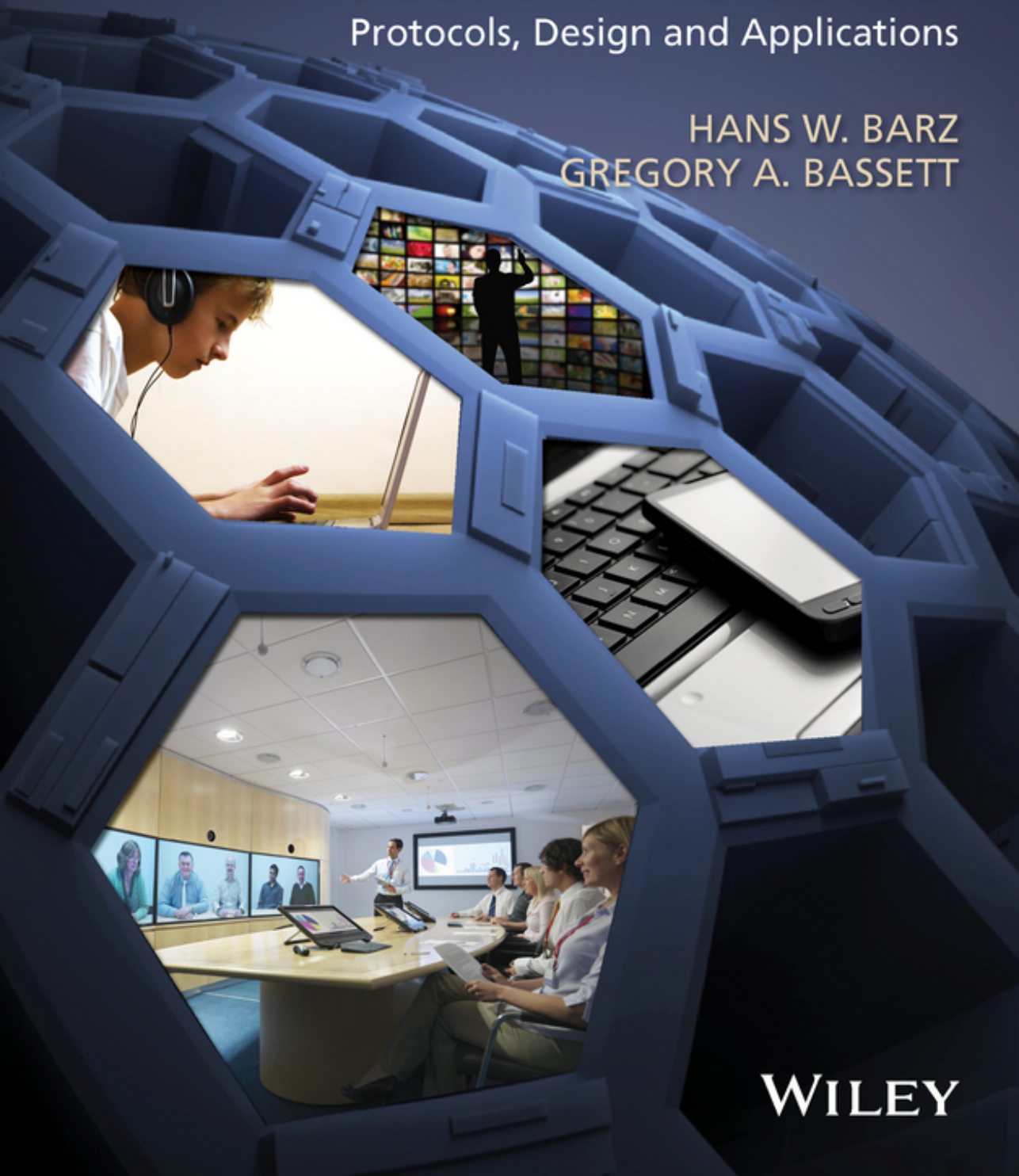
MULTIMEDIA NETWORKS

Protocols, Design and Applications

HANS W. BARZ
GREGORY A. BASSETT



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Preface

It is obvious to almost any consumer with a PC, Smartphone, radio, TV, or even a "normal" telephone that the methods of communicating, listening to, or viewing content have changed radically over the past years. Napster, iPhone, Skype, Netflix, Android, Internet Radio, YouTube, VoIP, streaming programs from TV networks (the list is almost endless) have all profoundly changed the way we talk, listen, and watch.

What sets multimedia delivery somewhat apart from other technology topics is its unusually high level of complexity. Different user platforms, different network media, different types of content, and of course, many different vendors and standards all make this topic a challenging one.

