Chapter 1

(Week 2)

Introduction

(continuation)

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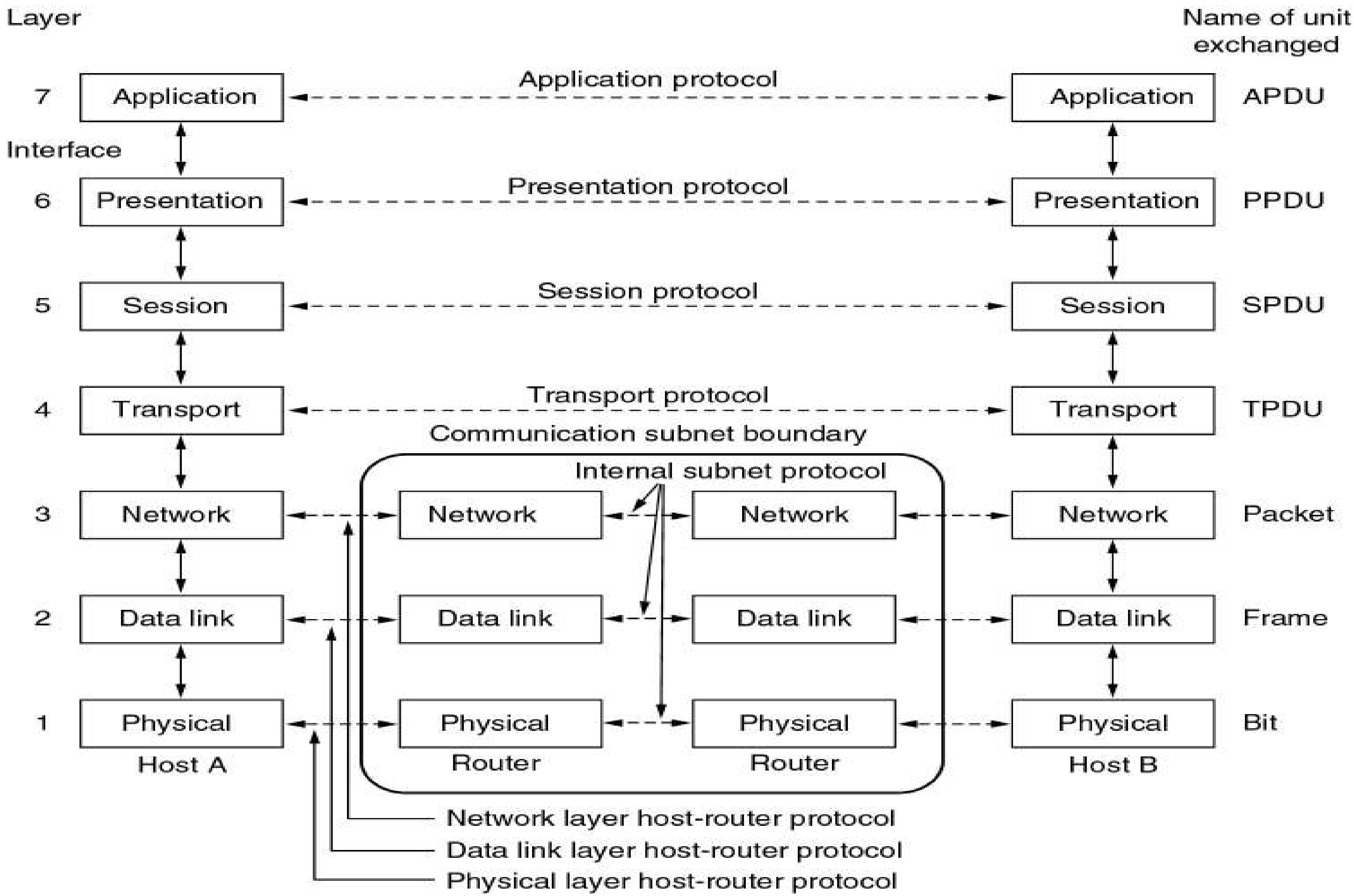
Reference Models

- The OSI (Open Systems Interconnection) Reference Model
- The TCP/IP (Transmission Control Protocol / Internet Protocol) Reference Model
- A Comparison of OSI and TCP/IP
- A Critique of the OSI Model and Protocols
- A Critique of the TCP/IP Reference Model

The OSI Reference Model



Design Principles of the OSI Model

1. A layer should be created where a different abstraction is needed;
2. Each layer should perform a well-defined function;
3. The function of each layer should be chosen with an eye toward defining internationally standardized protocols;
4. The layer boundaries should be chosen to minimize the information flow across the interfaces;
5. The number of layers should be large enough that distinct functions need not be thrown together in the same layer out of necessity and small enough that the architecture does not become unwieldy.

Physical Layer of the OSI Model (1/2)

The Physical Layer is concerned with transmitting raw bits over a communication channel. The typical questions here are:

- How many volts should be used to represent a 1 and a 0;
- How many nanoseconds a bit lasts;
- Whether transmission may proceed simultaneously in both directions;

Physical Layer of the OSI Model (2/2)

- How the initial connection is established and how it is torn down when both sides are finished;
- How many pins the network connector has and what each pin is used for;

The design issues here largely deal with mechanical, electrical, and timing interfaces, and the physical transmission medium, which lies below the physical layer.

Data Link Layer of the OSI Model (1/2)

- The main task of The Data Link Layer is to transform a raw transmission facility into a line that appears free of undetected transmission errors to the network layer.
- The Data Link Layer executes this task by having the sender break up the input data into data frames (typically a few hundred or a few thousand bytes) and transmit the frames sequentially.
- If the service is reliable, the receiver confirm correct receipt of each frame by sending back an acknowledgement frame.

Data Link Layer of the OSI Model (2/2)

- Another issue that arises in Data Link Layer (and most of the higher layers as well) is how to keep a fast transmitter from drowning a slow receiver in data.
- Some traffic regulation mechanism is offen needed to let the transmitter know how much buffer space the receiver has at the moment. Frequently, this flow regulation and the error handling are integrated.
- Medium access control sublayer: which is the part of the data link layer in the broadcast networks, deals how to control access to the shared channel.

Network Layer of the OSI Model (1/2)

- The Network Layer controls the operation of the subnet.
- A key design issue is determining how packets are routed from source to destination.
- Routes can be based on static tables that are "wired info" the network and rarely changed.
- Tables can also be determined at the start of each conversation.
- Tables can be highly dynamic, being determined anew for each packet, to reflect the current network load.

Network Layer of the OSI Model (2/2)

- The Network Layer controls the congestions when too many packets are present in the subnet at the same time;
- More generally, the quality of service provided (delay, transit time, jitter, etc.) is also a network layer issue.
- Converting the addresses and packet sizes between networks is also a job of the network layer.
- In broadcast networks, the routing problem is simple, so the network layer is often thin or even nonexistent.

Transport Layer of the OSI Model (1/2)

- The Transport Layer’ s basic function is to accept data from above, split it up into smaller units if need be, pass these to the network layer, and ensure that the pieces all arrive correctly at the other end.
- Furthermore, all this must be done efficiently and in a way that isolates the upper layer from the inevitable changes in the hardware technology.
- The Transport Layer also determines what type of service to provide to the session layer, and, ultimately, to the users of the network.

Transport Layer of the OSI Model (2/2)

- An error-free point-to-point channel that delivers messages or bytes in the order in which they were sent is the most popular type of transport connection.
- The transport layer is a true end-to-end layer, all the way from the source to the destination.
- Due to the transport layer a program on the source machine carries on a conversation with a similar program on the destination machine, using the message headers and control messages.

