

EE-6607

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- Network Software

Text: *Computer Networks*, 3rd Edition
by Andrew S. Tanenbaum

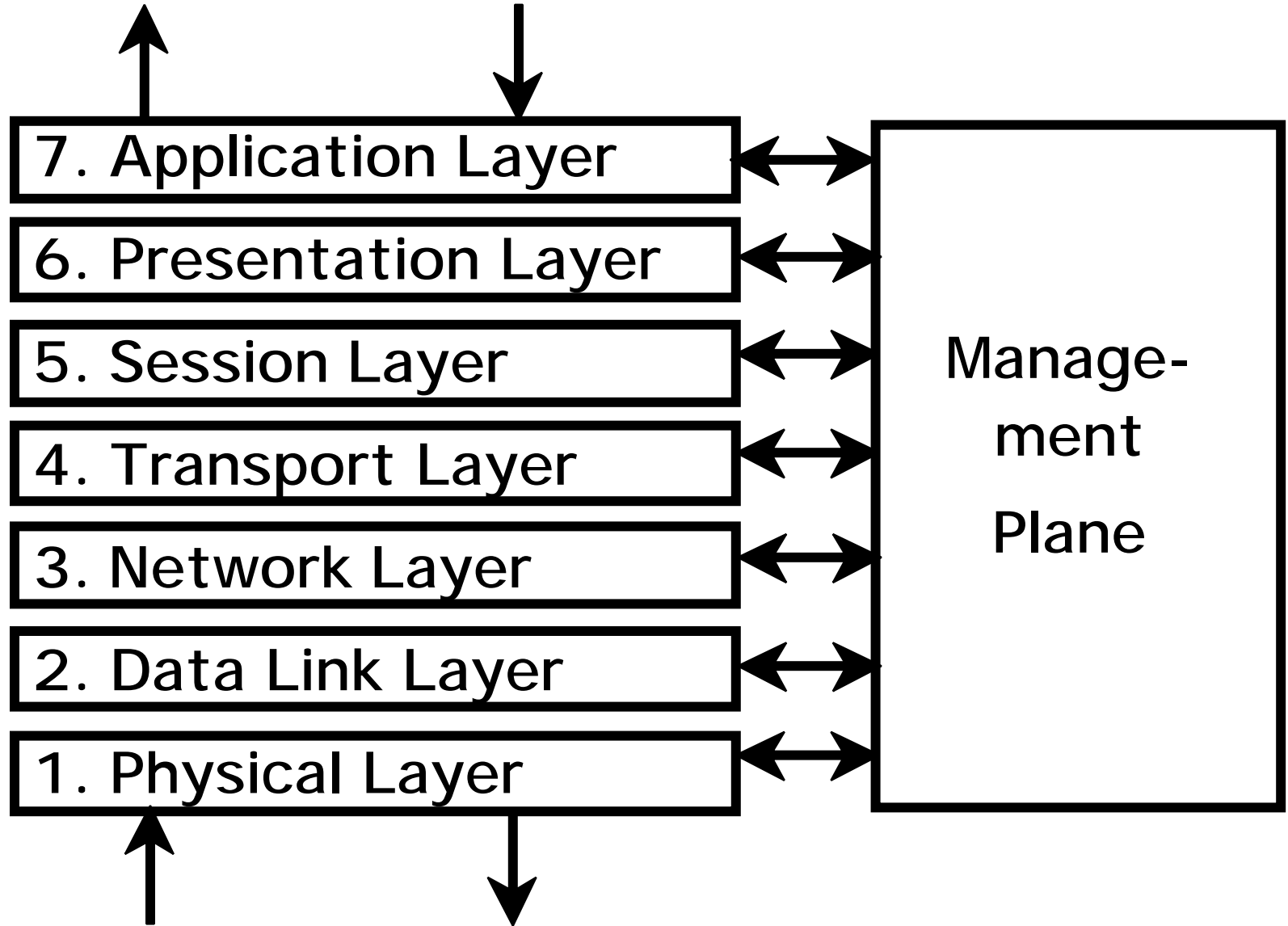
Chap. 1, pp 16-44

OSI Reference Model

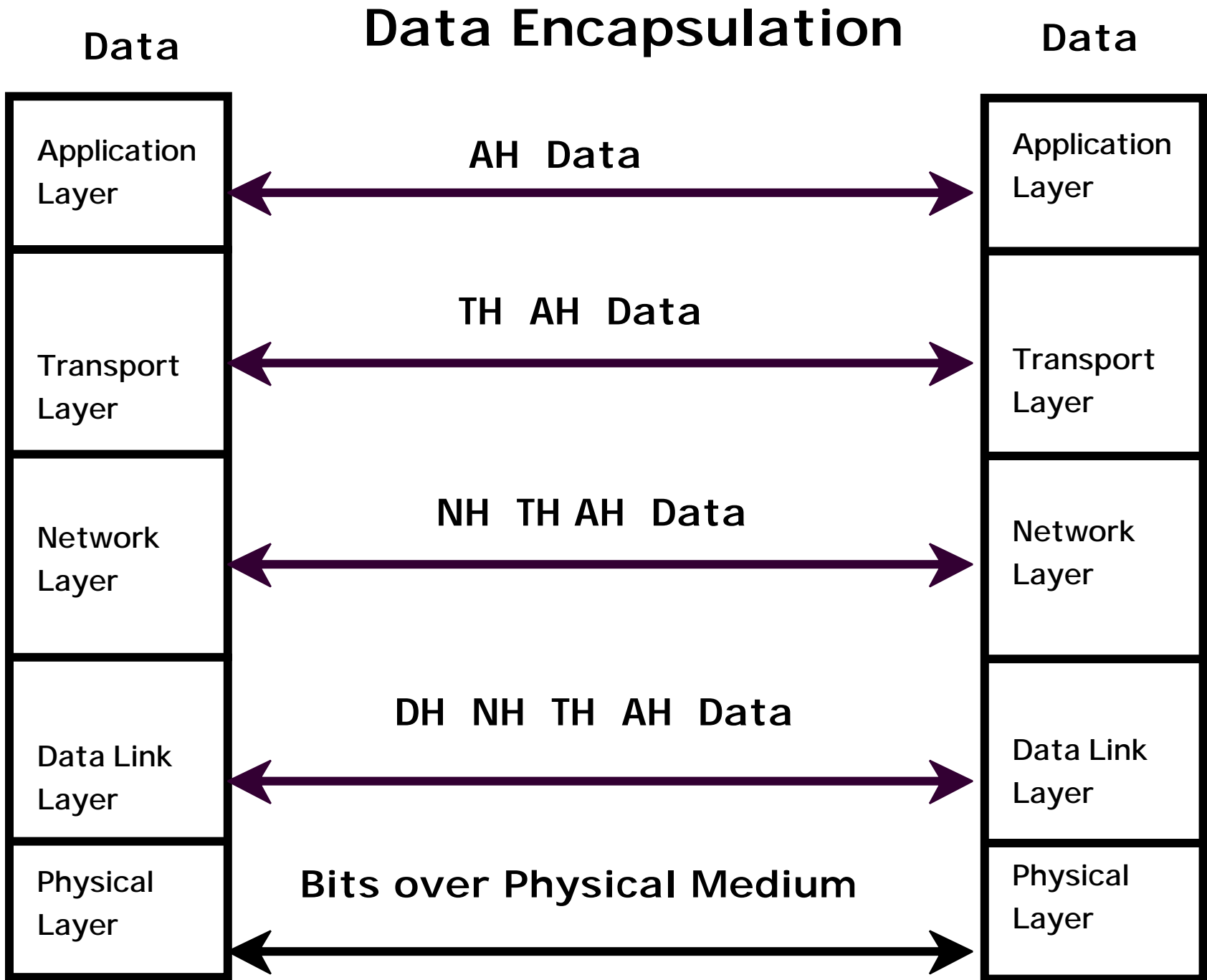
From 1977 to 1983 the International Standardization Organization (ISO) developed a architectural model that separated computer communication protocol functions into layers. This system is known as the Open Systems Interconnection (OSI) Reference Model (ISO Standard 7498).

