Energy and mobility in OLSR routing protocol

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***Abstract: We* present in this paper a new mechanism for the OLSR routing Protocol, aiming to improve mobility and energy management in mobile adhoc network. As known OLSR use the concept of an MPR mechanism where only nodes selected as MPRs can relay broadcast packet received from their selectors, those nodes have to satisfy certain requirements to assure this mission , speaking of stability and physical capacity (energy).we are describing a modification in the MPR selection based on the willingness concept , introducing two critical factors :Energy and mobility, we explain how choosing stable nodes with an important residual energy as MPRs can enhance the performance of a mobile adhoc networks.**

***Index Terms*: OLSR,adhoc-networks,energy,mobility,MPR selection.**

I. Introduction

MANET is a collection of wireless mobile nodes, which dynamically form a temporary network, without using any existing network infrastructure or centralized administration. These are often called infrastructure-less networking since the mobile nodes in the network dynamically establish routing paths between themselves. Most recent works in the domain ,aim to enhance MANET performances , due to the multiple problems caused by the wireless transmission constraints , and also the limited resources of mobiles nodes .In order to make the network aware of its status at each moment , nodes need to exchange an important number of information, which results a traffic overload , at network level , and more energy consumption at nodes level .A routing protocol is used to discover routes between nodes. The primary goal of such an ad hoc network routing protocol is correct and efficient route establishment between a pair of nodes so that messages may be delivered in a timely manner. Route construction should be done with a minimum of overhead and bandwidth consumption. The performance of a mobile ad hoc network depends on the routing scheme employed, and the traditional routing protocols do not work efficiently in a MANET. This kind of network, in fact, has a dynamic topology Developing routing protocols for MANETs has been an extensive research area in recent years, and many proactive and reactive protocols have been proposed .

One of well-known routing protocols for MANETs is OLSR. The OLSR is a proactive routing protocol where the routing table of each mobile node is constructed by periodically performing flooding of broadcast packets. In order to reduce the number of broadcast packets, OLSR uses the idea of multipoint relay (MPR) [1]. Each mobile node selects one-hop neighbor nodes as MPR nodes based on their reachability and degree. Only MPR nodes can forward broadcast packets received from other mobile nodes. So MPR nodes transmit more packets than other mobile nodes. In order to efficiently use the energy resource of each mobile node, we have to select MPR nodes in an efficient way.

We describe in this paper a new extension of OLSR,
With a novel Mobility-energy-aware mechanism for the MPR selection, we evaluate this new algorithm, and compare its performance with the original OLSR, and E-OLSR where willingness depends only on residual energy of nodes.

The rest of this paper is organized as follows, Section 2 describes the OLSR routing protocol and MPR issues, in section 3 we present and explain our approach .Section 4 discusses performance of our extension with results of simulation experiments, while section 5 concludes the paper.

II. MPR selection

A. OLSR presentation:

Olsr (optimized link state protocol) is developed for mobile ad hoc networks. It operates as a table driven and proactive protocol, thus exchanges topology information with other nodes of the network regularly. The nodes which are selected as a multipoint relay (MPR) by some neighbor nodes announce this information periodically in their control messages. Thereby, a node announces to the network, that it has reachability to the nodes which have selected it as MPR. In route calculation, the MPRs are used to form the route from a given node to any destination in the network. The protocol uses the MPRs to facilitate efficient flooding of control messages in the network, thus the MPRs play the most important role in the functioning of the protocol, they are responsible on relaying broadcast traffic and also to form route from any source to any destination in the network.

