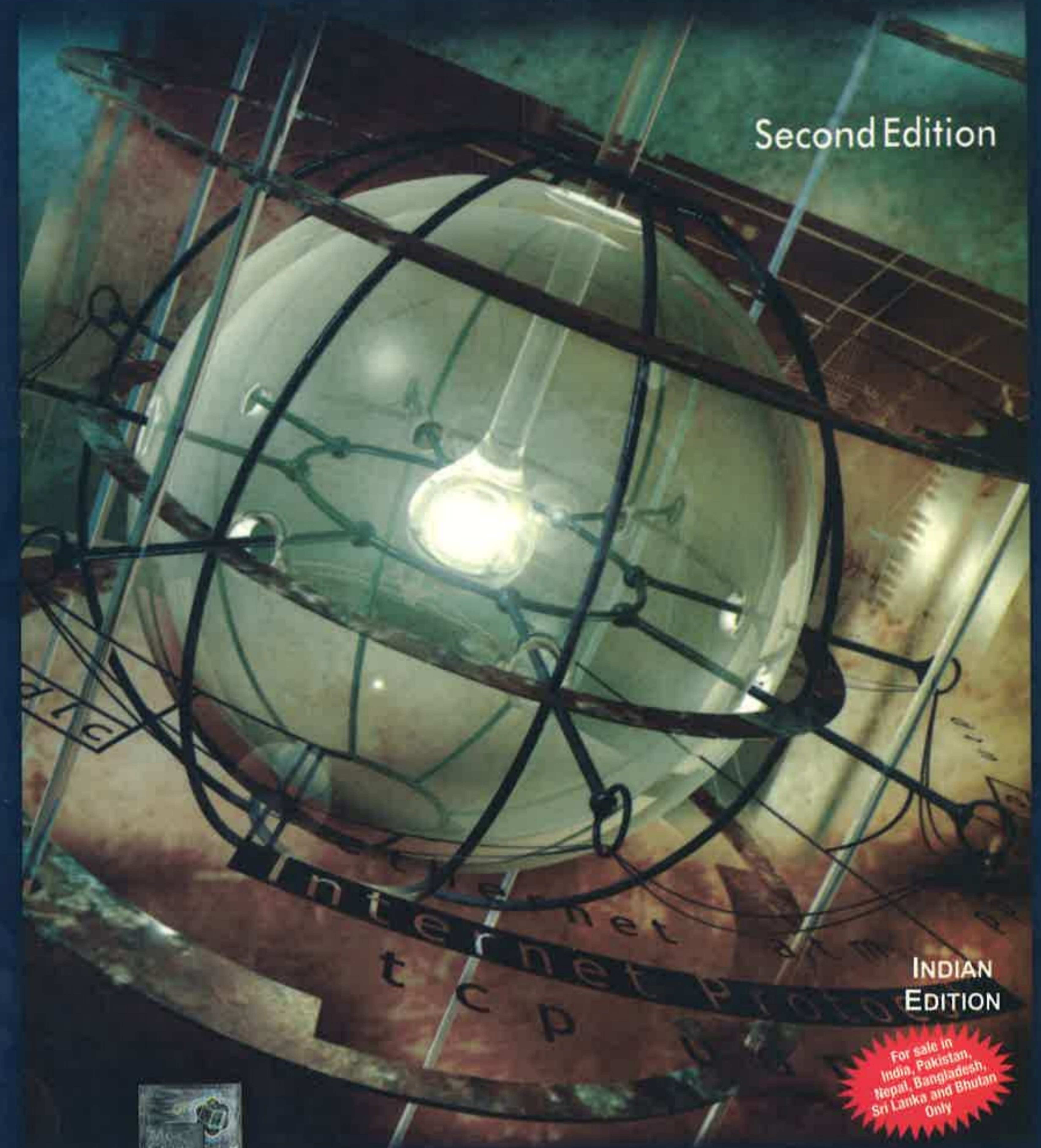


Alberto Leon-Garcia

Indra Widjaja

Second Edition



INDIAN
EDITION

For sale in
India, Pakistan,
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Only



