Journal of Theoretical and Applied Information Technology
15th May 2018. Vol.96. No 09

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

MULTIPOINT RELAYS SELECTION THROUGH STABILITY OF ESTIMATED SPATIAL RELATION IN MOBILE AD HOC NETWORKS

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ABSTRACT

In Mobile Ad hoc Networks (MANETs), the mobility concept is an essential element of network performances. MANETs has a scalability constraint in terms of reachability and stability. Optimized Link State Routing (OLSR) protocol is a proactive routing protocol for wireless mobile ad hoc networks and the key idea behind it is to improve Multi-Point Relays (MPRs) selection algorithm. This paper proposed a new mechanism based on, a spatial mobility which speed, acceleration and direction Prediction-based Localization are included; named, Stability of Estimated Spatial Relation MPR. Furthermore, this mobility value will be exchanged between nodes using HELLO message and it will be used as a condition when a node selects its MPRs set. In addition, simulation results by Network Simulator 3 (NS3) have revealed that the improved algorithm could improve network performances in terms of throughput, delay and lost packets. Similarly, the proposed algorithm can be used as a functional mobility mechanism to improve MANETs.

Keywords: *MANETs, OLSR, MPRs, Estimated Spatial Relation, Stability, NS3 Simulator*

1. INTRODUCTION

Nodes in Mobile Ad hoc Networks (MANETs) being self-organizing and self-administering, this allows communications without any preexisting infrastructure. Moreover, each node can move with different speed and direction which may not be constant and may change rapidly and unpredictably over time. Hence, MANETs can be considered as an infrastructure-less network, where one node can relay packets to another node without using any base stations. In MANETs, each node has a transmission range within which signals emitted are strong enough to enable other nodes to extract meaningful information. Two nodes can communicate directly, when they happen to be within the transmission range of each other. If not, they use a number of links involving one or more intermediate nodes to communicate with each other. This mode of communication is called multi-hop communication and this is the reason why MANETs are called ~~as~~ multi-hop wireless networks. 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 link~~s~~ changes occur, due to their highly dynamic and distributed nature. Many routing protocols have been proposed for MANETs over the recent years and they 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], 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 combine the basic properties of the first two classes of protocols into one.

In wireless networks, OLSR protocol is an important routing protocol, because it is considered to be the key to support this routing protocol by Multipoint Relays (MPRs) technology (Figure.1)

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[5],[6]. However, MANETs consist generally of mobile devices which makes routing more complicated as it must be performed in a mobility-adaptive and real time. Having stable nodes in MANETs makes dynamic topology appear less dynamic and large networks seem smaller.

Definitely, minimizing number of hops does not guarantee the quality of the selected links. Therefore, several strategies have been proposed to enhance the stability, routing performance, scalability, reachability in OLSR. While some of these strategies tried to offer the greatest paths in relation of a selected metric as distance and signal power, etc. or a combination of metrics like speed and angle of movement of nodes, other methods focus on reservation of resources.

Mobility is considered as an essential phenomenon of MANETs and so, discussing mobility schemes by assuming low mobility becomes necessary [7]. Apart from this, it has been revealed that in various application scenarios, such as military operations [8] and rescue or searching operation, mobile nodes are moving in a similar design in a number of groups, it’s called, group mobility[9]. For this mobility, the 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 changes may still happen with group partitions. OLSR is one of the routing protocols that offer~~s~~ a better performance in the network by using MPRs nodes that can characterize the mobility pattern considering its functionality [10],[11]. This functionality can ~~be~~ make this node as a leader among several nodes or groups, that is the reason why our algorithm goes to capture the group mobility pattern and use this information to choose stable MPRs. To resolve the insufficiency in current MPRs Selection schemes, this paper proposes a new probability-based mechanism allowing a correct estimation of the node's stability. In fact, the author considers the mobility function variation as a key indicator of the nodes' mobility. It should be noted that the use of such metric tolerates to successfully select best MPRs in terms of stability and reachability.

