Analysis of Energy Consumption and Evaluation of Metric Parameters of Routing Protocols in Ad hoc (MANET) Networks Using: NS2 Simulator

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Abstract —MANET networks represent a technological revolution in measurement instruments resulting from the convergence of miniaturized electronic systems and wireless communication systems. Despite the many advantages of wireless sensor networks in many areas, they have many problems such as managing the power consumption of mobile devices, selecting the routing protocol, limiting bandwidth and the shortest path. In order to guarantee a good quality of service, to ensure the routing of the information and to prolong the lifetime of the entire network, the analysis of the performances of the protocols is the main step to make before selecting a particular protocol. Therefore, the selected protocol should have the best results in terms of delivery and data integrity. Indeed, the purpose of our experiments is to examine and quantify the effects of various factors and their interactions on the overall performance of ad hoc networks. This article presents a performance analysis of three types of routing protocols namely, OLSR, TORA, and ZRP, which are evaluated and simulated according to a well-defined scenario using the NS2 simulator. The results of the simulation give a better performance of the protocols studied according to the packet delivery rate, the average end-to-end delay, and the throughput.

Index Terms—MANET, Wireless Sensor Network, Energy consumption, Routing, Performance metric, PDF, EED, Throughput, NS2

I. Introduction

Mobile Ad hoc Networks (MANET) represent a technological revolution of measurement instruments, resulting from the convergence of miniaturized electronic systems and wireless communication systems. Indeed, a wireless sensor network is a data transmission system designed to operate for a long time. These are sets of miniaturized electronic units capable of measuring certain physical phenomena in the environment where they are employed and transmitting them autonomously and at a reasonable cost [1]. Thanks to their high potential, sensor networks are at the heart of many applications covering such diverse fields as safety, the environment, medicine, the military, and industry, etc. However, the main challenge for these applications is the optimization of power consumption, the performance of network protocols and the routing of nominal traffic to ensure a good quality of service.

In general, the primary purpose of wireless sensor networks is energy conservation with the goal of extending network life, and the delay in transmitting and retrieving information to ensure a high level of reliability acceptable to network performance [2]. To meet these needs, the protocols used in wireless sensor networks must be able to provide their core functionality while taking these constraints into account.

Routing protocols for Ad-hoc mobile networks used to efficiently route data can be classified in different ways and according to several criteria [3]. Any routing strategy is based on techniques that can be divided into three major classes namely: proactive protocols, reactive protocols, and hybrid routing protocols.

- **Proactive Routing Protocol:** Protocol allowing to establish routing tables and to know the topology of the network. In general, proactive routing protocols try to maintain the best existing paths to all possible destinations at each node of the network [4]. To do this, they use the regular exchange of control messages to update the routing tables to any destination that can be reached from there. The routing tables are modified each time the network topology changes. Two main methods are used for this category: the Link state method and the Distance Vector method. The proactive routing protocol we are going to study for this class is Optimized Link State Routing Protocol (OLSR).
- **Reactive Routing Protocol**: Protocol to the ability to perform a routing table when a sensor node decides to transmit data, which invokes a path discovery mechanism to the destination. The created path is always valid as long as the final sensor node is reachable or until the route is no longer used. It has no data on the network [5]. Not knowing the topology of this one nor the available energy. Generally, these are protocols whose control of the routes is done on demand, that is to say when a source wants to transmit data packets to a destination. In this framework several mechanisms can be adopted, the most important are: Backward Learning Technique and

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Source Routing technique. The reactive routing protocol studied in this paper is Temporary Ordering Routing Algorithm Protocol (TORA).

- **Hybrid Routing Protocol:** This type of routing protocol combines the best mechanisms and features of proactive and reactive protocols. In this approach, hybrid protocols use proactive methods to discover routes in a predefined neighborhood [6]. Flooding techniques of reactive protocols are used to obtain routes to distant nodes. This class of protocols is well suited to large networks, however, it also combines the disadvantages of proactive and reactive protocols at the same time. The hybrid routing protocol considered for this class is Zone Routing Protocol (ZRP).

