Multipoint Relay Selection based on Stability of Spatial Relation in Mobile Ad hoc Networks

Ayoub Abdellaoui[1], Jamal Elmhamdi[2] and Halim Berradi[3]

[1,2]Research Laboratory in Electrical Engineering, Team ERIT, Mohammed V University, ENSET, Morocco
[3]School Laboratory Computer & Telecommunication, Team M3S, Mohammed V University, ENSIAS, Morocco

Abstract: Increasing stability is one of the main objectives in designing routing protocols for Mobile Ad-Hoc Networks (MANETS). Various research schemes have been addressed to this challenge to support it. In fact, some papers have considered modifications to MPRs selection mechanism in OLSR. In this paper, the author proposes a new mechanism to elect stable and sustainable nodes relay between all nodes in MANETs. In this mechanism, a mobility function is used as the main selection criterion based on the calculation of the spatial relation of a node relative to its neighbor. This mechanism is applied in OLSR protocol to choose stable and supportable MPRs nodes. This mechanism significantly finds more stable MPRs and it promises QoS metrics such as lost packets and delay. Simulation results reveal a significant performance gains and it motivates further examinations to develop the mechanism in order to improve the routing protocol requirements. Performances are evaluated based on Random Waypoint model and network simulator ns3.

Keywords: Manets, Olsr, Mprs selection, Spatial relation, Ns3 simulator**.**

1. Introduction

Mobile Ad hoc Networks (MANETs) are a class of a collection of mobile wireless nodes intercommunicating on shared wireless channels. Essential features of such networks make a biggest challenge in the support of multimedia applications. In fact, the mobility of nodes directly impact delivery conditions of packets. MANETs are highly suitable for uses related to special outdoor events, communications in regions with no wireless infrastructure, emergencies or natural disasters and military operations. Therefore, routing is one of the key problems, since individual devices in MANETs are free to move in any direction and frequently devices links changes occur, due to their highly dynamic and distributed nature. Many routing protocols have been proposed for MANETs over the recent years. These protocols can be categorized into three different groups: proactive, reactive and hybrid.

In proactive routing protocols such as Destination-Sequenced Distance-Vector (DSDV) [1] and Optimized Link State Routing Protocol (OLSR) [2], the routes to all the destination or parts of the network are determined at the start up and maintained by using a periodic route update process. In reactive protocols such as Ad hoc On Demand Distance Vector (AODV) [3] and Dynamic Source Routing (DSR) [4], routes are determined when they are required by the source using a route discovery process. Hybrid routing protocols combined the basic properties of the first two classes of protocols into one. This routing protocols are mostly motivated on minimizing the number of hops of the provided paths. Definitely, minimizing the number of hops does not promises the quality of the selected links. Regardless of the attractive consumptions, the features of MANET present numerous challenges that must be considered with judgment. Some of these challenges take account of routing, location management, topology maintenance, security, restricted wireless transmission range, broadcast nature, packets lost, path changes due to the mobility of nodes, battery constraints, routing overhead, quality of service, scalability and security.

In this way, several strategies have been proposed to enhance the stability, routing performance, scalability and reachability in OLSR. Some of these strategies attempt to offer best paths in relations of a selected metric as distance and signal power or a combination of metrics as speed and direction of nodes. Some other approaches concentrated on reservation of resources.

Apart from this, it has been indicated that in various application scenarios, such as military operations [5] and rescue or searching operation, mobile nodes are moving in a similar design in a number of groups ,it’s called ,group mobility [6]. For this mobility, node group membership does not change regularly and thus it is more efficient to elect that node to be part of our routing and to represent our mobility pattern in the network, to maintain a reasonably stable network even if that topology variations may still happen with group partitions. OLSR is one of the routing protocol that offers better performances in the network by using MPRs nodes (Fig.1) that can characterize our mobility pattern considering its functionality [7],[8]. This functionality can be make this node as a membership of a several nodes or a group.

Researchers evaluated the link stability based on the geographical positions of the nodes, provided by Global Positioning System (GPS) or suggested probabilistic methods to estimate the reliable link lifetime.

In this way, the paper presents a probability-based mechanism allowing a correct estimation of the node's stability. The mobility function variation is considered as a main indicator of the nodes' mobility. Based on this mechanism better MPRs are successfully selected, in terms of stability and reachability.

Therefore, the mechanism goes to capture the group mobility pattern and to use this information to choose stable MPRs. To resolve the insufficiency in current MPRs Selection schemes, the paper proposes a new mobility mechanism adaptive MPRs Selection algorithm for OLSR in MANETs. The inspiration is to provide an optimal method for nodes to choose more stable MPRs as described before. The improved

MPRs selection algorithm is determined by the mobility pattern of neighbors to ensure maximum network stability. The mechanism is greater to other mobility schemes in OLSR in many features. Firstly, speed is no longer a limitation on the utility of the mechanism because it can be adjusted to high speed environment. Secondly, the mechanism is a simple algorithm implemented at each node. The paper proposes a probability-based mechanism for MPRs Selection named Stability of Spatial Relation MPR as a mobility information acquired from nodes. In the network, variations in positions are measured for nodes periodically. A mobile node must have the information of its location by using GPS. This information will be the base of our design to determine the mechanism.

