Systematic Assessment of Path Extent Time in Mobile Ad Hoc Networks

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ABSTRACT
A mobile ad-hoc network (MANETs) is a self-configuring infrastructureless network of mobile devices are connected by wireless. Each node in a MANETs is free to move independently in any direction, and it changes its links to other devices frequently. Accurate prediction of path duration will help to increase the performance of a routing protocol. Path duration is the minimum link residual life along the path to the destination consisting of individual links. Previous work done on this subject relied mainly on simulations. There is no analytical model in the literature that includes node density that can be used for estimating path duration in a MANETs. Due to the highly unpredictable nature of mobile nodes, it is a challenge to model path duration. This paper proposes an analytical model for estimating the path duration in a MANETs and city section mobility model, the accuracy of the proposed model is validated by comparing the results obtained from the analytical model with the experimental results available in the literature and with the results of simulations carried out in NS-2.28.

Keywords
MANETs, performance, city section mobility model.

1. INTRODUCTION
A Mobile Ad hoc Network (MANETs) is a group of wireless mobile computers in which nodes cooperate by forwarding packets to each other to allow them to communicate beyond direct wireless transmission range. An application such as military exercises, disaster relief, and mine site operation may Benet from ad hoc networking, but secure and reliable communication is a necessary pre-requisite for such applications.

Mobile ad hoc networks have numerous real world applications including emergency search and rescue, defense, and surveillance to mention a few [1]. Although fixed or static ad hoc networks (for example, metro Wi-Fi mesh network) have gained momentum in the business community, there are numerous challenges that need to be addressed by the research community, before the deployment of MANETs becomes practical. One such challenge is the design and development of routing techniques that can adapt to the highly unpredictable topological changes that occur due to mobility of nodes in a MANETs [2]. Whenever a route becomes invalid, a mobile node has to find a new route to the destination. This affects the ongoing communication and increases the overhead (for eg, control traffic) created by the routing protocol [3], [4]. Accurate prediction of path duration (for which a typical route will be valid) will increase the performance of a routing protocol. Having the knowledge of link residual life and path duration in the network helps in the assignment of an optimum value to the route's expiry time parameter, the duration for which a route should be active at the routing table, in a routing protocol [5].

The prediction of path duration for a selected path is not easy, as it depends on several parameters such as the position and number of relay nodes, their velocity, direction of movement etc. Such a prediction would be easy for GPS (Global Positioning System) installed networks, but very few MANETs use GPS [6], [7]. The most popular routing protocols (designed for ad hoc networks) such as the Dynamic Source Routing (DSR) and the Ad hoc On-demand Distance Vector (AODV) routing protocol; it will not select a path based on its expected lifetime. DSR selects a path which has the minimum hop count to reach the destination and AODV selects the first available route [8]. The knowledge of the expected path duration, if incorporated, will significantly enhance the performance of the routing protocols as well as the throughput of the MANETs.

It demonstrates its feasibility under a few reasonable assumptions [9]. It makes use of the fact that most routing protocols developed for MANETs are based on the principle of Least Remaining Distance (LRD). The LRD forwarding technique is similar to the shortest path forwarding, where a route to a destination is selected based on the principle of least number of hops

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2. RELATED WORK
The proposed model is validated by comparing the theoretical results obtained from this model with the experimental results obtained based on RWP mobility model. In the following subsections, average path duration is computed by varying the each parameter that path duration depends on. The set of independent parameters that determine path duration include transmission range, maximum velocity, number of hops and node density. Validation of the proposed model is achieved by using the same values for input parameters [10], a method of estimating the distance and the relative speed of mobile nodes is the use of GPS receivers. But generally, using GPS is infeasible under many conditions. E.g. unavailable in is indoor environments and it is not suitable for small devices due to its high power consumption [11]. In [12], Unlike the MANET environment is resource-constrained, i.e., the mobile nodes have the limited- bandwidth and constrained power. Thus, it seems that providing guaranteed moreover, mobility is also expected to affect the service quality significantly. For example, the frequent topology changes caused by node movement in high mobility scenarios may result in the disruption of established routes, leading to packet losses and

