Intelligent MultiPoint Relays Selection

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Abstract: - In MANETs, routing protocols are needed to ensure reliable communications between nodes. They are classified in three categories according to how they establish the routes between any two distanced nodes. There are reactive, proactive or hybrid protocols. The OLSR (Optimized Link State Routing) belongs to the proactive category in which the relays are used to reduce the number of retransmitter nodes and hence to avoid the network flooding with the control traffic. Therefore, it is very important to ensure the maximum reliability for the selected relays in order to increase the performance of the network. In this article, to achieve this goal, we propose an intelligent new method based on dynamic selection of the MPR (MultiPoint Relay) sets construction process. According to constraints related to the nodes environment, we select from many strategies the one that it is the more suitable for being elected as MPR. In this article, two enhanced versions of the OLSR protocol are proposed. In the first one, we use the nodes mobility degree of the neighborhood to select the more suitable MPR. In the second one, we use the quantity of transiting traffic per node. In addition, extensive and rigorous simulations are made by a discrete event simulator to evaluate the efficiency of our approach.

Key-Words: - Mobile Ad hoc Networks (MANET), Mobility, MultiPoint Relay (MPR), OLSR Routing protocol.

1 Introduction

MANET (Mobile Ad hoc Network) [1, 2] refers to an autonomous system composed of independent mobile nodes equipped with wireless interface. It is characterized by the absence of any fixed infrastructure or any base station that charged coordinates the communication tasks between the nodes. All nodes are supposed to work as terminals and routers at the same time. Thus, the presence of a routing protocol is required for connecting nodes that cannot communicate directly with each other. However, the rapid evolution of the MANET network topology over time, due to the presence of nodes mobility and the high control traffic generated by the routing protocols, deteriorates the performance of the MANET network. Therefore, it would be very useful to envisage optimizations to ensure more stability for the nodes and the links between them. In this context, the discovery of the network topology done by the routing protocols must take into account the constraints of the mobility and the traffic load in addition to other factors such as the available bandwidth, the delay and the nodes lifetime.

In the reactive routing protocols, the node does not begin the route construction process unless it needs to send data. On the contrary, proactive routing protocols are characterized by the availability of pre-established routes that are maintained in advance by periodic exchanges of the control messages.

In proactive routing mechanism [3], the use of relays aims to reduce the number of retransmitters so as to avoid the flooding of the network with the control messages. Thus, in the case of OLSR (Optimized Link State Routing) protocol [4], since MPRs (MultiPoint Relay) are responsible for the broadcast of the topology control messages, hence, it is necessary to insure the maximum reliability for the elected relays. Different studies [15, 16, 27] are made with the aim to reduce the effects of both the nodes mobility and the traffic broadcast through the network. They just focused on the different calculating metrics to improve the MPRs selection. In the section 3, we present some works related only to the MPRs selection process.

Unlike these researches, we propose, in this paper, a new solution based on dynamic selection of the MPRs construction process. In other words, each node changes its strategy for selecting its MPRs according to the constraints related to its environment. To achieve this objective, the metrics are frequently recalculated and updated in real time by each node to evaluate its neighborhood and adopt the most appropriate heuristic.

The rest of the paper is organized as follow: In Section 2, we present a brief overview of OLSR protocol. Section 3 presents some previous works that aim to improve the MPRs selection process used by the OLSR protocol. In section 4, we present in detail our approach based on the dynamic selection of the MPR set selection process and all metrics used to achieve this. Section 5 gives some simulations and results concerning the evaluation of our approach. Finally, section 6 presents some conclusions about the current work and perspectives for future works.

2 OLSR Overview

OLSR [4] is a routing protocol dedicated to dense and mobile networks. Due to its proactive aspect, the OLSR has the advantage of providing available paths, which are periodically maintained over the time, between any nodes in the network. It is also an adaptation of the classical OSPF [7] (Open Shortest Path First) routing protocol used by the routers in the internet environment to the MANET environment. Indeed, in addition to its stability, the OLSR gives a significant optimization by using the MPRs concept. With this technique, the OLSR significantly minimizes the broadcast of the control traffic in the network since only nodes qualified as MPR are only allowed to retransmit control messages. Additionally, messages declaring the neighborhood (Hello message) are never retransmitted. For the construction of all MPR sets, the OLSR uses an algorithm (Figure 1) to select among nodes in the first neighborhood, a minimal set providing the ability to reach all nodes in the second neighborhood.

The core of OLSR consists of the following functionalities: Links sensing, Neighbors Discovery, MPR selection, TC-Message broadcasting and Route calculation. To accomplish these functions, this protocol uses four types of messages: HELLO, Topology Control (TC), Multiple Interface Declaration (MID) and Host and Network Association (HNA) messages.

Among the weaknesses of this algorithm, the case where there is two nodes which are candidates to be chosen as MPR with the same reachability, willingness and degree. The choice is purely random, and may lead to bad selection. Because of its importance, this next section presents some works related only to the MPR selection process.

MPR SELECTION PROCESS

```
Initial: A node k,N1(k),N2(k).
Return: MPRk; MPR set of k
begin
  Add to MPRk from N1(k) nodes which are
  the only way to reach nodes in N2(k)
  Remove from N2(k) nodes which are
  covered by MPRk
  Calculate Degree¹ of N1(k)
  While (N2(k) not empty) do
    For each node in N1(k),
      ▪ Calculate reachability² of N1 (k).
      ▪ Add to MPRk nodes which have the
        highest Willingness³,
        If multiple choices exists, add
        nodes which provide the highest
        reachability.
        If multiple choices exists,
        select node with highest degree.
      ▪ Remove the nodes from N2(k) which
        are covered by a node in MPRk
end
```

1: Degree (k): number of symmetric 1-hop neighbors x / .x≠k & $x \notin N_1(k)$.
2: number of nodes in $N_2(k)$ which are not yet covered by MPR(K).
3: willingness of a node to carry and forward traffic for other nodes.

