NCA: New Cooperative Algorithm for Reducing Topology Control Packets in OLSR

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Abstract—OLSR (Optimized Link State Routing Protocol) is a routing protocol designed especially for MANETs (Mobile Ad hoc Networks) and is currently the most widely deployed for this type of networks. OLSR uses multipoint relay (MPR: MultiPoint Relay) flooding mechanism to optimize topology control messages broadcasting throughout the network. Each node of the network selects a subset of nodes (MPR) among its neighbors to disseminate control messages. Reducing topology control packets (TC) is the key functionality of OLSR. In the Ad hoc network, the number of TC depends on the choice of MPR. In this paper, we propose a new cooperative MPR selection algorithm with the aim to reduce TC packets. We implemented this algorithm in NS2 and three other algorithms are known to be performant in the domain. Simulation results show that our algorithm reduces TC packets relative to other algorithms. This reduction is reflected positively on other performance parameters.

Index Terms—Ad hoc Network; MANET; OLSR; UM-OLSR; NFA; MPR; TC; NS-2

I. INTRODUCTION

Nowadays, the need for more mobility and power to share or to exchange information, at any time and by using mobile devices only (mobile phones, laptops, etc.), has made the notion of Mobile Ad hoc Networks (MANETs) very widespread. MANET is a kind of distributed multi-hop wireless network, which does not rely on a pre-existing infrastructure, such as routers or access points. Such network is composed of a number of autonomous, wireless and mobile nodes. Unfortunately, the classical routing protocols, designed for the networks with strong infrastructure, are inappropriate with the inherent characteristics of MANETs. Therefore, a new routing technique is used; the nodes agree to relay communications of their neighbors so that messages can spread beyond the coverage area of their original transmitters. This routing technique has been widely studied. As a result, several protocols have been proposed namely AODV [1], DSR [2], DSDV [3] and OLSR[4].

OLSR (Optimize Link State Routing Protocol) [4] is the well-known and often implemented protocol in MANETs. It is a proactive routing protocol on which each node regularly exchanges topology information with other nodes. The main idea of OLSR is the optimization of the broadcast discovery messages and routes updating throughout the network. The optimization is performed by the use of the Multipoint Relay (MPR) as a flooding mechanism. Indeed, each node selects, independently, its MPR nodes as a subset of one-hop neighbors that allows it to reach all two-hop neighbors. So, only nodes that are selected as MPR are allowed to broadcast control messages containing topology information. In conclusion, we can say that the use of the multipoint relay technique reduces, significantly, the impact of the dissemination of control messages and contributes to the overall performance of the protocol. This makes the MPR selection problem a keystone of the OLSR protocol studies.

The MPR selection problem, which aims to find an optimal set of MPR nodes covering the whole of two-hop neighbors, has been proven to be NP-complete [5] [6]. Therefore, several heuristic algorithms have been proposed to address this problem in practice [4] [7] [8] [9]. They mostly used only the knowledge of one-hop neighbors and two-hops, and are aimed to optimize the MPR selection with a specific purpose such as minimizing the number of MPR nodes, reducing the TC packets, improving QoS, etc. In this respect, we have proposed, in an earlier work [10], an algorithm with the purpose of reducing the number of topology control packets (TC) by minimizing the number of MPR nodes, locally in each node of the network. While analyzing its simulation results, we found that reducing the number of MPR locally does not necessarily lead to the reduction of the whole TC packets in the network. We have also observed an increase in the total number of MPR nodes. Therefore, we have concluded that the reduction of the total number of MPR in the network is relaying to the degree of cooperation between nodes when selecting their MPR. In this case, each node needs to know, among its one-hop neighbors those which have been selected as MPR by other nodes.
In this paper, we propose a new algorithm, called New Cooperative Algorithm (NCA), to select MPR in OLSR. It is a cooperative algorithm which is based on a heuristic that enhances the one presented in [10]. The purpose of this heuristic is firstly to minimize the number of MPR locally in each node, and secondly, to favor the one-hop neighbor nodes which have already been selected as MPR by the maximum of nodes. We have implemented our algorithm, the NFA algorithm [7], and the cooperative algorithm [9] on NS2 [11]. The simulation results show that our algorithm reduces the number of topology control packets (TC) up to 15% for fixed networks and 19% for mobile networks.

