Computer Networks

Lecture 14

Topics Covered In Last Lecture

- Data Transmission (Mediums cont., Modes and Methods)
- Synchronous and Asynchronous Transmission
- Modems (Types and Functions)

Sequence of Content

- **What is a Network?**
- **Networking Applications**
  The Internet, Telephone, GPS, Television and Radio Broadcasting, Wi-Fi and Bluetooth, Cellular Radio Transmissions
- **Network Characteristics**
  Topologies, Architectures, Size and Coverage Area
- **Communication Protocols and Networking Standards**
  TCP/IP, Ethernet, WiMAX, Cellular Standards, Wireless Standards
- **Networking Hardware**
  Network Adapters, Hubs, Switches and Routers

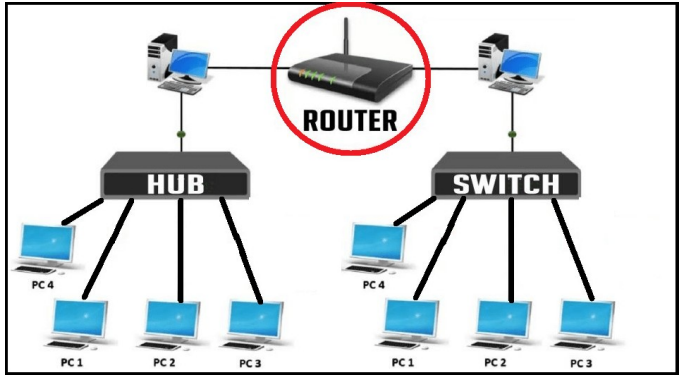
What is a Network?

Network:

Interconnection of two or more devices to share resources, software or data

- A network can be wired or wireless.

  The internet is the largest network.



What do networks do or what are they used for?

- Networks allow file sharing, printer sharing, data sharing and other resources.

Internet:

- A global network of interconnected computers and servers that communicate with each other using standardized communication protocols
- Allows users to access and share information, communicate with others, and use a variety of services such as websites, email, and social media

Telephone Network:

- A system of interconnected devices and infrastructure that enables the transmission of voice communication between individuals over distances

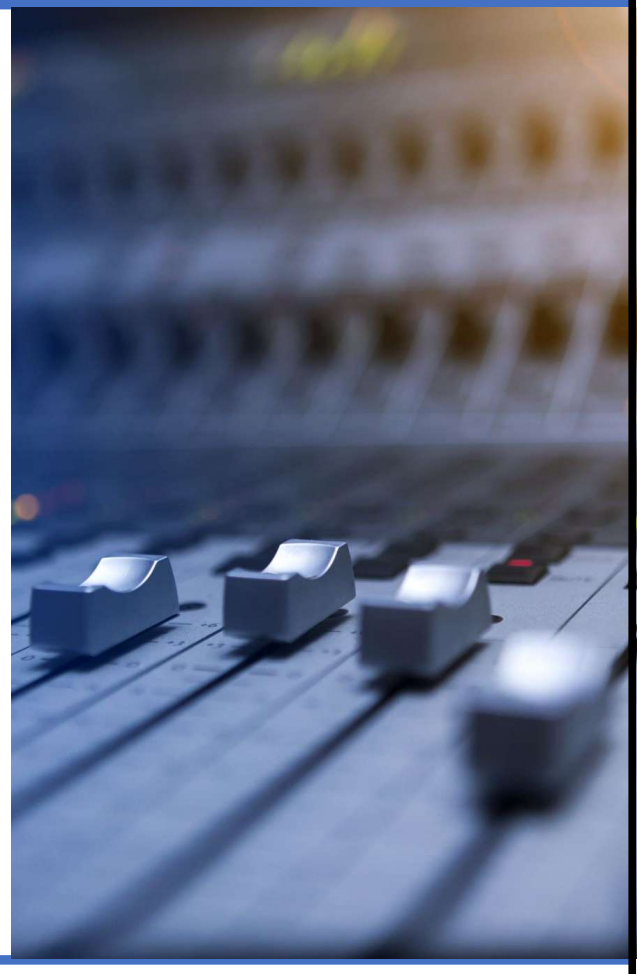
GPS (Global Positioning System):

- A satellite-based navigation system that provides location, velocity, and time information to a GPS receiver anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites

Television and Radio Broadcasting:

Systems designed to transmit audio and visual content over distances to a wide audience

