CSCI 251
Systems and Networks

Physical Layer

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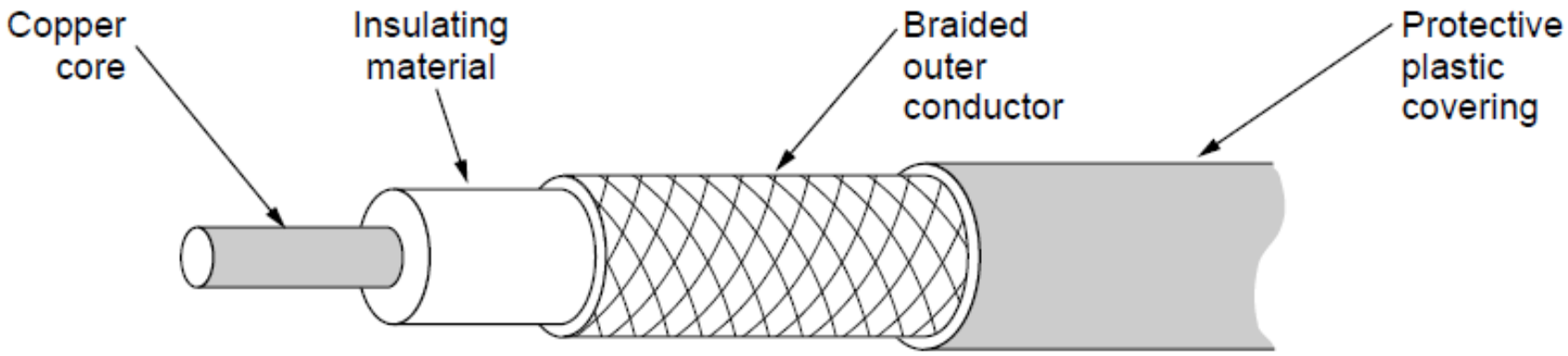
Outline

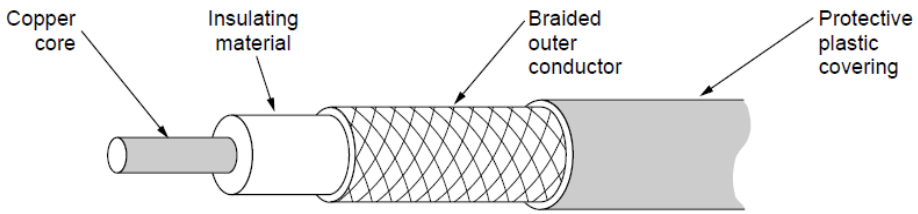
- Wired Transmission
  - Coaxial Cable
  - Twisted Pair
  - Fiber Optics
- Wireless Transmission

Wires – Coaxial Cable (“Co-ax”)

Better shielding and longer distances than twisted pair.



Wires – Coaxial Cable (“Co-ax”)



