CS5310, Fall 2009

Computer Networks and Communication Systems

(08/26/2009)

Lecture 1: Introduction

Lecture Outline

1. Motivations and Histories

(1) Motivations

a. Disadvantages of centralized systems

b. Resource sharing, load sharing

c. Improving reliability

d. Communication media (banking, airline reservation)

(2) Classification of computer systems

a. Centralized systems

b. Computer networks

(a) LANs

(b) WANs

(c) MANs

c. Distributed systems

d. Parallel computers

(a) Shared memory multiprocessor systems

(b) MIMD parallel computers

e. Data flow machines

(3) Networks vs. distributed systems

a. Common issues: various (middle to low level) protocols, resource management, concurrency control

b. Differences: transparent services

(4) Computers and data communications (Fig.1)

a. Layers of communications: applications talk with each other at the highest level

b. The computer-communication network part is called *data communication network*. Its composition is very diversified.

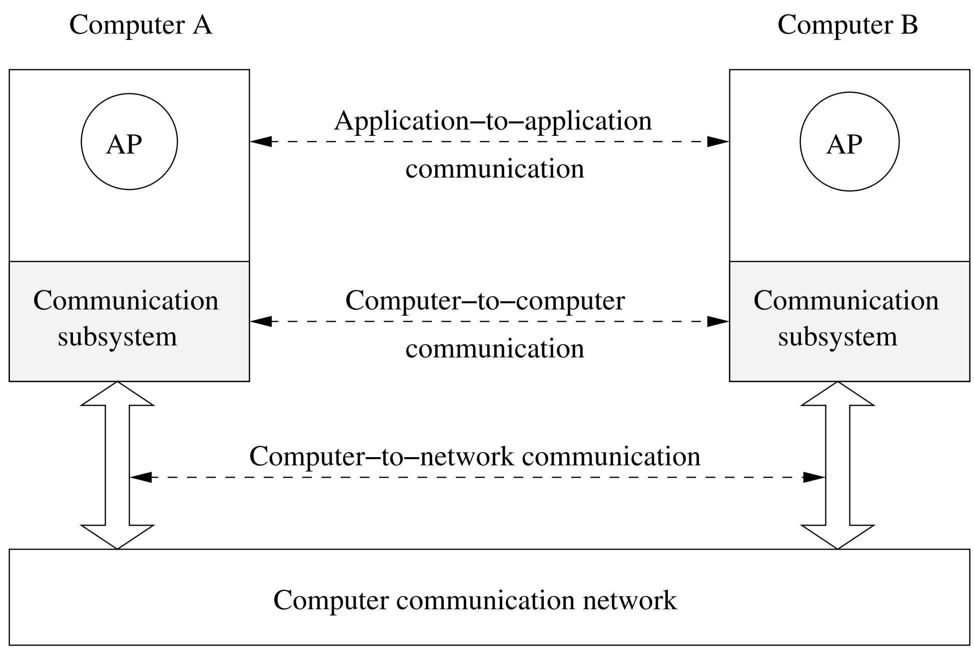

Figure 1: Computer communication schematic

2. Data Communication Networks

(1) Direct wire connection: Fig.2(a)

(2) Connection through PSTN (Public Switched Telephone Network): Fig.2(b)

