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A Dynamic Route Optimization Mechanism for AODV in MANETs

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***Abstract*—In reactive routing protocols, active routes for connections retain their topological structure even when node movements over time make the route sub-optimal (in terms of path length). In AODV, for example, a connection route is recomputed only when one of its constituent links suffers catastrophic failure–at which point repair is initiated, often requiring global route discovery and introducing significant control traffic overhead. In this paper, we propose extensions to AODV which perform continuous route optimization. The objective of our proposed extension is to ensure connection path lengths are topologically efficient in spite of node mobility. Our experiments indicate that in many typical operational regimes, this objective is achieved successfully by our proposed scheme. The proposed mechanism has been implemented and tested in ns2 as an extension to AODV.**

I. Introduction

Issues of *routing* in wireless networking have been well-studied in 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 peculiarities which developers must consider is the behavior of the proposed algorithm in the presence of node movement. Mobility has a potential to result in dynamic changes to network topology, making the task of routing algorithms more difficult. Two major challenges introduced by mobility, are the occurrence of *disconnection* and *suboptimality* in connection routes. More precisely, if the network topology is dynamically changing due to node movement, at least one of the following two events eventually occurs: (i) the connection breaks because one of its constituent links becomes disconnected, or (ii) the route becomes sub-optimal in terms of path length (i.e. number of hops) due to changes in the network topology. Reactive routing protocols generally take care of the former event by initiating local recovery or restarting the route discovery process. The latter event is not often considered, and accordingly is the focus of this paper. An example in which route suboptimalty occurs (over time) is depicted in Figure 1.

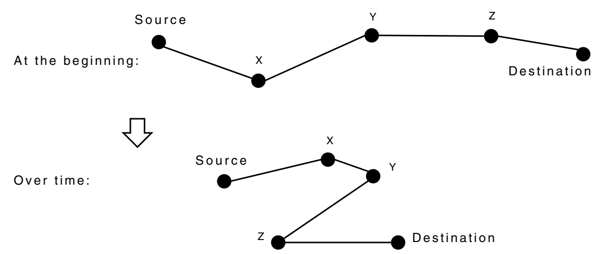

Fig. 1. Formation of a non-optimal route

In reactive routing protocols, connection routes between source-destination pairs are constructed on-demand at the very outset, when their necessity becomes known due to a request by the source node. At the very beginning of a connection, the number of hops that the route takes tends to be very close to the number of hops on a min-hop path (e.g. one that would be calculated by Dijkstra's algorithm). As time passes, nodes move, yet as long as no link breaks, the connection retains its topological structure, and in doing so may become require significantly more hops than the instantaneous min-hop path between source and destination.

In this paper, we propose a dynamic route optimization mechanism which eliminates the unnecessary hops in an active route "on the fly". The mechanism amortizes the additional control traffic for this optimization against the data traffic on the connection itself. Thus, connections with low traffic are less optimized than connections that exhibit high traffic volumes. The proposed scheme attempts to maintain near-optimality for connections throughout their lifetime. We give a concrete instantiation of the mechanism in the context of AODV, though the proposed method can be readily adapted to other reactive routing protocols.

II. Related Work

One of the earliest studies in this field is the work of Wu et al. [1] which considers several route optimization schemes for the routing protocols DSR, SSA, AODV, and ZRP. The authors exploit the promiscuous receive mode of wireless devices to collect fresh routing information. This strategy is criticized because the use of promiscuous mode may consume excessive power and thereby degrade the performance of the wireless cards. This study aims to optimize active routes, and requires some modifications to packet headers and routing tables of the original routing protocols.

In another study Park and Voorst [2] present an algorithm, called "Anticipated route maintenance" which predicts whether a link between two nodes will be broken within a predefined time interval, using their locations and velocities as determined

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than it is in pure AODV. This is a sign of the fact that shrinking operation makes routes more consistent against node movements. It can also be explained by the fact that the probability of experiencing disconnection on shorter paths is smaller than it is on longer paths. Another interpretation of the figures is that more frequent shrinking operation increases connection lifetime more (notice that Shrink4 performs shrinking operation four times frequent than Shrink32). As mobility level decreases, the average route lifetime in each version converges to each other.

