Networks: Communicating and Sharing Resources
Network Fundamentals

• **Networks**
  
  o Links multiple computer systems and enables them to share data and resources
  
  o Types of computer networks:
    
    • Local area network (LAN)
    • Wide area network (WAN)
    • Metropolitan area network (MAN)
    • Campus area network (CAN)
    • Personal area network (PAN)
Network Fundamentals

- **LAN**
  - Uses cables, radio waves, or infrared signals
  - Links computers in a limited geographic area

- **WAN**
  - Uses long-distance transmission media
  - Links computer systems a few miles or thousands of miles
  - Internet is the largest WAN

- **MAN**
  - Designed for a city
  - Larger than a LAN, smaller than a WAN
Network Fundamentals

• **CAN**
  - Several LANs located in various locations on a college or business campus
  - Smaller than a WAN
  - Use devices such as switches, hubs, and routers

• **PAN**
  - Network of an individual’s own personal devices
  - Usually within a range of 32 feet
  - Usually use wireless technology
**Network Fundamentals**

- **Communication devices**
  - Convert data into signals to travel over a medium
    - Computers
    - Modems
    - Routers
    - Switches
    - Hubs
    - Wireless access points
    - Network interface cards (NICs)
Network Fundamentals

• **Node**
  - Any device connected to a network

• **Logical address**
  - Unique name assigned to each node on the network

• **Physical address**
  - Unique numeric that identifies each node on the network built into the hardware

• **Network interface card (NIC)**
  - Expansion board or adapter that provides a connection between the computer and the network
  - Notebook computers have wireless NICs
IP Addressing

- An IP address has 32 bits divided into four octets
- To make the address easier to read, people use decimal numbers to represent the binary digits
  - Example: 192.168.1.1
- Dotted decimal notation
  - When binary IP addresses are written in decimal format
## IP Addressing (continued)

<table>
<thead>
<tr>
<th></th>
<th>128</th>
<th>64</th>
<th>32</th>
<th>16</th>
<th>8</th>
<th>4</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>192</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>168</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>255</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table 4-1** Binary to decimal conversion
MAC to IP Address Comparison

- **MAC address**
  - Identifies a specific NIC in a computer on a network
  - Each MAC address is unique
  - TCP/IP networks can use MAC addresses in communication

- Network devices cannot efficiently route traffic using MAC addresses because they:
  - Are not grouped logically
  - Cannot be modified
  - Do not give information about physical or logical network configuration
MAC to IP Address Comparison (continued)

- **IP addressing**
  - Devised for use on large networks
- **IP addresses have a hierarchical structure and do provide logical groupings**
  - IP address identifies both a network and a host

![IP Address Diagram](image)

An IP address: 126.54.9.70

01111110 . 00110110 . 00001001 . 01000110

Eight bits = One byte

32 bits = 4 bytes
IP Classes

• Internet Assigned Numbers Authority (IANA)
  o Devised the hierarchical IP addressing structure

• American Registry of Internet Numbers (ARIN)
  o Manages IP addresses in the United States

• Internet Corporation for Assigned Names and Numbers (ICANN)
  o A global, government-independent entity with overall responsibility for the Internet
  o ICANN has effectively replaced IANA
IP Classes (continued)

- **Class A**
  - Reserved for governments and large corporations throughout the world
  - Each Class A address supports 16,777,214 hosts

- **Class B**
  - Addresses are assigned to large- and medium-sized companies
  - Each Class B address supports 65,534 hosts
### IP Classes (continued)

<table>
<thead>
<tr>
<th>Binary Place Values</th>
<th>Decimal Equivalent</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>128</td>
<td>64</td>
<td>32</td>
</tr>
<tr>
<td>0 0 0 0 0 0 0 0 = 0</td>
<td>128</td>
<td>First Class B address</td>
</tr>
<tr>
<td>0 0 0 0 0 0 0 1 = 1</td>
<td>191</td>
<td>Last Class B address</td>
</tr>
</tbody>
</table>

*Figure 4-2* Class B addresses begin with a number between 128 and 191
**IP Classes (continued)**

- **Class C**
  - Addresses are assigned to groups that do not meet the qualifications to obtain Class A or B addresses
  - Each Class C address supports 254 hosts

- **Class D**
  - Addresses (also known as multicast addresses) are reserved for multicasting
  - **Multicasting** is the sending of a stream of data (usually audio and video) to multiple computers simultaneously