Wires – Cox and BNC Connector

10BASE2 cable with BNC T-Connector

BNC Male

BNC Female

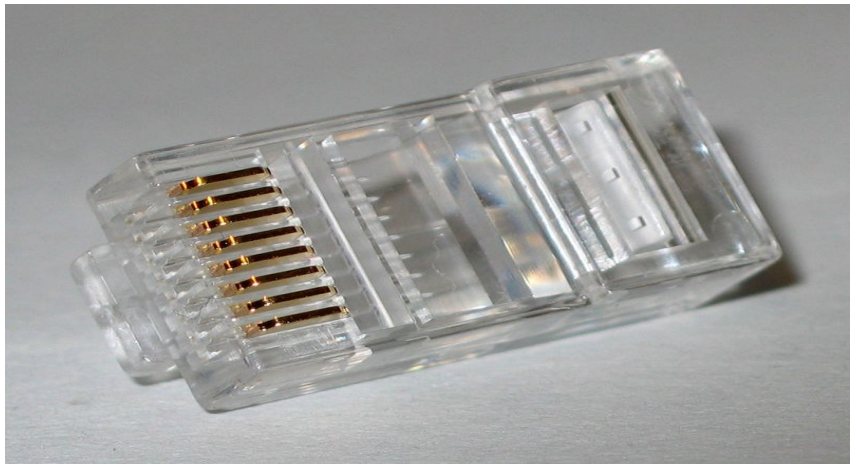
Wires – Twisted Pair

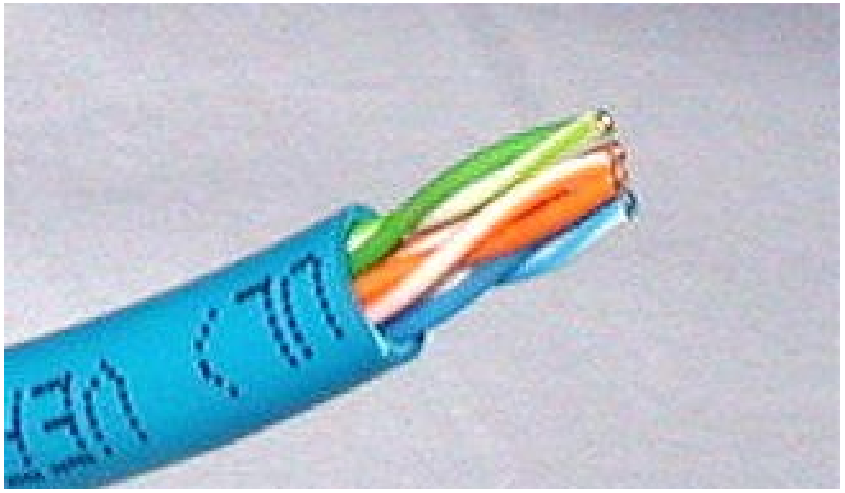
Very common; used in LANs, telephone lines

- Twists reduce radiated signal (interference)

Category 5 UTP cable
with four twisted pairs

Wires – Twisted Pair-RJ45 Connector

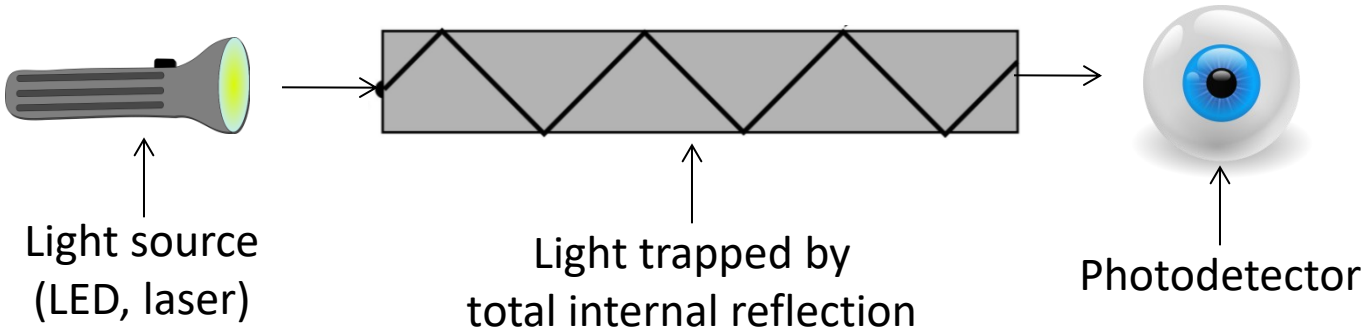




Fiber Cables

Common for high rates and long distances

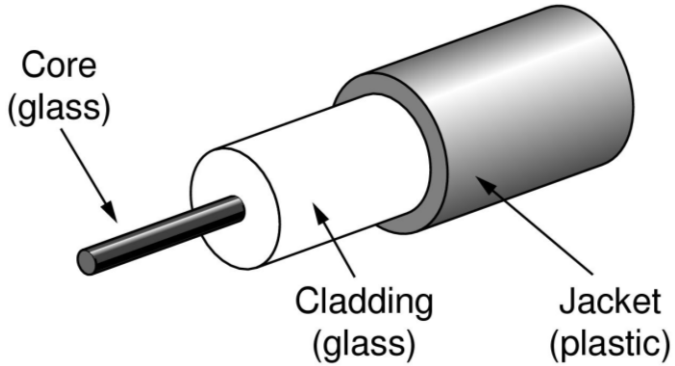
- Long distance ISP links, Fiber-to-the-Home
- Light carried in very long, thin strand of glass
- Fiber has enormous bandwidth (THz) and tiny signal loss – hence high rates over long distances