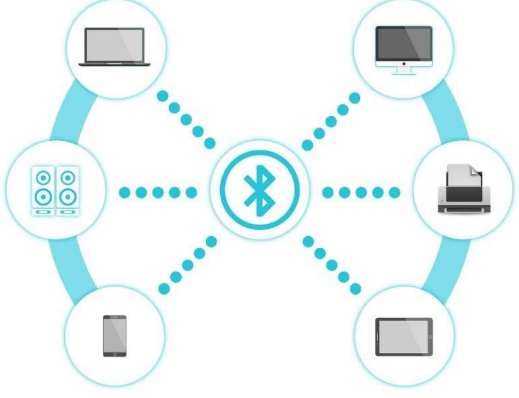
- Terrestrial TV (Over-The-Air), Cable TV (Coaxial/Fiber-optic Cables), Satellite TV (Satellite Dishes), Digital TV (Digital Signals)
- Satellite Radio (SiriusXM), Internet Radio (TuneIn, iHeartRadio)



Networking Applications

Wi-Fi and Bluetooth:

- They both enable wireless communication between devices.
- No cables involved, data is carried by electromagnetic radiations from device to device
- **Wi-Fi Features and Uses:**
  - Operating full-scale networks
  - Faster data transfer
  - Offers better transfer bandwidth (range) and security
  - Can transfer files between devices 100m apart
- **Bluetooth Features and Uses:**
  - Transfer data between devices close to each other (<30m apart)
  - Slow data transfer
  - Low-bandwidth applications such as sharing of small file sizes
  - Uses key encryption to create a secure wireless personal area network (WPAN)



Networking Applications

Wi-Fi and Bluetooth:

- Main advantages of Wi-Fi and Bluetooth networks
  - Cheap and reduces network cost, especially cabling cost
  - Easy to connect multiple devices to share resources
  - Reliable and easy transfer of files

Comparison between Wi-Fi and Bluetooth:

Wi-Fi Network	Bluetooth Network
▪ No cables involved, wireless data transfer	▪ No cables involved, wireless data transfer
▪ Data transfer is affected by obstacles like walls et cetera	▪ Data transfer is affected by obstacles like walls et cetera
▪ fast data transfer rates, up to 31 Mbytes/second	▪ Slow data transfer rates just up to 3 Mbytes/second
▪ Longer transfer range, up to 100 metres	▪ Range is only about 30 metres
▪ Allows multiple devices to connect depending on router used	▪ Only a maximum of 8 devices can connect in most cases

Cellular Radio Transmissions

- Uses cellular towers within cells
  - Calls are transferred from cell tower to cell tower as the individual moves
  - Cell tower forwards call to the MTSO (Mobile Telephone Switching Office)
  - Data works in similar manner
  - Cell phone transmission speed depends on the cellular standard being used