The following figure shows the three approaches that will be well detailed later in the next section (Fig. 1):

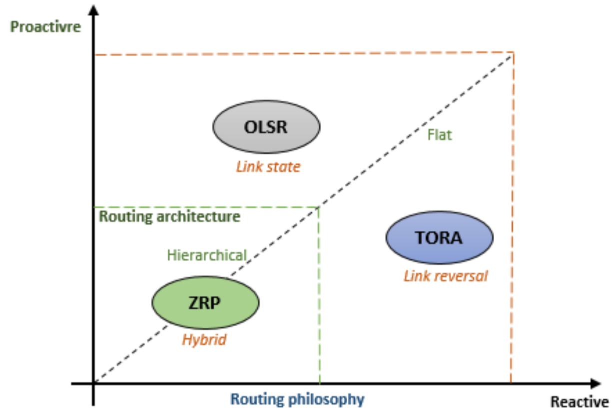

Fig. 1. Classification of Ad hoc protocols

This paper aims to present a performance analysis of three class of routing protocols for Ad Hoc mobile networks (Proactive / Reagents / Hybrid) in order to define an ideal routing algorithm for our future work, namely OLSR, TORA, and ZRP.

This document consisted of V sections as follows. In section II, a description of the three approaches has been made. In section III, the evaluation of metrics for network performance was explained. The results of the simulation will be analyzed and discussed in Section IV. In the end, we draw the conclusion and our perspectives.

II. Review of Existing Routing Protocols in MANET

It is very necessary during a data transmission fact to call a routing protocol that will perfectly convey the packet sent by the best route [7]. Indeed, many protocols have been proposed at the ad hoc level. In this article, we focused on OLSR as a proactive protocol, TORA as a reactive protocol, and ZRP as a hybrid routing protocol. In this section, we will present these three approaches for MANET networks, starting with a detailed study of the protocol, its way of acting, its operating principle, and we finish with the advantages and disadvantages of each routing protocol.

A. *Optimized Link State Routing Protocol (OLSR)*

OLSR is an optimized proactive link state routing protocol, which applies routing rules in an Ad-hoc context [8]. It uses a technique that allows each node to perfectly know a global vision on the topology of the network. Using this topological map, a source node can choose the shortest path to a destination. This routing protocol reduces the size of the control messages and declares a subset of links with its neighbors that are the noted multipoint relays (MPRs). It also minimizes the cost of flooding control traffic by using only multipoint relay nodes to broadcast its messages [9]. Only MPRs broadcast messages.

The Multi-Protocol Router technique significantly reduces the number of redundant retransmissions during the broadcast. OLSR nodes periodically exchange control messages and maintain routes to reach any OLSR node in the network [10]. The advantage of this technique is to significantly reduce the traffic for the distribution of the control messages in the network, but also to reduce the size of the subset of the links distributed to the whole network because the routes are created based on multipoint relay [9]. The idea of this technique is to reduce the flood of control traffic in a network by decreasing the same retransmissions in the same region. Each sensor in the network chooses a set of nodes in its surroundings for which the messages will be transmitted. A node chooses its MPRs in its neighborhood so that it is at a jump with a symmetric link. By this choice, the coverage area will be two jumps.

The nodes considered as MPR make it known in its vicinity by the control messages sent, they have the utility of setting up routes to all possible destinations of the network. By choosing the route using MPRs, the problems of packet transmission for unidirectional links are eliminated [11]. All nodes in the network keep information about their neighbors who have been chosen as MPRs.

In this type of routing protocol, the sensors exchange information periodically to obtain the information necessary for the choice of multipoint relays and also necessary for the calculation of the routing table. Nodes also send "HELLO" messages periodically to get information about their near neighbors. This allows each node to choose its multipoint relay set. There is another type of message that the OLSR protocol uses, the TC (Topology Control) message. With this message, multipoint relays are periodically declared in the network. They are broadcast using multipoint relays and this gives a controlled and optimized diffusion [8, 10]. The information disseminated gives a map of the network containing all the nodes of it but also a partial set of links.

