# A NEW APPROACH FOR MOBILITY ENHANCEMENT OF OLSR PROTOCOL

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### ABSTRACT

*Nowadays, Mobile networks offer a lot of advantages in terms of usage flexibility. However, they suffer from several problems such as the rapid change of network topology caused by the high mobility of nodes. More research has been done to measure the mobility of nodes with the objective to increase network performance. The work done in this paper concerns the improvement of the formula used in the routing protocol Mob-OLSR for measuring mobility of nodes by automating the setting. Herein, the improved protocol is called Mob-2-OLSR protocol.*

### KEYWORDS

*Network Protocols, Wireless Network, Mobile Network, Ad hoc Network, Routing, OLSR, Mob OLSR, Mobility & Quality of Service, Mob-2-OLSR*

## 1. INTRODUCTION

Ad hoc networks are emerging technologies characterized by the absence of any pre-existing infrastructure. They are composed of mobile nodes that share one or more wireless channels without centralized control. With this type kinds of Networks, several problems can be addressed, one of the mane problems is nodes' movement. Every host can randomly change position. The topology is generally unpredictable, and the network status is imprecise. However, in order to overcome the problems caused by mobility in ad hoc networks, it is important to quantify this mobility and then integrate it in the routing process. Researches in [1, 7, 8, 9] has been done on this topic. In this work, we focus on one of those studies [1] which defines a new metric measuring the degree of mobility (for each node) based on incoming and outgoing nodes from a coverage area. Our goal is to improve the weaknesses of this metric and exploit the information offered to improve the efficiency of the OLSR routing protocol.

The paper's sections are organized as follows: the first section provides a brief definition of the OLSR, sum related works about Mobility metrics and brief description of Mob-OLSR. The second section cites our contributions in this work, followed by another section that states the simulation environment. The fourth section presents the results obtained. Finally the last section states our conclusions and future works.

## 2. RELATED WORK

### 2.1. OLSR protocol (Optimized Link State Routing Protocol)

OLSR protocol [2] is an optimized link state protocol. Its concept is based on the use of multipoint relay (MPR) nodes that are elected among the first neighbourhood to build optimal routes and minimize traffic caused by the flooding of control messages in the network. OLSR

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(Optimized Link State Routing) is a proactive routing protocol that optimizes the flow generated by messages used in the neighbourhood discovery or the control messages. This is done by a technique of multipoint relays (called MPR, Multipoint Relays). In OLSR, each node selects its MPR set among its one hop neighbours to reach all its 2-hops neighbours. Only nodes selected as MPR broadcast messages concerning the links status. The aim is thus to obtain the smallest number of MPRs.

Indeed, OLSR uses 4 types of control messages:

- HELLO: used for neighbours detection.
- TC (Topology Control): broadcasts topology information.
- MID (Multiple Interface Declaration) allows publishing the list of interfaces on each node.
- HNA (Host and Network Association): used to declare the sub-networks and non-MANET machines reachable by a node acting as a gateway.

The OLSR performs two main actions:

- Neighbour detection by sending HELLO messages and the determination of MPR set.
- Topology management: produced by the combination of TC, MID and HNA messages and results in a setting of a global routing table for each node.

### 2.2. Mobility Metrics

There are many different metrics to calculate mobility of nodes. For example, sum researchers use the maximum speed and medium mobility. Other researchers use average speed, the degree of spatial and temporal dependence as parameters.

In [14] the mobility is represented by the average speed. It is based on the relative speed for the two pairs of nodes in the network.  if we suppose that M (m, t) and M (n, t) are respectively the positions of the two nodes m and n at any moment  t. then the relative speed between m and n is defined as:

$$V(m\ n\ t) = \frac{d(M(m;t) - dM(n;t))}{dt} \quad (1)$$

The average absolute value of the relative speed travelled over time is defined as:

$$M_{m\ n} = \frac{1}{T}\int_{t0}^{t0+T} |V(m\ n\ t)|\,dt \quad (2)$$

The second definition of the average relative sped is defined as the average over all pairs of nodes in the network:

$$M = \frac{1}{N(N-1)/2}\sum_{m}^{n} M_{m\ n} = \frac{1}{N(N-1)/2}\sum_{m=1}^{N}\sum_{n=m+1}^{N} M_{m\ n} \quad (3)$$

Or N is the number of nodes in the network.