In this paper, MPRs Selection algorithm was modified and the predicted position of nodes was added in Hello message with the predicted speed, the predicted acceleration, the predicted direction and the stability value. The motivation in our study is to modify and to improve MPRs selection in OLSR using a mechanism of mobility for more stability, reachability and performance in the network [7],[12],[13]. Furthermore, the author attempts to make the network adaptable to variable environments (slow speed, medium speed, high speed) with a better performance in terms of delivered packets, delay and lost packets. The speed is no longer a limitation on the utility of the algorithm because it is a mobility technique based algorithm that can be adjusted to high speed environment. There have been many existing routing protocols for ad hoc networks emphasizing different implementation scenarios. However, the basic goals have always been to devise a routing protocol that minimizes control overhead, packet loss ratio, energy usage and maximizing the throughput [14],[15]. These goals are subject to different issues concerning the improvement of protocols, their adaptation with the environment and their perfection in this adapted environment.

Note that the impact of these modifications on the network performance under Random Waypoint Model has been evaluated and that the performance of this work has been evaluated by NS-3 simulator. 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, while Section 3 reveals and describes the approach adopted. The modified OLSR and its comparison with OLSR Standard is given in Section 4. Finally, Section 5 concludes this paper.

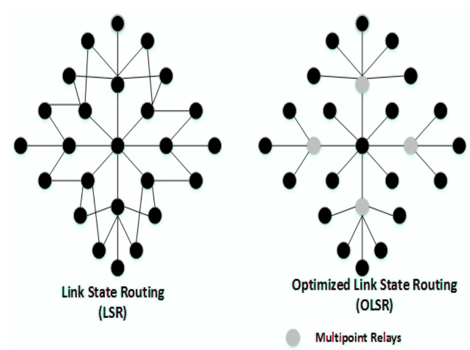

Figure 1: Multipoint Relay Representation

2. RELATED WORK

In geographic routing, the forwarding and the cooperation decision at each node are based on its location and the locations of the node’s one-hop neighbors. To give a report of these corporate issues in network, different types of forwarding strategies have been proposed. In this review paper [16], authors concentrated on beaconless forwarding methods and their forwarding methods in detail. Certainly, a revision of OLSR protocol, especially MPRs selection algorithm concluded that performance of paths can be improved by adopting additional conditions. Most of the literature relating to routing optimization in OLSR targets to find other efficient schemes rather than the default one. These protocols in MANETs are classified according to the distance and the mobility of nodes. Distance-based protocols attempts to reduce the distance between a node and its successor in the established path. In the other hand, protocols try to measure and to evaluate links between nodes of the network based on their mobility. This category presented two types of protocols: protocols based on speed, direction of movement, coordinates of nodes, etc. like parameters of nodes' mobility and the second category which is based on probabilistic methods or the degree of mobility.

Ticket- Based Probing with Stability Estimation (TBP-SE) proposed in [17] is an amelioration of Ticket-Based Probing protocol (TBP) [18]. 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 [19]. 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 other paths will be elected as the most stable. In [20], 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, authors 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. This paper [21], offered a new method to assess the quality of the link in terms of link duration. For that, authors adopted a variable sized sampling window and proposed a probabilistic method, based on Markov chain, to estimate the link transition rates i.e. the probability that a link changes the state from the connected to unconnected state and vice versa. To confirm the effectiveness of this method, authors proposed a routing method which adjusts its operating based on the estimated link stability.

