Social OLSR:

A Social Based Routing Algorithm for Mobile Ad Hoc Networks

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Abstract. In our area of *Mobile Multimedia*, the expansion of wireless networks is dazzling and mobility has become a major issue exacerbated by the significant increase in the number of mobile users. A node operating in a *basic mobile network* behaves the same way a blind person moving in our universe by developing his own representation with his stick, a mechanism known in the literature as *terminal mobility*. To reduce this blindness, several methods have been developed that are based on community behavior. One of the facets of the use of community behavior is the integration of the faculty of "perception" of groups in social communities at the heart of a routing protocol for mobile networks.

We propose a routing protocol based on the original *Optimized Link State Routing* protocol (*OLSR*) to which we add the component of social perception of groupings of individuals. We attache our proposal to tests in simulated environment which shows that indeed the stability of wireless network is more sustainable when the perception exists that in its absence.

Keywords: Ad Hoc networks · Social networks · Routing protocols · OLSR

1 Introduction

In this paper, we discuss the routing protocols themselves as new prospective space alternative to the use of community behavior in mobile networks. After a state of the art, we propose to revisit the *Optimized Link State Routing (OLSR)* protocol. Then we move to the heart of this paper which is a social approach of *OLSR* protocol (*OLSR-S*). We test this approach by simulating a mobile network which implements the resulting protocol. We report the results of measurements on the different organs of our simulated mobile network and conclude on the benefits of this approach.

2 State of the Art: Social Routing Protocols

"The routing of a message in a mobile network is made difficult because the graph of the network is rarely (or ever) connected. Under these conditions where

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the nodes are free in their movement, finding a path that offers good end to end delivery performance in a short time is a challenge " wrote [1] in an article that presents a multidisciplinary solution based on the consideration of the *small world dynamics*. It was initially proposed as a lever to facilitate economic and social studies. Recently, it is successfully applied to the dissemination of information in wireless networks. To this end, some bridge nodes are identified by their ability to be central (in the sense *PBX*), that is to say, according to their ability to act as a broker of information exchange between nodes that would otherwise be disconnected. Given the difficulty of measuring the centrality in a populated network, the notion of *ego networks* is exploited: nodes are not required to exchange global information on the network topology, but only local. *SimBet* routing protocol is then proposed [2], it operates the *betweenness* and the social *similarity* of destination node which is determined locally. The paper presents simulations using real data traces and shows that *SimBet* gives results, in terms of routing messages, that are close to the *epidemic* routing [3], but for a greatly reduced cost. In addition, the paper shows that *SimBet* surpasses the *PROPHET* routing protocol [4], especially when transmitting and receiving nodes have low connectivities. *SocialCast* [5] is a routing framework in *publish-and-subscribe* mode. It uses predictions based on the social interactions (such as modes of travel within a community) to identify the best carriers of information. The paper highlights the underlying principles of this protocol, illustrates its operation and evaluate its performance using a mobility model based on a social network validated using real traces. Analysis of the results shows that the prediction of collocation and mobility of nodes can publish for them, events steadily, keeping the control traffic and latency as low as possible, regardless of fluctuations in the density, the number of replicated messages and speeds. A sensitive to social relationships routing protocol, designed for sharing content on mobile applications, is proposed by [6]. It describes the design and implementation of a social relationship sensitive routing protocol. The social relationship is given a central role in the routing evaluation system *metrics*. Simulation results show that the proposed routing protocol has a higher flow rate and a lower control flow than the dynamic *Destination-Sequenced Distance-Vector, DSDV* routing protocol proposed by [7].

3 *Optimized Link State Routing, OLSR*

3.1 Why *OLSR?*

In [8], [9] and [10] we perform many simulations and shown that *OLSR* is more sensitive to social behavior than *AODV* and by the way it's more suitable for networks having social behavior especially when we use an adequate mobility model. Theses results make us thinking to try to ameliorate the existing *OLSR* protocol.