- **Advantages and disadvantages of OLSR:** Optimized Link State Routing Protocol is best suited for very dense network due to multipoint relays. OLSR does not need a centralized administrative system to manage the routing process. In addition, since the routing table is periodically updated, dynamic convergence is high in this routing protocol [12]. For the disadvantages, the OLSR protocol does not have enough backup space to maintain all its data and the computation generated by each modification of topology or neighborhood of a node leads to a degradation of the OLSR performance.

B. Temporary Ordering Routing Algorithm (TORA)

TORA is a reactive routing protocol that addresses bandwidth-saving issues by minimizing the effect of frequent changes in topology, which is a particular feature of Ad-hoc networks due to node mobility [13]. In this protocol, the use of the best paths to a secondary importance, long paths can be used to avoid the control induced by the discovery process of new paths. It is a highly adaptive, efficient and scalable routing protocol that allows for multiple routes between source and destination [14], [15]. In order to achieve this, the search for the best path is neglected not in terms of calculation but in terms of procedure. In this way a protocol will be able to choose a longer path between the source and the destination node in order to avoid the costly process of discovering a new neighbor. In addition, TORA [16] maintains several paths to the same destination and not only the best path, which has the effect of limiting the effects induced by a modification of the topology on the routing of the data.

TORA is based on the use of the property called "destination orientation" directed acyclic graphs (DAGs) [13]. A graph is oriented if the links that compose it have a direction, that is to say that a link is not necessarily bidirectional. An acyclic graph means that the graph has no loop. An oriented acyclic graph is said destination oriented if there is always a possible path to a specified destination. When the graph loses one or more arcs so as to become destination-oriented, then the algorithms use the concept of link reversal to allow a destination oriented graph to be found. Fig. 2 shows the size of the sensor nodes with the TORA protocol [15]:

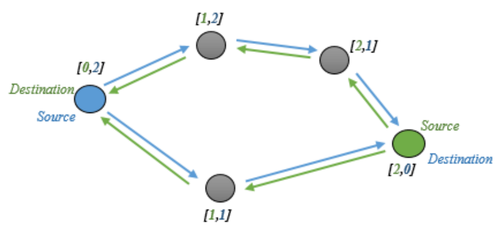

Fig. 2. The size of nodes with TORA.

For this realization [16], the TORA protocol uses the concept of size of the nodes, the destination has a size zero, and each node has for size, that of its neighbor having the smallest size incremented by one.

- **Advantages and disadvantages of TORA:** The advantage of Temporary Ordering Routing Algorithm is obviously in the management of link losses. It is an on-demand routing protocol that creates a DAG only when needed. This makes it a very robust protocol and very resistant in a very mobile network [14]. It allows the creation of multiple paths and adaptive to the dense network. On the other hand, TORA will not offer a good reliability, because it is sensitive to the empty zones of nodes and that it does not know how to circumvent them and these performances are degraded with the increasing mobility.

C. Zone Routing Protocol (ZRP)

ZRP is a hybrid routing protocol that combines proactive and reactive approaches [17]. It divides the network into different areas that can be of different sizes. Indeed, it defines for each node x a routing area expressed in number of maximum hops ρ. Thus, the routing area of the node x includes all the nodes which are at a maximum distance of ρ jumps with respect to x. The routing zone is then defined for each node, and the nodes that are exactly at ρ jumps of x are called peripheral nodes [18]. Within this zone, ZRP uses its proactive protocol but outside its routing area, it uses its reactive protocol.

Overall, ZRP offers a fast and efficient search in the network, and the detection of routing loops is possible in this protocol thanks to the knowledge of the network topology.

The ZRP routing mechanisms are therefore based on two types of protocols [19] (one operating locally and one operating between zones):

- **IARP** (IntrAzone Routing Protocol) provides optimal routes to destinations within the routing area of node x at a specified distance, and any changes are reflected only within the zone.
- **IERP** (IntErzone Routing Protocol) is responsible for searching on-demand routes for destinations outside a routing area of node x.