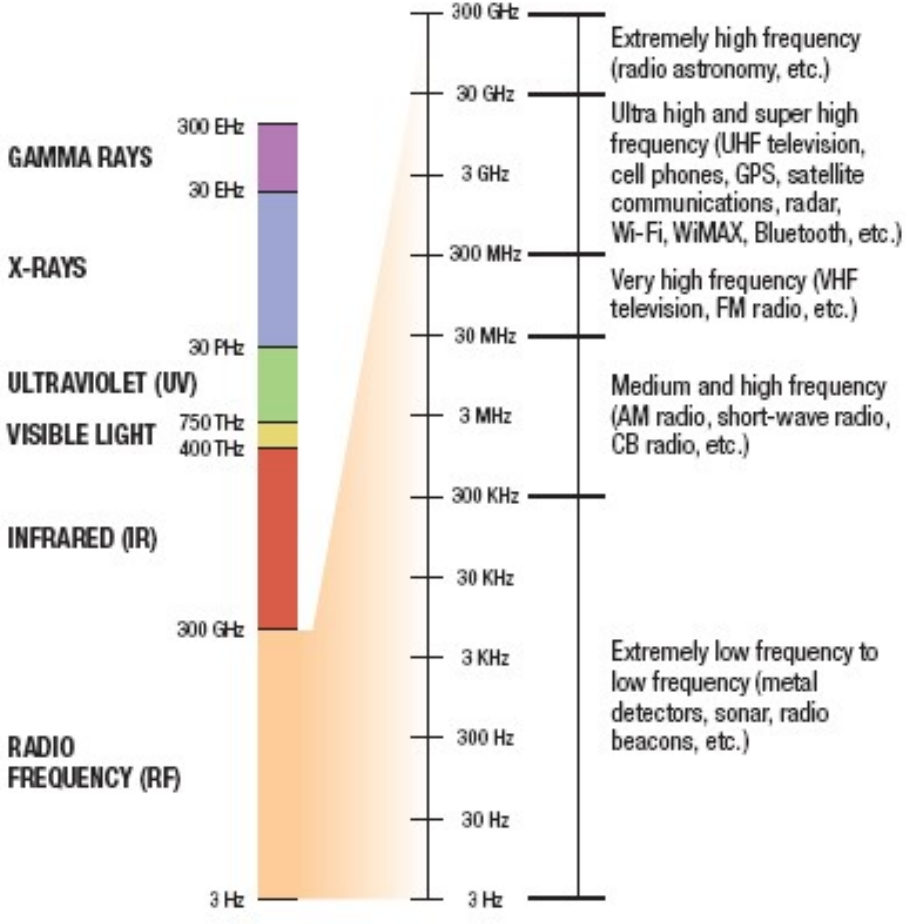
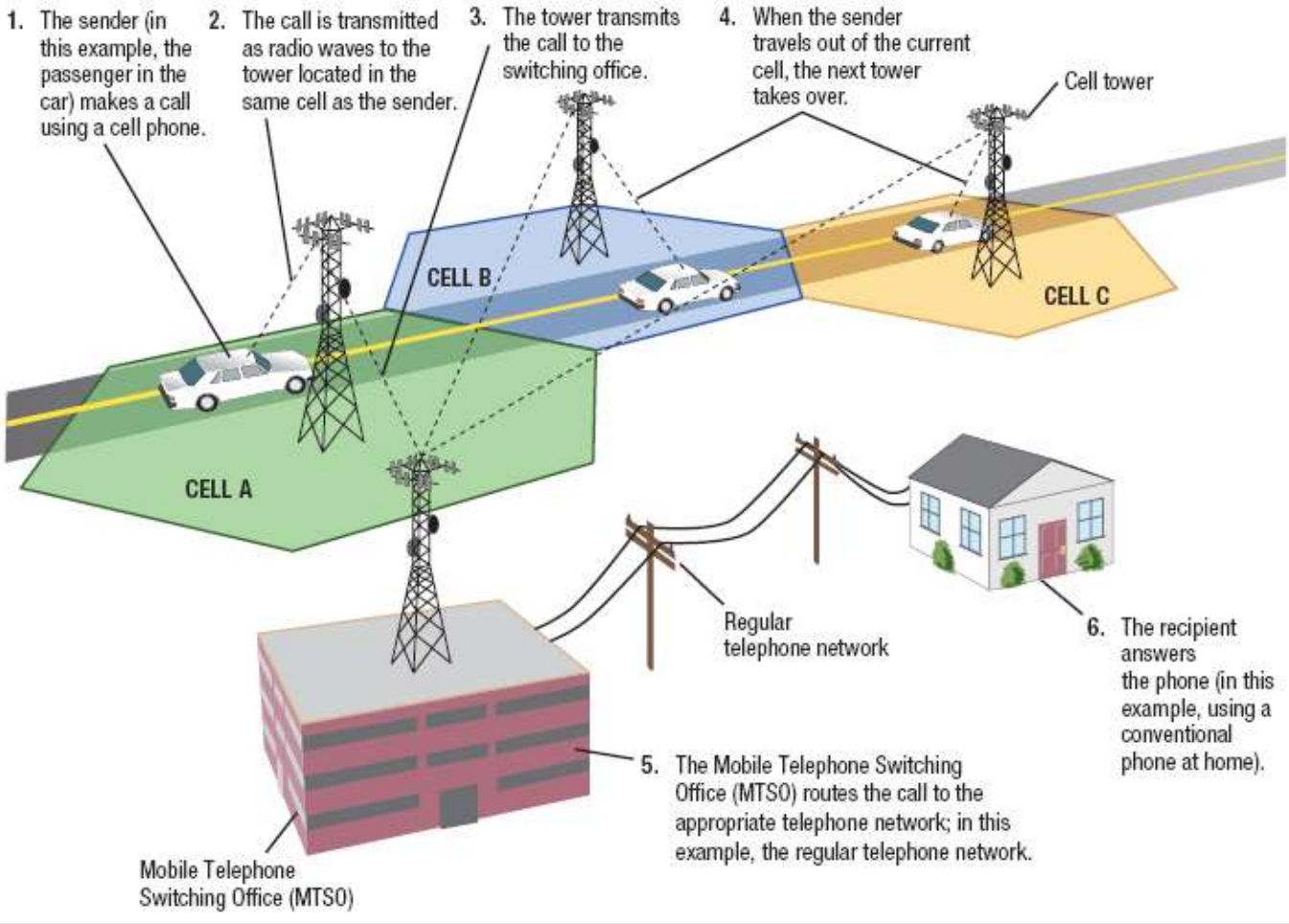


FIGURE 7-20
How cellular phones work.



