Agenda

- Last time
  - Properties of Dis sys, why dis sys?, challenges
- This time
  - More system models (chpt 1 + 2)
  - Networks (chpt 3)
- Next time (Tues)
  - No class Tuesday Jan 30 (Marty at conference)
  - Will be made up Thurs Feb 8 / Fri Feb 9
- Real next time (Thurs, Feb 1) – only one class
  - Interprocess Communication (chpt 4)
  - 1st HW/PA out.

Before we start

- How do we make-up classes? Thurs night AND/OR Friday afternoon?
  - Thurs night 5-6:15 AND Fri 3-4:15 ??
- Office hours:
  - How about Mon 2-4pm

Chapter 2: Distributed System Models

- Architectural models
  - How do components of the system interact?
  - How are these components map onto the underlying network of computers?
- Fundamental models
  - Formal description of system properties common in all architectural models
  - Interaction, failure, security models
  - Appear throughout the course, but not discussed in detail

Architectural Models

- Architecture: structure of separately specified components
- Overall goal: Structure should meet present and future demands on reliability, manageability, adaptability, and cost-effectiveness
- Functions of individual components not interesting
- Abstracted away
- Consider instead:
  - Placement (across network)
  - Patterns for data/workload distribution
  - Interrelationships (Functional roles, communication patterns)

System Architectures: Client-Server Model

- The most widely used
**System Architectures: Client-Server Model**

- Client: Process wishing to access data, use resources or perform operations on a different computer
- Server: Process managing data and all other shared resources amongst servers and clients, allows clients access to resource and performs computation
- Interaction: invocation / result message pairs
  - Example: http server: client (browser) requests page, server delivers page
- Passive (server) vs. active (client)
- Stateless vs. stateful
- Three-tier architecture: client, app server, and DB server ("business logic")

**System Architectures: Multiple Servers Model**

- Services may be provided by multiple servers
- Partitioned or replicated service-related objects
- Replication provides
  - Increased performance, availability and fault-tolerance
- But requires replica coordination / consistency preservation
- E.g. high availability web servers (portals, download centers), information services
- Servers maintain either replicated or distributed database

**System Architectures: Peer-to-Peer Model**

- Peer processes: processes that play similar roles
  - No absolute distinction between client/server
  - May still assume client/server roles from time to time
- Reduces inter-process communication delay for local object access
- Increased fault-tolerance and scalability
- Coordination difficult
  - E.g. distributed search, routing, distributed computing, news servers (and of course MP3s)

**Client/Server vs. P2P**

- **Client/Server**
  - More secure
- **P2P**
  - No single point of failure or bottleneck
**Basic idea:** break up the complexity of systems by designing them through layers and services
- **layer:** group of closely related and highly coherent functionalities
- **service:** functionality provided to a superior layer

**Examples of layered architectures**
- operating systems (kernel, other services)
- computer network protocol architectures

**Problem with layered approach:** not always possible to implement service at layer N using ONLY layer N-1 services

**Architectural Models: Layers**

**System Architectures: Proxy Server Model**
- **Cache:** a close store of recently used data
  - Considerably increases performance in many applications
  - But requires cache coherence protocols
- **Proxy server:** a shared cache of resources
  - Renders replication/distribution transparent
  - Most commonly used for web access
  - Frequently used in WWW (e.g., Akamai)

**Variations on the Client-Server Model**
- **Mobile code:** Code that is sent to a client process to carry out a specific task
  a) client request results in the downloading of applet code
  b) client interacts with the applet

- **Mobile agents**
  - Executing program (code + data) that migrates between processes in a network
  - Carries out an autonomous task usually on some other process' behalf
  - Has internal knowledge, beliefs and goals
  - Advantage: local access everywhere
  - Savings in communication costs
  - Potential security threat
  - Limited applicability
  - E.g., information collection from multiple sources, installation of programs, worm programs (e-mail)
Variations on the Client-Server Model

- **Network computer**
  - Thin Client
  - All files stored remotely
  - Minimum of local software
  - Any local disk used mainly as a cache
- **Thin client**
  - Does not even run its own applications
  - Executes windows-based user interface on a local computer
  - Programs are run by a powerful compute server

Chapter 3: Networks - Basics

- **A network consists of:**
  - Transmission media (wire, cable, ...).
  - Hardware devices (routers, switches, ...).
  - Software components (protocol stacks, drivers, ...).
- **Terminology:**
  - **Host:** Computers and other devices that use a network.
  - **Node:** Any computer or switching device attached to a network.
  - **Subnet:** Set of interconnected nodes.
- **Design issues:** Performance, scalability, reliability, security, mobility, quality of service.