B. MPR selection issues:

As cited above, the MPR nodes have an important role in an OLSR architecture, that’s way they must be selected carefully and according to a number of requirements , the literature proposed many algorithms to assure this task , we mention the simple greedy heuristic [2] , where MPRs are selected based on their coverage degree which means the numbers of 2-hop neighbors covered by those nodes, the simple greedy algorithm does not take into consideration the quality of links with these nodes or their ability to perform the relaying ,the drawbacks of this algorithm are presented in more detail in [13], later a new mechanism was proposed ,actually implemented by the RFC3626 [4], this new mechanism introduces a new concept : the willingness; this parameter express a node ability to became an MPR, represented by a value between 0 and 7, we give bellow the details of this algorithm[3]:

1) Select nodes, with N_willingness=WILL_ALWAYS, from N_a as members of an MPR set Then, remove two-hop neighbor nodes which are covered by selected nodes from N_b .

2) For each node y in N_a , calculate the degree D(y), which is defined as the number of symmetric one-hop neighbors.

3) Add nodes in N_a , which are the only nodes to provide reachability to a two-hop neighbor node in N_b to the MPR set. Then, remove two-hop neighbor nodes which are covered by the selected nodes in the MPR set from N_b .

4) Unless N_b is empty, the following steps a) and b) are repeated:

a) For each node y in N_a , calculate the reachability R(y), where the reachability denotes the number of nodes in N b which are not yet covered by at least one MPR node in the MPR set, and which are reachable through node y.

b) Select node y with the highest N willingness from nodes with non-zero reachability in N_a . In case of multiple choices, select a node with highest R(y). If there are multiple nodes with highest reachability, select one with largest D(y) from those nodes. Then add the selected node to the MPR set, and remove the two-hop neighbor nodes which are covered by the selected node from N_b .

5) For optimization, MPR nodes can be removed from the MPR set if the remaining MPR nodes in the MPR set still Cover all two-hop neighbor nodes.

MPR selection is proved to be an NP-complete problem [4], especially when introducing many constraints (additive and multiplicative), Standing in the field of graph theory, this problem could be concluded as “bipartite cover”, which means how to cover all the 2 hop neighbors with the least number of 1 hop neighbors[13].In order to reduce the complexity of such algorithms , it is recommended to decrease the number of input parameters, which does not appear to be effective in resolving such problems.

MPR nodes play a very important role in an OLSR architecture, besides being responsible of relaying traffic from their selectors, they are used to form routes from a source node to any destination in the network, this reality preserve the fact that choosing those nodes randomly will not be a wise idea for the network interest, we will give in the following paragraphs a review of two major factors that can influence explicitly both node and network performance, it is: mobility and energy.

C. *Mobility impact on MPR selection:*

Since the beginning of wireless technologies deployment, The problem of mobility gets the biggest attention of researchers, network users need to be able to travel, while an established communication session have to be preserved, a number of works studying the mobility impact on adhoc networks were presented by the literature [5][6], however results obtained cannot be generalized , because of the excessive number of related parameters that control this impact ; the network connectivity , the area of simulation, mobility model, speed , …….

The mobility theory is highly probabilistic, as we cannot expect the input parameters variation sense, we give in figure below an example of the variation of loss rate for different nodes speed in a topology with 50 nodes, we simulate six scenarios for different speed considering the random waypoint as mobility model:

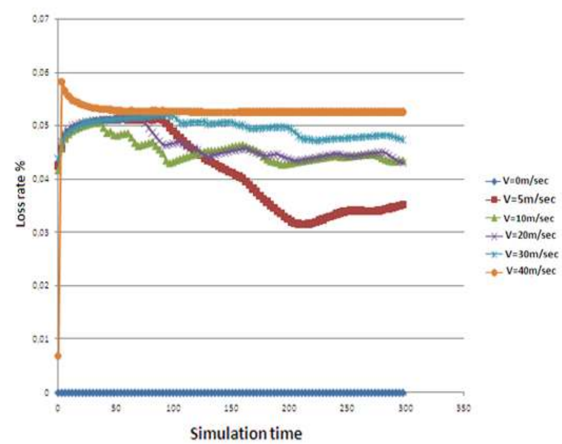

Figure 1: loss rate in an Ad hoc network for different speeds

As we can see, there is no logical variation of the loss rate , while increasing nodes speed , unless we don’t make a number of assumption about the characteristics of the graph of movement of nodes.

