Chapter 1

Introduction

Uses of Computer Networks

- Business Applications
- Home Applications
- Mobile Users
- Social Issues

Business Applications of Networks

A network with two clients and one server.

Business Applications of Networks (2)

The client-server model involves requests and replies.
Home Network Applications

- Access to remote information
- Person-to-person communication
- Interactive entertainment
- Electronic commerce

Home Network Applications (2)

In peer-to-peer system there are no fixed clients and servers.

Home Network Applications (3)

<table>
<thead>
<tr>
<th>Tag</th>
<th>Full name</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2C</td>
<td>Business-to-consumer</td>
<td>Ordering books on-line</td>
</tr>
<tr>
<td>B2B</td>
<td>Business-to-business</td>
<td>Car manufacturer ordering tires from supplier</td>
</tr>
<tr>
<td>G2C</td>
<td>Government-to-consumer</td>
<td>Government distributing tax forms electronically</td>
</tr>
<tr>
<td>C2C</td>
<td>Consumer-to-consumer</td>
<td>Auctioning second-hand products on-line</td>
</tr>
<tr>
<td>P2P</td>
<td>Peer-to-peer</td>
<td>File sharing</td>
</tr>
</tbody>
</table>

Mobile Network Users

<table>
<thead>
<tr>
<th>Wireless</th>
<th>Mobile</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>Desktop computers in offices</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>A notebook computer used in a hotel room</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>Networks in older, unwired buildings</td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>Portable office; PDA for store inventory</td>
</tr>
</tbody>
</table>

Some forms of e-commerce.

Combinations of wireless networks and mobile computing.
Network Hardware

- Local Area Networks
- Metropolitan Area Networks
- Wide Area Networks
- Wireless Networks
- Home Networks
- Internetworks

Broadcast Networks

Types of transmission technology
- Broadcast links
- Point-to-point links

Broadcast Networks (2)

<table>
<thead>
<tr>
<th>Interprocessor distance</th>
<th>Processors located in same</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 m</td>
<td>Square meter</td>
<td>Personal area network</td>
</tr>
<tr>
<td>10 m</td>
<td>Room</td>
<td>Local area network</td>
</tr>
<tr>
<td>1 km</td>
<td>Campus</td>
<td>Metropolitan area network</td>
</tr>
<tr>
<td>10 km</td>
<td>City</td>
<td>Wide area network</td>
</tr>
<tr>
<td>100 km</td>
<td>Country</td>
<td>The Internet</td>
</tr>
<tr>
<td>1000 km</td>
<td>Continent</td>
<td></td>
</tr>
<tr>
<td>10,000 km</td>
<td>Planet</td>
<td></td>
</tr>
</tbody>
</table>

Classification of interconnected processors by scale.

Local Area Networks

Two broadcast networks
(a) Bus
(b) Ring
Metropolitan Area Networks

A metropolitan area network based on cable TV.

Wide Area Networks

Relation between hosts on LANs and the subnet.

Wide Area Networks (2)

A stream of packets from sender to receiver.

Wireless Networks

Categories of wireless networks:
- System interconnection
- Wireless LANs
- Wireless WANs
Home Network Categories

- Computers (desktop PC, PDA, shared peripherals)
- Entertainment (TV, DVD, VCR, camera, stereo, MP3)
- Telecomm (telephone, cell phone, intercom, fax)
- Appliances (microwave, fridge, clock, furnace, airco)
- Telemetry (utility meter, burglar alarm, babycam).

Network Software

- Protocol Hierarchies
- Design Issues for the Layers
- Connection-Oriented and Connectionless Services
- Service Primitives
- The Relationship of Services to Protocols
Network Software
Protocol Hierarchies

Layers, protocols, and interfaces.

Protocol Hierarchies (2)

The philosopher-translator-secretary architecture.

Protocol Hierarchies (3)

Example information flow supporting virtual communication in layer 5.

Design Issues for the Layers

- Addressing
- Error Control
- Flow Control
- Multiplexing
- Routing
Connection-Oriented and Connectionless Services

<table>
<thead>
<tr>
<th>Type</th>
<th>Service</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection-oriented</td>
<td>Reliable message stream</td>
<td>Sequence of pages</td>
</tr>
<tr>
<td></td>
<td>Reliable byte stream</td>
<td>Remote login</td>
</tr>
<tr>
<td></td>
<td>Unreliable connection</td>
<td>Digitized voice</td>
</tr>
<tr>
<td></td>
<td>Unreliable datagram</td>
<td>Electronic junk mail</td>
</tr>
<tr>
<td></td>
<td>Acknowledged datagram</td>
<td>Registered mail</td>
</tr>
<tr>
<td></td>
<td>Request-reply</td>
<td>Database query</td>
</tr>
</tbody>
</table>

Six different types of service.

