New Mobility Metric based on MultiPoint Relay Life Duration

Ali Ouacha[1], Noureddine Lakki [1], Ahmed Habbani [1,2] and Jamal El Abbadi [1]

[1]*Laboratoire d'Electronique et de Communications LEC, Ecole Mohammadia d'Ingénieurs EMI, Université Mohammed V-Agdal UM5A, BP 765, avenue Ibn Sina Agdal 10000, Rabat, Maroc*

[2]*Laboratoire SIME, Ecole Nationale Supérieure d'Informatique et d'Analyse des Systèmes ENSIAS, Université Mohammed V-Souissi UM5S, BP 713, Avenue Mohammed ben Abdallah Regragui, Agdal 10000, Rabat, Maroc*

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Abstract: Optimized Link State Routing (OLSR) is a proactive protocol designed to operate in Mobile Ad Hoc Networks (MANET). In this protocol, the topology is based on MultiPoint Relay (MPR) Mechanism. However, the loss of one or many MPRs caused by their movement affects the link state of the network. Therefore, the contribution of this paper is to keep the network links between the nodes and MPRs in stable state as long as possible. It was done by calculating a new parameter named Average Age of Death which estimates the life duration of MPRs. The experimental results illustrate that this parameter is affected by the environment (speed of node, network density and others). This result provides to use this parameter as a new mobility metric that can be used in the MPR sets Calculation.

1 INTRODUCTION

Currently, devices are becoming increasingly popular as they provide users communications by using wireless technology. Those devices form an arbitrary network, titled MANET(Corson and Macker,). In such network, the nodes communication without using any infrastructure requires a self management of the network. Consequently, several routing protocols are dedicated to this kind of network. Those protocols can be classified on two main categories: The first one is a reactive protocol that builds paths at the request and the second one is proactive protocol that maintains an updated routing table by using periodic exchanges of control messages. One of those proactive protocols, which proved its efficiency in large and dense environments, is the Optimized Link State Routing (OLSR)(Clausen and Jacquet, 2003).

In MANETs, mobility node sthat present an advantage to the users is a major handicap in this kind of networks. Indeed, the mobility of nodes is, in the most case, the origin of break links caused with the loss of one or more MPRs which are the key elements in the definition of the network topology. Hence, the requirement to produce techniques to quantify the node movements degree and produce values that can be used in the process of building MPR sets or data paths construction. Our aim is to provide a new approach to maintain, as long as possible, links between nodes and their MPRs. This approach is based on the average age of death for MPRs. Our first challenge in this paper is to show how this new metric will be calculated. Thereafter, we will study the impact of the variation of environment parameter on this metric. The second step is to take advantage of this new mobility metric by its integration in the MPR set selection processes. So, we aim, by selecting nodes with large average age of death, to augment stability of the network and prolong lifetime of links which are used in data transfer.

The rest of this paper is organized as follows. In the next section we provide an overview on the OLSR protocol. The third section presents a short description of related works for some different metrics developed for nodes mobility calculation. The fourth section is devoted for our contribution concerning the average age of death for MPRs. It also illustrates the simulation environment. Before concluding, we present the results about our work.

2 OLSR OVERVIEW

The Optimized Link State Routing (OLSR) is a proactive protocol proposed by HIPERCOM-INRIA team and defined by RFC 3626. It is recognized as one of protocols base used in MANET networks environment. In this protocol, every node must periodi-

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cally update its routing table. This is accomplished by broadcasting periodic control messages. However, to avoid network congestion, OLSR uses the concept of multipoint relays (MPR). This means, only nodes selected as MPR are authorized to retransmit traffic control intended to be broadcasted into the whole network. Therefore, the MPR mechanism reduces significantly the number of control messages forwarding in the network. To calculate the MPR set, each node in the network use periodic messages named HELLO-messages received from its neighbors. To diffuse information about Topology, OLSR uses a second type of messages named TC-messages (Topology Control messages). Information acquired from TC-messages allows nodes to compute and update their routing table.

Despite the great success of the OLSR in MANETs, several factors disrupt its performance. But the great threat comes from physical mobility of nodes. It has negative impact on the network topology. To reduce this impact, the authors of several studies (JOA-NG and LU, 1999)(Kumar and Suman, 2011)2011(Larson and Hedman, 1998)(Oudidi et al., 2010)(Shukla, 2001) suggest many different metrics to calculate nodes mobility and make it a quantifiable value that can be used in the calculation process of MPR-set or taken into account in the path computation. In the Following, we present brief description of some of such metrics.