MPRs Selection algorithm was modified and the speed, the acceleration and the direction were added in Hello message. The motivation in our study is to modify and to improve MPRs selection in OLSR using a technique of mobility for more performance in the network

Moreover, the author goes to make the network adaptable to variable situations for the network (slow speed, medium speed, high speed) to get an enhanced performance in terms of delivered packets, delay and lost packets. The speed is no longer a constraint on the effectiveness of the algorithm because it is a mobility method based algorithm that can be adjusted to high speed environment. Graphs revealed that the proposed algorithm of selection MPRs enhanced performances of the network.

However, the basic goals have always been to develop a routing protocol that minimizes control overhead, packet loss ratio, delay, energy usage and maximizing the throughput [9], [10].

The impact of these modifications on the network performance under Random Waypoint Model is evaluated. The performance of this work has been evaluated by NS-3 simulator [11]. The rest of the paper is organized as follows. Previous works done in the area of OLSR and improving MPRs Selection are reviewed in Section 2. Section 3 exposed and described the approach adopted to calculate the mobility mechanism for each node and highlighted how this mechanism is used in OLSR, especially MPRs Selection. The performance of the mechanism in OLSR and its comparison with OLSR Standard are given in Section 4. Finally, Section 5 concludes this paper.

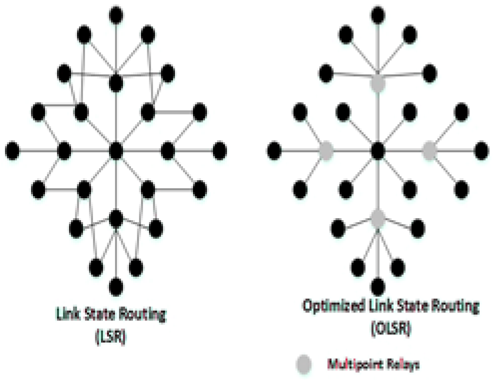

Figure 1. Multipoint Relays

2. Related Work

In this section, the author presents different proposed schemes used in some routing protocols for wireless ad hoc networks as the link stability and the mobility degree. These protocols are classified according to the distance and the mobility of nodes. This schemes presented two categories of protocols, protocols based on speed, direction, position of nodes, etc., as parameters of nodes' mobility and the other category is based on probabilistic methods or the degree of mobility.

TBP-SE (Ticket- Based Probing with Stability Estimation) proposed in [12] is an improvement of Ticket-Based Probing protocol (TBP) [13]. This last, installed paths based on QoS requirements but without considering their stability and their durability. For this, authors of TBP-SE have added to this protocol another metric for stable and durable paths selection. This metric of link stability, based on the distance between nodes, is calculated by the information provided by the GPS or the signal quality.

Nityananda Sarma and Sukumar Nandi have proposed a protocol based on the signal strength to estimate the stability of the link [14]. Authors considered the link stability with other QoS metrics to obtain a QoS routing protocol based on the link stability. The path that has the largest product of links' stability values compared to the other paths will be elected as the most stable.

In this paper [15], authors proposed a protocol where the choice of the path is done based on two metrics: the residual energy and the mobility of nodes. For this, they have proposed a formula to calculate the weighted sum of the two metrics. Authors calculated the residual energy metric as the remaining energy of a node divided by the rate of the traffic that passes through this node. The second metric is calculated as the difference of the number of the node's neighbors in time T and time $T-\delta$ (T) divided by the number of its neighbors in time T.

Authors proposed in [16] a new method to evaluate the quality of the link in terms of link duration. For this, authors adopted a variable sized sampling window and proposed a probabilistic method, based on Markov chain, to estimate the probability that a link switches the state from the connected to unconnected state and vice versa. To show the effectiveness of this method, authors proposed a routing method which adjusts its operating mode (i.e. OLSR, AODV and ZRP (Zone Routing Protocol)) based on the estimated link stability. In the same context, authors proposed in [17] a new mechanism to establish stable and sustainable paths between all pairs of nodes in a Mobile Ad hoc Network. In this mechanism, the author used a stability function as the main path selection criterion based on the calculation of the mobility degree of a node in relation to its neighbor.

In the context of Proactive routing, the multipoint relay selection perform very well to disseminate the broadcasted packet into the network. Actually, many works presented in the literature were interested in this topic. MPRs nodes can greatly affect the network performance, then selecting reliable MPRs presented promising problems to increase this performances. Numerous protocols reflected the mobility of nodes to estimate the stability of being neighbor for a long period.

MPRs nodes broadcast inside TC messages links which could establish paths from source to destination, then the set of MPRs creates a kind of backbone in the mobile ad hoc network. Thus, one hopeful subject of routes selection optimization is to sensibly choose MPRs that meet a given necessity to improve the network performance. Truly, an analysis of MPRs selection in OLSR Protocol [18] resolved that routes performance can be improved by adopting some additional criteria on MPRs mechanism. Furthermore, routing metrics can be also taken into consideration to select nodes relays. Most of works in OLSR aim to discover other efficient metrics rather than the default one defined in the RFC3626 where the path quality is measured by the number of hops.

Based on OLSR, the author [19] proposed a protocol employing a fuzzy logic into MPRs selection, considering the features of mobile ad hoc networks such as the high mobility and loss channels, the fuzzy logic is employed to take account of internode distance, node movement and received signal strength. Results indicated that the proposed protocol can provide a significantly higher packet delivery ratio compared to the original OLSR.

Another paper [20], proposed a MPRs selection algorithm. The author integrated this algorithm into a new mobility-aware OLSR protocol through spatial mobility techniques that are able to promptly monitor the degree of movement correlation between a node and its neighbors and that in order to improve the stability of MPRs set. This new technique provides a performance gain in terms of packet delivery ratio and end-to-end delay, besides presenting fewer out of order packets.