- Modem is needed
- Fig.2.4, p.101 illustrates more details

(3) LANs: Fig.3

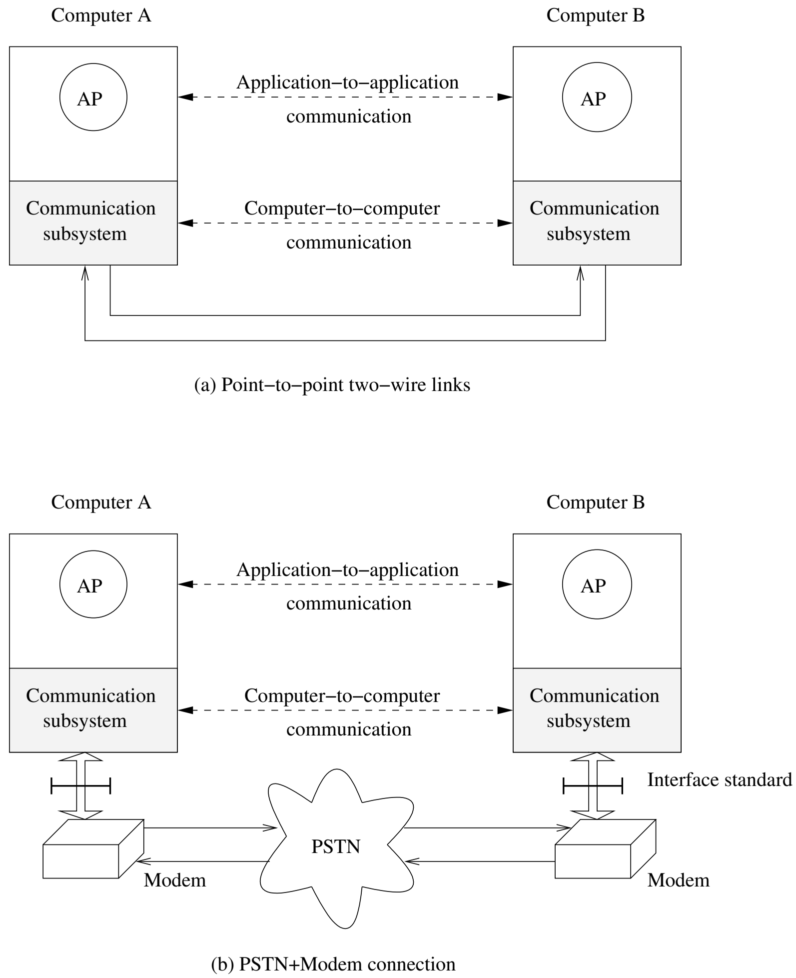

Figure 2: Simple computer-to-computer alternatives: (a) point-to-point wire link (b) PSTN + modem link.

a. Diversified structure (topology)

b. Diversified transmission media

(4) Enterprise-wide private networks: Fig. 3.26, p.215

(5) ISDN (Integrated Services Digital Network): Fig.3.23(a), p.209

a. Many public carries have been trying to convert its PSTN into ISDN

b. ISDN can be thought as one form of DSL (digital subscriber line)

(6) WANs and internetworking: Fig. 1.1, p.2 and Fig.2.35, p.155

3. <u>Standards</u>

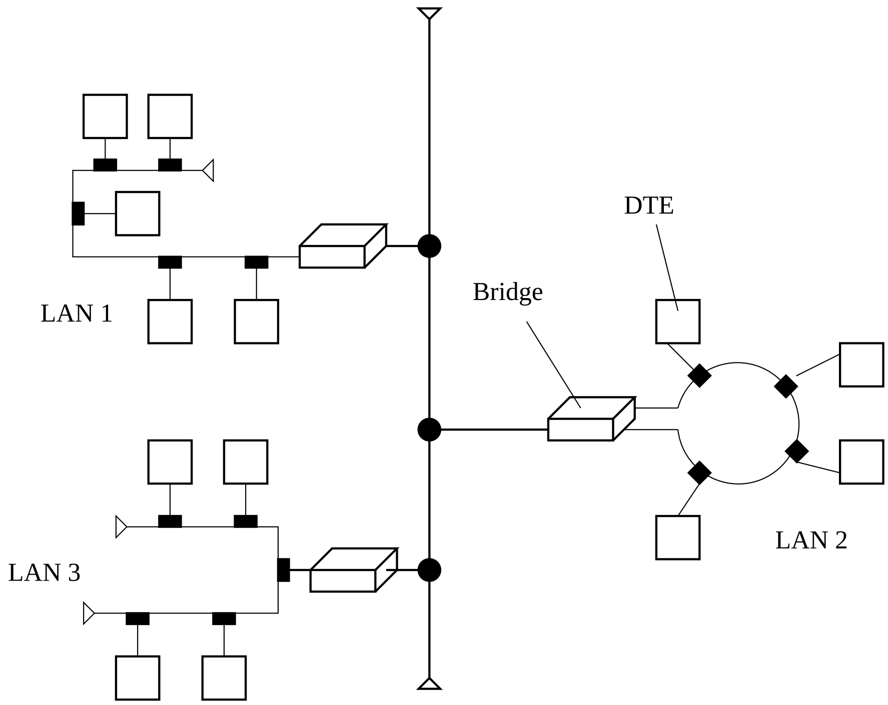

Figure 3: Illustration of LAN

(1) Closed systems and Open systems

a. Early computers had complex, activity-driven hardware and software components for networking (called *communication subsystems*).

b. Only machines of the same type, or from the same vendor, can communicate with each other (called *plug compatible systems*). such systems are called *closed systems*

c. In contrast, open systems are those that allow communication from various machines of potentially different vendors.

(2) International Standards

a. The need of standardization and and major standardization organizations

(a) Standardization leads higher productivity

(b) Major players: ISO, ITU (International Telecommunications Union), IEEE, CCITT

· IEEE, ECMA (European Computer Manufactures Association), EIA (Electrical Industries Association): represent computer industry, mainly promote proprietary standards for closed systems.

