A LINK'S FINENESS BASED ON SPATIAL RELATION FOR MULTIPOINT RELAYS SELECTION ALGORITHM IN MOBILE AD HOC NETWORKS

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ABSTRACT

The propagation of wireless mobile equipment has given rise to mobile ad hoc networks (MANET), which allow the establishment of networks deprived of infrastructure support. The improvements in these technologies have also resulted in the variety of link quality, scalability, stability and reachability limits. Principally, due to their incapability to guarantee node reliability, MANETs are weak in highly dynamic environment. Since high-speed nodes, low density, and rapid changes in the topology are directly damage networks performances and lifetime. In response, routing is an inspiring issue in these networks. This paper proposed a new routing scheme in MANETS. This technique is integrated in the optimized link state routing (OLSR). In the projected scheme, the author defines a link fineness based on spatial relation between mobile nodes, which exploits different parameters, speed, direction and acceleration, including the sent and received of hello packets. Correspondingly, the proposed selected multipoint relays (MPRs) based the projected methods is included in the algorithm. The scheme elected more stable MPRs with high link's quality, more neighborhood degree and higher willingness as MPR that can increase the reachability and stability of the network even in an extremely dynamic situation. This version of OLSR is verified by the network simulator (NS3) under the Radom Waypoint mobility model. Results revealed an important improvement for SLF_OLSR. In addition, this scheme can be integrated into other protocols in MANETs.

KEYWORDS

Mobile ad hoc networks; Olsr; Mprs selection; Link's Fineness; Spatial relation; Ns3 simulator

1. INTRODUCTION

Nowadays, location and time features are no longer issues for users to access information and data due to the wireless technology that proposes an endless flexibility of usage and networking. Different advantages are presented to people in several areas, provided by the growth of this technology to eliminate different limits such as interval of the network, uninstallation of equipment, hardware, making a prodigious flexibility in terms of communication between different nodes and helping mechanism to be adapted to numerous variations due to the mobility of mobile elements in the network.

Nowadays, the implementation of wireless technology and devices has hit the roof, resulting in an amplified claim for innovative network technologies that allow communication without

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requirement for traditional infrastructure. A typical technology that has ascended is the mobile ad hoc network (MANET) [1]. Furthermore, An ad Hoc network is defined as a group of mobile nodes that have the capability of exchanging data and communicating by wireless technology, establishing a provisional network without any help and use of any management or any fixed support. Therefore, in an Ad Hoc network, the cooperation of all nodes is important to create a momentary architecture for a successful communication.

The perception of VANET [2] acquired importance in the scientific community in computer science and telecommunications. Therefore, Vehicular Ad hoc networks are a derivation of MANETs. In VANET each mobile node (vehicle) is defined as part of the network. It offers an enhanced improvements of the intelligent transportation system in driving security [3][4].

In another way, when numerous drones communicate together in an ad hoc method, they build a novel and an innovative ad hoc network entitled flying ad-hoc network (FANET) [5][6]. In FANETs, a collection of UAVs works with each other without any access point, except that at least one of these nodes must communicate with satellite or ground station (GS) [7][8]. Certainly, this network is identified as a subcategory of MANET and VANET.

The regular physical changes of the topological structure oblige mobile nodes to accomplish all network's actions on their own, counting discovery of a network topology, routing tables and updates or transferring control messages between mobile nodes without forgetting the ability of sending, receiving and forwarding data among mobile nodes. In this situation, a distributed fashion is involved where mobile nodes inherit router's procedures to distribute connection requirements among mobile nodes [9][10]. Moreover, low processing power, restricted bandwidth links, small power resource and small memory present different limited resources that categorize mobile nodes.

Compared to supported networks, the wireless technology creates links wirelessly which makes data broadcast over MANETs exposed to high packet losses and more recurrent path disconnections. Also, it reduces the reliability of the network in sending data traffic. Achieve the connection, direct communication and collaboration with intermediate nodes is created based on mobile nodes that are in a radio range of other nodes. MANETs have various motivating applications that satisfy human needs such as military, emergency circumstances and natural disasters, etc. In such applications, the idea is to make communication possible where and when it is impossible to rely, due to the absence of fixed substructures or their high employment charges [11][12]. Therefore, self-configuration and self-routing are also features that made MANETs unique. Therefore, many challenges as resource limitations, changing topology, routing, security, energy and mobility are occurred.

As mentioned before, routing information in MANETs is a big issue, creating numerous challenges to project appropriate routing protocols. Hence, various routing protocols have been developed and well-matched with the features and the dynamic nature of these networks. Current routing protocols have their own mechanisms to improve some of the performance's metrics of MANETs as well as the throughput, Packet Delivery Ratio (PDR), routing overhead and end-to-end delay [12][13]. These metrics are employed to improve the quality of services in the network. For that, Routing protocols in MANETs are generally classified into three classes: proactive, reactive or hybrid [14][15].