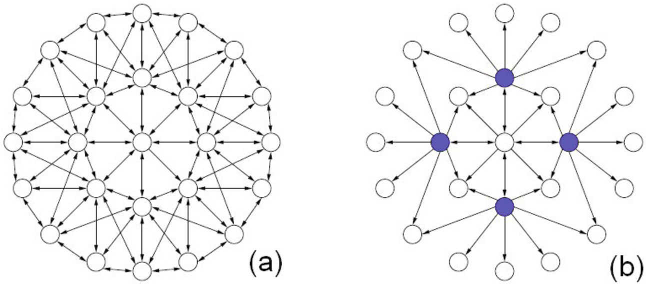

Fig. 1. Retransmission Gain 50 % : (a) without MPR, (b) with MPR

3.2 *OLSR* Protocol

The *Optimized Link State Routing (OLSR)* protocol can be described as an adaptation of *Open Shortest Path First (OSPF), RFC 2328*, for mobile networks. The optimization is the introduction of the notion of *MultiPoint Relay (MPR)*. The idea is to reduce the number of control packets avoiding their *flooding*, that is to say that all nodes always broadcast all control packets. In *OLSR*, a node n choses its *MPR* set, V_{n_m}, among its *one hop neighbors*, V_{n_1}. These *MPR* will disseminate its control packets. Its other neighbors, $V_{n_1} - V_{n_m}$, receive and process its packets without any broadcast. In addition, n holds another subset of its neighbors, V_{n_s}, including those who have designated it as their *MPR*. The elements of V_{n_s} are called the *MPR Selectors* of n. Any broadcast message from $s \in V_{n_s}$ received by n is broadcasted. V_{n_m} and V_{n_s} are defined and evolve with the emission of *Hello* messages every two seconds, *Hello Interval*.

A *Hello* message contains, besides the *Willingness* that indicates the propensity of a node to assume the role of *MPR*, a_n, the sending node's n address and $\forall v \in V_{n_1}$, a_v, the address of v and l_v, the type of link (n, v) which takes it values in T_L= {symmetric, asymmetric, lost, unknown, symmetric neighbor, *MPR*, ... }. Any new link (n, v) is declared by n as *asymmetric*. It becomes *symmetric* when n receives the same link from v. Thus v becomes eligible as an *MPR* of n and vice versa. V_{n_1} is then made up of v such that (n, v) is *symmetric*. V_{n_2}, the *two hop neighbors* of n consists of v_2 nodes such as v_2 is a neighbor of $v \in V_{n_1}$ and $v_2 \notin V_{n_1}$.

Fig. 1 shows the gain obtained by the use of *MPR*: 12 retransmissions are sufficient to broadcast a message to 3 hops nodes from the transmitting node, i.e. the central node in Fig. 1a. Without this concept, it needs 24 transmission, Fig. 1b. This is the *first optimization* of OLSR. The *second optimization* is that in a *Topology Control, TC* message, only the vicinity of the nodes is transmitted and not the entire network as in the *Link State Advertissement, LSA*, message of the *OSPF* protocol. Finally, the *third optimization* is that these *TC* messages (and other control messages *MID* and *HNA* that are outside of our discussion) are never relayed by the non *MPR* nodes.

4 A Social Approach of *OLSR*: OLSR-S

As the movement of mobile devices is mainly based on the decisions and behavior of people carrying them, it is important to consider the social behavior of humans in the modeling of the mobility of these devices. One can notice that the movements of a man can be represented as a compromise between the strong need of people to socialize with others and their habits and/or interests. So, human social behavior can be characterized by:

- Attraction Points: some places considered important for the group and should be visited by its members,
- Community of travelers: people in a given community and who visit the same places.

We choose to consider the heart of the *OLSR* protocol, that is to say his *MPR* selection algorithm, as the ideal place to introduce the consideration of social groupings of users in a mobile network, and create our *Social OLSR, OLSR-S*.

The concept of grouping criterion can be implemented in different ways. A mechanism of *publish-and-subscribe* can allow a node to issue an offer and the others to accept for a period determined by a date, a start time and an end time. During this time, our *Social OLSR (OLSR-S)* protocol will adapt to be local to this group. Another mechanism closer to our works is to consider that a node will take the "color" of the first Attraction Point that it visits, in the sense that it assigns a group identifier of its own for a specified period. Note that a group is often formed at an event and do not discard on rapidly. Finally, nothing prevents the nodes to assign an arbitrarily group identifier chosen before starting the simulation tests. The group aspect is a specialty going far beyond this paper, we choose for our test the latter option.