But before moving to the routing phase, each node must know its neighbors. For this purpose, the ZRP routing protocol uses the Media Access Control (MAC) protocol to know the immediate neighbors or the Neighbor Discovery Protocol (NDP) for the transmission and management of HELLO message exchanges [17], [20]. The following figure illustrates an architecture of this ZRP routing protocol, it presents the routing area of the node x, with (ρ = 2 hops):

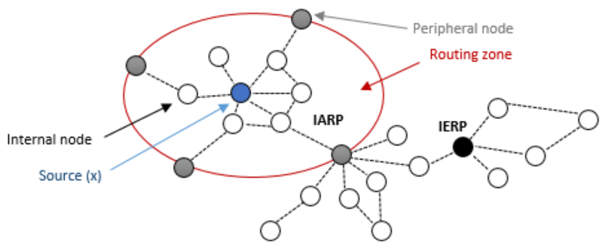

Fig. 3. The routing zone of the source node (x).

In addition to these two protocols, ZRP uses the Border cast Resolution Protocol (BRP) [21], which uses topology data provided by the IARP protocol to construct its list of edge nodes and how to achieve them. It is used to guide the propagation of IERP route search queries in the network.

- **Advantages and disadvantages of ZRP:** Zone Routing Protocol combines the benefits of responsive and proactive routing protocols with a properly configured zone radius. It outperforms proactive routing protocols and reactive routing protocols [18]. However, the potential disadvantage of ZRP is that, because hierarchical routing is used, the path to a destination may be suboptimal. In addition, each node having higher level topological information, memory requirements are more important.

The following table presents a comparison and a summary of the results of the theoretical analyzes of the three approaches described above:

TABLE I: COMPARISON BETWEEN AD-HOC ROUTING PROTOCOLS

	Routing protocols		
Parameters	**OLSR**	**TORA**	**ZRP**
Type	Proactive	Reactive	Hybrid
Routing architecture	Flat	Flat	Hierarchical
Multiple route	No	Yes	No
Without loop	Yes	Yes	Yes
Routing metric	Hop	Yes	Hop
Periodic issues	Yes	No	Yes
Critical node	Yes	No	Yes

III. SIMULATION METHODOLOGY AND PARAMETERS

Each routing protocol has the obligation to be efficient in energy, lifetime, and to be able to choose the best way to transmit the data packets from the source to a destination. Indeed, our simulation aims to evaluate the performance results of three families of Ad hoc protocols (proactive, reactive and hybrid) in terms of packet delivery rate, average end-to-end delay, and throughput. In this section, we will present the tool and the parameters of our simulation, as well as the metric performances chosen for our analysis.

A. Simulation Tools

The tool used for our simulation is Network Simulator 2 (NS2). It is the most suitable for sensor networks [22], because it includes basic energy modeling, and also makes it possible to very well model the physical layer of the OSI model with different transmission systems.

B. Network Parameters

The network of our simulation was composed of a number of nodes counted from 15 to 60 nodes deployed on a surface of 800m*800m, we assumed that all mobile network nodes are equipped with IEEE 802.11 communication interfaces. Each source generates packets of 512 bytes. The various parameters used according to the assumed simulation context are represented on the following table:

TABLE II: SIMULATION PARAMETERS

Parameters	Value
Simulator	NS2
Protocols	OLSR, TORA, ZRP
Radio-Propagation model	Propagation/TwoRayGround
Channel Type	Channel/Wireless channel
Network Interface Type	Phy/WirelessPhy
Interface Queue Type	Queue/DropTail/PriQueue CMUPriQueue
Antenna Model	Omni Directional Antenna
MAC Type	Mac /802.11
Mobility Model	Random Waypoint
Area of the network	800m*800m
Number of nodes	15, 30, 45, 60
Traffic Type	CBR (UDP)
Simulation Time	100 S
Transmission Range	250 m
Node speed	15 m/s
Packet size	512 Mbit