The rest of the paper is organized as follows: In Section II, we discuss the related work on the MPR selection; In Section III, we present the functionalities of OLSR and the basic MPR selection algorithm; Section IV is devoted to our MPR selection algorithm. Parameters and simulation results of our algorithm are presented in Section V.

II. RELATED WORK

The reduction of routes flooding is the key to all routing protocol in MANETs. OLSR performs this reduction by using a set of nodes, called multipoint relays (MPRs), which are responsible for generating and broadcasting the topology control messages (TC) through the network. Indeed, each node (selector node) independently selects a set of MPR nodes, from its one-hop neighbors with the aim of covering all two-hop neighbors. These MPR nodes act as relay nodes for messages sent by the selector node, and thus organize the broadcast of the communications in the network. This broadcasting is very consumer of resources such as bandwidth and throughput. It also generates collisions and can disrupt the data traffic routing. Hence, selecting an optimal MPR-set is primordial for more performance and efficiency in OLSR protocol.

Finding an optimal MPR set has been proven to be an NP-complete problem [5] [6]. So, heuristic algorithms are used to select MPR sets in practice. In the literature, the existing heuristics are mostly designed to find the adequate MPR sets with a specific objective such as minimizing the number of MPR nodes, as was the goal in the original specification [4] and in other works [5] [12]; improving QoS [13]; reducing the number of collisions, minimizing the overlap between MPRs or maximizing the global bandwidth [14]. In this section, we present some important works that focus on reducing topology control packets (TC).

In [12] the authors proposed a heuristic to select the MPR-set. This heuristic has been used in the original specification of OLSR [4]. The basic idea is to select, as MPRs, the one-hop neighbors having the strongest coverability or covering two-hop neighbors that cannot be covered by other neighboring nodes. This heuristic has been deeply analyzed [15] [16], the results show that the heuristic allows to provide a set MPR near optimal that greatly reduces the retransmission of messages topology control (TC).

In [17] the authors have found incoherence between the RFC 3626 specification of OLSR and the UM-OLSR implementation. Indeed, two bugs are identified, in the MPR selection procedure, as a result of a deep inspection of the code of the UM-OLSR implementation. Thus, the authors have proposed the solutions for correcting this incoherence with the aim to be conforming to the RFC specification of OLSR. The corrected implementation was then validated by simulations, which show that these solutions provide more credible results.

Li et al. have presented in [7] a new algorithm, called Necessity First Algorithm (NFA), to select MPR-sets in OLSR. In contrast to the original heuristic, NFA is based on the notion of “necessity of selecting” that may be associated with a one-hop neighbor node, which is the only to cover some two-hop neighbor nodes. This notion describes the ability of a node to be, imperatively, selected as MPR. Thus, the heuristic of NFA selects, as MPRs, the one-hop neighbors with “necessity of selecting”. Then, the neighbor with poorest cover ability is deleted to purposely create nodes with “necessity of selecting”. The results of simulation show that NFA improves the original heuristic; the algorithm reduces the number of MPR nodes and topology control messages (TC).

A cooperative algorithm for selecting MPR sets is described in [9]. It consists to give priority to the nodes that are already selected as MPR by other nodes. Thus, before calculating its MPR, each node i determines the set, MN(i), of its one-hop neighbors that have been selected as MPR for other nodes. If the MN(i) set covers all two-hop nodes of i, the MPR nodes are selected from this set, if not the basic algorithm is applied. This algorithm reduces the number of TC packets compared with de UM-OLSR implementation [4].

In [8] the authors claimed that the local optimization of the MPR sets does not necessarily lead to a global optimization MPRs through the network. They proposed two strategies: The first one attempts to minimize the total number of MPR with the aim of reducing the number of topology control messages. This strategy chooses among the candidates to become MPR, those having the maximum MPR selectors. The second strategy aims to increase the stability of routes; it focuses on reducing changes in the sets of MPR selectors by favoring the candidates which were already MPR in the previous run of the algorithm.