- ITU-T (International Telecommunication Union Telecommunication Sector), CEPT (Conference European of Post and Telecommunications), ANSI (American National Standards Institute): represent telecommunication industry, promote interface standards and standards for multi-vendor systems.
- ISO and ITU-T: represent integrated computer and telecommunication industries, promote international standards and standards for open system interconnections.

b. Standardization of different parts

* *V-series recommendations* for connection of equipment (normally referred as *data terminal equipment* (DTE)) to a modem or to the PSTN;
* *X-series recommendations* for connecting DTEs to a public data network;
* *I-series recommendations* for connecting DTEs to an ISDN.

c. Data transmissions are primary targets initially. More recently, exchange of electronic messages (Teletex), and access to public databases (Videotex). Formal syntax and control of the exchange of these various forms of information are needed. The resulting systems are called **open systems** (more completely as **open system interconnection environment (OSIE)**).

4. <u>The ISO's OSI Reference Model</u>

(1) Layered structure: a strategy for dealing with complex problems: Fig.4

a. Example: two philosophers want to converse. One of them can only speak English while the other can only speak French.

(a) They have to engage translators. The translators rely on secretaries to carry out the real physical communication (phone calls, faxes, emails)

(b) Each sentence from a philosopher is first given to his/her translator through the layer 3 to 2 interface, who then passes it to his/her secretary through the layer 2 to 1 interface. Notice that the two translators must agree on a common language, and the secretaries must also agree on the communication method.

(c) The secretary then sends the translated sentence through some communication medium to the other secretary.

b. Observation:

(a) The philosophers rely on the services of the translators, who in turn rely on the secretaries. The philosophers can be completely unware of the complex communication process involved.

(b) The two translators can change their agreed language, so long as the philosophers can express their thinkings with the chosen.

(c) The secretaries can choose the communication methods without affecting the whole process.

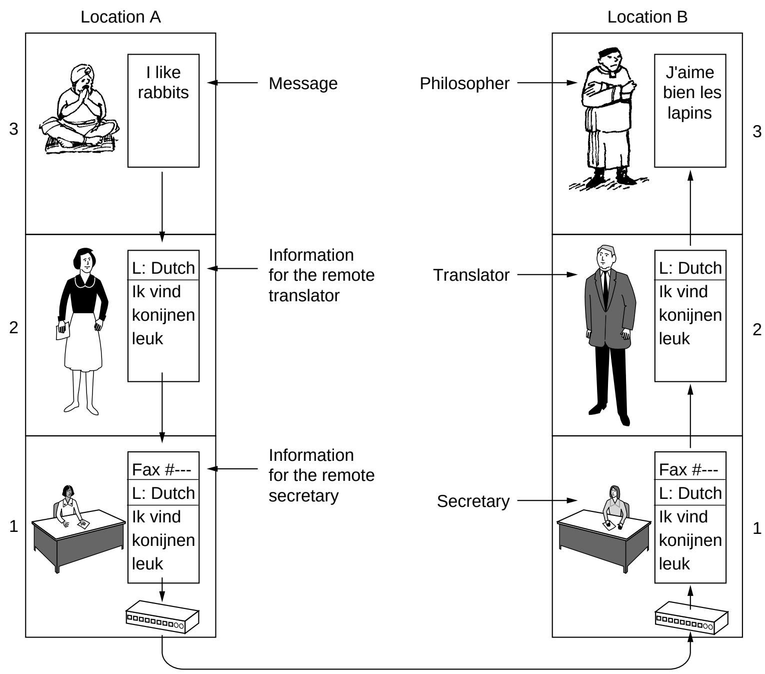

Figure 4: Layers in OSI model and Internet protocol suite

(2) Principles of OSI layers (Fig.6)

a. Layer creation criteria: level of abstraction;
b. Each layer: perform a well-defined function;
c. Layer function: easy to be standardized;
d. Layer boundaries: minimize information flow between layers;
e. Number of layers: reasonable.

(3) The Physical Layer

General Services: transmitting bits through physical channels

Design issues: (ensure that a bit 1 sent will be received as 1)
transmission media selection
signal (electrical, optical, electromagnetic) encoding and decoding

(4) The Data Link Layer

Gen. Services: providing error-free transmission services to its upper layer

Design issues: disassemble messages and reassemble messages
detecting loss of messages, retransmitting, detecting duplicates
flooding control, piggybacking