Another technique can also measure the average mobility M (relative mobility) of a node n as the average change in the average distance A (t) node n during a time interval $T - \Delta t$ (T being the duration of the simulation and $\Delta t$ computation time):

$$M_n = \sum_{t=0}^{T-\Delta t} \frac{|A_n(t) - A_n(t+\Delta t)|}{T - \Delta t} \quad (4)$$

Or the average distance of a node n at time t $A_n(t)$ is the average of the distances dist ( $N_n$ ,$N_i$ ) separating it from each node i the network:

$$A(t)_n = \sum_{i=0}^{n} \frac{dist(\ N_n ,N_i\ )}{n-1} \tag{5}$$

## 2.3. Mob-OLSR Protocol

In OLSR [2] each node in the network can be found within a set of other neighbouring nodes. The main idea of the Mob-OLSR protocol is to find a metric that measures mobility by considering the number of nodes entering and leaving the neighbourhood of a node. This metric is defined by equation (6):

$$M_i^{\lambda}(t) = \lambda \frac{NodesOut(t)}{Nodes(t-\Delta t)} + (1-\lambda)\frac{NodesIn(t)}{Nodes(t)} \tag{6}$$

Where:
**Δt** : Time interval equals to 0.05 Second
**λ** : A parameter set in advanced to 0.75.
**NodesOut(t)** : The number of nodes that have left the coverage area of the node during the interval [t, t+Δt].
**NodesIn(t)** : The number of nodes that have entered the coverage area of the node during the interval [t, t+Δt].
***Nodes(t)*** : The number of nodes in the coverage area of a node at time $t$.

The Mob-OLSR protocol is an improvement of the standard OLSR protocol. The Mob-OLSR adds a new criterion in the selection of MPR sets. Indeed, the algorithm MPR set construction gives priority to the less mobile node. The degree of node mobility is measured by the equation (6).

To take advantage of the previously defined formula (Equation 6), several criteria [1] used in the MPR set construction are defined: direct criterion, product criterion and sum criterion.

$$DIR_{CRITERIA} = \min_{v \in N(x)} M_x^{\alpha}(t) \tag{7}$$

$$PROD_{CRITERIA} = 1 - \prod_{v \in N}^{w \in N2} \left( \frac{M_v^{\alpha}(t) + M_w^{\alpha}(t)}{2} \right) \tag{8}$$

$$SUM_{CRITERIA} = 1 - \frac{\sum_{v \in N}^{w \in N2} \left( \frac{M_v^{\alpha}(t) + M_w^{\alpha}(t)}{2} \right)}{n} \tag{9}$$

With:

N [2] is the set of neighbouring nodes of node performing the computation
n = Cardinal (N)
N2 [2] the set of all 2-hop neighbours, excluding:

- Nodes only accessible by members of N with **willingness** = WILL_NEVER
- The node performing the computation itself.
- All the neighbours of node performing the computation.

Willingness [2] is the willingness of a node to carry and forward traffic for other nodes.

# 3. OUR CONTRIBUTION

The formula given above in equation 6 shows the changes that the link state of a node has undergone. Indeed the variation in the number of nodes entering or leaving the neighbourhood varies from one station to another, which gives us an idea about the concerned node's degree of mobility. However, the drawback in this approach is that the λ parameter must be fixed in advanced (λ equals to 0, 0.25, 0.5, 0.75 or 1). Therefore, if λ is set to a value $\lambda > 0.5$, the outflow of nodes will be favoured over the incoming flow of nodes. Likely, the choice of $\lambda < 0.5$ results in the incoming flow being favoured over the outflow of nodes. The unpredicted movement of nodes results in the impossibility of predicting the exact number of nodes entering and exiting the network, and therefore makes it more difficult to better choose the parameter λ. That is why we thought about automating the parameter λ and reformulating the equation for mobility calculation as follows (Equation 10):

$$M_i^{\alpha}(t) = \alpha_1 \frac{NodesOut(t)}{Nodes(t-\Delta t)} + \alpha_2 \frac{NodesIn(t)}{Nodes(t)} \qquad (10)$$