substantial degradation of service quality. In [13], the status of a path between every source - destination pair in the network is monitored. The path duration is counted as the interval between the time when the path is set up and the time when the path is broken. However, there can be potentially exponential paths between any specific source destination pair. Analyzing the duration of all these paths might not be feasible. As a reasonable approximation, we define the path duration as the duration of the shortest path. In [14], a common weakness of the two pure measurements-based criteria or link reliability is that they cannot reflect possible changes in link status happening in the future. That is, the reliability of a link measured as 'better' based on past and/or current information on link status may become worse with time than that of those currently measured as' worse' due to the dynamic nature of mobile environments. This possible misjudgment to link reliability would affect the network performance especially in a high mobility environment. In [15], Mobility models have focused on a single node moving relative to a fixed base station or network of base stations. To our knowledge, however, no work which addresses the two-body mobility problem encountered in ad-hoc networks has been published.

3. NETWORK MODEL

A wireless MANETs can be viewed as a static network at a particular instant of time, in which, the topology changes can be predicted from that instant to the next instant based on the assumed mobility model. Consistent with the literature, let us use the LRD forwarding process as an approximation to shortest path based forwarding. Since there could be between the source and the destination, analyzing the duration of all these paths is not feasible. Given that many paths the behavior of "on demand" routing protocols is closely associated with the shortest path, the analysis of average path duration based on shortest path principle is appropriate and meaningful.

3.1 Least Remaining Distance

The LRD forwarding technique is similar to the shortest path forwarding, where a route to a destination is selected based on the principle of least number of hops. In LRD forwarding, among all the available forwarding (or relay) nodes, the node which has the minimum distance to the destination is selected as relay node. The behavior of LRD forwarding technique as same as shortest path because shortest path attempts to reach the destination with the least number of hops, which is possible only when the node with minimum remaining distance to destination is selected as a relay node.

4. PROPOSED SYSTEM

An analytical model is estimated for the path duration in a MANET. This paper demonstrates its feasibility under a few reasonable assumptions. In this process, we make use of the fact that most routing protocols developed for MANETs are based on the principle of Least Remaining Distance (LRD). The LRD forwarding technique is similar to the shortest path forwarding, where a route to a destination is selected based on the principle of least number of hops and city section mobility model that contribute to the average path duration. Inclusion of city section mobility models makes the random nature of node movement partially predictable, which in turn, will contribute to the prediction of average path duration. The complexity in computing the average path duration could also be reduced so that it will be useful frame works with resource constraints

4.1 Lrd and Shortest Path

In LRD forwarding, among all the available forwarding (or relay) nodes, the node which has the minimum distance to the destination is selected as relay node. High is possible only when the node with minimum remaining distance to destination is selected as a relay node. This observation is true when suboptimal methods (such as greedy methods) for shortest path selection are used. It may not be true in certain cases for example, when the node density is low and shortest path based on global optimization is used.

4.2 Link Residual Life

Link residual life is define as the time during which a link will be active once it becomes a part of a path. A link between two mobile nodes will be active as long as they are in the transmission range of each other. Link residual life (t) can be expressed as the ratio

$$t = d/Vr \qquad (1)$$

Where, $d = r - z$, which is the straight line distance that the neighbor (relay) node needs to travel to get out of the transmission range of its neighbor and Vr is the relative velocity between the two neighbors. In order to findout the distribution of link residual life, the distributions of D and Vr need to be known.