In routing protocols for mobile networks, the necessity of reachability and high stability is a problematic related to the limits imposed by dynamic environment caused by mobile nodes. In this way, numerous studies were proposed, which taking into consideration the degree of mobility effect to systematically examine the impact of mobility on the performance of routing protocols for ad hoc networks.

Since a mobile node may move according to other node's movement it is an opportunity to think about mobility metrics that measure this relationship.

Related to this statement, Bai et al. [21] suggested the important framework to systematically analyze the impact of mobility on the performance of routing protocols for ad hoc networks. They proposed two mobility techniques for quantifying temporal and spatial movement dependence among mobile nodes. Both techniques are based on the cosine similarity between the velocities of nodes.

The first technique is Degree of Spatial Dependence between nodes (i) and (j) at time t, DSD (i,j,t), as exposed in Eq. (1).

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

The average Degree of Spatial Dependence (DSD) is computed as the average among all nodes during simulation time. Group-based mobility models (e.g., RPGM) are expected to present high values for DSD.

The second mobility technique proposed in the framework is Degree of Temporal Dependence (DTD) (Eq. (2)), which is similar to DSD, but DTD takes into account the difference between velocities along two time slots. Thus, the current node speed is expected to depend on its past moving pattern. This technique reflects the smoothness of node movement.

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

DSD [21] and DTD [22] are two examples of spatial mobility metrics.

In order to provide a better understanding of spatial dependence, authors in [23] proposed a more comprehensive mobility metric, Degree of Node Proximity (DNP), based on the average distance among mobile nodes. Through simulation, authors compared their metric against other well-known spatial metric over an extensive set of mobility models. DNP is shown able to capture spatial dependence in scenarios with different levels of node pause time.

Based on the work by Bai et al., Zhang [24] extended and developed the concept of a very similar spatial mobility technique (spatial dependence (SD)) called linear distance based spatial dependency (LDSD). The author employed SD on the design of a distributed group mobility adaptive clustering algorithm. In the same area Wei Fan and Yan Shi [25] extended the definition of the mobility technique, Spatial Dependency (SD), and used it as the key in clustering algorithm design. The technique captured the similarity of the mobility features between two nodes that are within their communication range. Authors used this scheme to extract the characteristics of group mobility in VANETs. The node calculates Cluster Relation (CR) and the node with highest CR value is entitled as the cluster head which represents and reflects the mobility features of the cluster.

In the same context, the paper [26] presented a new method for clustering in VANETs to select the cluster heads based on the standard deviation of average relative velocity and density matrices in their neighborhood. Vehicle, which is having more homogeneous environments, will become the cluster heads and rest of the vehicles in their communication range will be the Cluster Members (CMs). The simulation results demonstrate the better performance of MADCCA over other clustering algorithms new ALM and MOBICA.

Another paper [27] proposed a new opportunistic routing protocol (DPOR) that uses driving path predictability and vehicular distribution in its route selection procedure. This protocol is composed of two phases: intersection and next hop selection phases. A utility function is calculated to select the next intersection and a new mechanism is also proposed for the next hop selection phase. Simulation results show that DPOR achieves high delivery ratio and low end-to-end delay in the network. Therefore, researchers in [28] and [29] developed a new mechanism through mobility integration to enhance network performance in OLSR protocol. The first is based on the mobility rate and the last is based on the formula of mobility to improve OLSR and Mob-OLSR with presenting a new protocol called Mob-2-OLSR.

Diverse mobility models can be used to evaluate MANETs routing protocols performance. They can be ordered into two categories: entity and group mobility models. Detailed analysis of these models can be found in [30], [31]. This paper is based on Random Waypoint model [32].

3. Proposed Mechanism

In Mobile Ad hoc Networks, there is no completely stable nodes due to a randomly movement at any time. The mechanism of stability that the paper proposes is based on spatial dependency and statistics.

3.1 Terminology and Introduction of the Improvements

Related to works cited before, the author developed and extended a mobility mechanism named Stability of Spatial Relation MPR (SSRMPR) to use it in the basic selection of MPRs in OLSR.

SD captures the similarity of mobility characteristics between two nodes that are within their communication range. Nodes with same mobility characteristics are more expected to move together over a period of time to complete their tasks until one of this nodes leaves the transmission range and cannot be selected as MPR.

Table 1. Terminology of the Improvement

Terminology	Description	Unit of measure
D	The linear distance	[m]
S	The average speed	[m/s]
Θ	The node's direction	[°]
V	The node's velocity	[m/s]
A	The average acceleration	[m/s^2]
∆T	Time interval	[s]
t	The current time	[s]
RS(i,j)	Relative speed	
RA(i,j)	Relative acceleration	
RD(i,j)	Relative direction	
SD	Spatial dependency	
TSD	Total Spatial dependency	
SRMPR	Spatial Relation of mpr	
SSRMPR	Stability of Spatial Relation Mpr	
∆xT,∆yT	The increment of the linear distance in x and y coordinates	
xit0,yit0,xti,yti,xTi,yTi	The coordinates of the node i at different time	

Network mobility is mainly characterized by the degree of dependence of movement between nodes. Schemes that measures this property are said spatial mobility as in [10]. For instance, Degree of Spatial Dependence (DSD) is a familiar mobility scheme, it measures the spatial correlation between movements of users and it is based on the cosine correspondence between nodes velocities.