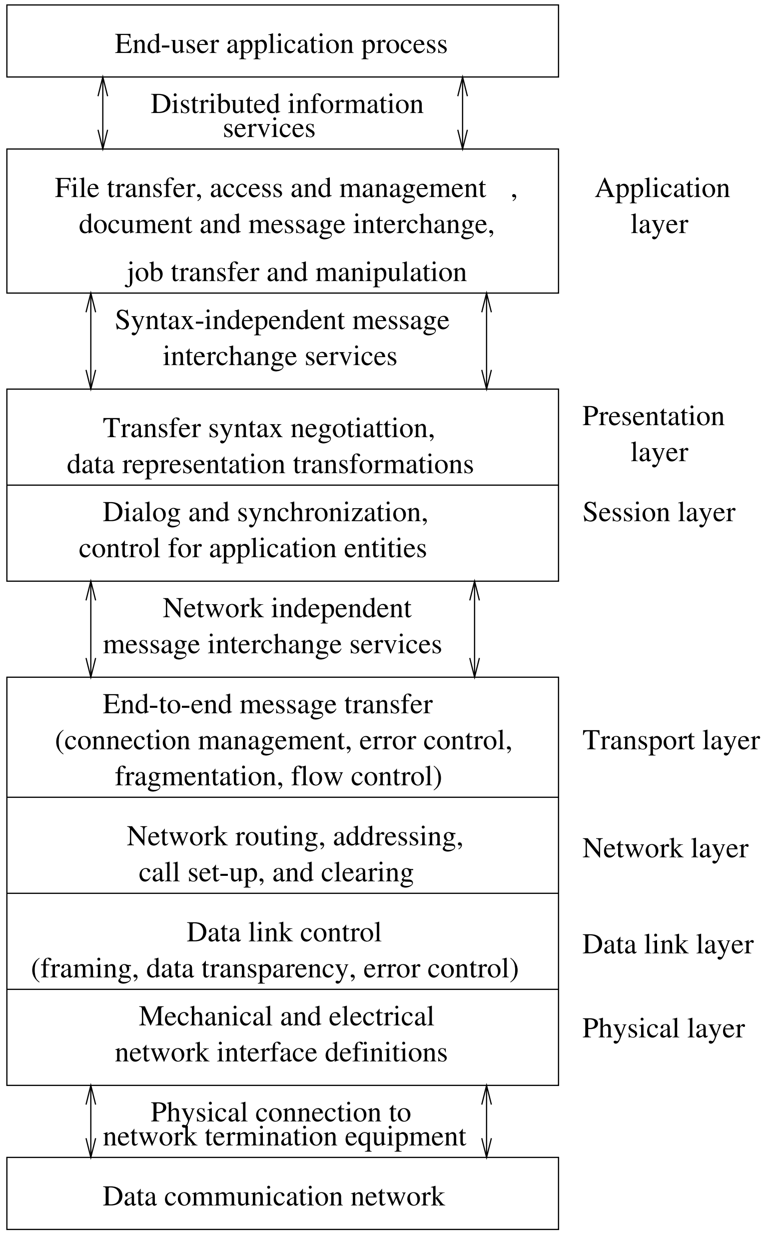

Figure 5: OSI reference model

(5) The Network Layer

Gen. Services:	controlling the network operations
Design issues:	routing: static, semi-dynamic, dynamic
	congestion control
	accounting
	internetworking