Fig.1 MPR-set construction algorithm

3 Related Work

Improving the performance of the routing protocols is the purpose that dominates the work of the majority of researchers. Indeed, they provide specific solutions according to the type of routing protocol (proactive, reactive, hybrid, etc.) or target objectives (design solutions to real-time applications, etc.) or according to the performances needed to be enhanced (reducing the end to end delay, packet loss rate, etc.). In proactive routing protocol OLSR, the number of topology control messages, which are generated in the network, is proportional to the number of MPR nodes. Regarding this situation, many efforts have been done to analyze the MPR selection algorithm and different solutions for its enhancement are proposed. Many researchers attempt to ameliorate the MPRs selection based on the real-time nodes measurements or on the experienced new routing metrics [15, 16, 27]. Thus, to satisfy QoS requirements requested by the applications of the higher layers, the authors of [5] proposed an innovative heuristic that aims to find an optimal path in terms of delay and available bandwidth. These latter parameters are calculated based on information derived from the MAC 802.11 layer. The work achieved in [10] aims to reduce the rate of traffic generated by the control messages used by the OLSR protocol to manage the network. The authors of this article propose a procedure for cooperative MPR selection which consists of combining many TC messages coming from several other nodes in one message. As a result, the reducing of the number of the sender nodes will cause a reduction in the total number of TC messages that will be circulating in the network. To limit the effects produced by the neighbor nodes mobility, and hence reduce the rate of the packets loss and the end to end delay, the authors of [6, 9] introduce metrics that calculate the mobility of the neighbor nodes in the selection process of the MPRs in order to give the priority to the least mobile candidates. The work proposed in [12] aims to increase the broadcast packet delivery ratio with a redundant selection of MPRs. With this approach, another possibility to receive a copy of the lost message (due to any reason) is available to nodes covered by several MPRs. In the technique proposed in [11], each node attempts to maintain its MPRs as long as possible. The authors of this article change the order of MPRs selection in such by introducing a new metric based on the lifetime of the node already selected as MPR. To increase the performance of the OLSR routing protocol, the authors of [13] propose two strategies: The first one attempts to reduce the rate of the control traffic through the network by reducing the total number of MPRs selected by all nodes. This strategy is called Selector Set Tie Breaker (SSTB) and consists of changing the MPR sets construction process. The second strategy is called Stability Driven MPR Choice (SDMC) and is also based on the modification of the heuristic for MPRs selection in such way to give priority to nodes that has been already selected as MPR. The objective here is to ensure more stability in the MPR sets by reducing the number of changes that occurred in these sets. The main idea of [14] is the use of an estimation of link reliability model. It is introduced in the MPR selection and in the routing table calculation procedures to guarantee reliable data transmission. The authors of this article use the Bayesian inference method to estimate the links reliability based on the accumulated information from the historic of the old data transmissions. Reducing the number of MPRs node is the objective of researches made in [15, 16]. The approach used by the authors of [15] consists of designing an MPR set construction algorithm based on three models of improved ant colony algorithm (In Ant-Cycle Model, In Ant-Quantity Model and In Ant-Density Model). They let nodes to compute an in-degree parameter used with another out-degree parameter to represent the pheromone intensity. Otherwise, the NFA (Necessity First Algorithm) algorithm proposed in [16] tries to solve the problem of greedy algorithm. It is based on the “necessity of selecting” concept (defined as the ability of two nodes to provide only reachability to some 2 hop neighbors) to select MPRs.

Combination of several criteria in one metric is the strategy adopted by the research made in [18,19]. Indeed, to introduce more intelligence in routing process, the authors of [18] assume that a good choice of configuration parameters presents a method to significantly improve the performance of existing routing protocols. They aim in this work to define a technique that is based on self-resolution of an offline optimization problem in order to automatically and effectively improve the operation of the OLSR. In other words, they aim to define the optimization problem to obtain automatically the best fits configuration to the VANET context. To ensure the QoS in OLSR, the authors of the research made in [19] propose a Fuzzy logic based on three routing metrics that are energy, stability and buffer occupancy of the nodes in order to select quality MPR (QMPR). The develop FIS (Fuzzy Inference System) model that uses information gathered during the initialization of the OLSR protocol to compute the fore-mentioned metrics may be useful in the future to predict the best nodes that can be selected as MPR.

The next section gives detailed description of our dynamic selection approach of multipoint relays and all metrics used either to help nodes to adapt their choice, or to consolidate the MPR selection process.

4 Used Metrics and Our Contribution

Before illustrating our technique, we start by explaining the *RTTQ_Metric* inserted as another parameter in the MPR set construction process. It will be followed by an explanation of two other metrics (*Mobility_Metric* and *Traffic_Metric*) allowing each node to assess its environment.