However, various works discussed routing optimization based on online nodes measurements in order to classify paths which are better used for routing. But these works have a mutual weakness, where they cannot avoid possible modification in links status occurring in the future. A reliable link may become defective with time because of dynamic nature of mobile environments. In various works, authors pay attention to the stability of routes. Definitely, in [22], the goal is to find stable paths between source and destination that also have lower hop count based on the Predicted Link expiration Time (LET) concept [23] used for the Flow-oriented routing protocol (FORP) [24]. While many previous studies focused on statistical analysis of link availability, the study prepared in [25] suggested a prediction method explored with random walk mobility model based on link availability prediction. This system aims to predict a probability of a link available with a continuously manner for a certain period, which is acquired based on the current node's movement. Based on OLSR, authors in [26] proposed a protocol employing a fuzzy logic into MPRs selection considering 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 exposed that the proposed protocol can provide a significantly higher packet delivery ratio compared to the original OLSR. An optimized method for the selection of the minimum MPRs set computed by greedy algorithm proposed by authors in [27]. Based on node density, an incomplete traversal process is executed in common MPRs set calculated by greedy algorithm in order to reselect minimum MPRs set. Simulation results displayed that the optimized method can reduce the number of nodes in minimum MPRs set and TC packets flooding in the network. In another paper [28], an improved algorithm based on node localization is proposed combined with node localization technology. Node localization information is used in this algorithm and the blindness is reduced in MPRs selection algorithm in OLSR protocol. The number of routing packets needed to deliver in the network is reduced to a certain extent and it can improve the network transmission capacity. On the other hand, authors in [29] proposed the usage of the probabilistic Monte Carlo method to predict the next position using received anchor beacons and the maximum speed of mobile nodes. It should be noted that this method does not consider any information about the direction of nodes and assumes that all nodes move with the same maximum speed. The method proposed in [30] used a mobile robot to predict the position of nodes in an indoor environment. The method is based on a Probabilistic Graphical Model (PGM) that estimates the sensor node position using range-only measurements of the received signal strength indicator (RSSI). Even if the method was validated by real-world experiments attesting that the probabilistic model is suitable, but the method do not consider the mobility of nodes. Authors in [31] proposed a method called Speed and Direction Prediction-based Localization to predict the real speed and the direction of the mobile nodes to increase the accuracy of the localization estimations.

In routing protocols for mobile networks, the necessity of reachability and high stability is a problematic related to 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.

Wei Fan and Yan Shi [32] extended the definition of the mobility scheme, Spatial Dependency (SD) and used it as the key in clustering algorithm design. The scheme captures the similarity of the mobility features between two nodes that are within their communication range. Authors used this scheme to extract characteristics of group mobility in VANETs. In the same context, Zhang in [33] extended and developed the concept of a very similar spatial mobility scheme (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. On the other hand, in order to provide a better understanding of spatial dependence, authors in [34] proposed a more comprehensive mobility scheme, Degree of Node Proximity (DNP), based on the average distance among mobile nodes. Through simulation, authors compared their scheme with other well-known spatial scheme over an extensive set of mobility models. DNP is revealed able to capture spatial dependence in scenarios with different levels of node pause time.

The main limitation of some works is that they don't consider spatial dependence (i.e., correlation) during periods of no node movement. While any two nodes i and j are pausing, their correlation is always zero, what is not necessarily true, because this tow nodes might have paused (i.e., switched to velocity zero) just because there is some dependence between them. Other techniques as presented in [13] object to make them able to capture both movement and pause correlation among mobile nodes and to distinguish between temporal and timeless mobility models.

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 [35],[36]. This paper is based on Random Waypoints model [37],[38].

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 Mechanism

Table 1: Terminology of the Mechanism.

Terminology	Description	Unit of measure
D	Linear distance	[m]
S	Speed	[m/s]
θ	Node's direction	[°]
V	Node's velocity	[m/s]
A	Acceleration	[m/s2]
PD	Predicted linear distance	[m]
PS	Predicted speed	[m/s]
Pθ	Predicted node's direction	[°]
PV	Predicted node's velocity	[m/s]
PA	Predicted acceleration	[m/s2]
ΔT	Time interval	[s]
t	Current time	[s]
PRS(i,j)	Predicted Relative speed	
PRA(i,j)	Predicted	

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

	Relative acceleration	
PRD(i,j)	Predicted Relative direction	
PSD	Predicted Spatial dependency	
PTSD	Predicted Total Spatial dependency	
ESRMPR	Estimated Spatial Relation	
SESRMPR	Stability of Estimetd Spatial Relation	
ΔxT,ΔyT	Increment of linear distance	
xit0,yit0,xti,yti,xTi,yTi	Coordinates of node i at different time	

Network mobility is mainly characterized by the degree of dependence of movement between nodes. Schemes that measure this property are called spatial mobility as in [10]. For instance, Degree of Spatial Dependence (DSD) is a familiar mobility scheme, it measures the spatial correlation between the movement of users and it is based on the cosine correspondence between node's velocities. However, in some case scenarios including battlefield communication, certain specific leader nodes influenced the movement pattern of a mobile node in its neighborhood. In our case, MPRs plays that role which leads the conclusion that there is a correlation of mobility between a numbers of nodes. 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 value depending on the variance of ESRMPR of the node calculated in relation with its neighbors.