Microwave and Satellite Transmissions

- High-frequency radio signals
  - Sent and received using microwave stations or satellites
  - Signals are line of sight, so microwave stations are usually built on tall buildings, towers, mountaintops
  - Communication satellites are launched into orbit to send and receive microwave signals from earth
    - Traditional satellites use geosynchronous orbit
    - Low earth orbit (LEO) satellites were developed to combat delay
    - Medium earth orbit (MEO) satellites are most often used for GPS systems

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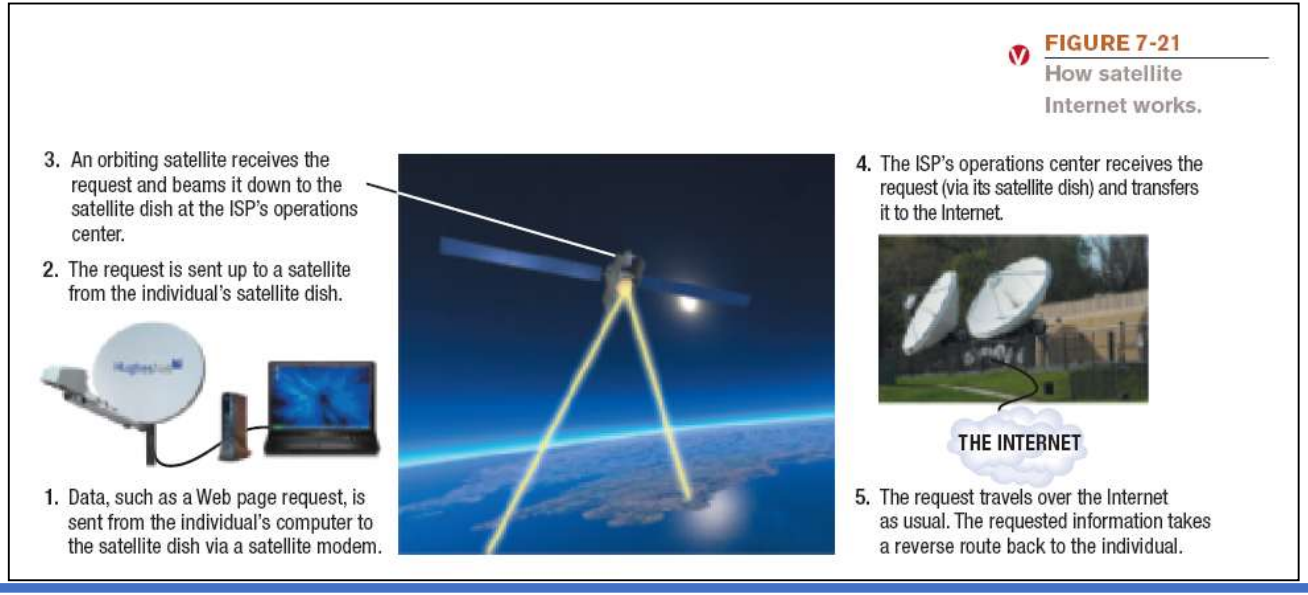


Infrared (IR) Transmissions

- IR: Sends data as infrared light
  - Like an infrared television remote, IR requires line of sight
  - Because of this limitation, many formerly IR devices (wireless mice, keyboards) now use RF technology
  - IR is still sometimes used to beam data between portable computers or gaming systems, or send documents from portable computers to printers