In proactive, each node controls its own routing tables to save the routing information for all connected mobile nodes. Hence, to preserve the routing information continually updated, the mobile nodes share updated data frequently or periodically, helping to make routing information accessible when required and at the same time, increasing routing overhead. Some of these routing protocols are Fisheye State Routing protocol (FSR) [16] and the Optimized Link State Routing protocol (OLSR) [17][18]. Additionally, in reactive, mobile nodes do not save routing information, but these nodes diffuse path requests to the destination node on demand. This phase is only executed when information routing is required, which enhances the throughput and the end-to-end delay. Dynamic Source Routing (DSR) [19] and Ad Hoc On-demand Distance Vector (AODV) [20] are participating in this category. Therefore, to improve the performance of the routing protocol, a mixture of positive features of both protocols (proactive and reactive) created a Hybrid protocol as well as a Zone Routing Protocol (ZRP) [21].

Due to the frequent movement of nodes, communications or links are nonstop cracked. All metrics cited above are affected by these issues. In wireless networks, OLSR is categorized as an important routing protocol outstanding to Multipoint Relays (MPRs) technology [22][23] (Figure 1). Due to the mobility issue in MANETs, stable mobile nodes make dynamic topology looks less and big networks seem smaller. Furthermore, OLSR protocol offers an improved performance in the network by involving MPRs nodes that can illustrate the mobility pattern considering its functionality [24],[25] by making this mobile node as a leader of numerous nodes or groups.

Therefore, in this paper, the author exposed an algorithm accomplished to captures the group mobility pattern with link's quality and integrates this information to select stable MPRs. Resolving the inefficiency in existing MPRs Selection algorithm, a new mobility technique adaptive MPRs Selection algorithm for OLSR in MANETs is presented. The technique provides a finest way for mobile nodes to elect more stable MPRs. The enhanced MPRs selection algorithm is defined by mobility pattern of neighbors to guarantee extreme network stability. The technique is adapted to high environment. To conclude, the proposal is a linear distance based spatial dependency and link's quality as a method for MPRs Selection named Spatial Link's Fineness MPR.

The positions of mobile nodes in the network are periodically measured by consuming some kind of system localization like GPS. Also, the information of positions will be considered as the base of our algorithm to create optimal routes with a minimum delay, lost packets and to have more stability and reachability in the network. The modification of MPRs Selection algorithm was integrated and the position of mobile nodes was injected in Hello message with link's fineness, different mobility's features as the speed, the acceleration, the direction and also, the value of spatial link's Fineness MPR. The motivation for the author, is to adapt and to improve MPRs selection for more performance in the network [26][27][28]. Additionally, the proposed method can be efficiently used even in dynamic network situations such as MANETs, VANETs and FANETs.

Results shown that the projected algorithm of selection MPRs improved the quality of services in the network. The impact of these adjustments on the network performance under Random Waypoints Model has been evaluated by NS-3 simulator [29].

The rest of the paper is organized as follows. In Related works section, the author presents many routing methods. In Proposed Mechanism section, the author describes the concepts related to the algorithm used. In Results and Discussion section, the author presents graphs and reflections by comparing results. Finally, a Conclusion section is presented.

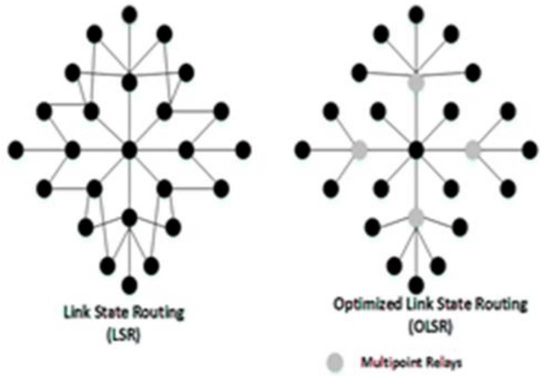

Figure 1. Multipoint Relays Illustration

2. RELATED WORKS

This section acts as a review of different studies. Therefore, the author summarizes diverse proposed schemes involved to enhance routing protocols. A classification of these protocols is presented according to the mobility, distance and link quality of mobile nodes. Then, different categories of these schemes are described depending on speed, direction, quality, position of nodes, probabilistic methods or degree of mobility etc.

Therefore, the Authors proposed in [30] a survey of approaches and procedures associated to improve MPR selection. For this, the author presented a synthetic study of various procedures and approaches for scheming and selecting MPR nodes based on a set of criteria as energy, mobility, bandwidth, quality of links, etc. The result of this work illustrated that most procedures consider a restricted number of metrics to select MPR nodes, so, they are inadequate to tolerate OLSR protocol to be quite complete and efficient due to several metrics that occurred at the same time in the real environment.

The author in this paper [31] offered a summary of the idea of vehicular ad hoc networks, applications, characteristics. Therefore, the paper is providing some of problems and challenges in VANET.