However, in some case scenarios including battlefield communication, certain specific nodes (leader) influenced the movement pattern of a mobile node in its neighborhood. In our case, MPRs play that role. Therefore, there is a correlation of mobility between a numbers of nodes.

In our proposed mobility mechanism, each node has a characteristic S(t), D(t) and A(t). Based on this parameters, nodes can calculate their RS, RD and RA to define their SRMPR value. SRMPR represents the relationship of mobility features closing to nodes that selected it as MPRs. Further, the author extends MPRs Selection Algorithm based on mobility features. The acceleration acts as a random variable and depends on velocity variation over the time. With the acceleration, the mechanism can signify more exact correlation between nodes to extract their mobility features.

Depending on the interval of time, this mechanism is based on the calculation of the probability that a node will remain stable for a long time with its neighbors. The method, measures the stability values depending on the variance of SRMPR of the node calculated in relation with its neighbors.

3.2 Description of the Proposed Mechanism

In probability theory, Bienaymé-Chebyshev inequality [33] guarantees that in any data sample or probability distributions whatever be the discrete variable X, the strictly positive expectation E(X) and the variance V(X) we have the following inequality:

$$P\{|X-E(X)|\langle\varepsilon\}\geq 1-\frac{\text{var}(X)}{\varepsilon^2}$$

The probability $P\{|X-E(X)|\langle\varepsilon\}$ is always true if the variance tends to 0.

$$1-\frac{\text{var}(X)}{\varepsilon^2} \text{ tends to 1 } \Rightarrow V(X) \text{ tends to 0}$$

This also reflects the probability that the value of the random variable X is always close or equal to its expectation (little change in the future):

$P\{|X-E(X)|\langle\varepsilon\}$ Little change in the future

By definition

$$V(X)=E(X^2)-E(X)^2 \text{ And } E(X)=\sum_i \frac{X_i}{n}$$

$$V(X)=\left(\sum_i \frac{X_i^2}{n}\right)-\left(\sum_i \frac{X_i}{n}\right)^2 \quad (3)$$

Let MPR(S), N(S) and N2(S) as the MPR, N and N2 of the node S which are computed as the original OLSR protocol. The default algorithm of selection MPR is used to keep the original algorithm of OLSR and after studying all steps in this algorithm, the place to add our technique without changing the OLSR algorithm is founded.

Let's considering a network of a mobile ad hoc network consisting of a set of nodes among which a 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 transmission range of (i).

At every time interval (∆T), let (∆xT) and (∆yT) be the increment of the linear distance in (x) and y coordinates as:

$$\Delta xT_i=(xt_i - xT_i)$$
$$\Delta yT_i=(yt_i - yT_i) \quad (4)$$

Where (t) is the current time and (xti), (yti), (xTi), (yTi) are the coordinates of the node (i) at time (t) and (T) respectively. Therefore, the linear distance (D) can be calculated by:

$$D=\sqrt{\Delta xT^2+\Delta yT^2} \quad (5)$$

Accordingly, the speed (S) over time (∆T) can be calculated as:

$$S=\frac{D}{\Delta T} \quad (6)$$

The values of the node's direction (θ) can be defined as:

$$\theta_i=\begin{cases}\varphi.sin(\Delta yT_i) & \Delta xT_i\rangle 0\\ \frac{\pi}{2}.sin(\Delta yT_i) & \Delta xT_i=0\\ (\pi-\varphi).sin(\Delta yT_i) & \Delta xT_i\langle 0\end{cases} \quad (7)$$

$$where \quad tan\varphi = \left|\frac{\Delta yT_i}{\Delta xT_i}\right| and \quad \theta_i \in (-\pi, \pi)$$

Based on the velocity (V), the node can compute the acceleration (A) over time ΔT as:
The velocity (V) is the speed (S) with the direction (θ)

$$A = \frac{\Delta_V}{\Delta T} \quad (8)$$

Based on this values, a node calculates its Total Spatial Dependency (TSD) and its Stability of Spatial Relation MPRs (SSRMPR) with the following steps:
First step: Nodes exchange its mobility information, speed (S), acceleration (A) and direction (θ) with its directly connected neighbors through Hello packets (Fig.2).

Reserved		Htime	Willingness
Link Code	**Reserved**	**Link Message Size**	
Speed	**Acceleration**	**Direction**	**SSRMPR**
Neighbor Interface Address			
Neighbor Interface Address			

Figure 2. Modified Hello Message in OLSR Protocol

Second step: A node calculates its Relative Speed (RS), Relative acceleration (RA) and Relative Direction (RD) with its directly connected neighbors.
For example, for nodes (i) and (j), RS of these two nodes is defined as:

$$RS_{(i,j,t)} = log(1 - \frac{|S_i - S_j|}{S_{max}}) \quad (9)$$

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:

$$RD_{(i,j,t)} = cos(\theta_i(t) - \theta_j(t)) \quad (10)$$

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

$$RA_{(i,j,t)} = log(1 - \frac{|A_i - A_j|}{A_{max}}) \quad (11)$$

Where (Amax) is the node's maximum acceleration.
Third step: Spatial Dependency (SD) between node (i) and node (j) can be calculated as:

$$SD_{(i,j,t)} = RS_{(i,j,t)} * RA_{(i,j,t)} * RD_{(i,j,t)} \quad (12)$$

Fourth step: the node takes the summation of all (SD) it has and calculates Total Spatial Dependency (TSD) by the following equation:

$$TSD_{(i,t)} = \sum_{j=1}^{n} SD_{(i,j,t)} \quad (13)$$

Where n is direct neighbors of the node (i).
Fifth step: Spatial Relation MPR (SRMPR) of a node is defined as the average (TSD) of all its n neighbors and it can be calculated as:

$$SR_{MPR(i,t)} = \frac{1}{n}\sum_{j=1}^{n} SD_{(i,j,t)} = \frac{1}{n} TSD_{(i,t)} \quad (14)$$

