Multipoint Relay Selection through Estimated Spatial Relation in Smart City Environments

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***Abstract*—The future Internet will be able of connecting and communicating with practically all physical and virtual objects around us to the Internet to create smart homes and cities. Thus smart things are expected to send and receive data, in particular, effective data collection is crucial for services that require a timely delivery of urgent data while reacting independently to the events with or without any human intervention and self-configuring themselves such as homeland security, city surveillance, irrigation, smart buildings & industries, ecommerce, auto vehicle systems, etc. The current challenges have led to deploy the mobile ad hoc networks (MANETs) in the Smart Cities due to their easy implementation and to be the fastest and the most efficient way to establish connection in smart environments. However, the challenge is, the environments that these communications act through, are variables and unstable. This paper proposes an original solution to integrate and exploit MANETs to allow immediate adaptation in smart city environments. This proposed is an improved algorithm based on a mobility scheme named Estimated Spatial relation by discovering both modification to MPRs selection and the routing decision in goal to decrease effects that lead to more disconnecting of the network, more delay and more lost packets due to unpredictable environment for smart city networks. Proposed design has been checked using NS3 simulator and demonstrated good results in most of the circumstances.**

Keywords— smart cities; manets; mprs selection; estimated spatial relation; ns3 simulator

I. Introduction

In recent times, Smart Cities and Internet of Things (IoT) have been designated as an emerging tendency with huge potential and are expected to lead the digital economy forward into the future. Similarly, the developments and popularity in smart mobile devices with embedded sensors, computing resources and wireless technologies, associated to the demand for Smart City and IoT applications present an innovative mobile environment. The mobile ad hoc networks (MANETs) are ideal candidates and essential components to give rise to reactions in several useful services and applications for smart cities. The infrastructure of Smart Cities needs to integrate wireless networks to make them accessible and controllable for applications and services. MANETs and IoT networks have many similarities in network structure. For example, both are self-organizing and self-configuring networks, implying that they have no central management system with specific configuration responsibilities. Moreover, the nodes in both networks have the same priority. One more similarity between the two networks is that, for both of them, it is necessary to create connections between nodes quickly and to update the routing table frequently because of the dynamic nature of the nodes. These routing protocols should be efficient in terms of quality of service (QoS) metrics and stability due to the high mobility change and energy consumption to promise the data transmission over the wireless links. Ad hoc networks can offer a better solution to these difficulties.

In MANETs, each node has a transmission range within which the 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 usages related to special outdoor events, communications in regions with no wireless infrastructure or emergencies, 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 the 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

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

Several strategies have been proposed to enhance the stability, routing performance, scalability, reachability in OLSR. Mobility is considered as an essential phenomenon of MANETs, therefore, discussing mobility schemes by assuming low mobility becomes necessary [7]**.**

Apart from this, it has been indicated that in various application scenarios, such as military operations [8], rescue and searching operation, mobile nodes are moving in a similar design in a number of groups ,it's called ,group mobility [9]. 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 changes may still happen with group partitions.

As suitability of the proposed technique for smart city scenarios, the author aims to provide innovative technique for mobility computation and city mobile users distributed in the regions, to provide solutions for sustainable mobility, communication and systems. The technique helps mobile users to be an ideal candidates to improve systems and services in smart cities and to make MANETs as an essential component of the smart city infrastructure. The infrastructure of smart cities needs to integrate all these necessities to be accessible and controllable.

OLSR is one of the routing protocol that offers a better performance in the network by using the MPRs nodes that can characterize the mobility pattern considering its functionality [10]-[11]**.** This functionality can be make this node as a membership of a several nodes or a group. Therefore, our algorithm 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 an estimated spatial relation adaptive MPRs Selection algorithm for OLSR in MANETs. The scheme discussed in the paper is a mobility scheme used to make stability and reachability. The motivation is to improve the MPRs selection in the OLSR by using a mechanism of mobility for more stability, reachability and performance in the network [7]-[12]-[13].