Fiber Cables

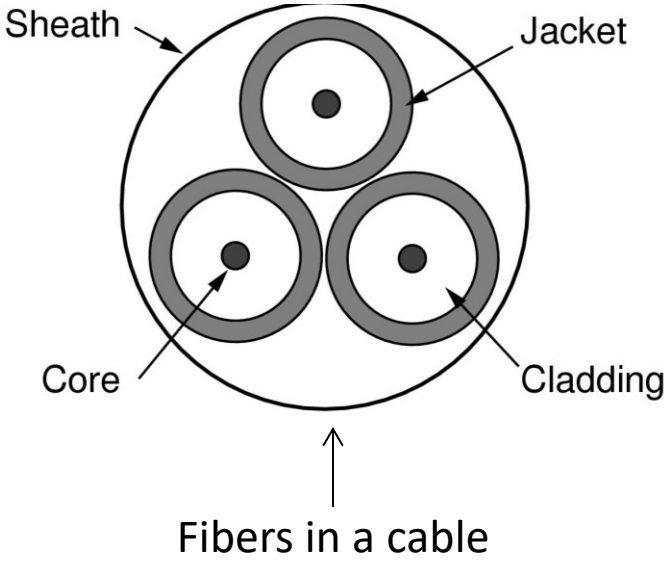
Single-mode

- Core so narrow (10um) light can't even bounce around
- Used with lasers for long distances, e.g., 100km