4.3 Link Distance

Let us start with the link distance, which is dependent on the underlying routing protocol used in the MANET. Since most "on demand" routing protocols such as DSR and AODV are based on the principle of shortest path, link distances can be analyzed based on the same principle. The shortest path is achieved in a LRD forwarding method by the selection of a relay node with least distance to the destination. According to the LRD principle, the source node selects a node located at a distance x from the destination if it cannot find any other node within a_{int} (x) and there is at least one node within the stripe a_{arc}(x, x), then the corresponding probability of random variable X is given by

$$P\,(x \le x \le x + \Delta x) = \Pr \times \mathrm{pr}$$
$$= e^{-\lambda a_{int}(x)}\,(1 - e^{-\lambda a_{arc}(x,\Delta x)}), l - r \le x \le l \quad \text{-------} \quad (2)$$

In the equation 2 Pr represents no nodes in a_{int} (x) and second Pr represents at least one node in a_{arc}(x, Δx). Note that a_{int} (x) and a_{arc}(x,Δx) represent segments or areas in which the source nodes looks for a relay node. The division a_{int}(Δx) into two (A1andA2) segments makes it easier to compute its area. It is assumed that the source node gets to know the distances, in terms of hops, of the relay nodes using the standard routing protocols

4.4 Relative Velocity

In order to find the PDF corresponding to the relative velocity, the source node S is assumed to be fixed and the relative movement of the relay node with respect to S is considered. Relative velocity between the source and relay nodes

$$v_r = \sqrt{v_1^2 + v_2^2 - 2v_1v_2\cos\alpha}\sqrt{V1} \qquad (3)$$

Where, α is the angle between the velocity vectors v1, v2.Assuming that all nodes move with an average (constant).

4.5 Path Duration

Path duration (t_{path}) is derived from the PDF of the link residual life. If the number of hops needed to reach the destination is h, then tpath can be written as,

$$t_{path} = \min(t1, t2, t3....th). \quad (4)$$

4.6 City Section Model

The city section mobility model puts constraints on the movement of a node on a city street grid, constructed of horizontal and vertical streets. Each street on the grid is assigned a speed limit. A MNs (mobile nodes) moves along the streets according to the speed limit set in that street. Initially, each MN is randomly placed on an intersection. A MNs then moves to another randomly chosen intersection with at most one vertical and one horizontal motion. This movement is also the shortest path between the two street intersections. Each MN continues to move to randomly chosen street intersections until the simulation time is reached.

For the random waypoint, random direction and gauss-markov mobility models, the nodes are initially uniform-randomly distributed in the network. For the city section and manhattan mobility models, assume the network is divided into grids: square blocks of length (side) 100m. The network is thus basically composed of a number of horizontal and vertical streets. Each street has two lanes: one for each direction (north and south direction for vertical streets, east and west direction for horizontal streets). A node is allowed to move only along the grid lines representing the horizontal and vertical streets. Initially, assume that the nodes are placed uniformly-randomly along the grid lines. The random waypoint mobility model yields the longest lifetime with respect to single-path routing. In the random waypoint model, a mobile node selects a random position (x, y) in the simulation area as a destination point and a velocity (v) from a uniformly distributed range [speedmin, speedmax]. Then node starts to travel to the chosen destination point with the constant selected speed, v. When the node arrives the destination point, it pauses for a specific time (pause time) defined as a simulation parameter. After this time, the node selects a new destination and the speed and repeats the process. The random waypoint mobility model is placed into the intersection of entity and statistical models in our classification. Studies on the properties of the random waypoint model show that it creates a non-homogenous spatial distribution of nodes.

It uses a simulation area that represents a street network of a city. A node is not allowed to choose any point on the graph. It selects a point that is on some street network of the city. After selecting the destination point, the travel path is determined by an algorithm, which calculates the shortest travel time between the source and destination points. After reaching to the destination point, the node waits there for a defined pause time and randomly chooses another destination on the street network and repeats the process. In addition to this behavior, in the city section mobility model, a mobile node should obey some pre-defined driving characteristics, such as “speed limit” and “minimum distance allowed between any two nodes”. These rules and the use of pre-defined paths (street network) make the movement behavior of the mobile node similar to a vehicle moving in a city central. The city section mobility model into the intersection of constrained topology based and entity models in our classification.

