

INTRODUCTION TO MULTIMEDIA COMMUNICATIONS

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Applications, Middleware,
Networking

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PREFACE

Multimedia communications have emerged as a major research and development area. In particular, computers in multimedia open a wide range of possibilities by combining different types of digital media such as text, graphics, audio, and video. The emergence of the World Wide Web (WWW), two decades ago, has fuelled the growth of multimedia computing. Because the number of multimedia users is increasingly daily, there is a strong need for books on multimedia systems and communications. Generally speaking, the books can be divided into two major categories. In the first category, the books are purely technical, providing detailed theories of multimedia engineering with an emphasis on signal processing. In the second category, the books on multimedia are primarily about content creation and management. Today, there is a strong need for books somewhere between these two extremes.

This unique book intends to fill this gap by explaining multimedia communications in three areas: applications, middleware, and networking. In this way, the volume will be useful for readers who are carrying out research and development in systems area such as television engineering and storage media. It will also provide readers with the protocol information needed to support a wide variety of multimedia services.

The book reflects the latest work in the field of multimedia communications, providing both underlying theory and today's best design techniques, by

- systematically addressing aspects of recent trends and standardization activities in multimedia communications, and
- covering the layered structure of multimedia communication systems.

BOOK OBJECTIVES AND INTENDED AUDIENCE

Anyone who seeks to learn the core multimedia communication technologies will need this book. The practicing engineering or scientist working in the area of

multimedia communication is forced to own a number of different texts and journals to ensure a satisfactory coverage of the essential ideas and techniques of the field. The pressing need for a comprehensive book on important topics in multimedia communications is apparent. Our first objective for the handbook is to be the source of information on important topics in multimedia communications, including the standardization process. The organization of standard bodies is currently vertical, and this should be changed to a horizontal one. There should be one body addressing the delivery layer issues, possibly structured along different delivery media, one body for the application layer, and one body for middleware. The only thing that digital technologies leave as specific to the individual industries is the delivery layer.

One of the proposed book's objectives is a distillation from the extensive literature of the central ideas and primary methods of analysis, design, and implementation of multimedia communication systems. The book also points the reader to the primary reference sources that give details of design and analysis methods.

To conclude, the objective of the book is not only to formalize the reader with this field, but also to provide the underlying theory, concepts, and principles related to the power and practical utility of the topics.

ORGANIZATION OF THE BOOK

Following an Introduction, Chapter 2 of the handbook begins by introducing the reader to the convergence of communications and computing for integrated multimedia applications and services. Following the introduction, we provide technologies for multimedia communications. Next, we invoke the multimedia database. We then discuss trends in multimedia standardization.

Chapter 3 covers frameworks for multimedia standardization. With the increasing demand for multimedia services, multimedia standardization has drawn tremendous levels of attention. First, the ITU MEDIACOM2004 framework for multimedia standardization will be presented. A framework includes an application layer, a middleware layer, and a network layer. After that, we will present an overview of ETSI standardization and describe various standardization projects with regard to applications, middleware, and networks. Next, we will discuss the key elements defined in the MPEG-21 multimedia framework: digital item declaration, identification and description, content handling and usage, intellectual property management and protection, content representation, and event reporting.

Chapter 4 is devoted to the application layer. We cover ITU applications, ISO MPEG applications (multimedia videoconferencing, interactive video and broadcast, streaming content over the Internet, browsing and searching), IETF multimedia applications over IP. Finally, ETSI Digital video broadcasting (interactive TV, Multimedia Home Platform) and ATSC Digital TV will be analyzed.

Chapter 5 provides an overview of the middleware layer. We will describe media coding and conversion, and clarify multimedia protocol architecture. After that, we deal with a model for distributed system multimedia services, together with quality

of service and end-to-end performance in multimedia systems. We continue with accessibility to multimedia systems and services. The problem of security of multimedia systems and services will be demonstrated, too. This chapter will conclude with media-streaming middleware.