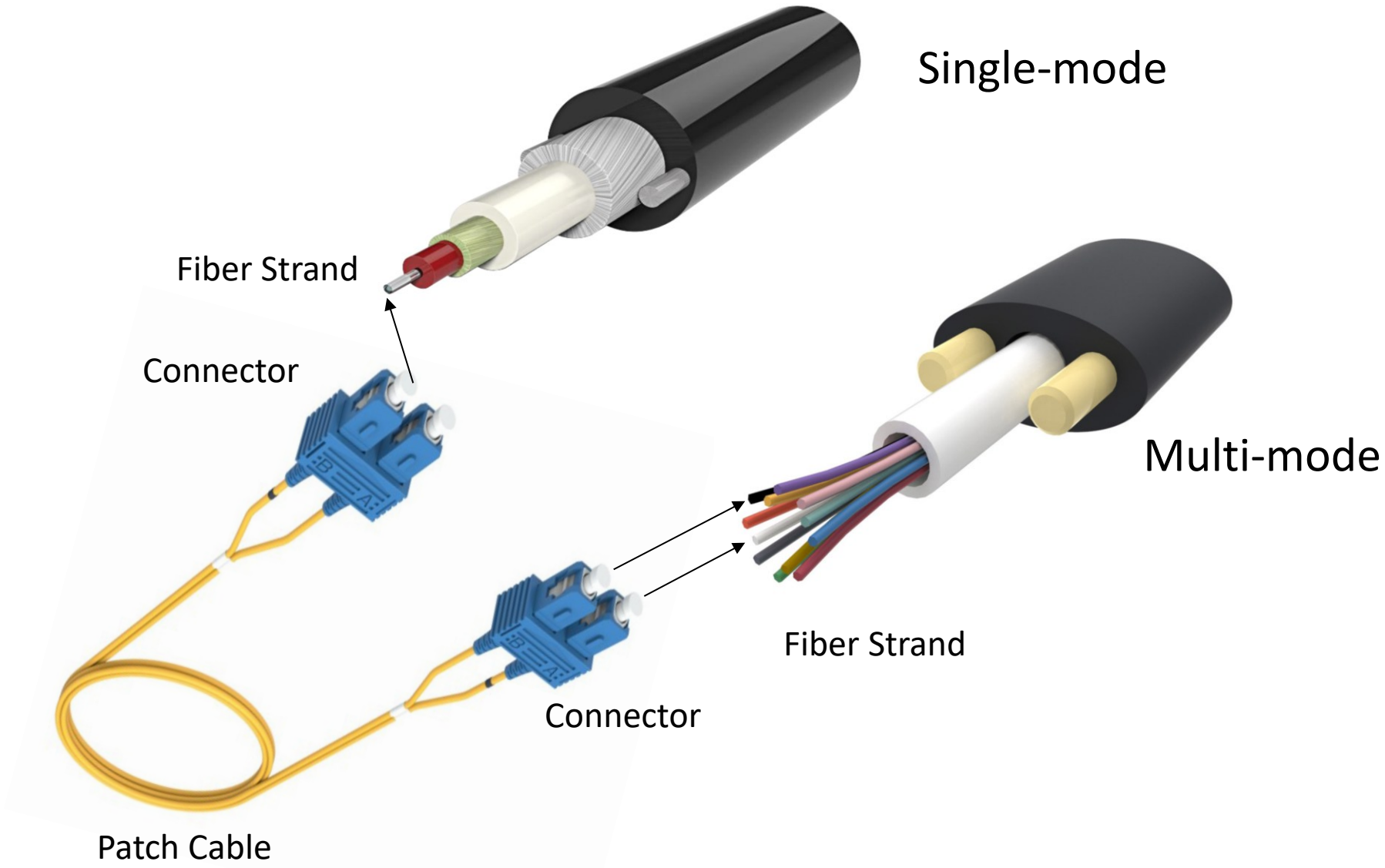


Multi-mode

- Core (50um) light can bounce
- Used with LEDs for cheaper, shorter distance links



Fiber Cables



Fiber Cables

Comparison of the properties of wires and fiber:

Property	**Wires**	**Fiber**
Distance	Short (100s of m)	Long (tens of km)
Bandwidth	Moderate	Very High
Cost	Inexpensive	Expensive
Convenience	Easy to use	Not so easy
Security	Easy to tap	Hard to tap

Wireless Transmission

- Transfers information between devices that are not connected with the wires or cables.
- Data is transported using **electromagnetic waves** or signals.
- Electromagnetic waves propagate without wires or cables.
  - Bluetooth
  - Wi-Fi Access Points
  - Mobile networks, like 3G, 4G or 5G
  - Radio and TV (Unidirectional)
  - Satellites

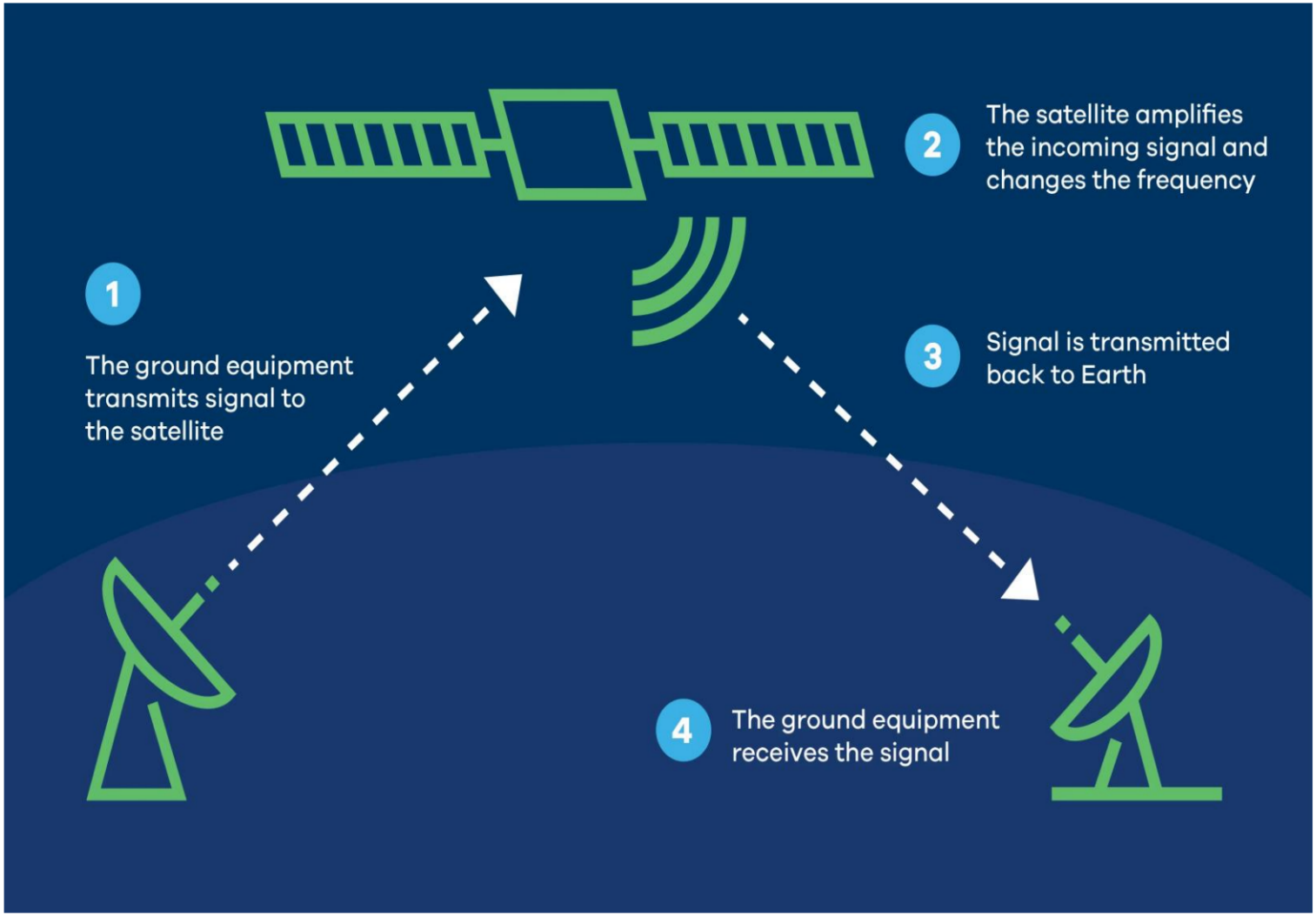
Bluetooth Personal Area Network Transmission