In the context of Proactive routing protocols, authors [32] have constructed a complete mathematical-based model to evaluate the Destination-Sequenced Distance Vector protocol (DSDV) and examined its performance on estimating the route length based on the concepts of the probability density purpose and the predictable values to discovery greatest estimate values in real scenarios. Authors have confirmed the validity of the projected model using simulation scenarios applied by the Network Simulator (NS3). Results obtained from the mathematical model and the simulation have revealed that the route length is inversely proportional to the speed of mobile node and the hop count. Moreover, the route length estimated from the DSDV protocol is fewer than the actual, because to the implementation of the settling time concept and keeping periodic routes update parameter at a constant level, despite the fact that the speed of mobile nodes can reduce the operative route employment.

Correspondingly, the MPR selection works very well to broadcast packets in the network. Truly, various studies accessible in the literature were attracted by this subject. MPRs nodes can significantly disturb the performances of the network, that means, choosing reliable MPRs revealed hope to increasing these performances. Inside TC messages, MPRs nodes diffuse links which might create routes from source to destination, formerly MPRs form a kind of support in mobile ad hoc network. Hence, choose MPRs that encounter a specified requirement to enhance the networks performance. Hence, an examination of MPRs selection in OLSR Protocol [33] determined that paths performance can be improved by using additional criteria in MPRs mechanism. Additionally, routing metrics are taken into reflection to choose mobile nodes relays. Greatest works in OLSR hope to find other efficient metrics rather than the default one presented in the RFC3626 [18] where the path quality is defined by number of hops.

Grounded on OLSR, authors in the paper [34] have matched the improved Optimal Link State Routing Protocol (MMPROLSR) with the GSA-PSO (Gravitational Search-Particle Swarm Optimization) scheme in grouping with the cognitive radio technique. This method can be useful to Vehicular Sensor Networks. MMPR-OLSR with GSA-PSO optimization simplifies the MMPR-OLSR protocol to elect the appropriate mobile nodes using a finest searching technique. GSA-PSO not only supports in selecting suitable MMPR nodes, but also helps in reducing the needless overheads due to the broadcast of control packets and in reducing the number of relay selector nodes used in communication. This scheme also focuses on assigning stations between all users of the network, which is measured by the proposed method. A group of mobile nodes are designated before the start of the actual transmission.

These vehicular nodes within the transmission range are selected as relays. Cognitive radio acts by recognizing the idle channels, thus allowing the usage of the unexploited channels.

The projected method works efficiently in reaching the objective of operative channel utilization united with efficient transmission. The proposed approach is simulated using the NS2 platform and shown a sharp reduction in delay and a high packet delivery ratio in addition to a high channel utilization. The effective channel utilization used in the GSA-PSO method helps to decrease the delay in packet transmission and delivery by providing a good PDR.

Another paper [35], used OLSR to explore the performance of VoIP applications in the VANET network. The network was verified before and after running the OLSR algorithm, the challenging absorbed on Quality of Service (QoS) parameters and probability of packet loss among two moving hops through multi-hop Ad-hoc networks in diverse situations based on the ITU G.711 VoIP codec. The simulation shown a decreased delay by 18.72%, while decreased jitter by 20.42% and decreased packet loss by 128.6%. Nevertheless, The OLSR has exposed primary good performance for four hops, and then supplementary hops, the delay surpassed 400ms which is not suitable according to ITU-T recommendations.

Therefore, this paper [36] objects to suggest an enhanced harmony search optimization (EHSO) algorithm that reflects the configuration of the OLSR parameters by joining two steps, a method for optimization approved out by the EHSO algorithm created on embedding two prevalent selection approaches in its memory, namely, roulette wheel selection and tournament selection. Simulation analysis demonstrated that the projected method has attained the QoS necessity, compared to the existing algorithms.

In the same area, the paper [37] proposed to use ELMs, which are renowned for their aptitude to estimated anything, to model and estimate the mobility of each mobile node in a MANET. Mobility-aware topology control approaches and location-assisted routing both influence the prediction of the mobility in MANETs. It is supposed that each mobile node taking part in these protocols is attentive of its current mobility information, including location, velocity, and movements direction angle. This method predicts locations of upcoming nodes and distances between succeeding nodes. A fuzzy logic-based routing protocol is exposed in another paper [38] to replicate battery level of nodes, hop count, and trust between nodes. The anticipated routing protocol adaptively chooses paths that use lowest hop count with the highest level of trust and a satisfactory battery level to improve the reliability of path selection while preserving the percentage of effectively delivered packets. The result of the simulation revealed that the proposed protocol can attain a high ratio of successfully delivered packets, a lower average end-to-end delay, and a normalized routing load.