3.2 Description of the Proposed Mechanism

In probability theory, Bienaymé-Chebyshev inequality [39] 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):

Little change in the future

$$P\{|X - E(X)|\langle\varepsilon\}$$

By definition

$$V(X) = E(X^2) - E(X)^2$$

And

$$E(X) = \sum_i \frac{X_i}{n}$$

$$V(X) = \left(\sum_i \frac{X_i^2}{n}\right) - \left(\sum_i \frac{X_i}{n}\right)^2 \quad (1)$$

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

Author supposes that nodes follow a rectilinear movement where they have a constant speed, acceleration and direction during certain time periods (Δt). This reflects the reality where nodes as human beings keep their speed, acceleration and direction, at least, for a moment which allows nodes to predict positions. Therefore, the linear distance (D) can be calculated by:

$$D_i = \sqrt{(x_i(t_0) - x_i(t))^2 + (y_i(t_0) - y_i(t))^2} \quad (2)$$

Where (t0) and (t) are times corresponding to the last position and to the current position respectively.

Accordingly, S can be calculated as:

$$S_i = \frac{D}{\Delta t} \qquad (3)$$

If the calculated speed is equal to zero, the node deduces that it is static during (Δt).

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

$$\theta_i = \begin{cases} \varphi.\sin((y_i(t_0)-y_i(t)) & (x_i(t_0)-x_i(t)\rangle 0 \\ \frac{\pi}{2}.\sin((y_i(t_0)-y_i(t)) & (x_i(t_0)-x_i(t)=0 \\ (\pi-\varphi).\sin((y_i(t_0)-y_i(t)) & (x_i(t_0)-x_i(t)\langle 0 \end{cases} \qquad (4)$$

$$\text{where} \quad \tan\varphi = \left|\frac{(y_i(t_0)-y_i(t)}{(x_i(t_0)-x_i(t)}\right| \text{ and } \quad \theta_i \in (-\pi, \pi)$$

Based on the velocity (V), the node computes the acceleration (A) as:

$$A_i = \frac{\Delta V_i}{t-t_0} \quad \text{Where} \quad \Delta PV_i = (PV - PV_0) \qquad (5)$$

The velocity (V) is based on the speed (S) and the direction (θ).

After the speed, the acceleration and the direction, a node predicts its coordinates Xi (T) and Yi (T) as follows:

$$X_{i(T)} = S_i * \cos(\theta_i) * A_i * \Delta T + x_i(t)$$
$$Y_i(T) = S_i * \sin(\theta_i) * A_i * \Delta T + y_i(t) \qquad (6)$$

Where xi(t) and yi(t) is the current position and (ΔT) is the time between current time and time of the previous estimation.

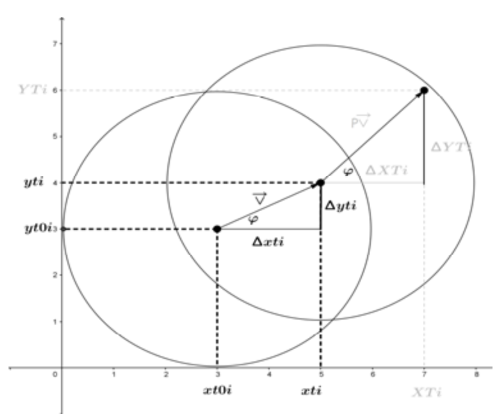

Figure 2: The Predicted Location Illustration

Let (ΔXT) and (ΔYT) be the increment of the predicted linear distance:

$$\Delta XT_i = (x_{i(t)} - X_{i(T)})$$
$$\Delta YT_i = (y_{i(t)} - Y_{i(T)}) \qquad (7)$$

Therefore, PD can be calculated by:

$$PD_i = \sqrt{\Delta XT_i^2 + \Delta YT_i^2} \qquad (8)$$

Accordingly, PS can be calculated as:

$$PS_i = \frac{D}{\Delta T} \qquad (9)$$

If the calculated PS is equal to zero, the node deduces that it is static during the interval (ΔT).