Session Layer of the OSI Model (1/1)

- The Transport Layer allows users on different machine to establish sessions between them.
- Sessions offer various services:
- Dialog control (keeping track of whose turn it is to transmit);
- Token management (preventing two parties from attempting the same critical operation at the same time);
- Synchronization (check pointing long transmissions to allow them to continue from where they were after a crash).

Presentation Layer of the OSI Model (1/1)

- The Presentation Layer is concerned with the syntax and semantics of the information transmitted.
- In order to make it possible for computers with different data representations to communicate, the data structures to be exchanged can be defined in an abstract way, along with a standard encoding to be used “on the wire”.
- The Presentation Layer manages these abstract data structures and allows higher-level data structures to be defined and exchanged.

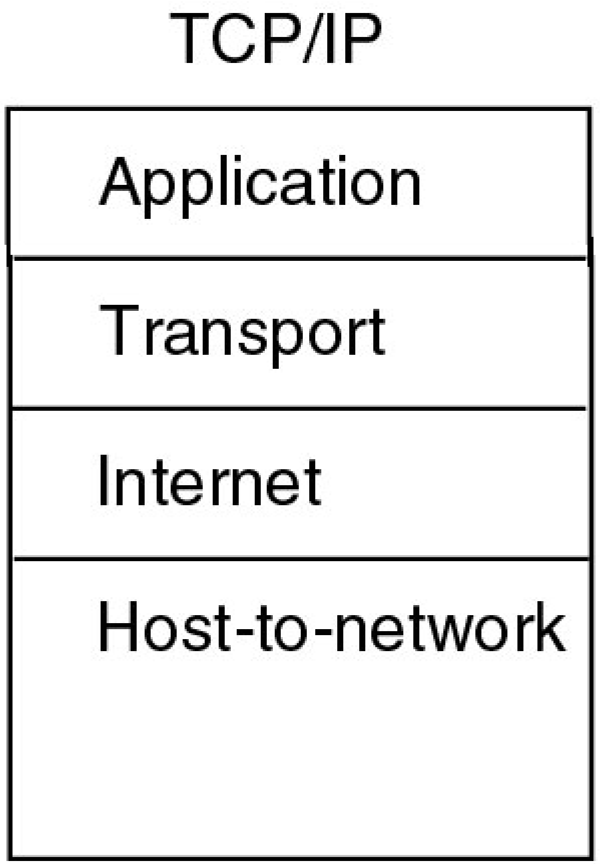
Application Layer of the OSI Model (1/1)

- The Application Layer contains a variety of protocols that are commonly needed by users.
- One widely used application protocol is HTTP (Hyper Text Transfer Protocol) which is the basis for World Wide Web. When a browser wants a Web page, it sends the name of the page it wants to the server using HTTP. The server then sends the page back.
- Other application protocols are used for file transfer, electronic mail, and network news.

The TCP/IP Reference Model

- ARPANET was a research network;
- ARPANET was the grandparent of all WAN;
- The Worldwide INTERNET is the successor of ARPANET;
- The TCP/IP Reference Model was used in both ARPANET and The Worldwide INTERNET;
- The TCP/IP Reference Model includes 4 layers.

The TCP/IP Reference Model



Host-to-Network Layer of the TCP/IP Reference Model (1/1)

- Host-to-Network Layer allow the host to connect to the network using some protocol so it can send IP packets to it.
- Protocols used here are not defined and vary from host to host and network to network.

Internet Layer of the TCP/IP Reference Model (1/1)

- The Internet Layer provides a packet-switching network based on a connectionless internetwork layer;
- The Internet Layer permits hosts to inject packets into any network and have them travel independently to the destinition (potentially on a different network);
- The Internet Layer defines an official packet format and protocol called IP (Internet Protocol).
- Paket routing is clearly the major issue in the Internet Layer, as is avoiding congestion.

Transport Layer of the TCP/IP Reference Model (1/2)

- The Transport Layer allows peer entities on the source and destination hosts to carry on a conversation;
- There are two end-to-end transport protocols;
- The first one is TCP (Transmission Control Protocol), which is a reliable connection-oriented protocol.
- TCP fragments the incoming byte stream into discrete messages and passes each one on to the internet layer.
- TCP also handles flow control to make sure a fast sender cannot swamp a slow receiver.

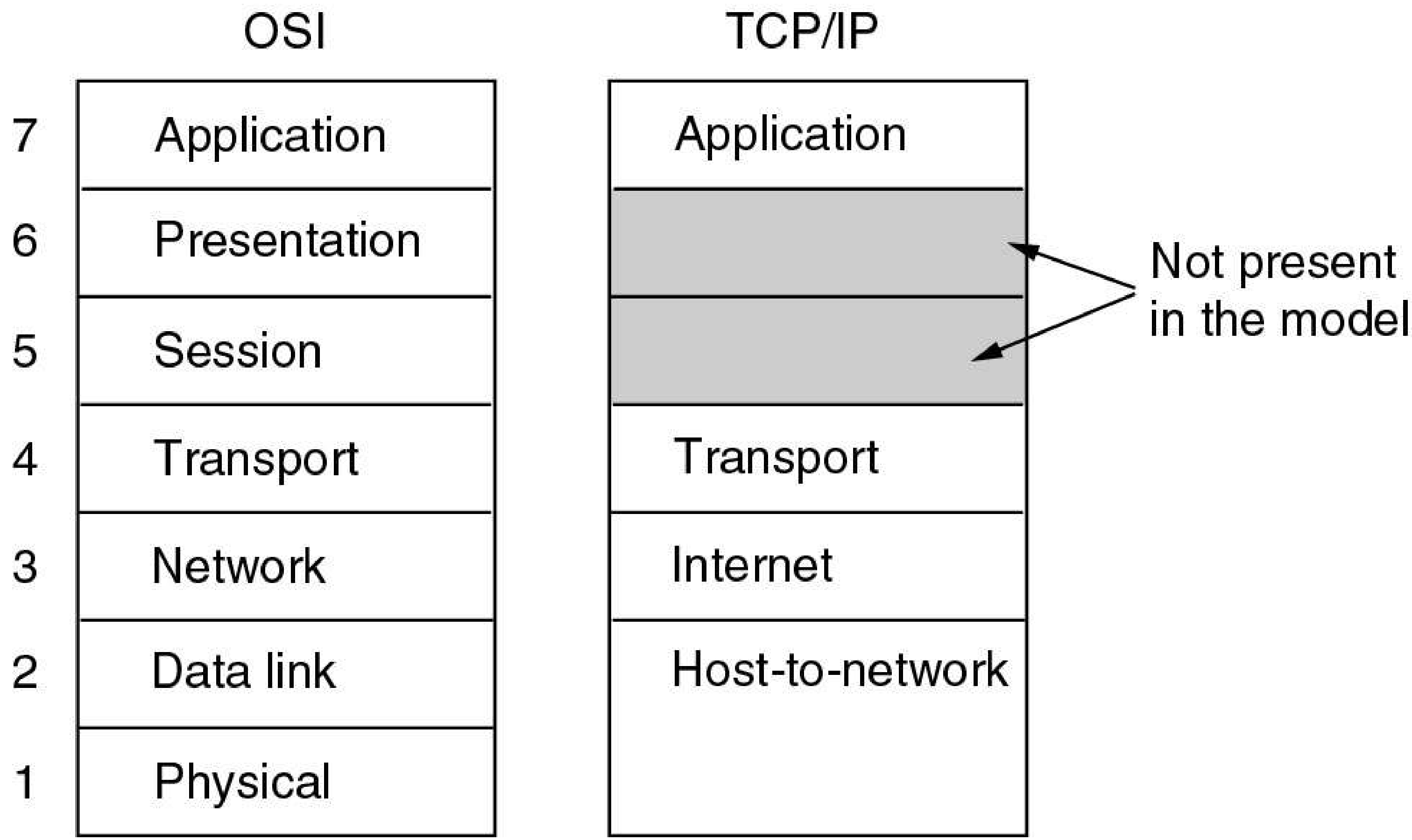
Transport Layer of the TCP/IP Reference Model (2/2)

- The second protocol is UDP (User Datagram Protocol), which is unreliable, connectionless protocol for applications that do not want TCP's sequencing or flow control and wish to provide their own.
- UDP is also widely used for one-shot, client-server-type request-reply queries and applications in which prompt delivery is more important than accurate delivery, such as transmitting speech or video.