Here :

$\alpha 1 = \frac{IN}{IN+OUT}$ , $\alpha 2 = \frac{OUT}{IN+OUT}$ and **α1+ α1=1**

The Mob-2-OLSR protocol is an improvement of Mob-OLSR Protocol by changing the equation 6 of mobility calculation by our proposed equation 10. In this equation, the parameter λ, which was set to a static value in equation 6, is replaced by two other parameters α1 and α2. α1 and α2 are defined automatically during the MPR set calculation process. The product criterion defined by equation 4 is chosen to be used in the MPR selection process. This is justified by better results obtained during the simulations in [1].

# 4. SIMULATIONS

## 4.1. Simulation Environment

NS2 (Network Simulator) [3] is a network simulation software implemented in C++ and having a TCL (Tool Command Language) interface. NS2 is an open source software allowing developers to change its source code and add new features to it. NS2 has a variety of tools allowing simulating many protocols belonging to different OSI network architecture layers (routing protocols, transport protocols, etc.). It has also many mechanisms to integrate and manage the mobility of nodes in real time.

In our study, we used a standard version of OLSR [2] developed by MASIMUM (MANET Simulation and Implementation at the University of Murcia) which we integrated in NS2 (version 2.34) and modified in order to take account of mobility metrics present in Mob-OLSR and Mob-2-OLSR.

## 4.2. Simulation Parameters

Our network consists of 50 mobile nodes in an area of size 1000 m x 1000 m. Each node moves according to the RWP (Random Way Point) mobility model, with a variable pause time between 0 and 300 seconds and a maximal speed of 140 m/s. The defining scenario of nodes' mobility is changed in every simulation.

Among the 50 nodes, 10 were randomly selected to be the source of CBR (Constant Bit Rate) traffic on UDP connections, with an order of one 512 bytes packet every 2.5 seconds.

Table 1. Simulation Parameters.

| parameter | values |
|---|---|
| Simulation time | 300s |
| Ad hoc Network Area | 1000m x 1000m |
| Number of nodes | 50 nodes |
| Pause time | 0, 50, 100, 150, 200, 250, and 300s |
| Maximum Speed | 140 m /s |
| Mobility model | RWP (Random Way Point) |
| Traffic model used | CBR |
| Package size | 512 bytes |

### 4.3. Mobility Models

A mobility model is used to represent the realistic movements of nodes in a simulation. There are two categories of models:

- Entity Mobility Models where the movements of nodes are independent of each other.
- Group Mobility Models where the movements of nodes belonging to the same group are synchronized.

The RWP [6] is an entity mobility model where all nodes are distributed uniformly in the simulation space and the movement of each node is typically random. The operating principle of this model is defined as follows:

- Each node tries to reach a random destination point by moving with a constant speed randomly chosen from an interval [V_Min, V_Max].
- Once the destination point is reached, the node stays immobile for a pause time randomly chosen from an interval [0, P_Max].
- When the pause time is elapsed, the node targets a new destination point with a new randomly selected speed.

## 5. RESULT

### 5.1. First Case

The results of the study done on the variation of pause time are shown in this part. The main purpose of the experiments done with NS2 simulator is to analyze the performance of our proposed version of routing protocol Mob-2-OLSR, and compare it to the standard OLSR and Mob-OLSR by using the following performance indicators: The average delay, average throughput, and rate of successful packet delivery. The used version of the Mob-OLSR is the one with $\lambda$ equals to 0.75. The Mob-OLSR protocol gives better results when $\lambda$ is equal to 0.75 as shown in a study in [1].

#### 5.1.1. Packet Delivery Ratio (PDR)

The rate of successful packet delivery (PDR) is the total number of data packets successfully delivered divided by the total number of data packets transmitted in the network. This metric gives an idea about the returns of the protocol in terms of packet delivery.

