A New Mobility Metrics for MPRs Selection in OLSR Protocol

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ABSTRACT. The OLSR (Optimized Link State Routing) protocol is an optimization of link state protocols designed for MANETs (Mobile Ad hoc Networks). In the process of learning routes, it bases the flooding technique by using multipoint relays (MPR). We present in this paper an improvement of the process of MPR selection based on mobility quantification for adapting OLSR protocol in case of high dynamic of topology. We aim to select stable (less mobility) nodes as MPRs.

Résumé. Le protocole OLSR (Optimized Link State Routing), est une optimisation des protocoles à états des liens désignés pour les MANETs (Mobile Ad hoc Networks). Dans le processus de découverte de routes, il se base sur la technique d'inondation en utilisant les multipoints relais (MPRs). Dans ce papier nous présentons une amélioration du processus de sélection des MPRs en utilisant une quantification de la mobilité dans un but d'adapter le protocole OLSR au cas où il y a une forte dynamique de la topologie. Notre objectif est de sélectionner les nœuds stables (moins mobiles) comme noeuds MPRs.

KEYWORDS: Ad hoc network, MANET, OLSR protocol, Multipoint relays, Mobility quantification.

Mots clés: Réseau Ad hoc, MANET, Protocole OLSR, Multipoints relais, mobilité quantification

1. Introduction

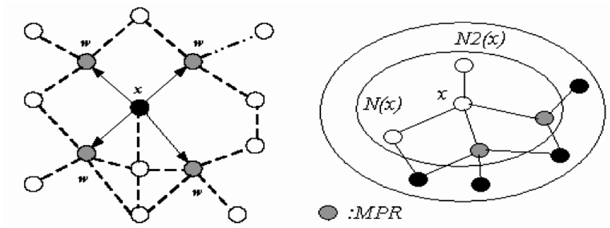
A mobile ad hoc network (MANET) is a collection of mobile nodes which form a communication network with no pre-existing wiring or infrastructure. Due to the dynamic nature of MANETs, designing communication and networking protocols for these networks is a challenging process. One of the most important aspects of the communication process is the design of routing protocols used to establish and maintain multi-hop routes to allow data communication between nodes. Several researches have been done in this area, and many multi-hop routing protocols have been developed. The Optimized Link State Routing (OLSR) protocol [1] [2], Dynamic Source Routing protocol (DSR) [5], Ad Hoc on Demand Distance Vector protocol [6], Temporally Ordered Routing Algorithm (TORA) [7], and others protocols that establish and maintain routes on a best-effort basis. In this paper, we aim to enhance the performance of the OLSR protocol by choosing best and stable routes in term of mobility. Our contribution consists on using information about nodes mobility to select routes where MPRs are less mobile. Moreover, we will estimate the quality of the links to avoid nasty surprises (routes indeed shorter, but made up of fragile and unstable links). This avoids the process of link failure that causes a huge overhead in the network due the flooding process.
This paper is organized as follows. Section 2, describes briefly the standard algorithm for MPRs selection used by OLSR protocol. Section 3 presents how we quantify and estimate the nodes mobility in MANETs. Section 4 presents our mobility metrics to adapt the OLSR protocol in the presence of mobility. Section 5 presents some simulations and results. Section 6 concludes the paper and presents some future works.

2. Optimized Link State Routing Protocol

The OLSR protocol is a proactive table driven routing protocol designed for MANETs [1]. As a link state routing protocol, OLSR periodically advertises information about links to build the network. (Figure 1(a)) shows an example of a message transmitted by a source node ***x*** which is only retransmitted by the ***w*** nodes that ***x*** selected as its MPRs. This example shows the efficiency of the MPR mechanism because only five transmissions are required to reach all the fifteen nodes building the network, which is a significant saving when compared to traditional flooding mechanism where every node is asked to retransmit to all neighbours.
As the computation of the MPR set with minimal size is a NP-complet problem [9], OLSR protocol uses a heuristic for MPR selection. Based on notation used in Figure 1(b), the MPR selection algorithm is as follow:

1. start with an empty MPR set
2. for each node y in the 1-hop neighbor set N(x), calculate D(y) . the degree (the number of neighbors) of y

3. select as MPRs those nodes in N(x) which provide the “only path” to some nodes in the 2-hop neighbor set N2(x)
4. while there exist nodes in N2(x) which are not covered
{Select as an MPR a 1-hop neighbor, which reaches the maximum number of uncovered nodes in N2(x). If there is a tie, the one with higher degree is chosen.}
5. As an optimization, process each node y in MPR. If MPR\{y} still covers all nodes in N2(x), y should be removed from the MPR set.