Application Layer of the TCP/IP Reference Model (1/1)

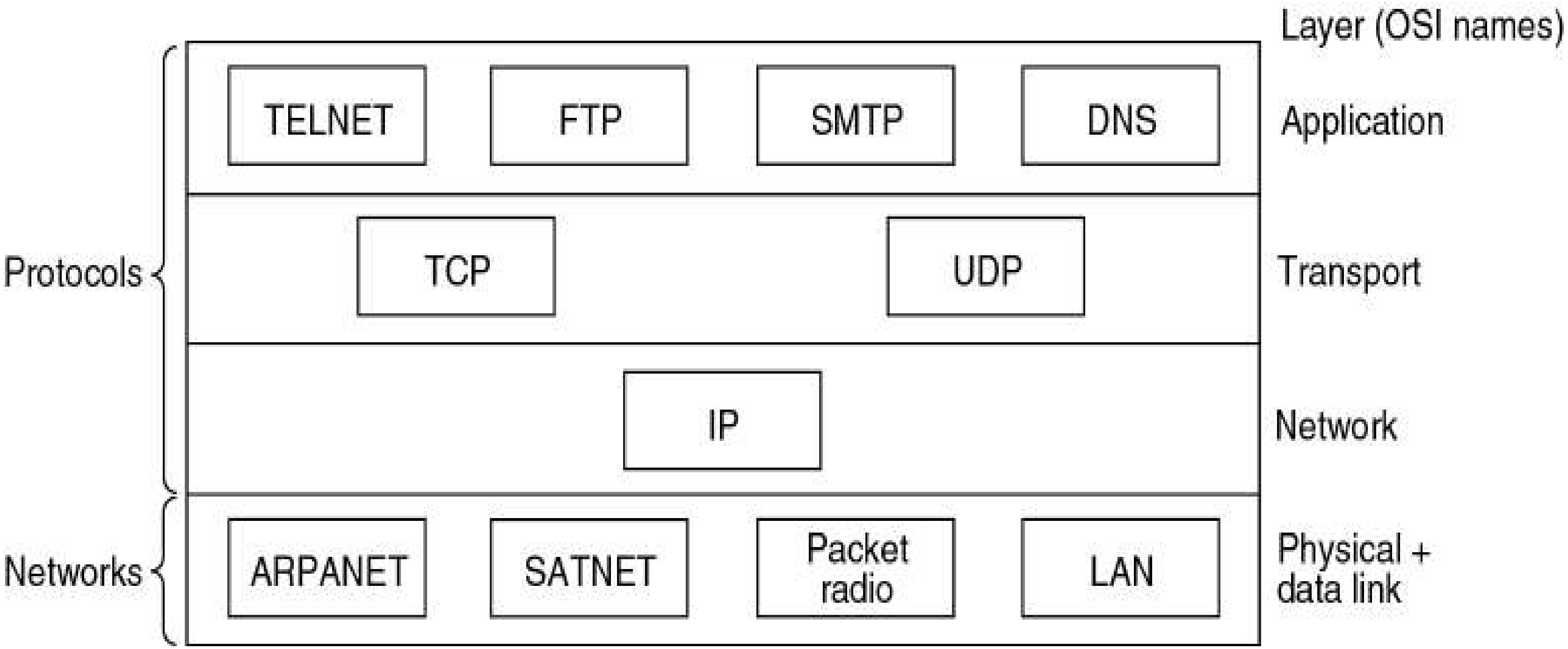
- The Application Layer contains all the higher–level protocols like virtual terminal (TELNET), file transfer (FTP), and electronic mail (SMTP);
- TELNET allows a user on one machine to log onto a distant machine and work there;
- FTP provides a way to move data efficiently from one machine to another;
- SMTP is a specialized protocol to deliver e-mails.
- Over years: DNS, NNTP, HTTP, and etc.

Reference Models (2)



The TCP/IP reference model.

Reference Models (3)



Protocols and networks in the TCP/IP model initially.

Comparing OSI and TCP/IP Models

Concepts central to the OSI model

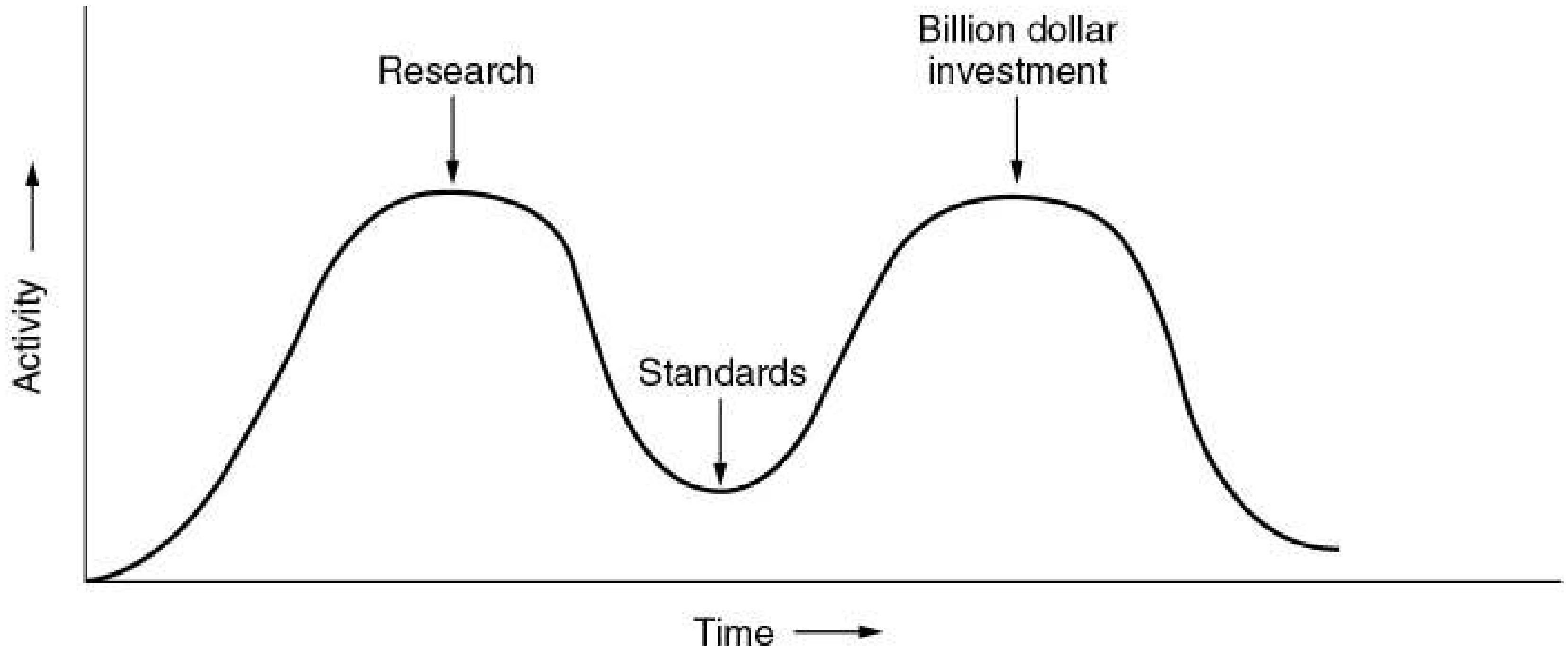
- Services
- Interfaces
- Protocols

A Critique of the OSI Model and Protocols

Why OSI did not take over the world

- Bad timing
- Bad technology
- Bad implementations
- Bad politics

Bad Timing



The apocalypse of the two elephants.

