

Chapter 9

Network Address Management in MANETs Using an Ant Colony Metaphor

Alvaro Pachón
Universidad Icesi, Colombia

Juan M. Madrid
Universidad Icesi, Colombia

ABSTRACT

Address management is a critical network process, since any node wishing to join a network must first obtain an address. Network address management in a mobile ad-hoc network (MANET) is a particular challenge due to the unique operating conditions of such networks, their dynamic topology, and the events that take place inside them. This chapter presents a proposal for solving the address management problem in a MANET by applying the self-organization and emergency principles governing the behavior of social insect colonies, particularly ant colonies.

INTRODUCTION

This chapter presents a solution to the network address management problem in a MANET.

The chapter follows this structure: First, we will identify the unique operation features of a MANET. Then, we will present several approaches that have been proposed in order to solve the network address management problem. Next, we will present and support the utilization of two key concepts in our solution, namely, the self-organization concept and the ant colony metaphor. Finally, we present the design of a self-organized

network address assignment function, inspired in an ant colony behavior, and evaluation results for the proposed model.

BACKGROUND

A MANET is defined as an autonomous system, integrated by mobile hosts using wireless links to communicate with each other (Murthy & Manoj, 2004). Such hosts constitute a temporary network without the need for centralized management, but without the normally available network support services. Network nodes may move in a random fashion and organize themselves arbitrarily. Thus,

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topology in a MANET may change dynamically, in a very fast and unpredictable manner. The unique features of a MANET must be taken into account as design directives, and also as performance constraints, when designing protocols for them.

Some characteristics of a MANET are:

- a) Nodes generate dynamic topologies. Nodes move freely in any direction, at any speed, and require a high capability of adaptation in the network.
- b) Routing works in a multi-hop fashion. Each node in the network can behave as a router, and may participate cooperatively in packet delivery through an established route.
- c) Bandwidth constraints. This is due to the wireless nature of the communication channels. Constraints considered here include multiple accesses to the channel, multipath interference, noise, fading and limited available spectrum; all these constraints cause limited data transmission rates.
- d) Power-restricted operation. This directly impacts proposed algorithms for this kind of network, since these algorithms must not be processor-intensive.
- e) Limited physical security. Because it is decentralized, a MANET is robust because it does not have a unique point of failure. However, MANETs are also vulnerable to multiple types of attacks.
- f) Scalability limitations. This point is extremely important and complex due to resource limitations.

THE NETWORK ADDRESS ASSIGNMENT PROBLEM

Every node connected to a network needs a unique ID address. This address allows the node to take part in any information exchange. For this reason, address management in a network is a critical task. Address management activities include: a) select-

ing, reserving and assigning a unique address to every node in the network; b) releasing/recovering the address of a node leaving the network; c) solving address conflicts, if they happen, and d) solving events that negatively impact network stability, if they occur.

Two approaches for network address assignment are used in the wired network environment: the static approach, in which the network administrator assigns a network address to each network node in a manual fashion; and the dynamic approach, which needs no intervention from the network administrator. In this approach, network address assignment is implemented as a network service through the Dynamic Host Configuration Protocol (DHCP).

Neither of these two approaches can be applied directly in a MANET, because:

- MANETs have no infrastructure, and
- Nodes are mobile and move dynamically. This may prevent the DHCP server from being permanently available. Also, other nodes might not be able to establish a communication path to such a server.

The dynamic nature of MANETs generates events that do not take place in wired networks, such as network partition and merging. A MANET is partitioned when it splits into two or more subnetworks; similarly, a merge event occurs when two or more MANETs become a single network. All of these events cause the network address assignment process in a MANET to be particularly complex.

Approaches for Network Address Assignment

This section presents the different approaches proposed to solve the network address assignment problem. This is done in order to identify the key aspects and basic features a new solution approach should take into account.

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