In other subject of Ad hoc Networks, specifically Fanets, authors of this paper [39] projected an innovative optimized link-state routing technique with a greedy and perimeter forwarding Aptitude entitled OLSR+GPSR in flying ad hoc networks. The planned scheme uses a fuzzy system to adjust the broadcast period of hello messages based on velocity of UAVs and position prediction error, accordingly, that high-speed UAVs have a shorter hello broadcast period than low-speed UAVs. In OLSR+GPSR, MPR nodes are selected based on some metrics, particularly neighbor degree, node stability which is derived from velocity, direction and distance, the occupied buffer capability, and residual energy. Finally, the proposed scheme removes two phases in OLSR, i.e., the TC message broadcasting and the calculation of all routing routes to decrease routing overhead. OLSR+GPSR is simulated on an NS3 simulator, and this evaluation presented the superiority of OLSR+GPSR in terms of delay, packet delivery ratio, throughput, and overhead compared to Gangopadhyay et al., P-OLSR, and OLSR-ETX.

Authors Of another paper [40], presented a smart filtering-based adaptive optimized link state routing (SFA-OLSR) scheme in FANETs. To enhance flexibility in the FANET environment, SFA-OLSR offers a novel solution to regulate the hello broadcast period so that each flying node specifies its broadcast period based on an innovative scale titled cosine similarity among real and predicted positions. Moreover, in SFA-OLSR, each flying node develops a filtering algorithm based on link lifetime and remaining energy. The goal of this algorithm is to decrease the size of the single-hop neighboring set of each flying node and diminish the search space when finding multi-point relays (MPRs). Then, SFA-OLSR exploits the sparrow exploration algorithm (SSA) to elect the best MPRs. This algorithm presented a multi-objective purpose by concentrating on energy, link lifespan, and neighbor degree. Finally, the simulation of SFA-OLSR is accomplished by the NS3 simulator. These evaluations illustrated that SFA-OLSR has a good performance in terms of packet delivery ratio, delay, and throughput, but its overhead is increased.

Authors in [41] proposed a complete search of cluster-based routing protocols (CBRPs) in terms of their strengths, weaknesses, specific applications, methods, number of nodes, and future perfections for helping FANETs. Furthermore, 21 CBRPs based FANETs were studied in terms of their topology, challenges, scalability, characteristics, clustering strategy, outstanding features, cluster head (CH) selection, routing metrics, and performance measures. Additionally, open problems that need to be talked in future revisions in the field of routing protocols for UAV networks.

In other way, this paper [42] objected to stream time sensitive applications using mobile ad hoc network (MANET), the author has selected the Optimal Link State Routing (OLSR) protocol. Still, the protocol has increased overhead because each node chooses a set of multipoint relays (MPR) nodes. Hence, authors proposed quality of service (QoS) supporting the MPR selection method and a novel lower maintenance clustering method for diminishing the overhead of the network. As a result, the projected method exposed a great result in the average end-to-end delay, packet delivery ratio, routing load, and throughput. Furthermore, authors in [43] developed a new dynamic hello technique, where new neighbour nodes and lost neighbour nodes are used to compute link change rate (LCR) and hello-interval/refresh rate (r). The Exchange of link connectivity information at a fast rate consumes unnecessary bandwidth and energy. In MANET resource wastage can be controlled by avoiding the re-route discovery, frequent error notification, and local repair in the entire network. We are enhancing the existing hello process, which shows significant improvement in performance.

Additionally, several revisions proposed schemes that integrated the degree of mobility to systematically study the impact of mobility on the performance of routing protocols for ad hoc networks. These studies offered an opportunity to think about mobility metrics that measure this relationship.

Correlated to this report, Bai et al. [44] advised the important framework to methodically investigate the impact of mobility on the performance of routing protocols for ad hoc networks. Authors suggested two mobility schemes for measuring temporal and spatial movement dependence between mobile nodes. Both schemes are based on the cosine similarity between the velocities of nodes.

The first is Degree of Spatial Dependence between nodes (i) and (j) at time t, named DSD (i,j,t).

$$DSD(i,j,t)=Cos(i,j,t)*SR(i,j,t) \quad (1)$$

The second planned a Degree of Temporal Dependence (DTD) [45], which is like to DSD, but the difference is that DTD considered the difference among velocities along two time slots. Thus, depending on its past moving pattern, mobile nodes expected its speed. This scheme reproduces the smoothness of node movement.

$$DTD(i,t,t')=Cos(i,t,t')*SR(i,t,t') \quad (2)$$

In order to provide a better understanding of spatial dependence, authors in [46] proposed a more comprehensive mobility metric and schemes. The simulations were based on the NS3 simulator and the proposed method presented great performances compared to OLSR standard.

Various mobility models can be integrated to evaluate the performance of routing protocols in MANETs. Comprehensive examination of these models is presented in [47], [48]. This paper is built on Random Waypoint model [49] and it suggests a new method for the mechanism of multipoint relays based on mobility and quality of links called as Spatial Link's Fineness MPR (SLFMPR) integrated in the algorithm of the MPRs selection in OLSR Protocol.

3. PROPOSED MECHANISM

In Mobile Ad hoc Networks, at any time and randomly, mobile nodes change their positions that disturb the link's quality and stability.