4.1 Remaining Time To Quite

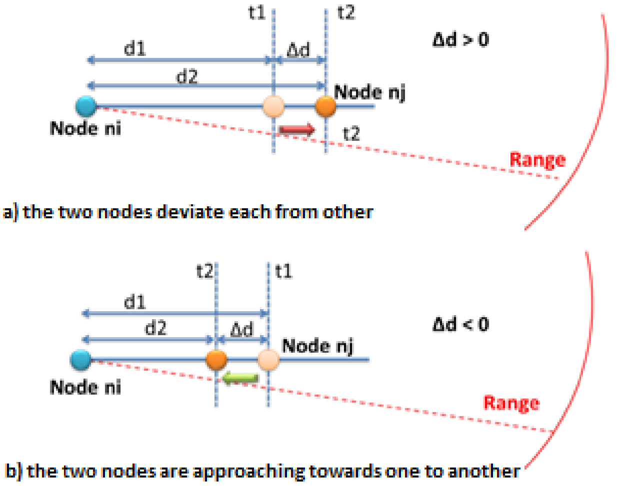

Fig.2 RTTQ Metric Computation

Figure 2 represents the Remaining Time To Quite (RTTQ) [20, 21] of each node *nj* that is susceptible to leave the neighborhood of another node *ni*. It is estimated based on the traveled distances Δd between two consecutive messages receptions, the elapsed time Δt during this travel and radio range. In Δd computation, ($\Delta d = d2 - d1$), the obtained sign gives us an idea about the direction of the neighbor node *nj* relatively to the node *ni* during the MPR set computation. Indeed, negative value indicates that the distance between these two nodes is getting closer. In this case, the RTTQ is set to its maximum value computed by (2). However, the positive value indicates that they are getting larger. In this case, the predicted instant when the connection well be lost (in other word, the RTTQ) is estimated by the (1).

$$RTTQ_{nj}\left(t+dt\right)=\begin{cases}\dfrac{\left(Range-d2\right)}{\Delta d}*\Delta t, & \Delta d>0 \qquad (1)\\[2mm] \dfrac{Range}{v}, & \Delta d\leq 0 \qquad (2)\end{cases}$$

Where: the times *t1* and *t2* are respectively the time required for traveling the two distances *d1* and *d2*. These distances are calculated based on nodes Cartesian coordinates (assuming the nodes movement is in 2 dimensions area). The symbol *v* is the nodes velocity.

4.2 Mobility Metric

To evaluate the degree of mobility of its first neighborhood, each node uses a metric [6] based essentially on changes occurring in its neighbors set. Thus, this metric calculates the sum of the number of nodes logged in or logged out from the neighbors set in regular time intervals Δt (Figure 3). The Choose of this metric is justified by the fact that it reflects the degree of agitation around a node and that is strongly related to the nodes velocity. It is calculated by (3) and will be used to differentiate between low or high mobility environments.

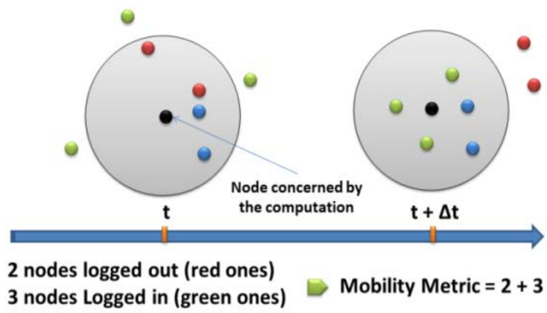

Fig.3 Neighborhood Mobility Computation

$$Mobility\_Metric_{ni}(t+\Delta t)=NN\_In(t+\Delta t)+NN\_Out(t+\Delta t) \quad (3)$$

$$AVG\_Mobility\_Metric_{ni}=\frac{\sum_{k}Mobility\_Metric_{ni}(t+\Delta t)}{K} \quad (4)$$

$$AVG\_Mobility\_Metric=Average(Mobility\_Metric_{ni}) \quad (5)$$

Where *NN_In* (respectively *NN_out*) are the number of nodes logged in (logged out from) the neighbor set. $k \in [\Delta t, 2\Delta t, 3\Delta t, \ldots k\Delta t]$. *K* is the number of intervals $[t+\Delta t]$. *Mobility_Metric* is the average of all computed $Mobility\_Metric_{ni}$ for all nodes and during the simulation Time.

4.3 Traffic Metric

Two types of traffics pass through each node in routing level: The traffic generated by all OLSR nodes and data traffic comes from the upper layers and represented in our case by the CBR (Constant Bit Rite) which is generated by some nodes. To quantify the amount of traffic passed through each node (Figure 4), we used the metric that calculates the rate of received traffic by the formula represented in (6). This metric is equal to the number of CBR and OLSR packets received by this node divided respectively on total number of CBR and OLSR packets received by all nodes.

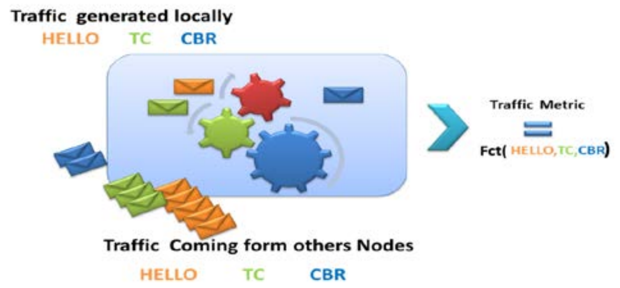

Fig.4 Traffic Metric Computation

$$Trafic\_Metric_{ni}(t) = \alpha \frac{CBR\_Trafic_{ni}(t)}{Total\_CBR\_Trafic(t)} + \beta \frac{OLSR - Trafic_{ni}(t)}{Total\_OLSR\_Traffic(t)} \quad (6)$$

Since the number of the OLSR packets is very important relatively to the number of CBR packets, two weighting parameters α and β are used for normalizing.

$$AVG\_Traffic\_Metric_{ni} = \frac{\sum_k Traffic\_Metric_{ni}(t)}{K} \quad (7)$$

$$AVG\_Traffic\_Metric = Average(Traffic\_Metric_{ni}) \quad (8)$$

Where K is the number of $Traffic\_Metric_{ni}$ computation for the node *ni* until current time. *AVG_Traffic_Metric* is the average of all computed $Traffic\_Metric_{ni}$ for all nodes during the simulation time.