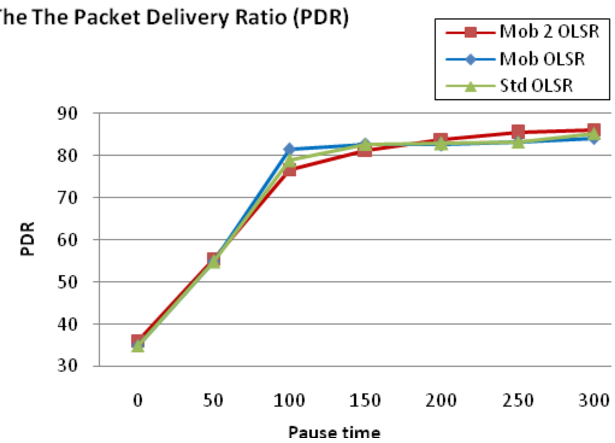


Figure 1. PDR by pause time for the three versions of OLSR: OLSR-2-Mob, Mob-OLSR and Std OLSR

We notice that for highly mobile environments (where pause time=0), our protocol Mob-2-OLSR is on the top compared to the other versions of OLSR. For Environments with medium mobility, all the versions of OLSR protocols have approximately the same PDR. For low mobility environments, the PDR for Mob-2-OLSR is slightly higher compared to the other protocols.

Mob-2-OLSR protocol has better results for highly mobile environments compared to the other OLSR protocols due to the rapid change of topology.

### 5.1.2. Average Throughput

Average throughput is the volume or quantity of information per unit of time. It gives a general overview over all the information transmitted on the channel.

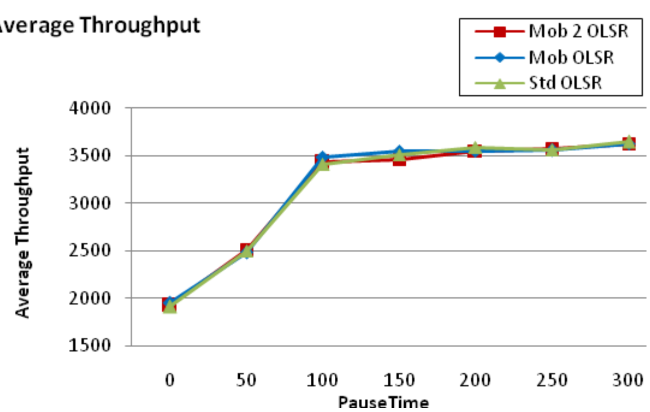


Figure 2. Average Throughput by pause time for the three versions of OLSR: OLSR-2-Mob, Mob-OLSR, and Standard OLSR

For the three versions of OLSR, throughput remains the same for environments with low and high mobility. But in the case of medium mobility, there is a major flow of Mob-2-OLSR compared to Mob- OLSR and Standard OLSR.

The exceeding flow of mob-2-OLSR compared to that of Mob-OLSR is explained by the fact that the rate of packets successfully delivered is very important especially for environments with high mobility.

### 5.1.3. Average Delay

This metric is the average delay of data packets transmitted from source to destination.

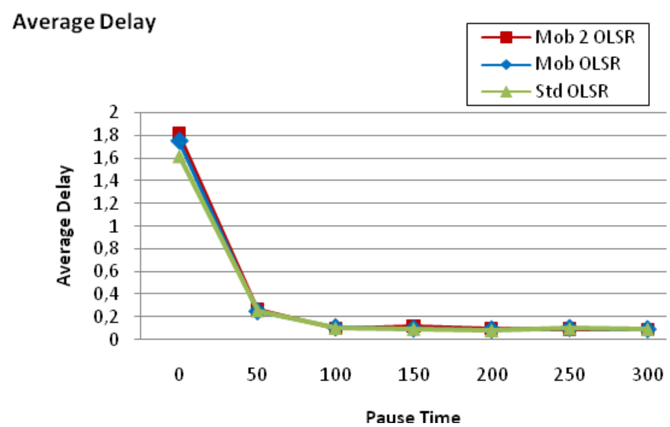


Figure 3. Average Delay by pause time for the three version of OLSR: OLSR-2-Mob, Mob-OLSR, and Standard OLSR

The average delay of the Mob-OLSR protocol is higher than that of Mob-2-OLSR protocol in the case of high mobility environments. For environments with low and medium mobility, the three versions of the OLSR protocol give similar results.