<table>
<thead>
<tr>
<th>Rule</th>
<th>Minimums and maximums</th>
<th>Decimal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A:</td>
<td>00000000 = 0</td>
<td>1 - 126*</td>
</tr>
<tr>
<td>First bit is always 0.</td>
<td>01111111 = 127</td>
<td></td>
</tr>
<tr>
<td>Class B:</td>
<td>10000000 = 128</td>
<td>128 - 191</td>
</tr>
<tr>
<td>First two bits are always 10.</td>
<td>10111111 = 191</td>
<td></td>
</tr>
<tr>
<td>Class C:</td>
<td>11000000 = 192</td>
<td>192 - 223</td>
</tr>
<tr>
<td>First three bits are always 110.</td>
<td>11011111 = 223</td>
<td></td>
</tr>
<tr>
<td>Class D:</td>
<td>11100000 = 224</td>
<td>224 - 239</td>
</tr>
<tr>
<td>First four bits are always 1110.</td>
<td>11101111 = 239</td>
<td></td>
</tr>
</tbody>
</table>
### IP Classes (continued)

<table>
<thead>
<tr>
<th>Binary Place Values</th>
<th>Decimal Equivalent</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>128 64 32 16 8 4 2 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1 0 0 0 0 0 0</td>
<td>192</td>
<td>First Class C address</td>
</tr>
<tr>
<td>1 1 0 1 1 1 1 1</td>
<td>223</td>
<td>Last Class C address</td>
</tr>
</tbody>
</table>

**Figure 4-3** Class C addresses begin with numbers between 192 and 223

<table>
<thead>
<tr>
<th>Binary Place Values</th>
<th>Decimal Equivalent</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>128 64 32 16 8 4 2 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1 1 0 0 0 0 0</td>
<td>224</td>
<td>First Class D address</td>
</tr>
<tr>
<td>1 1 1 0 1 1 1 1</td>
<td>239</td>
<td>Last Class D address</td>
</tr>
</tbody>
</table>

**Figure 4-4** Class D addresses begin with a number between 224 and 239
IP Classes (continued)

• Class E
  o Addresses are reserved for research, testing, and experimentation
  o The Class E range starts where Class D leaves off

• Private IP ranges
  o Many companies use private IP addresses for their internal networks
    • Will not be routable on the Internet
  o Gateway devices have network interface connections to the internal network and the Internet
    • Route packets between them
IP Classes (Class E)

Binary Place Values

<table>
<thead>
<tr>
<th>128</th>
<th>64</th>
<th>32</th>
<th>16</th>
<th>8</th>
<th>4</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Decimal Equivalent

1 1 1 1 0 0 0 0 = 240  First Class E address
1 1 1 1 1 1 1 1 = 255  Last Class E address

Figure 4-5  Class E addresses begin with a number between 240 and 255

<table>
<thead>
<tr>
<th>Class</th>
<th>Private Address Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10.x.x.x</td>
</tr>
<tr>
<td>B</td>
<td>172.16.x.x – 172.31.x.x</td>
</tr>
<tr>
<td>C</td>
<td>192.168.x.x</td>
</tr>
</tbody>
</table>

Table 4-2  The private IP ranges
Network Addressing

- IP addresses identify both the network and the host
  - The division between the two is not specific to a certain number of octets

- **Subnet mask**
  - Indicates how much of the IP address represents the network or subnet

- **Standard (default) subnet masks:**
  - Class A subnet mask is 255.0.0.0
  - Class B subnet mask is 255.255.0.0
  - Class C subnet mask is 255.255.255.0

<table>
<thead>
<tr>
<th>Class</th>
<th>IP Address</th>
<th>Netmask</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>16.1.1.1</td>
<td>255.0.0.0</td>
</tr>
<tr>
<td></td>
<td>network</td>
<td>host</td>
</tr>
<tr>
<td>B</td>
<td>172.16.1.1</td>
<td>255.255.0.0</td>
</tr>
<tr>
<td></td>
<td>network</td>
<td>host</td>
</tr>
<tr>
<td>C</td>
<td>221.138.62.1</td>
<td>255.255.255.0</td>
</tr>
<tr>
<td></td>
<td>network</td>
<td>host</td>
</tr>
</tbody>
</table>
Network Addressing (continued)

- TCP/IP hosts use the combination of the IP address and the subnet mask
  - To determine if other addresses are local or remote
  - The binary AND operation is used to perform the calculation

- **Subnetting**
  - Manipulation of the subnet mask to get more network numbers
<table>
<thead>
<tr>
<th>Source IP:</th>
<th>64.168.1.1</th>
<th>01000000.10101000.00000001.00000001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subnet mask:</td>
<td>255.255.255.0</td>
<td>11111111.11111111.11111111.00000000</td>
</tr>
<tr>
<td>ANDing result:</td>
<td>64.168.1.0</td>
<td>01000000.10101000.00000001.00000000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination IP:</td>
<td>64.168.5.7</td>
<td>01000000.10101000.0000101.0000011</td>
</tr>
<tr>
<td>Subnet mask:</td>
<td>255.255.255.0</td>
<td>11111111.11111111.11111111.00000000</td>
</tr>
<tr>
<td>ANDing result:</td>
<td>64.168.5.0</td>
<td>01000000.10101000.00000101.00000000</td>
</tr>
</tbody>
</table>

When the mask 255.255.255.0 is used the hosts are remote.