Chapter 6 concentrates on the network (distribution/delivery) layer. It includes many issues relating to the quality of service and network performance, traffic analysis, and management. We will also present modeling video source and network traffic. Traffic management will be analyzed, together with routing procedures, in multimedia communication. Signalling in communication networks will be discussed. Security issues in networks with Internet access will be provided as well. We will conclude this chapter with a description of multimedia transport and distribution, together with generic networks, broadband access networks, wireless communication networks, and streaming media networks. The goal of this chapter is to pave the way for future developments in the field and for a better understanding of its potential in today's world.

Each chapter has been organized so that it can be covered in one to two weeks when this handbook is used as a principal reference or text in a senior or graduate course at a university. It is generally assumed that the reader has prior exposure to the fundamentals of multimedia communication systems.

The bibliographic references will be grouped according to the various chapters. Special efforts will be taken to make this list as up to date and exhaustive as possible.

A major challenge during the preparation of this book was the rapid pace of development. Many specific applications have been realized in the past few years. We have tried to keep pace by including many of these latest developments. In this way it is hoped that the book is timely and will appeal to a wide audience in the engineering, scientific, and technical communication fields. In addition we have included more than 250 figures and over 570 references. Although this book is primarily for graduate students, it can also be very useful and suitable for advanced-level courses in multimedia communications (for academia, researchers, scientists, and engineers dealing with multimedia communications). Also, this is a well-needed addition to professional reference research. We feel that this book will serve as an essential and indispensable resource for many years.

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ACRONYMS

3GPP	Third Generation Partnership Project
A/V	Audio/Video
AAC	Advanced Audio Coding
AAL	ATM Adaptation Layer
AAP	ATM Access Point Process
ABME	All Binary Motion Estimation
ABR	Available Bit Rate
ACELP	Algebraic Code-Excited Linear Prediction
ACF	Autocovariance Function
ACK	Positive Acknowledgment
ADM	Add/Drop Multiplexer
ADSL	Asymmetrical Digital Subscriber Loop
AES	Advanced Encryption Standard
AGI	Active Group Integrity
AH	Authentication Header
AIR	Adaptive Intra Refresh
AL	Adaptation Layer
ALF	Application Level Framing
AM	Amplitude Modulation/Accounting Management
AMAC	Americas Market Awareness Committee
AMR	Adaptive Multirate
ANS	Announcement Server
ANSI	American National Standards Institute
API	Application Programming Interface
APMAC	Asia-Pacific Market Awareness Committee
AQM	Active Queue Management
ARMA	Autoregressive Moving Average
ARS	Actual Route Selection
AS	Autonomous System
ASIC	Application Specific Integrated Circuits
ASN	Abstract Syntax Notation

ASO	Arbitrary Slice Order
ASP	Application Service Provider/Active Service Pages
ATM	Asynchronous Transfer Mode
ATSC	Advanced Television System Committee
AuC	Authentication Center
AVC	Advanced Video Coding
AVO	Audio Visual Object
AVT	Audio Video Transport
B2B	Business to Business
B2C	Business to Consumer
B2E	Business to Employee
BB	Bandwidth Broker
BER	Bit Error Rate
BGP	Border Gateway Protocol
B-ICI	Broadband Inter Carrier Interface
BIFS	Binary Format for Scenes
BISDN	Broadband ISDN
BIU	Broadband Interface Unit
BLES	Broadband Loop Emulation Services
BMAP	Batch Markovian Arrival Process
BRAN	Broadband Radio Access Network
BS	Bearer Service
BSC	Base Station Subsystem
BTS	Base Transceiver Station
BUS	Broadcast and Unknown Server
CA	Conditional Access
CAB	Charging Accounting and Billing
CABAC	Context-based Adaptive Binary Arithmetic Coding
CAC	Connection Admission Control
CAT	Conditional Access Table
CATS	Consortium for Audiographics Teleconferencing Standards
CATV	Cable Television
C-BAR	Capacity-balanced Alternate Routing
CBR	Constant Bit Rate
CBT	Core-Based Tree
CC	Copyright Compliant
CCS	Computation/Communication Sensing
CD	Compact Disc
CDMA	Code Division Multiple Access
CDN	Content Delivery Network
CD-ROM	CD – Read Only Memory
CDV	Cell Delay Variation
CDVT	Call Delay Variation Tolerance
CEA	Consumer Electronic Association
CELP	Code Excited Linear Prediction