The question is then: how to cheaply add the "perception" of community groups in *OLSR*? Inspired by [11] who proposes an original and simple approach for an energy aware OLSR, the answer we give is as follows: give to the nodes of the same community the same propensity to be *MPR*. Indeed, as mentioned above, the *Willingness* parameter of the *Hello message* indicates the propensity of a node to assume the role of *MPR*. This parameter can take any value between 0 (*Will_Never*) and 7 (*Will_Always*) with a default value of 3. Nothing prevents us to define, a priori, a particular value for each community group and assign it to the *Willingness* of all its stations.

5 Application

We add new values for the *Willingness* parameter: *Will_Social_Group_a*, where $a = A, B, C, D$, that defines a community group identifier. For our tests we need four groups, but there is no reason to not create more if needed.

In addition, we add the following condition to the *MPR* selection algorithm (written in pseudo-code) :

```
// Place the following code in the branch where you can choose
// between several MPR candidates and the criterion of choice
//is to take the larger Willingness

// Initialize the selected MPR,m ,to null
m = null

// n is social ?
IF n.Willingness > Will_Always THEN

    // n is social

    // Browse MPR candidates, search of that which
    // would have the same Willingness as n

    FOR every MPR candidate c DO
        IF  c.Willingness = n.Willingness THEN
            m = c
            EXITFOR
        ENDSI
    ENDFOR
ENDSI

// Place the basic OLSR algorithm
IF m = null THEN
    m = c[0]
    FOR every MPR candidate c DO
        IF  c.Willingness > m.Willingness THEN
            m = c
        ENDSI
    ENDFOR
ENDSI
```

Note that the "EXITFOR" is optional: in the version *with* "EXITFOR", we choose the first suitable candidate *MPR*; in the version *without* "EXITFOR", we choose the first suitable candidate *MPR*. In our algorithm, we choose the first one.

6 *AMN* Mobility Model

Assuming that mobile divices are carried by people, *Ant Mobility Model, AMN* [10] is a social mobility model which tries to mimic the realistic motion of people in a network. This model is based on *Ant Colony Systems (ACS)*.

We all notice for example, in sales period, there are some stores more crowded then others and the more a store is crowded, the more people enter it; the same goes when choosing destination of ones vacancy, the more a place is crowded, the more people choose it; when shoping upon the Internet too: if a item appears in the most-bought product list, more people will rush to buy it. This is because people do think if it is so crowded or chosen, its because its a good bargain or an interesting place. In the literature, attraction points model such centers of interest.

AMN uses this notion of attraction points and introduce some social behavior shows interresting results when used to simulate a network. We choose this model for the evaluation of the performances of our new algorithm.

7 Implmentation

We compare our approach with the basic *OLSR* protocol using our *Ant Manhattan Mobility Model (AMN)* mobility model.

For our performance studies, we use the following statistic:

- *Node statistics, OLSR, MPR Status* which relates the "*is MPR*" attributes of the considered node.

The network will consist of:

- 4 Attraction Points: AP_a where $a = A, B, C, D$;
- 4 mobile nodes "Station An" where $n = 1, 2, 3, 4$ for group A;
- 4 mobile nodes "Station Bn" where $n = 1, 2, 3, 4$ for group B.

The resulting network is shown in Fig. 2.

To implement our OLSR-S, we add our new values of *Willingness* to allow node to recognize the group as an eventual *MPR*

The corresponding code allows us to establish the corresponding control flow :

```
Initializes the process;
Sleep mode;
Wake up if: Packet arrival or Timeout.
```

Each neighborhood or [1] topology changes [2] , the computation [3] of the *MPR* set is done.

Assuming that the nodes "*Station Ai*" and the nodes "*Station Bi*" belong respectively to the same groups, the nodes of a group will, as we can notice in real life, have the same behavior and move towards the same places (i.e. the same Attraction Points, AP).

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[1] appearance/disappearance of a one or two hops neighbor, or new asymmetric link. Appearance $\Longleftrightarrow$ link becomes symmetric. Disappearance $\Longleftrightarrow$ not a link at all. Asymmetric link $\Longleftrightarrow$ potential one hop neighbor.

[2] create/delete/end interfaces of node, resulting from the arrival of a *Topology Control Message, TC* or a timeout for a validity of en interface.