A Critique of the TCP/IP Reference Model

Problems:

- Service, interface, and protocol not distinguished
- Not a general model
- Host-to-network “layer” not really a layer
- No mention of physical and data link layers
- Minor protocols deeply entrenched, hard to replace

Hybrid Model

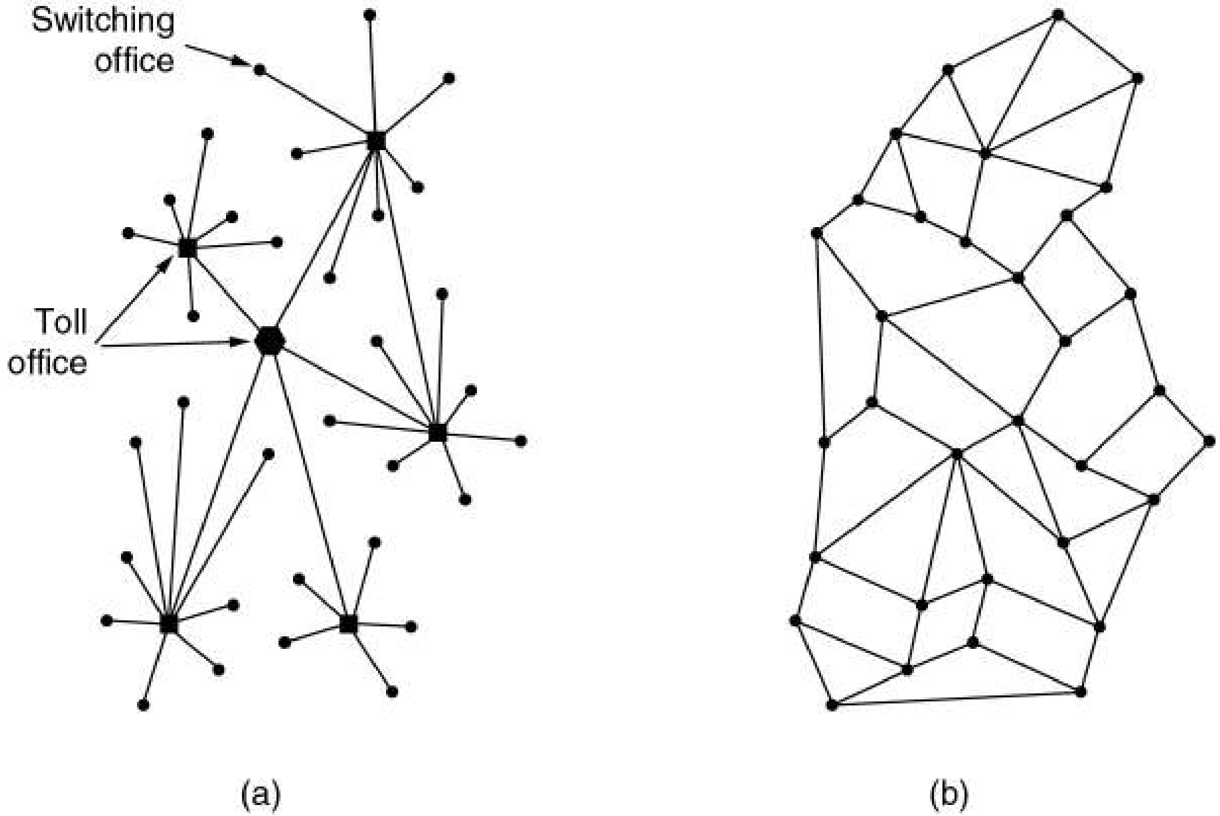
5	Application layer
4	Transport layer
3	Network layer
2	Data link layer
1	Physical layer

The hybrid reference model to be used in this book.

Example Networks

- The Internet
- Connection-Oriented Networks:
  X.25, Frame Relay, and ATM
- Ethernet
- Wireless LANs: 802:11

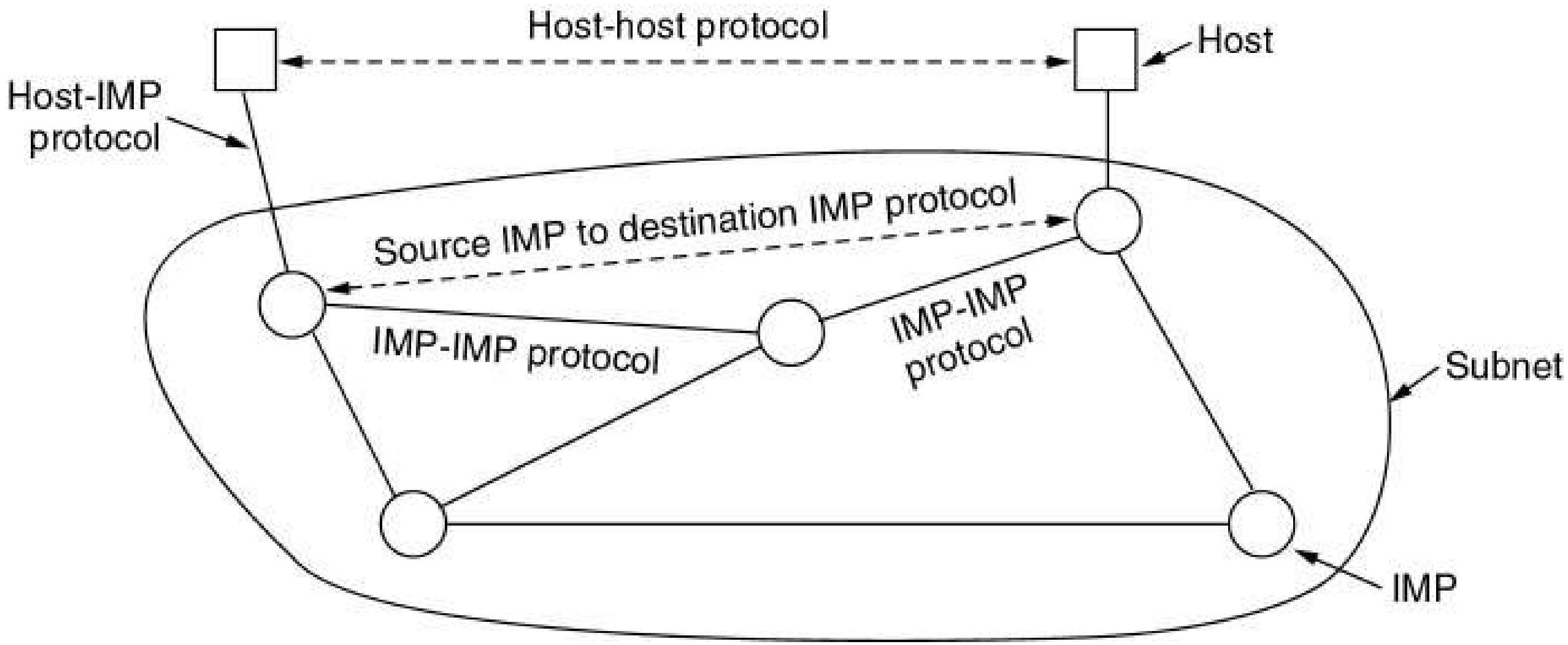
The ARPANET



(a) Structure of the telephone system.

(b) Baran's proposed distributed switching system.