With respect of the existing mechanisms, the proposed technique has different advantages. First, speed is not a limitation on the efficacy of the algorithm since it is a mobility mechanism based on an algorithm that can be regulate to high speed environment. Second, the scheme is simple and is applied at every node. Third, as presented in the simulation studies, the scheme is adaptive to high environment. Lastly, the paper proposes a study of predicted spatial dependency as a mechanism for selecting node relay. For this, MPRs Selection algorithm was improved and the predicted position of nodes with the predicted speed, the predicted acceleration, the predicted direction and the Estimated Spatial Relation MPR (ESRMPR) were added in the Hello message.

Smart city solutions are related to several issues like access to data, association and collection, access and delivering services. The final object is the participation of city users to the city strategies for goal to get smarter and more efficient smart cities. For that reason, created, collected and distributed data are used to simplify and to assist the conception of this smart cities

The graphs prove that the proposed algorithm improve the performances of the network. The performance of this work has been evaluated by NS-3 simulator [14].

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 represents the case study and describes the approach adopted to calculate the mobility scheme for each node and highlights how this mobility value is used in OLSR, especially MPRs Selection. The performance of the scheme in OLSR and its comparison with the standard are given in Section 4. Finally, Section 5 concludes this paper.

II. RELATED WORK

The adoption of the smart mobile devices has presented a new ensemble mobile environment. These smart mobile devices are ideal choice to offer several useful services and applications in Smart City applications.

Any short service-outage like a link failure or a node failure can cause a loss of network services in developing broadband digital networks where the smart city networks are in place as the capacity of network traffic transmitted through a single link or node is boundless. This disorder forced the users to try to reconnect intermittently. It makes the problems poorer as the link establishment increases the transmission volume further. Quick restoration from such network failures produced a critical issue in positioning high-speed links. With the increasing tendency in terms of network usage by smart city's users, numerous algorithms are proposed for enhancing the stability and the reachability to get better performance of the network.

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. Certainly, a revision of OLSR protocol, especially MPRs selection algorithm concluded that routes performance can be improved by adopting additional conditions on MPRs mechanism. Most of the literature relating to routing optimization in OLSR targets to find other efficient schemes rather than the default one.

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, the authors make attention to the stability of routes; definitely, in [15], the goal is to find for stable paths between source and destination that also have lower hop count based on the “predicted link expiration time (LET)” concept [16] used for the Flow-oriented routing protocol (FORP) [17]**.** Many previous studies focused on statistical analysis of link availability. The study prepared in [18] suggested a prediction method explored with random walk mobility model based on link availability prediction. The system aimed to predict the 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 [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. The results exposed that the proposed protocol can provide a significantly higher packet delivery ratio compared to the original OLSR. Another optimized method for the selection of the minimum MPR set computed by greedy algorithm proposed by the authors in [20]. Based on node density, an incomplete traversal process is executed in the common MPRs set calculated by greedy algorithm in order to reselect the minimum MPR set. The 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 the same context, the paper [21] presented an improved algorithm based on node localization is proposed combined with node localization technology. Node localization information is used in this algorithm, the blindness is reduced in the MPRs selection algorithm in the OLSR protocol and it can make full use of the network resources. The number of routing packets needed to deliver in the network is reduced to a certain extent and therefore the network transmission capacity can be improved.

Authors in [22] proposed the use of the probabilistic Monte Carlo method to predict of the next position using received anchor beacons and the maximum speed of the mobile nodes. The method does not consider any information about the direction of the nodes and assumes that all the nodes move with the same maximum speed. In the other hand, the method proposed in [23] 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. More surveyed localization methods can be found in [24]**.** Authors in [25] 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 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.

A mobile node may move according to the movement of other nodes, it is appropriate thinking about mobility schemes that characterizes this relationship. Correlated to this statement, Bai et al. suggested in [12] the important framework to systematically analyze the impact of mobility on the performance of routing protocols for ad hoc networks. They proposed two mobility schemes for quantifying temporal and spatial movement dependence among mobile nodes. Both schemes are based on the cosine similarity between the velocities of nodes.