3 RELATED WORK

Several Studies propose various metrics to calculate the mobility of nodes in ad hoc networks. They can be classified into several categories (Kumar and Suman, 2011)(Oudidi et al., 2010).

The first one includes **direct mobility metrics**. They are flexible and easy measurement methods which are based on direct information extracted from nodes movement. For example, the speed or average speed can be one of this simple direct metrics. Moreover, various papers, published by many authors, fall into this category of metrics. In (Larson and Hedman, 1998), the average speed is based on the relative velocity for two nodes of the network. The average mobility M (relative mobility) of node **n** can be also represented as the average change in the average distance of the node **n** during a time interval $T - \Delta t$ being the duration of the simulation and Δt computation time. Or the average distance of a node **n** at time **t** is the average of the distances separating it from each node **i** in the network.

The Paper presented by (Vazifehdan et al., 2012) is another sample of direct mobility metrics. the main equation for the authors is how long any two arbitrary nodes in a wireless ad hoc network with a random topology can communicate with each other without interruption due to lack of routes between them before their own battery runs out. To answer this question, they utilize node-to-node communication lifetime. It is defined as the duration that two nodes can communicate with each other without any break. In the case where communications can be established through several alternative routes, sometimes communication might be ended due to the failure of one of the two nodes (source node and destination node) or failure of the last available route between them. In other case, batteries depletion of one or more nodes form paths can be the reason of the communication failure. Based on this, to determine node-to-node communication lifetime, the authors consider the energy consumption rate of nodes.

The second type of mobility metrics is named **derived mobility metrics**. Those metrics use parameters characterizing the state of links in the network like the rate of changes of link states or the average length of the path. In (Oudidi et al., 2010), authors observe that each node in the network can be in one of four states (the node moves and its neighbors are fixed, the node is stable and its neighbors are moving, the node and its neighbors are moving, the node and its neighbors are immobile) which is caused by changes in the links state. So, they define a new metric of measurement of mobility that is based on the number of nodes entering (or exiting) in the neighborhood in a laps of time Δt .

With the third category of the mobility metrics, **lifetime of links or routes** is used. In the research made in (Yawut et al., 2007), in order to ameliorate the OLSR performance, the authors attempt to improve the MPRs selection procedure. They modify the Link tuple by adding a new field named Start Connection Time **(Start_t)**. With this, the node calculates in the first step the link duration (**LD**) which is the difference between current time and **Start_t** for each node in the neighborhood. After that, the procedure of MPRs selection is modified in order to choose nodes with the longest **LD** when **D(y)** of MPR candidate nodes are the same. Where **D(y)**, the degree of node **y**, is defined (Clausen and Jacquet, 2003) as the number of symmetric neighbors of node **y** excluding all the members of **N** and the node performing the computation and **N** is the subset (Clausen and Jacquet, 2003) of neighbors of the node (node with single interface) performing the computation. For example, with the nodes having the same value of **Willingness**, **reachability** and **Degree**, we have to select the one in which the **LD** is the greatest.

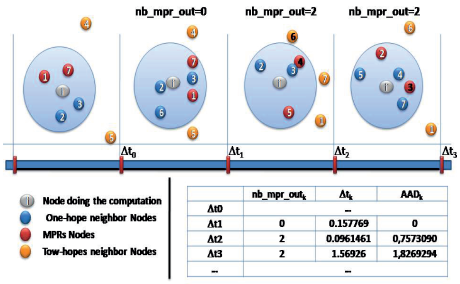

Figure 1: Example of the AAD computation.

If the research presented above is based on the link duration, in (Lenders et al., 2006) the authors study the impact of nodes mobility on the link and on the route lifetime in the network. Their first goal is to determine the reason of link breaks. Therefore, they differentiate between link transmission failures caused by movement of one of the linked nodes, and other failures caused by interference. So, to represent link and route lifetimes, the authors give two different viewpoints: In the first, the total lifetime of a link or route describes the time interval between the moment the link (or route) appeared until it breaks; in the second, the residual lifetime represents the time interval between a sample moment after the creation until the link or path breaks. However, the residual lifetime is also considered in the remaining part of their research.