In the MPR selection algorithm, For both the simple greedy and the RFC3626, the steps related to selecting MPR with high coverage degree on two-hop-neighbors , imply the node being at (or near of) the extremity of the cercal representing the radio coverage of its the MPR selector , this is the only way to reach the maximum number of 2-hop-neighbors, in this case , the node movement can be presented by three possibilities and three probabilities of speed direction ,let *i* be the MPR selector , $j \in N_1(i)$ and the marks "×" presents the 1-hop-neighbors for *j* and the 2-hop-neighbors for *i*,and $\vec{v}$ the velocity of node *j* , figure 2 give a review of this assumption :

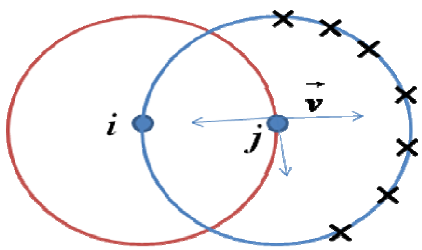

Figure 2: Major traveling directions for a MPR at the extremity of transmission range of its selector

As shown , node *j* has the possibility to move according to three major directions , with the same probability , according to a random mobility model, *j* can move inside , around or outside the transmission range of node *i* wich will enhance the transmission in first case in the $\overrightarrow{ji}$ sens or corrupt definitively the link between *i* and *j* for the last case.

Authors in [7] assume that for the fixed ad hoc network model, the fundamental performance limitation comes from the fact that long-range direct communication between many user pairs is infeasible due to the excessive interference caused. As a result, most communication has to occur between nearest neighbors, at distances of order $1/\sqrt{n}$, with each packet going through many other nodes before reaching the destination. The number of hops in a typical route is of order $\sqrt{n}$. Because much of the traffic carried by the nodes are relayed traffic, the actual useful throughput per user pair has to be small. With mobility, a seemingly natural strategy to overcome this performance limitation is to transmit only when the source and destination nodes are close together, at distances of order $1/\sqrt{n}$.

As a conclusion, in order to predict correctly the mobility effect, nodes need to compare distance with their MPRs, to know if nodes are getting closer or not, so the traveling direction can mostly light up the biggest picture of the new graph disposition of the network.

In most cases it is confirmed [6] that mobility induces an approximate deterioration of network performance, especially when the nodes concerned are those responsible of relaying traffic in the network.

D. Eneegy impact on MPR selection:

Besides mobility, another factor need to be treated , it is energy , a physical characteristics of mobile node and one of their critical limited resource , authors in [10] shows that the larger part of energy is spent in idle state (when the node is not using its network device): this state absorbs about 90% of the energy consumption of mobile devices.

To give a close idea about the necessity to choose energy as of selection metric in OLSR , we present in figure 2 the energy consumption for two nodes, one selected as MPR and the other node is configured with willingness=will_never, which will act in FTP transfer session , we set the initial energy at 500 joules:

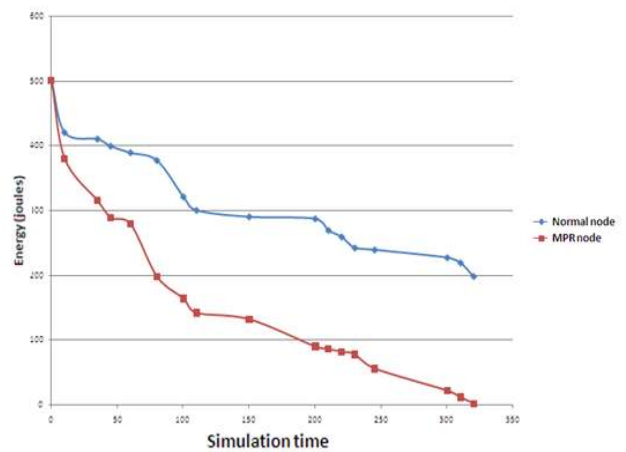

Figure 3:Energy consumption for one MPR node and a second node with willingness=WILL_NEVER

An MPR node consume its energetic stock faster than other node due to its important activity in the network , in forwarding packet from its selectors to the rest of the networks, and also relaying data packets intended to its selector .