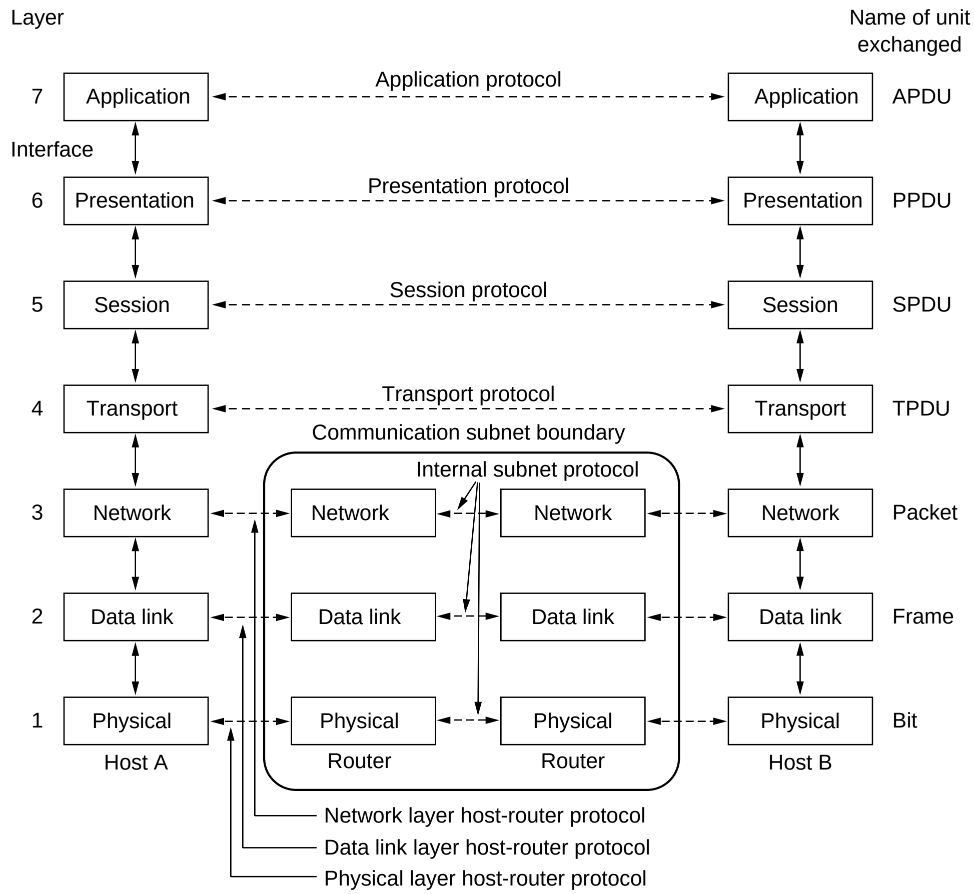

Figure 6: OSI reference model: another illustration

(6) The Transport Layer

Gen. Services: Accept and pass data

Design issues: multiple and multiplex transport
determine service types to session layer and network
(error-free point-to-point FIFO channel, no guaranteed order)
the first end-to-end layer
connection management

(7) The Session Layer

Gen. Services: establish sessions between users
data transport
enhanced services: remote login, file transfer
token management
synchronization (checkpointing in long transmissions)

(8) The Presentation Layer

Gen. Services: ensure syntax and semantics of the information
coding and encoding of abstract data structures (eg bank records)
data compression, cryptography

(9) The Application Layer

Gen. Services: general and special user-support facilities
Examples: terminal mapping
file system mapping
electronic mails
HTTP services

(10) Comments:

a. The OSI Reference Model is intended as a template for the structure of communication subsystems, not as a mandatory requirement.

b. Standards for different protocols in the different layer of the OSI Reference Model have been proposed by ISO, IEEE, ITU, and DARPA.

c. TCP/IP used by Internet has been used as the bases of ISO standards as the internetworking protocol.

d. The service and functionalities of the top three layers are sometime overlapping and difficult to distinguish clearly. The TCP/IP model (to be discussed) next combine them into one layer.

(11) Protocol stacks: Section 1.5 of first textbook.

a. Fig.1.38, p.84 illustrates the notion of protocol stacks

b. The Internet protocol stack is to be discussed next.

5. The TCP/IP Reference Model

(1) The TCP/IP model: developed with the Arpanet.

a. Goal of Arpanet: connecting different hosts and networks in the US military reliably.

b. Packet switching (to be covered later) is the technique was employed by Arpanet. The layer that ensured reliability (keeping communications possible as long as the source and destination machines are still up) is the **internet layer**.

c. Structure of the TCP/IP model: Fig.7

(a) The *presentation* and *session* layers are not present.

(b) The *network* layer in the OSI model corresponds to the *internet* layer.

(c) The *data link* and *physical* layers together correspond to the *host-to-network* layer. The TCP/IP model itself didn't say much about this layer. It is a combination of various hardware techniques and software (drivers) that provide support for host-to-host, network-to-network, and host-to-network communications using IP packets.

d. Protocols and networks in the initial TCP/IP model: Fig.8

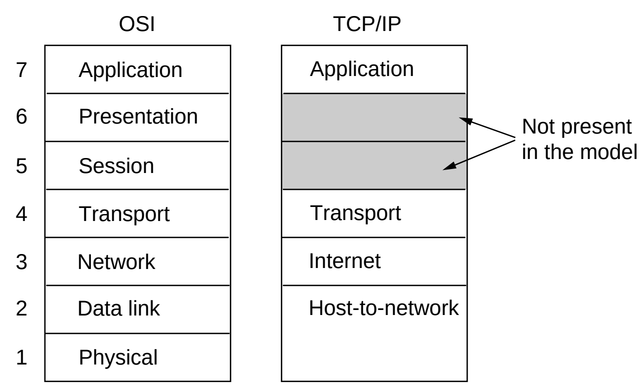

Figure 7: The TCP/IP reference model

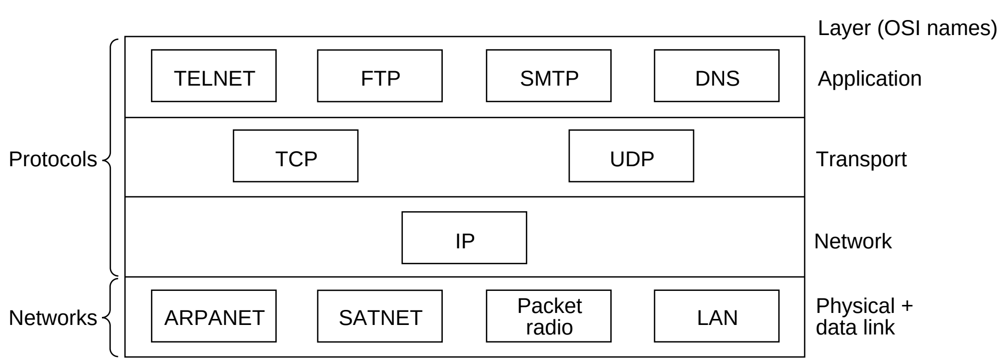

Figure 8: Protocols and networks in the initial TCP/IP reference model

6. Example Networks

(1) ARPANET – created by ARPA, now DARPA (defense Advanced Research Projects Agency), in 1969

a. Background

(a) DoD funded many CS depts for computer network researches.