Service Primitives

<table>
<thead>
<tr>
<th>Primitve</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>LISTEN</td>
<td>Block waiting for an incoming connection</td>
</tr>
<tr>
<td>CONNECT</td>
<td>Establish a connection with a waiting peer</td>
</tr>
<tr>
<td>RECEIVE</td>
<td>Block waiting for an incoming message</td>
</tr>
<tr>
<td>SEND</td>
<td>Send a message to the peer</td>
</tr>
<tr>
<td>DISCONNECT</td>
<td>Terminate a connection</td>
</tr>
</tbody>
</table>

Five service primitives for implementing a simple connection-oriented service.

Service Primitives (2)

Packets sent in a simple client-server interaction on a connection-oriented network.

Services to Protocols Relationship

The relationship between a service and a protocol.
Reference Models

- The OSI Reference Model
- The TCP/IP 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

Reference Models (2)

<table>
<thead>
<tr>
<th>OSI</th>
<th>TCP/IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Application</td>
</tr>
<tr>
<td>6</td>
<td>Presentation</td>
</tr>
<tr>
<td>5</td>
<td>Session</td>
</tr>
<tr>
<td>4</td>
<td>Transport</td>
</tr>
<tr>
<td>3</td>
<td>Network</td>
</tr>
<tr>
<td>2</td>
<td>Data Link</td>
</tr>
<tr>
<td>1</td>
<td>Physical</td>
</tr>
</tbody>
</table>

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 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 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 Virtual Circuits

A virtual circuit.

ATM Virtual Circuits (2)

An ATM cell.

The ATM Reference Model

The ATM reference model.

The ATM Reference Model (2)

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

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

IEEE 802 Standards

<table>
<thead>
<tr>
<th>Number</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.1</td>
<td>Overview and architecture of LANs</td>
</tr>
<tr>
<td>802.2</td>
<td>Logical link control</td>
</tr>
<tr>
<td>802.3</td>
<td>Ethernet</td>
</tr>
<tr>
<td>802.4</td>
<td>Token bus (was briefly used in manufacturing plants)</td>
</tr>
<tr>
<td>802.5</td>
<td>Token ring (IBM’s entry into the LAN world)</td>
</tr>
<tr>
<td>802.6</td>
<td>ISDN (private digital loop (PDL) for metropolitan area networks)</td>
</tr>
<tr>
<td>802.7</td>
<td>Technical advisory group on broadband technologies</td>
</tr>
<tr>
<td>802.8</td>
<td>Technical advisory group on fiber optic technologies</td>
</tr>
<tr>
<td>802.9</td>
<td>Synchronous LANs (for real-time applications)</td>
</tr>
<tr>
<td>802.10</td>
<td>Virtual LANs and security</td>
</tr>
<tr>
<td>802.11</td>
<td>Wireless LANs</td>
</tr>
<tr>
<td>802.12</td>
<td>Demand priority (Hewlett-Packard’s AnyLAN)</td>
</tr>
<tr>
<td>802.13</td>
<td>Unlikely number. Nobody wanted it</td>
</tr>
<tr>
<td>802.14</td>
<td>Cable modulation (defined an industry consortium got there first)</td>
</tr>
<tr>
<td>802.15</td>
<td>Personal area networks (Bluetooth)</td>
</tr>
<tr>
<td>802.16</td>
<td>Broadband wireless</td>
</tr>
<tr>
<td>802.17</td>
<td>Broadcast packet ring</td>
</tr>
</tbody>
</table>

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

Metric Units

<table>
<thead>
<tr>
<th>Exp.</th>
<th>Explicit</th>
<th>Prefix</th>
<th>Exp.</th>
<th>Explicit</th>
<th>Prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>10⁻¹</td>
<td>m</td>
<td>milli</td>
<td>10⁻²</td>
<td>cm</td>
<td>centi</td>
</tr>
<tr>
<td>10⁻³</td>
<td>mm</td>
<td>micro</td>
<td>10⁻⁴</td>
<td>μm</td>
<td>microm</td>
</tr>
<tr>
<td>10⁻⁶</td>
<td>μm</td>
<td>nanometer</td>
<td>10⁻⁷</td>
<td>nm</td>
<td>femtometer</td>
</tr>
<tr>
<td>10⁻⁹</td>
<td>nm</td>
<td>attometer</td>
<td>10⁻¹²</td>
<td>pm</td>
<td>zeptometer</td>
</tr>
<tr>
<td>10⁻²⁴</td>
<td>pm</td>
<td>yoctometer</td>
<td>10⁻²⁷</td>
<td>zeptometer</td>
<td>yottometer</td>
</tr>
</tbody>
</table>

The principal metric prefixes.