Chapter 3

Fourier-Based Assessment Strategies for Simulated Ad Hoc Networks

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ABSTRACT

An ad hoc network comprises mobile devices with limited computing and energy resources together with wireless communication, which have to cooperate to provide networking services. This communication scenario presents many specific challenges that make ad hoc networks very different from traditional wired and wireless data networks. It makes classical approaches for network analysis insufficient. To deal with the design, implementation and test of this innovative communication paradigm, simulation techniques are of primary importance, since they allow to specify the level of detail of the simulated model. At the same time, the complex interaction among different entities make the performance evaluation of real ad hoc systems through simulation very hard. This chapter discusses traditional simulation strategies for ad hoc networks, highlighting their limits, drawbacks and possible overcoming. It presents efforts of the research community in improving the quality of simulation analysis according to different aspects, such as metrics definition, model design and simulation tools extensions. Then, the chapter focuses its attention on the benefits that the Discrete Fourier Transform analysis can produce if it is applied on simulation data. It describes a detailed methodology to gather and elaborate simulation measurements in order to avoid loss of information on rare events that occur in simulations. The presented methodology gets advantages (such as simplicity and flexibility) from simulative investigation approaches and, at the same time, offers a new analysis tool suitable for both protocol debugging and system performances evaluation. In fact, it transfers time-dependent measurements into the frequency domain, allowing to point out the occurrence of events which take place only under particular conditions and to detect occasional misbehaviors of the system.

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INTRODUCTION

In the next generation of wireless systems, a main target will be the ability of rapid deployment of the communication infrastructure, independent from fixed access points and specific hardware devices. In a such dynamic scenario, ad hoc networks represent the emerging technology which allows establishing a communication system without relying on pre-existing agreements.

An ad hoc network is a set of mobile nodes which cooperate in a distributed fashion, in order to provide network functionalities, such as delivering messages, service discovering and so. Since nodes are mobile, the network topology may change rapidly and unpredictably over time. So, ad hoc networks needs to automatically reconfigure the communication system to offer an undisrupted networking service.

The application of ad hoc networks successfully cover a wide range of scenarios: collaborative and distributed mobile computing (sensors, conferences, conventions), disaster recovery (such as fire, flood, earthquake), law enforcement (crowd control, search and rescue) and tactical communications (digital battlefields) (Haas 2002). However, they presents unique challenges which differentiate them from traditional wireless and wired systems (Toh 2002; Giordano 2002; Sesay et al. 2004). Ad hoc networks are self-organizing and nodes have to be highly cooperative: management tasks are distributed over nodes and any service is the result of collaboration among them. To increase the network capacity, nodes relay traffic on behalf of one another to reach distant stations along multi-hop paths. In many cases, nodes are battery-driven and it makes the power budget tight for all the power-consuming components in devices. Also, wireless links have limited bandwidth and are not reliable. All these features affect CPU processing, memory size/usage, signal processing and transceiver output/input power. Additional issues result from node mobility. In fact, users can connect or abruptly disconnect from the network or move in the surrounding space, causing continual changes in the network topology. Nonetheless, end-to-end communication services have to operate seamlessly to provide good experience to users.

Such a complex communication paradigm requires new networking approaches and specific functionalities, that have to be accurately investigated in order to guarantee efficiency and robustness. In the past years many research groups have developed a lot of protocols and architectures to support ad hoc scenarios and most of them have been tested through simulative methodologies. In fact, simulations allow to study easily ad hoc networks through a model of the system. Working conditions (e.g., node mobility, transmission range, etc...) can be modified by simply tuning network parameters and a large spectrum of network scenarios can be considered. However, the simulation analysis suffers from approximations in measurements due to simplified network models and limited observation periods. From this consideration, the necessity to improve the analysis based on simulation tools arise. This necessity is particularly felt in the ad hoc network context, where constrains in available resources and complexity in the communication system make the efficiency of networking services a main target. The behavior of the network depends not only on active protocols, but also on the placement of the nodes in the network, interference arising from neighboring communications and mobility patterns.

The necessity of accuracy in the simulation of ad hoc networks is proved by the great interest of the scientific community in improving the quality of simulation results. Proposed solutions cover different issues, since several aspects of a simulative analysis can be investigated and improved. They range from the definition of meaningful metrics, able to capture the actual behavior of ad hoc system, to the design of realistic simulation models, from the implementation of additional features in simulation tools, to have more robust