3.1. Brief Description of OLSR

OLSR is an efficient table-driven protocol developed for mobile ad hoc networks, it's not complicated logic and easier to adjust. Topological information of the network is regularly exchanged among nodes in OLSR. In the network, mobile nodes diffuse Hello messages (Figure2) [18] to their 1-hop neighbors, defining several of them to run as MPRs (Figure 1) to diffuse topological information and create link state information to be directed throughout the network. MPRs propose a powerful mechanism for monitoring traffic by reducing the required number of transmissions. Also, MPRs are used in path calculation to link all destinations in the network. Due to the mechanism of MPRs, OLSR offers finest paths considering number of hops and it is mainly appropriate for large and dense networks. In other way, OLSR routing protocol presents restriction in calculation of minimum MPRs (NP complete problem). Hence, to elect MPRs is very inspiring and diverse heuristics algorithms can be explored in order to find the perfect result.

<table>
<tr><th colspan="2">Reserved</th><th>Htime</th><th>Willingness</th></tr>
<tr><td>Link Code</td><td>Reserved</td><td colspan="2">Link Message Size</td></tr>
<tr><td colspan="4">Neighbor Interface Address</td></tr>
<tr><td colspan="4">Neighbor Interface Address</td></tr>
</table>

Figure 2. Standard Hello Message in OLSR Protocol

3.2. Terminology and Introduction of the Improvement Mechanism

Related to studies cited before, the author developed and extended an innovative scheme named Spatial Link's Fineness MPR (SLFMPR) used in basic selection of MPRs in OLSR.

The scheme defines the quality of the connection and the similarity of mobility features between two nodes that are within their transmission range. Mobile nodes with the high link quality and the same mobility features are more likely to move together over a period of time with a great linking to achieve their tasks until one of them leaves the transmission range and cannot be selected as MPR.

Table 1. Terminology Of The Improvement.

Terminology	**Description**	**Unit of measure**
D	Linear distance	[m]
S	Average speed	[m/s]
θ	Direction of a node	[°]
V	Velocity of a node	[m/s]
A	Average acceleration	[m/s2]
ΔT	Time interval	[s]
t	Current time	[s]
RS(i,j)	Relative speed	
RA(i,j)	Relative acceleration	
RD(i,j)	Relative direction	
SD	Spatial dependency	
LF	Link's Fineness	
SLFMPR	Spatial Link's Fineness MPR	
ΔxT,ΔyT	The increment of the linear distance in x and y coordinates	
xi(t)), yi(t), Xi(T),Yi(T)	The coordinates of the node i at different time	

3.3. Description of the Proposed Mechanism

Let MPR(S), N(S) and N2(S) as the MPR, N and N2 of the node S which are defined as the original OLSR protocol. After studying all the steps in this algorithm, the technique was added without changing the OLSR algorithm.

Let's consider numerous mobile ad hoc nodes in a network, involving the dynamic establishment of links such as G (U, E) is a direct graph and (U) is the set nodes and E is the set of links l = (i, j), where the node (j) is within the area of (i).

At (ΔT), (ΔxT) and (ΔyT) are the increment of the linear distance in (x) and (y) coordinates as:

$$\Delta xT_i = \left(x_{i(t)} - X_{i(T)} \right)$$
$$\Delta yT_i = \left(y_{i(t)} - Y_{i(T)} \right) \quad (3)$$

Where (t) is the current time and (xi(t)), (yi(t)), (Xi(T)), (Yi(T)) represent the spatial coordinates at time (t) and (T) respectively.

Hence, the linear distance (D) can be defined as:

$$D=\sqrt{\Delta yT^2 + \Delta yT^2} = \sqrt{(x_{i(t)} - X_{i(T)})^2 + (y_{i(t)} - Y_{i(T)})^2} \quad (4)$$

Therefore, the speed (S) over time (ΔT) is defined as:

$$S = \frac{D}{\Delta T} = \frac{\sqrt{(x_{i(t)} - X_{i(T)})^2 + (y_{i(t)} - Y_{i(T)})^2}}{T-t} \quad (5)$$

The direction of node (θ) can be defined as:

$$\theta = \begin{cases} \varphi . \sin(\Delta yT_i) & \left(x_{i(t)} - X_{i(T)} \right) > 0 \\ \frac{\pi}{2} . \sin(\Delta yT_i) & \left(x_{i(t)} - X_{i(T)} \right) = 0 \\ (\pi - \varphi) . \sin(\Delta yT_i) & \left(x_{i(t)} - X_{i(T)} \right)_i < 0 \end{cases} \quad (6)$$

Where $\tan \varphi = \left| \frac{\Delta yT_i}{\Delta xT_i} \right| = \left| \frac{\left(y_{i(t)} - Y_{i(T)} \right)}{\left(x_{i(t)} - X_{i(T)} \right)} \right|$ and $\theta_i \in (-\pi, \pi)$

The node computes its acceleration (A) over time ΔT based on the velocity (V) which is the speed combined with the direction:

$$A = \frac{\Delta v}{\Delta T} \quad (7)$$

each node evaluates the connection quality according to the equation below:

$$LF_{(i,j,t)} = \frac{\sum R_{hello}(i,j,t)}{\sum S_{hello}(i,j,t)} \quad (8)$$

where, Rhello(i, j) and Shello(i, j) indicate the number of Hello messages received and the number of Hello messages sent from node(j) to node(i).