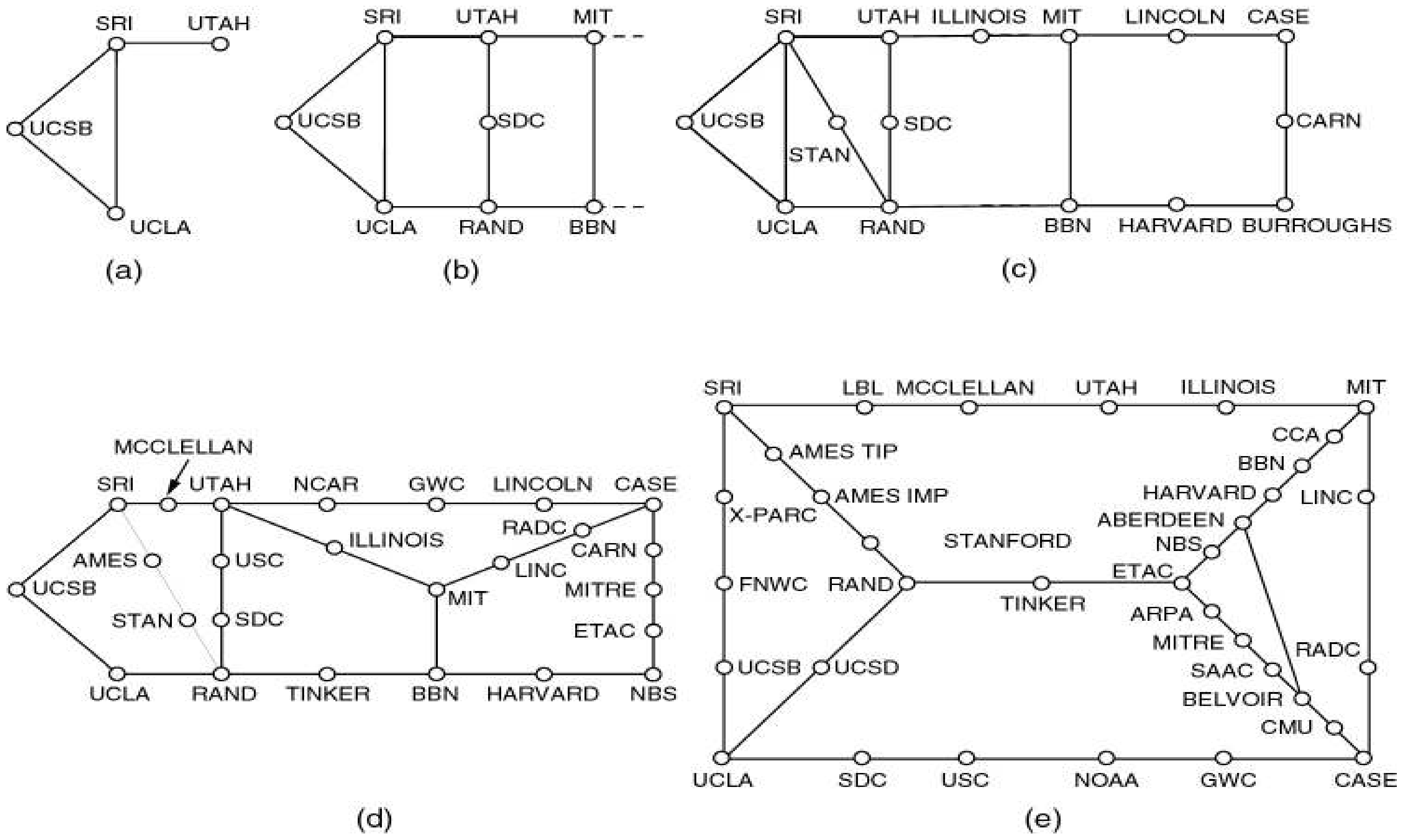
The ARPANET (2)



IMP-Interface Message Processors

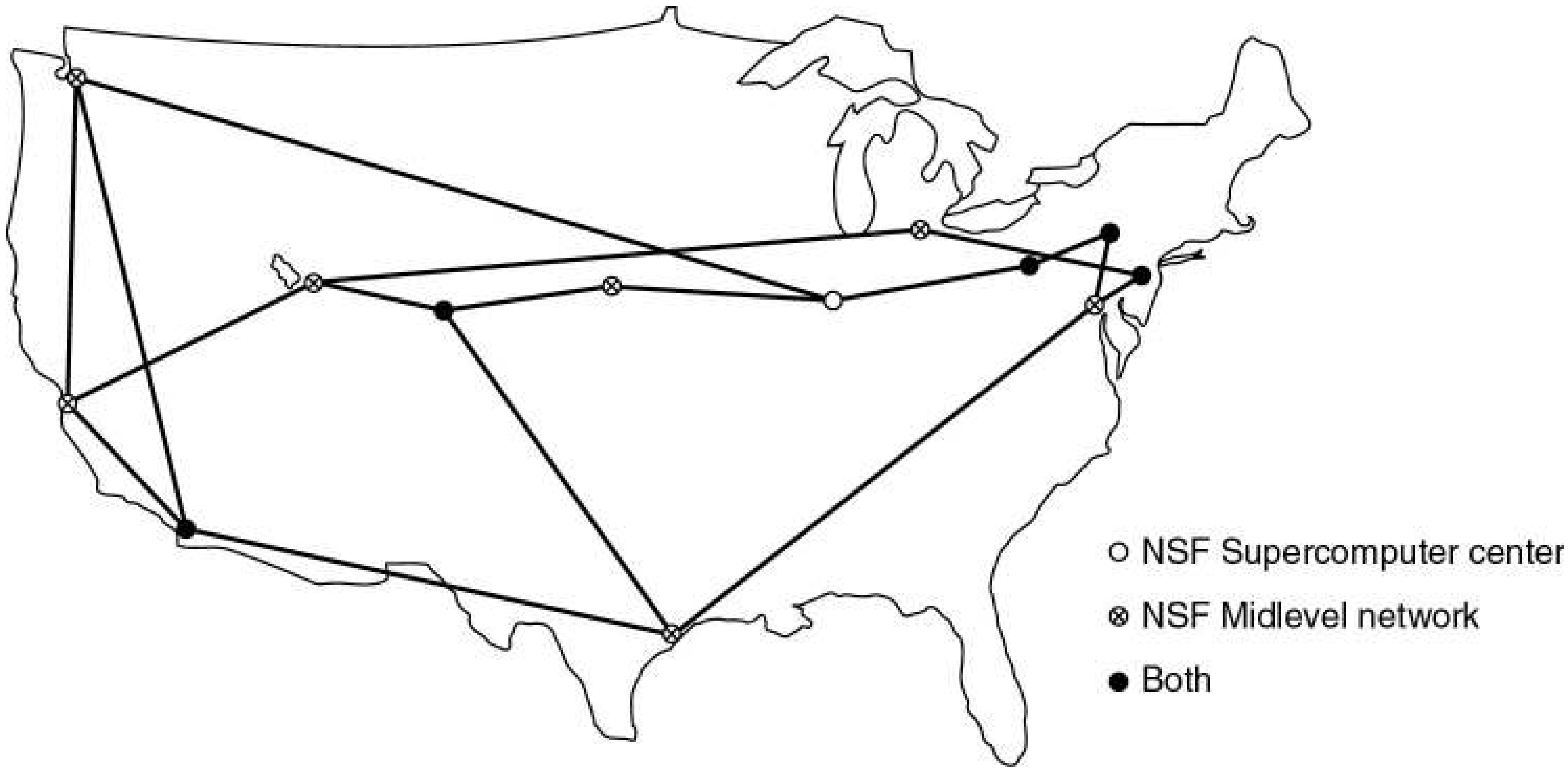
The original ARPANET design.