E. Related works:

Authors in [9][10] , present an new extension of OLSR, EE-OLSR, aiming to improve its energy performance , by introducing two parameters: the residual energy based on battery power and its lifetime based on node activity, the willingness of each node is now controlled by those two values, this approach allows node energy to be preserved for longer time , and it is compatible with the standard, other works [3][8] consider residual energy as metric for the MPR selection and route calculation , those approaches require to exchange additional information's about nodes energy , so that every node keeps an information about its neighbors energy to decide lately about the ability of those nodes to became MPRs or not.

III. EM-OLSR ENERGY-MOBILITY-AWARE OLSR

Authors presented many ways to make routing protocol ,aware about mobility or energy ,in many works , authors choose to make nodes exchanging their information about a number of parameters , so that every node can construct its proper repository based on data collected from its neighbors, this approach has several advantages ,each node can have a local idea about the networks, and can use those information's to build certain specific route with specific constraints, but produces a supplement traffic .in our approach ,Unless MPRs are used to construct route from any source to any destination in the network, we choose to bind those parameters to willingness, each node must decide about his ability to became an MPR, based on his energy and mobility rate, this proposition has the advantage to be compatible with the standard and need no more control traffic or modifications of the core functioning of OLSR.

We suppose that nodes have a GPS receiver, so that longitude and latitude can be obtained. By matching the known longitude and latitude to the map, we can obtain the position. By continuously updating position, a GPS receiver can also provide data regarding speed and direction of travel,

We settle an interval of observation , to calculate locally , node's speed , hello packet are generated every 2s, besides , OLSR implement a mechanism for detecting links corruption , when 2 hello messages are lost, in the meaning of 4 seconds in total , so our interval must be smaller enough to enable a fast detection of the node's current status .

We define first three level of willingness: default, low and high , each node calculate its residual energy and it's speed , so that those two parameters could decide about the value to attribute to the willingness. The MPR selection will remains the same as defined by the RFC 3626 , our algorithm is described as follow:

```
if ( lifetime > energy_threshold && mobility_speed > mobility_threshol || energy < energy_threshold && mobility_speed < mobility_threshold )

 willingness=willigness_default

 if ( energy < energy_threshold && mobility_speed > mobility_threshold)

 willingness=willigness_low

 if ( energy > energy_threshold && mobility_speed < mobility_threshold)

 willingness=willigness_high;
 FIN
```

as we can see the high value of willingness is related to a high level of energy and small speed value, this option enable the possibility of choosing node with an important link and power longevity, this conclusion still available in a static and mobile network, in first case, the decision about willingness will depends only on the residual energy of nodes, which is considered as a first gain , as we have the possibility to choose as MPRs, better nodes regarding their disposition in terms of energy so EM-OLSR will operate simply as E-OLSR.

For energy we chose to consider less than 10% of residual capacity as low battery values,. As for speed threshold we choose the point ,representing the critical inflexion of the curve representing the PDR (packet delivery ratio), since mobility depends highly on many factors : density, mobility model and speed of nodes, Various mobility models have been considered in the literature to evaluate the effect of the node mobility on the performance of algorithms and protocols. The most widely used of these is probably the "random waypoint model" [12].We consider for our simulations the three following models :Random waypoint, manhattan grid and freeway point, using NS2.34 and bonnmotion for generating mobility files for different models, and different density, in order to locate the worst conditions to retrieve the speed threshold , we choose a scenario with 25 nodes as reference, and fixe the speed of 10m/s , as threshold , the three models react approximately in a similar way for different speeds values in term of packet delivery ratio deterioration.

