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The Broadcast Storm Problem in a Mobile Ad Hoc Network

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Abstract. Broadcasting is a common operation in a network to resolve many issues. In a mobile ad hoc network (MANET) in particular, due to host mobility, such operations are expected to be executed more frequently (such as finding a route to a particular host, paging a particular host, and sending an alarm signal). Because radio signals are likely to overlap with others in a geographical area, a straightforward broadcasting by flooding is usually very costly and will result in serious redundancy, contention, and collision, to which we call the *broadcast storm* problem. In this paper, we identify this problem by showing how serious it is through analyses and simulations. We propose several schemes to reduce redundant rebroadcasts and differentiate timing of rebroadcasts to alleviate this problem. Simulation results are presented, which show different levels of improvement over the basic flooding approach.

Keywords: broadcast, communication, mobile ad hoc network (MANET), mobile computing, wireless network

1. Introduction

The advancements in wireless communication and economical, portable computing devices have made mobile computing possible. One research issue that has attracted a lot of attention recently is the design of mobile ad hoc networks (MANET). A MANET is one consisting of a set of mobile hosts which may communicate with one another and roam around at their will. No base stations are supported in such an environment. Due to considerations such as radio power limitation, channel utilization, and power-saving concerns, a mobile host may not be able to communicate directly with other hosts in a *single-hop* fashion. In this case, a *multihop* scenario occurs, where the packets sent by the source host are relayed by several intermediate hosts before reaching the destination host.

Applications of MANETs occur in situations like battlefields or major disaster areas where networks need to be deployed immediately but base stations or fixed network infrastructures are not available. Unicast routing in MANET has been studied in several articles [7,8,15,16,23,25]. A working group called "manet" has been formed by the Internet Engineering Task Force (IETF) to study the related issues and stimulate research in MANET [22].

This paper studies the problem of sending a broadcast message in a MANET. Broadcasting is a common operation in many applications, e.g., graph-related problems and distributed computing problems. It is also widely used to resolve many network layer problems. In a MANET in particular, due to host mobility, broadcasting is expected to be performed more frequently (e.g., for paging a particular host, sending an alarm signal, and finding a route to a particular host [7,15,16,25]). Broadcasting may also be used in LAN emulation [3] or serve as a last resort to provide multicast services in networks whose topologies change rapidly.

In this paper, we assume that mobile hosts in the MANET share a single common channel with *carrier sense multiple access* (CSMA), but no collision detection (CD), capability. Synchronization in such a network with mobility is unlikely, and global network topology information is unavailable to facilitate the scheduling of a broadcast. So one straightforward and obvious solution is broadcasting by *flooding*. Unfortunately, in this paper we observe that serious redundancy, contention, and collision could exist if flooding is done blindly. First, because the radio propagation is omni-directional and a physical location may be covered by the transmission ranges of several hosts, many rebroadcasts will be redundant. Second, heavy contention could exist because rebroadcasting hosts are probably close to each other. Third, collisions are more likely to occur because the RTS/CTS dialogue is inapplicable and the timing of rebroadcasts is highly correlated.

Collectively, we refer to these problems associated with flooding as the *broadcast storm* problem. Through analyses and simulations, we demonstrate how serious the problem is. Two directions to alleviate this problem are to reduce the possibility of redundant rebroadcasts and to differentiate the timing of rebroadcasts. Following these directions, we develop several schemes, called *probabilistic*, *counter-based*,