Computer Networks 1
(Mạng Máy Tính 1)

Lectured by: Dr. Phạm Trần Vũ
Course details

- Number of credits: 4
- Study time allocation per week:
  - 3 lecture hours for theory
  - 2 lecture hours for exercises and lab work
  - 8 hours for self-study
- Website:
  - [http://www.cse.hcmut.edu.vn/~ptvu/net1/](http://www.cse.hcmut.edu.vn/~ptvu/net1/)
Course outline (1)

- Fundamental concepts in the design and implementation of computer networks
  - Protocols, standards and applications
  - Introduction to network programming.
Course outline (2)

- The topics to be covered include:
  - Introduction to network architecture, OSI and the TCP/IP reference models.
  - Network technologies, especially LAN technologies (Ethernet, wireless networks and Bluetooth).
  - Issues related to routing and internetworking, Internet addressing and routing.
  - Internet transport protocols (UDP and TCP)
  - Network-programming interface
  - Application layer protocols and applications such as DNS, E-mail, and WWW.
References

Assessment

- Assignment 20%
  - Two assignments, 10% each
- Midterm exam: 20%
- Final exam: 60%
- Laboratory work is compulsory
  - No lab work = No assignment mark
Lecture 1: Introduction to Computer Networks

Reference:
Uses of Computer Networks

- Business Applications
- Scientific Applications
- Home Applications
- Mobile Users
Business Applications of Networks (1)

- A network with two clients and one server.
The client-server model involves requests and replies.
Scientific Applications

- Grid computing infrastructure to support scientific research
Home Network Applications (1)

- 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.
Some forms of e-commerce.

<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

- Combinations of wireless networks and mobile computing.

<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>
Network Hardware

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

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

- A metropolitan area network based on cable TV.
Wide Area Networks (1)

- Relation between hosts on LANs and the subnet.
Wide Area Networks (2)

- A stream of packets from sender to receiver.
Wireless Networks (1)

- Categories of Wireless Networks
  - System interconnections
  - Wireless LANs
  - Wireless WANs
Wireless Networks (2)

- (a) Bluetooth configuration
- (b) Wireless LAN
Wireless Networks (3)

- (a) Individual mobile computers
- (b) A flying LAN

![Diagram of a flying LAN with a flying router and wired LAN](image-url)
Home Network Categories

- Computers: desktop PC, PDA, shared peripherals
- Entertainment: TV, DVD, VCR, camera, MP3
- Telecomm: telephone, cell phone, intercom, fax
- Appliances: microwave, fridge, clock, aircon
- 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.

![Diagram of network software with layers and protocols](image-url)
Protocol Hierarchies (2)

- The philosopher-translator-secretary architecture.

1. Fax ---
   - L: Dutch
   - Ik vind
   - konijnen
   - leuk

2. Information for the remote secretary
   - L: Dutch
   - Ik vind
   - konijnen
   - leuk

3. Message
   - Philosophers
   - J’aime bien les lapins

- Location A
- Location B
Protocol Hierarchies (3)

- Example information flow supporting virtual communication in layer 5.

```
Source machine
```

```
Destination machine
```

Diagram:

- Layer 5 protocol
- Layer 4 protocol
- Layer 3 protocol
- Layer 2 protocol

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

- Six different types of service.

<table>
<thead>
<tr>
<th>Connection-oriented</th>
<th>Service</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></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>Connection-</td>
<td>Unreliable datagram</td>
<td>Electronic junk mail</td>
</tr>
<tr>
<td>less</td>
<td>Acknowledged datagram</td>
<td>Registered mail</td>
</tr>
<tr>
<td></td>
<td>Request-reply</td>
<td>Database query</td>
</tr>
</tbody>
</table>
Service Primitives

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

<table>
<thead>
<tr>
<th>Primitive</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>
Service Primitives (2)

- Packets sent in a simple client-server interaction on a connection-oriented network.
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
The OSI reference model.
TCP/IP Reference Models (1)

- The TCP/IP reference model.

<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>
<tr>
<td></td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td>Transport</td>
</tr>
<tr>
<td></td>
<td>Internet</td>
</tr>
<tr>
<td></td>
<td>Host-to-network</td>
</tr>
</tbody>
</table>

Not present in the model
TCP/IP Reference Model (2)

- 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

- The hybrid reference model to be used in this book.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Application layer</td>
</tr>
<tr>
<td>4</td>
<td>Transport layer</td>
</tr>
<tr>
<td>3</td>
<td>Network layer</td>
</tr>
<tr>
<td>2</td>
<td>Data link layer</td>
</tr>
<tr>
<td>1</td>
<td>Physical layer</td>
</tr>
</tbody>
</table>
Example Networks

- The Internet
- Connection-Oriented Networks: X.25, Frame Relay, and ATM
- Ethernet
- Wireless LANs: 802:11
The ARPANET (1)

- (a) Structure of the telephone system.
- (b) Baran’s proposed distributed switching system.
The ARPANET (2)

- The original ARPANET design.
The ARPANET (3)

The NSFNET backbone in 1988.