COMMUNICATION NETWORKS

Fundamental Concepts and Key Architectures

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PREFACE

OBJECTIVE

Communication networks are in a period of transition from networks that are based on telephone architecture and standards to networks based on the Internet Protocol (IP) architecture. The main reason for this change is that new services and applications can be deployed with unprecedented speed over an Internet that has attained the global reach of the telephone network. Many of these new applications and services are quite visible to the student. For example, in addition to e-mail and web surfing, there is buying/selling over the Internet (eBay), MP3 and other file exchanges (Napster, KaZaA), interactive games (Counterstrike), video streaming (CNN), and voice-over-IP (Net-Meeting, ICQ). Many other applications and services are having profound impact on business, manufacturing, international commerce, medicine, and government.

The infrastructure of communication networks is undergoing dramatic change under pressure from the new services and enabled by technology innovation. A new generation of wireless devices combines aspects of cellular phones, personal digital assistants, and even digital cameras and is enabling new modes of mobile communication such as short text messaging, event notification, e-mail, and web browsing. These wireless services are blazing a trail away from traditional telephony to new modes of IP-based multimedia communications. Inevitably the signaling system that enables all of the functionality of the cellular and telephone network will be replaced by more versatile signaling based on Internet protocols. A new generation of IP-based protocols will control and manage the resources in the next generation of networks.

It is in this exciting context of new services and emerging next-generation network architecture that we offer this second edition of our textbook. The purpose of this book is to provide an introduction to fundamental network architecture concepts and their application in existing and emerging networks. We emphasize the pivotal role of Internet protocols in future network architecture and at the same time provide a broad coverage of fundamental network concepts. Our view is that the student will be best prepared for a future of constant change through exposure to network design alternatives.

TARGET COURSES

The book is designed for introductory courses in computer networks and in communication networks at the upper-level undergraduate and first-year graduate programs in electrical engineering, computer engineering, and computer science. The book contains all the basic material covered in typical one-semester first courses in computer networks and in communication networks. The book also provides additional material in each chapter as well as advanced topics in the later chapters so that the book can be used in a two-semester course sequence. The book is up-to-date in its coverage of emerging network architecture and can also be used by engineering and computer professionals.

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A GUIDE TO THE ALPHABET SOUP OF COMMUNICATION NETWORKS

AAL	ATM adaptation layer	CLP	cell loss priority
ABM	asynchronous balanced mode	CLR	cell loss ratio
ABR	available bit rate	CPCS	common part convergence sublayer
ACK	acknowledgment frame	CRC	cyclic redundancy check
ADM	add-drop multiplexer	CS	convergence sublayer
ADPCM	adaptive DPCM	CSMA	carrier sensing multiple access
AES	Advanced Encryption Standard	CSMA-CA	carrier sensing multiple access with collision avoidance
ADSL	asymmetric digital subscriber line	CSMA-CD	carrier sensing multiple access with collision detection
AF PHB	assured forwarding PHB	CTS	Clear-to-Send
AH	authentication header	DCC	digital cross-connect
AMPS	Advanced Mobile Phone Service	DCF	distributed coordination function
ANSI	American National Standards Institute	DCT	discrete cosine transform
AP	access point	DES	Data Encryption Standard
API	application programming interface	DHCP	Dynamic Host Configuration Protocol
APS	automatic protection switching	DIFS	DCF interframe space
ARP	Address Resolution Protocol	DISC	Disconnect
ARQ	automatic repeat request	DNHR	dynamic nonhierarchical routing
AS	autonomous system	DNS	Domain Name System
ASCII	American Standard Code for Information Interchange	DPCM	differential PCM
ASK	amplitude shift keying	DS- <i>n</i>	digital signal- <i>n</i>
ATM	asynchronous transfer mode	DS	differentiated services model
BGP	Border Gateway Protocol	DTE	data terminal equipment
B-ICI	broadband intercarrier interface	DTL	designated transit List
BLSR	bidirectional line switching ring	DVMRP	Distance-Vector Multicast Routing Protocol
BRI	basic rate interface	eBGP	external BGP
BSS	basic service set	ECB	electronic codebook
CA	certification authority	ECMP	equal-cost multipath
CBC	cipher block chaining	EF PHB	expedited forwarding PHB
CBR	constant bit rate	EGP	Exterior Gateway Protocol
CCITT	Consultative Committee for International Telegraphy and Telephony	ENQ	enquiry frame
CDPD	cellular digital packet data	ESP	Encapsulating Security Payload
CDMA	code division multiple access	ESS	extended service set
CDV	cell delay variation	FA	foreign agent
CEPT	Comité Européen de Post et Télégraphie	FDD	frequency division duplex
CFP	contention-free period	FDDI	Fiber Distributed Data Interface
CH	correspondent host	FDM	frequency-division multiplexing
CHAP	Challenge-Handshake Authentication Protocol	FCS	frame check sequence
CIDR	classless interdomain routing	FDMA	frequency-division multiple access
		FEC	forward error correction
		FEC	forwarding equivalence class