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

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

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 scheme proposed in the framework is the Degree of Temporal Dependence (DTD) (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 scheme reflects the smoothness of node movement.

$$DTD(I,t,t')=Cos(I,t,t')*SR(I,t,t') \qquad (2)$$

The paper [12] and the Improved Degree of Spatial Dependence suggested in [26] are two examples of spatial mobility schemes.

In order to provide a better understanding of spatial dependence, authors in [27] 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. Additionally, based on the work by Bai et al., Zhang [28] 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.

In the same area, Wei Fan and Yan Shi [26] extended the definition of the mobility scheme; Spatial Dependency (SD) and used it as the basic in clustering algorithm design. The scheme captured the similarity of the mobility features between two nodes that are within their communication range. They used to extract the characteristics of group mobility in Vehicles

Ad hoc Networks (VANETs). The node calculated its Relative Velocity and Relative Acceleration to calculate the Cluster Relation (CR).The node with highest CR value is entitled as the cluster head which represented and reflected the mobility features of the cluster.

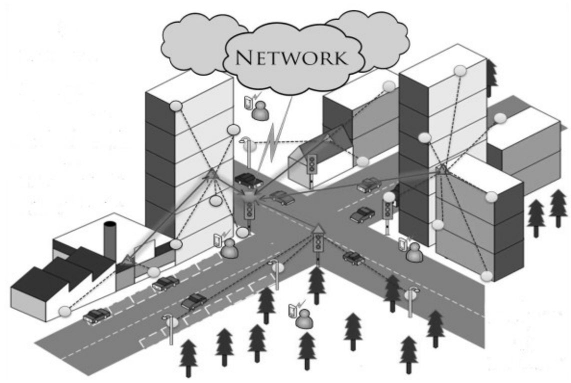

Fig. 1. Smart City Illustration.

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 [29]-[30]. This paper is based on the Manhattan Grid model [31].

III. CASE STUDY

A. Brief Examination of OLSR

OLSR is a table-driven protocol, it's simpler than complicated logic, easier to modify and more efficient. It's developed for mobile ad hoc networks. OLSR is categorized by a frequently exchanged topological information between nodes of the network. In detail, nodes transmit Hello messages (Fig.2) to their 1-hop neighbors and then define a set of them to act as MPRs (Fig.3). In OLSR, only these nodes relays diffuse topological information and only MPRs are able to produce link state information to be sent throughout the network. MPRs decrease the number of transmissions necessary, in this manner, they offer a powerful mechanism for controlling traffic. Furthermore, these nominated nodes do a particular role and responsibility regarding link state information and declaring it in the network. Definitely, the only necessity for OLSR is to deliver shortest path to all destinations. Selected nodes announce they have been selected as MPRs and broadcast this information periodically in their control messages. Thus a node declares to the network, that it has reachability to the nodes which have selected it as MPRs. In path calculation, MPRs are used to form the route from a given node to any destination in the network.

Reserved		Htime	Willingness
Link Code	Reserved	Link Message Size	
Neighbor Interface Address			
Neighbor Interface Address			

Fig. 2. Standard Hello Message in OLSR Protocol

Through Hello messages, the OLSR protocol determines 2-hop neighbor and executes a distributed election of a set MPRs. When a node is elected as a MPR, there is always a route to each of its 2-hop neighbors. OLSR is reflected to be distinctive compared to other link state routing protocols in several techniques, because MPRs nodes send and forward TC messages that contain the MPR selectors. The forward path for TC messages is not shared among all nodes but differs depending on the source, only a subgroup of nodes send link state information, and not all links of a node are advertised. Thereby, an optimization is done by reducing the number of control messages flooded in the network, and this can decrease network bandwidth occupied by the routing protocol.

OLSR provides best paths in terms of number of hops and it is particularly suitable for large and dense networks as the technique of MPRs works well in this context. OLSR routing protocol also presents various limitation concerning the calculation of the minimum MPRs (NP complete problem). So, to compute a node's MPRs is very challenging and some heuristic algorithm must be used in order to find the ideal result.