[3] it is rather an update.

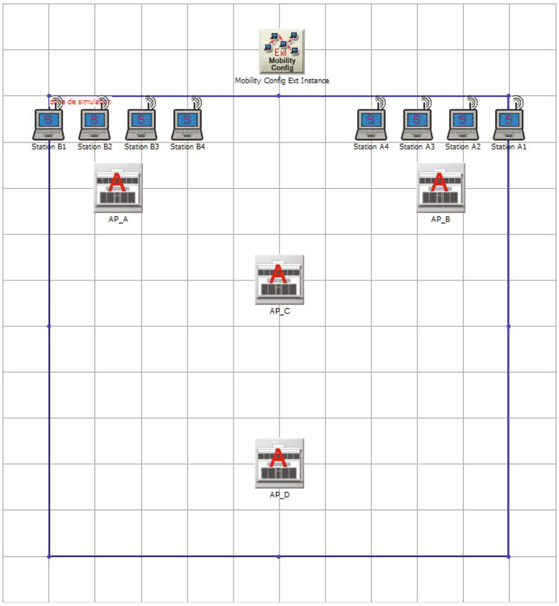

Fig. 2. Simulated Network

The trajectories of the nodes of A and B groups are described in Fig. 3.

This configuration will allow us to see the impact of our *OLSR-S* algorithm on the selection of *MPR*.

Places where a node has a high probability to change its *MPR* are represented by two circles.

To force the groups to follow these trajectories, we simply select the Attraction Points to visit.

To compare our new approach with basic *OLSR* algorithm we realize two scenarios:

- "Without Social OLSR" : *Willingness* is set to *Will_default*;
- "With Social OLSR" : initializes *Willingness* to:
  - → *Willingness_grpA* for group A;
  - → *Willingness_grpB* for group B.

Our choice is to have a uniform stations (iso-functional stations). So we set the traffic generator uniformly over all stations. Finally, the statistic *OLSR Status* of *Opnet Modeler* is chosen.

OLSR Status is set to 1 when a node is *MPR*, 0 otherwise.

In our results, we display the average value of this statistic. Do not be surprised to see different values from 0 and 1.

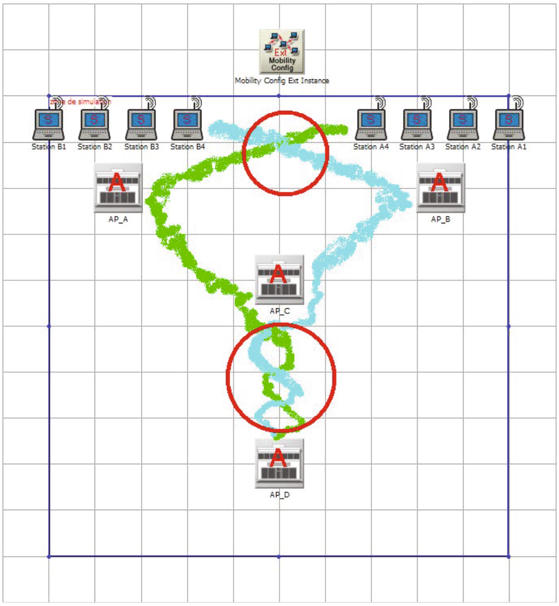

Fig. 3. Trajectories

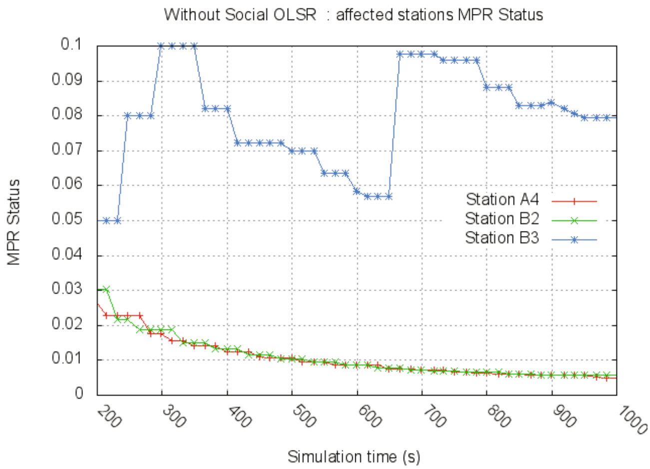

Fig. 4. MPR Status (OLSR)