The ARPANET (3)



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

NSFNET



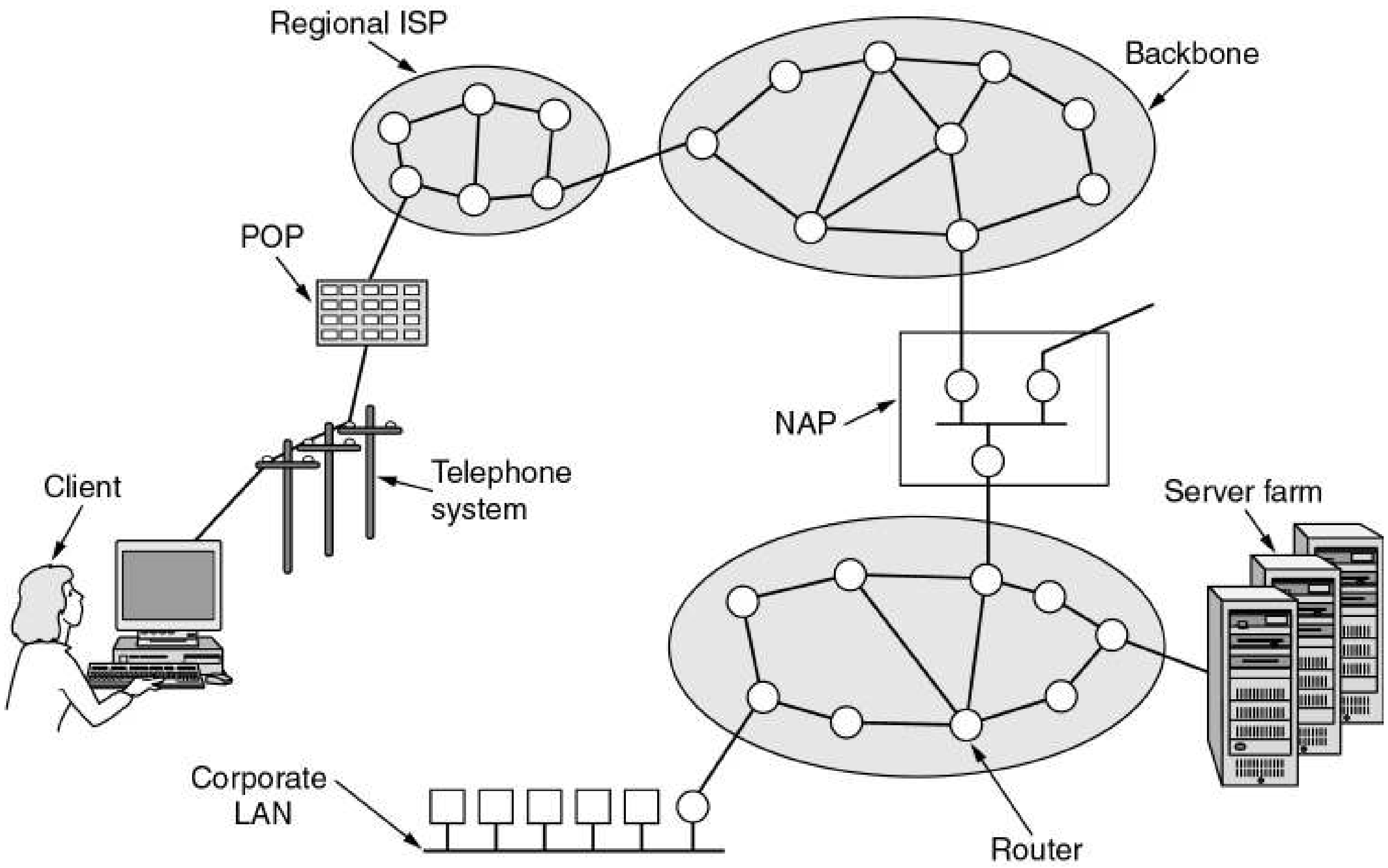
The NSFNET (the U.S. National Science Foundation Network) backbone in 1988.

Internet Usage

Traditional applications (1970 – 1990)

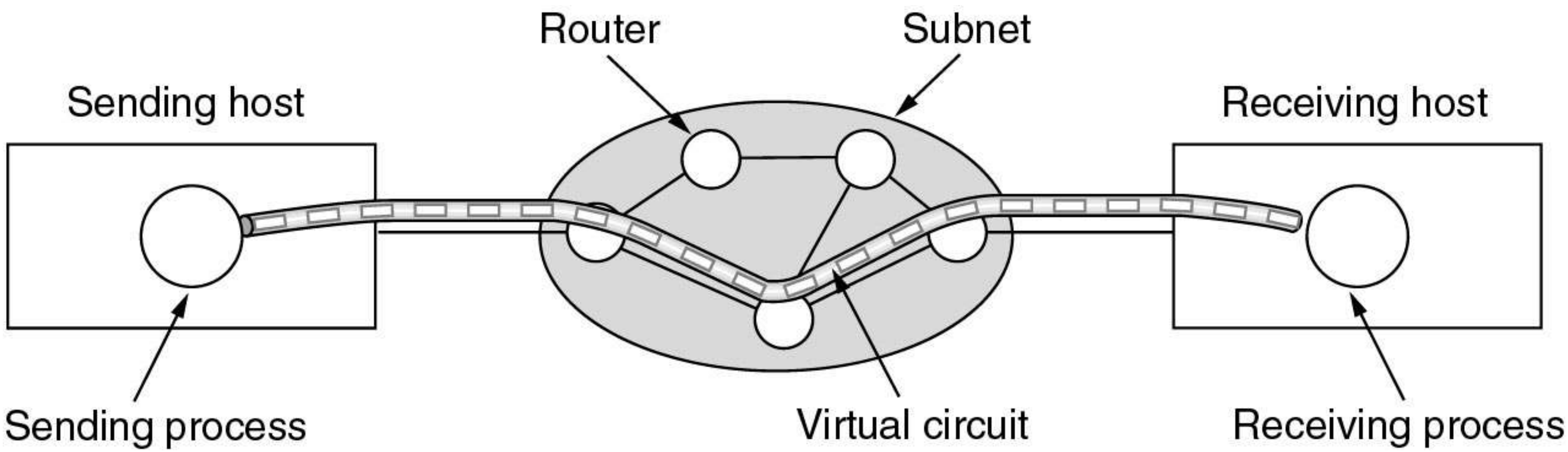
- E-mail
- News
- Remote login
- File transfer

Architecture of the Internet



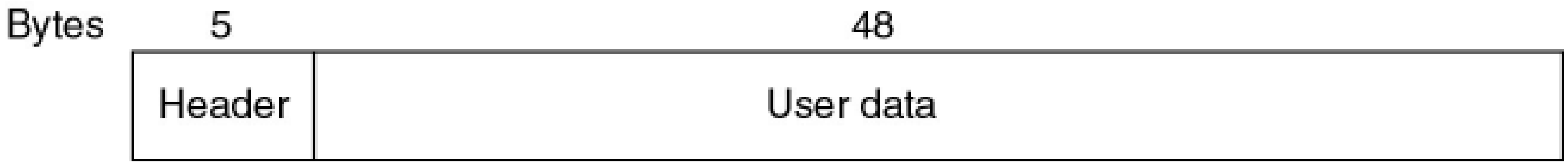
Overview of the Internet.