In the city section mobility model, the simulation area is a street network that represents a section of a city where the ad hoc network exists. The streets and speed limits on the streets are based on the type of city being simulated. For example, the streets may form a grid in the downtown area of the city with a high-speed highway near the border of the simulation area to represent a loop around the city. Each MNs begins the simulation at a define point on some street. The MNs then randomly chooses a destination, also represented by a point on some street. The movement algorithm from the current destination to the new destination locates a path corresponding to the shortest travel time between the two points; in addition, a safe driving characteristic such as a speed limit and a minimum distance allowed between any two MNs exists. By calculating reaching the time of the destination, the MNs pauses for a specific time and then randomly chooses another destination (i.e., a point on some street) and repeats the process.

In addition, people typically tend to travel in similar patterns when driving across town or walking across campus. Enforcing that all MNs follow pre define paths will increase the average hop count in the simulations compared to other mobility models. Improvements to the city section mobility model are the following: include pause times at certain intersections and destinations, incorporate acceleration and deceleration, and account for higher/lower concentrations of MNs depending on the time of day. In addition, the model should be expanded to include a larger simulation area, an increased number of streets, a high-speed road along the border of the simulated area, and other novel path-finding algorithms.

5. RESULTS AND DISCUSSION

5.1 The City Section Mobility Model

The movements of MNs using a city section in the city section mobility model. Within this example, the center-most vertical and horizontal streets are designated as mid-speed roads (i.e., x = 3and y = 3), similar to main thoroughfares within a city; all other roads are considered to be slow residential roads. A MNs starts the simulation at (1, 1), moves to (5, 4) and then moves to (1, 4).

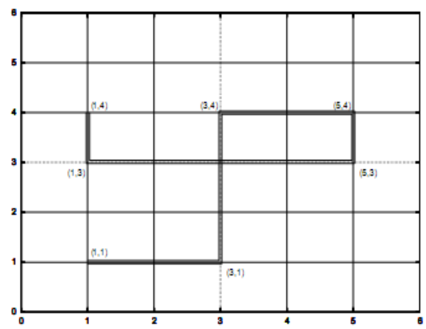

Fig. 1 Traveling pattern of an MN using the city section mobility model

The dashed lines in Figure 1 indicate the mid-speed roads and the double lines represent streets traveled by the MNs in our example. As shown, both moves from (1, 1) to (5, 4) and from (5, 4) to (1, 4) use mid-speed roads. The City Section Mobility Model provides realistic movements for a section of a city since it severely restricts the traveling behavior of MNs. In other words, all MNs must follow pre-defined paths and behavior guidelines (e.g. traffic laws). In the real world, MNs do not have the ability to roam freely without regard to obstacles and traffic regulations.

5.2 Average Path Duration versus Transmission Range

The average path duration increases linearly with increase in transmission range. If the transmission range is high, the probability of a relay node's location being well within the circle of transmission range is higher. Hence, the distance that the relay node needs to travel for the link to break is higher. This gives greater room for mobility of the relay node, thereby resulting in higher path duration.

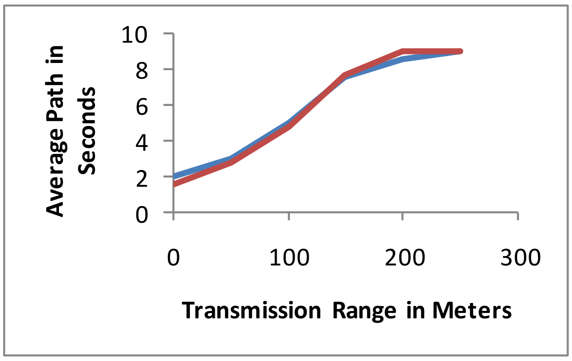

Fig. 2 Average path duration versus transmission range

The blue line represents the experimental results and red line represents the analytical results. Parameters: velocity = 30 m/s, number of nodes = 20, number of hops = 2, and area = 800 m × 800 m.

5.3 Average Path Duration versus Average Node Velocity

The average velocity and average path duration are determined. The plots show that the average path duration can be approximated to the exponential distribution.