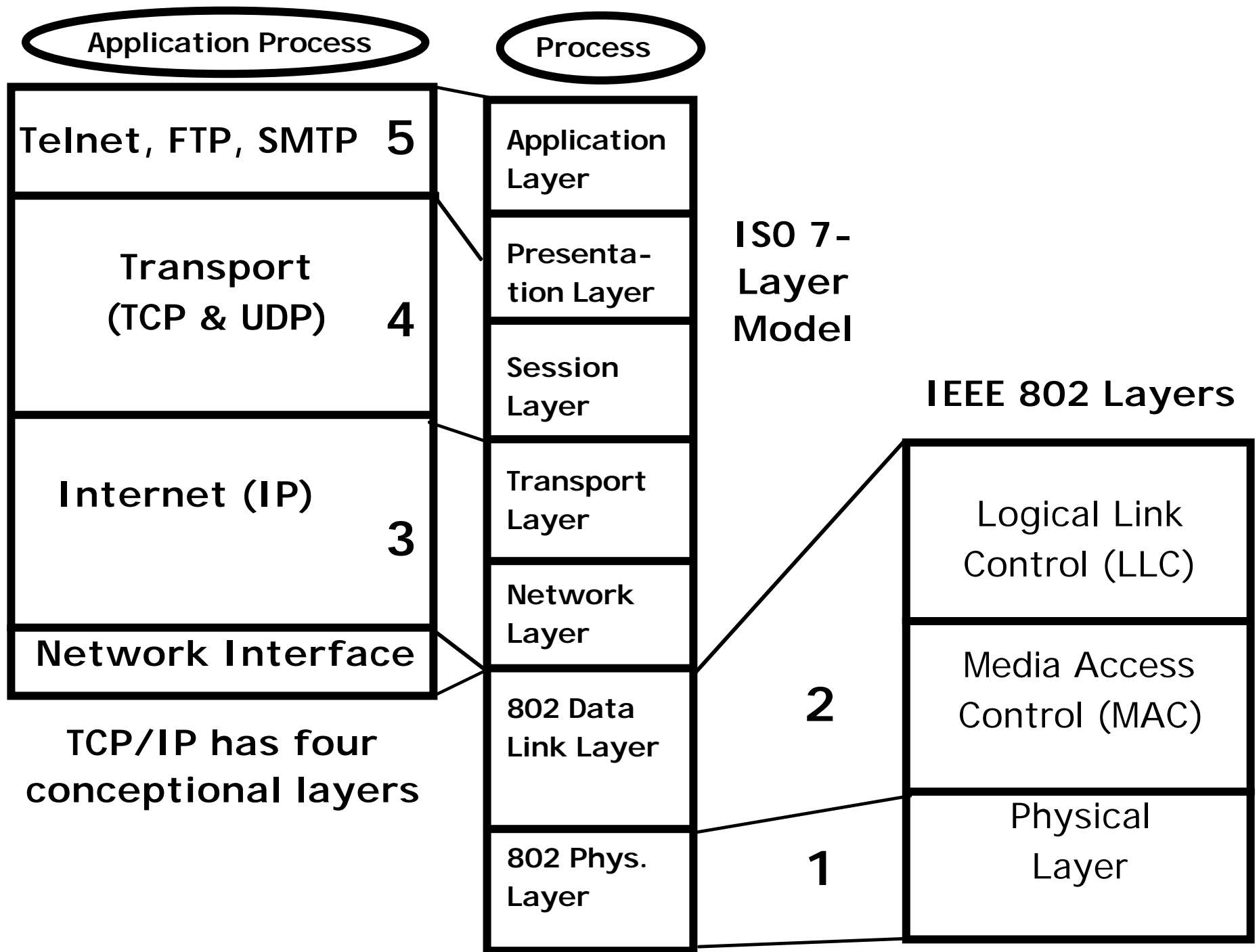
This model is also known as the "seven-layer" model. These layers take outgoing data from the level above, perform certain functions on it, then pass the processed data down to the layer below. They also take received data from the layer below, perform (undo) the same functions, and pass the processed data up to the layer above.

The Seven OSI Layers



Memmonic: APeS Transport Network Data Physically.