Telemedicine

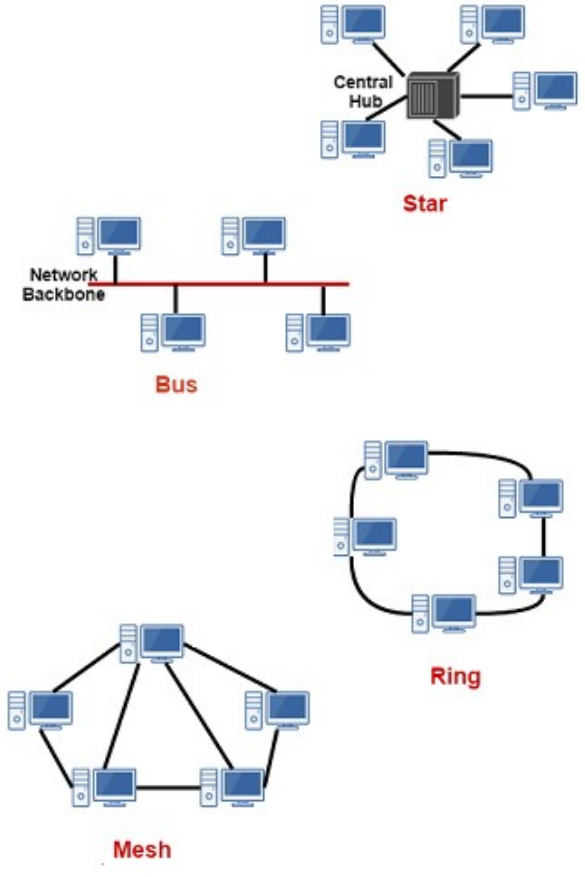
- Use of networking technology to provide medical information and services
  - Remote monitoring and consultations
  - Remote diagnosis
  - Telesurgery
    - Robot assisted
    - May be needed for space exploration

FIGURE 7-8 Examples of telemedicine applications.

Network Topologies:

Arrangement or layout of different elements (links, nodes, etc.) in a computer network

- **Star Network:** All devices are connected to a central device, typically a switch or hub
- **Bus Network:** All devices are connected to a single central cable, called the bus or backbone
- **Ring Network:** Devices in a ring topology are connected in a circular fashion
- **Mesh Network:** Every device is connected to every other device in the network



Network Characteristics

Comparative Analysis:

Network Topology	Advantages	Disadvantages
Star Network	▪ Easy to install/manage centrally ▪ Failure of one node doesn't disrupt others (if switch/hub robust) ▪ Scalable (add devices to central point)	▪ Central point is single point of failure (if hub/switch fails) ▪ High cabling cost if central point far from nodes
Bus Network	▪ Simple, cost-effective cabling ▪ Suitable for small networks	▪ Single cable issue affects whole network ▪ Troubleshooting hard; terminators needed at ends ▪ Limited distance/speed
Ring Network	▪ Deterministic data flow (token passing) ▪ Can be efficient in controlled environments	▪ One node failure can disrupt whole ring (unless dual ring) ▪ Adding/removing nodes tricky
Mesh Network	▪ High redundancy; robust against failures ▪ Great for critical systems needing high reliability	▪ Complex, costly cabling & management ▪ High resource usage for full mesh

Key Considerations:

- **Scalability:** Star often favoured for growth ease
- **Fault Tolerance:** Mesh excels; star depends on central node robustness
- **Cost:** Bus simple/cheap; mesh often costly
- **Performance:** Depends on implementation & traffic patterns

Network Characteristics

IoT Network Topologies:

1. **Star Topology in IoT:** Common with central hubs/gateways collecting data from devices
   - **Examples:** Smart home hubs (e.g., Google Home, Amazon Echo) connecting sensors/devices
   - **Advantages:** Easy management; central data processing
   - **Considerations:** Gateway can be bottleneck/single point of failure
2. **Mesh Topology in IoT:** Popular for extending coverage, robustness
   - **Examples:** Wireless sensor networks; IoT devices routing data peer-to-peer
   - **Advantages:** Self-healing; extended range via multi-hop
   - **Challenges:** Complexity; power constraints on nodes
3. **Other Topologies:** Hybrid approaches seen; bus/ring less common in modern IoT

Key IoT Networking Aspects:

- **Low Power Wide Area Networks (LPWAN):** Technologies like LoRaWAN, NB-IoT for long-range, low-power IoT
- **Short-range Protocols:** Bluetooth, Zigbee, Z-Wave for local IoT connectivity
- **Gateway Role:** Often translate protocols; connect constrained IoT devices to cloud/IP networks

IoT Applications & Topology Relevance:

1. **Smart Homes:** Star-like with hubs controlling devices (e.g., lighting, thermostats)
2. **Industrial IoT (IIoT):** Meshes for robust industrial sensing/control networks
3. **Wearables/Health Monitoring:** Often connect via star (e.g., smartphone hub for wearables)
4. **Smart Cities:** Mesh networks for sensors spread across urban areas
5. **Agricultural IoT:** Sensors in mesh/star for monitoring soil, environment