CEMA	Consumer Electronics Manufacturers Association
CGI	Common Gateway Interface
cHTML	Compact HTML
CIF	Common Intermediate Format
CL	Connectionless
CLIP	Calling Line Identification Presentation
CLP	Cell Loss Priority
CLR	Cell Loss Rate (Ratio)
CM	Cable Modem/Configuration Management
CMIP	Common Management Information Protocol
CMOS	Complementary Metal Oxide Semiconductor
CMS	Call Management Server
CMTS	Cable Modem Terminations System
CN	Core Network
CO	Connection – Oriented
CODFM	Coded Orthogonal Frequency Division Multiplex
COPS	Common Open Policy Service
COPS-PP	COPS for Policy Provisioning
CORBA	Common Object Requests Broker Architecture
COTS	Commercial Off-the-Shelf
CPB	Coded Picture Buffer
CPE	Customer Premises Equipment
CPU	Central Processing Unit
CR	Code Rate
CRC	Cyclic Redundancy Code
CR-LDP	Constraint-based Routing Label Distribution Protocol
CS	Coding Scheme
CSA	Carrier Serving Area
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
CSP	Content Service Provider
CSS	Content Scrambling System
CTD	Cell Transfer Delay
CUG	Closed User Group
CVoDSL	Channelized Voice over DSL
D+R	Drop and Repeat
DAB	Digital Audio Broadcast
DAI	Delivery Application Interface
DAVIC	Digital Audio Visual Council
DBS	Digital Broadcast Satellite
DCP	Dynamic Configuration Protocol
DCT	Discrete Cosine Transform
DDL	Description Definition Language
DDoS	Distributed DoS
DES	Data Encryption Standard
DI	Digital Item

DIA	Digital Item Adaptation
DID	Digital Item Declaration
DiffServ	Differentiated Service
DII	Digital Item Identification
DLC	Digital Loop Carrier
DMIF	Delivery Multimedia Integration Framework
DNG	Delivery Network Gateway
DNH	Digital Home Network
DNI	DMIF Network Interface
DNS	Direct Name System
DoS	Denial of Service
DPB	Decoded Picture Buffer
DPE	Distributed Processing Environment
DRM	Digital Rights Management
DS	Description Scheme
DSL	Digital Subscriber Line
DSLAM	DSL Access Multiplexer
DSM	Digital Storage Media/Dynamic Spectrum Management
DSM-CC	Digital Storage Media – Command and Control
DSNG	Digital Satellite News Gathering
DSR	Digital Satellite Radio
DSSS	Direct Sequence Spread Spectrum
DTH	Direct-to-Home
DTS	Decoding Time Stamp
DTTB	Digital Terrestrial Television Broadcasting
DVB	Digital Video Broadcasting
DVB-RCS	DVB – Return Channel Satellite
DVB-RCT	DVB – Terrestrial Return Channel
DVD	Digital Video Disk
DVI	Digital Video Interface
DVT	Digital Television
DWT	Discrete Wavelet Transform
EACEM	European Association of Consumer Electronics Manufacturers
EBU	European Broadcast Union
EC	Error Concealment
ECM	Encryption Controlled Message
ECN	Explicit Congestion Notification
EDGE	Enhanced Data rates for GSM Evolution
EIA	Electronics Industries Association
EII	European Information Infrastructure
EIR	Equipment Identity Register
EMEA	Europe Middle East Africa Market Awareness
EMM	Encryption Management Message
EOB	End of Blocks
EPG	Electronic Program Guide