4.4 Dynamic Choice of MPR-Set computation

As already stated, the aim is to introduce a dynamic selection of all MPRs. In other words, each node can execute a different heuristic chosen according to the conditions dictated by its environment. In this sense, the two metrics (*Traffic_Metric* and *Mobility_Metric*), which reflect the environment state of the nodes, are used to decide which procedure should be chosen. They are respectively calculated by (5) and (8). The first one allows us to evaluate the degree of node's neighborhood mobility and the second one allows us to be aware of the amount of the traffic that transiting through each node. In the implementation of our approach, two strategies are available to the nodes to build their sets of MPRs. In the first one, priority will be given to the mobility prediction metric (RTTQ) before the reachability (*1-Willingness*, ***2-RTTQ***, ***3-Reachibility***, *4-Degree*). In the second, priority will be given to the reachability before the RTTQ metric (*1-Willingness*, ***2-Reachibility***, ***3-RTTQ***, *4-Degree*). These choices take into account that all nodes start with the same Willingness (*WILL-DEFAULT*).

Mobility-OLSR:

Regardless of the choice of the adopted procedure, the first solution is to use the degree of stability obtained by the number of changes that occur by the 1-hop node neighborhood which is calculated by $Mobility\_Metric_{ni}(t)$. By comparing this latter with our benchmark (*AVG_Traffic_Mobility*), each node can distinguish between the low and high mobility environments. As shown in figure 5, with the neighborhood degree of mobility greater than *AVG_Traffic_Mobility*, priority will be given to heuristic 1. Otherwise, it is the heuristic 2 that well be chosen. The version of the protocol produced by this approach is entitled *Mobility-OLSR*

Traffic-OLSR :

Traffic load intercepted by nodes is considered in our second version of OLSR Protocol. In this latter, to choose the MPRs selection procedure, each node compares its calculated $Traffic\_Metric_{ni}(t)$ with the landmark *AVG_Traffic_Metric*. Thus, the figure 5 illustrates the strategy adopted by the second version of OLSR protocol (named *Traffic-OLSR*) to choose heuristic 1 or heuristic 2 according to the result of the comparison.

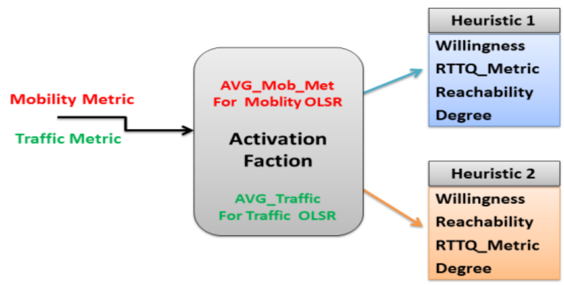

Fig.5 Dynamic choice of MPR selection process for the two versions *MOBILITY-OLSR* and *TRAFFIC-OLSR*

5 Simulation and Result

5.1 Simulation Environments

All our Simulations are done in NS2 [22-24] (Network Simulator) 2.35 version in which we have integrated a standard version of OLSR (UM-OLSR-1.0 [25]) that is developed by MASIMUM (MANET Simulation and Implementation at the University of Murcia). Our simulation parameters are as follow: The network is consisted of a 60 mobile nodes whose radio scoop is 250 m, moving in an area of 1000 x 1000 m². Each node moves according to the RWP (Random WayPoint) mobility model [22, 26] with pause time fixed to 0 second and maximum speed varied between 5 and 30 meter/second (with a step of 5). The scenario that defines the nodes movement is regenerated at the beginning of each simulation. To generate traffic in the network, 20 of nodes are randomly selected to be a source of CBR (Constant Bit Rate) traffic. And these selected nodes use UDP (User Datagram Protocol) connections to send packets with 1024 bytes with the rate of one packet every 2.5 second. The Table I below summarizes all the parameters used during simulations:

Simulation environment	Options and parameters
Flat size	1000m x 1000m
Max number of nodes	60 nodes
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
The number of connections	5, 10, 15, 20, 25, 30 nodes
Mobility model	RWP (Random Way Point)
Pause time	0 second
Maximum speed of nodes	5, 10, 15, 20, 25 and 30 m/s
Simulation time	500 sec

Table I. Simulation Parameters

5.2 Points Mark Calculation.

To determine the landmark values which will be used to distinguish between types of environments (low or high mobility - small or large rate of transiting traffic), one first round of simulations is made with NS2 to calculate the mean values: *AVG_Mobility_Metric* and *AVG_Traffic_Metric*.

5.3 Performances Studies

All results obtained by the NS2 simulator concerning the three versions of OLSR are addressed in this research. In addition to the standard version (*Standard-OLSR*) traced in blue color, there is the *Traffic-OLSR* version that is represented by the green color and *Mobility-OLSR* version plotted with red color.

In order to compare the different versions of OLSR protocols, two metrics are used. The first one (9) is *AVG_RTTQ* which represents the average residual time to quit for all nodes belonging to the first neighborhood. The second one (10) is *AVG_MPR_Lifetime* which represents the average of MPRs lifetime. This is the average of all time that lasted each node as MPR to another node.

$$AVG\_RTTQ_{ni}(t) = \frac{\sum_{j=1}^{j=nn} RTTQ_{nj}(t)}{nn} \quad | \quad nj \in nb\_set(ni) \quad (9)$$

$$AVG\_MPR\_Lifetime = Average(MPR\_Lifetime_{n_k}) \quad (10)$$

Where *nb_set(ni)* is the node n_i neighbor set, *nn* is the size of *nb_set(ni)* and $MPR\_Lifetime_{nk}$ is the lifetime of the MPR node n_k

The number of nodes selected as MPR has a large impact on the amount of the control traffic circulating in a MANET. For this reason, we decided to study this important factor. Thus, in figures 6 and.7, we present the average number of MPR nodes selected for the three studied versions of OLSR. In the first one, it is traced depending on the nodes maximum speed. In the second one, it is plotted on depend the numbers of established connections between nodes.