The motivation for this book is based on the many new multimedia technologies that have appeared or changed in the past 15 years, the immense number of new standards, and the lack of overarching books on the subject. At the time of writing, there is no book available that covers the range of topics you find here, which are needed to cope with multimedia usage from a network point of view. It goes without saying that there are many excellent books on the individual subjects covered in this book. In fact, we cite many of them as references. While they cover specific topics in detail, this book provides the "big picture" and ties together the various principles for the entire multimedia space.

Another driver for this book is the authors' involvement in deploying multimedia applications and networks in large multinational companies. These deployments and operational involvement provided insight into what is important and what can safely be ignored. Many new multimedia technologies went live during our working time in networks, and the reader will profit from the combined practical experience and technological background of the authors.

This book focuses primarily on principles but sometimes dives into the details to show how the principles really work in practical situations. As a prerequisite for reading the book, you need basic knowledge of networks, but no additional literature is required. Since this book is aimed to give an overview in a rather active field, we provide the reader with extensive references – over 600 recent literature links – to dive deeper. In addition, the detailed index and the abbreviation list will help you easily find the treatment of a specific subject.

Acknowledgments

First and foremost, we must thank our spouses and families. The writing of a reference book is a long and difficult task. Without their patience and support over many months, including during holidays, we could not have completed this book.

We also thank Professor Bernhard Plattner from ETH Zürich (Switzerland) for his support of a lecture by Hans Barz from 2010 to 2014 on this subject at the ETH.

Finally, and equally important, we thank our former colleagues from the networking group at Hoffmann-La Roche in Basel, Switzerland (PGIN), for working together with us to create and implement many of the multimedia solutions described here in the book. Our special thanks to Andre Rudin for his expert review of our material, Andy Fringeli for world-class operational insight, and Brian O'Connor for all things related to voice. There are other members of the PGIN team too numerous to mention, but they know who they are.

About the Authors

Hans W. Barz
Hans Barz received a Master's Degree in Economical Engineering from the Technical University in Karlsruhe, Germany (Prof. H. Maurer) and a PhD in Computer Science from University Bonn, Germany (Prof. H. Zima) with a theme on the power of synchronization mechanisms. He worked for over 25 years with the IT staff at the headquarters of Ciba-Geigy, Novartis, Syngenta, and Hoffmann-La Roche in Basel. For many years, he held the position of Global Head of Architecture. At that time, he was responsible for major rollouts of new technologies (TCP/IP, X.400/X.500 backbone, E-Business-Infrastructure), technology trials (DECnet Phase V, OSI, PKI), and infrastructure consolidations in mergers and split-offs. In Hoffmann-La Roche, he was, for many years, Global Head of Network Services with engineering and operation responsibility for networks, telephony, and multimedia services in more than 80 countries.

He has lectured on telecommunication subjects at the University Freiburg (Germany), University Basel (Switzerland), and ETH Zürich (Switzerland). He did publish a number of articles on parallel processing and a book on telecommunication in 1994 (Hanser Verlag, in German).

Gregory A. Bassett
Greg Bassett received a Bachelor's Degree in Computer Engineering from Syracuse University, in Syracuse, NY, USA. The first 20 years of his career was spent working for Digital Equipment Corporation is a wide variety of roles including instructor (including teaching the first DECnet course offered), software engineer, technical leader for networking and personal computers, and program management.

For the next 18 years, he worked for the pharmaceutical companies of Syntex in Palo Alto, CA, USA, and Hoffmann-La Roche in Basel, Switzerland. He spent 8 years as a network engineer. For the remaining 10 years, he was an Enterprise Architect responsible for networking including data, fixed and mobile voice, video, and call center. He earned the Cisco Certified Internetworking Engineer (CCIE) in Routing and Switching certification in 2002.

During his years as an Enterprise Architect for Roche, he worked closely with Hans Barz to develop networking strategies and implementation plans.

Abbreviations

This list contains more than 1500 abbreviations. Many abbreviations are in bold. Those abbreviations in bold are handled in this book and mentioned in the index. When searching abbreviations in the index, it may be helpful first to expand the abbreviation in this list and then look it up in the index.