LF(i,j) is the link's fineness between two mobile nodes in the network.

Based on these values, a node calculates its Spatial Link's Fineness MPRs (SLFMPR) with the next phases:

First phase: Nodes exchange their mobility features and their link's fineness with its directly connected neighbors through Hello packets (Figure 3).

<table>
<tr><th colspan="2">Reserved</th><th>Htime</th><th colspan="2">Willingness</th></tr>
<tr><td>Link Code</td><td>Reserved</td><td colspan="3">Link Message Size</td></tr>
<tr><td>Speed</td><td>Acceleration</td><td>LF</td><td>Direction</td><td>SLFMPR</td></tr>
<tr><td colspan="5">Neighbor Interface Address</td></tr>
<tr><td colspan="5">Neighbor Interface Address</td></tr>
</table>

Figure 3. Modified Hello Message in OLSR Protocol

Second phase: A node estimates its Relative Speed (RS), Relative acceleration (RA) and Relative Direction (RD) with its directly connected neighbors.

For nodes (i) and (j), RS of these two nodes is defined as:

$$RS_{(i,j,t)} = log(1 - \frac{|S_i - S_j|}{S_{max}}) \tag{8}$$

Where (Smax) is the node's maximum speed and RD of these two nodes is the cosine of the angle between (i) and (j) at time (t) and it can be calculated as:

$$RD_{(i,j,t)} = cos\ (\theta_i\ (t) - \theta_j\ (t)) \tag{9}$$

And RA between two nodes (i) and (j) is given by:

$$RA_{(i,j,t)} = log(1 - \frac{|A_i - A_j|}{A_{max}}) \tag{10}$$

Where (Amax) is the maximum acceleration of node.

Third phase: Spatial Dependency (SD) between node (i) and node (j) can be defined as:

$$SD_{(i,j,t)} = RS_{(i,j,t)} * RA_{(i,j,t)} * RD_{(i,j,t)} \tag{11}$$

Fourth phase: Spatial Link's Fineness MPR (SLFMPR) of a node is defined as the average of the summation of all (SD) it has of all its n neighbors with the incorporation of the link's fineness which is also calculated as the average of the summation of all (LF) it has of all its n neighbors. Then, it can be calculated as:

$$SLF_{MPR(i,t)} = \frac{1}{n}\sum_{j=1}^{n} SD_{(i,j,t)} * \frac{1}{n}\sum_{j=1}^{n} LF_{(i,j,t)} \tag{13}$$

A higher (SLFMPR) value implies that node (i) has a bigger neighbor set with a better connection quality. The spatial relation and the link's fineness may be powerfully associated together. Accordingly, to reproduce linking quality and mobility features of the group (neighbors connected), a node with a higher the SLFMPR value is elected as MPR. Also, SLFMPR value defined above can extend stability, and improve connection's quality and reachability by making the routing applicable in extremely and various mobile environment.