A higher (SRMPR) value implies that node (i) has a larger neighbor set and it has a similar mobility pattern with its neighbors. The speed, the direction and the acceleration may be powerfully associated together. Accordingly, a node with a higher SRMPR value is eligible as MPR which represents and reflects the mobility features of the group (neighbors connected).
SRMPR value defined above can extend stability, improve reachability and make the routing applicable in extremely mobile environment.
Our mechanism based on Bienaymé–Chebyshev inequality will take values of Spatial Relation MPR in different intervals of time. The mechanism of stability proposed is as follows:

$$SSR_{MPR} = V(X_i) \quad (15)$$

According to (3) and (15)

$$SSR_{MPR} = \left(\sum_i \frac{X_{Bi}^2}{n}\right) - \left(\sum_i \frac{X_{Bi}}{n}\right)^2$$

$$SSR_{MPR} = \left(\sum_i \frac{Spatial\_relation_i^2}{n}\right) - \left(\sum_i \frac{Spatial\_relation_i}{n}\right)^2 \quad (16)$$

The node is stable if values of spatial relation are very close to their expected value. In a specific case, if the mathematical variance of these spatial relation values is equal to zero, it can say that the node is strictly stable with its neighbors based on SRMPR and it can be selected as stable MPR.

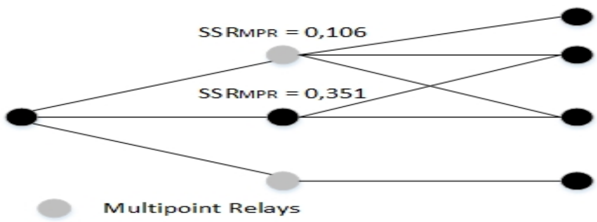

Figure 3. The Modified MPRs Selection (SSRMPR)

3.3 Flow Chart of MPRs Selection with Stability of Spatial Relation

The flow chart of the new MPRs Selection is needed to fully understand the process and mechanism process within the MPRs selection algorithm (Fig.4).

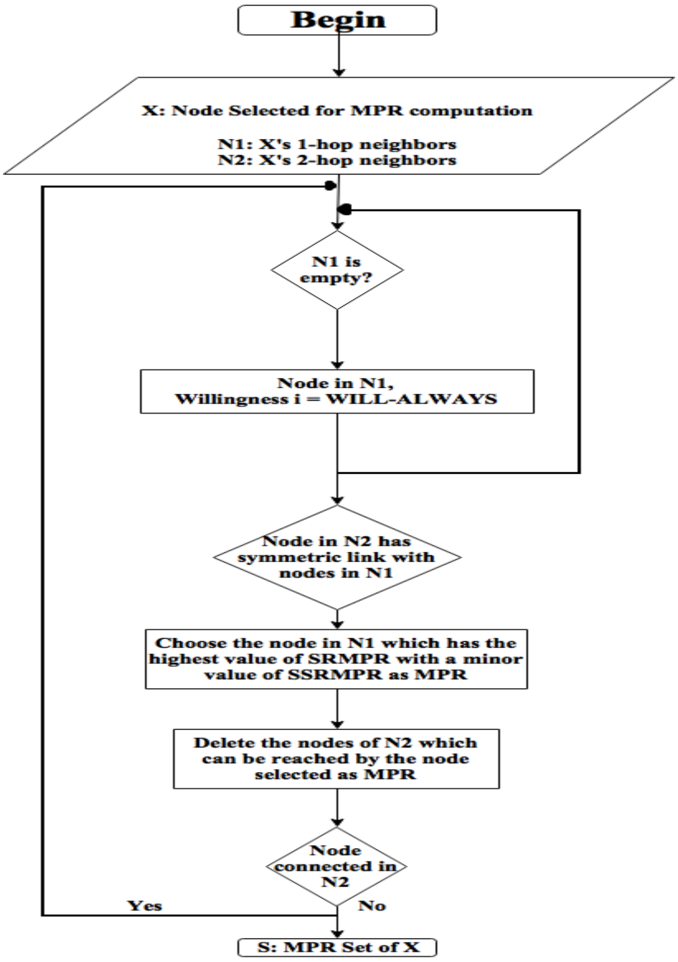

Figure 4. The Flow chart of the Modified MPRs Selection (SSRMPR)

4. Results and Analysis

4.1 Simulation Mobility Model

Diverse studies have been done in modeling mobility for MANETs but Random Waypoint stills the greatest used. Our experiment is configured in a C++ environment which is created by ourselves under the NS3 simulator.
Table 2 summarizes all the parameters used during simulations.

4.2 Comparison and Discussion

It can observe the effect of node number on Delay, Jitter, Packet Delivery Ratio, Packet Loss Ratio, Throughput and Lost Packets. The comparison for both protocols is exposed in graphs below. It is observed that SSROLSR revealed improvement as compared with OLSR when the network contains more number of nodes. This confirms the effective use of SSROLSR for dense networks. The impact of node number on performances of the protocol can be observed in the comparison result. Compared to OLSR, SSROLSR minimizes the delay using the spatial dependency and the relativity between nodes. Generally, SSROLSR has a minimum delay and jitter among all (Fig.5 and Fig.6). Therefore, this mechanism minimizes the delay and the jitter. This attests, that our version gives a change in transmission delays and particularly in environments that are categorized by more agitation nodes.