3DTV:	3-Dimensional TV
3GPP:	3rd-Generation Partnership Project
AAA:	Authentication, Authorization, and Accounting
AAC:	Advanced Audio Coding
AAL:	ATM Adaption Layer
AAM:	Audio Activity Metric
AAR:	AA Request
ABNF:	Augmented Backus – Naur Form
ABR:	Available Bit Rate
AC:	Alternating Current
ACA:	Accounting Answer
ACD:	Automatic Call Distribution
ACE:	Advanced Coding Efficiency
ACELP:	Algebraic Code Excited Linear Prediction
ACF:	Admission ConFirm
ACK:	ACKnowledge
ACM:	Address Complete Message
ACR:	Automatic Call Return/Accounting Request
ACS:	Auto Configuration Server
AD:	Active Directory (Microsoft)
A/D:	Analog-to-Digital
ADC:	Analog-to-Digital Converter
ADPCM:	Adaptive Differential Pulse Code Modulation
ADSL:	Asymmetric Digital Subscriber Line
ADTS:	Audio Data Transport Stream
ADU:	Application Data Unit
AEC:	Adaptive Error Concealment/Acoustic Echo Canceller
AES:	Audio Engineering Society, Advanced Encryption Standard
AF:	Adaption Field/Assured Forwarding

AFC: Automatic Frequency Control
AFX: MPEG-4 Animation Framework eXtension
AGCF: Access Gateway Control Function
A-GNSS: Assisted Global Navigation Satellite System
AGW: Access GateWay
AHS: Adaptive HTTP Streaming
AHT: Average Holding Time
AIT: Application Information Table
AKA: Authentication and Key Agreement
ALC: Asynchronous Layered Coding
ALF: Application Layer Framing/Adaptive Loop Filtering
AL-FEC: Application Layer-FEC
ALG: Application Layer Gateway
ALI: Automated Location Identifier
ALL: Application Layer Logic
ALM: Application Layer Multicast
ALS: Audio Lossless Coding
ALTO: Application Layer Traffic Optimization
AM: Amplitude Modulation
AMF: Action Message Format
A-MGF: Access Media Gateway Function
AMI: Alternate Mark Inversion
AMP: Adaptive Media Play-out/Access Network Provider
AMR: Adaptive Multirate
ANDSF: Access Network Discovery and Selection
ANI: Automatic Number Identification
ANSI: American National Standard Institute
AOC: Advice Of Charge
AOI: Area Of Interest
AOR: Address Of Record
AP: Authentication Proxy
APC: Adaptive Predictive Coding
APE: Application Protocol Entities
API: Application Programming Interface
APN: Access Point Name
APT: Actual Presentation Timestamp
AQM: Active Queue Management
ARED: Adaptive Random Early Detection
ARF: Access Relay Function
ARIB: Association of Radio Industries and Business
ARJ: Admission Reject
ARP: Allocation and Retention Priority
ARQ: Automated Repeat-reQuest/Admission Request
ARTS: Advanced Real Time Simple profile
AS: Application Server/Application-Specific maximum bandwidth/Application Sharing

ASA: Abort Session Answer
ASF: Advanced Streaming Format
AS-FE: Application Support Functional Entity
ASI: Asynchronous Serial Interface
ASM: Any Source Multicast
ASN.1: Abstract Syntax Notation 1
ASO: Arbitrarily Slice Ordering
ASP: Application Service Provider/Application Server Processes
ASR: Abort Session Request/Automatic Speech Recognition
ATCF: Access Transfer Control Function
ATGW: Access Transfer GateWay
ATIS: Alliance for Telecommunication Industry Solutions
ATM: Asynchronous Transfer Mode
ATS: Adaptive Transport Stream
ATSC: Advanced Television Systems Committee
AT&T: American Telephone & Telegraph company
AU: Access Unit
AUC: Authentication Center
AUCX: AUdit Connection
AUEP: Audit EndPoint
AUID: Application Usage Identification
AUR: Address of Record
AUTN: AUTHentificatioN Token
AutoIP: Automatic IP addresses
AV: Audio-Visual/Audio Video
A/V: Audio/Video
AVC: Advanced/Audio Video Codec
AVI: Audio Video Interleave
AVO: Audiovisual Object
AVP: Audio Video Profile/Audio Visual Profile
AVPF: Audio Video Profile Feedback
AVS: Audio Video coding Standard
AVT: Audio Video Transport
B2BUA: Back-to-Back User Agent
BAP: Body Animation Parameters
BAT: Bouquet Association Table
BBC: British Broadcasting Service
BBF: BroadBand Forum
BC: BroadCast
BCF: Bandwidth Confirm Message
BCG: Broadband Content Guide
BCH: Bose-Chaudhuri – Hocquenghem code
BCP: Best Current Practice
BD: Blue-ray Disk
BDP: Body Definition Parameters
BE: Best Effort