EPII	European Project on Information Infrastructure
EREC	Error Resilient Entropy Code
ES	Elementary Stream
ESI	Elementary Stream Interface
ESP	Encapsulating Security Payload
ETSI	European Telecommunications Standards Institute
FAP	Facial Animation Parameters
FAR	Fixed Alternate Routing
FBM	Fractional Brownian Motion
FCAPS	Fault Configuration Accounting Performance Security
FCC	Federal Communications Commission
FCS	Feedback Control Signaling
FDD	Frequency Division Duplex
FDDI	Fiber Distributed Data Interface
FDDSS	Fiber Distributed Data Service
FDL	Fiber Delay Line
FDP	Facial Definition Parameters
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FIFO	First-In First-Out
FM	Frequency Modulation
FMO	Flexible MacroblocK Ordering
FPLS	Fair Packet Loss Sharing
FR	Fixed Routing
FRF	Frame Relay Forum
FSA	Framework Study Area
FSAN	Full Service Access Network
FTP	File Transfer Protocol
FTTC	Fiber To The Curb
FTTH	Fiber To The Home
FWA	Fixed Wireless Access
G2C	Government-to-Citizen
GDMO	Guidelines for the Definition of Managed Objects
GGSN	Gateway GPRS Support Node
GI	Guard Interval
GIF	Graphic Interchange Format
GII	Global Information Infrastructure
GIOP	General Inter-Operability Protocol
GMM	Global Multimedia Mobility
GOP	Group of Pictures
GPRS	General Packet Radio System
GPS	Global Positions Systems
GRM	Generic Relationship Model
GSC	Global Standards Collaboration
GSM	Global System for Mobile

GSTN	General Switched Telephone Network
GTP	GPRS Tunneling Protocol
GUI	Graphical User Interface
HAN	Home Access Network
HAS	Human Audible System
HDLC	High-bit-rate Data Link Control
HDSL	High-data-rate DSL
HDTV	High Definition Television
HFC	Hybrid Fiber Coaxial
HI	Hearing Impaired
HLN	Home Local Network
HLR	Home Location Register
HRD	Hypothetical Reference Decoder
HSS	Home Subscriber System
HTML	Hypertext Mark-up Language
HVXC	Harmonic Vector Excitation Coding
IAB	Internet Architecture Board
IANA	Internet Assigned Number Authority
IBAC	In-Band Adjacent-Channel
IBOC	In-Band On-Channel
IBT	Intrinsic Burst Tolerance
ICANN	Internet Corporation for Assigned Names and Numbers
ICTSB	Information and Communication Technology Standardization Board
IDB	Interactive Data Broadcast
IDL	Interface Definition Language
IDR	Instantaneous Decoder Refresh
IEC	International Electrotechnical Committee
IEEE	Institute of Electrical and Electronics Engineers
IESG	Internet Engineering Steering Group
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IGP	Interior Gateway Protocol
IHDN	In-Home Digital Network
IIF	Integrated Intermedia Format
IIP	Internet Interoperability Protocol
IISP	Information Infrastructure Standards Panel
IMT	International Mobile Telecommunication
IMTC	Internet Multimedia Telecommunications Consortium
IN	Intelligent Network
INAP	Intelligent Network Application Protocol
INF	Interworking Function
IntServ	Integrated Services
IOR	Interoperable Reference
IP	Internet Protocol
IPCDN	IP over Cable Data Network

IPDC	Internet Protocol Datacast
IPI	Internet Protocol Infrastructure
IPMP	Intellectual Property Management and Protection
IPR	Intellectual Property Rights
IPSEC	Internet Protocol Security
IPv6	Internet Protocol version 6
iQoS	Individual Quality of Service
IRD	Integrated Receiver Decoder
ISD	Independent Segment Decoding
ISDN	Integrated Services Digital Network
IS-IS	Intermediate System to Intermediate System
ISM	Industrial, Scientific, Medical
ISMA	Internet Streaming Media Alliance
ISO	International Organization for Standardization
ISOC	Internet Society
ISP	Internet Service Provider
ITSC	Interregional Telecommunications Standards Conference
ITU	International Telecommunication Union
ITU-R	ITU — Radio-communication Standardization Sector
ITU-T	ITU — Telecommunications Standardization Sector
IVB	Interactive Video Broadcast
JIDM	Joint Inter Domain Management
JPEG	Joint Photographic Experts Group
JSP	Java Service Pages
JTC	Joint Technical Committee
JVT	Joint Video Team
Kbps	Kilobits per second
KDC	Key Distribution Center
LAN	Local Area Network
CAVLC	Context-based Adaptive Variable Length Coding
LCS	Location Service Server
LEC	Local Exchange Carriers
LGMP	Local Group Multicast Protocol
LIFO	Last-In First-Out
LMDS	Local Multipoint Distribution Service
LOS	Line-of-Site
LSB	Last Significant Bit
LSI	Large Scale Integration
LSP	Label Switch Path
M4IF	MPEG-4 Industry Forum
MA	Multimedia Authentication
MAC	Medium Access Control/Message Authentication Code
MAN	Metropolitan Area Network
MAP	Manufacturing Automation Protocol
MB	Macroblock

