## **Computer Communications**

#### Macmillan Computer Science Series

**Consulting Editor** 

Professor F.H. Sumner, University of Manchester

S.T. Allworth, Introduction to Real-time Software Design

Ian O. Angell, A Practical Introduction to Computer Graphics

R.E. Berry and B.A.E. Meekings, A Book on C

G.M. Birtwistle, Discrete Event Modelling on Simula

T.B Boffey, Graph Theory in Operations Research

Richard Bornat, Understanding and Writing Compilers

J.K. Buckle, Software Configuration Management

W.D. Burnham and A.R. Hall, Prolog Programming and Applications

J.C. Cluley, Interfacing to Microprocessors

Robert Cole, Computer Communications, second edition

Derek Coleman, A Structured Programing Approach to Data

Andrew J.T. Colin, Fundamentals of Computer Science

Andrew J.T. Colin, Programming and Problem-solving in Algol 68

S.M Deen, Fundamentals of Data Base Systems

S.M. Deen, Principles and Practice of Database Systems

P.M. Dew and K.R. James, Introduction to Numerical Computation in Pascal

M.R.M. Dunsmuir and G.J. Davies, Programming the UNIX System

K.C.E. Gee, Introduction to Local Area Computer Networks

J.B. Gosling, Design of Arithmetic Units for Digital Computers

Roger Hutty, Fortran for Students

Roger Hutty, Z80 Assembly Language Programming for Students

Roland N. Ibbett, The Architecture of High Performance Computers

Patrick Jaulent, The 6800 - Hardware and Software

J.M. King and J.P. Pardoe, Program Design Using JSP - A Practical Introduction

H. Kopetz, Software Reliability

E.V. Krishnamurthy, Introductory Theory of Computer Science

V.P. Lane, Security of Computer Based Information Systems

Graham Lee, From Hardware to Software - an introduction to computers

A.M. Lister, Fundamentals of Operating Systems, third edition

G.P. McKeown and V.J. Rayward-Smith, Mathematics for Computing

Brian Meek, Fortran, PL/1 and the Algols

Barry Morrell and Peter Whittle, CP/M 80 Programmer's Guide

Derrick Morris, System Programming Based on the PDP11

Pim Oets, MS-DOS and PC-DOS - A Practical Guide

Christian Queinnec, LISP

John Race, Case Studies in Systems Analysis

W.P. Salman, O. Tisserand and B. Toulout, FORTH

L.E. Scales, Introduction to Non-linear Optimization

Peter S. Sell, Expert Systems - A Practical Introduction

Colin J. Theaker and Graham R. Brookes, A Practical Course on Operating Systems

J.M. Trio, 8086-8088 Architecture and Programming

M.J. Usher, Information Theory for Information Technologists

B.S. Walker, Understanding Microprocessors

Peter J.L. Wallis, Portable Programming

I.R. Wilson and A.M. Addyman, A Practical Introduction to Pascal - with BS6192, second edition

# **Computer Communications**

### **Robert Cole**

Department of Computer Science University College, London

**Second Edition** 



#### © Robert Cole 1982, 1986

All rights reserved. No reproduction, copy or transmission of this publication may be made without written permission.

No paragraph of this publication may be reproduced, copied or transmitted save with written permission or in accordance with the provisions of the Copyright Act 1956 (as amended).

Any person who does any unauthorised act in relation to this publication may be liable to criminal prosecution and civil claims for damages.

First edition 1982 Reprinted 1982 (twice), 1983, 1984, 1985 Second edition 1986

Published by
MACMILLAN EDUCATION LTD
Houndmills, Basingstoke, Hampshire RG21 2XS
and London
Companies and representatives
throughout the world

British Library Cataloguing in Publication Data Cole, Robert, 1952-

Computer communications. — 2nd ed.

- 1. Computer networks
- I. Title

004.6

TK5105.5

ISBN 978-0-333-39502-8 ISBN 978-1-349-18271-8 (eBook) DOI 10.1007/978-1-349-18271-8

# Contents

Preface			
1	Intro	oduction	1
2	Transmission in Wires		
	2.1	Information Channel Theory	4
	2.2	Channel Organisation	11
	2.3	Character Framing	16
	2.4	Send and Receive Equipment	19
	2.5	Comparison of Character Framing Techniques	22
	2.6	Summary	22
3	The Telephone Network as a Medium		
	3.1	The Telephone System	24
	3.2	Modulation Techniques	28
	3.3	The MODEM	31
	3.4	Digital Data Network	36
	3.5	Standards	37
	3.6	Summary	38
4	Character Terminal Networks		
	4.1	Character Codes	40
	4.2	The Star Arrangement	42
	4.3	Remote Multiplexers	44
	4.4	Multiplexer Networks	50
	4.5	Designing an Asynchronous Terminal Network	51
	4.6	Summary	52
5	Simple Message-based Techniques		
	5.1	Multipoint (Multidrop) Lines	53
	5.2	Applications	56

vi Contents

	5.3	Remote Job Entry Stations	57
	5.4	A Simple Message Protocol	58
	5.5	Distributed Computing	61
	5.6	Summary	63
6	Erro	64	
	6.1	The Nature of Errors	64
	6.2	Error Control	66
	6.3	Echo Checking	67
	6.4	Forward Error Correction (FEC)	67
	6.5	Automatic Repeat Request (ARQ)	71
	6.6	Sequence Numbering and Acknowledgement	77
	6.7	Flow Control	82
	6.8	Summary	83
7	Com	84	
	7.1	Wide Area Networks	85
	7.2	Radio and Satellite Broadcast Networks	93
	7.3	Local Area Networks	97
	7.4	Ring Networks	99
	7.5	Summary	102
8	Netw	104	
	8.1	Open Systems Interconnection	104
	8.2	The Reference Model	105
	8.3	The Seven Layers	107
	8.4	Example Protocol Combinations	110
	8.5	Network Management	111
	8.6	The Network as a System	113
9	The	119	
	9.1	The X.25 Protocol	119
	9.2	X.25 Level 1 — the Physical Circuit	120
	9.3	X.25 Level 2 — Link Level	121
	9.4	Operation of X.25 Level 2	125
	9.5	X.25 Level 3 — the Network Level	128
	9.6	X.25 Implementation	133
	9.7	Summary of X.25	134
	9.8	Connectionless Network Protocol	134
	9.9	Internetworking	136
	9.10	Summary	140

Contents		vii
10	End-to-end Services	141
	10.1 The End-to-end Layers	141
	10.2 Common Applications	147
	10.3 Security, Authentication and Encryption	156
Glo	ossary	161
Bibliography		166
Ind	lex	169

## Preface

The preface of the first edition of this text began with the sentence: "The subject of communications is changing very rapidly." The rate of change is sufficient to justify a new edition after only 3 years. Considerable material on the emerging international standards for networks has been added and the remaining material on networking substantially rewritten.

This book is intended for anyone familiar with using computers who wishes to understand the techniques used in computer communications. It is also an introduction to the architecture of computer communication systems. The text has been revised with the needs of the computer professional in mind. The mixture of theory, technique and example is intended to be easily followed and to allow reading of small sections as required.

I would like to thank Roland Ibbett, Steve Treadwell, Peter Kirstein and Del Thomas for their help with the first edition; much of their advice is carried into the second edition. Peter Lloyd and Jon Crowcroft have provided good advice on the changes in the second edition. I am grateful to Professor Kirstein for his continued support and encouragement, particularly in providing facilities which have made the text preparation considerably easier this time around. Finally I would like to acknowledge the help and support of Jo, Rosemary and George, who have a habit of putting everything into perspective.