computing and Communications; IEEE 17th International Conference on Smart City; IEEE 5th International Conference on Data Science and Systems (HPCC/SmartCity/DSS), 2019.

[48] M. A. Hassan, S. I. Ullah, I. U. Khan, S. B. Hussain Shah, A. Salam, and A. W. Ullah Khan, "*Unmanned Aerial Vehicles Routing Formation using fisheye state routing for flying ad-hoc networks*," The 4th International Conference on Future Networks and Distributed Systems (ICFNDS), 2020.

[49] P. Kaur, A. Singh, and S. S. Gill, "*RGIM: An integrated approach to improve QoS in AODV, DSR and DSDV routing protocols for FANETS using the chain mobility model*," The Computer Journal, vol. 63, no. 10, pp. 1500–1512, 2020.

[50] C. Anitha, and K. G. Asvini, "*Performance of Routing Protocols and File Transfer in FANET Using Shortest Path Algorithm*," Science, Technology and Development, vol. ix, no. ii, pp. 77-87.

[51] Q. Liu, H. Wang, Y. Sun, and T. Han, "*A Multi-UAVs communication network simulation platform using OPNET modeler*," ICC 2020 - 2020 IEEE International Conference on Communications (ICC), pp. 1-6, 2020.

[52] H. Yang and Z. Liu, "*An optimisation routing protocol for FANETs*," EURASIP Journal on Wireless Communications and Networking, vol. 2019, no. 1, pp. 1-8, 2019.

[53] A. V. Leonov and V. O. Ryabchevsky, "*Performance evaluation of AODV and OLSR routing protocols in relaying networks in organization in Mini-UAVs based FANET: Simulation-based study*," 2018 Dynamics of Systems, Mechanisms and Machines (Dynamics), pp. 1-6, 2018.

[54] H. M. Taher, "*Sea Ad hoc Network (SANET) challenges and development*," International Journal of Applied Engineering Research, vol. 13, no. 8, pp. 6257-6261, 2018.

[55] E. Chauhan, M. Sirswal, D. Gupta, and A. Khanna, "*A critical review: SANET and other variants of ad hoc networks*," Advances in Intelligent Systems and Computing, pp. 1093–1114, 2020.

[56] Z. xu, X. Xiaoyang, S. Liwei, Z. Jinyu, Z. Wu, and D. Wenjing, "*Performance analysis of sea unmanned ship routing protocol based on Ad Hoc Network*," 2019 International Conference on Information Technology and Computer Application (ITCA), pp. 221-224, 2019.

[57] S. Zhang, X. Xiang, and S. Yang, "*Communication Network and QoS Evaluation for Formation Control of Unmanned Surface Vehicles*," Brodogradnja: Teorija i praksa brodogradnje i pomorske tehnike, vol. 71, no. 4, pp. 19-37, 2020.

[58] R. Mohsin and J. Woods, "*Performance evaluation of MANET routing protocols in a maritime environment*," 2014 6th Computer Science and Electronic Engineering Conference (CEEC), 2014.

[59] S. Peng, Y. Wang, H. Xiao, and B. Lin, "*Implementation of an improved AODV routing protocol for maritime ad-hoc networks*," 2020 13th International Congress on Image and Signal Processing, BioMedical Engineering and Informatics (CISP-BMEI), pp. 7-11, 2020.

[60] Z. Li, B. Yin, M. X. Gao, and X. Zhao, "*Improved GPSR routing protocol based on weight function in shipborne ad hoc networks*," IOP Conference Series: Materials Science and Engineering, vol. 768, p. 052134, 2020.

[61] P. Gopalakrishnan, S. Gupta, R. Krishnan, D. Patel, J. P. Dhivvya, S. Anand, and D. Raj, "*Routing protocol analysis for heterogeneous nodes in a dynamic and sparse environment*," 2020 11th International Conference on Computing, Communication and Networking Technologies (ICCCNT), 2020.

[62] S. Ghoreyshi, A. Shahrabi, and T. Boutaleb, "*A novel cooperative opportunistic routing scheme for Underwater Sensor Networks*," Sensors, vol. 16, no. 3, p. 297, 2016.

[63] S. M. Ghoreyshi, A. Shahrabi, and T. Boutaleb, "*A stateless opportunistic routing protocol for Underwater Sensor Networks*," Wireless Communications and Mobile Computing, vol. 2018, pp. 1–18, 2018.

[64] M. Hoyhtya, "*Connectivity manager: Ensuring robust connections for autonomous ships,*" 2019 2nd International Conference on Intelligent Autonomous Systems (ICoIAS), 2019.

[65] Z. xu, X. Xiaoyang, S. Liwei, Z. Jinyu, Z. Wu, and D. Wenjing, "*Performance analysis of sea unmanned ship routing protocol based on Ad Hoc Network*," 2019 International Conference on Information Technology and Computer Application (ITCA), 2019.

[66] R. Al-Zaidi, J. Woods, M. Al-Khalidi, K. M. Ali Alheeti, and K. McDonald-Maier, "*Next Generation Marine Data Networks in an IOT environment*," 2017 Second International Conference on Fog and Mobile Edge Computing (FMEC), pp. 50-55, 2017.

[67] C. Yun, S.-G. Kim, A.-R. Cho, and Y.-K. Lim, "*Sea-experiment test of a shipborne ad-hoc network (SANET) for maritime VHF Digital Data Communications*," The Journal of Korean Institute of Communications and Information Sciences, vol. 41, no. 6, pp. 681–688, 2016.

[68] R. J. Mohsin, J. Woods, and M. Q. Shawkat, "*Density and mobility impact on MANET routing protocols in a maritime environment*," 2015 Science and Information Conference (SAI), pp. 1046-1051, 2015.