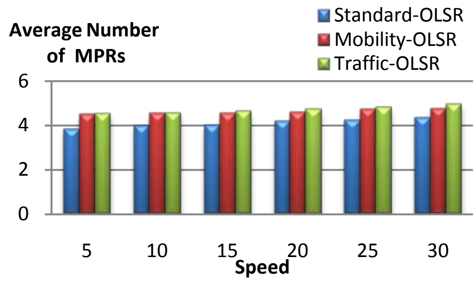

Fig.6 Average number of selected MPRs depending on nodes max speed.

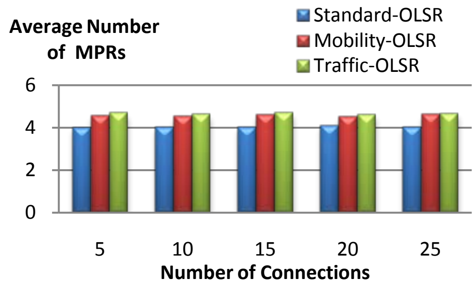

Fig.7 Average number of selected MPRs depending on connections number.

From these two figures, we note that for all speeds and all connection numbers, our two versions of the OLSR protocol present almost the same average number of nodes selected as MPR with a very little improvement recorded by the *Mobility-OLSR*. We also observe that all these values are modest compared to the standard version. The first figure shows also a small increase in the average number of selected MPR when speed increases. Unlike the first one, the second figure shows the number of MPRs remain constant for each protocol and for all number of connections.

The modest values obtained by the *Mobility-OLSR* and *Traffic-OLSR*, compared with those obtained by the standard version, are logical and can be interpreted by the fact that these two versions use the RTTQ criterion before reachability and degree criterions. Note that these two last criterions are used by the *Standard-OLSR* and produce, in most cases, the smallest sets of MPR.

The small improvement seen in the case of the *Mobility-OLSR* version is due to the use of the mobility metric affected by nodes speed unlike the *Traffic-OLSR* that uses a metric related to the amount of traffic. In the case of the second figure, the same values, which are obtained by the three versions of the protocol, are logical since the exchanged traffic doesn't affect at all the MPRs selection process. We select our MPRs based on the willingness, RTTQ, reachability and degree criterions.

The three figures 8, 9 and 10 concern the average lifetime of MPR nodes. In the first one, it is plotted depending on the nodes' speed. In the second one, we trace the difference between the average life duration of our two protocol versions and the values marked by the *standard-OLSR* (Standard-Traffic = Average MPR Lifetime for *Standard OLSR* - Average MPR Lifetime for *Traffic OLSR*. Standard-Mobility = Average MPR Lifetime for *Standard OLSR* - Average MPR Lifetime for *Mobility OLSR*). The figure 9 is similar to the figure 7, but it represents the MPRs lifetime average depending on connections number.

The figure 8 shows some degradation at the average lifetime for the nodes selected as MPR for both versions *Mobility-OLSR* and *Traffic-OLSR* compared to the standard version. We also observe that the values presented by the *Mobility-OLSR* remain lower than that obtained by the *Traffic-OLSR*.

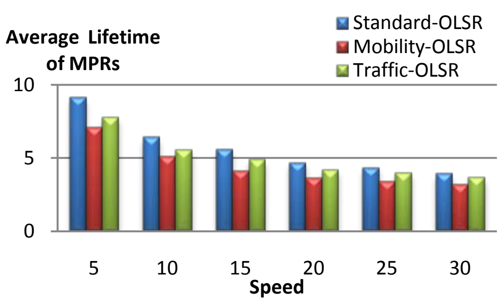

Fig.8 Average MPR's Lifetime depending nodes speed.

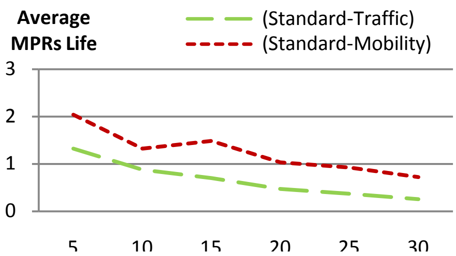

Fig.9 Average Traffic metric for each node.

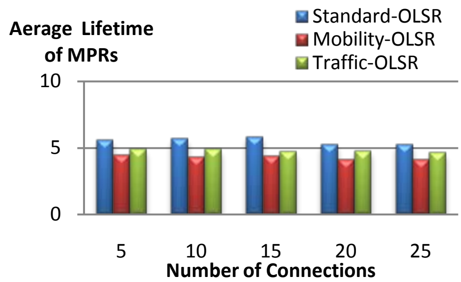

Fig.10 Average MPR's Lifetime depending on the connections number.

This figure also shows a large difference for the MPR lifetime in environments with high mobility and low mobility. Indeed, we note that when the speed becomes higher, the life duration of nodes selected as MPRs for the three versions of the protocol is reduced and converges to the values obtained by the standard. This is confirmed by the figure 9. Indeed, in this latter, we trace the difference between average MPRs lifetime obtained by the standard version and our two versions of the protocol OLSR. The both curves are in continuous decrease, as the speed increases, and tend to zero in the very high mobility environment. This figure also shows that the values obtained by the *Traffic-OLSR* version are closer to those obtained by the standard unlike the values recorded by the *Mobility-OLSR* Version. The curves of figure 10 also present the average MPR lifetime, but depending on the number of connections. They confirm that the *Traffic-OLSR* version remain closer to the standard version.