The simulation results shown above after comparing the average delay, average throughput, and rate of successful packet delivery for our proposed protocol Mob-2-OLSR, Mob-OLSR and Standard OLSR, prove that automating the parameter $\lambda$ is a good decision.

Noticing that the three OLSR protocols keep the same behaviour when we studied performance indicators based on pause time for environments with medium and high mobility, leads us to make more experiences by emphasizing the case of high mobility.

## 5.2. Second case

### 5.2.1. The effect of break time on mobility degree

The pause time in the above studies was configured to a value between 0 and 300 seconds. To see the effect of pause time on mobility, the graph in Figure 4 represents the network mobility by pause time.

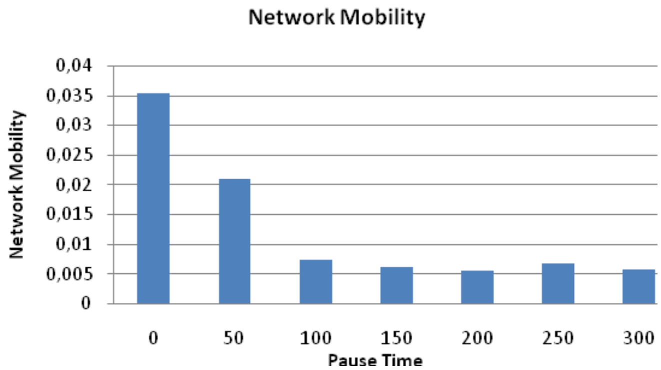


Fig. 4. Network Mobility by pause time for an interval of Δt=0.5.

We notice that the degree of mobility gets to its maximum value for a pause time equal to zero. The degree of mobility is also important for a pause time equal to 50. We notice also that the network mobility decreases as we increase the pause time. . In order to work in an environment with high network mobility, our study focuses on the case where pause time equals to 0.

### 5.2.2. The effect of Δt on the degree of mobility

Δt is the time interval chosen to store changes produced in the nodes neighbourhood in a network. Δt is fixed to a specific value before simulation.

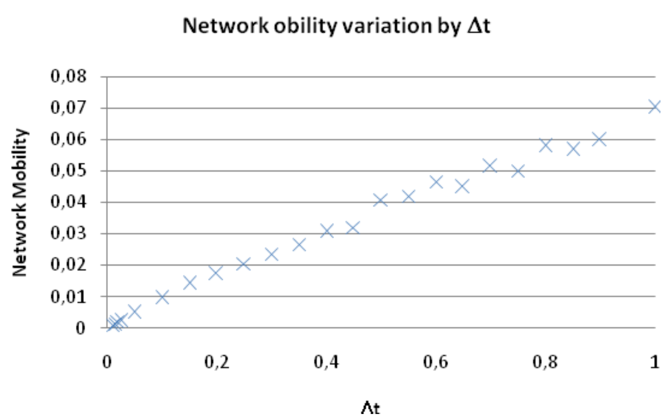


Fig. 5 Network mobility by Δt.

The degree of mobility importantly increases as the interval Δt increases. This means that incoming and outgoing flows are important at the intervals Δt.

In the next section we will study the behaviour of the three OLSR routing protocols in environments with high mobility (pause time = 0).