ATM (Asynchronous Transfer Mode) Virtual Circuits



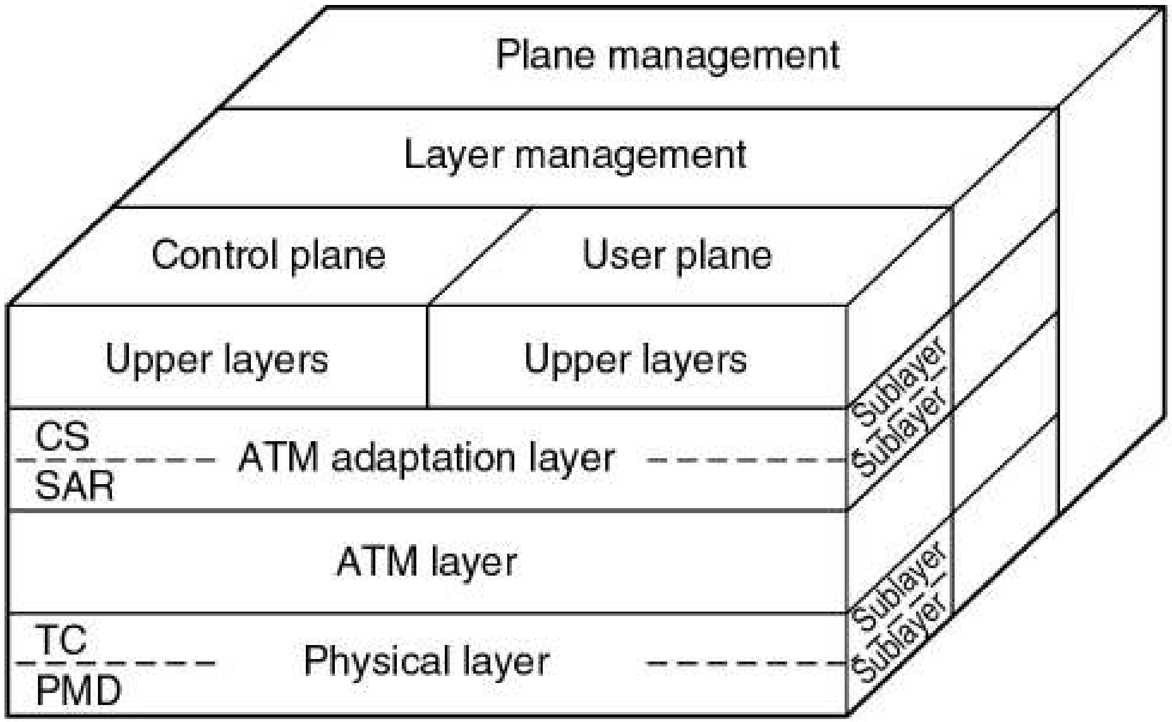
A virtual circuit.

ATM Virtual Circuits (2)



An ATM cell.

The ATM Reference Model



CS: Convergence sublayer
SAR: Segmentation and reassembly sublayer
TC: Transmission convergence sublayer
PMD: Physical medium dependent sublayer

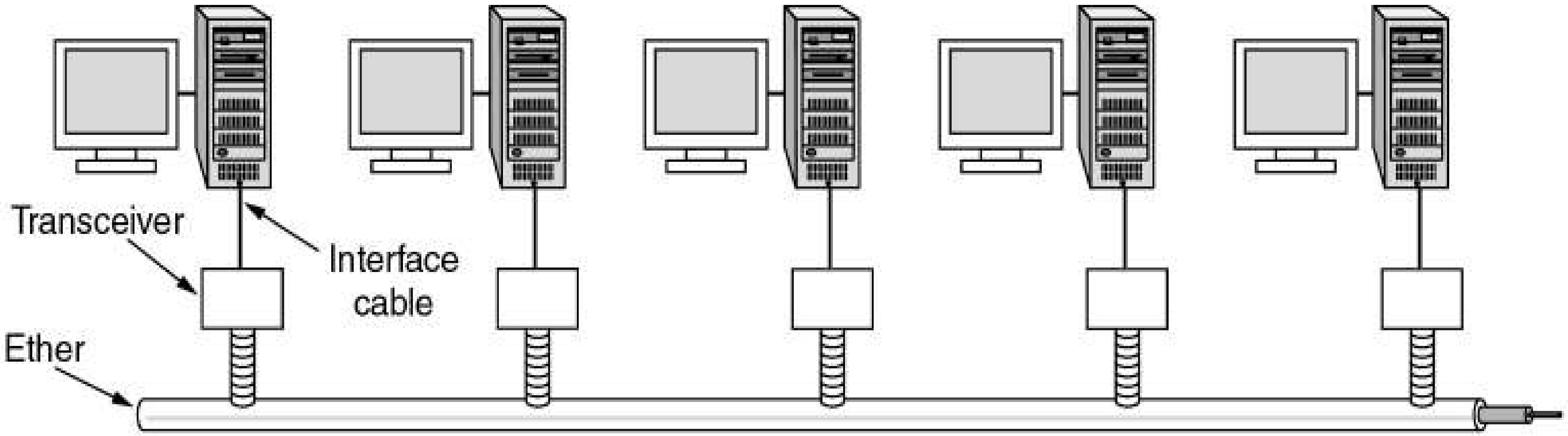
The ATM reference model.

The ATM Reference Model (2)

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

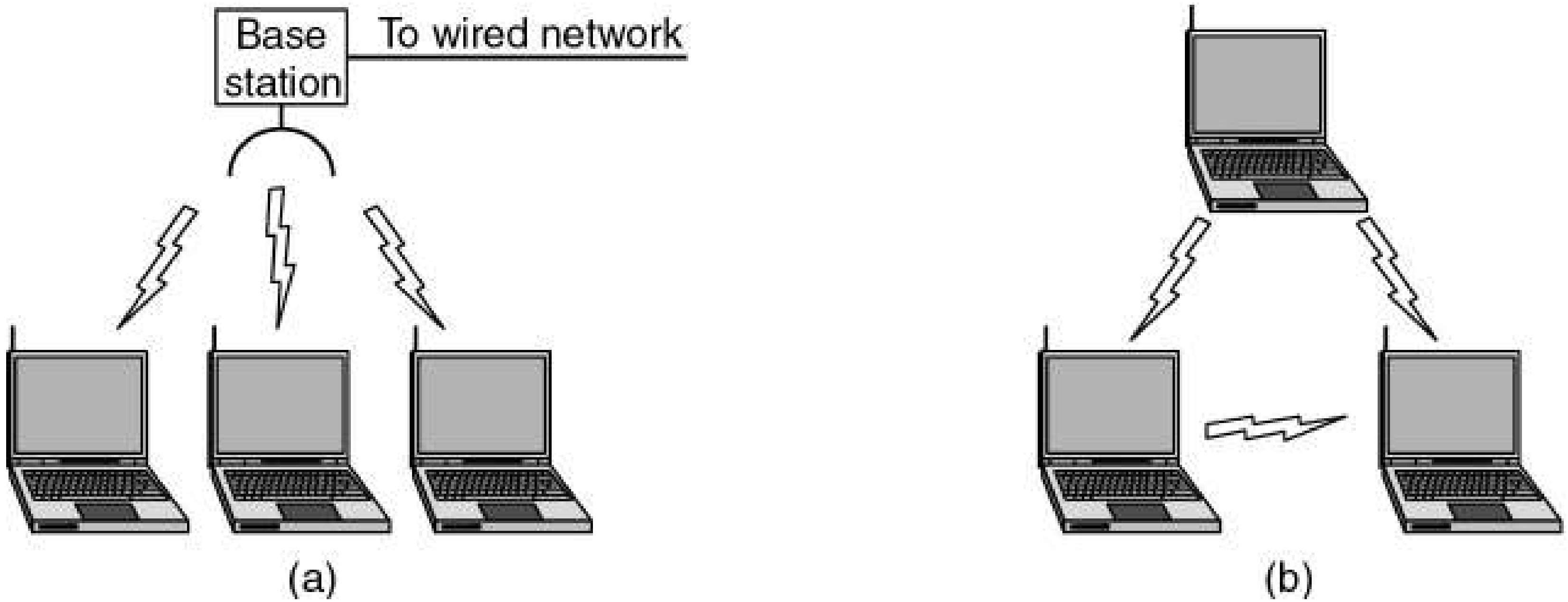
The ATM layers and sublayers and their functions.

