Performance Study of Proactive Flow Handoff for Mobile Ad Hoc Networks

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Abstract. A Mobile Ad hoc Network (MANET) is a collection of wireless mobile computers forming a temporary network without any existing wire line infrastructure. Searching for feasible paths, or routing, is very challenging in mobile ad hoc networks because of frequent topology changes caused by users’ mobility. Location information is required by some applications and can be used to facilitate routing implementation. In this paper, we propose a proactive flow handoff method based on nodes’ location information. In summary, location information is utilised to reduce the control overhead in route discovery phase, to search quickly for a feasible path upon link breakage, and to hand off a flow to a stable path if the active one breaks based on prediction. Keeping “always-on” end-to-end connectivity once a flow is established is the main advantage of this routing method. A thorough simulation study is performed to demonstrate the efficiency of this method.

Keywords: Mobile Ad Hoc Networks, routing, proactive flow handoff, performance

1. Introduction

Currently, great demands for self-organizing, fast deployable wireless Mobile Ad Hoc Networks (MANETs) come along with the advances in wireless portable technologies. Unlike the conventional cellular wireless mobile networks that rely on extensive infrastructure to support mobility, a MANET does not need expensive base stations or wired infrastructure. This feature is important in battlefields or disaster rescue sites where fixed base stations are undesirable or unavailable. For commercial applications such as convention centers, electronic classrooms, and conferences, a rapid deployment of all-on-air networks provides users with more flexible and cheaper ways to share information.

The absence of a fixed infrastructure, however, requires every mobile user to cooperate together for message transmission. Since radio transmission range is limited for each host, a source host must depend on several intermediate hosts to send its messages to a host far away. Finding a path from the source to the destination, or routing, is fundamental for providing other advanced services. Routing, however, is very challenging in MANETs due to frequent network topology changes and power and bandwidth constraints.

In this paper, we present a proactive flow handoff method for routing in MANETs. The main motivation behind this method is to keep connectivity once a path is established on demand of sending data traffic. In this method, the location information is used to reduce the control overhead in the route discovery phase, to search quickly for a feasible path upon link breakage, and to hand off a flow to a stable path if the active one breaks based on prediction. Compared with other on-demand protocols, such as Dynamic Source Routing (DSR) [5], Ad hoc On Demand Distance Vector (AODV) routing [9], and Location-Aided Routing (LAR) [7], simulation studies show that this method can keep a very high packet delivery ratio even in a high mobility environment with acceptable control overhead and end-to-end delay.

The rest of the paper is organised as follows. Related work is introduced in Section 2. In Section 3, we present a LOcation Trace Aided Routing (LOTAR) protocol. Section 4 describes link prediction models. Sections 5 and 6 present the simulation model and simulation results respectively. Finally, we conclude the paper in Section 7.

2. Related work

Several research studies [6,7,13,14] have been done to utilise mobile users’ location information to facilitate routing implementation and enhance routing performance. They fall roughly into two categories: the purely geographic forwarding method and the location auxiliary method. In the purely geographic forwarding method, a routing decision is made based solely on the mobile users’ geographic locations. In the location auxiliary method, routing protocols use the location
information as an auxiliary criterion to improve routing performance.

The purely geographic forwarding method can scale well to large networks [6,13] since no or little route state information is stored. A routing decision in a node is made with the information about the node's current location, its neighbours’ locations, and the destination’s location. In order to obtain the neighbours’ locations, each node announces its position and velocity information to its neighbours. Furthermore, it is supposed to know the locations of the intended message destinations via some mechanism such as location database query. A localised routing decision is made via heuristic searching rules. These rules include the closest direction principle and the closest distance principle [13]. In figure 1, according to the closest direction principle, node A chooses node B as its next node to destination D since B is the closest direction to D (α is the smallest positive angle). According to the closest distance principle, A chooses C as its next node to D since C has the closest distance to D. The routing decisions are made in this way step by step until the messages reach the destination.

Several problems must be handled in order to deploy the purely geographic forwarding protocols. First, a purely geographic forwarding protocol must be carefully designed to deal with the “geographic holes” when a feasible route may actually exist but the local next hop decision cannot be made based solely on the geographic forwarding rules [6,13]. Second, loop freedom is difficult to guarantee without memorising the forwarded data messages. In [13], Stojmenovic and Lin proved that any memory-less direction-based purely geographic forwarding protocol is not loop-free. They proved that distance-based geographic forwarding methods are loop-free except for some specific mobility patterns, which they argued were “unrealistic” cases. Third, location inaccuracy is unavoidable and may result in a high packet loss ratio caused by incorrect local routing decisions. Finally, the environment will affect radio propagation, and the physical locations might not reflect the real network topology. For example, two nodes may be close enough but cannot communicate with each other because of an obstacle (such as a high building) between them; two nodes may be far away but are within each other’s radio range because of favourable echoes, for example, two nodes in a long narrow street between steel-glass buildings. In this case, purely geographic routing decisions that do not take the environment into account are likely to be wrong.

In contrast, the location auxiliary protocols do not need to cope with these difficulties since the location information is used to improve routing performance under the prerequisite that feasible paths can be explicitly claimed to exist for data transmission. In other words, the feasible paths are confirmed by control messages before they are actually used. The Location Aid Routing (LAR) [7] protocol searches for routes in a way very similar to the Dynamic Source Routing (DSR) protocol except that it uses location information to limit the flooding range of route request messages during the route discovery phase. LAR can reduce control overhead since the route request messages do not need to be propagated to the whole network, and it is loop-free since it uses source routing to transmit data packets once a feasible path is found. The Flow Oriented Routing Protocol (FORP) [14] selects paths with the longest lifetime, which is predicted with information about the mobile nodes’ speeds and directions. When the predicted lifetime of an active path is lower than a given threshold time, an entire new path will be searched for, and the sender hands off its data stream to the new path.

It is necessary to mention that the assumption of location information available to routing protocols might be too strong in real systems. In the circumstance that obtaining and maintaining location information requires non-trivial system cost, all location-based (pure geographic forwarding and location auxiliary) routing protocols might not be overall efficient schemes. Nevertheless, location-based routing can be an efficient approach in the systems in which location management is a component in the application layer and location information is re-usable by the network layer, or location information can be obtained easily (such as city transit systems and tourist guide systems). For example, schemes that require periodic flooding of location information may benefit performance-wise by combining the routing with the location update.

3. Location trace aided routing protocol (LOTAR)

3.1. Introduction

Our proposed LOcation Trace Aided Routing (LOTAR) protocol is a type of location auxiliary method [16]. In order to utilise location information, every node must know its own location, its own mobile speed, and the global time. It also knows other nodes’ approximate positions and mobile speeds. In addition, we assume that the link lifetime can be roughly predicted in the mobility model. In this paper, we study two mobility models, namely the Random Drunken model and the Random Waypoint model, and present how to predict link lifetime in each model. For other well-behaved mobile environments where the mobility is predictable or controllable, link lifetime prediction may be easier and more accurate.