NETWORK MODELING AND SIMULATION

Network Modeling and Simulation: A Practical Perspective Mohsen Guizani, Ammar Rayes, Bilal Khan and Ala Al-Fuqaha
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A PRACTICAL PERSPECTIVE

Mohsen Guizani
Kuwait University, Kuwait

Ammar Rayes
Cisco Systems, USA

Bilal Khan
City University of New York, USA

Ala Al-Fuqaha
Western Michigan University, USA

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Preface

Networking technologies are growing more complex by the day. So, one of the most important requirements for assuring the correct operation and rendering of the promised service to demanding customers is to make sure that the network is robust. To assure that the network is designed properly to support all these demands before being operational, one should use the correct means to model and simulate the design and carry out enough experimentation. So, the process of building good simulation models is extremely important in such environments, which led to the idea of writing this book.

In this book, we chose to introduce generic simulation concepts and frameworks in the earlier chapters and avoid creating examples that tie the concepts to a specific industry or a certain tool. In later chapters, we provide examples that tie the simulation concepts and frameworks presented in the earlier chapters to computer and telecommunications networks. We believe that this will help illustrate the process of mapping the generic simulation concepts to a specific industry.

Therefore, we have concentrated on the core concepts of systems simulation and modeling. We also focused on equipping the reader with the tools and strategies needed to build simulation models and solutions from the ground up rather than provide solutions to specific problems. In addition, we presented code examples to illustrate the implementation process of commonly encountered simulation tasks.

The following provides a chapter-by-chapter breakdown of this book's material.

Chapter 1 introduces the foundations of modeling and simulation, and emphasizes their importance. The chapter surveys the different approaches to modeling that are used in practice and discusses at a high level the methodology that should be followed when executing a modeling project.

In Chapter 2, we assemble a basic discrete event simulator in Java. The framework is not very large (less than 250 lines of code, across three classes) and yet it is extremely powerful. We deduce the design of the simulation framework (together with its code). Then, we discuss a few "toy examples" as a tutorial on how to write applications over the framework.

In Chapter 3, we turn to a case study that illustrates how to conduct large discrete event simulations using the framework designed in Chapter 2. We then design and

develop a simulation of a system that will generate malware antivirus signatures using an untrusted multi-domain community of honeypots (as a practical example encountered usually in today's networks).

Chapter 4 introduces the well-known Monte Carlo simulation technique. The technique applies to both deterministic and probabilistic models to study properties of stable systems that are in equilibrium. A random number generator is used by Monte Carlo to simulate a performance measure drawn from a population with appropriate statistical properties. The Monte Carlo algorithm is based on the law of large numbers with the promise that the mean value of a large number of samples from a given space will approximate the actual mean value of such a space.

Chapter 5 expands upon the concepts introduced in earlier chapters and applies them to the area of network modeling and simulation. Different applications of modeling and simulation in the design and optimization of networked environments are discussed. We introduce the network modeling project life cycle and expose the reader to some of the particular considerations when modeling network infrastructures. Finally, the chapter attempts to describe applications of network modeling within the linkage between network modeling and business requirements.

In Chapter 6, we define a framework that will allow for modular specification and assembly of dataflow processing modules within a single device. We call this framework the Component Architecture for Simulating Network Objects (CASiNO). A discussion on how to use CASiNO and code its components is presented in some detail.

Then, in Chapter 7, we study a set of statistical distributions that could be used in simulation as well as a set of random number generation techniques.

In Chapter 8, we create some useful network simulation elements that will serve as building blocks in the network structures that we consider in the context of queuing theory in Chapter 9.

Chapter 9 presents a brief discussion on several topics in queuing theory. In the first part, we cover the basic concepts and results, whereas in the second part we discuss specific cases that arise frequently in practice. Whenever possible, there are code samples implemented using the CASiNO framework (developed in Chapter 6), the SimJava Package, and the MATLAB package.

Chapter 10 elaborates on the importance of data collection as a phase within the network modeling project life cycle. It lists the different data types that need to be collected to support network modeling projects, and how to collect the data, choose the right distribution, and validate the correctness of one's choice.

Chapter 11 presents traffic models used to simulate network traffic loads. The models are divided into two main categories: models which exhibit long-range dependencies or self-similarities and Markovian models that exhibit only short-range dependence. Then, an overview of some of the commonly used global optimization techniques to solve constrained and unconstrained optimization problems are

presented. These techniques are inspired by the social behaviors of birds, natural selection and survival of the fittest, and the metal annealing process as well as the fact of trying to simulate such behaviors.

Finally, we hope that this book will help the reader to understand the code implementation of a simulation system from the ground up. To that end, we have built a new simulation tool from scratch called "CASiNO." We have also treated all the examples in a step-by-step fashion to keep the user aware of what is happening and how to model a system correctly. So, we hope that this book will give a different flavor to modeling and simulation in general and to that of network modeling and simulation in particular.

Mohsen Guizani
Ammar Rayes
Bilal Khan
Ala Al-Fuqaha

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