Wireless Access Point Transmission

Mobile networks, like 3G, 4G or 5G

Radio

Sattelite


1
The ground equipment transmits signal to the satellite
2
The satellite amplifies the incoming signal and changes the frequency
3
Signal is transmitted back to Earth
4
The ground equipment receives the signal

Wireless Transmission

- Every wireless transmitter has an oscillator and an transmission antenna.
- Oscillator creates the signals or alternating current against the data.
- Antenna radiates the alternating current as electromagnetic waves up in the air.

Wireless Reception

- Every wireless receiver has a receiver antenna and receiver circuitry.
- When electromagnetic waves hit the receiver antenna alternating current is induced into the receiver circuitry.
- Receiver circuitry converts the alternating current or signal into data.

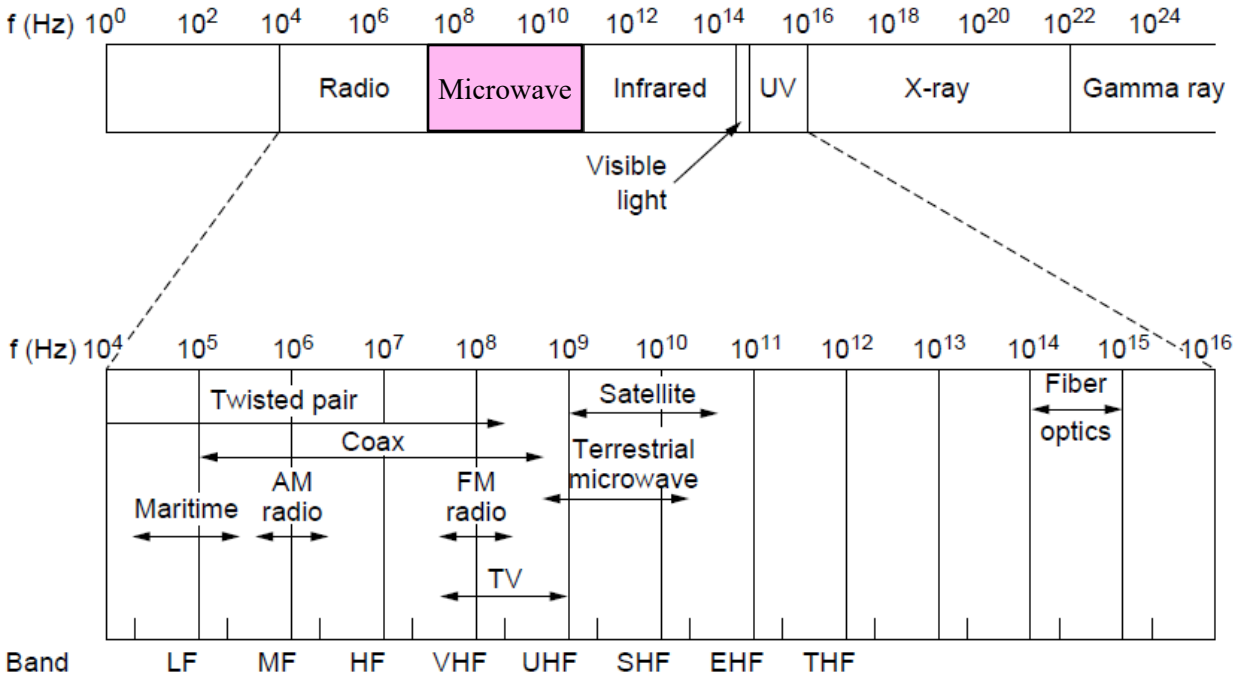
Wireless Communications

- The rate at which alternating current or signal is changing is called its **frequency**.
- The frequency of an electromagnetic wave is exactly the same that of its signal.
- The **wave length** of an electromagnetic wave is inversely proportional to its frequency.
- The whole range of electromagnetic frequencies is called **electromagnetic frequency spectrum**.