For the both versions of OLSR, the degradation in the average MPR life duration is logical since each node must change the used strategy to select its MPR. This means that each node must completely remove the old set and select another one that containing new elements. In other words, the nodes that are selected in the strategy i at time t can be different to these selected by strategy j at time $t + dt$.

The two figures below show the average of remaining lifetime to leave the neighborhood (RTTQ) for the three versions of the OLSR protocol depending on nodes' speed (Figure 11) and connections number (Figure 12). It is calculated from RTTQ for all nodes in the first neighborhood. Obviously, they show almost the same values. It degrades when the speed is increasing and it tends to the stability when the network topology changes rapidly. It remains constant in the case of varying the number of connections.

The approximate values of RTTQ obtained by the three protocols are due to the fact that all of them are based on the coordinates in their distance calculation and on the radio range that is the same for all nodes. This reduction recorded in the RTTQ as speed increases is justified by the fact that with a higher speed, the probability of leaving the neighborhood in shorter time increases.

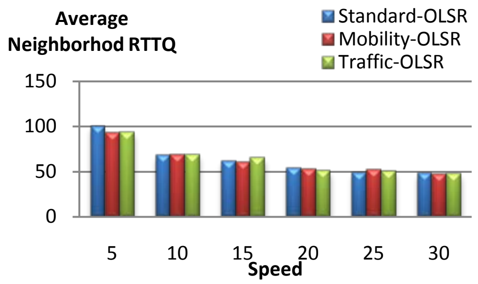

Fig.11 Average neighbouring RTTQ depending nodes speed.

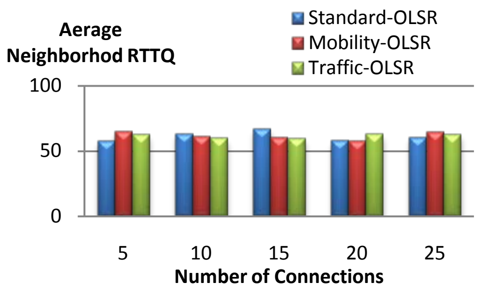

Fig.12 Average neighbouring RTTQ depending on the connections number.

As results, our two versions of OLSR protocol give values of RTTQ closer to the standard version in all types of environments and with closer values of MPRs lifetime to the standard just in high mobility environments. Moreover, *Traffic-OLSR* version gives an improvement in the MPRs life duration compared to the *Mobility-OLSR* version in all environments with more traffic exchange. However, it has some disadvantages in terms of the number of MPR which is slightly larger than the standard version and with MPRs lifetime smaller than the MPRs selected in the standard.

To illustrate the contribution of our approach, we have studied three performance indicators (PDR: Packet Delivery Ratio, Average Throughput and Average End to End Delay) of our two versions of OLSR protocol compared to the *standard-OLSR*.

Figures 13 and 14 show respectively the average RDP and the average throughput depending on nodes'speed. It is clear that they present the same behavior. From these figures, and for the three versions of the OLSR protocol, we note that those two indicators become more degraded when the speed increases. Moreover, compared to the *standard-OLSR*, we note that the *Traffic-OLSR* protocol presents an improvement for almost all speeds, except the case of 25 m/s. We also note a clear distinction between the low mobility and the high mobility environments for the *Mobility-OLSR* version. Indeed, it presents low performances in terms of the average PDR and average throughput in high mobility environments with speed exceeding 15 m/s. However, it indicates better values in low mobility environments compared to the standard version.

We know that the amount of traffic (a periodic exchange of messages and periodic sends of the CBR traffic) is not greatly affected by the nodes speed. As a consequence, the *Traffic-OLSR* keeps often the same performance and remains more efficient than the two other versions.

The change in the behavior of *Mobility-OLSR*, which is related to the mobility degree, is justified by the fact that mobility is affected by the speed of the nodes. Indeed, with high mobility, the neighborhood knows more changes. This means that it is heuristic 2 that will be often selected. And because it gives priority to the reachability before our RTTQ metric, it is the nodes that cover a larger number of second adjacent neighbors that are selected first. So, it will have, as a result, the degradation in the PDR, throughput and delay. Otherwise, in the low mobility environment, it is the heuristic 1 that will often be selected, which will give the opposite results.

For the average end to end delay plotted in figure 15, the version *Traffic-OLSR* presents the best values compared to the *Mobility-OLSR* and the *Standard-OLSR* for almost all speeds, except the exception of 25 m/s. This figure shows also the degradation of the average delay obtained by the *Mobility-OLSR* compared to the *Standard-OLSR*.

The improvements registered by *Traffic-OLSR* version in term of PDR, Throughput and delay are due to the integration of metric RTTQ in the MPRs selection process. With such a metric, the priority is given to nodes that give the longest predicted lifetime. This reduces the loss packet rate, and therefore increases the performance indicators.

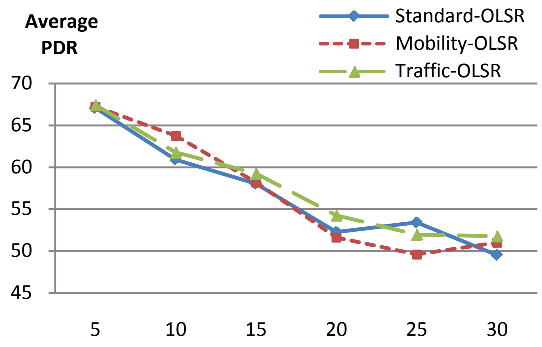

Fig.13 The Average PDR depending speed.