### 5.2.3. NRL

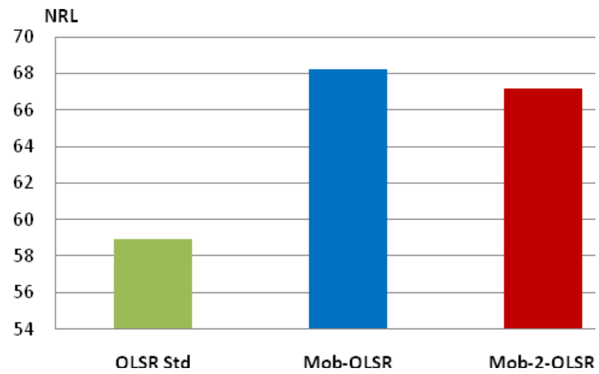


Fig. 6 NRL of the three versions of OLSR: Mob-2-OLSR, Mob-OLSR and Standard OLSR

For a pause time equal to zero, we notice that both Mob-OLSR and Mob-2-OLSR exceed the standard OLSR. Also, given this pause time where mobility is high, we notice that Mob-2-OLSR gives better results than the Mob-OLSR. This is due to the difference between the number of messages routed and the number of messages sent in the network, and also to the high speed of nodes that requires a considerable number of messages for connection establishment.

### 5.2.4. Packet Delivery Ratio (PDR)

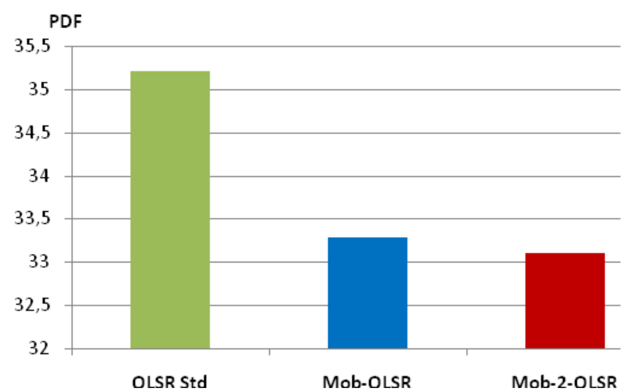


Fig. 7 PDR for the three versions of OLSR: Mob-2-OLSR, Mob-OLSR and Standard OLSR

The standard version of OLSR protocol outperforms all the other versions. The Mob-OLSR and OLSR-2-Mob protocols produce approximately the same PDR. Therefore, we can say that the high speed of nodes increases the rate of packet loss for the Mob-OLSR and OLSR-2-Mob versions of the protocol.

### 5.2.5. Collisions

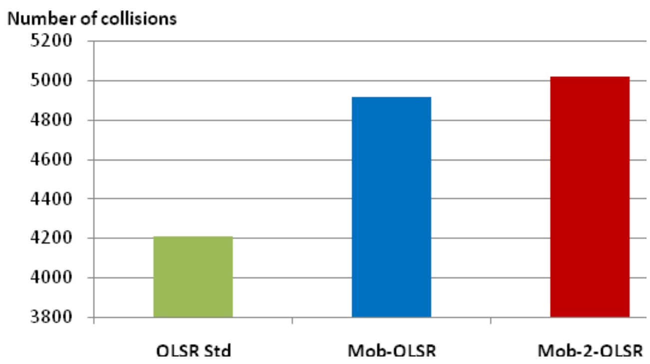


Fig. 8 Number of collisions for the three versions of OLSR: Mob-2-OLSR, Mob-OLSR and Standard OLSR

Collisions are a common factor in all types of media. Packet collisions cause data loss in the network, which degrades the network's performance, and particularly its quality of service. Figure 8 shows that the standard OLSR protocol produces the lowest amount of packets as collision increases, compared to the Mob-OLSR and OLSR-2-Mob protocols. However, we notice that Mob-OLSR andMob-2-OLSR produce an important number of packets as collision increases. This is due to the high speed of nodes that disrupts the network.