BER: Basic Encoding Rules
BFCP: Binary Floor Control Protocol
BGCF: Breakout Gateway Control Function
BGD: Broadband Gateway Device
BGMP: Border Gateway Multicast Protocol
BGP: Border Gateway Protocol
BHCA: Busy Hour Call Attempts
BHT: Busy Hour Traffic
BICC: Bearer Independent Call Control
BIFS: Binary Format for Scenes
BiM: Binary MPEG Format for XML
BIOP: Broadcast Inter ORB Protocol
BISDN: Broadband ISDN
BLF: Busy Lamp Field
BLP: Bitmask Lost Packet
BMA: Boundary Matching Algorithm
BMFF: Base Media File Format
BMP: BitMaP
BNF: Backus-Naur Form
BNG: Broadband Network Gateway
bpp: bits per pixel
BRA: Basic Rate Access
BRAS: Broadband Remote Access Server
BRI: Basic Rate Interface
BRJ: Bandwidth Reject Message
BRQ: Bandwidth Request
BSAC: Bit-Sliced Arithmetic Coding
BSP: Broadband Service Provider
BSR: BootStrap Router
BSS: Base Station System
BT: British Telecom
BTS: Base Transceiver Station
CA: Conditional Access/Civic Address
CABAC: Content-Adaptive Binary Arithmetic Coding
CAC: Connection/Call Admission Control
CAF: Control of Agent Features
CAN: Connectivity Access Network
CAP: Competitive Access Provider
CAPI: Common ISDN Application Programming Interface
CARP: Cache Array Routing Protocol
CAS: Channel Associated Signaling/Conditional Access System
CAT: Conditional Access Table
CAT: Customized Alerting Tone
CATV: Community Access Television/Community Antenna Television/CAble TeleVision
CAVLC: Content-Adaptive Variable Length Coding

CB:	Coding Block/Communication Barring
C-BGF:	Core Border Gateway Function
CBMS:	Convergence of Broadcast and Mobile Services
CBR:	Constant Bit Rate
CBS:	Committed Burst Size
CBT:	Center-Based Tree/Core-Based Tree
CCBS:	Call Completion to Busy Subscriber
CCBS:	Completion of Communication to Busy Subscribers
CCF:	Common File Format/Charging Collection Function
CCI:	Congestion Control Identifier
CCIR:	Consultative Committee International Radio (now ITU-R)
CCITT:	Consultative Committee International Telecommunication Union (now ITU-T)
CCM:	Codex Control Messages
CCMP:	Centralized Conference Manipulation Control
CCN:	Content-Centric Networking
CCNR:	Completion of Communication on No Reply
CCS:	Common Channel Signaling
CCSA:	China Communication Standards Association
CCXML:	CallControl XML
CD:	Communication Deflection/Committee Draft
CDB:	Coded Data Buffer
CDF:	Content Delivery Function/Charging Data Function
CD&LCF:	Content Distribution and Location Control Function
CDMA:	Code Division Multiple Access
CDN:	Content Delivery Network
CDNI:	Content Delivery Network Interconnection
CDP:	Cisco Discovery Protocol
CDR:	Call Detail Record/Charging Data Record/Committed Data Rate/Common Data Representation
CDS:	Content Download Service/Content Directory Service
CD&SF:	Content Delivery and Storage Function
CDV:	Cell Delay Variation
CE:	Congestion Experience/Core Experiment
CEC:	Commission of the European Communities
CEI:	Commission Electrotechnique Internationale (in English IEC)
CELP:	Code(-book) Excited Linear Prediction
CEN:	Comité Européen de NormaliSation
CENC:	Content ENCoding/Common ENCryption
CENELEC:	Comite Europeen de NormaliSation Electrotechnique
CEPT:	European Conference of Postal and Telecommunications Administrations
CER:	Confidential Encoding Rules
CFB:	Communication Forwarding Busy
CFF:	Common File Format
CFNL:	Communication Forwarding on Not Logged in
CFNR:	Communication Forwarding No Reply