Since the protocol is particularly suitable for large and dense networks as the technique of MPRs works well in this context, we aim to increase the life duration of elements in this set of nodes. Therefore, the stability of network becomes an important factor

4 OUR CONTRIBUTION

Before showing how we calculate Age of Death for MPRs, let us give some definitions: $\mathbf{n_i}$ is the node number **i** executing the computation. Node is considered **death** when it lefts the **MPR Set** of the node $\mathbf{n_i}$. Δt_j is the time between two successive MPR Sets Computation (**Age**). $nb\_mpr\_out_j$ is the number of nodes which left the MPR Set in Δt_j period (**Number of Deaths**). **N** is the number of nodes in the network.

The **Average Age of Death for MPRs** (**AAD**) of the node $\mathbf{n_i}$ until the MPR Set computation number **M** is defined by equation (1). Figure 1 present an example for AAD metric computation.

$$AAD_i = \frac{\sum_{k=0}^{k=M} \Delta t_k * nb\_mpr\_out_k}{\sum_{k=1}^{k=n} \Delta t_k} \quad (1)$$

The Average Age of Death for the entire network during the simulation time is defined by equation (2).

$$AAD = \frac{\sum_{i=0}^{i=N} AAD_i}{N} \quad (2)$$

5 SIMULATION A RESULTS

5.1 Simulation Environment and Parameters

In our study, we used a standard version of OLSR developed by MASIMUM (MANET Simulation and Implementation at the University of Murcia) which we integrated in NS2 (version 2.34).

Our network is consisted of a variable numbers of mobile nodes (20, 30, 40, 50 and 60 nodes for each simulation) moving in an area of 1000 x 1000 m. Each node moves according to the RWP (Random WayPoint) mobility model (Bai and Helmy, 2004) with pause time fixed to 0 s and maximum speed varies between 5 and 30 m/s with a step of 5. For each number of nodes and each max speed several simulations are done. The scenario that defines the nodes movement is regenerated at the beginning of all simulations. To generate traffic in the network, 10 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 512 bytes of size in the order of one packet every 2.5 second.

5.2 Results and Discussions

Average Age of Death: An MPR leaving the neighborhood of node is considered as dead. In the Figure 2, we trace the average age of death based on the speed for different numbers of nodes

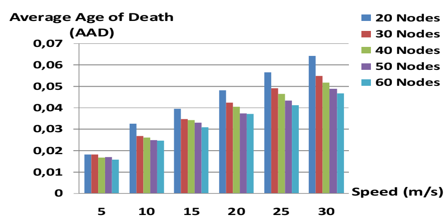

Figure 2: AAD depending on speed for each number of nodes.

From this histogram, we see that the increase number of nodes causes increase of average age of death for all speeds values from 5 to 30 m/s. But, with increasing the number of nodes, the average age of death is reduced. We also note that the average age of death is greatest for maximum speed and minimum number of nodes.

The increase in speed which cause the increase of average age of death is interpreted by the fact that the increase in speed increases also the rate of changes in the network. In this respect, when the network topology changes, the number of elements in the neighborhood change as well. So the number of MPR varies potentially with those changes. This is seen also in highly mobile environments even if there is not a large number of nodes.

Average of the Maximum Life of MPRs: The maximum life of MPR is the maximum life time recorded of MPRs. The Figure 3 shows the average of the maximum life of MPRs based on the speed for each number of nodes.

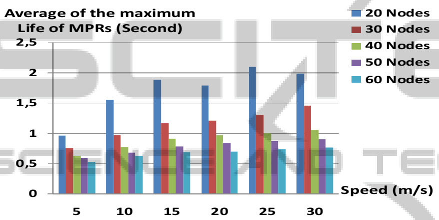

Figure 3: Average of the Maximun life of MPRs depending on speed for each number of nodes.

For all values of the speed, we can see that with the increase in the number of nodes, the average of the maximum life of MPRs decreases. But with the increase in the average speed, the maximum life of MPR increases.

With high speed, there is always movement in the network. What explains the increase in the average of the maximum life of MPRs is that there are many sets of MPR which are calculated during these periods.

According to the results previously recorded, we note that our new metric (AAD) shows a close relationship with the network environment (density, movement of stations). In other words, this metric reflects the life of MPRs depending on the network environment. Consequently, by using it as a new parameter in the MPRs selection presses, we give a new OLSR protocol version that is named as OLSR-AAD.

The results depicted over here are related to the environment approximately dense where the number of nodes is equals to 50. In those figures shown blow (Figure 4, 5 and 6), we respectively plot the variation of Packet Delivered Ration (PDR), Normalized Routing Load (NRL), Average end to end Delay and Average Throughput Traffic depending on nodes max speed for three versions of OLSR protocol. The blue curves represent the standard OLSR (OLSR-STD). The green curves concern the Mob OLSR (OLSR-MOB) proposed in [10]. Our version of the OLSR protocol (OLSR-AAD) is represented with the red curves.