Table 2. Simulation Parameters

Simulation Parameters	Value
Flat Size	1000 m × 1000 m
Max Number Of Nodes	5,10,15,20,25,30,35,40,45,50,55,60,65,70
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	RandomWayPoint
Pause Time	1 seconds
Maximum Speed of Nodes	30 m/s
Simulation Time	200 Seconds
Flat Size	1000 m × 1000 m
Max Number Of Nodes	5,10,15,20,25,30,35,40,45,50,55,60,65,70
Radio Scoop	250 m
MAC Layer	IEEE.802.11.peer to peer mode

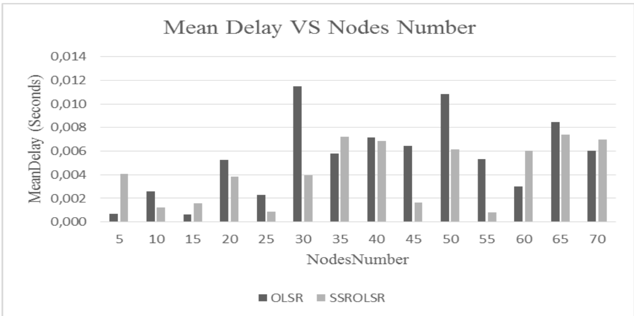

Figure 5. Mean Delay Comparison

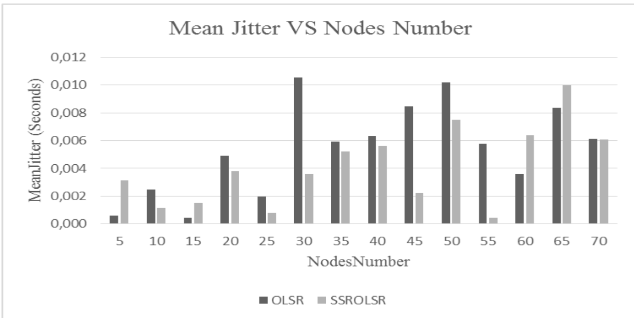

Figure 6. Mean Jitter Comparison

The lowest value of packet loss ratio and lost packets, the highest value of throughput and packet delivery ratio mean better performance of SSROLSR protocol. The author interprets these results that in OLSR the data is high for unreliable connection due to MANET's nature. Inversely it is revealed that SSROLSR can achieve lowest packet loss ratio and with the help of relativity node the transmission of packet is successfully reached. The probabilistic method used in this mechanism help the networks to become stable for better communication and fewer lost packets between nodes as exposed in graphs below.