We present in figure 3, the results obtained for the PDR, for different speed values for the three mobility models:

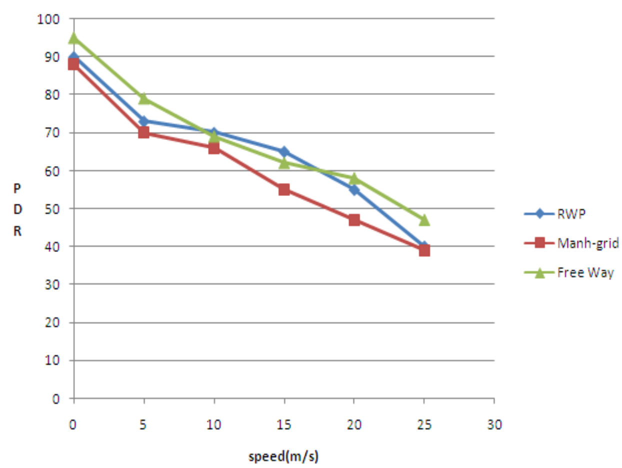

Figure 4: Packet delivery ratio for different mobility models

Authors in [14] show that when the mobility behaviors of nodes change in an ad hoc network, the performance of the network can be vastly affected from this. So that choosing a realistic mobility model for network simulations plays an important role on the validity of the simulation results.

IV. SIMULATION AND RESULTS :

We are studying in this section the performance of two extension of OLSR: E-OLSR (energy aware), where decision about willingness depends only on residual energy of node and EM-OLSR (energy and mobility aware), where decision will consider both : residual energy and node's speed, we compare the two extensions with the original version of OLSR.

Simulations have been done using ns version 2.34.The scenario consists of 50 nodes moving in a 1000 × 1000 m area .40% of nodes are moving in a complete random way , in this area, changing both direction and speed frequently, the speed value varies from 1m/s to 40 m/s and no pause time. The duration of each simulation is 500 seconds. We choose provided by ns-2, as the mobility model. We use the IEEE 802.11 MAC protocol. The channel data rate is set to 5.5Mbps. Packets size is set to 512 bytes. The transmission range is set to 250m.

The communication sessions between nodes begins with different offset times, it will enable a differentiation of energy consumption process at each node.

We evaluate energy consumption through the throughputs and the average residual energy available, for both original OLSR , E-OLSR and EM-OLSR.

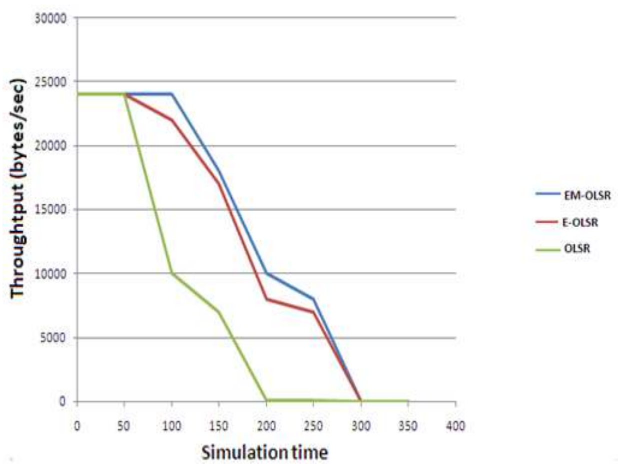

Figure 5: throughputs for classic OLSR, E-OLSR and EM-OLSR

As shown in figure 5, E-OLSR and EM-OLSR enhances network performance, nodes with low level of battery power will not be able to set themselves as MPRs, which give them the opportunity to preserve their energy and continue to send and receive packets for a significant time compared with OLSR, for static nodes EM-OLSR and E-OLSR will have the same behaviors, the decision about willingness will depend only on their energy level.