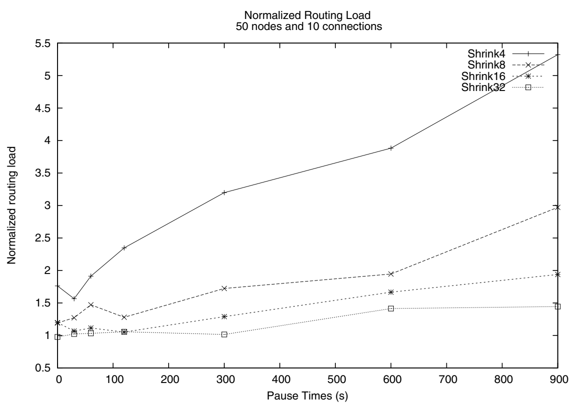

Fig. 7. Routing load normalized by pure AODV for the 50-node with 10 traffic connections

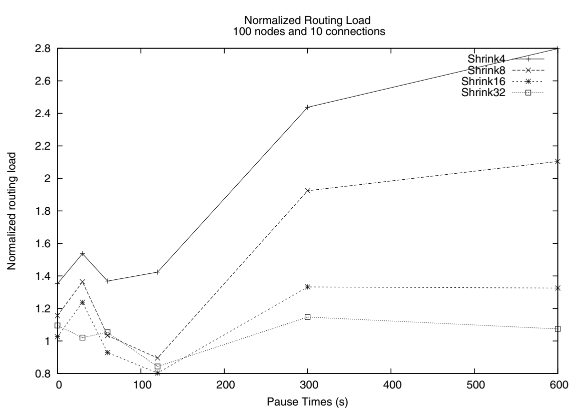

Fig. 8. Routing load normalized by pure AODV for the 100-node with 10 traffic connections

Normalized Routing Load: In this set of experiments, we examined the traffic load incurred by the proposed mechanism. Figure 7 and 8 indicate normalized routing load of Shrinking mechanisms at different mobility levels with respect to plain AODV. For example, in Figure 7, NRLs of Shrink-16 and Shrink-32, when pause time is 300 seconds, are about 1.25 and 1 respectively, which means the corresponding schemes increases NRL 25% and 0%. It is an expected result that more frequent shrinking operation produces more control traffic as seen in the corresponding figures. On the other hand, according to the figures, normalized routing load at high mobility is lower than it is at low mobility. This is because of the fact that when there is no mobility, all control traffic caused by the shrinking operation are wasted. Another observation from the figures is that the normalized routing load in 100-node experiments is lower than it is in 50-node experiment. This is because of the fact that the shrinking operation reduces the number of route discovery attempts (which is an expensive operation in terms of control traffic overhead especially in large networks) performed in the network by causing increase in connection lifetime, and thus decreases the amount of control traffic produced. As a final observation, the shrinking operation sometimes reduces the NRL below 1 at high mobility, which means it may even beat pure AODV in terms of NRL.

VII. Conclusion and Future Work

We propose and evaluate an extension to AODV which makes use of continuous route optimization through a *shrinking* process. We show that the proposed extension performs well with respect to routing overhead incurred, while serving to minimize path stretch relative to optimality. The experimental results show that the proposed route optimization mechanism works well.

As a future work, we are planning to improve the proposed scheme in terms of both control traffic incurred and resulting gain in path optimality. Indeed, the proposed scheme detects the shortcuts, if any, only between the nodes which are located 2-hop away to each other. Therefore, as a next step, we would like to develop a route optimization scheme which is able to detect shortcuts between any pair of nodes on a connection. Finally, such a route optimization scheme can lead researchers to develop efficient local recovery protocols without worrying about the path optimality, which has been addressed as a problem in local recovery operations.

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