Networks - types

<table>
<thead>
<tr>
<th>Range</th>
<th>Bandwidth (Mbps)</th>
<th>Latency (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAN</td>
<td>1-2 kms</td>
<td>10-1000</td>
</tr>
<tr>
<td>WAN</td>
<td>worldwide</td>
<td>0.010-600</td>
</tr>
<tr>
<td>MAN</td>
<td>2-50 kms</td>
<td>1-150</td>
</tr>
<tr>
<td>Wireless LAN</td>
<td>0.15-1.5 km</td>
<td>2-11</td>
</tr>
<tr>
<td>Wireless WAN</td>
<td>worldwide</td>
<td>0.010-2</td>
</tr>
<tr>
<td>Internet</td>
<td>worldwide</td>
<td>0.010-2</td>
</tr>
</tbody>
</table>

Networks - packet transmission

- **Message:** Sequence of data items of arbitrary length.
- **Messages subdivided into packets.**
- **Switching schemes:**
  - Broadcast.
  - Circuit switching.
  - Packet switching.
  - Frame relay.

Protocols - basics

- **Protocol:** Set of rules and formats to be used for communication between processes in order to perform a given task.
- **Should include specification of:**
  - Sequence of messages that must be exchanged.
  - Format of the data in the messages.
- **Implemented by a pair of software modules in the sending and receiving computers.**
Protocol layers - encapsulation and headers

Presentation header
Application-layer message
Session header
Transport header
Network header

Protocol layers - OSI protocol summary

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Protocols that are designed to meet the communication requirements of specific applications, often defining the interface to a service.</td>
<td>HTTP, FTP, SMTP, CORBA IIOP</td>
</tr>
<tr>
<td>Presentation</td>
<td>Protocols at this level transport data in a network representation that is independent of the representations used in individual computers, which may differ. Encryption may be performed in this layer.</td>
<td>Secure Sockets (SSL), CORBA Data Rep.</td>
</tr>
<tr>
<td>Session</td>
<td>At this level reliability and adaptation are performed, such as detection of failures and automatic recovery.</td>
<td>TCP, UDP</td>
</tr>
<tr>
<td>Transport</td>
<td>This is the lowest level at which messages (rather than packets) are handled. Messages are addressed to communication ports attached to processes, and when in the layer may be connection-oriented or connectionless.</td>
<td>TCP, UDP</td>
</tr>
<tr>
<td>Network</td>
<td>Transfers data packets between computers in a specific network. In a WAN or internetwork, IP, defines the provisions of a route passing through routers. In a single LAN or ring, no routing is required.</td>
<td>IP, ATM virtual circuits</td>
</tr>
<tr>
<td>Data link</td>
<td>Responsible for transmission of packets between nodes that are directly connected by a physical link. In a WAN transmission is between pairs of communication between different points. In a LAN it is between any pair of hosts.</td>
<td>Ethernet MAC, ATM cell transfer, PPP</td>
</tr>
<tr>
<td>Physical</td>
<td>The circuits and hardware that drive the network. It transmits sequences of binary data by high-speed or other electromagnetic signals, or radio and microwave signals.</td>
<td>Ethernet base-band signalling, ISDN</td>
</tr>
</tbody>
</table>

Protocol layers - internetwork layers

Internetwork protocols
Internetwork packets
Network-specific packets
Underlying network

Message
Application
Transport
Network
Network interface
Underlying network

Protocol layers - the ISO Open Systems Interconnection (OSI) model

Layers
Message sent
Message received