MBN	Multiservice Broadband Network
MBONE	Multicast Backbone
Mbps	Megabits per second
MC	Motion Compensation
MCC	Mobile Competence Centre
MCCOI	Multimedia Communications Community of Interest
MCN	Multimedia Communication Network
MCP	Multimedia Car Platform
MCR	Maximum Cell Rate
MCU	Multipoint Central Unit
MD	Metering Device
MDC	Multiple Description Coding
MDS	Multipoint Distribution System/Multimedia Description Scheme
MG	Media Gateway
MGCP	Media Gateway Control Protocol
MHEG	Multimedia and Hypermedia Experts Group
MHP	Multimedia Home Platform
MIB	Management Information Base
MIDI	Musical Instrument Digital Interface
MIME	Multipurpose Internet Mail Extension
MIT	Manager Information Tree
M-JPEG	Motion JPEG
ML	Main Level
MMDS	Microwave Multipoint Distribution Systems
MMM	Multimedia Mailing
MMPP	Markov Modulated Poisson Process
MMS	Multimedia Messaging Services
MMUSIC	Multiparty Multimedia Session Control
MN	Mobile Node
MOM	Message Oriented Middleware
MOS	Mean Opinion Score
MoU	Memorandum of Understanding
MP	Main Profile
MPEG	Motion Picture Expert Group
MPLS	Multiprotocol Label Switching
MRO	Maintenance Repair and Operation
MS	Mobile Station
MSB	Most Significant Bit
MSC	Mobile Switching Center
MSE	Mean Square Error
MSPN	Multimedia Services over Packet Networks
MTA	Multimedia Terminal Adapter
MTU	Maximum Transit Unit
MVDS	Multipoint Video Distribution System
MW	Middleware

NAB	National Association of Broadcasters
NACK	Negative Acknowledgment
NAL	Network Abstraction Layer
NAT	Network Address Translation
NBC	Nonbackward Compatible
NCCE	Network Computing and Communication Environment
NCCI	Network Control Center Interface
NCR	Network Clock Reference
NCS	Network-based Cell Signaling
NCTA	National Cable Television Association
NGBAN	Next Generation Broadband Access Network
NGM	Network Management Forum
NGN	Next Generation Network
NHPR	Next Hop Resolution Protocol
NIC	Network Interface Card
NISDN	Narrow-band ISDN
NIU	Network Interface Unit
NMAP	Network Management Application Process
NOC	Network Operating Center
NRIM	Network Resource Information Model
NRSC	National Radio System Committee
NSAP	Network Service Access Point
NSP	Network Service Provider
NTSC	National Television System Committee
OBS	Optical Burst Switching
OCI	Object Content Information
OD	Object Descriptor
ODL	Object Definition Language
ODP	Open Distributed Processing
OE	Optical-to-Electrical
OFDM	Orthogonal Frequency Division Multiplexing
OLT	Optical Line Terminator
OMG	Object Management Group
ONU	Optical Network Unit
OPS	Optical Packet Switching
OS	Operating System
OSA	Open Service Access
OSI	Open System Interconnection
OSIE	Open System Interconnection Environment
OSI-SM	OSI System Management
OSPF	Open Shortest Path First
OSS	Operational Support System
OTB	Object Time Base
P2P	Peer-to-Peer
PAC	Perceptual Audio Coder