For mobile nodes with slow speed, it can considerably reduce the routing protocol information, save network bandwidth and improve the transmission ability of network. On the other hand, for high speed of mobile nodes, it is a very important factor, the presently created MPRs maybe not completely valid accordingly with the network topology.

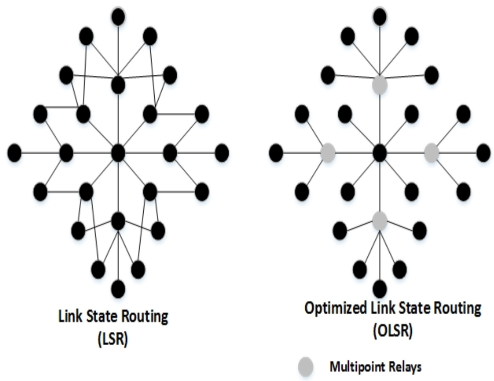

Fig. 3. Multipoint Relays

B. Terminology and Introduction of the Improvments

TABLE I. TERMINOLGY OF THE IMPROVMENTS

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/s2]
PD	The Predicted lineare distance	[m]

PS	The Predicted average speed	[m/s]
Pθ	The Predicted node’s direction	[°]
PV	The Predicted node’s velocity	[m/s]
PA	The Predicted average acceleration	[m/s2]
ΔT	Time interval	[s]
t	The current time	[s]
PRS(i,j)	Predicted Relative speed between node i and j	
PRA(i,j)	Predicted Relative acceleration between node i and j	
PRD(i,j)	Predicted Relative direction between node i and j	
PSD	Predicted Spatial dependency	
TPSD	Total Predicted Spatial dependency	
ESRMPR	Estimated Spatial Relation of mpr	
ΔxT,ΔyT	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 categorized by the degree of dependence of movement between nodes. Methods that measure this property are called spatial dependence scheme [32]. For illustration, the Degree of Spatial Dependence (DSD) is a familiar mobility scheme that measures the spatial dependence between the displacement of users and it is based on the cosine correspondence between the nodes velocities.

However, in some scenarios like battlefield communication, certain specific nodes called leaders influence the movement pattern of a mobile node in its neighborhood. In our case, the MPRs acts like leaders. Therefore, there is a relation mobility between a numbers of nodes, neighbors.

In our suggested mobility mechanism, the variation in velocity over the time interval is entitled acceleration. Each node has a characteristic PS(t), PD(t) and PA(t). Based on this parameters, the nodes can calculate their PRS, their PRD and their PRA to determine their ESRMPR value. With this value, the MPR node is nominated. This MPR have similar mobility features with the nodes that selected it as MPR. Further, the author modified the MPR Selection Algorithm based on mobility features. The acceleration acts as a random variable and depends on velocity variation. With the acceleration, the mechanism can signify more exact correlation between nodes to extract their mobility feature. In the next sections, the author illustrates how this value can be calculated and used in OLSR.

C. Proposed Protocol

Based on the works cited before, the author extended a mobility mechanism named Estimated Spatial Relation MPR (ESRMPR) to develop a new mechanism to use it in the basic selection of the MPR in OLSR.

PSD is mainly based on the prediction of the speed, the acceleration and the direction and it captures the similarity of the mobility characteristics between two nodes that are within their communication range. The nodes with the same mobility characteristics are more expected to move together over a period of time to do their tasks until one of the nodes leaves the transmission range and cannot be selected as MPRs.

The idea of predicting the speed, the acceleration and the direction of the moving nodes is very promising and allows decreasing the localization error with better prediction location.

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 MPR 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 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, (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 supposed that nodes follow a rectilinear movement during small intervals where nodes have a constant velocity and direction during certain time periods (Δt). This reflects the reality where nodes (e.g. Human beings) keep their speed, acceleration and direction, at least, for moments which allows nodes to predict positions.