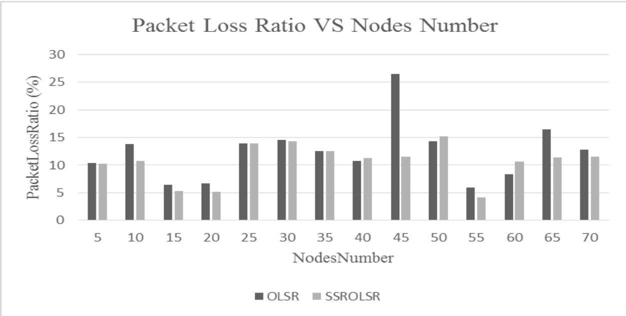

Figure 7. Packet Loss Ratio Comparison

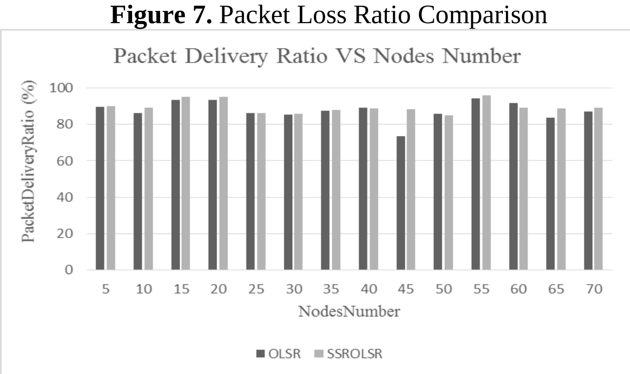

Figure 8. Packet Delivery Ratio Comparison

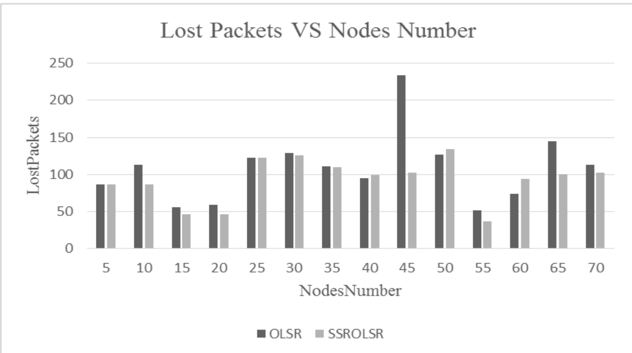

Figure 9. Lost Packets Comparison

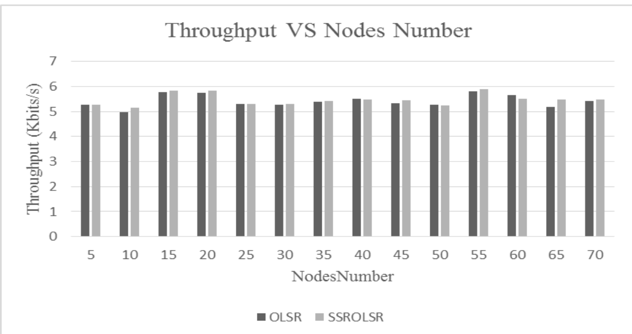

Figure 10. Throughput Comparison

5. Conclusion

In mobile environment, such as Ad hoc networks, it is very challenging to make available perfect solutions to satisfy the QoS necessities. This paper proposed a mechanism that allows stability and preservation reachability. For this, the author suggests a mobility mechanism in the routing decision algorithm by adopting different parameters which are speed, acceleration and direction of mobile nodes to elect stable MPRs nodes by adopting a probabilistic method. The simulation results approve the efficiency of the suggested mechanism in terms of packet delivery ratio, delay, lost packets, etc. The mobility is not the unique limitation of nodes in MANETs. Fort this, as future works, the author attempts to progress efforts to support other parameters like node's energy and reputation to implement it in the real experiment.

References

[1] C. E. Perkins, and P. Bhagwat, "Highly dynamic Destination-Sequenced Distance-Vector routing (DSDV) for mobile computers," SIGCOMM Comput. Commun. Rev., vol. 24, no. 4, pp. 234-244, 1994. https://doi.org/10.1145/190809.190336

[2] Clausen, T. and Jacquet, P. "Optimized Link State Routing Protocol (OLSR)", RFC Editor, 2003.

[3] C. Perkins, E. Belding-Royer, and S. Das, Ad hoc On-Demand Distance Vector (AODV) Routing: RFC Editor, 2003.

[4] D. B. Johnson, D. Maltz, and J. Broch, DSR: The Dynamic Source Routing Protocol for Multi-Hop Wireless Ad Hoc Networks, 2002.

[5] T. Plesse, C. Adjih, P. Minet, A. Laouiti, A. Plakoo, M. Badel, P. Muhlethaler, P. Jacquet, and J. Lecomte, "OLSR performance measurement in a military mobile ad hoc network," Ad Hoc Networks, vol. 3, no. 5, pp. 575-588, 2005/09/01/, 2005.

[6] X. Hong, M. Gerla, G. Pei, and C.-C. Chiang, "A group mobility model for ad hoc wireless networks," in Proceedings of the 2nd ACM international workshop on Modeling, analysis and simulation of wireless and mobile systems, Seattle, Washington, USA, 1999, pp. 53-60. https://doi.org/10.1145/313237.313248

[7] A. Boushaba, A. Benabbou, R. Benabbou, A. Zahi, and M. Oumsis, "Multi-point relay selection strategies to reduce topology control traffic for OLSR protocol in MANETs," Journal of Network and Computer Applications, vol. 53, pp. 91-102, 7//, 2015.

[8] T. Kitasuka and S. Tagashira, "Finding more efficient multipoint relay set to reduce topology control traffic of OLSR," 2013 IEEE 14th International Symposium on "A World of Wireless, Mobile and Multimedia Networks" (WoWMoM), Madrid, 2013, pp. 1-9. doi: 10.1109/WoWMoM.2013.6583478.

[9] H. Nishiyama, T. Ngo, N. Ansari, and N. Kato, "On Minimizing the Impact of Mobility on Topology Control in Mobile Ad Hoc Networks," IEEE Transactions on Wireless Communications, vol. 11, no. 3, pp. 1158-1166, 2012. https://doi.org/10.1109/TWC.2012.010312.110783

[10] N.Sarmah, Y. Yang, H. Sharif, Y. Qian, "Performance Analysis of Mobile Ad-Hoc Routing Protocols By Varying Mobility, Speed And Network Load", Masters Thesis, University of Nebraska-Lincoln, July 2014.

[11] G. F. Riley, and T. R. Henderson, "The ns-3 Network Simulator," Modeling and Tools for Network Simulation, K. Wehrle, M. Güneş and J. Gross, eds., pp. 15-34, Berlin, Heidelberg: Springer Berlin Heidelberg, 2010.