PAL	Phase Alternating Line
PAS	Publicity Available Specification
PAT	Program Association Table
PCR	Program Clock Reference
PCT	Peak Cell Rate
PCWG	Personal Conferencing Work Group
PDA	Personal digital Assistant
PDH	Plesiochronous Digital Hierarchy
PDP	Packet Data Protocol
PES	Packetized Elementary Stream
PGM	Pragmatic General Multicast
PHB	Per Hop Behavior
PID	Packet Identifier
PIM	Protocol Independent Multicast
PIM-DM	PIM – Dense Mode
PIM-SM	PIM – Sparse Mode
PLMN	Public Land Mobile Network
PM	Performance Management
PMT	Program Map Table
PN	Pseudo Noise
PNG	Portable Network Graphics
POCS	Projection Onto Convex Set
PON	Passive Optical Network
POTS	Plain Old Telephone Service
PPC	Preliminary Path Caching
PPP	Point-to-Point Protocol
PRBS	Pseudo-Random Binary Sequence
PSI	Program Specific Information
PSK	Phase-Shift-Keying
PSN	Packed Switched Networks
PSO	Protocol Supporting Organization
PSTN	Public Switch Telephone Network
PTR	Priority Token Ring
PTS	Presentation Time Stamps
PVC	Permanent Virtual Connection
PVR	Personal Video Recording
QAM	Quadrature Amplitude Modulation
QCIF	Quarter Common Intermediate Format
QoS	Quality of Service
QoS-A	Quality of Service – Architecture
QP	Quantization Parameters
QPSK	Quadrature Phase-Shift Keying
RA	Radio Assembly
RAM	Resource Availability Matrix
RC	Rate Control

RCSP	Reconfiguration Control and Service Provision Platform
RD	Rate Distortion
RDD	Rights Data Dictionary
RDS	Requests for Detailed Specifications
RED	Random Early Detection
REL	Rights Expression Language
REM	Rate Envelope Multiplexing
RFC	Request for Comments
RfP	Request for Proposal
RfQ	Request for Quotes
RIP	Routing Information Protocol
RKS	Record Keeping Server
RMI	Remote Method Invocation
RMODP	Reference Model of Open Distributed Processing
RMP	Reliable Multicast Protocol
RMTP	Reliable Multicast Transport Protocol
RPC	Remote Procedure Call/Resource Provisioning Cycle
RS	Reed-Solomon
RSVP	Resource Reservation Protocol
RTE	Run Time Engine
RTP	Real-Time Protocol
RTSP	Real-Time Streaming Protocol
RTT	Round-Trip Time
RUI	Routing Update Interval
RVS	Remote Video Surveillance
RWA	Routing and Wavelength Assignment
SA	Secure Agent
SCN	Switched Circuit Network
SCP	Service Control Point
SCR	Sustainable Cell Rate/System Clock Reference
SD	Source Destination
SDARS	Satellite Digital Audio Radio Services
SDES	Source Description
SDH	Synchronous Digital Hierarchy
SDL	Specification and Description Language
SDM	System Decoder Model
SDMI	Secure Digital Music Initiative
SDO	Standards Development Organization
SDP	Session Description Protocol
SDR	Software Defined Radio
SDSL	Single Line DSL
SDU	Service Data Unit
SFC	Stream Flow Connection
SFN	Single Frequency Network
SG	Study Group