<table>
<thead>
<tr>
<th>Source IP:</th>
<th>64.168.1.1</th>
<th>01000000.10101000.00000001.00000001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subnet mask:</td>
<td>255.255.0.0</td>
<td>11111111.11111111.00000000.00000000</td>
</tr>
<tr>
<td>ANDing result:</td>
<td>64.168.1.0</td>
<td>01000000.10101000.00000000.00000000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination IP:</td>
<td>64.168.5.7</td>
<td>01000000.10101000.0000101.0000011</td>
</tr>
<tr>
<td>Subnet mask:</td>
<td>255.255.0.0</td>
<td>11111111.11111111.00000000.00000000</td>
</tr>
<tr>
<td>ANDing result:</td>
<td>64.168.5.0</td>
<td>01000000.10101000.00000000.00000000</td>
</tr>
</tbody>
</table>

When the mask 255.255.0.0 is used the hosts are local.

**Figure 4-6** ANDing operations
Network Addressing (continued)

- **Subnet address**
  - Network is identified by the first, or first few, octets
  - A TCP/IP host must have a nonzero host identifier

- **Broadcast address**
  - When the entire host portion of an IP address is all binary ones
  - Examples: 190.55.255.255 and 199.192.65.63
## Network Addressing (continued)

<table>
<thead>
<tr>
<th>Subnet ID</th>
<th>199.192.65.0</th>
<th>11000111.11000000.01000001.00000000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subnet mask</td>
<td>255.255.255.0</td>
<td>11111111.11111111.11111111.00000000</td>
</tr>
<tr>
<td>Broadcast Addr.</td>
<td>199.192.65.255</td>
<td>11000111.11000000.01000001.11111111</td>
</tr>
</tbody>
</table>

**Figure 4-7** Broadcast addresses

<table>
<thead>
<tr>
<th>Subnet ID</th>
<th>199.192.65.32</th>
<th>11000111.11000000.01000001.00100000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subnet mask</td>
<td>255.255.255.224</td>
<td>11111111.11111111.11111111.11100000</td>
</tr>
<tr>
<td>Broadcast Addr.</td>
<td>199.192.65.63</td>
<td>11000111.11000000.01000001.00111111</td>
</tr>
</tbody>
</table>

**Figure 4-8** Broadcasts on partially masked octets
Network Fundamentals
Network Fundamentals

• **USB wireless network adapter**
  o Plugs into a USB port
  o Usually provides an intuitive graphical user interface (GUI) for easy configuration

• **USB dongle**
  o Device inserted into a USB port that adds additional features to the base system
  o Examples: enabling network connectivity and increasing RAM

• **Wireless PC card adapter**
  o About the size of a credit card
  o Inserted into a slot on the side of most notebooks and netbooks
  o Has built-in WiFi antenna that provides wireless capability
  o LED lights that indicate whether the computer is connected
Network Fundamentals

- **Hub**
  - Joins multiple computers together in a single network
  - Does not manage traffic between the connections

- **Switches**
  - Filter and forward data between nodes
  - Are similar to routers but work within a single network

- **Routers**
  - Connect two or more networks
  - Inspect the source and target of a data package
  - Determine the best route to transmit data
Network Fundamentals

- **Wireless access point (WAP)**
  - Receives and transmits radio signals
  - Joins wireless nodes to a wired network
Network Fundamentals

• **Server**
  - Computer or device with software that manages network resources, such as files, e-mails, printers, databases

• **File server**
  - Most common type of server
  - High-speed computer that provides program and data files to network users
  - Contains the **network operating system (NOS)**
    - File directories for file and resource location on the LAN
    - Automated distribution of software updates to desktop computers on the WAN
    - Internet services support
    - Protection of services and data
    - Access to connected hardware by authorized users
Network Fundamentals

- **Network administrator**
  - Also called network engineer
  - Installs, maintains, supports computer networks
  - Interact with users
  - Handle security
  - Troubleshoot problems
Advantages and Disadvantages of Networking

**Networking**

- **Advantages**
  - Reduced hardware costs
  - Application sharing
  - Sharing information resources
  - Data management centralization
  - Connecting people

- **Disadvantages**
  - Loss of autonomy
  - Lack of privacy
  - Security threats
  - Loss of productivity