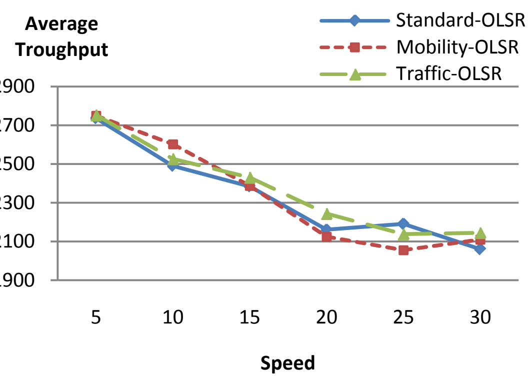

Fig.14 The Average Throughput depending speed.

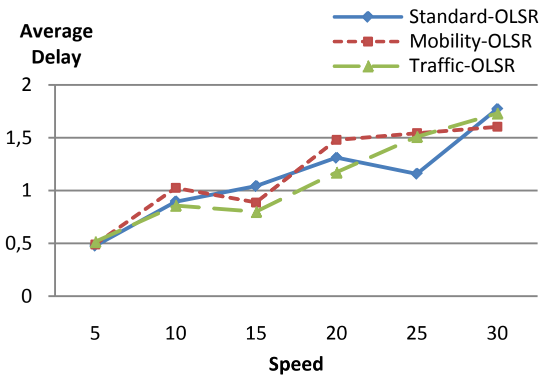

Fig.15 The Average Delay depending speed.

In figures 16, 17 and 18, we studied the average PDR, the average throughput and the average end to end delay, as function of the number of connections for the three protocol versions.

The curves in these three figures present the same behavior. They have degradation in the average PDR, average throughput and average delay when the number of connections increases. We also see a clear distinction between environments with low exchanged traffic and environments with high exchanged traffic for *Traffic-OLSR* and *Mobility-OLSR* versions. Indeed, the *Traffic-OLSR* protocol presents better results in terms of the average PDR, the average throughput and the average delay in high active environments when the number of connections exceeds 15. Otherwise, in low active environments, this version gives the modest results with comparison with the *Mobility-OLSR*.

The observed degradation of these three indicators, when the connections number increase, is justified by the fact that with a very active environment, the number of exchanged messages becomes greater which increases the probability of collisions.

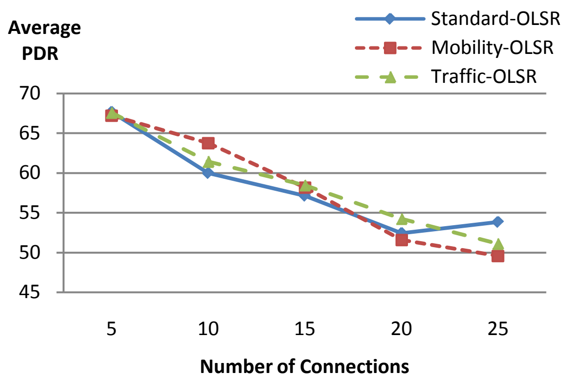

Fig.16 The Average PDR depending connections number.

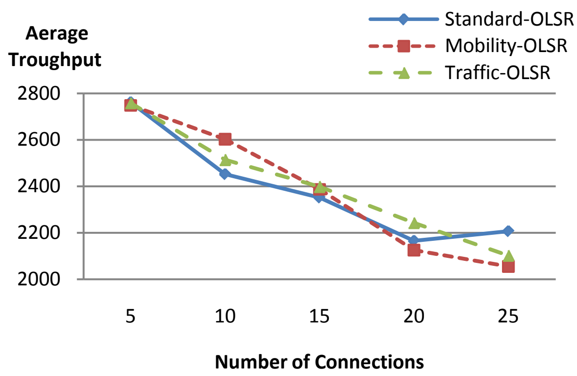

Fig.17 The Average Throughput depending connections number.

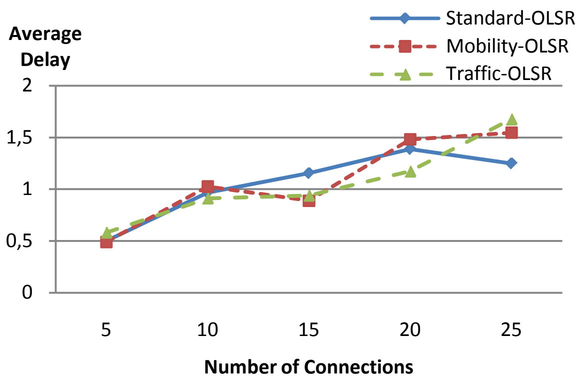

Fig.18 The Average Delay depending connections number.

In the case where the traffic load decreases and the *Avg_Mobility_Metric* value increases, the selected heuristic is the one that gives priority to the RTTQ criterion which allows the selection of MPRs with the longest lifetime. In this case, the PDR, the end to end delay and the throughput become better.

In conclusion, the technique of changing the MPRs building process with choosing of the most suitable strategy seems more effective when it is based on the state (quantity) of traffic criterion in environments with low exchanged traffic.

6 Conclusion

The approach adopted in this article provided a technique that allows a dynamic choice of the MPRs construction heuristic that is suitable to the nodes environment encountered in MANETs. Indeed, in its implementation, two versions of OLSR are made. They are differentiated according to the metric used for evaluating the nodes neighborhood. Thus, the use of the metric that quantifies the degree of mobility of the neighborhood gives birth to the *Mobility-OLSR* version protocol. On the other hand, the use of the metric that calculates the amount of the transiting traffic gives birth to the *traffic-OLSR*.