SG-MMS	Study Group for Multimedia Services
SGSN	Serving GPRS Support Node
SHD	Super High Definition
SI	Service Information
SIG	Special Interest Group
SIP	Session Initiation Protocol
SL	Synchronization Layer
SLA	Service Level Agreement
SM	Security Management
SMFA	Specific Management Functional Area
SMG	Statistical Multiplexing Gain
SMI	Structure of Management Information
SMPTE	Society of Motion Picture and Television Engineers
SMS	Short Message Service
SMTTP	Simple Mail Transfer Protocol
SMUX	Synchronous Multiplexing
SNMP	Simple Network Management Protocol
SNR	Signal-to-Noise Ratio
SOAP	Simple Object Access Protocol
SOHO	Small Office/Home Office
SONET	Synchronous Optical Network
SP	Simple Profile
SQF	Service Quality Function
SRC	Strategic Review Committee
SRLG	Shared Risk Link Group
SRM	Scalable Reliable Multicast
SrvMgt	Service Management
SS7	Signaling System No. 7
SSG	Special SG
SSL	Secure Sockets Layer
SSM	Serial Storage Media
SSP	Service Switching Point/Stream Synchronization Protocol
SSRC	Synchronization SouRCe Identifier
STB	Set-Top-Box
STD	Systems Target Decoder
STM	Synchronous Transport Module
STS	Synchronous Transport Signal
STU	Subscriber Terminal Unit
SUI	Synchronization Interval Unit
SVC	Switched Virtual Connection
TCP	Transmission Control Protocol
TD	Technical Direction
TDD	Time Division Duplex
TDM	Time Division Multiplex
TFB	Tandem-Free Bridge

TFC	Tandem-Free Conferencing
TGCP	Trunking Gateway Control Protocol
TGS	Ticket Granting Server
TINA	Telecommunication Information Network Architecture
TLD	Top Level Domain
TLS	Transport Level Security
TM	Traffic Management
TMF	Tele-Management Forum
TMN	Telecommunication Management Network
TN	Transport Network
ToS	Type of Service
TPDU	Transport Protocol Data Unit
TS	Transport Stream
TSAG	Telecommunication Standardization Advisory Group
TTC	Telecommunication Technology Committee
TTS	Text-to-Speech
TVoD	True VoD
UBR	Unspecified Bit Rate
UDDI	Universal Description Discovery and Integration
UDP	User Datagram Protocol
UEP	Unequal Error Protection
UMA	Universal Multimedia Access
UME	Universal Multimedia Experience
UML	Unified Modeling Language
UMTS	Universal Mobile Telecommunication System
U-N	User–Network
UNI	User–Network Interface
UPC	Usage Parameter Control
UPnP	Universal Plug and Play
UPO	Updated Path Ordering
UPS	United Parcel Service
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
USO	Universal Service Obligation
UTRA	Universal Terrestrial Radio Access
U-U	User–User
UVLC	Universal Variable Length Coding
VAR	Variance
VASP	Value-Added Service Provider
VBI	Vertical Blanking Interval
VBR	Variable Bit Rate
VC	Virtual Connection/Virtual Circuit
VCC	Virtual Circuit Connection
VCEG	Video Coding Experts Group
VCI	Virtual Connection Identifier

VCL	Video Coding layer
VCR	Video Cassette Recorder
VDSL	Very-high-rate DSL
VESA	Video Electronics Standards Association
VFW	Video for Windows
VHS	Video Home System
VLC	Variable Length Coding
VLD	Variable Length Decoder
VM	Virtual Machine
VO	Video Object
VoD	Video-on-Demand
VoIP	Voice over IP
VOL	Video Object Layer
VOP	Video Object Plane
VP	Virtual Path
VPI	Virtual Path Identifier
VPN	Virtual Private Network
VQ	Vector Quantization
VRML	Virtual Reality Markup Language
VSF	Vestigial Side Band
VTC	Visual Texture Coding
W3C	World Wide Web Consortium
WA	Wavelength Allocation
WAN	Wide Area Network
WAP	Wireless Applications Protocol
WARC	World Administrative Radio Conference
WATM	Wireless ATM
WCDMA	Wideband Code-Division Multiple Access
WCS	Wireless Communications Services
WDM	Wavelength Division Multiplex
WG	Working Group
W-HDN	Wireless Home Distribution Network
WLAN	Wireless LAN
WP	Working Party
WR	Wavelength Routing
WSDL	Web Service Description Language
WSN	Wireless Sensor Network
WSS	Wide Sense Stationary
WTSA	World Telecommunication Standardization Assembly
WWW	World Wide Web
XML	Extensible Markup Language
XTP	Xpress Transport Protocol