

Expert Network Time Protocol

An Experience in Time
with NTP

PETER RYBACZYK

Apress®

Expert Network Time Protocol: An Experience in Time with NTP

Copyright © 2005 by Peter Rybaczyk

Lead Editor: Jim Sumser

Technical Reviewer: Jim Cornelson

Editorial Board: Steve Anglin, Dan Appleman, Ewan Buckingham, Gary Cornell, Tony Davis,

Jason Gilmore, Jonathan Hassell, Chris Mills, Dominic Shakeshaft, Jim Sumser

Assistant Publisher: Grace Wong

Project Manager: Sofia Marchant

Copy Manager: Nicole LeClerc

Copy Editor: Kim Wimpsett

Production Manager: Kari Brooks-Copony

Production Editors: Kari Brooks-Copony, Kelly Winkquist

Compositor: Linda Weidemann

Proofreader: Liz Welch

Indexer: Carol Burbo

Artist: April Milne

Cover Designer: Kurt Krames

Manufacturing Manager: Tom Debolski

Library of Congress Cataloging-in-Publication Data

Rybaczyk, Peter.

Expert Network Time Protocol / Peter Rybaczyk.

p. cm.

Includes bibliographical references.

ISBN 1-59059-484-3

1. Network Time Protocol (Computer network protocol) I. Title.

TK5105.575R93 2005

004.6'2--dc22

2005013042

All rights reserved. No part of this work may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage or retrieval system, without the prior written permission of the copyright owner and the publisher.

Printed and bound in the United States of America 9 8 7 6 5 4 3 2 1

Trademarked names may appear in this book. Rather than use a trademark symbol with every occurrence of a trademarked name, we use the names only in an editorial fashion and to the benefit of the trademark owner, with no intention of infringement of the trademark.

Distributed to the book trade in the United States by Springer-Verlag New York, Inc., 233 Spring Street, 6th Floor, New York, NY 10013, and outside the United States by Springer-Verlag GmbH & Co. KG, Tiergartenstr. 17, 69112 Heidelberg, Germany.

In the United States: phone 1-800-SPRINGER, fax 201-348-4505, e-mail orders@springer-ny.com, or visit <http://www.springer-ny.com>. Outside the United States: fax +49 6221 345229, e-mail orders@springer.de, or visit <http://www.springer.de>.

For information on translations, please contact Apress directly at 2560 Ninth Street, Suite 219, Berkeley, CA 94710. Phone 510-549-5930, fax 510-549-5939, e-mail info@apress.com, or visit <http://www.apress.com>.

The information in this book is distributed on an "as is" basis, without warranty. Although every precaution has been taken in the preparation of this work, neither the author(s) nor Apress shall have any liability to any person or entity with respect to any loss or damage caused or alleged to be caused directly or indirectly by the information contained in this work.

Contents

About the Author xiii

About the Technical Reviewer xv

Acknowledgments xvii

Introduction xix

PART 1 ■ ■ ■ **NTP: The Key to
Time Transcendence**

■ **CHAPTER 1 Multiple Views of Time 3**

 Time: The Scientific Perspective 6

 Classical Mechanics 7

 Definition of an Atomic Second 8

 Definition of a Clock 9

 The Special Theory of Relativity 10

 The General Theory of Relativity 11

 Quantum Mechanics 12

 The Superstring Theory 14

 Time: The Philosophical Perspective 16

 Time: The Historical Perspective 16

 The Calendars 18

 The Julian Calendar 18

 The Gregorian Calendar 19

 Other Earthly Calendars 20

 Leap Year: The Earthly Time Synchronizer 22

 Time: The Literary Perspective 23

 “Even Such Is Time” by Sir Walter Raleigh 23

 Sonnet 64 by William Shakespeare 24

 Sonnet 123 by William Shakespeare 24

 “The New Year” by John Greenleaf Whittier 24

 The Mysteries of Time 25

| | | |
|--------------------|---|-----------|
| ■ CHAPTER 2 | Network Administration and IT Trends Throughout History! | 27 |
| | The Prehistoric Times | 27 |
| | Ancient Greece | 29 |
| | The Networking Aspects of the Trojan War | 29 |
| | Sparta vs. Athens (Determinism vs. Creative Chaos) | 31 |
| | Ancient Rome and the Roman Empire | 32 |
| | The Middle (Dark) Ages | 35 |
| | The Industrial Revolution | 36 |
| | The Modern Times | 36 |

