Characterizing Multihop Routing Requirements for Node Mobility Support

Namusale Chama*, Rute C. Sofia*
IANLab, SITI, University Lusófona

***Abstract*—Node mobility in mobile ad-hoc networks has an adverse impact on the perfomance of traditional multihop routing protocols. A way to assist in routing stability is to consider mobility tracking parameters. As such, a number of mobility metrics have been developed. This position paper provides an overview on such metrics and addresses their shortfalls and vantage points. Moreover, the paper briefly describes a our perspective on how to assist multihop routing to become more sensitive to node movement and therefore, how to make multihop routing more robust.**

***Index Terms*—mobility, multihop routing, routing metrics.**

I. Introduction

Today's wireless architectures (e.g. *Mobile Ad-hoc Networks (MANETs))* incorporate nodes which correspond to wireless handheld devices often carried by humans and hence exhibit some movement patterns that are based on specific routines. Moreover, node movement (*mobility of nodes*) impacts the performance of routing as it may originate temporary or permanent topology changes being the consequence path re-computation.

Path recomputation has a cost in terms of delay and signaling overhead and hence, a consequence may be a significant decrease in network performance. Hence, previous work on routing metrics has been trying to deal with mobility aspects in multihop routing. For instance, Liang and Thomas have carried out an analysis of different mobility parameters[6]. Some examples of previously considered parameters that can assist in tracking some features of node mobility are: *aggregate pause time*, where e.g. nodes with longer pause times are expected to be more adequate to form stable links[5]; the *rate of change of neighbours*, which has also been used to determine node mobility[1].

This position paper provides a brief overview on the main aspects that we believe are useful to consider for wireless based scenarios where nodes are expected to exhibit realistic (human based) movement patterns. The paper also identifies potential issues related to the impact of node movement.

The remainder of the paper is organised as follows; Section II goes over related work on capturing the mobility extent of nodes and also highlights the importance of realistic mobility models. Section III discusses aspects related to node mobility and the routing sensitivity to it, i.e., up to what extent it affect routing. We conclude in section IV.

*(namusale.chama,rute.sofia)@ulusofona.pt. Internet Architectures and Networking Laboratory (IAN Lab), Research Unit in Informatics Systems and Technology (SITI), Universidade Lusófona. Campo Grande, 376, 1749-024 Lisboa, Portugal.

II. Related Work

In previous related work, we have enumerated a set of related work that worked upon routing metrics which had in common the inability to distinguish between a topology change that is long-lasting, and a topology change that is so short (in terms of time) that in fact it should not result in route recomputation[2]. Our belief is that by defining a multihop routing metric more sensitive to node mobility, multihop routing can become more robust and better adjusted to the current wireless dynamic scenarios.

Adding to the work described in this section, related work has explored routing metrics to track specific aspects of mobility. Liang and Thomas suggest the integration of a specific mobility metric capable of predicting handovers. The presence of such a metric will enable adaptive routing using a feedback mechanism, so that mobility effects can be countered as soon as possible[6]. On their analysis they have endorsed the *number of link breakages* as a good metric for adaptive routing. Nonetheless, much as the number of link breaks is a parameter that can assist routing sensitivity to mobility, frequent and repetitive movement patterns (e.g. ping-pong effect) of some nodes cannot truly be captured by such a parameter.

A number of studies have also considered the notion of *Link Duration* (LD) as a useful mobility tracking parameter. Wu et al. as well as Tsao et al. have defined LD as the period of time when two nodes stay in each other´s transmission ranges[9][7]. Chen et al. have redefined such notion as the period of time that the signal strength between two nodes is above an acceptable threshold[3].

Link Duration assists in partially capturing a spatial correlation between the nodes the form a link; however it is not a parameter that can capture whether link breaks are temporary and short enough to be ignored by the routing process. Nor does it assist in choosing nodes (sucessors) that may form more robust links upon the need to recompute a path..

Pause time is another parameter that has been considered in related literature. *Pause time* is by definition considered to be the period of time when a node is *stationary*, i.e.its speed is zero[8]. Khamayseh et al. have used the pause time to determine mobility levels, by assuming that nodes with longer pause times are less mobile than the nodes with smaller pause times, and hence assist in developing more stable links[5]. However, stable links can be attained by mobile nodes that keep a fix spatial correlation even when both nodes that form a link are moving. In other words, if two nodes that form a link hold a synchronized movement (speed, relative distance, direction) then from a link perspective such link is also stable.

Divecha et al. highlight the impact of the most common mobility models on multihop routing[4]. The motivation for such analysis is the fact that mobility models currently being applied are used to emulate real life scenarios and assist in developing, among other aspects, routing protocols. Therefore, if a model is not realistic enough, the routing protocol will suffer from the choice. With the increase in human handheld devices, mobility models should mimic human mobility patterns. Therefore, routing metrics that incorporate mobility aspects and that assist routing in becoming more sensitive to node movement have to be capable of capturing properties of social mobility (social mobility pattern properties).

