

Present Status and Future Trends in Telecommunications

Robert F. Linfield



**U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary**

Thomas J. Sugrue, Acting Assistant Secretary
for Communications and Information

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PREFACE

Certain commercial equipment, instruments, services, protocols, and materials are identified in this report to adequately specify the engineering issues. In no case does such identification imply recommendation or endorsement by the National Telecommunications and Information Administration, nor does it imply that the material, equipment, or service identified is necessarily the best available for the purpose.

To whatever degree I have managed to bring together this comprehensive overview of telecommunication trends at least some of the credit goes to Messrs. V.J. Pietrasiewicz, W.J. Pomper, and J.A. Hull who provided technical suggestions. In addition, helpful discussions were held with many other members of the staff at the Institute for Telecommunication Sciences.

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ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
ACSE	Association Control Service Element
ACTS	Advanced Communications Technology Satellite
ADPCM	Adaptive Pulse Code Modulation
AI	Artificial Intelligence
AIN	Advanced Intelligent Network
AM	Amplitude Modulation
AMSC	American Mobile Satellite Corporation
ANSI	American National Standards Institute
ARPA	Advanced Research Project Agency
AT&T	American Telegraph and Telephone Company
ATM	Asynchronous Transfer Mode
AWO	Asian Workshop for OSI
b/s	Bits per Second
B-ISDN	Broadband Integrated Services Digital Network
Bellcore	Bell Communications Research
BER	Bit Error Rate
BIPS	Billion Instructions per Second
BOC	Bell Operating Company
BRI	Basic Rate Interface
BSA	Basic Serving Arrangement
BSE	Basic Service Element
C	Codec
CATV	Cable Television
CBR	Constant Bit Rate
CCIR	International Radio Consultative Committee
CCITT	International Telegraph and Telephone Consultative Committee
CCS	Common Channel Signaling
CD	Compact Disk
CDMA	Code Division Multiple Access
CEI	Comparably Efficient Interconnection
CL	Connectionless
CLNS	Connectionless Network Service
CNS	Complementary Network Services
CO	Connection-Oriented
COS	Corporation for Open Systems
CPE	Customers Premises Equipment
CPU	Central Processing Unit
CS	Capability Set

ACRONYMS AND ABBREVIATIONS (cont.)

CSMA/CD	Carrier Sense Multiple Access with Collision Detection
CT	Cordless Telephone
DAS	Dual Attached Station
DDD	Direct Distance Dialing
DoD	Department of Defense
DQDB	Distributed Queue Dual Bus
DS1	Digital Signal at 1.544 Mbls
DS3	Digital Signal at 44.76 Mbls
DTE	Data Terminal Equipment
DTS	Digital Termination Service
EDI	Electronic Data Interchange
EIA	Electronic Industries Association
ESP	Enhanced Service Provider
ESS	Electronic Switching System
EWOS	European Workshop for OSI Standardization
FAX	Facsimile
FCC	Federal Communications Commission
FCS	Fiber Channel Standard
FDDI	Fiber Digital Data Interface
FDMA	Frequency Division Multiple Access
FIPS	Federal Information Processing Standard
FM	Frequency Modulation
FO	Fiber Optic
FTAM	File Transfer, Access, and Management
FTS	Federal Telecommunication System
FTTC	Fiber to the Curb
FTTH	Fiber to the Home
Gb/s	Gigabits per Second (10 ⁹ b/s)
GM	General Motors
GNP	Gross National Product
GOSIP	Government Open System Interconnection Profile
HDTV	High Definition Television
HIPPI	High Performance Parallel Interface
IA	Implementation Agreement
IAB	Internet Activities Board

ACRONYMS AND ABBREVIATIONS (cont.)