PART 2 ■ ■ ■ **NTP: The Story Behind the Accuracy and Synchronization of Network Time**

| | | |
|--------------------|---|-----------|
| ■ CHAPTER 3 | NTP Operational, Historical, and Futuristic Overview | 41 |
| | NTP: What, Why, and How? | 42 |
| | What Is NTP? | 43 |
| | Why the Need for NTP? | 45 |
| | How Does NTP Operate? | 47 |
| | NTP Deployment Concepts | 47 |
| | NTP and Routing | 48 |
| | The Hierarchical Nature of NTP | 48 |
| | NTP Messages | 50 |
| | NTP Data Messages | 50 |
| | NTP Control Messages | 54 |
| | NTP Versions 1, 2, 3, and 4 | 55 |
| | The Initial NTP Proposal: RFC 958 | 55 |
| | NTP Version 1: RFC 1059 | 55 |
| | NTP Version 2: RFC 1119 | 57 |
| | NTP Version 3: RFC 1305 | 57 |
| | Secure NTP | 58 |
| | Simple Network Time Protocol (SNTP) | 58 |
| | The Network Time Synchronization Project | 59 |
| | The Interplanetary Internet | 60 |

| | | |
|------------------|--|-----|
| CHAPTER 4 | NTP Architecture | 63 |
| | NTP Servers, Clients, Hosts, and Peers | 64 |
| | NTP Modes of Operation and Associations | 64 |
| | Symmetric Active Mode | 65 |
| | Symmetric Passive Mode | 68 |
| | Client Mode | 68 |
| | Server Mode | 69 |
| | Broadcast Mode | 71 |
| | Multicast Mode | 71 |
| | Manycast/Anycast Mode | 72 |
| | NTP Mode Categories | 74 |
| | NTP Variables and Procedures | 74 |
| | NTP Variables Classes | 75 |
| | Sample Analysis of NTP Variables | 75 |
| | NTP Sanity Checks | 78 |
| | Configurable Variables | 79 |
| | Nonconfigurable Variables | 79 |
| | NTP Security Considerations | 80 |
| | NTP Access Control | 81 |
| | NTP Cryptographic Authentication | 82 |
| | Symmetric Key Cryptography | 83 |
| | The Autokey Protocol | 86 |
| | NTP Time Sources | 87 |
| | Additional NTP Terms and Definitions | 88 |
| CHAPTER 5 | NTP Design, Configuration, and Troubleshooting | 93 |
| | Motivation for NTP Deployment on a Network | 93 |
| | Approach to NTP Design and Configuration | 94 |
| | Step 1: Choosing Your NTP Time Source | 96 |
| | Dedicated Private Timeserver | 96 |
| | Public Server(s) or NTP Pool | 98 |
| | Public Server's Availability Consideration | 98 |
| | Public Server's Security, Accuracy, and Load Consideration | 100 |
| | The Impact of Public NTP Servers' Use on Your Network's Security | 102 |
| | A Local NTP "Master" Device | 103 |
| | Summary of NTP Time Sources Features | 103 |

| | |
|--|-----|
| Step 2: Deciding Upon NTP Topology at Deployment Site | 104 |
| The Number of NTP Clients | 104 |
| The Level of Network Redundancy | 104 |
| Impact of Network Physical Topology and Geography on NTP Topology | 106 |
| Step 3: Determining NTP Features to Configure | 106 |
| Basic NTP Configuration | 107 |
| Basic Dedicated Timeserver Configuration | 107 |
| Basic Unix/Linux NTP Client Configuration | 108 |
| Basic Unix/Linux NTP Primary Timeserver Configuration | 110 |
| Typical Unix/Linux Client Configuration | 111 |
| Basic Cisco Router/Switch NTP Configuration | 113 |
| Basic Juniper Router NTP Configuration | 116 |
| NTP Security Features | 116 |
| NTP Security in Unix/Linux Environments | 117 |
| NTP Security on Cisco Routers and Switches | 119 |
| Redundant NTP Time Sources | 123 |
| NTP Operational Modes | 124 |
| Additional NTP Configuration Options | 126 |
| Step 4: Monitoring and Managing NTP Operations | 126 |
| NTP Deployment on Networks with and without Internet Access | 127 |
| NTP Deployment Guidelines for Small, Medium, and Large Networks | 128 |
| Small NTP Networks | 129 |
| Medium-Size NTP Networks | 129 |
| Large NTP Networks | 130 |
| Use of NTP Within the Network Infrastructure | 131 |
| Use of NTP in the Desktop Environment | 132 |
| Microsoft Windows Workstations and Servers | 132 |
| Unix/Linux Workstations and Servers | 133 |
| Troubleshooting NTP Operations | 133 |
| NTP-Related Programs and Utilities | 134 |
| NTP Configuration with Monitoring and Troubleshooting in Mind | 135 |

| | | |
|----------------|--------------------------------|-----|
| ■ EPILOGUE | NTP: A Journey in Time! | 137 |
| ■ APPENDIX | Additional NTP Resources | 139 |
| ■ BIBLIOGRAPHY | | 141 |
| ■ INDEX | | 143 |