TCP/IP - the Protocol of the Internet

While the Internet Protocol Suite is generally known as TCP/IP, there are a number of protocols at different layers that make the Internet work.

Program (e.g., Browser)

**Telnet
(Terminal)**

**File Transfer
Protocol
(FTP)**

**Simple Mail
Transfer
(SMTP)**

**Hyper-Text
Transfer
Protocol (HTTP)**

**Transmission Control
Protocol (TCP)**

**User Datagram
Protocol (UDP)**

Internet Protocol

Protocol Layer Design Issues

Data Directions

- Simplex - one way only (fire alarm)
- Half Duplex - one way at a time (CB radio)
- Duplex - Both ways at once (telephone)

Error Control (Detection)

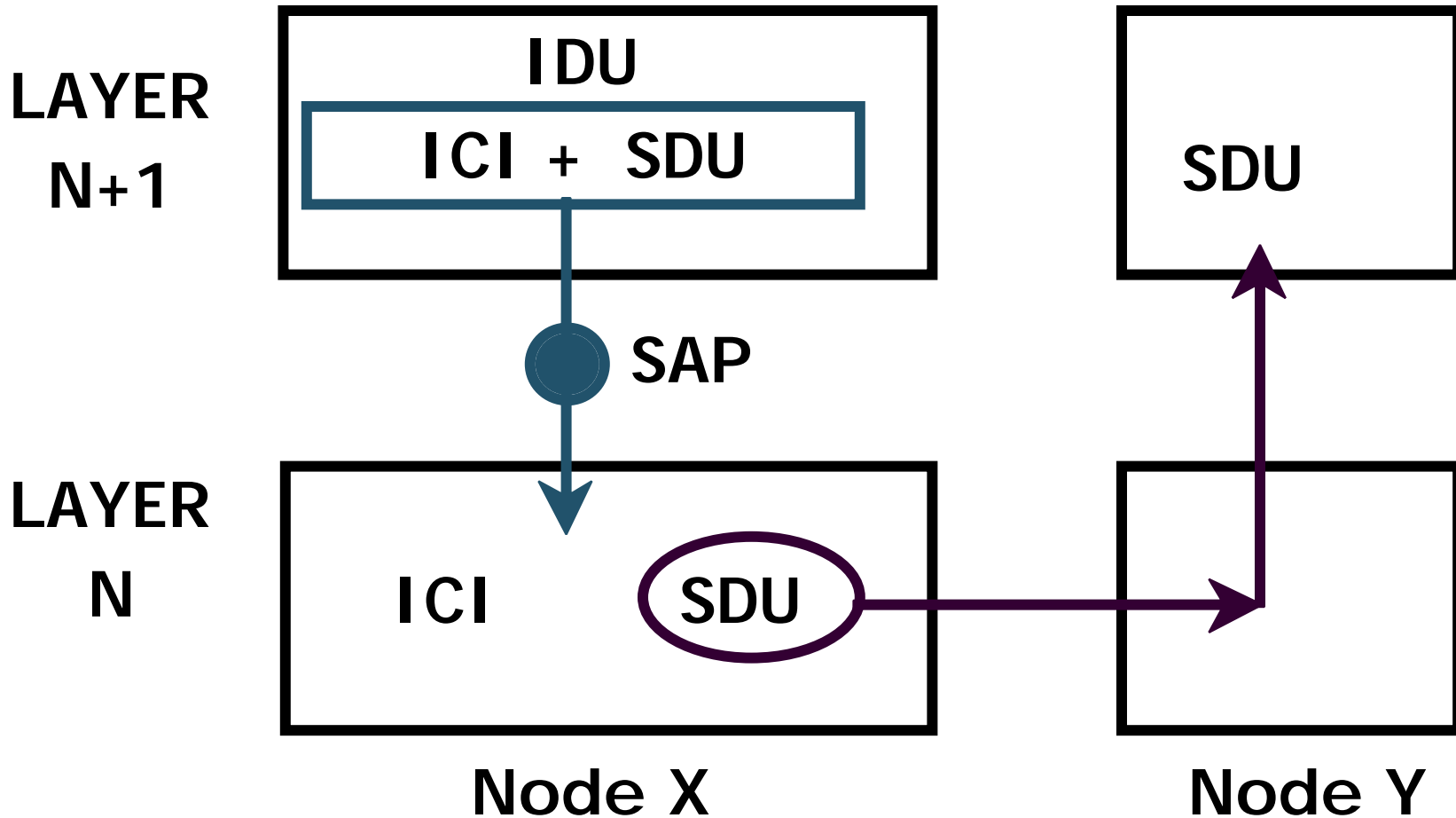
- Retransmission (ACK, NAK, time-out)
- Forward error correction

