Chapter 11
Connectivity and Topology Organization in Ad-Hoc Networks for Service Delivery

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ABSTRACT

This chapter introduces the concept of connectivity and robustness of a mobile ad-hoc network as a function of the node density and coverage radius. It presents an elementary analytical model based on the spatial Poisson process to formulate the connectivity problem as the computation of the existence of wireless links forming paths obtained by Dijkstra's shortest path algorithm. It also introduces a simple clustering strategy that starts forming groups based on one-hop distance and then adjust the coverage radius of the nodes in order to decrease the interference, processing load and isolated nodes in the network. It includes results of scenarios with different robustness of origin-destination pairs and number of clusters and shows the benefits of using the introduced policies.

INTRODUCTION

Every service provider needs to deliver to its end-users the information and applications satisfying certain parameters indicating levels of quality and satisfaction. In an ad-hoc network, nodes are mobile or fixed, and have limited processing capabilities for energy, processing, memory, transmission power, etc. These limitations can produce critical scenarios for service delivery to end-users. In this chapter, we discuss important issues that a network provider must resolve in order to satisfy such quality parameters, when

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an ad-hoc network is implemented. Among these issues, we have node and network connectivity, the topology formation, the use of clusters in the topology, the network monitoring to balance traffic load, the network coverage, the wireless channel impairments, and so on.

In this chapter, we introduce a model that measures path availability that depends on user density and transmission power. The model is based on a spatial Poisson process and the coverage radius of the nodes, and it provides a measure of the *strength* of a path. The model brings together the concepts of reachability, robustness and connectivity to provide means to measure service delivery success in an ad-hoc network, and helps to make evident connectivity for service delivery by detecting trouble areas where coverage or link availability is compromised. This evidence can help service providers to determine areas where nodes can be turned on and off, depending on user density, time of day and traffic load, providing network adaptability that changes dynamically according to existing conditions of traffic, interference, and node density.

We also provide a network topology organization based on clusters that minimizes the number of disconnected nodes, and maximizes network connectivity by using paths with the minimum number of hops possible. We discuss wireless channel propagation problems in order to modify coverage of the nodes and provide a clustering organization of the nodes in the network with their decision rules and algorithms. This clustering organization is studied by varying the user density, coverage radius and mobility of nodes to provide evidence of the effects of such issues on service delivery and connectivity of the ad-hoc network.

The purpose of this chapter is to evaluate connectivity and quality as performance measures, using a connectivity method (algorithm) to find paths and clustering routines that maintain an effective topology capable of adapting to node mobility so that routing can be more responsive and optimal when mobility rates are low and more efficient when they are high.

The main ideas of a communication system are to maintain an effective topology and provide service to the users at any time. Therefore, this service needs to be fast, efficient and of quality. To maintain an effective topology, we can use a dynamic algorithm where nodes are organized into clusters where probabilistic bounds can be calculated on the availability of paths to cluster destinations over a specified interval of time. In the case of Ad-hoc networks, the main issues to be considered are mobility, interference, connectivity and quality. When some problems related to these issues appear, it is necessary to have an organization within the network, through the nodes. This organization helps to diminish the negative effects of these issues through cooperative network maintenance.

BACKGROUND

A mobile ad-hoc network, (Macker & Corson, 1998; Chakrabarti & Mishra, 2001), is defined as an autonomous system of mobile nodes connected by wireless links, where these nodes are free to move randomly and organize themselves arbitrarily, changing the wireless network topology quickly and unpredictably. It is a self-configuring network of mobile devices connected throughout wireless links. Nodes establish communication in a point to point fashion, without the need of a central unit to enable communication between nodes. Such a network may operate in a standalone fashion, or may be connected to Access Points (APs), which are larger processing units that provide communication with the rest of the public switched network.

Wireless ad-hoc networks became a popular subject for research as laptops and 802.11/Wi-Fi wireless networking became widespread in the mid to late 1990s. Many of the academic papers evaluate protocols and abilities assuming varying