CFU: Communication Forwarding Unconditional
CGF: Charging Gateway Function
CGI: Cell Global Identification/Common Gateway Interface
CGS: Coarse Granularity Scalability
C/I: Carrier to Interference ratio
CI: Common Interface/Content Identifier
CIC: Circuit Identification Code
CID: Context Identifier
CIF: Common Image Format/Common Intermediate Format/Common Interface Format
CII: Content Identification and other Information
CIPA: Camera & Imaging Products Association
CIPID: Contact Information for the Presence Information Data
CIR: Cyclic Intra Refresh
CK: Ciphering Key
CLC: Channel CLose
CLEC: Competitive Local Exchange Carrier
CLI: Call Line Identification
CLIP: Call Line Identification Presentation
CLUE: ControLling mUltiple streams for tElepresence
CLUT: Color LookUp Table
CM: Connection Manager/Content Marker
CMD: Carousel Multicast Download
CMS: Content Management System
CMTS: Cable Modem Termination System
CN: Core Network
CNAME: CaNonical Name
CNCGF: Customer Network Gateway Configuration Function
CND: Customer Network Device
CNG: Comfort Noise Generation/Customer Network Gateway
CO: Central Office
CoD: Content on Demand
CONF: CONFerence calling
CORBA: Common Object Request Broker Architecture
CoS: Class of Service
CP: Content Protection/Customer Premises/Control Point
CPB: Coded Picture Buffer
CPC: Continuous Packet Connectivity
CPCM: Content Protection and Copy Management
CPDT: Cascaded Pixel-Domain Transcoders
CPE: Customer Premise Equipment
CPF: Content Provider Function
CPG: Call ProGress
CPI: Common Interface Plus
CPL: Call Processing Language
CPN: Customer Premise Network

CPVR: Client Personal Video Recorder
CQ: Custom Queuing
CR: Carriage Return
CR: Content Recommendation
CR LF: Carriage Return Line Feed
CRC: Cyclic Redundancy Check
CRID: Content Reference IDentifier
CR-LSP: Constraint-Based LSP
CRM: Customer Relationship Management
CRS: Customized Ringing Signal/Content Recommendation Service
CRT: Carriage ReTurn
CRTP: Compressed RTP
CS: Circuit Switched/Communication Session/Companion Screen
CSA: Companion Screen Application, Common Scrambling Algorithm
CSCF: Call State Control Function
CS-DON: Cross Sessions DON
CSF: Content Security Function
CSFB: Circuit Switch FallBack
CS-MGW: Circuit-Switched Mobile GateWay
CSMO: Circuit Switched Mobile Originating
CSP: Content Service Provider
CSQ: Contact Service Queues
CSRC: Contributing SouRCe
CSS: Companion Screen and Supplementary streams/Cascaded Style Sheet
CSV: Capture Scene View
CT: Coding Tree/Composition Time
CTB: Coding Tree Block
CTF: Charging Trigger Function
CTI: Computer Telephony Integration
CTU: Coding Tree Unit
CU: Coding Unit
CUG: Closed User Group
CU-RTC-Web: Customizable, Ubiquitous Real Time Communication over the Web
CVBS: Color-Video Blanking System
CVT: Commercial Video Player Format
CW: Communication Waiting
CWMP: CPE WAN Management Protocol
CWT: Continuous Wavelet Transform
D2D: Device-to-Device
DA: Directory Agent
DAAP: Digest Access Authentication/Digital Audio Access Protocol
DAB: Digital Audio Broadcasting
DAC: Digital-to-Analog Converter
DAI: DMIF Application Interface
DASH: Dynamic Adaptive Streaming over HTTP
DAVIC: Digital Audio VIsual Council

dB: DeciBel
DBC: Dictionary-Based Coding
DBE: Data path Border Element
dBOV: dB OVerload
DC: Direct Current
DCEP: Data Channel Establishment Protocol
DCF: Disengage ConFirm/DRM Content Format
DCH: Dedicated CHannel
DCIA: Distributed Computing Industry Association
DCP: Device Control Protocol
DCT: Discrete Cosine Transform
DDB: Downloadable Data Block
DDC: Device Discovery and Control
DDD: Device Description Document
DDL: Description Definition Language
DECE: Digital Entertainment Consortium Ecosystem
DECT: Digital Enhanced Cordless Telecommunications
DER: Distinguished Encoding Rules
DF: Digital Fountains/Do not Fragment
DFCA: Dynamic Frequency and Channel Allocation
DFT: Delay Factor/Discrete Fourier Transform
DFXP: Distribution Format eXchange Profile
DHCP: Dynamic Host Configuration Protocol
DHT: Distributed Hash Table
DIAL: DIscovery And Launch
DIBR: Depth Image-Based Rendering
DID: Direct Inward Dialing
DIDL: Digital Item Declaration Language
DiffServ: Differential Services
DII: Downloadable Indication Message
DL: DownLink
DLCX: DeLete Connection
DLNA: Digital Living Network Alliance
DLSR: Delay Last Sender Report
DM: Dense Mode
DMAP: Digital Media Access Protocol
DMC: Digital Media Controller
DMIF: Delivery Multimedia Integration Framework
DMP: Digital Media Player
DMPr: Digital Media Printer
DMR: Digital Media Renderer
DMS: Digital Media Server
DND: Do Not Disturb
DNG: Delivery Network Gateway
DNI: Digital Number Identification/DMIF Network Interface
DNS: Domain Name Service