Only the Short Die Old: Route Optimization in MANETs by Dynamic Subconnection Shrinking

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ABSTRACT

In reactive routing protocols, active routes for multihop connections retain their topological structure in spite of node movement over time. Unfortunately, node movements may make the connection route sub-optimal in terms of hop length, thereby resulting in unnecessarily high end-to-end delays, energy consumption and channel contention. In AODV, for example, a connection route is recomputed only if one of its constituent links suffers catastrophic failure, at which point global route discovery attempts repair, and after which the topological structure of the connection again returns to near-optimality.

In this paper, we propose an extension to AODV that performs periodic subconnection shrinking of the topological substructure within each connection. We show that this not only reduces the average end-to-end connection length, but also increases the mean time between catastrophic link failures of the connection's constituent links, thereby reducing the number of repair-related global route discoveries experienced. The control traffic needed to operate our scheme can be amortized against the reduction in repair-related global route discovery traffic. Through ns2 simulations, we show that our dynamic subconnection shrinking scheme manifests connections that, on average, have (i) shorter hop length, (ii) higher packet delivery fraction; moreover, this extension operates using less control traffic than standard AODV. We demonstrate that these conclusions continue to hold scalably over a wide range of operating regimes.

Categories and Subject Descriptors

C.2.2 [**Computer-Communication Networks**]: -Networks Protocols–*Routing Protocols*

General Terms

Algorithms, Design, Performance

Keywords

MANET, Ad hoc, mobility, route optimization

1. INTRODUCTION

Routing issues have been well-studied for wireless networking during the last two decades. Many routing protocols have been proposed in accordance with different network structures, mobility scenarios and types of applications. While developing a routing algorithm for MANETs, one of the most challenging factors which developers must consider is the behavior of the proposed algorithm in the presence of node movement, since mobility can yield in dynamic changes to network topology.

Connection *suboptimality* arises in reactive routing protocols because the topological structure of connection routes between source-destination pairs is determined at the very outset, during the connection establishment phase. At the very beginning of a connection, the number of hops that the route takes tends to be close to the number of hops on the min-hop path (e.g. one that would be calculated by an omniscient instance of Dijkstra's algorithm). As time passes, nodes move, but as long as no link breaks, the connection retains its topological structure, and so in time can become significantly longer (in terms of hops) when compared to the length of the min-hop path between source and destination at that instant of time. An example in which route suboptimality occurs (over time) is depicted in Figure 1. In this

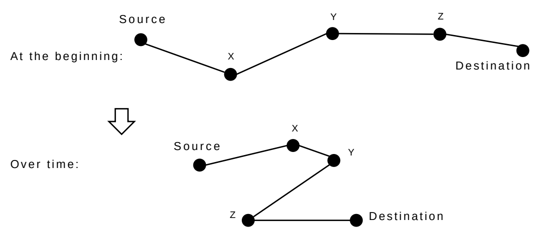

Figure 1: Formation of a non-optimal route

paper, we propose a route optimization scheme which eliminates the unnecessary hops in an active route "on the fly" while the connection is active. As we shall see, the scheme amortizes the additional control traffic for this optimization against the *data traffic on the connection itself.* Thus, connections with low traffic are less frequently optimized than connections than those that carry high traffic volumes. The than the less frequent version of it (e.g. Shrink-32). The increase in PDF is mostly because of the decrease in contention due to both shorter routes and lower control traffic overhead (as shown in the following subsection).