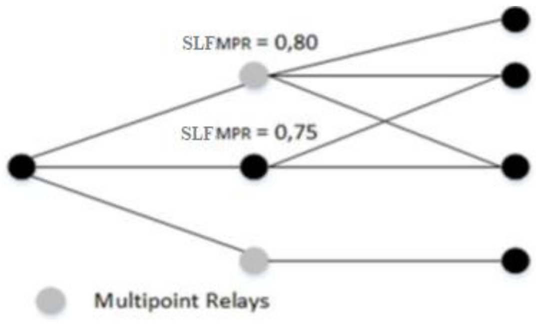

Figure 4. The modified multipoint relay selection

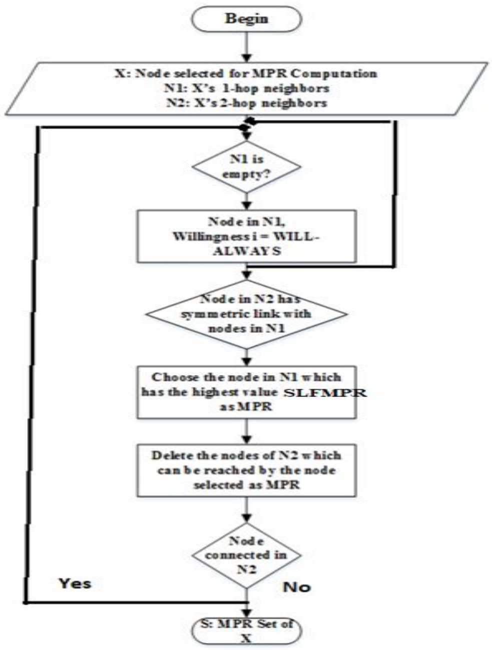

Figure 5. Modified MPRs Selection Flow Chart

4. RESULTS AND ANALYSIS

4.1. Simulation Mobility Model

The research is constituted in a C++ environment created by the author under the NS3 simulator [29]. Assorted studies were based on Random Waypoints as the greatest mobility model for MANETs to evaluate the performance of routing protocols. The paper compares the performance of diverse scenarios of the modified OLSR and the original (i.e. SLF_OLSR with OLSR). The simulation is executed for 100 s. 10,20,30,40,50,60,70,80,90,100 identical mobile nodes are arranged in a terrain of 1000 m by 1000 m.

An investigation of diverse graphs was presented to discuss simulation results and Table II summarizes all parameters used during simulation.

Table 2. Simulation Parameters.

Simulation Parameters	**Value**
Flat Size	1000 m × 1000 m
Max Number Of Nodes	10,20,30,40,50,60,70,80,90,100
Radio Scoop	250 m
MAC Layer	IEEE.802.11.peer to peer mode
Transport Layer	User Datagram Protocol (UDP)
Traffic Model Used	CBR
Package Size	1024 bytes
Rate	0,4
Mobility Model	Random Waypoint
Pause Time	1 seconds
Maximum Speed of Nodes	25 m/s
Simulation Time	100 Seconds

4.2. Comparison and Discussion

Both protocols are compared and exposed in the graphs below. It is observed that SLF_OLSR exposed enhancement compared with the original OLSR, especially, when the network contains the largest set of nodes. It approves the effectiveness of SLF_OLSR for dense networks. Comparison results exposed the impact on the performances of the protocol.

In Figure 6, the author examined the time for data packets diffused from source to destination. The comparison shown that SLF_OLSR presented a lower delay compared to the original OLSR. The enhancement can be clarified by efficiency that relativity and link's quality between nodes involved in the selection of MPRs to get more proficiency direct neighbors. This method helps paths to still valid with a perfect linking.

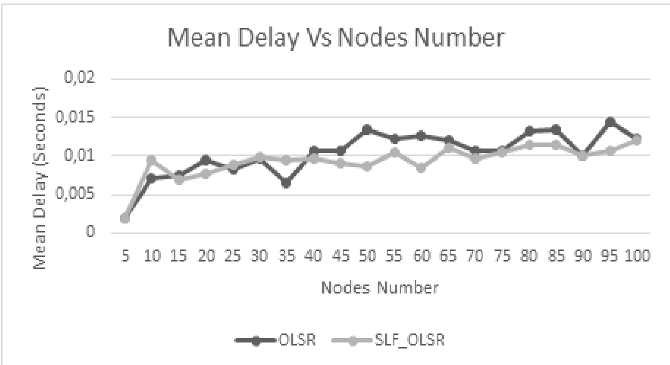

Figure 6. Mean Delay Comparison

The jitter is decreased due to mobility scheme and link's fineness between mobile nodes. In the context, SLF_OLSR has a minimum jitter compared to original OLSR as presented in Figure 7. The enhancement proves that the method defined by authors offers a dissimilarity in broadcast and communication, mainly in situations that contains more agitation nodes.

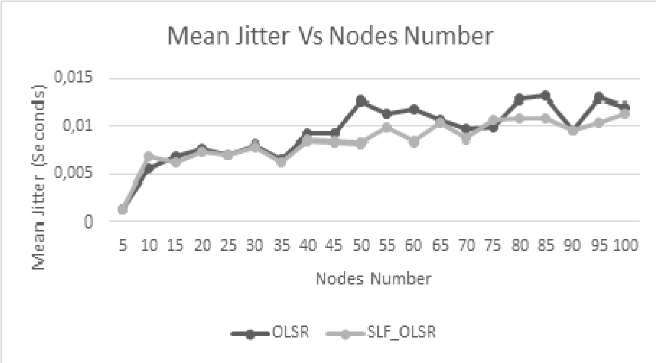

Figure 7. Mean Jitter Comparison

compared to original OLSR, SLF_OLSR protocol reflected a lowest value of the packet loss ratio as presented in Figure 8 and this is due to the quality of links and the relativity approach between mobile nodes which help the transmission of packet to be successfully completed.

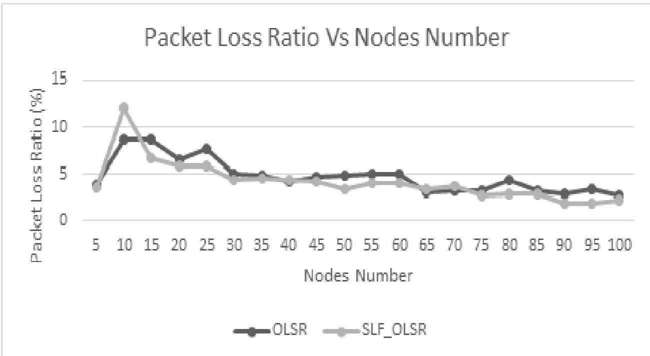

Figure 8. Packet Loss Ratio Comparison

Packets successfully broadcasted in both protocols are compared in Figure 9. Even in dense network, SLF_OLSR certified a better delivery of packets compared to original OLSR. In addition, the graph approves that SLF_OLSR protocol has good performance for packet delivery ratio (PDR).