Packet Delivered Ratio (PDR): The Figure 5 shows the behavior of the PDF (rate of successful packet delivery) depending on the speed of the three versions of the OLSR protocol. We found that these three versions retain approximately the same paces for all values of speed. In the range of 5 to 15 m/s version OLSR-MOB go beyond the other versions but in other interval our version OLSR-AAD has increased compared to other versions. In addition, we can see that OLSR-AAD performs well in terms of PDF, in comparison with other protocols (OLSR-STD and OLSR-MOB) for all the maximum speeds. So our protocol is more suitable in highly mobile environments.

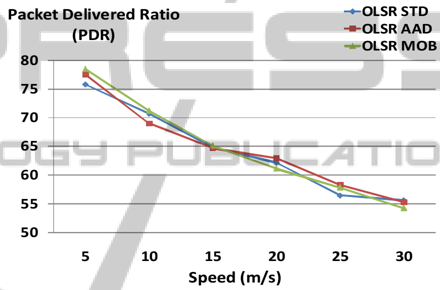

Figure 4: PDR depending on nodes speed.

Average Delay: For the Average time End-to-End (Moy-End-to-End), we note that in the speed interval from 5 to 15 m/s the values presented by the three OLSR versions are approached. But from 15 m/s there is a change between the three versions of OLSR. we Note also that for both values of speed 15 and 30m/s the Average time is the minimum for the OLSR-AAD Protocol. Note that for the majority of speed OLSR-AAD protocol optimizes the average delay between the source and destination especially in highly mobile environments.

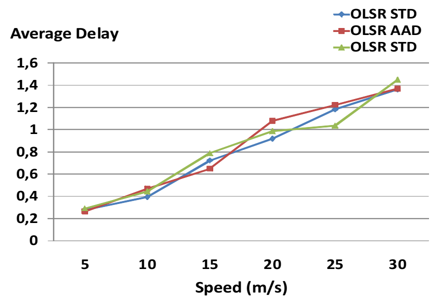

Figure 5: Average Delay Depending of nodes max speed.

Average Throughput Traffic: Average throughput allows to measure the quantity of information per time unit transmitted in a communication channel according to the curve we find that for the speeds 5, 10 and 15m/s OLSRMOB protocol optimizes the other two versions. But in the interval 15 to 30 m/s OLSR-AAD protocol improves the other two versions of OLSR. Therefore the modified version of OLSR protocol is well suited especially in highly mobile areas.

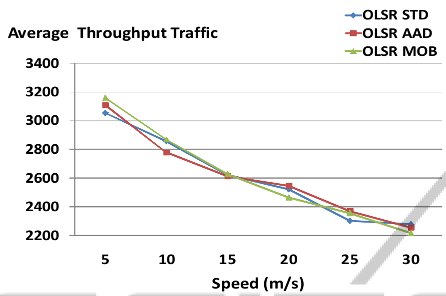

Figure 6: Average Throughput Trafic depending of nodes max seeds.

6 CONCLUSIONS

Our problem is the high mobility which would harm the operating of the network. Nodes, (may be an MPR) coming out from the neighborhood and cause changes in the link status of the network, the result is the rupture of one or more links, a thing which contradicts the state of the routing table before the recalculation of MPR set. Our proposed solution was to calculate a new metric named Age of death for MPRs that was always updated and gives an idea of life time of MPRs. Indeed, the results recorded during the simulations show that this parameter is a close relationship with the network environment (density, movement of stations). In other words, this parameter reflects the life of MPRs depending on the network environment. By its integration in the MPR set calculation procedure, we enhance the performance of the network. So, compared to the other OLSR protocols versions (OLSR-STD and OLSR-Mob), our modified version of OLSR protocol (OLSR-AAD) is well suited especially in highly mobile areas.

Despite those better results, OLSR-AAD can be more perfect if we add other metrics to the MPR selection process or to the routing table calculation. For example, making paths with nodes having more levels of energy can reduce the link breaks probability. Moreover, using clustering metrics can provide a longer life for MPRs. Due to this, our next goals are to integrate more metrics in order to increase life duration of paths. Moreover, this metric that is actually restricted to MPRs can be extended to be applied to all types of neighbors, whether MPR or not .

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