FIFO	first in, first out queueing	LEC	LAN Emulation Client
FRMR	Frame Reject	LEC	local exchange carrier
FSK	frequency shift keying	LLC	logical link control
FTP	File Transfer Protocol	LMP	Link Management Protocol
GCAC	generic connection admission control	LPC	linear predictive coders
GCRA	generalized cell rate algorithm	LSP	label switched path
GFC	generic flow control	LSR	label switch router
GFP	Generic Framing Protocol	MAC	medium access control
GIF	graphical interchange format	MAC	message authentication code
GMPLS	generalized MPLS	MBONE	multicast backbone
GPRS	general packet radio service	MBS	maximum burst size
GSM	Global System for Mobile Communications	MD5	message digest 5 algorithm
HA	home agent	MH	mobile host
HDLC	High-level Data Link Control	MIB	management information base
HMAC	hashed message authentication code	MID	message identifier
HEC	header error check	MP3	MPEG audio layer 3
HOL	head-of-line priority queueing	MPC	MPOA client
HTML	hypertext markup language	MPEG	Motion Picture Expert Group
HTTP	Hypertext Transfer Protocol	MPLS	multiprotocol label switching
iBGP	internal BGP	MPOA	multiprotocol over ATM
ICMP	Internet Control Message Protocol	MPS	MPOA server
IEEE	Institute of Electrical and Electronics Engineers	MSC	mobile switching office
IETF	Internet Engineering Task Force	MSL	maximum segment lifetime
IGMP	Internet Group Management Protocol	MSS	maximum segment size
IGP	Interior Gateway Protocol	MTSO	mobile telephone switching office
IKE	internet key exchange	MTU	maximum transmission unit
IP	Internet Protocol	NAK	negative acknowledgment frame
IPCP	IP Control Protocol	NAV	network allocation vector
IPSec	IP security	NCP	Network Control Protocol
IS	Interim Standard	NIC	network interface card
ISDN	Integrated Services Digital Network	NNI	network-network interface
ISN	initial sequence number	NRM	normal response mode
ISO	International Organization for Standardization	NRZ	nonreturn-to-zero encoding
ISUP	ISDN user part	NRZ-I	NRZ-Inverted
ITU	International Telecommunications Union	NVT	network virtual terminal
IXC	interexchange carrier	OADM	optical add-drop multiplexer
JPEG	Joint Photograph Expert Group	OC-n	optical carrier level-n
KDC	key distribution center	OSI	open systems interconnection
LAN	local area network	OSPF	open shortest path first
LAP	link access procedure	P2P	peer-to-peer
LATA	local access transport areas	PAP	Password Authentication Protocol
LCP	Link Control Protocol	PCF	point coordination function
LDP	Label Distribution Protocol	PCM	pulse code modulation
		PDU	protocol data unit
		PHB	per-hop behavior
		PIFS	PCF interframe space
		PLCP	physical layer convergence procedure
		PMD	physical medium dependent