The authors proposed in [18] two enhancements of the original MPR selection algorithm described in the UM-OLSR implementation [4]. These enhancements are meant to extend the visibility of a node to three hops when two nodes are candidate to be MPR having the same reachability and the same degree. The first enhancement favors the candidate which has more isolated nodes from the two hop neighbors. A two hop node is isolated if it has no one-hop neighbors, except one which is candidate to become MPR. While the second enhancement gives priority to improving the node that has more not-MPR nodes from the two hop neighbors. The results of simulation show that both variants can
reduce the number of TC packets, the routing cost and the efficiency compared to UM-OLSR implementation [4].

In [19] a multipoint relay selection method for robust broadcast in a wireless ad hoc network is proposed. In this method, a node selects additional MPR nodes so that it can cover two-hop nodes m-times. The proposed method can improve network throughput and delivery ratio compared to the original MPR selection algorithm of OLSR [4].

III. OLSR PROTOCOL

OLSR (Optimized Link State Routing Protocol) is a proactive routing protocol for ad hoc networks, which establishes routes based on local knowledge of the topology. A node discovers its one-hop neighbors and two-hop neighbors. It uses an optimized technique based on nodes called multipoint relays (MPR) to ensure optimized broadcast messages. The choice of MPRs is done after the discovery phase of the neighbors of all nodes in the network using HELLO messages (default broadcast every 2 seconds). These messages allow each node u to know its neighbors in one-hop noted N(u) and 2-hop neighbors denoted N2(u) and then calculate its MPR. Each node stores a database containing information network topology which is constructed from topology control message (TC: Topology Control). TC message contains a list of nodes which selected the original node of TC as MPR. These messages are broadcast by default to all nodes in the network every 5 seconds. Neighbor nodes of a node u that are not MPR of u, receive and process messages TC, but do not broadcast them. Each node maintains all its selectors and multipoint relays and retransmits only the packets received for the first time from these multipoint relays selectors.

The principle of MPR is to use the knowledge of two-hop neighbors to locally optimize the broadcast. Thus, each node u is a set of nodes MPRs among its neighbors in the first level that can reach all two-hop nodes. The example in Fig. 1 shows the difference between the classical flooding (Fig. 1(a)) and the optimized multipoint relays (Fig. 1(b)) [12].

![Figure 1. The classical diffusion (a) and the optimized diffusion through MPR nodes (b)](image)

In the classical case it takes 24 retransmissions to achieve the 3-hop nodes; while only 12 retransmissions are needed with MPRs.

To transmit a message to all nodes in N2(u) of a node u using optimized diffusion by MPR, [MPR(u)] emissions are necessary. So, to increase the network performance, we must find a minimum number of multipoint relays for each network node. The choice of MPR nodes is a NP-complete problem [5] and several algorithms have been proposed to solve it. The basic MPR selection algorithm is described in RFC 3626 [4] specification as shown in Fig. 2. Before introducing this algorithm, some notations should be described first:

- u a node in Ad hoc Network
- N(u) the subset of one-hop neighbors of the node u
- N2(u) a set of two-hop neighbors of u by excluding:
  - (i) The nodes only reachable by members of N(u) with willingness WILL_NEVER. The willingness is a parameter stored and maintained by each node in MANET. Willingness may be set to any integer value from 0 to 7, and specifies how willing a node is to be forwarding traffic on behalf of other nodes. Nodes will, by default, have willingness WILL_DEFAULT (3). WILL_NEVER (0) indicates a node which does not wish to carry traffic for other nodes, for example due to resource constraints (like being low on battery). WILL_ALWAYS (7) indicates that a node always should be selected to carry traffic on behalf of other nodes, for example due to resource abundance (like permanent power supply, high capacity interfaces to other nodes).
  - (ii) The node u performing the computation
  - (iii) All the symmetric neighbors: the nodes for which there exists a symmetric link to this node on some interface.

D(y) the degree of a one-hop neighbor node y (where y is a member of N(u)), is defined as the number of symmetric neighbors of node y, excluding all the members of N(u) and excluding the node u performing the computation.

MPR(u) the MPR set of u.

