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Adaptive backup routing for ad-hoc networks

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Abstract

The network topology changes frequently in ad-hoc networks. Some on-demand protocols with multi-paths or backup routes have been proposed to improve the performance in ad-hoc networks. AODV-BR scheme improves AODV routing protocols by constructing a mesh structure and providing multiple alternate routes. The algorithm establishes the mesh and multi-path using the RREP of AODV, which does not transmit many control messages. In this paper, we propose two schemes: AODV-ABR and AODV-ABL to increase the adaptation of routing protocols to topology changes by modifying AODV-BR. In AODV-ABR, the alternative route can be created by overhearing not only RREP packets but also data packets. AODV-ABL combines the benefits of AODV-ABR and Local repair. Finally, we evaluate the performance improvement by simulations.

Keywords: Ad-hoc wireless networks; Routing Algorithm; AODV; Backup route

1. Introduction

In recent years, the progress of communication technology has made wireless device smaller, less expensive and more powerful. Such rapid technology advance has promoted great growth in mobile devices connected to the Internet. There are two variations of wireless networks: infrastructure networks (as shown in Fig. 1) and ad-hoc networks (as shown in Fig. 2). In infrastructure wireless network, there exists a base station (BS) or an access point (AP) to be the portal of wireless devices. Ad-hoc network [3,5,15] is a self-organized, dynamically changing multi-hop network. All mobile nodes in an ad-hoc network are capable of communicating with each other without the aid of any established infrastructure or centralized controller. Each mobile station has a function for routing messages.

The routing protocols supported in infrastructure wireless networks are suitable for one-hop wireless transmission. Many of them cannot be applied directly to the communication in ad-hoc networks because of the characteristics of wireless communication, such as the mobility of wireless nodes. The mobility of wireless nodes will cause the change of network topology. In [25,26], the authors introduced new mechanisms to adapt to the topology variation. The routing algorithm has to react to the topology changes as soon as possible. So, the communication path can remains connected. Many routing protocols have been proposed for ad-hoc networks [2,4,16,17,19,21]. These routing protocols can be divided roughly into two types, table-driven and on-demand routing protocol [19]. Table-driven routing protocols, such as Destination-Sequenced Distance-Vector routing (DSDV) [17], attempt to keep a global picture of network topology and respond to topological changes by propagating update messages throughout the wireless network. One or more tables are required to maintain consistent, up-to-date routing information for each node in the wireless network. In a highly mobility network environment, to maintain the routing information fresh causes heavy overheads.

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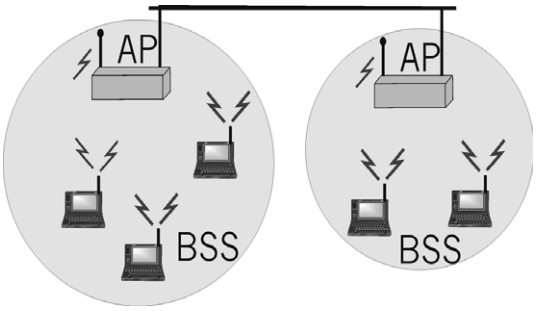

Fig. 1. Infrastructure network.

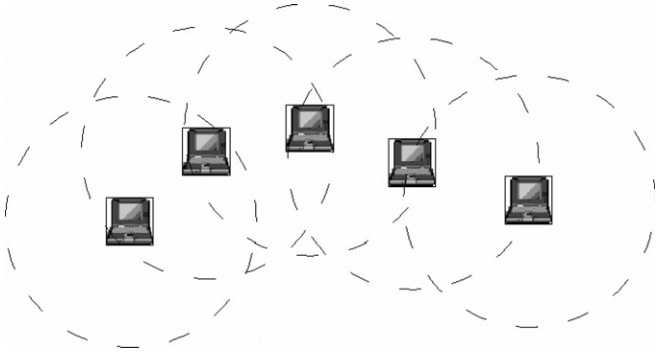

Fig. 2. An ad-hoc network.

Recently, the on-demand routing protocols for ad-hoc network are appealing because of their low routing overheads and effectiveness when the frequency of route re-establishment and the demand of route queries are not high. The route is created only when it is desired by the source node in the on-demand routing protocols. Many on-demand routing protocols have been proposed in [4,14,16,21]. High routing overheads usually have significant impacts on performance in low-bandwidth wireless links. Therefore, the reactive on-demand routing algorithms where routing paths are established only when required are the recent trend in ad-hoc networks, such as the Ad-hoc On-Demand Distance-Vector (AODV) routing protocol.

In the AODV protocol, there is only a single path established during the transmission. Therefore, when the transmission path fails, data packets are simply dropped by nodes along the broken path. For a time sensitive traffic, it's not acceptable to drop too many packets in the period of path failure. For TCP connections, due to packets dropping, it may reduce the performance considerably. Many on-demand protocols with multi-paths or backup routes have been proposed in order to alleviate these problems [1,6–13,21–26]. Multi-path and backup routes could be formed by many different ways. New route discovery is needed only when all paths fail. This could reduce both route discovery latency and routing overheads. Multiple paths can also be used to balance loads by forwarding data packets on multiple paths at the same time [7]. In this paper, we propose two schemes: AODV-ABR (Adaptive Backup Route) which takes advantage of overhearing of RREP and data packets and AODV-ABL (Adaptive Backup Route and Local repair) which integrates the local repair scheme into AODV-ABR. Both schemes can increase the adaptation of routing protocols to topology changes.

The rest of this paper is organized as following. In Section 2, we review some related works. In Section 3, our schemes are proposed. Section 4 presents the simulation results. Finally, Section 5 summarizes key results and issues.

2. Related works

The Ad-hoc On-demand Distance-Vector (AODV) routing algorithm [14,16] is a routing protocol designed for ad-hoc mobile networks. AODV is capable of both unicast and multicast routing. It maintains these routes as long as they are needed by the source node. Operations of unicast routing on AODV can be simply divided into three parts: route request, route reply and route maintenance [14,16].

When the node mobility speed rises or the transmission path is long, the probability of link failures in active routes also rises. The source node may encounter another link failure before current failure fixed. Therefore, to improve the transmission performance, a local repair mechanism [1] has been added to AODV which tries to repair the link error without informing the source node and interrupting the data delivery. The upstream node of the broken link will initiate the local repair process. It broadcasts a RREQ for the destination. The process may cause the flooding of RREQ messages to the entire network. To limit the hop count of the repaired path, the TTL field of the RREQ message which is broadcasted by the upstream node of the broken link will be set to a limited number which is the last known distance to the destination plus a small value [1]. On the other hand, to prevent the forming a loop, the new sequence number, incremented by one, for the destination is also assigned to the RREQ. If the RREQ is delivered to the destination successfully, a substitute path is established. If the first attempt of route repair is unsuccessful, the upstream node of the broken link will send a RERR to the source node. After receiving the RERR, the source node will initiate a new route discovery process.

Based on AODV routing protocol, Sung-Ju Lee and Mario Gerla proposed a new scheme called AODV-BR (Backup Route) [8] which can improve the performance of the AODV routing protocols by constructing a mesh structure and providing multiple alternate routes. When establishing the mesh and looking for multi-path routes, the algorithm takes advantage of the RREPs (Route Replies) messages of AODV without generating additional control messages. In AODV-BR [8], the alternate routes are constructed by the RREP packet. Each neighboring node overhears the RREP packets and records the source