(a) (b)
Figure 1. Flooding with MPR selection algorithm.

3. Node mobility quantification

In this section, we define how we estimate the node mobility in MANET. Mobility is quantified locally and independently of the localisation of a given node. We represent this local and relative quantification by the change of the neighbouring, of each node. The node mobility at a given time t for node ***i*** in the ad hoc network is defined as the change in its neighbouring compared to the previous (state) at time $t - \Delta t$. Thus, nodes that join or/and leave the neighbouring of the node ***i*** will have surely an impact on the evaluation of its mobility.
As we explained before, we define the mobility of a node ***A*** at time t, by the following formula:

$$Mobility_{\lambda}(i,t) = \lambda \frac{NodeOut(t)}{Nodes(t-\Delta t)} + (1-\lambda)\frac{NodesIn(t)}{Nodes(t)} \qquad (1)$$

Where:

- *NodesIn*(*t*) and *NodesOut*(*t*) **:** is the number of nodes that joined and left the transmission range of ***i*** during the interval [$t - \Delta t$,*t*], respectively.
- *Nodes* (*t*)**:** is the number of nodes in the transmission range of ***i*** at time *t*.
- λ **:** The mobility coefficient between 0 and 1 defined in advance.

This mobility measure of the node is quantified locally and independently of the localization of a given node. We represent this local and relative quantification by the change of the neighbours of each node. The node mobility measure at a given time t for node ***i*** in the wireless network is defined as the change in its neighbours compared to the previous (state) at time $t - \Delta t$. Thus, nodes that join and/or leave the neighbours of node A will surely have an impact on the evaluation of its mobility measure. Moreover, we have chosen coefficient λ between 0 and 1 in order to have the node mobility measure at interval [0; 1].

For illustration, let us take an example when node ***i*** is on the state shown in (Figure 2(a)) with 10 neighbours, and during interval Δt, its neighbours will undergo the state changes shown in (Figure. 2(b)): four nodes (with blue color) will leave the communication range, and two nodes (with red color) will join it. Consequently the node will be after Δt (at time t) in the state (Figure. 2(c)) with six changes. At the end of each time interval, the node will be able to make an evaluation of the change of its neighbours represented by this relative mobility, which is in our example equal to 13/40 = 32,5% (with λ = ½). This node mobility has no unit, and it's always between 0 and 1, and does not suppose any model of mobility [3] to evaluate it.

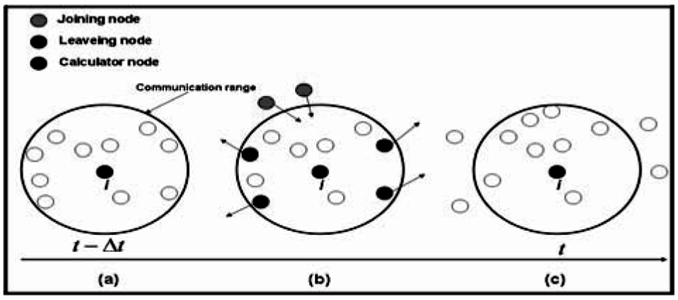


Figure 2. Estimation of node mobility.

4. Proposed Criterions

Mobility is a crucial problem in MANETs, and until now, the majority of routing protocols have shown some weaknesses to face a high mobility in some parts of the network. Our work consists in positively using the mobility, in order to improve the performance of the OLSR protocol.