C. Performance Metrics

In this article, the focus has been on the performance capability of each routing protocol measured quantitatively. In this context, by comparing the ad hoc routing protocols: OLSR, TORA, and ZRP, we chose to evaluate them according to the following three metrics:

- Packet Delivery Fraction (PDF)
- End-to-End Delay (EED)
- Throughput

- **Average PDF:** Shows the number of all data packets successfully received by the destination sensor node over the total number of information packets sent by all network sensor nodes [23]. This ratio is mathematically defined by the following formula:

$$PDF = \frac{\sum_{n=1}^{n} Nb_{Packets_{receiv}}}{\sum_{n=1}^{n} Nb_{Packets_{sent}}} \qquad (1)$$

- **Average EED**: This parameter represents the time taken by the information packets from the source node to the destination node. This delay also includes queues during retransmissions of information packets and the time of discovery of information routing paths [24]. It is a report of the difference (from the time each packet sending from the source node to the time when receiving the same packet by the destination node) to the total number of packets received by the destination node:

$$EED = \frac{\sum_{n=1}^{n}(Packets\_Sent\_Time - Packets\_Receiv\_Time)}{\sum_{n=1}^{n} Total\_Packets\_Receiv} \qquad (2)$$

- **Average Throughput:** It is defined as the total number of data packets successfully received from the source node to the destination node over the total time of the simulation. This rate is represented in bits/bytes per second [25]. This metric is proof that the network manages to send the information constantly to the collection point. This is an important parameter for analyzing network protocols. The rate is calculated as follows:

$$T\_put = \frac{\sum Nb\_Packets\_Succeefully\_Receiv}{Unit\_Time} \quad (3)$$

IV. Simulation Result and Discussion

MANET networks, there are many quantitative and qualitative measures of network performance that can be used to compare ad hoc routing protocols. Indeed, the purpose of our experiments is to examine and quantify the effects of various factors and their interactions on the overall performance of ad hoc networks.

In this section, our comparison focused on the success rate and energy consumption of three routing algorithms over a well-defined scenario and traffic model, varying the number of nodes and the speed of the network sensor nodes, and based on the three metric parameters mentioned in the previous section.

The results of the simulation are illustrated in the following figures. The graphs show successively the packet delivery rate, the average end-to-end delay, and the speed of the three families of the routing protocols.

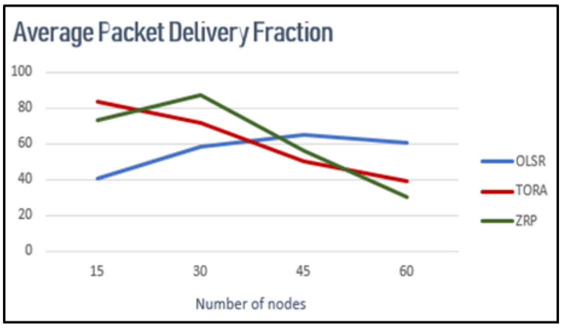

Fig. 4. Average packet delivery fraction

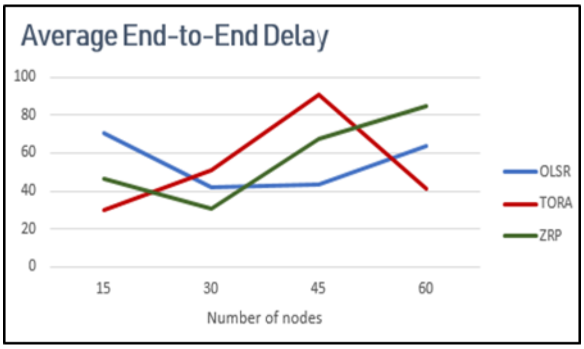

Fig. 5. Average End-to-End Delay.