8 Results

The first scenario does not use *Social OLSR (OLSR-S)* and gives the results shown in Fig. 4. This represents the three stations that played a role of *MPR*. These stations are $A4$, $B2$ and $B3$. $B3$ is, from the start, well positioned to

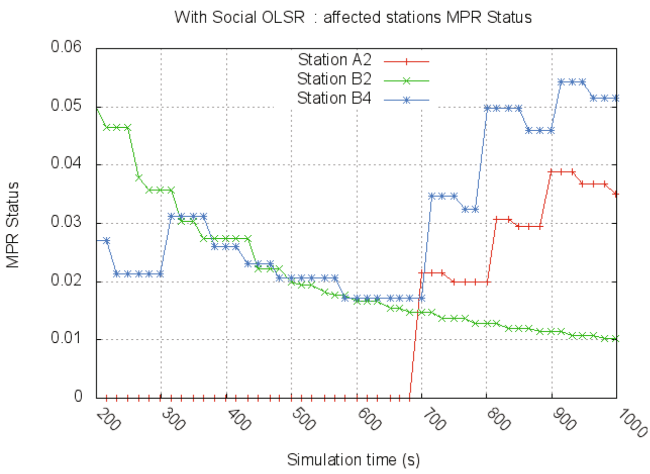

Fig. 5. MPR Status (OLSR-S)

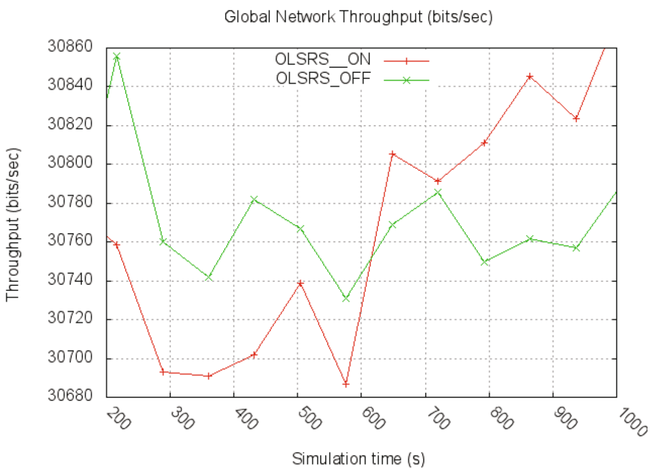

Fig. 6. Throughput (OLSR vs OLSR-S)

be the unique *MPR*. After about 4 minutes, we see that $A4$ and $B2$ bow and surrender their *MPR* position for $B3$. The group A has taken as *MPR* a station from group B.

The second scenario uses *Social OLSR (OLSR-S)* and gives the results shown in Fig. 5. This represents the three stations that played a role of *MPR*. These stations are $A4$, $B2$ and $B3$. $B3$ is, from the start, well positioned to be the unique *MPR*. But after about 10 minutes, we find instead that $B2$ tilts and sold its *MPR* position for *A*4 and not *B*2. The stations of the group *A* have always an *MPR* of their group and it's the same for group *B*.

One can ask what it changes for the network as a whole to have less change of *MPR*. We compare the *Throughput* of both scenarios and the answer is given by the curves of Fig. 6.

These shows that the overall amount of received data, on average, on all stations of the mobile network is higher when we use *Social OLSR (OLSR-S)* than when we do not use it where it stagnates.

9 Conclusion

In this paper, we introduced one of the aspects of the use of community behavior in mobile networks: the integration of a "perception" of social aspects into the hearts of routing protocols for mobile networks. We first gave a brief overview of what is being done in this area. Then, we proposed a routing protocol based on the *Optimized Link State Routing* protocol and which adds the social component of perceiving groupings of individuals. We have attached to our proposal a simulation test environment which shows that the stability of a wireless network is more sustainable when this perception exists. However, a drawback should be mentioned and it is the energy management of social *MPR*, being more stable, they are likely to consume more energy and become the weak link of the whole network (in term of energy). Hence the interest of a hybrid *e-OSLR* + *OSLR-S*.

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