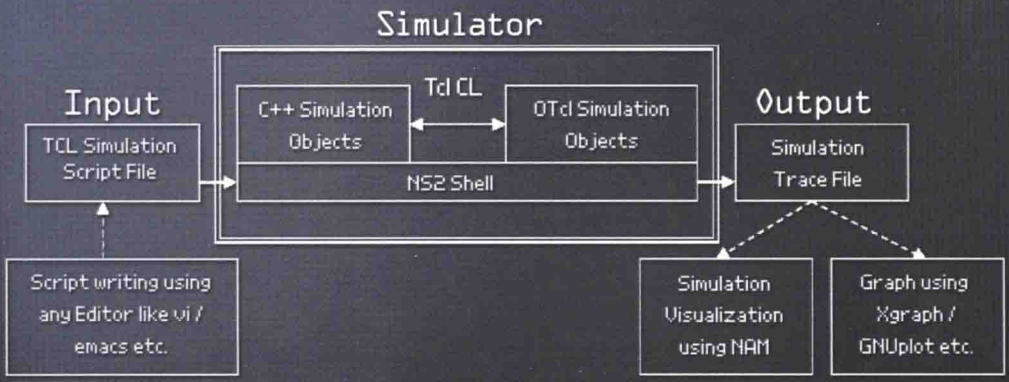
Computer Network Simulation Using NS2



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PREFACE

This book is intended to help students understand certain practical aspects of computer networking. We focus on simulation of basic computer networking protocols for a deeper understanding of the workings of the protocols as well as for performance evaluation. We have also included socket programming taught at the undergraduate level to help students develop skills for network programming. Considering that students may have widely different backgrounds, we have included certain basics of networking to make the book self-contained. However, the introductory treatment on networking issues is given as a refresher of the basic concepts involved, and thorough learning of the relevant concepts from a networking book is a necessity before this book can be used.

It is well accepted that the knowledge acquired from a theoretical reading, especially in a subject such as computer networking, is incomplete when not accompanied by hands-on practice. The book is sprinkled with examples of simulations of both wired and wireless networking protocols. The assignments have been designed to be suitable for undergraduate and postgraduate levels of learning. For the advanced learner, suitable hints have been provided throughout the text to develop the skills for evaluation of new protocols.

Salient Features

(i) Emphasis on implementation and simulation of real-world network protocols.

(ii) Covers a wide ranging set of topics, starting from certain basic operating system commands to socket programming, wired network simulation, wireless network simulation, performance evaluation, and visualization.

(iii) Plenty of example programs have been provided (around ninety odd programs and scripts along with their explanations and outputs). Also many exercises (both theory and programming) requiring investigation

and application of the learned concepts have been provided across all the chapters for practice.

(iv) We have tried our best to explain the concepts using simple language and analogies.

Content & Structure

Chapter 1 Discusses the evolution of data communication techniques and the fundamental issues associated with performance evaluation. It then provides an overview of simulation and other performance evaluation techniques.

Chapter 2 Introduces computer network protocols along with TCP/IP and OSI models. It also provides a brief overview of the networking devices used.

Chapter 3 Explains a socket and its use in network programming. This gives an idea of developing network applications using C and socket API.

Chapter 4 Introduces the NS2 network simulator, and exhibits the internal architecture of NS2 and its constituent software packages. It also provides pointers to installation of the package in different operating systems.

Chapter 5 Provides basic knowledge about simulation using NS2. It elaborates on the use of Tcl and OTcl scripts along with an introduction to AWK scripting and plotting with Gnuplot.

Chapter 6 Deals with the simulation of wired networks in detail. It shows how to simulate different protocols in different layers.

Chapter 7 Deals with the simulation of wireless networks in detail. It also discusses the idea of simulation, very large networks and measuring the various network parameters and plotting them in suitable graphs.

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Satyananda Champati Rai is currently working as an associate professor and head of the Department of Information Technology at the Silicon Institute of Technology, Bhubaneswar. He earned his M. Tech. (CS) and Ph.D. (computer science) from Utkal University in 2001 and 2012, respectively. He has published 20 research articles in national and international conference proceedings as well as in journals. He has written a monograph titled *QoS Provisioning in Mobile Ad Hoc Networks: Principles, Practices and Models*, published by LAMBERT Academic Publishing, Germany in 2013. He is a member of IEEE and a life member of the Orissa Information Technology Society (OITS) and ISTE. He has guided 22 M. Tech. students and served as a program committee member in several international conferences. His current research interests include mobile ad hoc networks, wireless sensor networks, and mobile cloud computing related to quality of service and performance analysis.