The value of Pθ can be defined as:

$$P\theta_i = \begin{cases} \varphi.\sin(\Delta YT_i) & \Delta XT_i\rangle 0 \\ \frac{\pi}{2}.\sin(\Delta YT_i) & \Delta XT_i=0 \\ (\pi-\varphi).\sin(\Delta YT_i) & \Delta XT_i\langle 0 \end{cases} \qquad (10)$$

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

Based on PV, the node can compute PA as:

PV is based on PS and Pθ.

$$PA_i = \frac{\Delta PV_i}{\Delta T} \quad \text{Where} \quad \Delta PV_i = (PV_i(T) - PV_i(t)) \qquad (11)$$

Based on this values, a node calculates its TPSD and its ESRMPR with the following steps:

First step: Node exchanges its mobility information, PS, PA and Pθ with its directly connected neighbors through Hello packets (Figure.3).

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

Figure 3: Multipoint Relay Representation

Second step: A node calculates its PRS, PRA and PRD with its directly connected neighbors.

For example, for nodes (i) and (j), PRS of these two nodes is defined as:

$$PRS_{(i,j,T)} = \log(1 - \frac{|PS_i - PS_j|}{S_{max}}) \quad (12)$$

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

$$PRD_{(i,j,T)} = \cos(P\theta_i(T) - P\theta_j(T)) \quad (13)$$

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

$$PRA_{(i,j,T)} = \log(1 - \frac{|PA_i - PA_j|}{A_{max}}) \quad (14)$$

Where Amax is the node's maximum acceleration.

Third step: PSD between node (i) and node (j) can be calculated as:

$$PSD_{(i,j,T)} = PRS_{(i,j,T)} * PRA_{(i,j,T)} * PRD_{(i,j,T)} \quad (15)$$

Fourth step: the node takes the summation of all PSD it has and calculates TPSD by the following equation:

$$TPSD_{(i,T)} = \sum_{j=1}^{n} PSD_{(i,j,T)} \quad (16)$$

Where n is the direct neighbors of the node (i).

Fifth step: ESRMPR of a node is defined as:

$$ESR_{MPR(i,T)} = \frac{1}{n} TPSD_{(i,T)} \quad (17)$$

A higher ESRMPR value implies that node (i) has a larger neighbors set and it has a similar mobility pattern with its neighbors. The speed, the acceleration and the direction may be powerfully associated together. Accordingly, a node with a higher ESRMPR value is eligible to represent and reflect the mobility features of the group (neighbors connected).

Our mechanism based on Bienaymé–Chebyshev inequality will take values of ESRMPR in different intervals of time. The mechanism of stability proposed is as follows:

$$SESR_{MPR} = V(X_i) \quad (18)$$

According to (1) and (18)

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

$$SESR_{MPR} = \left(\sum_i \frac{ESRMPR_i^2}{n}\right) - \left(\sum_i \frac{ESRMPR_i}{n}\right)^2 \quad (19)$$

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

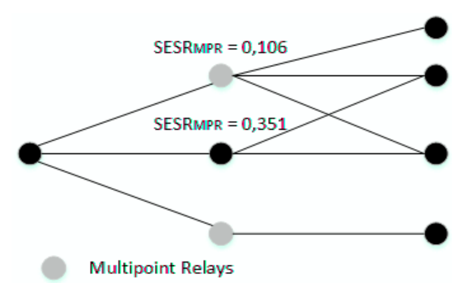

Figure 4: The modified MPRs Selection Representation

In context of previous works, our proposal helps MANETs to predict necessary information that can improve their functionalities considering the performance of the network. In many cases, due to high dynamic mobility, the link between the nodes should be variable, which affects path stability. This affects the stability of the entire network. Thus, providing a rapid response to changes in the network, may reduce the excess of network resources and may produce a significant improvement in the data transmission rate with decreasing the control overhead for the reconstruction of a routing path.