Therefore, the linear distance (D) can be calculated by:

$$D_i = \sqrt{(x_i(t_0)-x_i(t))^2+(y_i(t_0)-y_i(t))^2} \qquad (3)$$

Where (t_0) and (t) are times corresponding to the last position and to the current position respectively.

Accordingly, the speed (S) can be calculated as:

$$S_i = \frac{D}{\Delta t} \quad \Delta t=(t - t_0) \qquad (4)$$

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

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

$$\theta_i = \begin{cases} \varphi.\sin((y_i(t_0)-y_i(t)) & (x_i(t_0)-x_i(t)) > 0 \\ \frac{\pi}{2}.\sin((y_i(t_0)-y_i(t)) & (x_i(t_0)-x_i(t)) = 0 \\ (\pi-\varphi).\sin((y_i(t_0)-y_i(t)) & (x_i(t_0)-x_i(t)) < 0 \end{cases} \qquad (5)$$

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

Based on the velocity, the node computes the acceleration as:

$$A_i = \frac{\Delta V_i}{t-t_0} \text{ Where } \Delta_{PV_i} = (PV - PV_0) \qquad (6)$$

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:

$$X_{i(T)} = S_i * \cos(\theta_i) * A_i * \Delta T + x_i(t)$$
$$Y_i(T) = S_i * \sin(\theta_i) * A_i * \Delta T + y_i(t) \qquad (7)$$

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

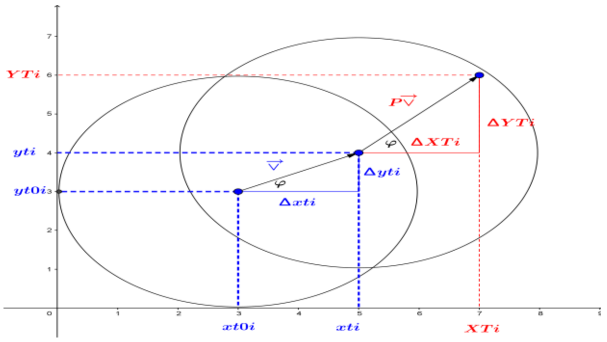

Fig. 4. The Predicted location illustration.

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

$$\Delta XT_i = (x_{i(t)} - X_{i(T)})$$
$$\Delta YT_i = (y_{i(t)} - Y_{i(T)}) \qquad (8)$$

Therefore, the predicted linear distance (PD) can be calculated by:

$$PD_i = \sqrt{\Delta XT_i^{\,2} + \Delta YT_i^{\,2}} \qquad (9)$$

Accordingly, the predicted speed (PS) can be calculated as:

$$PS_i = \frac{D}{\Delta T} \qquad (10)$$

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

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

$$P\theta_i = \begin{cases} \varphi.\sin(\Delta YT_i) & \Delta XT_i \rangle 0 \\ \frac{\pi}{2}.\sin(\Delta YT_i) & \Delta XT_i = 0 \\ (\pi-\varphi).\sin(\Delta YT_i) & \Delta XT_i \langle 0 \end{cases} \qquad (11)$$

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

Based on the Predicted velocity, the node can compute the Predicted acceleration as:

The predicted velocity (PV) is based on the predicted speed (PS) and the predicted direction (Pθ).

$$PA_i = \frac{\Delta_{PV_i}}{\Delta T} \text{ Where } \Delta_{PV_i} = (PV_i(T) - PV_i(t))$$
(12)

Based on this values, a node calculates its Total Predicted Spatial Dependency (TPSD) and its Estimated Spatial relation MPR (ESRMPR) with the following steps:

First step: The node exchanges its mobility information, predicted speed (PS), predicted acceleration (PA) and predicted direction (Pθ) with its directly connected neighbors through Hello packets (Fig.8).

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

Fig. 5. Modified Hello Message in OLSR Protocol

Second step: A node calculates its Predicted Relative Speed (PRS), Predicted Relative acceleration (PRA) and Predicted Relative Direction (PRD) with its directly connected neighbors.