PNNI	private network-to-network interface	SNRM	Set Normal Response Mode
POP3	Post Office Protocol version 3	SONET	synchronous optical network
POS	packet over SONET	SPE	synchronous payload envelope
POTS	plain old telephone service	SREJ	Selective Reject
PPP	Point-to-Point Protocol	SSCOP	Service Specific Connection-Oriented Protocol
PRI	primary rate interface	SSCS	service specific convergence sublayer
PSK	phase shift keying	SS7	Signaling System #7
QAM	quadrature amplitude modulation	STM-n	synchronous transfer module-n
QoS	Quality of Service	STP	signal transfer point
RARP	Reverse Address Resolution Protocol	STS-n	synchronous transport signal level-n
RBOC	regional Bell operating company	SVC	switched virtual connection
RED	random early detection	TCA	traffic conditioning agreement
REJ	Reject	TCAP	transaction capabilities part
RIO	RED with IN/OUT	TCB	transmission control block
RIP	Routing Information Protocol	TCP	Transmission Control Protocol
RM	resource management	TDD	time-division duplex
RMON	remote network monitoring	TDM	time-division multiplexing
RNR	Receive Not Ready	TDMA	time-division multiple access
RPB	reverse-path broadcasting	THT	token holding time
RPM	reverse-path multicasting	TLS	transport layer security
RR	Receive Ready	TRPB	truncated reverse-path broadcasting
RSA	Rivest, Shamir, and Adleman algorithm	TRT	token rotation timer
RSVP	ReSerVation Protocol	TSI	time-slot interchange
RSVP-TE	RSVP with Traffic Engineering	TST	time-space-time switch
RTCP	RTP Control Protocol	TTL	time-to-live
RTP	Real-Time Transport Protocol	TTRT	target token rotation time
RTS	Request-to-Send	UA	unnumbered acknowledgment
RTT	round trip time	UBR	unspecified bit rate
SABM	Set Asynchronous Balanced Mode	UDP	User Datagram Protocol
SAP	service access point	UNI	user-network interface
SAR	segmentation and reassembly	UPSR	unidirectional path switched ring
SCP	signal control point	URL	uniform resource locator
SCCP	signaling connection control part	UTP	unshielded twisted pair
SDH	synchronous digital hierarchy	VBR	variable bit rate
SDP	Session Description Protocol	VC	virtual circuit
SDU	service data unit	VCC	virtual circuit connection
SHA-1	secure hash algorithm-1	VCI	virtual channel identifier
SIFS	short IFS	VCI	virtual circuit identifier
SIP	Session Initiation Protocol	VLAN	virtual LAN
SLA	service level agreement	VOIP	voice over IP
SMS	short message service	VPI	virtual path identifier
SMTP	Simple Mail Transfer Protocol	VPN	virtual private network
SNAP	Subnetwork Access Protocol	WAN	wide area network
SNMP	Simple Network Management Protocol	WAP	Wireless Application Protocol
SNR	signal-to-noise ratio	WDM	wavelength-division multiplexing
		WWW	World Wide Web

An introduction to communication networks that is organized to prepare students for the exciting possibilities of next generation networks and services

- **Big picture first**
 - How services and applications drive network architecture evolution
 - How layers work together to deliver services
 - Application layer, transport layer, and sockets
- **Fundamental concepts in Network Architecture**
 - Digital transmission; copper, cable, radio, and optical media
 - SONET and optical networking
 - Circuit switching, signaling, telephone services, mobility
 - Peer-to-peer protocol design; PPP, HDLC, POS and GFP
 - Medium-access control; Ethernet and 802.11 wireless LANs
 - Voice and data cellular networks
 - Packet switching, routing, congestion control and QoS
- **Key architectures, Advanced Topics, and Next Generation Networks**
 - IPv4 and IPv6; TCP, UDP; RIP, OSPF, BGP; DHCP and mobile IP
 - ATM networks
 - New Architectures: IntServ, RSVP, DiffServ, Peer vs. Overlay Interconnection, MPLS and GMPLS, RTP, SIP, H.323, and WAP
 - Network Security: DES and AES, RSA, IPSec, SSL and TLS, 802.11
 - Multimedia standards: JPEG, MPEG, Audio, MP3, Voice-Over IP
 - Network management and performance modeling

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 - Ping, IPconfig, netstat, and traceroute introduced with exercises
- **Sockets provide hands on experience in protocol design**
 - Berkeley sockets introduced and exercises and projects included
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