After the explanation of these notations and concepts, the heuristic used by OLSR is described as follows:

**Algorithm 1**

1. Start with an MPR set made of all members of N(u) with N willingness equal to WILL ALWAYS.
2. Calculate D(y), where y is a member of N(u), for all nodes in N(u).
3. Add to the MPR set those nodes in N(u), which are the only nodes to provide reachability to a node in N2(u). For example, if node b in N2(u) can be reached only through a symmetric link to node a in N(u), then add node a to the MPR set. Remove the nodes from N2(u) which are now covered by a node in the MPR set.
4. While there exist nodes in N2(u) which are not covered by at least one node in the MPR set:
   4.1. For each node in N(u), calculate the reachability, i.e., the number of nodes in N2(u) which are not yet covered by at least one node in the MPR set, and which are reachable through this one-hop neighbor.
   4.2. Select as a MPR the node with highest N_willingness among the nodes in N(u) with nonzero reachability.
      4.2.1. In case of multiple choices select the node which provides reachability to the maximum number of nodes in N2(u).
      4.2.2. In case of multiple nodes providing the same amount of reachability, select the node as MPR who’s D(y) is greater.
4.3. Remove the nodes from N2(u) which are now covered by a node in the MPR set.

![Figure 2. The basic algorithm for selecting MPR](image)
This heuristic does not always provide an optimum solution. Fig. 3 shows that this heuristic gives three MPR nodes for node u, whereas the optimal solution is two MPRs.

![Figure 3. Comparison between the solution of the basic algorithm and the optimal solution](image)

**IV. PROPOSED ALGORITHM FOR SELECTING MULTIPoint RELAYS**

In this section we present our new heuristic for selecting MPR nodes in OLSR. The undelaying algorithm enhances the previous one presented in [10], which attempts to reduce the number of MPR locally in each node by introducing cooperation between nodes. So, our heuristic selects MPR for a source node by giving priority to one-hop neighbor nodes that have already been selected as MPR by other nodes. The heuristic maximizes the intersection of MPR sets, and therefore, minimizes the total number of MPR in the network.

Before stating our algorithm, some notations should be presented first. For each node u of the network and its one-hop neighbor a, we propose the notation shown in Fig. 4:

![Figure 4. Algorithm parameters illustration](image)

- **u** is a node in the MANET.
- **N(u)** is a subset of one-hop neighbors of the node u.
- **N2(u)** is the set of two-hop neighbors of u.
- **NNC (a)** is the number of nodes in N2(u) covered by node a.
- **NNA(a)** is the number of nodes N(u) that have the coverage with node a (named associates of a).
- **CA(a)** is the number of nodes in N2(u) covered by the associates of node a.
- **MPRSEL(a)** is the neighbors nodes that have selected the node a as MPR.
- **MPRSEL_ONEHOP** is the nodes that have selected a one-hop node of u as MPR.

**Weight (a)** is the weight of the node a defined as follows:

\[
Weight(a) = \frac{NNC(a)}{NNC(a) + CA(a)} 
\]  

(1)

**Weight_C(a):** is the cooperative weight of the node a defined as follows:

\[
Weight_C(a) = Weight(a) \times cf 
\]  

(2)

where \( cf = \left(1 + \frac{MPRSEL(a)}{MPRSEL\_ONEHOP}\right) \)

The weight parameter, weight(a), defined by the formula (1) represents the coverage rate of the two-hop nodes of u by the node a according to its associates. The choice of this parameter gives more chance to associate nodes, which cover more nodes of N2(u), to become MPR. Using this parameter reduces the number of MPR locally for each network node. But the number of TC packets did not follow the same trend; instead it has increased in the majority of cases [10]. Additionally, to take into account the cooperation between the nodes, we introduce, in the formula (2), the multiplicative factor, cf. This factor allows the MPR selection procedure, to favor the nodes that have more than MPR selectors, and increases the chance of the node, a, to become MPR. Accordingly, the cooperative weight parameter, weight_C, defined in the formula (2), makes to combine two purposes at the same time: favoring the nodes that have more than MPR selectors and locally reducing, the number of MPR.

Our algorithm is based on the weight_C parameter to select the MPR set for each source node. It iteratively eliminates one-hop node with the minimal weight_C parameter to bring up the nodes of N(u) that only reach one or some nodes in N2(u). These nodes will be added to MPR set. The sketch of our algorithm is presented in Fig.5.