Ethernet



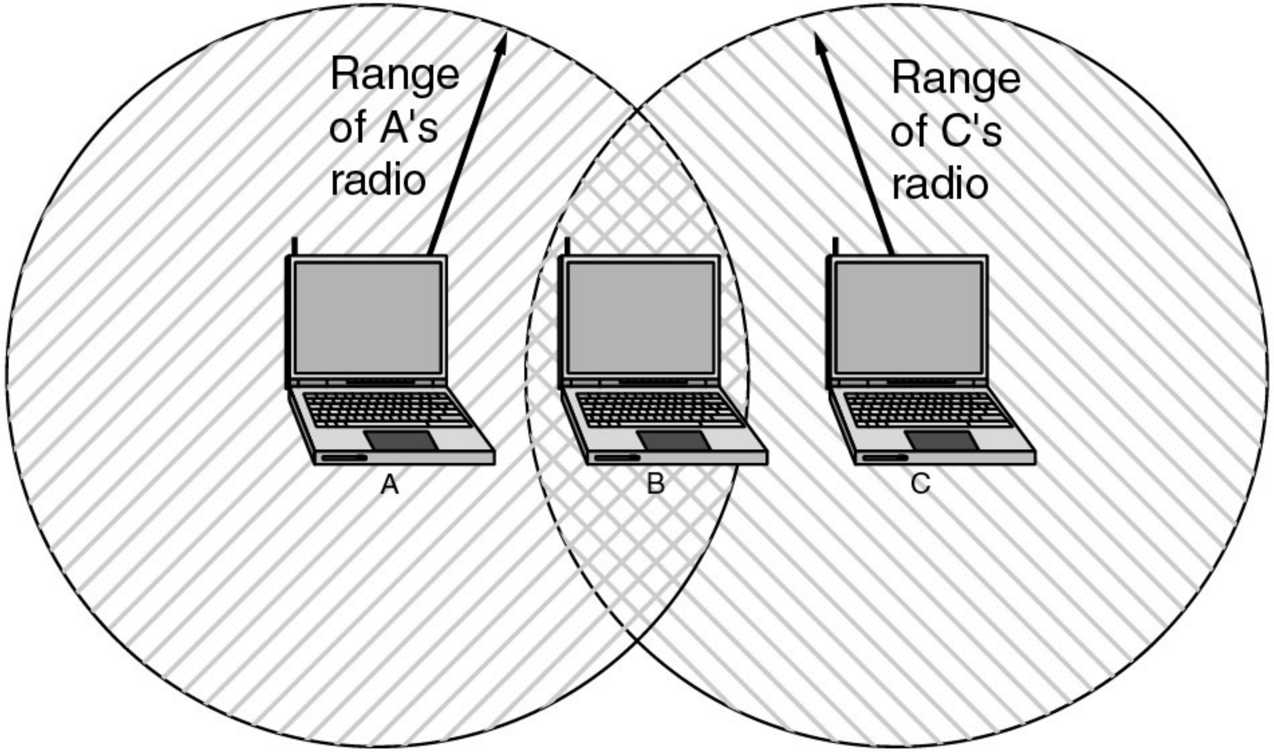
Architecture of the original Ethernet.

Wireless LANs



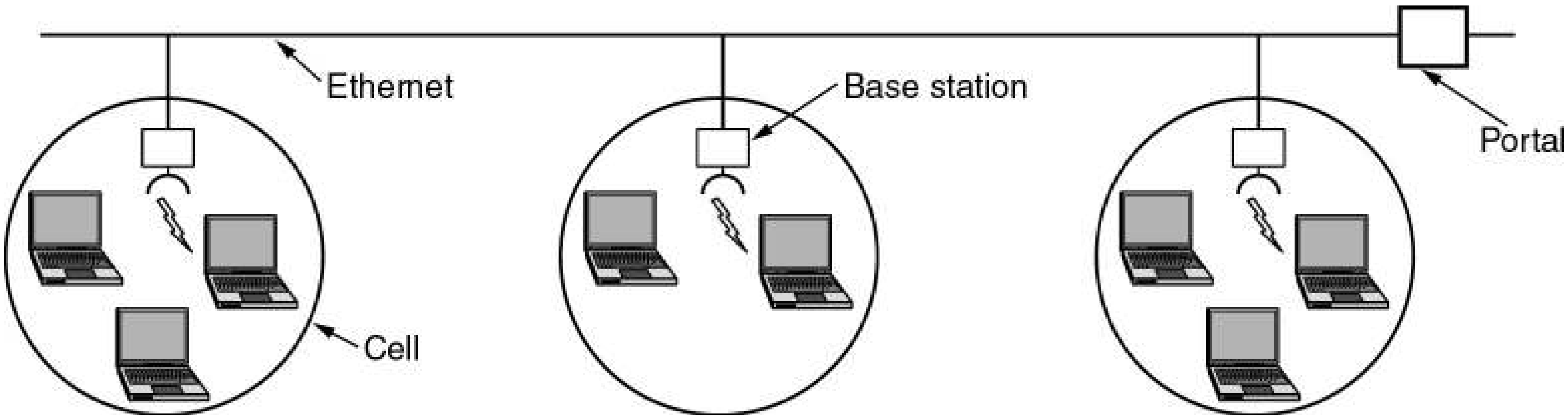
(a) Wireless networking with a base station.
(b) Ad hoc networking.

Wireless LANs (2)



The range of a single radio may not cover the entire system.

Wireless LANs (3)



A multicell 802.11 network.

Network Standardization

- Who’s Who in the Telecommunications World
- Who’s Who in the International Standards World
- Who’s Who in the Internet Standards World

ITU (International Telecommunication Union)

- Main sectors
  - Radio communications
  - Telecommunications Standardization
  - Development
- Classes of Members
  - National governments
  - Sector members
  - Associate members
  - Regulatory agencies

IEEE 802 Standards

Number	Topic
802.1	Overview and architecture of LANs
802.2 ↓	Logical link control
802.3 *	Ethernet
802.4 ↓	Token bus (was briefly used in manufacturing plants)
802.5	Token ring (IBM's entry into the LAN world)
802.6 ↓	Dual queue dual bus (early metropolitan area network)
802.7 ↓	Technical advisory group on broadband technologies
802.8 †	Technical advisory group on fiber optic technologies
802.9 ↓	Isochronous LANs (for real-time applications)
802.10 ↓	Virtual LANs and security
802.11 *	Wireless LANs
802.12 ↓	Demand priority (Hewlett-Packard's AnyLAN)
802.13	Unlucky number. Nobody wanted it
802.14 ↓	Cable modems (defunct: an industry consortium got there first)
802.15 *	Personal area networks (Bluetooth)
802.16 *	Broadband wireless
802.17	Resilient packet ring

The 802 working groups. The important ones are marked with *. The ones marked with ↓ are hibernating. The one marked with † gave up.

Metric Units

Exp.	Explicit	Prefix	Exp.	Explicit	Prefix
10^{-3}	0.001	milli	10^{3}	1,000	Kilo
10^{-6}	0.000001	micro	10^{6}	1,000,000	Mega
10^{-9}	0.000000001	nano	10^{9}	1,000,000,000	Giga
10^{-12}	0.000000000001	pico	10^{12}	1,000,000,000,000	Tera
10^{-15}	0.000000000000001	femto	10^{15}	1,000,000,000,000,000	Peta
10^{-18}	0.000000000000000001	atto	10^{18}	1,000,000,000,000,000,000	Exa
10^{-21}	0.000000000000000000001	zepto	10^{21}	1,000,000,000,000,000,000,000	Zetta
10^{-24}	0.000000000000000000000001	yocto	10^{24}	1,000,000,000,000,000,000,000,000	Yotta

The principal metric prefixes.