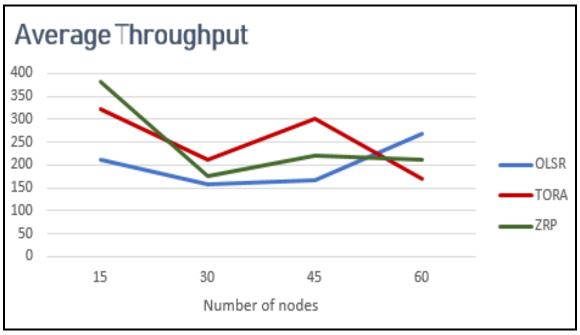

Fig. 6. Average Throughput.

A. *Simulation Result for Packet Delivery Fraction*

Fig. 4 shows the results of the simulation of the ratio between the number of packets generated by the sources of the application layer and the number of packets received by the receivers of the final destination of the three families of the routing protocols as a function of the number of nodes and mobility.

It is found that the TORA routing protocol works well when the network size is less than the load. However, its performance decreases as the number of nodes increases due to increased network traffic. For the OLSR protocol, these performances are better with a higher number of nodes than other protocols. It increases positively when the number of nodes increases from 15 to 45 knots. On the other hand, OLSR is unable to return the data captured during the break of the link.

Still, in terms of packet delivery report, we note that the performance of ZRP is a bit higher by 5% compared to other routing protocols. Its PDF increases when the network size increases from 15 to 30 nodes, and then it fails in an autonomous way, because it is a routing protocol that has a nature both proactive and reactive. In addition, it is effective for nearby cluster and network nodes. The packet delivery fractions of both the TORA and ZRP protocols are almost similar, however, the optimized OLSR routing protocol has an average packet delivery fraction ratio.

B. *Simulation Result for Average End-to-End Delay*

FIG. 5 represents the average end-to-end delay as a function of the number of nodes of the network, it indicates the average time required for a packet to move from the application layer of the source to the destination.

The ZRP and OLSR routing protocols lag behind the TORA protocol when the network size increases from 15 to 45 nodes. Indeed, because of the large memory of the roads, TORA uses obsolete routes resulting in frequent retransmissions of information packets, which gives a very long average end-to-end delay. As shown in Fig. 5, the average TORA end-to-end delay is reduced when the number of nodes increases from 45 to 60 nodes, while the performance of the other OLSR and ZRP protocols is slightly increased because the EED is affected by the high rate of CBR packets when a link break occurred.

The exchange load of the routing tables is becoming higher and the frequency of exchanges is also increasing due to the mobility of the nodes. In addition, spreading messages across the network for destination search requires more time for route discovery. So, the average end-to-end time of ZRP and OLSR offers better performance. On the other hand, the TORA protocol has a moderate average delay.

C. *Simulation Result for Throughput*

Fig. 6 depicts the output of the rate as a function of network speed and size. The graphs show that throughput increases and decreases for all three families of routing protocols. From the results of the simulation obtained, it is noted that the ZRP has the highest value in terms of bit rate compared to all other routing protocols due to its proactive and reactive characteristics. In addition, it uses well-defined route information available in the routing table, allowing the data to be routed quickly to the destination node.

The performance of the TORA protocol in terms of throughput is almost similar to that of ZRP, their throughput varies according to the size of the network, it decreases from 15 to 30 nodes, then it remains almost constant for ZRP while for TORA increases when the network size is between 30 and 45 nodes, then decreases for both routing protocols after 45 nodes. Indeed, the performances of these two protocols vary according to the number of nodes, and have an average throughput.

Also in terms of throughput, OLSR performance is lower than other protocols because most sensor nodes cannot participate in data transfer. In addition, OLSR does not repair the path of the break path. In general, TORA and ZRP have good throughput performance compared to OLSR but, when the network size is between 45 and 60 nodes, their performance is lower than OLSR.