(b) MILNET was derived from ARPANET.

b. Original Arpanet design: Fig.9

(a) IMP (interface message processor). The Arpanet began as a group of IMPs connected with 56Kbps transmission lines.

(b) Software: IMP-to-IMP protocol; IMP-to-Host protocol; Host-to-host protocol.

c. Growth of the Arpanet (from Dec. 1969 to Sept. 1972): Fig.10.

(a) It eventually grew to a network with thousands of sites and more than 100,000 users.

(b) The use of TCP/IP protocol suite demonstrated its viability to growth.

d. Main contributions:

(a) TCP and IP. TCP (transfer control protocol), IP (internet protocol) were developed to connect multiple subnetworks.

(b) Very influential, besides TCP and IP, many network protocol, such as FTP (file transfer protocol), SMTP (simple mail transfer protocol), TELNET (remote login).

(c) It played the role of the direct predecessor of today's Internet

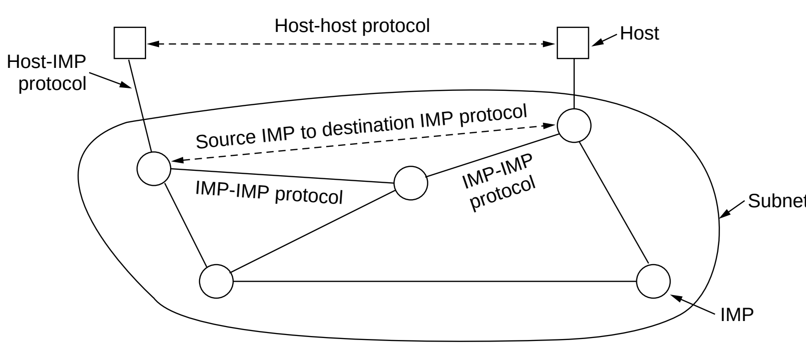

Figure 9: The original Arpanet design

(2) CSNET – funded by NSF in 1980, to connect CS depts in US.

a. Not a real network like ARPANET. It is a *metanetwork*, using transmission facilities provided by other networks and adding a uniform protocol on top to make it look like a single logical network to users.

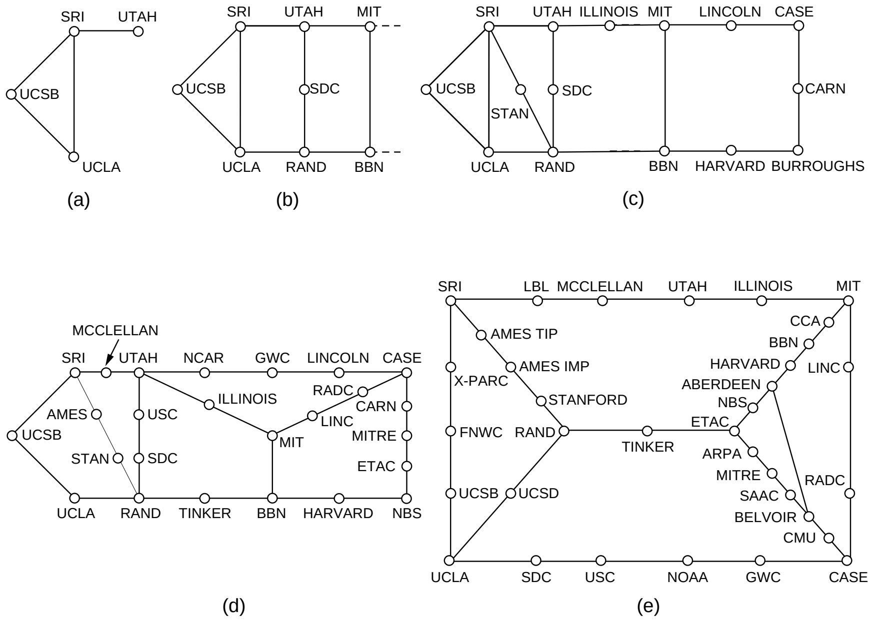

Figure 10: Growth of the Arpanet. (a) December 1969. (b) July 1970. (c) March 1971. (d) April 1972. (e) September 1972.

b. Four components, tied together by a machine called CSNET-RELAY (run by a company called BBN, in Cambridge , Mass.) ARPANET, public X.25 networks (Telenet and Uninet), PHONENET (calling up CSNET-RELAY through phones), CYPRESS (use leased lines and Microvax).

c. Basic services: emails. Remote login possible except PHONENET.

d. Extended to NSFNET, use 1.5Mbps microwave links for long distance transmission.