Rajib Mall earned B.E., M.E., and Ph.D. degrees from the Indian Institute of Science, Bangalore. He worked for nearly 3 years for Motorola India Ltd. before he joined the Department of Computer Science and Engineering, Indian Institute of Technology, Kharagpur in 1994 as a faculty member. He is currently a professor and the head of the CSE Department and the School of IT. His current research interests include program testing and software engineering issues in large systems and those in real-time embedded systems. He has published about 200 research papers and refereed international journals and conference proceedings and has carried out a number of sponsored projects in the areas of program analysis and program testing. He is a senior member of IEEE (USA).

CONTENTS

CHAPTER 1

INTRODUCTION

The history of computers dates back more than 60 years. In the initial two decades, computers were operated largely as standalone machines, and primarily served as powerful number crunchers. About a decade later, the need for devising techniques to let applications running on different computers share information with each other was felt. This led to the birth of computer communication networks. An interconnected set of computers made it possible to develop powerful information sharing applications. This was in contrast to the plain number crunching applications that existed. This exemplified the potential advantages that computer communication networks can bring and caused the nascent computer communication technology to evolve at a rapid pace.

The mind boggling progress achieved in the area of computing technologies over the relatively short time span of the last six decades is now folklore. But even that pales when compared to the progress that has been achieved over the last half a century in the field of computer networking technologies. The dizzying speed with which computer networking technologies have advanced can be gauged from the fact that, almost every decade, the scope and contents of every networking textbook have been dramatically revised. In the following, we recount a few milestones in this evolution.

1.1 Rapid Evolution of Voice and Data Communication Techniques

In a groundbreaking work, Samuel Morse publicly demonstrated in 1838 that pulses of electric current can be used to move an electromagnet placed in a remote machine to produce dots and dashes on a piece of paper. The crude prototype demonstrated by Morse soon evolved into the telegraph system. The telegraph system revolutionized communications with far off places. However, with its inherent dot-and-dash Morse code mechanism, its

use was largely restricted to communications of simple text messages. About 40 years later, in 1876, Alexander Graham Bell showed that voice signals can be transmitted as encoded time varying electric currents and then the current received at a remote destination can be used to reconstruct the voice signals. Bell's prototype was soon made into a simple telephone system that consisted of a pair of connected phone handsets. Such a simple telephone system could be used to connect a pair of fixed users. For example, a pair of phones could link two offices of a company. This was a network of size two (number of nodes is 2) and was obviously of very limited utility, as the utility of a telephone network is proportional to the square of the number of the nodes in the network. Shortly afterwards, on-demand connection establishment among different pairs of telephone handsets belonging to various subscribers was achieved through the use of manually operated exchanges. With the discovery of automatic telephone exchange technologies in 1879, circuit switching among different handset pairs became possible, and a subscriber could talk to other subscribers by simply dialing their numbers. This came to be known as the Public Switched Telephone Network (PSTN) system. A switch located in a telephone exchange could route calls to other exchanges. Efficient communication among subscribers residing in far away cities became possible with the invention of signal multiplexing techniques. Signal multiplexing made it possible to transmit multiple calls over the same trunk line. This led to more efficient usage of the physical medium.

Development of signal filtering techniques helped to reduce cross talk and other forms of noise in a phone call. The connection between two exchanges became known as a trunk line. The name trunk (analogous to a tree trunk) denotes that multiple communications are carried on the same line through use of either time division or frequency division multiplexing techniques. Initially, the telephone system carried only voice traffic and therefore was called a voice network. This completely analog technology is now called Plain Old Telephone Service (POTS) to differentiate it from the modern telephone systems, which, to a large extent, are carrying digital data with the help of many computing and electronic devices, rather than using analog devices such as filters, multiplexers, amplifiers, etc.

Wireless communication technology evolved independently almost over the same period of time as its wired counterpart. Wireless communication was born with the ground-breaking work of Guglielmo Marconi in 1899, when he made a bell ring at a remote place by pressing a button in the absence of any wired connections. Marconi's prototype was quickly commercialized, and it rapidly evolved into a host of technologies such as radio, wireless telegraphy, and wireless telephony.