![Algorithm 2](image)

**Algorithm 2**

1. Start with an MPR set made of all members of N(u) with N willingness equal to WILL ALL WAYS.
2. While there exist nodes in N2(u) which are not covered by at least one node in the MPR set:
   1. Add to the MPR set those nodes in N(u), which are the only nodes to provide reachability to a node in N2(u).
   2. For example, if node b in N2(u) can be reached only through a symmetric link to node a in N(u), then add node a to the MPR set. Remove the nodes from N2(u) which are now covered by a node in the MPR set.
   3. For each node v of N(u) Calculate the weight:
      \[ Weight_C(e) \]
   4. Delete the node v0 with a minimal weight_C of N(u).

In our algorithm, in order to select its MPR, a network node needs both a number of MPR selectors for each one-hop neighbor and the total number of MPR selectors of all the one-hop neighbors (without repetition). These numbers are not available for each node. HELLO packet can be used to exchange the numbers of MPR selectors between the neighbor nodes in the network. For example, if a and b are two neighbor nodes, and the number of MPR selectors of a is 4 and the number of MPR selectors of b is 3. Then node a informs the node b indicating in a Hello message that the number of its MPR selector is 4. Conversely, b informs the node a specifying in the
HELLO message that the number of MPR selector of node b is 3. Fig.6(b) shows the format of the HELLO message described in RFC3626 [4]. This message contains the reserved fields and other fields to exchange important information between nodes. We have extended the structure of the HELLO message as shown in Fig.6(c) to use a reserved field in the HELLO messages to exchange the number of MPR selector (MPRSEL). In addition, we have extended the structure of a one-hop neighbor node (neighbor tuples) by adding a field (N_Nb_MPRSEL) to keep updating the number of MPR selectors of a one-hop neighbor nodes as shown in Fig. 6(a).

So, there is no additional signaling overhead introduced by our algorithm; we just used a reserved field of HELLO messages to disseminate the number of MPR selectors.

To calculate the number of MPR selectors of all one-hop nodes (MPRSEONEHOP), the topology table is used, since this table contains the fields: T_dest_addr, T_last_addr, T_seq and T_time. T_dest_addr is the main address of node, which may be reached in one-hop from the node with the main address T_last_addr. Thus, T_last_addr is a MPR of T_dest_addr [4].

Let’s take an example to better illustrate the operating principle of our algorithm. As shown in Fig. 7(a), the network consists of 12 fixed nodes placed in an area of 1000m x 1000m. Numbers in brackets next to each node represents the MPR selectors of this node, for example nodes 10, 11, 5, 9, 3 and 0 chose node 4 as a MPR node.

In this example we will calculate only the MPR of node 3. Where N (3) = {0, 4, 10, 2, 7, 8, 9} and N2 (3) = {1, 5, 11, 6}. We have, also, shown only the wireless links between the node 3 and the nodes of N(3) (represented by continuous lines) and those between the nodes of N(3) and nodes of N2(3) (represented by dashed lines).

As there is no node in N(3) that only covers nodes in N2(3), we proceed to calculate the weight_C parameter for each node in N(3). We have | MPRSEL_ONEHOP | = 12 because the network nodes that have chosen one or nodes in N(3) as MPR are: 2, 5, 1, 4, 0, 3, 10, 11, 9, 8, 7 and 6.
Now we remove the node 10 with the minimum weight_C of N(u) and we get the network shown in Fig. 7 (c).

Node 4 is the only in N (3), which covers 11, then it is chosen as MPR and 5, 11 are removed. The algorithm stops because N2(3) becomes empty, finally, the nodes 2 and 4 are selected as MPR of node u, while the basic MPR for the same example.

We have also calculated the MPR of each node using a three other algorithms: UM-OLSR [20], NFA [7] and cooperative algorithm [9]. Table III summarizes the obtained results.

<table>
<thead>
<tr>
<th>TABLE III.</th>
<th>PARAMETER SELECTION OF MULTIPoint RELAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>N(3)</td>
<td>NNC associates</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
</tr>
</tbody>
</table>

We note that our algorithm reduces, locally and globally the number of MPR. The global reduction in three other algorithms: UM-OLSR [20], NFA [7] and cooperative algorithm [9]. Table III summarizes the weight_C of N(u) and we get the network shown in Fig. 7 (c).