(3) NSFNET – funded by NSF in 1980, as a version of the successful Arpanet to connect research groups in all academic institutions

a. Backbone network (Fig.11): NSF already had six supercomputers located in San Diego, Boulder, Champaign, Pittsburgh, Ithaca, and Princeton. NSF funded the building of a backbone network that connects them.

(a) Each supercomputer was associated with a microcomputer called *fuzzball*, which were connected with 56kbps leased lines to form the subnet (within the city). The fuzzball used TCP/IP from the beginning (hence NSFNET is the first TCP/IP based WAN).

(b) The backbone supported 1.5Mbps data rate

b. NSF funded about additional 20 subnets connecting to the backbone.

c. To further its growth through commercialization, in 1990 NSF established (with MERIT, MCI, and IBM) a non-profit organization ANS (advanced networks and services) to manage NSFNET.

   (a) ANS upgraded NSFNET to 45Mbps and NSFNET was renamed to ANSNET.

   (b) ANSNET was sold to AOL around 1995.

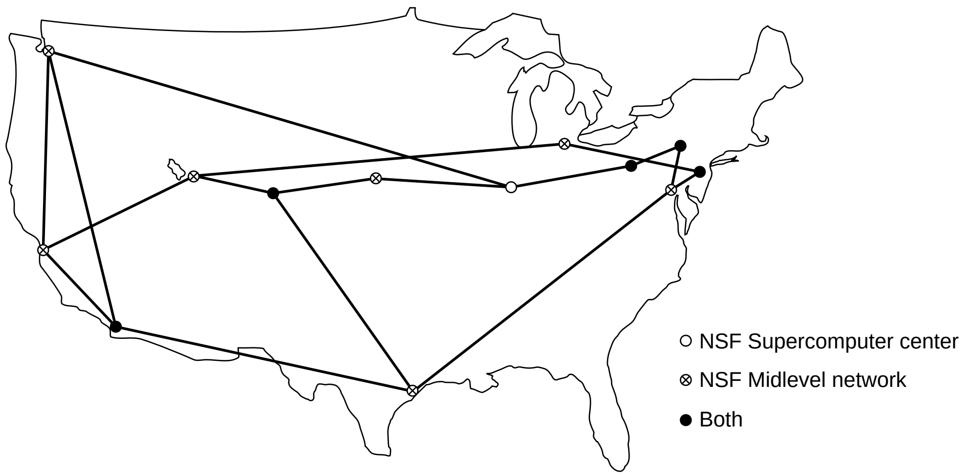

Figure 11: The NSFNET backbone in 1988

(4) SNA, by IBM, in 1974.

a. Intended to unify communication methods among IBM machines. Before SNA, hundreds of comm. products, three dozens access methods, more than one dozen data link protocols.

b. Featured by layered architectures. OSI reference model is strongly influenced by SNA

c. Important concepts: routing, flow control.

(5) BITNET (Because It's Time to NETwork), started in 1981 at CUNY and Yale.

a. With ideas same as CSNET, except for all departments, not just the CS depts. In late of 1990's it had more than 500 sites around the world.

b. Similar to CYPRESS, using leased lines

c. Transmission protocols, donated by IBM, not compatible with TCP/IP and OSI (based on ideas of transmitting 80-column punched cards).

d. Financial policy: leased line. Must agree to be connected by other sites.

e. Basic services: file transfers and emails, very limited remote logins.

