Client-Server Paradigm

- Computers in a network that “provide services” to other computers in the network are called servers; computers that requests and enjoy their services are called clients.
- In most cases, server applications wait passively for client applications to initiate communication.
  - This is called the client-server paradigm.

Client Application

- Invoked directly by the user.
- Runs locally on the user’s PC.
- Actively initiates contact with a server (only one server at a time).
- Does not require specialized hardware or operating system.
Server Application

- Special-purpose software
- Invoked automatically when system boots, and executed continuously
- Usually runs on shared, powerful computers
  - But it may run also on your PC
- Waits passively for contact from arbitrary remote clients
- Can handle multiple (many!) remote clients at the same time

Examples of Server Types

- **File servers**
  - Store files that can be accessible by clients in the network
    - Example: databases
  - Very **reliable** and **secure**
  - Control multiple (and possibly simultaneous) access to shared files
  - May run specialized software applications in response to clients’ requests
    - Example: WWW servers
Examples of Server (cont’d)

• **Printer servers**
  – Accept “print jobs” (i.e., files that need to be printed) by clients in the network
  – Are connected to a printer, and manage the printing operation
  – Given that the printing speed is much slower than the data transmission speed, they need to save the print job in their hard disk until the printer is ready (**spooling**)
    • The client can then disconnect without having to wait for the end of the printing process (**background printing**)

• **DNS servers**
  – Convert “Domain Names” into IP addresses
  – Set of servers that function as a distributed database

Local Area Networks (LAN)

• **Problem**: Transfer data between computers

• **Early days solution**: Removable media storage devices (disks, tapes)

• **Modern days solution**: Interconnect computers

• **LANs**: Technology for connection multiple computers across short distances (“within a building” - up to a few KM in size)
  – Inexpensive
  – Highly reliable
  – Convenient to install and manage
Direct Connection

- Direct connection: each computer in the connection has a dedicated I/O board
  - Pros: speed
    - One physical link per connection
  - Cons: inconvenient
    - To connect to a new computer, must add a new board

For each new computer, we need to add a new I/O board (and a new cable)
**LAN**

- **Local Area Network (LAN):** each computer is connected to the network through a special Network Interface Card (NIC)
  - The LAN transfers data independently of the types of computers attached to it
  - The interface board “shields” the LAN from the characteristics of each device (e.g., speed)

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**LAN (cont’d)**

- LANs are usually privately owned
- Available bit-rates: up to 1 Gb/s with low delay (~10 µs) and low error rate
- Topology: linear, ring or star
- Typical technologies for LAN:
  - Ethernet
  - Token Ring
  - ATM
CMPE 80N - Introduction to Networks and the Internet

**LAN Topologies**

- **Bus topology** (e.g.: 10Base5 Ethernet)
- **Ring topology** (e.g.: Token Ring)
- **Star topology** (e.g.: 10BaseT Ethernet)

**Network Interface Card (NIC)**

- **A.k.a. LAN adapter.** Acts as the interface between the computer and the network
  - It separates the CPU from electrical and low-level networking issues
- Can directly access the computer’s memory independently of the CPU
  - “Direct Memory Access” or DMA
- Accesses PC memory through the “data bus” within the computer (typically **PCI bus**)
Figure 10.1 The location of I/O sockets inside a typical computer. Each socket aligns with an opening in the back of the cabinet, and the computer’s bus connects the socket to other major components such as the processor and memory.

Figure 10.2 The back of a computer with a NIC installed in one of the sockets. A cable attaches the exposed connector to the network.
NIC: Data Transmission

- To transmit a data packet on the network:
  - CPU forms the packet in memory and instructs NIC to begin transmission
    - After this, CPU can go back to its other tasks
  - NIC grabs the packet in memory and handles the details of accessing the medium and transmitting bits
  - When it is done transmitting the data packet, NIC informs the CPU
    - Uses the “interrupt” mechanism

NIC: Data Reception

- To receive an incoming data packet:
  - CPU allocates buffer space in memory and instructs the NIC to read the next incoming packet into the buffer
  - NIC waits for a packet to cross the network, reads it and checks the destination address
  - If the destination’s address matches the computer’s address, NIC reads into the buffer memory and informs the CPU
  - Otherwise, it just discards the packet
PC Cards

- Laptop and handheld PDAs often use credit-card-like NIC that fit into a special slot
- **PCMCIA:** overall standard for expansion slots in laptops (not only for NIC!)
- Two types of PCMCIA cards:
  - **PC Cards:** older technology - ~ 8 MB/s
  - **Cardbus:** up to 133 MB/s

Network Cables

- **General rule:**
  - Available bitrate on a cable depends on **type** and **length** of the cable
  - If you increase the cable length, the maximum bitrate will decrease

<table>
<thead>
<tr>
<th></th>
<th>Twisted pair</th>
<th>Coax cable</th>
<th>Fiber optic</th>
</tr>
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<tbody>
<tr>
<td>Speed</td>
<td>Fast</td>
<td>Fast</td>
<td>Very fast</td>
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<tr>
<td>Length</td>
<td>Short</td>
<td>Medium</td>
<td>Very long</td>
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<tr>
<td>Cost</td>
<td>Cheap</td>
<td>Medium</td>
<td>Expensive</td>
</tr>
</tbody>
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**Network Cables (cont’d)**

- **Coaxial cables**
  - Used for bus topology (e.g. 10Base5 Ethernet)
  - Less prone to interference than twisted pairs
  - Can transmit hundreds of Mb/s over distances of ~1Km
  - Uses BNC connectors (thick)
  - Requires a “terminator”
  - More expensive and bulky than twisted pairs
Network Cables (cont’d)

- **Unshielded Twisted Pairs**
  - More than one twisted pair in the cable
  - Used in the 10BaseT and 100BaseT scheme for Ethernet
    - Star topology - uses a “wiring hub”
  - Uses RJ-45 connectors
  - Wires are twisted in pairs to reduce interference
  - Economical, but can’t be longer than ~100 meters
  - Supports bitrates of up to Gb/s
Cabling a Building

Thin Ethernet

Twisted pairs

Network Cables (cont’d)

• **Fiber Optic Cables**
  – Data is transmitted in the form of **pulses of light**
  – Very high bitrate (up to 1 Gb/s) over many miles
  – Rather expensive
  – Connections and splices are difficult to make
    (→ very expensive)
  – Often used to interconnect different LANs
    • Remember that LANs have a maximum length specification!
Wireless LANs

- Wireless LANs use radio bridges to transmit data
  - Example: 802.11 (up to 11 Mb/s)

- An **Access Point** (a.k.a. base station) is connected to the wired LAN and communicates with the wireless card of nearby computers

- For 802.11: each Access Point only covers a radius of no more than 200 feet (and less if there are walls or obstacles)
  - Therefore, to allow for LAN access within a building, several Access Points need to be installed in the different rooms/corridors