

Building Secure and Reliable Network Applications

Kenneth P. Birman

Department of Computer Science

Cornell University

Ithaca, New York 14853

Cover image: line drawing of the golden gate bridge looking towards San Francisco?

@ Copyright 1995, Kenneth P. Birman. All rights reserved. This document may not be copied, electronically or physically, in whole or in part, or otherwise disseminated without the author's prior written permission.

TRADEMARKS CITED IN THE TEXT	14
PREFACE AND ACKNOWLEDGEMENTS	15
INTRODUCTION	16
A USER’S GUIDE TO THIS BOOK	26
PART I: BASIC DISTRIBUTED COMPUTING TECHNOLOGIES	28
1. FUNDAMENTALS	29
1.1 Introduction	29
1.2 Components of a Reliable Distributed Computing System	32
1.2.1 Communications Technology	35
1.2.2 Basic transport and network services	36
1.2.3 Reliable transport software and communication support	38
1.2.4 “Middleware”: Software tools, utilities, and programming languages	38
1.2.5 Distributed computing environments	39
1.2.6 End-user applications	40
1.3 Critical Dependencies	41
1.4 Next Steps	42
1.5 Additional Reading	43
2. COMMUNICATION TECHNOLOGIES	44
2.1 Types of Communication Devices	44
2.2 Properties	45
2.3 Ethernet	46
2.4 FDDI	48
2.5 B-ISDN and the Intelligent Network	50
2.6 ATM	53
2.7 Cluster and Parallel Architectures	56
2.8 Next steps	57
2.9 Additional Reading	58

3. BASIC COMMUNICATION SERVICES	59
3.1 Communications Standards	59
3.2 Addressing	59
3.3 Internet Protocols	63
3.3.1 Internet Protocol: IP layer	64
3.3.2 Transport Control Protocol: TCP	64
3.3.3 User Datagram Protocol: UDP	64
3.3.4 Internet Packet Multicast Protocol: IP Multicast	65
3.4 Routing	66
3.5 End-to-end Argument	67
3.6 O/S Architecture Issues, Buffering, Fragmentation	68
3.7 Xpress Transfer Protocol	70
3.8 Next Steps	71
3.9 Additional Reading	72
4. RPC AND THE CLIENT-SERVER MODEL	73
4.1 RPC Protocols and Concepts	75
4.2 Writing an RPC-based Client or Server Program	77
4.3 The RPC Binding Problem	79
4.4 Marshalling and Data Types	81
4.5 Associated Services	83
4.5.1 Naming services	83
4.5.2 Time services	84
4.5.3 Security services	85
4.5.4 Threads packages	85
4.6 The RPC Protocol	89
4.7 Using RPC in Reliable Distributed Systems	92
4.8 Related Readings	95
5. STREAMS	96
5.1 Sliding Window Protocols	96
5.1.1 Error Correction	97
5.1.2 Flow Control	98
5.1.3 Dynamic Adjustment of Window Size	98

5.1.4 Burst Transmission Concept	99
5.2 Negative-Acknowledgement Only	100
5.3 Reliability, Fault-tolerance, and Consistency in Streams	100
5.4 RPC over a Stream	102
5.5 Related Readings	102
6. CORBA AND OBJECT-ORIENTED ENVIRONMENTS	104
6.1 The ANSA Project	104
6.2 Beyond ANSA to CORBA	106
6.3 OLE-2 and Network OLE	107
6.4 The CORBA Reference Model	107
6.5 TINA	114
6.6 IDL and ODL	114
6.7 ORB	116
6.8 Naming Service	116
6.9 ENS	117
6.10 Life Cycle Service	118
6.11 Persistent Object Service	118
6.12 Transaction Service	118
6.13 Inter-Object Broker Protocol	118
6.14 Future CORBA Services	118
6.15 Properties of CORBA Solutions	119
6.16 Related Readings	120
7. CLIENT-SERVER COMPUTING	121
7.1 Stateless and Stateful Client-Server Interactions	121
7.2 Major Uses of the Client-Server Paradigm	121
7.3 Distributed File Systems	125

Chapter 1: Fundamentals	5
7.4 Stateful File Servers	129
7.5 Distributed Database Systems	136
7.6 Applying Transactions to File Servers	141
7.7 Message Oriented Middleware	143
7.8 Related Topics	143
7.9 Related Readings	145
8. OPERATING SYSTEM SUPPORT FOR HIGH PERFORMANCE COMMUNICATION	146
8.1 Lightweight RPC	147
8.2 Fbuf's and the xKernel Project	149
8.3 Active Messages	151
8.4 Beyond Active Messages: U-Net	153
8.5 Protocol Compilation Techniques	156
8.6 Related Readings	157
PART II: THE WORLD WIDE WEB	158
9. THE WORLD WIDE WEB	159
9.1 Related Readings	164
10. THE MAJOR WEB TECHNOLOGIES	165
10.1 Hyper-Text Markup Language (HTML)	166
10.2 Virtual Reality Markup Language (VRML)	166
10.3 Universal Resource Locators (URLs)	166
10.4 Hyper-Text Transport Protocol (HTTP)	167
10.5 Representations of Image Data	170
10.6 Authorization and Privacy Issues	171
10.7 Web Proxy Servers	174
10.8 Java, HotJava, and Agent Based Browsers	175

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.