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

$$PRS_{(i,j,T)} = \log(1 - \frac{|PS_i - PS_j|}{S_{max}}) \qquad (13)$$

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:

$$PRD_{(i,j,T)} = \cos(P\theta_i(T) - P\theta_j(T)) \qquad (14)$$

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

$$PRA_{(i,j,T)} = \log(1 - \frac{|PA_i - PA_j|}{A_{max}}) \qquad (15)$$

Where Amax is the node's maximum acceleration.

Third step: The Predicted Spatial Dependency (PSD) between node (i) and node (j) can be calculated as:

$$PSD_{(i,j,T)} = PRS_{(i,j,T)} * PRA_{(i,j,T)} * PRD_{(i,j,T)} \qquad (16)$$

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

$$TPSD_{(i,T)} = \sum_{j=1}^{n} PSD_{(i,j,T)} \quad (17)$$

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

Fifth step: the Estimated Spatial Relation MPR (ESRMPR) of a node is defined as:

$$ESR_{MPR(i,T)} = \frac{1}{n} TPSD_{(i,T)} \quad (18)$$

A higher ESRMPR value implies that node (i) has a larger neighbor 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 as MPR which represents and reflects the mobility features of the group (neighbors connected).

ESRMPR value defined above is used in the selection of MPRs and adapt it to make stability, improving reachability and to make it applicable in extremely mobile environment.

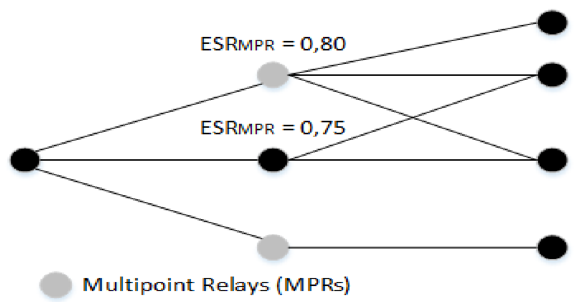

Fig. 6. The modified multipoint relay selection (ESRMPR)

IV. Results and Analysis

A. Simulation Mobility Model

Diverse studies have been done in modeling mobility for MANETs but the Manhattan Grid still one of the greatest used investigates. In this paper, the author explored the Manhattan Grid to evaluate the performance of routing protocols.

Our experiment is configured in a C++ environment which is created by ourselves under the NS3 simulator. The paper compared the performance of different scenario, i.e. ESROLSR with the OLSR. The simulation is executed for 100 s. 5,10,15,20,25,30,35,40,45,50,55,60,65,70 identical mobile nodes are deployed in a terrain of 1000 m by 1000 m. The author discussed the simulation results by given analysis of different graphs. Comparison is then followed to illustrate the performance [33] gain when the new mechanism is used in the MPRs Selection Algorithm in OLSR. Table 2 summarizes all the parameters used during simulations.

TABLE II. 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	ManhattanGrid
Pause Time	1 seconds
Maximum Speed of Nodes	25 m/s
Simulation Time	100 Seconds

B. Comparison and Discussion

In the mobility scenario, mobile nodes move based on a Manhattan Grid model with speed varying in a range of 0 to 25 m/sec. The maximum number of nodes is 70 and the pause time is 1, it can observe the effect of the number of nodes on the Delay, the Jitter, the Packet Delivery Ratio, the Packet Loss Ratio, the Throughput and the Lost Packets. The comparison for both protocols is exposed in figures below. It is observed from figures presented that, ESROLSR revealed improvement as compared with the standard OLSR when the network contains more number of nodes. This confirms the effective use of ESROLSR for dense networks. The impact of node number on performances of the protocol can be observed in the comparison result.

The figure.7 shows the time for data packets transmitted from source to destination in different protocols. It is observed that ESROLSR presents a lower delay compared to the standard OLSR. It can be explained by the efficiency that the prediction and the relativity between nodes has in selecting MPR to have more probability to be a direct neighbor. With this manner, paths still to be valid and the delay is decreased.