The obtained results related to the *Traffic-OLSR* versions show considerable improvements in terms of PDR, Throughput and the delay compared to *Mobility-OLSR* and *Standard-OLSR*. More specifically, this version is more suitable for situations where nodes exchange high amount of data traffic. We can also say that the use of traffic metric to select the most appropriate strategy is compatible with the use of the RTTQ metric in the MPRs selection process.

However, the poor result, which is obtained by the *Mobility-OLSR* regarding the network performances indicators, leads us to exclude the use of the mobility metric in the dynamic construction of MPR sets.

In perspective, the approach discussed in this article can be improved by adding other metrics to provide more information on the nodes neighborhood. They can be combined with the ones already used.

References:

[1] S. Corson and J. Macker, Mobile Ad hoc Networking (MANET): Routing Protocol Performance Issues and Evaluation Considerations: RFC Editor, 1999.

[2] R. Roy, "Mobile Ad Hoc Networks," in Handbook of Mobile Ad Hoc Networks for Mobility Models, ed: Springer US, 2011, pp. 3-22.

[3] A. Liotta and G. Exarchakos, "Proactive Networks," in Networks for Pervasive Services. vol. 92, ed: Springer Netherlands, 2011, pp. 79-93.

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

[5] H. Badis and K. Al Agha, "QOLSR, QoS routing for ad hoc wireless networks using OLSR," European Transactions on Telecommunications, vol. 16, pp. 427-442, 2005.

[6] K. Oudidi, A. Hajami, and M. Koutbi, "QoS routing using OLSR protocol," presented at the Proceedings of the 14th WSEAS international conference on Communications, Corfu Island, Greece, 2010.

[7] John T. Moy OSPF: Anatomy of an Internet Routing Protocol Addison-Wesley Professional 1998.

[8] A. Ouacha, N. Lakki, J. El Abbadi, A. Habbani, and M. El koutbi, "OLSR protocol enhancement through mobility integration," in Networking, Sensing and Control (ICNSC), 2013 10th IEEE International Conference on, 2013, pp. 17-22.

[9] K. Yamada, T. Itokawa, T. Kitasuka, and M. Aritsugi, "Cooperative MPR selection to reduce topology control packets in OLSR," in TENCON 2010 - 2010 IEEE Region 10 Conference, 2010, pp. 293-298.

[10] A. Ouacha, N. Lakki, A. Habbani, and J. E. Abbadi, "New Mobility Metric based on MultiPoint Relay Life Duration," presented at the Proceedings of the International Conference on Signal Processing and Multimedia Applications and Wireless Information Networks and Systems, Rome, Italy, 2012.

[11] A. Ji Hyoung and L. Tae-Jin, "A multipoint relay selection method for reliable broadcast in ad hoc networks," in ICT Convergence (ICTC), 2011 International Conference on, 2011, pp. 616-617.

[12] L. Maccari and R. Lo Cigno, "How to reduce and stabilize MPR sets in OLSR networks," in Wireless and Mobile Computing, Networking and Communications (WiMob), 2012 IEEE 8th International Conference on, 2012, pp. 373-380.

[13] H. J. Woo, D. Y. Lee, and C. W. Lee, "An enhanced OLSR protocol based on link reliability," presented at the Proceedings of the 4th International Conference on Uniquitous

Information Management and Communication, Suwon, Republic of Korea, 2010.
[14] Z. Xianming, S. Huazhu, X. Hongxia, and Z. Luo, "Using Ant Colony Algorithm for Solving Minimum MPR Set and OPNET Simulation," in Information Science and Engineering (ICISE), 2009 1st International Conference on, 2009, pp. 3898-3901.
[15] L. Zheng, Y. Nenghai, and D. Zili, "NFA: A New Algorithm to Select MPRs in OLSR," in Wireless Communications, Networking and Mobile Computing, 2008. WiCOM '08. 4th International Conference on, 2008, pp. 1-6.
[16] J. Toutouh, J. Garcia-Nieto, and E. Alba, "Intelligent OLSR Routing Protocol Optimization for VANETs," Vehicular Technology, IEEE Transactions on, vol. 61, pp. 1884-1894, 2012.
[17] A. Kots and M. Kumar, "The fuzzy based QMPR selection for OLSR routing protocol," Wireless Networks, pp. 1-10, 2013/04/27 2013.
[18] A. Ouacha, N. Lakki, J. El Abbadi, A. Habbani, B. Bouamoud, and M. Elkoutbi, "Reliable MPR selection based on link lifetime-prediction method," in Networking, Sensing and Control (ICNSC), 2013 10th IEEE International Conference on, 2013, pp. 11-16.
[19] A. Ouacha, B. Bouamoud, A. Habbani, and J. El Abbadi, "Novel Multipoint Relays Scheme Based on Hybrid Cost Function," ISRN Aerospace Engineering, vol. 2013, p. 9, 2013.
[20] "The ns Manual," UC Berkeley, LBL, USC/ISI, and Xerox PARC, May 9, 2010 2010.
[21] T. Issariyakul and E. Hossain, Introduction to Network Simulator NS2: Springer US, 2009.
[22] The Network Simulator - ns-2. Available:
[23] http://www.isi.edu/nsnam/ns/
[24] F. J. Ros. UM-OLSR. Available:
[25] http://masimum.inf.um.es/fjrm/development/um-olsr/
[26] R. Roy, "Random Walk Mobility," in Handbook of Mobile Ad Hoc Networks for Mobility Models, ed: Springer US, 2011, pp. 35-63.
[27] Joshi, R.D.; Rege, P.P., "Implementation and analytical modelling of modified optimised link state routing protocol for network lifetime improvement," Communications, IET , vol.6, no.10, pp.1270,1277, July 3 2012, doi: 10.1049/iet-com.2011.0257,