D. Synthesis for the Three Approaches

In proactive mode, each sensor node of the OLSR routing protocol permanently maintains the route between two nodes. Therefore, the creation and maintenance of the route is accomplished through a combination of periodic and event-triggered routing updates derived from the distance vector method or the link state. In addition, for the TORA Reactive Routing Protocol, routes are only discovered when they are really needed. Indeed, a node wishing to send a data packet to another sensor node, these search the route on an on-demand basis and establish a connection to transmit and receive the packet. In addition, route discovery typically involves flooding query messages across the network. In hybrid systems, local knowledge of the topology can be kept up to a predefined number of jump by periodic exchange of control frames, in other words by a proactive technique. The routes to more distant nodes are obtained by reactive scheme that is to say by the use of broadcast request packets.

V. Conclusions

In this article, a realistic analysis of the performance of three types of ad-hoc routing protocols (proactive, reactive, and hybrid) was evaluated and compared against three performance metrics and with a different number of nodes and a network size.

On the basis of the results obtained, the OLSR routing protocol displays better performance and operates with the least possible delay on the network compared to other protocols in terms of packet delivery fraction. The TORA and ZRP routing protocols work well in the case of average end-to-end time and average OLS flow, making them suitable for highly mobile random networks. In this context, the analysis of our scenario presented on the basis of the simulated performances approve better performances of the examined approaches in terms of the quality of service, reliability, and optimization of the consumption of the energy. In this context, we will be able to design for our future work a better, well-secured routing protocol that can appropriately provide data integrity and delivery in a highly random mobility network.

References

[1] A. Mouiz, A. Badri, A. Baghdad, A. Ballouk, and H. Lebbar, "Analysing study of a contribution to minimize the energy consumption and improve the performance of wireless sensor networks," *International Journal of Computer Science and Information Technology & Security*, vol. 6, pp. 523-527, 2016.

[2] I. F. Akyildiz, S. Weilian, S. Yogesh, and C. Erdal, "A survey on sensor networks," *IEEE Communications Magazine*, vol. 40, pp. 102–114, 2002.

[3] H. B. Sami, A. M. Haidar, and A. Bilal, "Classification of routing protocols in wireless sensor network," in *Proc. Int. Conf. on Computer Vision and Image Analysis Applications*, Sousse, Tunisia, 2015.

[4] T. Yoshihiro, Y. Kitamura, A. K. Paul, A. Tachibana, and T. Hasegawa, "A new hybrid approach for scalable table-driven routing in MANETs," in *Proc. IEEE Wireless Communications and Networking Conference*, Barcelona, Spain, 2018.

[5] F. Bai, N. Sadagopan, B. Krishnamachari, and H. Helmy, "Modeling path duration distributions in MANETs and their impact on reactive routing protocols," *IEEE Journal on Selected Areas in Communications*, vol. 22, pp. 1357–1373, 2004.

[6] C. Yuan and S. Wenxiao, "Access-enhanced hybrid routing protocol for hybrid wireless mesh network," in *Proc. Int. Conf. on Communication Software and Networks*, Guangzhou, China, 2017, pp. 138–141.

[7] A. Taslim, I. K. Tawhidul, and T. Ichihiko, "Performance analysis of mobile ad-hoc network routing protocols," in *Proc. Int. Conf. on Informatics, Electronics & Vision*, 2012, pp. 935–939.

[8] R. Kumawat and V. Somani, "Comparative analysis of DSDV and OLSR routing protocols in MANET at different traffic load," in *Proc. Int. Conf. on Computer Communication and Networks*, 2011, pp. 34–39.

[9] P. Jacquet, P. Muhlethaler, T. Clausen, A. Laouiti, A. Qayyum, and L. Viennot, "Optimized Link State Routing Protocol for Ad Hoc Networks," in *Proc. IEEE International Multi Topic Conference*, Lahore, Pakistan, 2001, pp. 62–68.

[10] S. A. Adel and P. A. Tijare, "Performance comparison of AODV, DSDV, OLSR and DSR routing protocols in mobile ad hoc networks," *International Journal of Information Technology and Knowledge Management*, vol. 2, pp. 545–548, 2010.