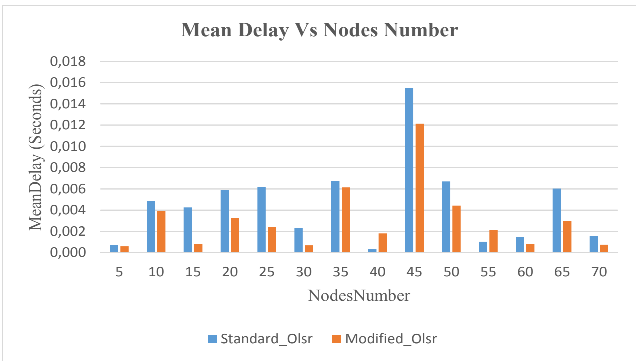

Fig. 7. Mean delay comparison.

Compared to OLSR, ESROLSR minimizes the jitter using the predicted spatial dependency and the relativity between nodes. Generally, ESROLSR has a minimum jitter among all as exposed in the Figure.8. Therefore, this scheme minimizes the jitter. This attests that our version gives a change in transmission and particularly in environments that are categorized by more agitation nodes.

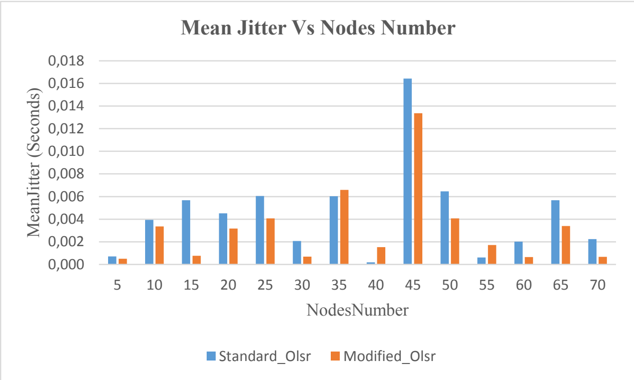

Fig. 8. Mean Jitter comparison.

The lowest value of packet loss ratio (0,26%) in Figure.9, means the better performance of ESROLSR protocol based on predicted spatial dependency and relativity strategy. The author interprets the result that in OLSR the data and the packet loss ratio are high for unreliable connection due to MANET's nature with mobility. Inversely it is revealed that ESROLSR can achieve the lowest rate packet loss and with the help of the relativity strategy, the transmission of packet is successfully reached.

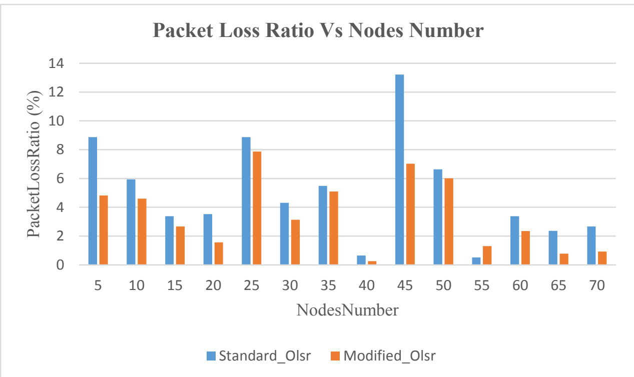

Fig. 9. Packet Loss ratio comparison

The subject of the next figure.10 is the packet delivery ratio (PDR) (i.e. the packets successfully broadcasted). ESROLSR with the technique of mobility ensures the delivery of packets better than the standard OLSR even in dense networks. In addition, the result of this figure confirms that ESROLSR version which is based on prediction and the relativity has guaranteed good performance for packets sent for successful reception.