III. Characterizing Routing Sensitivity to Movement

In order to attempt to better characterize routing sensitivity to node movement, we were provide some notions. Our belief is that routing sensitivity to node mobility can be summarized under three main categories. For the sake of clarity, we here assume the following: nodes i and j are adjacent in some moment in time; the link between i and j is defined as l_{ij}; node i moves. When the node moves, a topology change occurs and one out of three situations may occur:

1) this movement is not significant and does not affect routing computation;
2) this movement is significant and affects routing computation;
3) the movement is not significant, or corresponds to e.g. a ping-pong movement and yet affects route recomputation.

One of the aspects to address is to attempt to characterize (to provide a measure of) what significant means. Another aspect is to understand the impact of route recomputation due to mobility. A final aspect is how to assess that impact.

A. Mobility Relation to SNR

Node movement impact on route recomputation relates today to the perceived signal strength by a receiver node. Node movement is heavily related to the distance between nodes and it impacts *Signal to Noise Ratio (SNR),* which will fall below a desired quality threshold. When such ratio becomes lower than the predefined threshold, a link is said to be broken. For the sake of clarity let us consider what occurs when 802.11x is the underlying technology. The 802.11 standards do not specifically define a clear threshold for SNR. Instead, each wireless card relies on specific (not integrated into the standard) rate adaptation mechanisms. Based upon such mechanisms, the wireless device decides what to do and how to adjust the rate once the SNR lowers below an "adequate" threshold. A higher SNR value means that the signal strength is stronger than noise around, resulting in higher data rates and fewer retransmissions. A lower SNR requires wireless LAN devices to operate at lower data rates, which decreases throughput. In practice and highly vendor related, today if the SNR is above 40dB this is considered to be an excellent level, implying that the sender and receiver establish a high data rate connection. If the SNR is between 25 and 40dB, then this is a good signal level. Between 15dB and 25dB,this is a sufficient signal level assuming a channel that is not shared. A SNR between 5 and 10dB would imply no connectivity between the involved nodes, as the achieved data rates would go below an adequate level.

Node mobility impacts the routing process differently, depending on the routing stage (e.g. routing setup or maintenance phase) and such impact can be measured in terms of signaling overhead, latency due to the need to recompute paths often, potentially packet loss, and a decrease in throughput. It should be noticed that such impact is independent of the routing category considered, being the main categories here debated Distance-Vector and Link-State. Different protocols on these families may assist in preventing propagation of such impact through the network. However, none of them can truly decide on not triggering a path recomputation based on the knowledge where a failure can be temporary (e.g. last a few miliseconds) or permanent.

Both families shall therefore experience a degradation in terms of performance. However, the degradation can be measured on different parameters, depending on the protocol.

To provide an example let us consider the most popular routing protocols of each family, namely, the *Ad hoc On-Demand Distance Vector Routing (AODV)* and the *Optimized Link State Routing Protocol (OLSR)*.

AODV has a reactive nature and hence a link break triggers a path recomputation implying the need to generate additional control messages. While as in OLSR due to its flooding nature, most likely the required signaling overhead will be lower. Most likely, because this truly depends on the position, from a path perspective, where the link is, e.g., a link closer to a source, or to a destination, or somewhere in the path. this is also highly related to the type of path (long, short) and the usage of such path. These are aspects that we intend to analyse through simulations, as future work.

Upon node movement, the routing process may or may not trigger route recomputation,as discussed, as this is dependent upon the specific protocol operation. Upon topology reconfiguration and in the availability of additional routes, a new route will be established. However, this may simply be due to a slight variation of the SNR, and in some cases, such recomputation could be prevented by having routing metrics that are more sensitive to node movement.

B. Mobility Relation to Time

In addition to the distance between nodes, the impact of mobility on routing is related to timing, i.e., mobility is *time correlated*. Movement becomes significant if a topology change occurs in a specific period of time. For instance, if one node moves from a specific position to another and hence there is a link break but the node returns to its original position in a few miliseconds, this corresponds to a *temporary* link break. A temporary link break does not always imply discontinuity from a routing perspective.

C. Routing Sensitivity to Node Movement

From the discussion in sub sections III-A and III-B, today multihop routing triggers path recomputation based on a node's perception of a link break. This perception is based simply on a SNR threshold. As previously described, this does not suffice to assist a robust protocol in the event of dynamic, mobile nodes, as some movement patterns may simply result in temporary link breaks, which could be ignored if the routing process would integrate more adequate mobility metrics. For instance, the metric may be able to track mobility in a way that in the event of "repetitive" motion, temporary link breaks would be ignored because the routing process "learns" that the nodes that compose the link will soon be in place again.