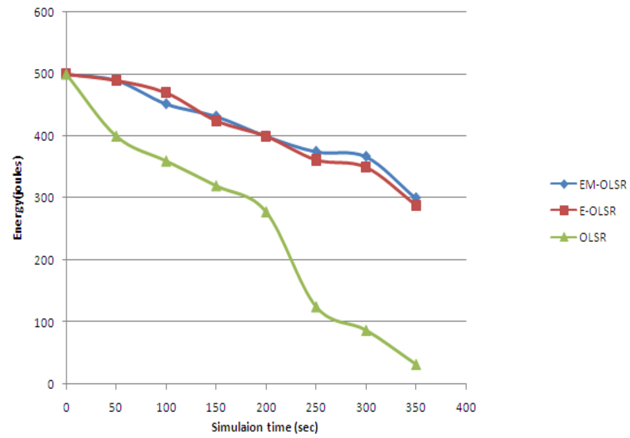

Figure 6: Energy consumption for classic OLSR ,E-OLSR and EM-OLSR

E-OLSR and EM-OLSR extend network life by preserving nodes energy. Acting as MPR, has a huge impact on energy consumption, nodes with a less battery power must hold back, and show no willingness to become MPR, so that they can prolong their lifetime.

Both E-OLSR and EM-OLSR, enhance network performances in the same manner for throughputs and network lifetime, compared with original OLSR, regardless the network status regarding mobility.

Figure 7 present the loss rate in function of the speed values for OLSR,E-OLSR and EM-OLSR:

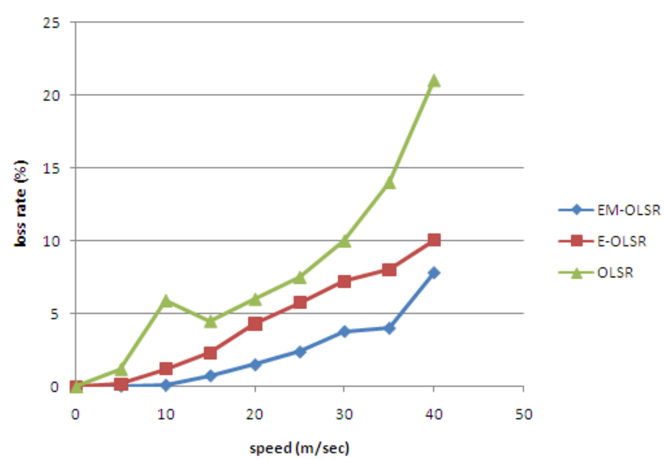

Figure 7: loss rate with classic OLSR,E-OLSR and EM-OLSR

Obviously EM-OLSR, perform better, the percentage of loss rate has decreased comparing with OLSR and E-OLSR, nodes now are able to detect their mobility, and decide about their stability regarding their speed value.

In static conditions E-OLSR and EM-OLSR give the same results for all the performance metrics, EM-OLSR has a significant impact in mobile networks, especially with a fast movements; nodes can detect rapidly their traveling, and decide about their willingness.

V. Conclusion

In spite of offering the possibility to detect fast movement This algorithm remains incomplete, the speed of a node doesn't give a real idea about the direction of travel, while velocity does, the necessity of using local information's restricts the prediction perimeter concerning the position of a given node, if it still in the range of the MPR selector, or is moving outside, but in both cases , and especially when we have fast moving , lost occurs , a node changing its positions frequently , will disturb the stability of links , we have done many simulation for different movement direction , and the results have shown that for different nodes behaviors , we obtain different results , especially if the travelling is done in a oscillated way in and out the transmission range, our approach aimed first to present a way of making OLSR aware of the environment conditions, including nodes status , this idea was motivated by two principal factors: the necessity to preserve to standard and to keep the core functioning of the protocol intact , those requirement restrict the evaluation area, we are studying the possibility to make the decision about MPR more conscious about a number of networks parameters , related to mobility and quality of service.

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