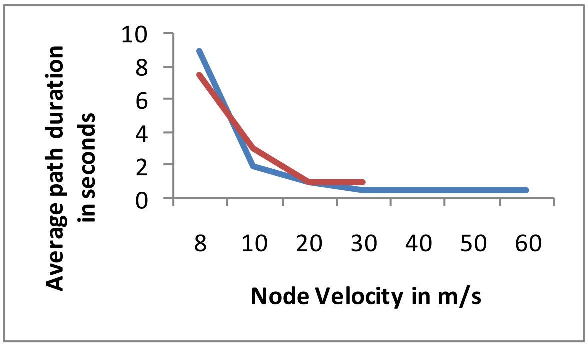

Fig. 3 Average path duration versus average node velocity

The blue line represents the experimental results and red line represents the analytical results. Parameters: transmission

5.4 Average Path Duration versus Number of Hops

range = 250 m, number of nodes = 20, number of hops = 2, and area = 800 m ×800 m.

The duration is much longer for one hop link, and there is a steep fall in the path duration when the hops increase from 1 to 2. The one hop path duration is nothing but link residual life, where the link distance could vary anywhere between 0 to R (transmission distance).

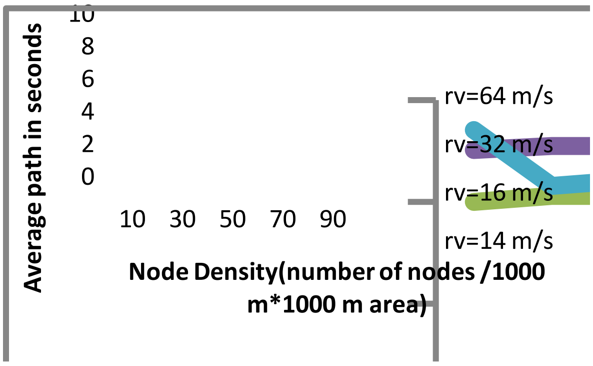

Fig. 4 Average path Duration versus number of hops

The all solid line represents the experimental results and blue line represents the analytical results. Parameters: transmission range = 250 m, number of nodes = 20, number of hops =2, and area = 800 m × 800 m.

5.5 Average Path Duration versus Node Density

Plots show the difference between node density and average path duration for different relative velocities between the nodes. An increase in node density is potentially beneficial and one would expect an increase in path duration with an increase in the number of nodes. It can be observed from the plots corresponding to high relative velocities, increasing node density results in increased path duration. This is applicable when the relative velocity between the nodes is high.

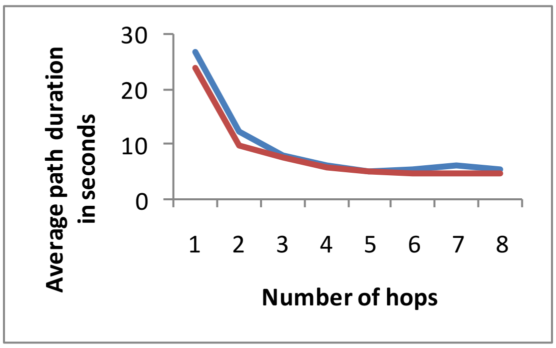

Fig. 5 Average path duration versus node density

Parameters: velocity = 30 m/s, number of hops = 2, transmission range = 250 m, and area = 800 m × 800 m. Theoretical results with varying relative velocities (rv) are shown in blue lines and the simulated results are shown in red lines.

6. CONCLUSION

Here demonstrate clearly the average path duration in a MANETs that predictable for the shortest path. The Path duration of the MANETs employing LRD forwarding. Although there are other routing strategies for Manet's path selection, this technique is widely used. All the on-demand routing protocols employ this procedure for path selection .Estimation of path duration is quite useful when routing decisions made by the given routing protocols.

7. REFERENCES

[1] Kamesh Namuduri "Analytical Estimation of Path Duration in Mobile Ad Hoc Networks" Ravi Pendse, Senior Member, IEEE SENSORS JOURNAL, VOL. 12, NO. 6, JUNE 2012.Ding, W. and Marchionini, G. 1997 A Study on Video Browsing Strategies. Technical Report. University of Maryland at College Park.