### 5.2.6. Average Delay

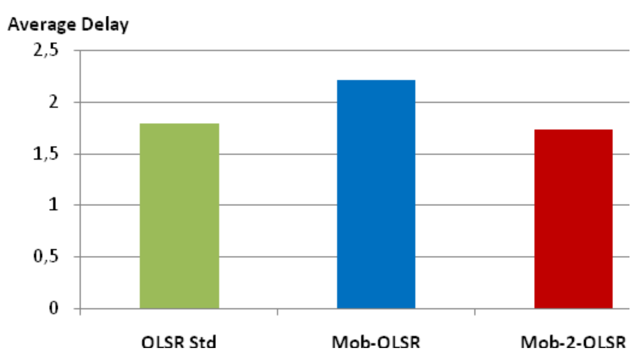


Fig. 9 The average delay for the three versions of OLSR (Mob-2-OLSR, Mob-OLSR, and Standard OLSR

In terms of average delay, the Mob-OLSR protocol outperforms the standard OLSR and the Mob-2-OLSR. However, the standard OLSR and the Mob-2-OLSR have almost the same delay. We can conclude that despite the dynamic topology of the network, the standard OLSR and the Mob-2-OLSR act roughly in the same way.

### 5.2.7. Dropped Packets

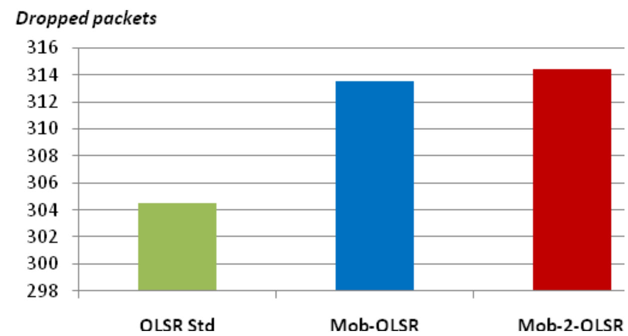


Fig. 10 the number of Dropped packets for the three versions of OLSR: Mob-2-OLSR, Mob-OLSR, and Standard OLSR

The number of dropped packets is almost the same for Mob-OLSR and Mob-2-OLSR protocols, which is higher than the number of dropped packets for the standard OLSR protocol. The increase in the number of dropped packets is explained by important total number of processed messages.

### 5.2.8. Routed Packets

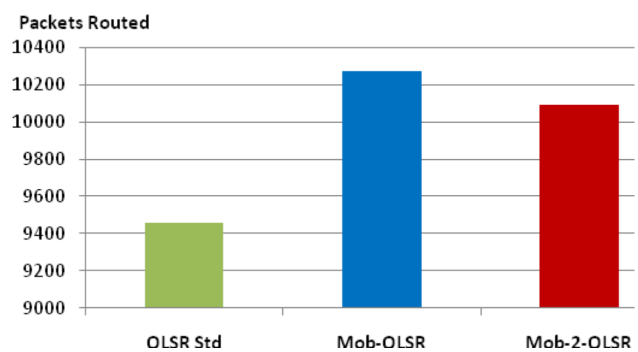


Fig. 1 Routed Packets for the three versions of OLSR: OLSR-2-Mob, Mob-OLSR, and Standard OLSR

Mob-OLSR- and Mob-2-OLSR produce approximately the same number of routed packets compared to the standard OLSR that produces less routed packet. In Mob-OLSR and Mob-2-OLSR versions of the protocol, there is more packet processing compared to the standard OLSR version of the protocol.

## 6. CONCLUSION

In this paper, a new formula for mobility calculation based on the change in nodes environment is given along with a proposition of the λ parameter (weight) automation. In order to prove the proposed OLSR protocol enhancement, we used the NS2 simulator to study the impact of pause time on the performance indicators: PDR, NRL, Average Delay, Average Throughput, and Collisions for the different versions of OLSR protocol: standard OLSR, Mob-OLSR and Mob-2-OLSR.

We noticed that our proposed protocol Mob-2-OLSR provides, in most cases, better results in terms of PDR, delay and throughput compared to the other versions. As a result, the proposed Mob-2-OLSR protocol is an improvement of the two previous versions: the standard OLSR and Mob-OLSR protocols.

It is possible to more perform the Mobility Metric by varying the λ parameter's settings. For example, in addition to the use of the change in the nodes' neighbourhood as a parameter; we can add other criteria such as speed of nodes, bandwidth, energy, and other information.

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