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Development of an Enhanced Mobile Based Link Model for Residual Link Lifetime (RLL) maximization in MANET

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Abstract— *The link established in the Mobile Ad hoc Networks (MANET) is not stable and hence not reliable. We estimate the residual link lifetime (RLL) in MANET by measuring the distances between the link's nodes. We propose a mobile-projected trajectory (MPT) algorithm, which estimates relative trajectory between two nodes by periodically measuring the distances between them. Using the relative trajectory, the algorithm estimates the RLL of the link between the two mobile nodes. For comparison purposes, we derive a theoretical upper bound on the achievable prediction inaccuracy by any distance based RLL prediction algorithm with unknown but finitely bounded measurement error distribution. To account for velocity changes, the MPT is enhanced with a velocity-change detection (VCD) test.*

The position of nodes and the time until which the nodes stay stable in the particular position are determined. The battery power of each node is calculated and thus the lowest hop energy of the path is determined. The energy consumed by the nodes will be more if the paths break up due to frequent movement of nodes. Hence alternate paths from source node to destination are identified and the packets are transmitted.

Index Terms- *Mobile ad hoc network (MANET), link lifetime, prediction, residual link lifetime, velocity-change detection.*

I. INTRODUCTION

A mobile ad hoc network (MANET), is a dynamic distributed system of wireless mobile nodes without any fixed infrastructure where the nodes can move in any direction independent of each other. In a wireless environment, a number of factors such as mobility, noise, terrain, jamming, physical obstructions and weather conditions contribute to the difficulty of accurately modeling the behavior of the link life time between two mobile nodes. Due to the inherently dynamic nature of the network topology, the current links are frequently broken, and new links are frequently established. The provision of QoS necessitates the availability of long-lived reliable paths along which robust data communications can be conducted. The quality-of-service (QoS) features, such as minimal end-to-end packet delay and tolerable data loss. Data packets routed between a sender node (source) and a receiver node (destination) of a MANET often traverse along a path spanning multiple links, which is known as the multihop path. Consequently, the challenge is to identify and select those paths in the network that are most stable and, thus, are most likely to satisfy the QoS requirements.

That is, a link is considered up or alive by measuring the Euclidean distance between the link's two nodes which is less than the minimum of the two transmission ranges of the nodes; otherwise, the link is deemed broken or down. The full link lifetime (FLL) is defined as the time duration from the moment when the two nodes enter into each other's transmission range till the time when the link breaks. The residual link lifetime (RLL) at time t, where t is $0 \leq t \leq FLL$, denoted as RLL(t),is the time duration until the time at which the link breaks, i.e., RLL(t)+t = FLL. For t>FLL, RLL (t) = 0. The residual path lifetime (RPL) at some time't' is the minimum of the RLLs of its constituent links, and it is denoted as RPL (t).

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II. Analytical Report

In 1867, Z. J. Haas and E. Y. Hua did work on Residual link lifetime prediction with limited information input in mobile ad hoc networks. The laggings found in this work was that the lifetime of the network is only predicted but not maximized.

In 2001, A. Tsirigos and Z. J. Haas did work on Multipath routing in the presence of frequent topological changes. The laggings found in this work was since nodes were mobile routing protocol was not efficient.

In 2002, M. Gerharz, C. de Waal, M. Frank and P. Martini did work on Link stability in mobile wireless ad hoc networks.

In 2003, D. Niculescu and V. Nath did work on Ad hoc positioning system using AoA. The laggings found in this work was that predicting link establishment is not possible.

In 2012, A. Kumar, S. Jophin, M.S. Sheethal and P. Philip did work on Optimal route lifetime prediction of dynamic mobile nodes in MANET.

In 2012, C. Priyadharshini and K. ThamaraiRubini did work on Predicting route lifetime for maximizing network lifetime in MANET. The laggings found in this work was that maximization algorithm is not implied.

III. Methodology

Neither node possesses knowledge of its own or the other node's velocity (both speed and direction) or position.

Each node is equipped with the following three mechanisms. First, it has an ID beacon that periodically broadcasts an ID signal to its neighborhood. Node 1 hears this signal from Node 2 if and only if the distance between the two nodes is no more than R. Second, each node is equipped with a timer to keep track of the presence of the other node in its neighborhood. Third, each node is equipped with a ranging mechanism to measure the distance between itself and another node. Well-known ranging techniques include ToA [25] and angle-of-arrival (AoA) [21].One technology particularly suitable for ranging is the ultrawideband (UWB) communication because of its use ofextremely short temporal pulses. Since our proposed algorithm requires very low measurement rate, UWB ranging can be deployed in a node with a fairly large transmission range. We propose to employ the same UWB pulses for both ID signaling and ranging; this combination imposes no additional costs on ranging. However, the distance measurements contain measurement errors that must be taken into consideration when developing the distance measurement-based algorithm. Since our proposed algorithm requires very low measurement rate, UWB ranging can be deployed in a node with a fairly large transmission range. We propose to employ the same UWB pulses for both ID signaling and ranging; this combination imposes no additional costs on ranging. However, the distance measurements contain measurement errors that must be taken into consideration when developing the distance measurement-based algorithm, We introduce two types of measurement errors defined in physics: systematic error and random error. A systematic error results from miscalibration of the ranging equipment, such as imperfect synchronization between the transmitter and the receiver. Random errors arise from unpredictable phenomena such as channel fading and thermal noise. It is based on the available information (four distance measurements) since, in practice, other real-time information might be limited and/or expensive to acquire. If additional information were available, a different minimization condition might be realized that could lead to a trajectory with a slope closer to the true trajectory slope.