To assist in this brief explanation, let us consider a topology where nodes exhibit a high mobility frequency. The topology is expected to change frequently and links that are formed are most likely bound to break frequently. Whether all links with at least one mobile node will break or not, depends not only on the distance between nodes but also on the mobility pattern nodes exhibit in relation to their neighbors. To illustrate this, assume a link made of one static node and the other one with a circular motion where after a few miliseconds the node passes through its original position. Hence, an increase in speed or the change of direction following the circular pattern will most likely not have a significant impact on the link characteristics.

In contrast, if we consider a topology where most nodes are static, expected link breaks for the few mobile nodes, even if frequent, may have a low impact on the topology. Moreover, if a topology in fact has a high number of mobile nodes but their motion is correlated (most nodes have the same pattern, keeping the relative distance between them, as happens in nodes moving in group) then, mobility has less impact on routing as the nodes remain in their respective relative positions in a topology. A concrete example for this are wireless devices transported in cars e.g. on a highway, moving at the same relative speed and keeping a similar inter-node distance. The capability to track such spatial-temporal correlation is key to devise an adequate, robust routing metric.

There are other aspects that are worth mentioning to address new metrics. While node mobility changes the length and additional features of a link the impact of node mobility in the routing process depends on the original link length. For instance, in a short length link, the impact of node movement is normally lower than the impact on a long link, but even this is related to the node mobility pattern.

Therefore our belief is that an adequate routing metric must be able to i) capture/differentiate a temporary link break from a permanent one; ii) anticipate node movement pattern; ii) be able to understand the node movement in regards to its neighbors.

By being able to device such a metric, it is feasible to add it to a multihop routing protocol, independently of the family (be it link-state or distance-vector based). Our expectations are that path recomputation becomes optimized and the consequence is a reduction in signaling overhead and an eventual increase in throughput.

Latency is also expected to be reduced due not only to the lower signaling overhead but also due to the optimization of the routing process.

IV. Conclusions and Future Work

This position paper briefly discusses the need to consider routing metrics that are more sensitive to node mobility for wireless networks of today, where the majority of users roam frequently. We went over mobility tracking notions and provided an overview on related work that attempted to optimize routing metrics, to assist node mobility. We then discussed mobility notions, namely, how nodes perceive movement and how node movement can impact a link, from a recomputation need perspective. We also addressed briefly novel aspects that are the basis to consider new ways to look into movement sensitive routing metrics. As next steps we intend to address current mobility tracking parameters and see (based on simulations) how the most popular multihop approaches (AODV and OLSR) perform when based upon such parameters.

References

[1] M. Benzaid, P. Minet, and K. Al Agha. Integrating fast mobility in the olsr routing protocol. In *Mobile and Wireless Communications Network, 2002. 4th International Workshop on,IEEE*, 2002.

[2] N. Chama. Mobility impact on user-centric routing thesis progress report, June,2010.

[3] S. Chen, H. Jones, and D. Jayalath. Effective link operation duration: a new routing metric for mobile ad hoc networks. *International Conference on Signal Processing and Communication Systems,ICSPCS 2007, 17-19 December 2007, Gold Coast, Australia.*, pages 17–19, 2007.

[4] B. Divecha, A. Abraham, C. Grosan, and S. Sanyal. Impact of node mobility on manet routing protocols models, 2008.

[5] Y. Khamayseh, O. Darwish, and S. Wedian. Ma-aodv: Mobility aware routing protocols for mobile ad hoc networks. In *Systems and Networks Communications, 2009. ICSNC '09. Fourth International Conference on*, pages 25–29, 2009.

[6] Q. Liang and T. Kunz. Mobility metrics to enable adaptive routing in manet. In *Wireless and Mobile Computing, Networking and Communications, 2006. (WiMob'2006). IEEE International Conference on*, pages 1 – 8, 2006.

[7] C. Tsao, T. Wu, W. Liao, and J. Kuo. Link duration of the random way point model in mobile ad hoc networks. In *Wireless Communications and Networking Conference, 2006. WCNC 2006. IEEE*, volume 1, pages 367–371, April 2006.

[8] J. Tsumochi, K. Masayama, H. Uehara, and M. Yokoyama. Impact of mobility metric on routing protocols for mobile ad hoe networks. In *Communications, Computers and signal Processing, 2003. PACRIM. 2003 IEEE Pacific Rim Conference on*, volume 1, pages 28–30, Aug 2003.

[9] Y. Wu, W. Liao, C. Tsao, and T. Lin. Impact of node mobility on link duration in multihop mobile networks. *IEEE Transactions on Vehicular Technology*, 58:2435 – 2442, June 2009.