IBM	International Business Machines
IC	Integrated Circuit
ICC	Interstate Commerce Commission
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IFRB	International Frequency Reservation Board
IN	Intelligent Network
IO	Integrated Optical
IP	Intelligent Peripheral
ISDN	Integrated Services Digital Network
ISO	International Standards Organization
ISP	International Standardized Profiles
ITU	International Telecommunications Union
IVD	Integrated Voice and Data
IXC	Interexchange Carrier
kb/s	Kilobits per Second (10^3 b/s) Kilometer
LAN	Local Area Network
LAP-B	Link Access Protocol B
LATA	Local Access Transport Area
LEC	Local Exchange Carrier
LEO	Low Earth Orbit
LFC	Local Function Capabilities
LLC	Link Level Control
M	Modem
MAC	Medium Access Control
MAN	Metropolitan Area Network
MAP	Manufacturing Automated Protocol
Mb/s	Megabits Per Second (10^6 b/s)
MCI	Microwave Communications Incorporated
MEO	Mid Earth Orbit
MF	Multiple Frequency
MGMT	Management
MHF	Medium High Frequency
MHS	Message Handling System
MILNET	Military Network
MIPS	Millions of Instructions per Second
MPC	Massively Parallel Computer
MUX	Multiplexer

ACRONYMS AND ABBREVIATIONS (cont.)

NIST	National Institute of Standards and Technology
NNI	Network: Node Interface
NREN	National Research and Education Network
NSF	National Science Foundation
NT	Network Termination
NTIA	National Telecommunications and Information Administration
OC	Optical Carrier
OSI	Open System Implementors Workshop
ONA	Open Network Architecture
OS	Operating System
OSI	Open Systems Interconnection
OSS	Operations Support System
PAN	Peculiar and Novel Service
PASS	Personal Access Satellite System
PBX	Private Branch Exchange
PC	Personal Computer
PCN	Personal Communications Network
PCS	Personal Communications System
PDN	Public Data Network
PDU	Protocol Data Unit
PLN	Private Line Network
PMD	Physical Medium Dependent
PMI	Physical Medium Independent
POSI	Pacific OSI (Japan)
POTS	Plain Old Telephone Service
PRI	Primary Rate Interface
PSTN	Public Switched Telephone Network
PTT	Postal Telegraph and Telephone
RBOC	Regional Bell Operating Company
RISC	Reduced Instruction Set Computer
ROM	Read Only Memory
RPOA	Recognized Private Operating Agency
SCP	Service Control Point
SCPC	Single Channel per Carrier
SDBN	Software Defined Broadband Network
SDH	Synchronous Digital Hierarchy
SDN	Software Defined Network

ACRONYMS AND ABBREVIATIONS (cont.)

SDO	Standards Development Organization
SF	Single Frequency
SHF	Super High Frequency
SMDS	Switched Multimegabit Data Service
SMS	Service Management System
SNA	Systems Network Architecture
SONET	Synchronous Optical Network
SPAG	Standards Promotion and Applications Group
SPC	Stored Program Control
SS7	Signaling System No.7
SSP	Service Switching Point
SST	Spread Spectrum Technology
STM	Synchronous Transfer Mode
STP	Shielded Twisted Pair
STS	Synchronous Transport System
SW	Switch
T-Carrier	Digital Transmission System
T1	T-Carrier Operated at 1.544 Mbls
TASI	Time Assignment Speech Interpolation
Tb/s	Terabits per Second (1012 b/s)
TBD	To Be Determined
TCP/IP	Transport Control Protocol/Internet Protocol
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
TE	Terminal Equipment
TIA	Telecommunications Industry Association
TMN	Telecommunications Management Network
TRW	Thompon Ramo Woolrich
TV	Television
TWP	Twisted Wire Pair
UPT	Universal Personal Telecommunications
UTP	Unshielded Twisted Pair
VAN	Value Added Network
VBR	Variable Bit Rate
VC	Virtual Channel
VCI	Virtual Channel Identifier
VLSI	Very Large Scale Integration
VP	Virtual Path
VPC	Virtual Path Connection

ACRONYMS AND ABBREVIATIONS (cont.)

VPI	Virtual Path Identifier
VPLN	Virtual Private Line Network
VPN	Virtual Private Network
VSAT	Very Small Aperture Terminal
VT	Virtual Tributaries
WAN	Wide Area Network
WARC	World Administrative Radio Conference
WP	Wire Pair
WS	Work Station
XC	Exchange

DEFINITIONS

These definitions are taken from Federal Standard 1037B (1991), a glossary of telecommunication terms, wherever possible.