We define the acquisition time Tacq as the duration from the time of the first distance measurement until the time of the last distance measurement. This definition will be useful for the VCD ability of the MPT. We define the acquisition time Tacq as the duration from the time of the first distance measurement until the time of the last distance measurement. This definition will be useful for the VCD ability of the MPT. The upper bound ηu results from a trajectory whose slope deviates the furthest from the true slope α.

We proceed to derive a theoretical upper bound of the RLL prediction inaccuracy, denoted as ηu, of the proposed algorithm. This represents the maximal inaccuracy achievable by the MPT. Recall that, in the derivations of the MPT, we imposed no constraints on the distribution of εi. We now assume that the distribution of εi is unknown but bounded by a finite-valued εd. This is a reasonable assumption since, in practice, the distance measured by ranging equipment usually deviates within a small neighborhood from the true distance.

One example of such a distribution used in the literature is the uniform distribution [23], i.e., $\varepsilon i \sim U(-\varepsilon d, \varepsilon d)$. Accordingly, it is clear that the ˆ di's must be in the interval $[di - \varepsilon d, di + \varepsilon d]$.

Moreover, in estimating the values of di's as ˜ di's, one should assume that the ˆ di's themselves can be within the error interval [ˆ di − εd, ˆ di + εd]. Thus, the estimates ˜ di's can be within the interval $[di - 2\varepsilon d, di + 2\varepsilon d]$, i.e., ˜ di will not deviate from di by more than $2\varepsilon d$.

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Our predicted trajectory is linear, allowing any line whose four distances lie within the 2εd interval of the respective true distances to be a potential trajectory estimate. In particular, as shown in Fig. 8, there will be two such lines: one with the largest slope α, where α > α, and one with the smallest slope α, where α < α. The upper bound ηu results from a trajectory whose slope deviates the furthest from the true slope α. Three Cartesian systems (x, y), (x, y), and (x, y) are superimposed with the overlapping x-axis, x -axis, and x -axis.

Node 1 is located at Point A, and Node 2 at Point O. Four di's, ∀i = 0, 3, are measured along y = αx (i.e., the true relative trajectory), with intersection points O, D, C, and B. Each semicircular area between two concentric semicircles with the radii di − 2εd and di + 2εd defines the region Ωi of possible values that the ˜ di can take.

IV. Conclusion and Future Work

We have studied the problem of RLL prediction in MANET based on distance measurements. We have first proved that, when mobile nodes do not possess any knowledge of their speed, direction, or position, it is necessary to periodically measure only four distances to compute a unique RLL solution. We then proposed the MPT algorithm to compute the RLL. MPT performs linear curve fitting based on the periodical distance measurements. If sampling becomes nonperiodic, its negative effects on the computed RLL could be mitigated by sampling more than four distance measurements. We analytically derived an upper bound on RLL prediction inaccuracy when the distribution of measurement errors is unknown but finite; under such conditions, the performance of any distance based RLL prediction algorithm with unknown but finitely bounded measurement-error distributions is upper bounded by our derived bound. As part of our MPT performance evaluation, we demonstrated that measuring more distances with a constant sampling period would improve the prediction performance, although it comes at the expense of more prediction misses. In general, a greater acquisition time leads to better prediction accuracy.

To account for velocity changes during the link lifetime, we proposed a VCD test and derived a minimal detection threshold that guarantees zero probability of false alarms. We demonstrated the effectiveness of the proposed VCD test in a scenario where node movements induced a piecewise-linear trajectory during the link lifetime. The results showed that the VCD test achieved a very robust detection probability with low probability of false alarms. The RLL prediction of the MPT-VCD algorithm improves prediction with a larger Δτvc.

Furthermore, increasing the number of velocity changes does not significantly impact its performance but can lead to an increase in prediction misses. In this paper, we provided formulation of the statistical properties of the MANETs' links lifetime, while taking into consideration the dependence between adjacent links. The goal of this paper was to propose a model for evaluation of path availability without the simplifying assumptions adopted in previous works. First, through an example, we showed the significance of the dependence between neighboring links. Then, we derived a formula for the joint probability density function of two neighboring links' RLLs. Finally, based on the comparison of simulation and formulation results, the accuracy of the proposed scheme is demonstrated. Further, we evaluated, for an exemplary case, the error in the residual path lifetime as the result of ignoring the dependence of neighboring links. Our results will allow more effective and efficient path selection protocols in MANET, leading to improved network quality of service.

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