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<table>
<thead>
<tr>
<th>TABLE III.</th>
<th>MPR NODES, TOTAL NUMBER OF MPR AND TOTAL NUMBER OF TC FOR THE FOUR ALGORITHMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPR nodes</td>
<td></td>
</tr>
<tr>
<td>Nodes</td>
<td>NCA</td>
</tr>
<tr>
<td>0</td>
<td>2.4</td>
</tr>
<tr>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>0.3</td>
</tr>
<tr>
<td>3</td>
<td>2.4</td>
</tr>
<tr>
<td>4</td>
<td>0.3</td>
</tr>
<tr>
<td>5</td>
<td>0.4</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>2.3</td>
</tr>
<tr>
<td>8</td>
<td>2.3</td>
</tr>
<tr>
<td>9</td>
<td>3.4</td>
</tr>
<tr>
<td>10</td>
<td>3.4</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Total MPR number</td>
<td>4</td>
</tr>
<tr>
<td>Total TC number</td>
<td>670</td>
</tr>
</tbody>
</table>

We note that our algorithm reduces, locally and globally the number of MPR. The global reduction in MPR versus NFA implies a decrease in TC packets generated by MPR every 5 seconds. And the local reduction of MPR compared to UM-OLSR implies a reduction of TC packets broadcasted. In both cases (locally and globally) this leads to a reduction of the total number of TC packets in the network as shown in Table III.

V. SIMULATION AND RESULTS

A. Evaluation Criteria

The objective of the experiments with the simulator NS-2 is to validate the influence of our MPR algorithm selection on the performance parameters by analyzing the following metrics:

- **Number of TC packets**: The number of topology control packets (TC) in the network.
- **PDR**: Is the ratio between the number of received data packets and the number of data packets sent.
- **Routing Cost**: Is the ratio between the number of routing packets sent and the number of data packets received by destinations.
- **Efficiency**: Is the ratio between the number of delivered packets which are transmitted (Data) and (Data + Routing overhead).

B. Simulation Parameters

The simulation parameters are summarized in Table IV.

<table>
<thead>
<tr>
<th>TABLE IV.</th>
<th>SIMULATION PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters used for traffic model</td>
<td></td>
</tr>
<tr>
<td>Simulation time</td>
<td>300 s</td>
</tr>
<tr>
<td>Type of traffic</td>
<td>CBR</td>
</tr>
<tr>
<td>Number of connections</td>
<td>30% of network nodes</td>
</tr>
<tr>
<td>Packet size</td>
<td>512 Octet</td>
</tr>
<tr>
<td>Parameters used for mobility model</td>
<td></td>
</tr>
<tr>
<td>Ad hoc network area</td>
<td>1000 m x 1000 m</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>30/50/75/100/125/150</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>2 Mbps</td>
</tr>
<tr>
<td>Maximum speed of nodes</td>
<td>20 m/s</td>
</tr>
<tr>
<td>Mobility model</td>
<td>RWP</td>
</tr>
<tr>
<td>MAC protocol</td>
<td>IEEE 802.11</td>
</tr>
<tr>
<td>Minimum time</td>
<td>100 ns</td>
</tr>
<tr>
<td>Transmission range</td>
<td>250 m</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>2 Mbps</td>
</tr>
</tbody>
</table>

C. Simulation Results

The objective of these simulations is to evaluate our MPR algorithm selection and to compare the obtained results with those of UM-OLSR implementation [20], the NFA algorithm [7] and cooperative algorithm [9]. To study the influence of MPR nodes selection on the number of topology control packets (TC), the RDP, the routing cost and the Efficiency, we conducted two experiments: the first, concerns the simulation of a static Ad hoc network; while the second deals with a simulation of a mobile ad hoc network.

1) Experiment 1

In this experiment, the static network nodes are randomly distributed in an area of 1000m x 1000m. To evaluate the impact of network density, we varied the number of nodes between: 30, 50, 75, 100, 125 and 150. The number of nodes that will generate data traffic represents 30% of the network nodes. For each number of nodes, four different scenarios are simulated, and the average of the four results is presented in the following figures.