Sequencing (SAR: Segment & Reassemble)

Multiplexing (multiple sessions, 1 circuit)

Reverse Multiplexing (1 session, multi-circuits)

Service Access Points



Interface Data Unit
Interface Control Info
Service Data Unit
Protocol Data Unit

PDU
Header +
SDU

Connection Oriented Service

- Like Telephone System
- Packets arrive in order

Connectionless Service

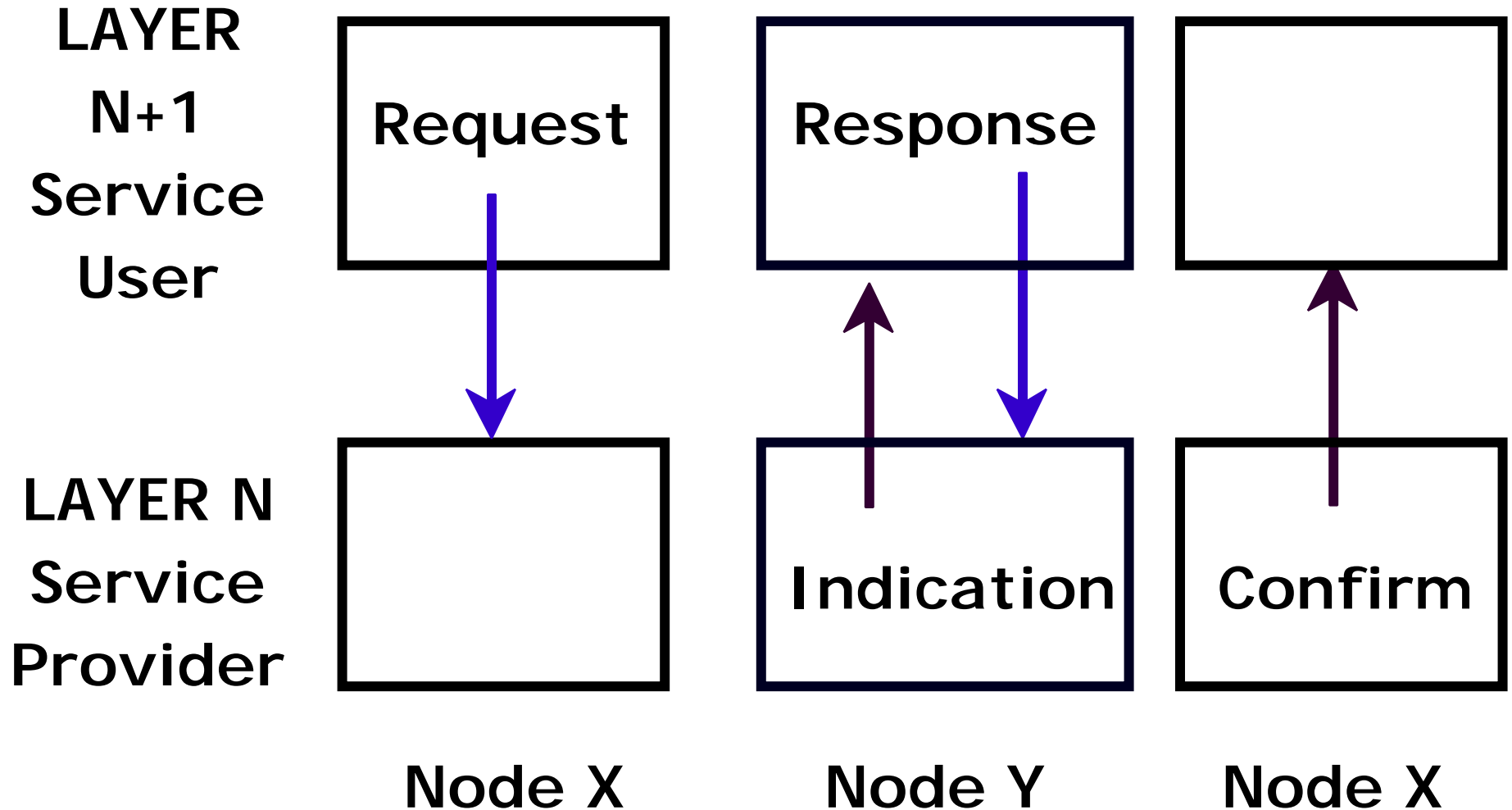
- Like Post Office with multiple letters
- Packets can be out of sequence
- Variable delay