4.1. Link quality estimation

Some OLSR experiments [4] [8] show that links must be more stable and less mobile to avoid fragile connections which involve data loss and frequent route changes. OLSR protocol maintains constantly the shortest paths to reach all possible destinations in the network. So, it is judicious to estimate the quality of links before adding them in the topological information that serves to calculate the best routes. We define the mobility of a link L between two nodes A and B as the average mobility of the involved nodes, as showed in following equation:

$$Mobility_{\lambda}(L,t) = \frac{Mobility_{\lambda}(A,t) + Mobility_{\lambda}(B,t)}{2} \qquad (2)$$

This evaluation of the link mobility alone is not significant because we can have a normal value of the link mobility with a high mobility value of one of the involved nodes. The dependence between the mobility of nodes composing a symmetric link (in the network core) at the time t can be seen as a mobility dependence of link L(A;B) as follows:

$$P_L(t) = | Mobility_{\lambda}(A,t) - Mobility_{\lambda}(B,t) | \qquad (3)$$

Therefore, a *reliable symmetric link* in terms of mobility can be seen as a link satisfying the two following conditions:

1) The link mobility is lower than a threshold THRESHOLD_Link defined in advance, which can be depending on the characteristics of the network (density, nodes mobility, network scalability…):

$$Mobility_{\lambda}(L,t) \leq \text{THRESHOLD\_Link} \qquad (4)$$

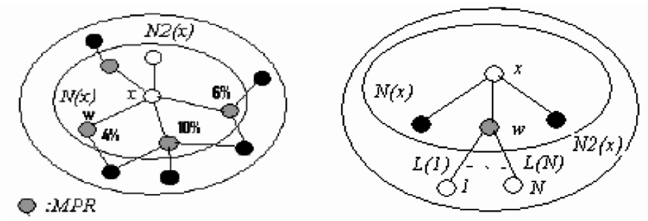
2) The mobility dependence of link is near to zero :

$$P_L(t) \to 0 \qquad (5)$$

The choice of such a link satisfying these two conditions ensures the link to have a low and a strong dependence of mobility between the involved mobile nodes.

4.2. Proposed criterions

In this section, we propose three new criterions for the operation of MPR selection. The first criterion is simple because it selects neighbour nodes that are less mobile as MPRs nodes (Figure 3 (a)). Precisely the node selected as MPR node is a node where its mobility is the smallest (Equation (6)). The two other criterions are based on the estimation of links quality between neighbours at one-hop and the neighbours at two-hop (Figure 3 (b)). The quality of the link is given by the loss probability of this link. A reliable link is a link where the loss link probability is near to 0. The selection of a neighbour node as a MPR node can be viewed as an operation of maximization of the selection criterion. The first criterion suggested is based on sum (Equation (8)), the second is based on the product (Equation (7)). The principal advantages of these proposed criterions are the facility of calculation, and fewer requirements of resources in memory and CPU.



(a) (b)

Figure 3. Criterion evaluation based on links estimation.

$$N - CRITERION(w) = \min_{w_i \in N(x)} Mobility_\lambda(w_i) \quad (6)$$

$$PRD - CRITERION(w) = 1 - \prod_{i=1}^{N} L(w,i) \quad (7)$$

$$SUM - CRITERION(w) = 1 - \frac{\sum_{i=1}^{N} L(w,i)}{N} \quad (8)$$

Our objective is to find a selection criterion of the MPR nodes, which converges to the standard criterion used in the OLSR implementation. The following section presents a comparison between this three proposed criterions with the standard criterion used by the implementation of the OLSR protocol. The objective of this comparison result is to find the best criterions which will be more suitable in MANET in case of the presence of high mobility of the nodes.

5. Simulations and results

We simulate our three proposed MPR selection algorithms based on three criterions using the Network Simulator NS-2 [11]. Precisely, we have used the NS-2 OLSR implementation [10] to proceed to a comparison of these three MPR selection algorithms with the standard one. This comparison is based on the average number of MPRs (the average is calculated based on 50 simulations) in the network. A highest number of MPRs in the network implicates a higher overhead and a degradation of the protocol performance. Simulations are running in the same network environment, the number of nodes is equal 100 nodes, the network area equal to 1000mX1000m, and the transmission range is set to 100m. Moreover, we consider in this work the step of quantification equal to the interval of HELLO exchange (Δt = 2 seconds), and λ = ½ for given the same weight for nodes leaving and joining the communication range.

The following graph represents a comparison between the MPRs the standard algorithm used by OLSR protocol and the three algorithms related to the three proposed criterions based on mobility estimation