Asynchronous Transfer Mode (ATM) - A data-transfer mode in which a multiplexing technique for fast packet switching in CCITT broadband ISDN is used. This technique inserts information in small, fixed-size cells (32-120 octets) that are multiplexed and switched in a slotted operation, based upon header content, over a virtual circuit established immediately upon a request for service.

Asynchronous Transmission - Data transmission in which the instant that each character, or block of characters, starts is arbitrary; once started, the time of occurrence of each signal representing a bit within the character, or block, has the same relationship to significant instants of a fixed time frame.

Bandwidth-on-Demand - A method of transporting information according to each user's instantaneous need (e.g., see ATM and B-ISDN).

Boundary - An abstract separation between functional groupings of protocols. May or may not be a physical interface as well.

Broadband (wideband) - 1. An imprecise designation of a signal that occupies a broad frequency spectrum. Note: This term is often used to distinguish it from a narrowband signal, where both terms are subjectively defined relative to the implied context. 2. That property of any circuit having a bandwidth wider than normal for the type of circuit, frequency of operation, and type of modulation carried. Note: The term has many meanings depending upon application. In telecommunications, the term implies a service or system requiring transmission channels capable of supporting rates greater than 1.5 Mb/s.

Broadband ISDN (B-ISDN) - A CCITT proposed Integrated Services Digital Network offering broadband capabilities including many of the following features or services: (a) from 150 to 600 Mb/s interfaces, (b) using ATM to carry all services over a single, integrated, high-speed packet-switched net, (c) LAN interconnection, (d) the ability to connect LANs at different locations, (e) access to a remote, shared disc server, (t) voice/video/data teleconferencing from one's desk, (g) transport for programming services (e.g., cable TV), (h) single-user controlled access to remote video source, (i) voice/video telephone calls, and (j) access to shop-at-home and other information services.

Cell - 1. In cellular radio, the smallest geographic area defined for a certain mobile communication system. 2. In OSI, a fixed-length block labeled at the physical layer of the OSI reference model.

DEFINITIONS (cont.)

Cell-Relay - A multiplexed information transport method in which information is organized into fixed-length cells with an identifying header and transmitted according to users' instantaneous needs (e.g., see ATM).

Communications System - A collection of individual communication networks, transmission systems, relay stations, tributary stations, and terminal equipment capable of interconnection and interoperation to form an integral whole.

End System and End User - The ultimate source or destination for information transferred over a network.

Frame - In data transmission, the sequence of contiguous bits bracketed by and including beginning and ending flag sequence.

Implementation - Software and hardware that performs the logical functions defined by the network architecture.

Integrated Services Digital Network (ISDN) - An integrated digital network in which the same time-division switches and digital transmission paths are used to establish connections for different services. Note 1: Such services include telephone, data, electronic mail, and facsimile. Note 2: How a connection is accomplished is often specified. For example, switched connection, non-switched connection, exchange connection, ISDN connection. See also communications, electronic mail, integrated digital network.

Intelligent Network (IN) - A network that allows functionality to be distributed flexibly at a variety of nodes on and off the network and allows the architecture to be modified to control the services; [in North America] an advanced network concept that is envisioned to offer such things as (a) distributed call-processing capabilities across multiple network modules, (b) real-time authorization code verification, (c) one-number services, and (d) flexible private network services [including (1) reconfiguration by subscriber, (2) traffic analyses, (3) service restrictions, (4) routing control, and (5) data on call histories]. Levels of IN development are identified below:

--IN/1 A proposed intelligent network targeted toward services that allow increased customer control and that can be provided by centralized switching vehicles serving a large customer base.

--IN/1 + A proposed intelligent network targeted toward services that can be provided by centralized switching vehicles, e.g., access tandems, serving a large customer base.

DEFINITIONS (cont.)

--IN/2 A proposed, advanced intelligent-network concept that extends the distributed IN/1 architecture to accommodate the concept called "service independence." Note: Traditionally, service logic has been localized at individual switching systems. The IN/2 architecture provides flexibility in the placement of service logic, requiring the use of advanced techniques to manage the distribution of both network data and service logic across multiple IN/2 modules.