Electromagnetic Frequency Spectrum

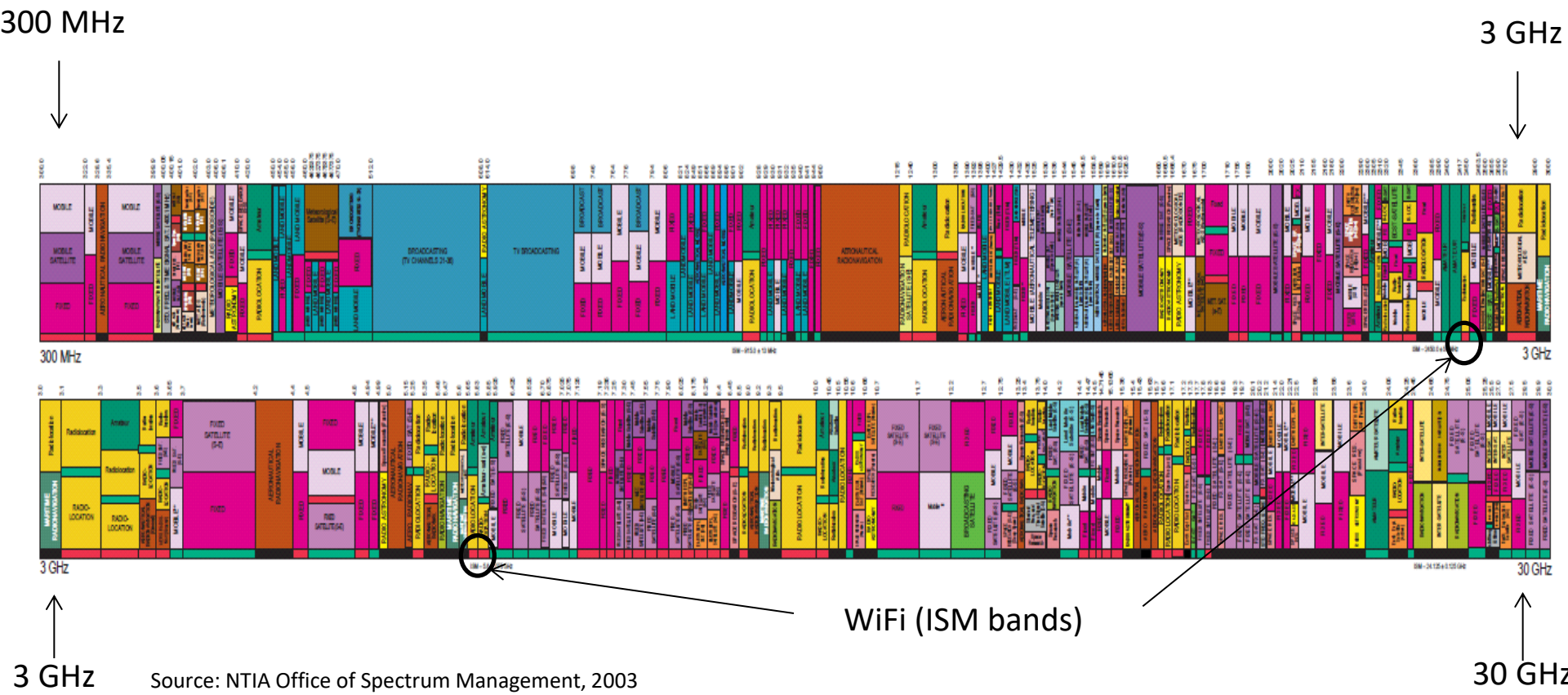
Different bands have different uses:

- Radio: wide-area broadcast; Infrared/Light: line-of-sight
- Microwave: LANs and 3G/4G; ← Networking focus



Electromagnetic Frequency Spectrum

To manage interference, spectrum is carefully divided, and its use regulated and licensed, e.g., sold at auction.