Furthermore, this technique provides a solution that can allow mobile nodes to better localize themselves. The idea of predicting speeds, accelerations and directions of mobile nodes is very promising and allows reducing the localization

Journal of Theoretical and Applied Information Technology
15th May 2018. Vol.96. No 09

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

error. Besides, based on this prediction, routes are reconfigured before they disconnect.

4. RESULTS AND ANALYSIS

4.1 Simulation Mobility Model

Diverse studies has 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: Parameters of the simulation

Simulation Parameters	Value
Flat Size	1000 m × 1000 m
Maw Number Of Nodes	5,10,15,20...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	RWP (Random Waypoint)
Pause Time	1 seconds
Maximum Speed of Nodes	25 m/s
Simulation Time	100 Seconds

4.2 Analysis Results

It can observe the effect of node number on Delay, Jitter, Packet Delivery Ratio, Packet Loss Ratio, Throughput and Lost Packets. The comparison of both protocols is exposed in graphs below. It is observed that SESROLSR revealed improvement as compared with OLSR when the network contains more number of nodes. This confirms the effective use of SESROLSR for dense networks. The impact of node number on performances of the protocol can be observed in the comparison result. Compared to OLSR, SESROLSR minimizes the delay using the estimated spatial dependency and the predicted relativity between nodes. Generally, SESROLSR has a minimum delay and jitter among all (Figure5 and Figure6). Therefore, this mechanism minimizes the delay and the jitter, which attests that our version gives a change in transmission delays and particularly in environments that are categorized by more agitation nodes.

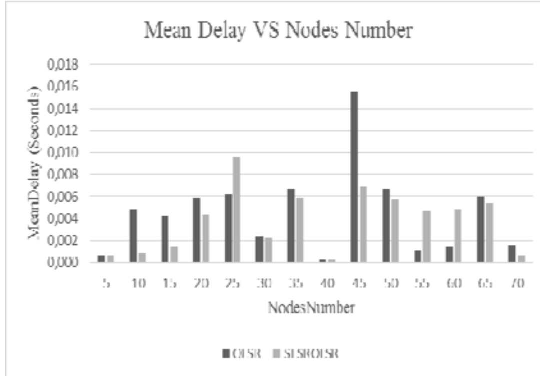

Figure 5: The Mean Delay Representation

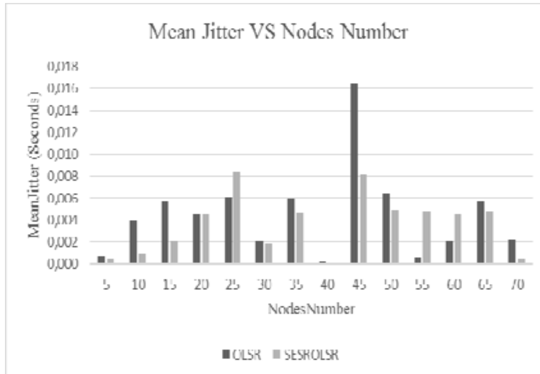

Figure 6: The Mean Jitter Representation

The lowest value of packet loss ratio and lost packets, the highest value of throughput and packet delivery ratio means better performance of SESROLSR 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 SESROLSR can achieve lowest packet loss ratio and also with the help of the predicted relativity node, the transmission of packet is successfully reached. The probabilistic method used in this mechanism helps networks to become stable for better communication and fewer lost packets between nodes as exposed in graphs below.