https://doi.org/10.1007/978-3-642-12331-3_2
[12] W. Zhu, M. Song and S. Olariu, "Integrating Stability Estimation into Quality of Service Routing in Mobile Ad-hoc Networks," 200614th IEEE International Workshop on Quality of Service, New Haven, CT, 2006, pp. 122-129. doi: 10.1109/IWQOS.2006.250459
[13] C. Shigang, and K. Nahrstedt, “Distributed quality-of-service routing in ad hoc networks,” IEEE Journal on Selected Areas in Communications, vol. 17, no. 8, pp. 1488-1505, 1999. https://doi.org/10.1109/49.780354
[14] N. Sarma, and S. Nandi, “Route Stability Based QoS Routing in Mobile Ad Hoc Networks,” Wireless Personal Communications, vol. 54, no. 1, pp. 203-224, July 01, 2010. https://doi.org/10.1007/s11277-009-9718-z
[15] Xia Li, Li Qilong, Zou Jian and Zhang Qianyu, "A state-aware routing protocol based on energy and stability for mobile Ad Hoc networks," 2010 Second International Conference on Communication Systems, Networks and Applications, Hong Kong, 2010, pp. 329-332. doi: 10.1109/ICCSNA.2010.5588734.
[16] Q. Song, Z. Ning, S. Wang, and A. Jamalipour, “Link stability estimation based on link connectivity changes in mobile ad-hoc networks,” Journal of Network and Computer Applications, vol. 35, no. 6, pp. 2051-2058, 2012/11/01/, 2012.
[17] A. Moussaoui, F. Semchedine, and A. Boukerram, “A link-state QoS routing protocol based on link stability for Mobile Ad hoc Networks,” Journal of Network and Computer Applications, vol. 39, pp. 117-125, 2014/03/01/, 2014.
[18] D. Nguyen, and P. Minet, “Analysis of MPR Selection in the OLSR Protocol,” in Proceedings of the 21st International Conference on Advanced Information Networking and Applications Workshops - Volume 02, 2007, pp. 887-892. https://doi.org/10.1109/AINAW.2007.94
[19] N. Dashbyamba, C. Wu, S. Ohzahata and T. Kato, "An improvement of OLSR using fuzzy logic based MPR selection," 2013 15th Asia-Pacific Network Operations and Management Symposium (APNOMS), Hiroshima, Japan, 2013, pp. 1-6.
[20] E. R. Cavalcanti and M. A. Spohn, "Enhancing OLSR protocol performance through improved detection of Spatial Dependence," 2014 IEEE Symposium on Computers and Communications (ISCC), Funchal, 2014, pp. 1-6. doi: 10.1109/ISCC.2014.6912477
[21] F. Bai, Narayanan Sadagopan and A. Helmy, "IMPORTANT: a framework to systematically analyze the Impact of Mobility on Performance of Routing Protocols for Adhoc Networks," IEEE INFOCOM 2003. Twenty-second Annual Joint Conference of the IEEE Computer and Communications Societies (IEEE Cat. No.03CH37428), San Francisco, CA, 2003, pp. 825-835 vol.2. doi: 10.1109/INFCOM.2003.1208920
[22] E. R. Cavalcanti, M. Aur, #233, and l. Spohn, “On improving temporal and spatial mobility metrics for wireless ad hoc networks,” Inf. Sci., vol. 188, pp. 182-197, 2012. https://doi.org/10.1016/j.ins.2011.11.015
[23] E. R. Cavalcanti, M. Aur, #233, and l. Spohn, “Degree of node proximity: a spatial mobility metric for manets,” in Proceedings of the 9th ACM international symposium on Mobility management and wireless access, Miami, Florida, USA, 2011, pp. 61-68.
[24] Yan Zhang, Jim Mee Ng, Chor Ping Low, ”A distributed group mobility adaptive clustering algorithm for mobile ad hoc networks”, Computer Communications, Volume 32, Issue 1, 2009, Pages 189-202, doi.org/10.1016/j.comcom.2008.10.002.
[25] Wei Fan, Yan Shi, Shanzhi Chen and Longhao Zou, "A mobility metrics based dynamic clustering algorithm for VANETs," IET International Conference on Communication Technology and Application (ICCTA 2011), Beijing, 2011, pp. 752-756. doi: 10.1049/cp.2011.0769
[26] N. Mirjazaee, and N. Moghim, “A Driving Path Based Opportunistic Routing in Vehicular Ad Hoc Network,” International Journal of Communication Networks and Information Security (IJCNIS), vol. 7, no. 3, pp. 162-168, December 2015, December 2015.
[27] A. Ram, and M. K. Mishra, “Mobility adaptive density connected clustering approach in vehicular ad hoc networks”, International Journal of Communication Networks and Information Security (IJCNIS), Vol. 9, No. 2, August 2017, 222-229.
[28] H. Amraoui, A. Habbani and A. Hajami, "Mobility quantification for MultiPoint Relays selection algorithm in Mobile Ad hoc Networks," 2016 5th International Conference on Multimedia Computing and Systems (ICMCS), Marrakech, 2016, pp. 278-283. doi: 10.1109/ICMCS.2016.7905672
[29] A. Ouacha, N. Lakki, J. El abbadi, A. Habbani and M. El koutbi, "OLSR protocol enhancement through mobility integration," 2013 10th IEEE INTERNATIONAL CONFERENCE ON NETWORKING, SENSING AND CONTROL (ICNSC), Evry, 2013, pp. 17-22. doi: 10.1109/ICNSC.2013.6548704
[30] T. Camp, J. Boleng, and V. Davies, “A survey of mobility models for ad hoc network research,” Wireless Communications and Mobile Computing, vol. 2, no. 5, pp. 483-502, 2002. https://doi.org/10.1002/wcm.72
[31] N. Sadagopan, F. Bai, B. Krishnamachari, and A. Helmy, “PATHS: analysis of PATH duration statistics and their impact on reactive MANET routing protocols,” in Proceedings of the 4th ACM international symposium on Mobile ad hoc networking & computing, Annapolis, Maryland, USA, 2003, pp. 245-256. https://doi.org/10.1145/778415.778444
[32] R. R. Roy, "Mobility Model Characteristics," Handbook of Mobile Ad Hoc Networks for Mobility Models, pp. 23-32, Boston, MA: Springer US, 2011. https://doi.org/10.1007/978-1-4419-6050-4_2
[33] Csiszár, Villő & Móri, Tamás & Szekely, Gabor. (2005). Chebyshev-type inequalities for scale mixtures. Statistics & Probability Letters. 71. 323-335. 10.1016/j.spl.2004.11.015.