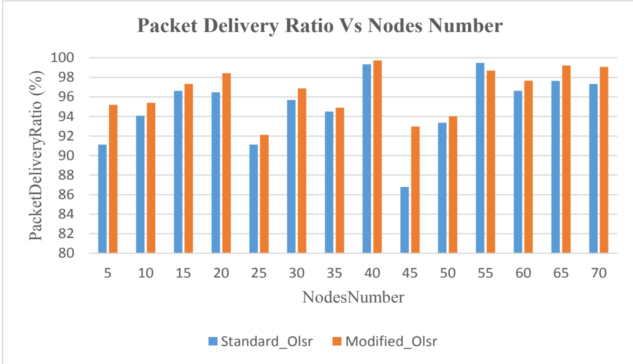

Fig. 10. Packet Delivery ratio comparison

The next figure.11, reveals the evolution of lost packets in relation to the number of nodes. The number of lost packets in ESROLSR is smaller than standard OLSR. The explanation of this result is related to the link duration, reachability and path stability, which are based on the prediction and the relativity between nodes and their MPRs. In addition, ESROLSR avoids the breaking of connections frequently done between nodes due to the impact of mobility on the stability of links.

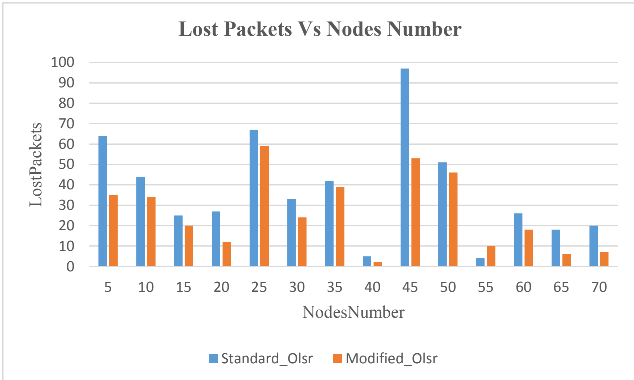

Fig. 11. Lost Packets comparison

The figure.12 presents the impact of the number of nodes on throughput performance regardless of the number of nodes. Furthermore, ESROLSR routing protocol based on the predicted spatial dependency and relativity strategy of nodes in MPR selection algorithm, promises a powerful throughput by the reachability and the stability of links between MPRs and mobile nodes.

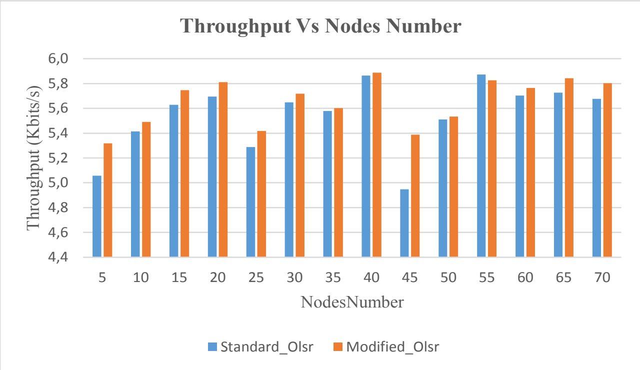

Fig. 12. Throughput comparison.

V. CONCLUSION

Nowadays, the smart environments are more popular and their make the daily life easy. They help in the hard work and increase the productivity in several areas like agriculture and transport. The smart devices are mobile and they need to communicate anytime and anywhere. In this paper a new scheme has been proposed that make the routing efficiency even in highly environment. The scheme can be used into any ad hoc routing protocol. As a case study, the proposed scheme has been integrated to OLSR. Simulation results revealed that the mechanism provides better solutions. The authors are interested to use prediction mobility mechanism in the routing decision scheme to reduce effects of mobility in the network, by adopting different parameters of mobile nodes like predicted speed, predicted acceleration and predicted direction. Based on the new mobility scheme, it ensures the maximum MPRs stability and reachability. As the author have expected, the MPRs selected by this scheme are more efficient compared with the standard. The mechanism proposed can effectively predicted the future location .However, making the technology based on relativity and predicted spatial dependency concept will help in creating adaptive systems and networks that provide better usage of the technology for smart environment. Fort this, as future works, the author attempts to progress efforts to support other parameters like node's energy and reputation and to make a comparison between ESROLSR protocol and the others protocols of the same category of OLSR to support the contribution.

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