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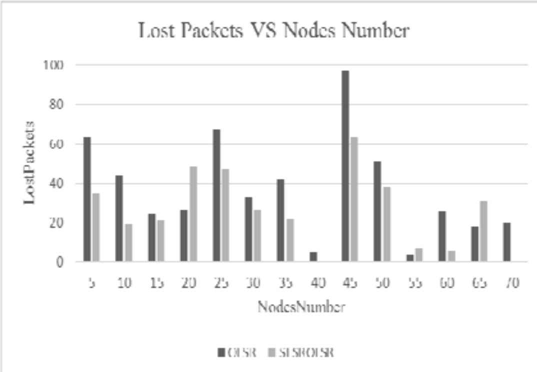

Figure 7: The Lost Packets Representation

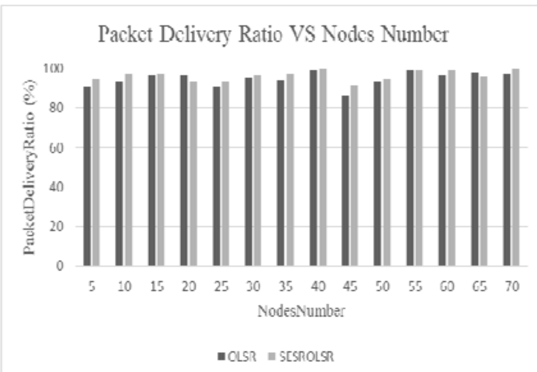

Figure 8: The Packet Delivery Ratio Representation

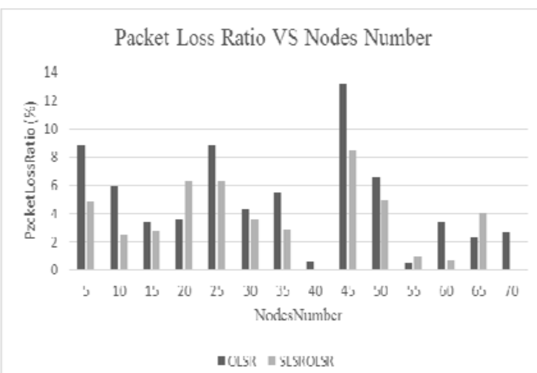

Figure 9: The Packet Loss Ratio Representation

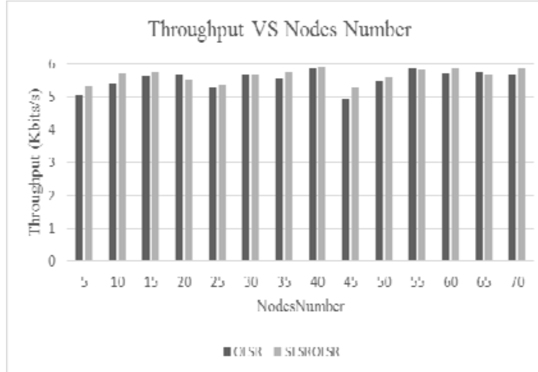

Figure 10: The Throughput Representation

5. CONCLUSION

In this paper a new mechanism has been suggested that attempts to make the routing efficiency even in highly environment and which can be used into any ad hoc routing protocol. To avoid disconnected links, proposed mechanism uses the predicted spatial dependency to route data packets and to choose MPRs by adopting a probabilistic method for more stability. As a case study, the mechanism has been integrated to OLSR and it has been observed that the performance was improved. The author was interested to incorporate mobility mechanism in the routing decision to reduce effects of mobility in the network, by adopting different parameters of mobile nodes like predicted speed, predicted acceleration and predicted direction. Simulation results proved the efficiency of the suggested mechanism in terms of packet delivery ratio, delay, lost packets, etc, and that the mobility is not the unique limitation of nodes in MANETs. In fact, Mobility, energy and security are the main pillars of a mobile network, and in this work, the author integrated a mobility technique that revealed an improvement in the performance of the network but which remains limited in terms of energy and security. This inefficiency pushes us to improve this mechanism by studying the other pillars. Future works in this direction can be done as comparison with the already established works and the enhancement of SESRMPR. As well as it can be enhanced as a reliable and secure routing protocol by adding new metrics based on the residual battery of mobile node, the reputation or testing in reactive protocols.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

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