Fig. 8 shows the number of topology control packets (TC) depending on the number of network nodes. We note that, regardless of the density of the ad hoc network (the number of nodes is varied between 30 and 150). Our MPR selection algorithm reduces the number of TC compared with the three other algorithms. This reduction can respectively reach 6% for original UM-OLSR, 15% for NFA and 5% for cooperative algorithm. The reduction of TC appears clearly in the case of dense networks (between 100 and 150 nodes). These improvements can be explained by the fact that, in the dense networks, the probability of selecting nodes that are already MPR for other nodes increases. So, our algorithm, which favors
those nodes, reduces the global number of MPR nodes in the network. Subsequently the number of topology control packets (TC) is also reduced because the MPR nodes are the only ones that generate the TC packets, and nodes that are not MPR, receive and process messages TC, but do not broadcast them.

Fig. 9 represents the PDR, the routing cost and the efficiency depending on the number of nodes. We note, in Fig. 9 (b), that the cost of routing followed the same trend as the number of TC. Indeed, whatever the density of the network, the routing cost given by our algorithm is less compared to other algorithms. It can be reduced up to 14% compared to the NFA algorithm. The reduction rate can also reach 5% for the other two algorithms (UM-OLSR and cooperative algorithm).

In Fig. 9 (c), we also note that our proposal is more efficient. It can increase efficiency up to 6% compared to NFA and up 2% compared to the other two algorithms. Despite the reduction in the number of TC packets and routing cost, we see in Fig. 9 (a) the PDR remains almost the same for all algorithms.

2) Experiment 2
Like the first experiment, we chose the area of 1000m x 1000m mobility. However, the number of node is fixed at 50. These nodes use the Random Waypoint mobility model [21]. The traffic between nodes is generated by a traffic generator that can create connections CBR at times uniformly distributed between 5 and 295 seconds. The size of packet data is 512 bytes. To study the impact of mobility on the four implementations, we varied the speed of mobile nodes between 2.5m/s and 30m/s.

Fig. 10 shows the number of TC in the network depending on the speed of nodes. We can confirm that regardless of the maximum speed of nodes in the network, our MPR selection algorithm reduces the number of TC packets in the network. Reducing TC is varied between 1% and 19% for the UM-OLSR implementation; between 12% and 19% for the algorithm NFA and between 1% and 4% for cooperative algorithm. We note that the reduction rate increases in the low and medium speeds. Whereas, moving with a relatively high speed, the reduction of TC packets is not significant. Indeed, the number of MPR selectors of a node sent to a neighbor node at a given time can change rapidly due to the high speed movement of the nodes. This may induce a node to select its MPR based on outdated information.

Fig. 11 shows the PDR, the routing cost and the efficiency according to the maximum speed of nodes. We note that our algorithm can reduce the
routing cost compared to the other three algorithms (until: 15% for NFA, 4% for the cooperative algorithm and 7% for UM-OLSR implementation). Fig. 11 (a) shows a small improvement in PDR at low speeds, indeed, our algorithm increased the PDR up to 2% to less than 10 m/s speeds. In addition as shown in Fig. 11 (c), we can note that our proposal is more efficient in mobile networks; it can increase efficiency up to 5% compared to NFA and can improve it by 1% compared to the other two algorithms.

VI. CONCLUSION AND PROSPECT

In this article, we proposed a new cooperative algorithm for selecting MPR nodes in OLSR protocol. The algorithm is based on heuristic favoring neighbors that have already been selected as MPR by the maximum of nodes. This reduces the total number of MPR nodes in the networks. This reduction leads to the reduction of the total number of TC packets and to the improvement of other performance parameters such as PDR, routing cost and efficiency. We have implemented our algorithm, the NFA algorithm and the cooperative algorithm on NS2 simulator. The simulation results show that our algorithm reduces the number of topology control packets compared to the other three algorithms for networks, both fixed and mobile. The reduction of TC affects positively other performance parameters.

As a future extension of this work, it would be interesting to consider other parameters of quality service during the cooperation between network nodes.

REFERENCES


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