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Query Localization Techniques for On-Demand Routing Protocols in Ad Hoc Networks

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Abstract. Mobile ad hoc networks are characterized by multi-hop wireless links, absence of any cellular infrastructure, and frequent host mobility. Design of efficient routing protocols in such networks is a challenging issue. A class of routing protocols called *on-demand* protocols has recently found attention because of their low routing overhead. We propose a technique that can reduce the routing overhead even further. The on-demand protocols depend on query floods to discover routes whenever a new route is needed. Our technique utilizes prior routing histories to localize the query flood to a limited region of the network. Simulation results demonstrate excellent reduction of routing overheads with this mechanism. This also contributes to a reduced level of network congestion and better end-to-end delay performance of data packets.

Keywords: ad hoc networks, routing protocols, on-demand routing, flooding

1. Introduction

A mobile, *ad hoc* network is an autonomous system of mobile hosts connected by wireless links. There is no static infrastructure such as a base station. If two hosts are not within radio range, all message communication between them must pass through one or more intermediate hosts that double as routers. The hosts are free to move around randomly, thus changing the network topology dynamically. Thus, routing protocols must be adaptive and able to maintain routes in spite of the changing network connectivity. Such networks are very useful in military and other tactical applications such as emergency rescue or exploration missions, where cellular infrastructure is unavailable or unreliable. Commercial applications are also likely where there is a need for ubiquitous communication services without the presence or use of a fixed infrastructure. Examples include home-area wireless networking [17], on-the-fly conferencing applications, networking intelligent devices or sensors, communication between mobile robots, etc.

Design of efficient routing protocols is the central challenge in such dynamic wireless networks. Much work has been done in this area starting from the seventies, when the US Defense Research Agency, DARPA supported the PRNET (Packet radio Network) [13] and SURAN (Survivable Adaptive Networks) [21] projects. They supported automatic route set up and maintenance in a packet radio network with moderate mobility. Interest in such networks has recently grown due to the common availability of wireless communication devices that can connect laptops and palmtops and operate in license free radio frequency bands (such as the Industrial-Scientific-Military or ISM band in the US). In an interest to run internetworking protocols on ad hoc networks, a working group for Mobile, Ad hoc Networking (MANET) [16] has been formed within the Internet Engineering Task Force (IETF), whose charter includes developing a routing framework for running IP-based protocols in ad hoc networks. Several new routing protocols have been proposed in connection with the MANET working group efforts [16]. Of particular interest is the new class of *on-demand, source-initiated* protocols, that set up and maintain routes from a source to a destination on an "as needed" basis. This approach is in sharp contrast with the traditional *shortest path*-based protocols (e.g., link-state and distance vector [14]) that have been used successfully in dynamic, wireline networks, including the Internet.

1.1. On-demand protocols and flooding

The motivation behind the on-demand protocols[1] is that the "routing overhead" (typically measured in terms of the number of routing packets transmitted, as opposed to data packets) is typically lower than the shortest path protocols as only the actively used routes are maintained. However, as some recent performance evaluation work has shown [7], the routing overhead still approaches that of the shortest path protocols, if a moderate to large number of routes needs to be actively maintained (when, for example, there is a moderate to large number of active peer-to-peer conversations). This is because the on-demand protocols discover routes via a *flooding* technique, where the source (or any node seeking the route) floods the entire network with a query packet in search of a

[1] In this paper, we use the term "on-demand routing" synonymously with protocols that search routes via flooding. Note that on-demand routing is a general paradigm which is used in other contexts as well (e.g., QOS routing).