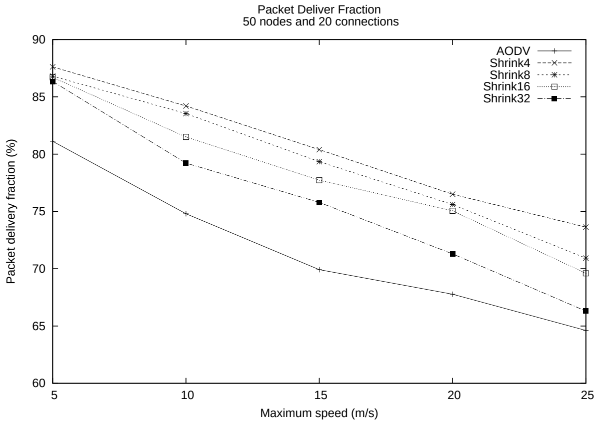

Figure 5: Packet delivery fraction for the 50-node with 20 traffic connections

Normalized Routing Load (NRL): Figure 6 indicates normalized routing load of both pure *AODV* and *AODV* + *Shrinking* mechanisms at different mobility levels. The first observation inferred from the figure is that although the proposed mechanism incurs additional control traffic over *AODV*, the NRL of *AODV* + *Shrinking* is lower than pure *AODV*'s NRL in almost all cases regardless of the shrinking period α. This is because of the fact that experiencing a link failure on shorter routes is less likely that it is on longer routes. Since the proposed scheme reduces the path length, it results in longer connection lifetime and fewer route discovery attempts–the latter being expensive in terms of control traffic incurred. Another exciting conclusion deduced from the figure is that there is an optimal frequency for Multihop Shrinking, as indicated by the observation that the lines cross each other at different mobility levels. For example, Shrink-32 has the lowest NRL for 5m/s maximum velocity, while Shrink-4 has the lowest NRL in the case of 25m/s maximum velocity.

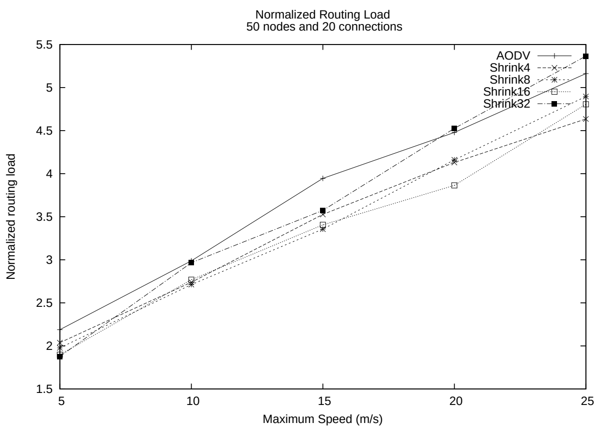

Figure 6: Routing load per delivered packet for the 50-node with 20 traffic connections

7. CONCLUSION

In this paper, we described a scheme called **Multihop Shrink** as an extension to AODV. The scheme seeks to counteract the inefficiencies in connection topology that arise due to node mobility. In contrast with AODV, however, our scheme works proactively; it does not wait for catastrophic link failure to occur, nor does it rely on global route recovery to serendipitously rectify connection topology inefficiencies. Instead, the proposed Multihop Shrink scheme performs periodic shrinking of the topological substructure within each connection.

Through extensive ns2 simulations, we showed that the proposed scheme reduces the average end-to-end connection length (compared to AODV). The proposed scheme reduces the number of repair-related global route discoveries triggered by a long lived connection. Indeed, the simulations indicate that the control traffic needed to operate our Multihop Shrink scheme can be amortized against the corresponding reduction in repair-related global route discovery traffic. Thus, the Multihop Shrink modification to AODV achieves intended objectives (i.e. NPL and PDF) with lower control traffic compared to even standard AODV in most settings. We demonstrated that our conclusions continue to hold scalably over a wide range of mobility scenarios.

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8. REFERENCES

[1] V. C. Giruka, M. Singhal, and S. P. Yarravarapu. A path compression technique for on-demand ad-hoc routing protocols. In *In Mobile Ad-hoc and Sensor Systems (MASS) 2004*, 2004.

[2] C. Gui and P. Mohapatra. Short: self-healing and optimizing routing techniques for mobile ad hoc networks. In *MobiHoc '03: Proceedings of the 4th ACM international symposium on Mobile ad hoc networking & computing*, pages 279–290, New York, NY, USA, 2003. ACM.

[3] X. Jia, L. Qian-mu, Z. Hong, and L. Feng-yu. Model and analysis of path compression for mobile ad hoc networks. *Computers and Electrical Engineering*, In Press, Corrected Proof:–, 2009.

[4] S. Wu, S. Ni, Y. Tseng, and J. Sheu. Route Maintenance in a Wireless Mobile Ad Hoc Network. In 33rd Hawaii International Conference on System Sciences, Maui, 2000.

[5] Y.-S. Yen, H.-C. Chang, R.-S. Chang, and H.-C. Chao. Routing with adaptive path and limited flooding for mobile ad hoc networks. *Computers and Electrical Engineering*, 36(2):280 – 290, 2010. Wireless ad hoc, Sensor and Mesh Networks.

[6] M. G. Zapata. Shortcut detection and route repair in ad hoc networks. *Pervasive Computing and Communications Workshops, IEEE International Conference on*, 0:237–242, 2005.