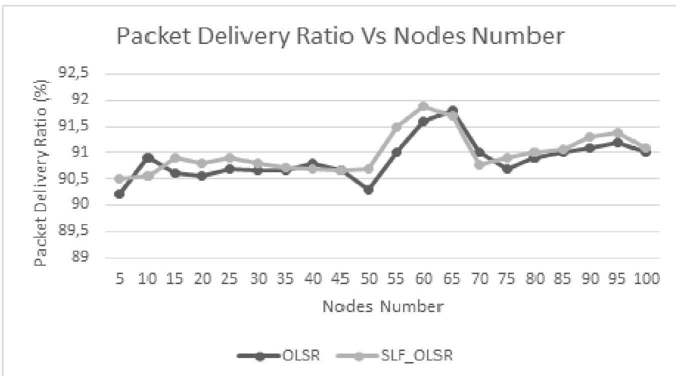

Figure 9. Packet Delivery Ratio Comparison

The Figure 10 exposes the comparison of lost packets in relation to node's number. The value of lost packets in SLF_OLSR is minor compared to original OLSR. The link quality, link duration, reachability and relativity are crucial to have an efficacy communication, which are attained by relativity and link's quality between nodes and their MPRs. SLF_OLSR avoids transmission's breaking frequently done between mobile nodes.

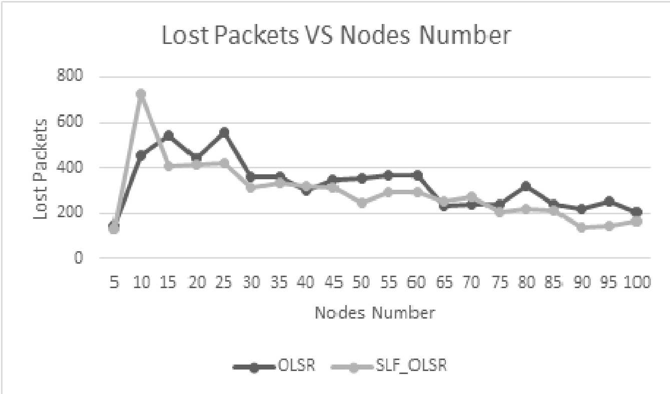

Figure 10. Lost Packets Comparison

Impact of node's number on throughput is shown in Figure 11. Furthermore, SLF_OLSR protocol based on relativity and link's quality integrated in the selection of MPRs, presented an enhanced throughput compared to original OLSR. Hence, the approach between mobile nodes helps the transmission of packet to be successfully accomplished.

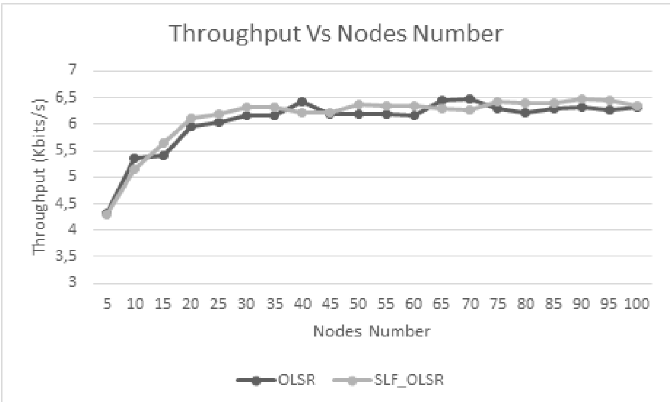

Figure 11. Throughput Comparison

5. CONCLUSIONS

In this paper, the author presented an efficient MPRs selection algorithm based on relativity and link quality which are based on mobility scheme and ratio of sent and received of hello packets. This approach helped to reduce the impact of mobility in mobile ad hoc networks by a purpose that objects to increase network reachability and quality. Based on the novel method, the maximum MPRs reachability with link's fineness are assured. As projected, MPRs designated are more powerful compared with original OLSR by involving new criteria in MPRs selection algorithm through SLFMPR value. NS3 simulator is used for evaluating performances. The Random Waypoint mobility model is considered for simulating the movement of mobile nodes in the simulation. Simulation results show that SLF_OLSR has an effective performance compared to the original OLSR in terms of lost packets, delay, jitter, PLR, PDR and throughput. In future works, an evaluation of the novel scheme with other mobility models and more scenarios will be expected to highlight the efficiency of the proposed method. Furthermore, a comparison of results with the latest OLSR-based protocol is also projected.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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