[11] H. Bali and N. Hemrajani, "Attack analysis and designing of quality of service framework for optimized link state routing protocol in MANET," *International Journal of Intelligent Engineering and Systems*, vol. 11, pp. 236–245, 2018.

[12] Y. Hamzaoui, M. Amnai, A. Choukri, and Y. Fakhri, "Enhancing OLSR routing protocol using k-medoids clustering method in MANETs," *International Journal of Applied Engineering Research*, vol. 12, pp. 200–206, 2017.

[13] Y. B. Zikria, N. Summera, and W. K. Sung, "Quality of service analysis for multimedia traffic using DSR, AODV and TORA over Wi-Media ultra-wide band," in *Proc. Int. Conf. on Applied Sciences and Technology*, Islamabad, Pakistan, 2015, pp. 539–546.

[14] B. S. Gouda, A. K. Dass, and K. L. Narayana, "A comprehensive performance analysis of energy efficient routing protocols in different traffic based mobile ad-hoc networks," in *Proc. Int. MultiConf. on Automation, Computing, Communication, Control and Compressed Sensing*, Kottayam, India, 2013, pp. 306–312.

[15] S. S. Davesh and S. Dhananjaya, "Performance Analysis and simulation of AODV, DSR and TORA routing protocols in MANETs," *International Journal of Recent Technology and Engineering*, vol. 1, pp. 122–127, 2012.

[16] K. G. Anuj, H. Sadawarti, and A. K. Verma, "Performance analysis of AODV, DSR & TORA routing protocols," *International Journal of Engineering and Technology*, vol. 2, pp. 226–231, 2010.

[17] T. I. Ali, L. A. K. Al Dulaimi, and Y. E. Majeed, "Review and performance comparison of VANET protocols: AODV, DSR, OLSR, DYMO, DSDV &ZRP," in *Proc. Int. Conf. on Multidisciplinary in IT and Communication Science and Applications*, Baghdad, IRAQ, 2016.

[18] P. Hrituparna and S. Priyanka, "A stady and comparison of OLSR, AODV and ZRP routing protocols in ad hoc networks," *International Journal of Research in Engineering and Technology*, vol. 2, pp. 370–374, 2013.

[19] R. Arafatur, A. Farhat, N. Jannatul, and S. M. Abedin, "A simulation based performance comparison of routing protocol on mobile ad-hoc network (Proactive, Reactive and Hybrid)," in *Proc. Int. Conf. on Computer and Communication Engineering*, Kuala Lumpur, Malaysia, 2010.

[20] N. Arora, "Performance analysis of AODV, DSR and ZRP in MANETs using QualNet simulator," *Journal of Engineering Science and Technology Review*, 2013.

[21] J. H. Zygmunt, M. R. Pearlman, and P. Samar, "The Bordercast Resolution Protocol (BRP) for ad hoc networks," *IETF Internet Draft*, 2003.

[22] A. Mouiz, A. Badri, A. Baghdad, A. Ballouk, and A. Sahel, "Analysis of modeling performance and simulation tools for wireless sensor networks," *International Journal of Computer Applications Technology and Research*, vol. 6, pp. 9–12, 2017.

[23] I. Ouafaa, E. Mustapha, K. Salah-ddine, and E. H. Said, "Performance analysis of SLEACH, LEACH and DSDV protocols for Wireless Sensor Networks(WSN)," *Journal of Theoretical and Applied Information Technology*, vol. 94, pp. 304–311, 2016.

[24] P. Rohal, R. Dahiya, and P. Dahiya, "Study and analysis of throughput, delay and packet delivery ratio in MANET for topology based routing protocols (AODV, DSR and DSDV)," *International Journal for Advance Research in Engineering and Technology*, vol. 1, pp. 54–58, 2013.

[25] S. Makker and V. Kiran, "Analysis and comparison of WiMax communication using cryptographic techniques," *International Journal of Advanced Research in Computer and Communication Engineering*, vol. 4, pp. 15–18, 2015.

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