Quality of Service

- Reliable - never loses data (ACKed)
- Unreliable - may lose data

Service Primitives

Messages Between Layers



Novell Netware

Layer

Application: Service Advertising Protocol, File Server

Transport: NCP (files) SPX (Lotus Notes)

Network: IPX

Datalink: Ethernet Token Ring ARCnet

Physical: Ethernet Token Ring ARCnet

Internet (TCP/IP)

Layer

Application: Mail, Terminal (Telnet), Web, File Transfer (FTP)

Transport: TCP (reliable) UDP (datagram)

Network: IP (Internet Protocol)

Datalink: Ethernet, Token Ring, FDDI, DOCSIS (CATV), ATM, ...

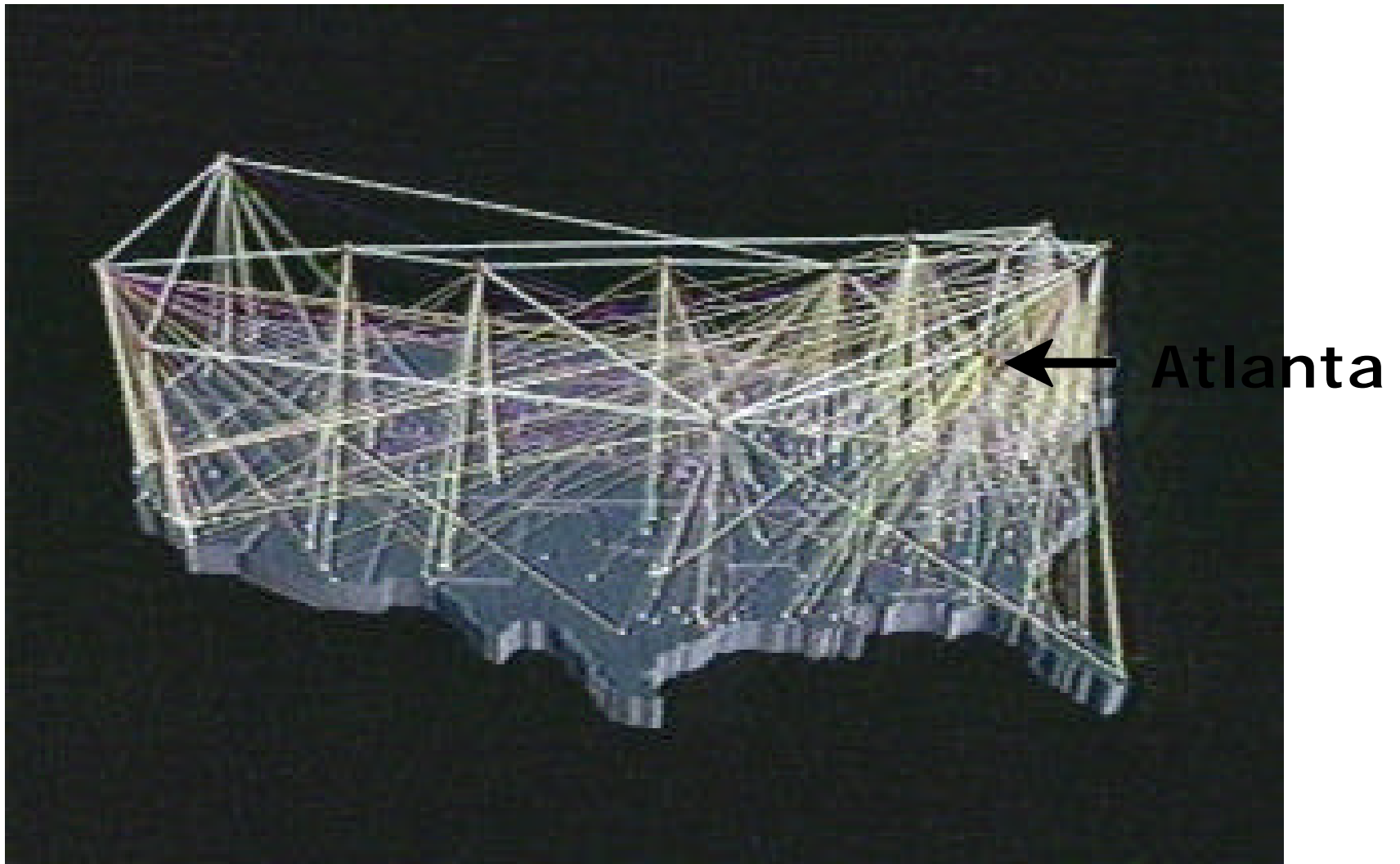
Physical: Ethernet, Token Ring, FDDI, DOCSIS (CATV), ATM, ...