Interface - A concept involving the definition of the interconnection between two equipment items or systems. The definition includes the type, quantity, and function of the interconnecting circuits and the type, form, and content of signals to be interchanged via those circuits.

Layered Architecture - Functional group of protocols that adheres to a logical structure of network operations.

Local Area Network (LAN) - A non-public data communication system, within a limited geographic area, designed to allow a number of independent devices to communicate with each other over a common transmission interconnection topology.

Metropolitan Area Network (MAN) - A loosely defined term generally understood to describe a network covering an area larger than a LAN. Note: It typically interconnects two or more LANs, operates at higher speed and may cross administrative boundaries.

Multimedia Communications - The field referring to the representation, storage, retrieval, and dissemination of machine-procurable information expressed in multimedia such as text, voice, graphics, images, audio, and video.

Network - 1. An interconnection of three or more communicating entities and (usually) one or more nodes. 2. A combination of passive or active electronic components that serves a given purpose.

Network Topology - The connecting structure, consisting of paths, switches, and concentrators that provides the communications interconnection among nodes of a network. Note: Two networks have the same topology if the connecting configuration is the same, although the networks differ in physical interconnections, distance between nodes, transmission rates, and signal types.

Open System - A system whose characteristics comply with specified standards and that therefore can be connected to other systems that comply with these same standards.

DEFINITIONS (cont.)

Open System Interconnection (OSI) - A logical structure for network operations standardized within the ISO; a seven-layer network architecture being used for the definition of network protocol standards to enable any OSI-compliant computer or device to communicate with any other OSI-compliant computer or device for a meaningful exchange of information.

Open System Interconnection (OSI) Architecture - Network architecture that adheres to that particular set of ISO standards that relates to Open Systems Architecture.

Overhead Bit - Any bit other than a user information bit.

Overhead Information - Digital information transferred across the functional interface separating a user and a telecommunication system (or between functional entities within a telecommunication system) for the purpose of directing or controlling the transfer of user information and/or the detection and correction of errors. Overhead information originated by the user is not considered as system overhead information. Overhead information generated within the system and not delivered to the user is considered as system overhead information.

Photonics - The field of telecommunications involving discrete packets of electromagnetic energy for switching and transmission.

Protocol - A set of unique rules specifying a sequence of actions necessary to perform a communications function.

T-Carrier - Generic designator for any of several digitally multiplexed telecommunications transmission systems.

Telecommunication - Any transmission, emission, or reception of signs, signals, writing, images, and sounds or intelligence of any nature by wire, radio, optical, or other electromagnetic systems.

Telecommunication Architecture - Within a telecommunication system, the overall plan governing the capabilities of functional elements and their interaction, including configuration, integration, standardization, life-cycle management, and definition of protocol specifications, among these elements.

Telecommunication Service - A specified set of user-information transfer capabilities provided to a group of users by a telecommunication system. The telecommunication service user is responsible for the information content of the message. The telecommunication service provider has the responsibility for the acceptance, transmission, and delivery of the message.

DEFINITIONS (cont.)

Synchronous Digital Hierarchy (SDH) - A newly adopted standard for multiplexing and interfacing signals for transmission over optical networks. Evolved from Synchronous Optical Network (SONET) developed in the United States.

Synchronous Transfer Mode (STM) - A proposed transport level, a time-division multiplex-and-switching technique to be used across the user's network interface for ISDN.

System - Any organized assembly of resources and procedures united and regulated by interaction or interdependence to accomplish a set of specific functions.

User - A person, organization, or other entity (including a computer or computer system), that employs the services provided by a telecommunication system, or by an information processing system, for transfer of information to others. Note: A user functions as a source or final destination of user information, or both.

User Information - Information transferred across the functional interface between a source user and a telecommunication system for the purpose of ultimate delivery to a destination user. Note: In data telecommunication systems, "user information" includes user overhead information.

Wide Area Network (WAN) - A physical or logical network that provides capabilities for a number of independent devices to communicate with each other over a common transmission-interconnected topology in geographic areas larger than those served by local area networks.