- NSF Supercomputer center
- NSF Midlevel network
- Both
Internet Usage

- Traditional applications (1970 – 1990)
  - E-mail
  - News
  - Remote login
  - File transfer
Overview of the Internet.
ATM Virtual Circuits

- A virtual circuit.
Ethernet

- Architecture of the original Ethernet.
(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>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.1</td>
<td>Overview and architecture of LANs</td>
<td></td>
</tr>
<tr>
<td>802.2</td>
<td>Logical link control</td>
<td>↓</td>
</tr>
<tr>
<td>802.3</td>
<td>Ethernet</td>
<td>*</td>
</tr>
<tr>
<td>802.4</td>
<td>Token bus (was briefly used in manufacturing plants)</td>
<td>↓</td>
</tr>
<tr>
<td>802.5</td>
<td>Token ring (IBM’s entry into the LAN world)</td>
<td></td>
</tr>
<tr>
<td>802.6</td>
<td>Dual queue dual bus (early metropolitan area network)</td>
<td>↓</td>
</tr>
<tr>
<td>802.7</td>
<td>Technical advisory group on broadband technologies</td>
<td>↓</td>
</tr>
<tr>
<td>802.8</td>
<td>Technical advisory group on fiber optic technologies</td>
<td>†</td>
</tr>
<tr>
<td>802.9</td>
<td>Isochronous LANs (for real-time applications)</td>
<td>↓</td>
</tr>
<tr>
<td>802.10</td>
<td>Virtual LANs and security</td>
<td>↓</td>
</tr>
<tr>
<td>802.11</td>
<td>Wireless LANs</td>
<td>*</td>
</tr>
<tr>
<td>802.12</td>
<td>Demand priority (Hewlett-Packard’s AnyLAN)</td>
<td>↓</td>
</tr>
<tr>
<td>802.13</td>
<td>Unlucky number. Nobody wanted it</td>
<td></td>
</tr>
<tr>
<td>802.14</td>
<td>Cable modems (defunct: an industry consortium got there first)</td>
<td>↓</td>
</tr>
<tr>
<td>802.15</td>
<td>Personal area networks (Bluetooth)</td>
<td>*</td>
</tr>
<tr>
<td>802.16</td>
<td>Broadband wireless</td>
<td>*</td>
</tr>
<tr>
<td>802.17</td>
<td>Resilient packet ring</td>
<td></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>$10^{-3}$</td>
<td>0.001</td>
<td>milli</td>
<td>$10^3$</td>
<td>1,000</td>
<td>Kilo</td>
</tr>
<tr>
<td>$10^{-6}$</td>
<td>0.000001</td>
<td>micro</td>
<td>$10^6$</td>
<td>1,000,000</td>
<td>Mega</td>
</tr>
<tr>
<td>$10^{-9}$</td>
<td>0.000000001</td>
<td>nano</td>
<td>$10^9$</td>
<td>1,000,000,000</td>
<td>Giga</td>
</tr>
<tr>
<td>$10^{-12}$</td>
<td>0.000000000001</td>
<td>pico</td>
<td>$10^{12}$</td>
<td>1,000,000,000,000</td>
<td>Tera</td>
</tr>
<tr>
<td>$10^{-15}$</td>
<td>0.000000000000001</td>
<td>femto</td>
<td>$10^{15}$</td>
<td>1,000,000,000,000,000</td>
<td>Peta</td>
</tr>
<tr>
<td>$10^{-18}$</td>
<td>0.000000000000000001</td>
<td>atto</td>
<td>$10^{18}$</td>
<td>1,000,000,000,000,000,000</td>
<td>Exa</td>
</tr>
<tr>
<td>$10^{-21}$</td>
<td>0.00000000000000000001</td>
<td>zepto</td>
<td>$10^{21}$</td>
<td>1,000,000,000,000,000,000,000</td>
<td>Zetta</td>
</tr>
<tr>
<td>$10^{-24}$</td>
<td>0.0000000000000000000001</td>
<td>yocto</td>
<td>$10^{24}$</td>
<td>1,000,000,000,000,000,000,000,000</td>
<td>Yotta</td>
</tr>
</tbody>
</table>

The principal metric prefixes.