[2] K. N. Sridhar and M. C. Chan, "Stability and hop-count based approach for route computation in MANET," in Proc. Comput. Commun. Netw. 14th Int. Conf., Oct. 2005, pp. 25–31Tavel, P. 2007 Modeling and Simulation Design. AK Peters Ltd.

[3] Y. Han, R. J. La, and A. M. Makowski, "Distribution of path durations in mobile ad-hoc networks-Palm's theorem at work," in Proc. ITC Special. Seminar Perform. Eval. Wireless Mobile Syst., 2004, pp. 1–10.

[4] A. Ayyasamy and K. Venkatachalapathy, "Increased Throughput for Load based Channel Aware Routing in MANETs with Reusable Paths", International Journal of Computer Applications, Vol. 40 (2), pp. 20-23, February 2012.

[5] N. Sadagopan, F. Bai, B. Krishnamachari, and A. Helmy, "Paths: Analysis of PATH duration statistics and their impact on reactive MANET routing protocols," in Proc.MobiHoc Proc. 4th ACM Int. Symp. Mobile Ad Hoc Netw. Comput., 2003, pp. 1–12..

[6] S. Jiang, D. He, and J. Rao, prediction-based link availability estimation for mobile ad hoc networks," in Proc. IEEE/ACM 20th Ann. Joint Conf. Computer Commun. Soc. Trans. Netw., Anchorage, AK, 2001, pp 1745 – 1752.

[7] X. Hong, M. Gerla, G. Pei, and C.-C. Chiang, "A group mobility model for ad hoc wireless networks," in Proc. 2nd ACM Int. WorkshopModeling Anal. Simul. Wireless Mobile Syst., 1999, pp. 53–60.

[8] N. Meghanathan, "On the Time between Successive Multi-Path Discoveries and Hop Count per Multi-Path for Zone-Disjoint Routing in Mobile Ad hoc Networks," The Second International Conference on Wireless and Mobile Networks (WiMo 2010), Ankara, Turkey, *Communications Computer and Information Science Series*, CCIS 84, pp. 254-265, June 2010.

[9] Waharte, S., Boutaba, R.: Totally Disjoint Multipath Routing in Multihop Wireless Networks. In: International Conference on Communications (ICC), vol. 12, pp. 5576–5581. IEEE, Istanbul (2006)

[10] S-J. Lee, W. Su, J. Hsu, M. Gerla and R. Bagrodia, "A Performance Comparison Study of Ad hoc Wireless Multicast Protocols," *Proceedings of the IEEE International Conference on Computers and Communications*, pp. 565 – 574, March 2000.

[11] Pearlman, M.R., Haas, Z.J., Sholander, P., Tabrizi, S.S.: On the Impact of Alternate Path Routing for Load Balancing in Mobile Ad hoc Networks. In: 1st Annual Workshop on Mobile Ad hoc Networking and Computing (MobiHoc), pp. 3–10. ACM, Boston (2000)

[12] Jun Zheng, David Simplot-Ryl, Shiwen Mao, Baoxian Zhang, "Advances in Ad Hoc Networks," *Ad Hoc Networks*, vol. 10, pp 61-66, 2012.

[13] S. Jain and S. R. Das, "Exploiting Path Diversity in the Link Layer in Wireless Ad Hoc Networks," *Proc. Sixth IEEE Int'l Symp. World of Wireless Mobile and Multimedia Networks*, 2005, pp. 22-30

[14] M. Souryal, B. Vojcic, R. Pickholtz, "Ad hoc multi hop CDMA networks with route diversity in a Rayleigh fading channel," *Communications for network-centric operations: Creating the information force. IEEE.* Vol. 2, 2001, pp. 1507 - 1511.

[15] M. Zorzi and R.R. Rao, "Geographic random forwarding (GeRaF) for ad hoc and sensor networks: multihop performance," *IEEE Trans. on Mobile Computing*. 2003, pp. 349–364

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