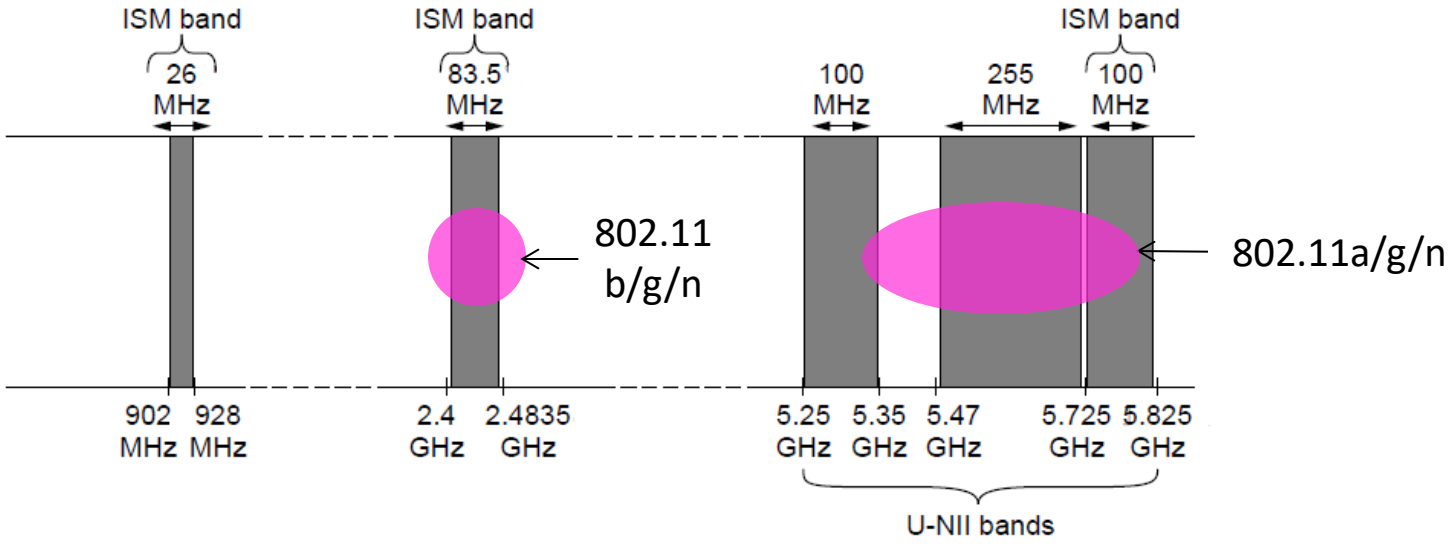
Source: NTIA Office of Spectrum Management, 2003

Part of the US frequency allocations

Electromagnetic Frequency Spectrum

Fortunately, there are also unlicensed ("ISM") bands:

- Free for use at low power; devices manage interference
- Widely used for networking; WiFi, Bluetooth, Zigbee, etc.



Wireless vs. Wires/Fiber

Wireless:

- \+ Easy and inexpensive to deploy
- \+ Naturally supports mobility
- \+ Naturally supports broadcast
- – Transmissions interfere and must be managed
- – Signal strengths hence data rates vary greatly

Wires/Fiber:

- \+ Easy to engineer a fixed data rate over point-to-point links
- – Can be expensive to deploy, esp. over distances
- – Doesn’t readily support mobility or broadcast

Comparision of Physical Mediums

Names	Mediums	Bit Rates	Range	Error Rates	Costs
Bluetooth	Wireless	1-3 Mbps	10m	High	Cheap
WiFi	Wireless	2-54 Mbps	45m (indoor) 90m (outdoor)	High	Cheap
UTP	Copper	100 Mbps to 10 Gbps	100 m	Moderate	Cheap
Coaxial Cable	Copper	10 Mbps To 4 Gbps	200- 500 m	Less than UTP (10^{-5})	More than UTP
Optical Fiber	Glass Fiber	1-768 Tbps	1-7000 Km	Very Low (10^{-9})	Very expensive

Summary

- Wired Transmission
  - Twisted Pair
  - Coaxial Cable
  - Fiber Optics
- Wireless Transmission

Next

Datalink Layer

- Connectionless and Connection-oriented services
- Framing
- Error Control
- Flow Control
- Error-Correcting Code
- Error-Detecting Code
- Data Link Layer Protocols