ARPAnet - by Advanced Research Projects Agency

- 1960's, used Interface Message Processors
- Built by BBN, hard to connect to other networks
- 1980's - Domain Naming System (DNS) developed

NSFnet

- Designed for university research groups (1984)
- NSF funded backbone and regional networks
- ANS (IBM, MCI et al) commercialized in 1994, sold to America Online in 1995.
- NREN (3 Gbps network) authorized by Congress in 1991
- NSF funded NAP's in San Fran., NYC, Chicago, Wash. DC
- Internet - many more .com's than .edu's, .gov's today.
Based on TCP/IP Protocols, defined by RFC.



Map of the Internet - Primary and Secondary Backbone Routes

Gigabit Testbeds (1996)

- Aurora - MIT, U. Penn., Watson, Bellcore
- Blanca - AT&T Bell Labs, Berkeley, U. Wisconsin
- CASA - Los Alamos, Cal Tech, JPL, San Diego S.C.
- Nectar - MAN from Pittsburgh SC to CMU
- VISTAnet - UNC, NCSU, MCNC (Res. Triangle Park)
- most used 622 Mbps (government Gigabit)

All closed now, except:

- vBNS - Very high-speed Backbone Network (622Mbps)
- **Internet II, 1 55 Mbps, 622 Mbps (www.sox.net)**
- **Latest research at 1 00 Giga-bps to 1 Tera-bps**
- **WDM – Wavelength Division Multiplexing – 64 lightwaves**

Commercial Data Communication Services

X.25 - plus X.3, X.28, & X.29 for dumb terminals

- virtual circuits over 56 kbps lines

Frame Relay

- skips error checking at intermediate nodes
- connection-oriented (virtual leased lines)

ATM - ditto, fixed length cells (53 bytes)

SMDS - Switched Multimegabit Data Service

- Packet service, connectionless, LAN interconnects
- Usually DS-3 (45 Mbps)

ISONET - Constant bit-rate, channelized or not

ISDN - BRI (2x64 kbps dialup) & PRI (24x64kbps)

B-ISDN - ATM switches and SONET

Standards Organizations

ITU - International Telecommunications Union

- Worldwide (CCITT until 1993 name change)

ISO - International Standards Organization

- OSI (Open Systems Interconnect) Model

IAB - Internet Architecture (Activities) Board

- set up by DOD in 1060's
- has IETF - Internet Engineering Task Force
- generates RFC's - requests for comments.
- >70 working committees

Internet Society - interest group created, Trustees now appoint IAB members.

U.S. - NIST (gov), ANSI (industry), IEEE (professional)