(6) Internet

a. A direct descendant of ARPANET

b. Standard communication protocols: TCP/IP

c. Enormous number of applications due to its open communication standards

d. Overview of the Internet: Fig.12

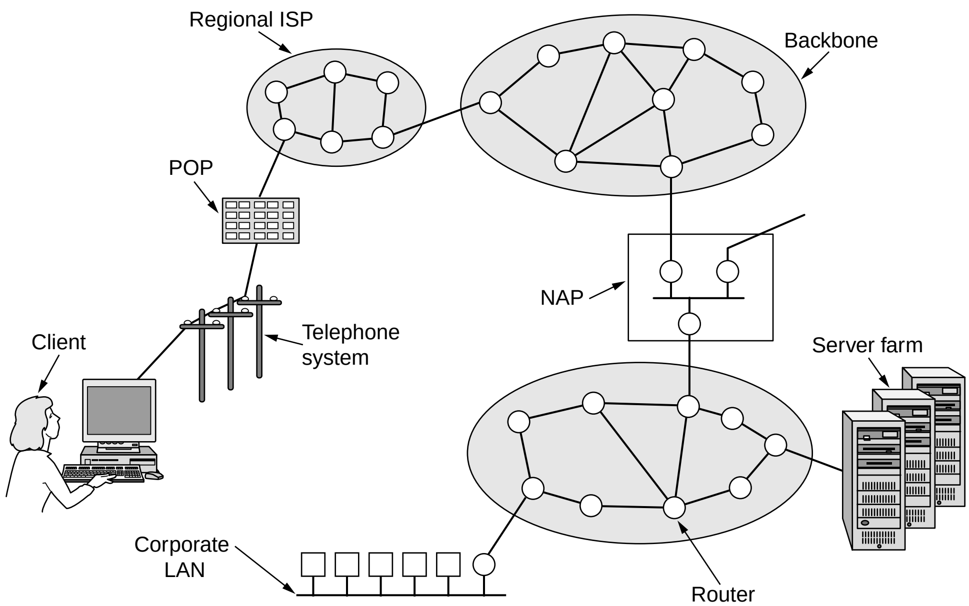

Figure 12: Overview of the Internet

(7) ATM networks

a. Motivations: as a new technique to provide unified transmission services to all Internet applications (files, audio, video, and etc)

b. ATM cells and ATM virtual circuits

(a) ATM cells: Fig.13. Motivation: to accommodate various types of applications. Each cell is of 53 bytes, with a 5-tyte header and 48-byte payload.

(b) ATM virtual circuits: each ATM communication session must establish an ATM virtual circuit first. Each virtual circuit will be assigned a a unique connection identifier (Fig.14).

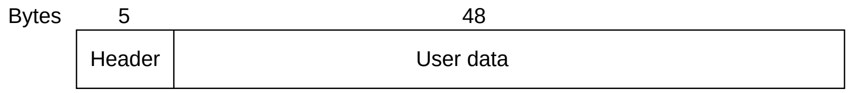

Figure 13: An ATM cell

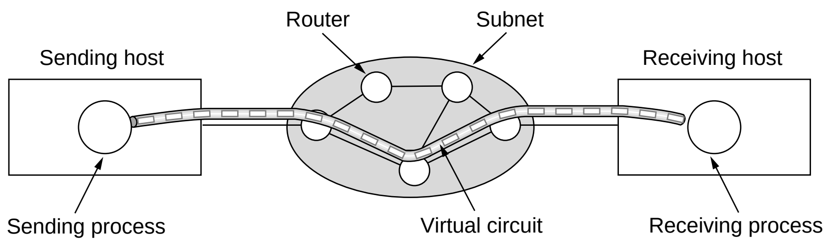

Figure 14: An ATM virtual circuit

c. ATM links: 155Mbps or 622Mbps

   (a) The 155Mbps is chosen to acommodate HDTV. The exact number is chosen for compability with IBM's SONET

   (b) The value 622Mbps is $155\times\ 4$ for better multiplexing.

d. The ATM reference model: Fig.15 and Fig.16

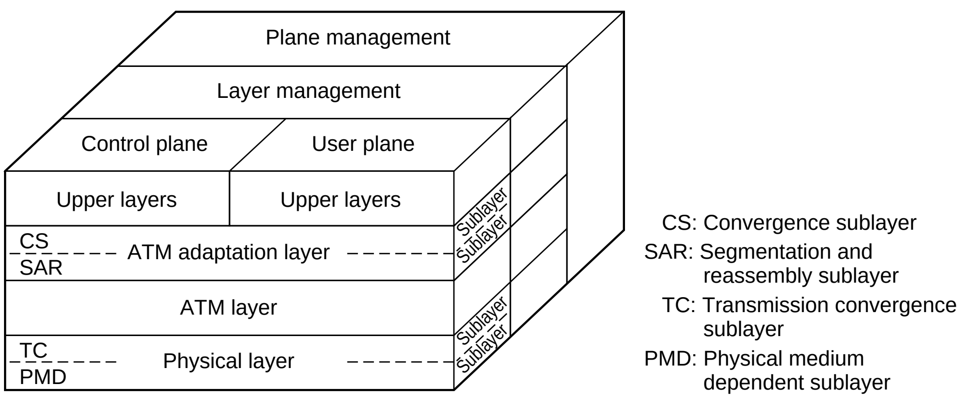

Figure 15: The ATM reference model

e. Future of ATM

   (a) As a relatively new technology, ATM has been accepted well and has become an integrated part of today's PSTN and Internet.

   (b) Due to the emergence of all optical networks and increasingly importance of wireless communications and networks, ATM's further development is limited.

OSI layer	ATM layer	ATM sublayer	Functionality
3/4	AAL	CS	Providing the standard interface (convergence)
		SAR	Segmentation and reassembly
2/3	ATM		Flow control Cell header generation/extraction Virtual circuit/path management Cell multiplexing/demultiplexing
2	Physical	TC	Cell rate decoupling Header checksum generation and verification Cell generation Packing/unpacking cells from the enclosing envelope Frame generation
1		PMD	Bit timing Physical network access

Figure 16: The ATM layers and sublayers, and their functions