Computer Networks

The Physical Layer

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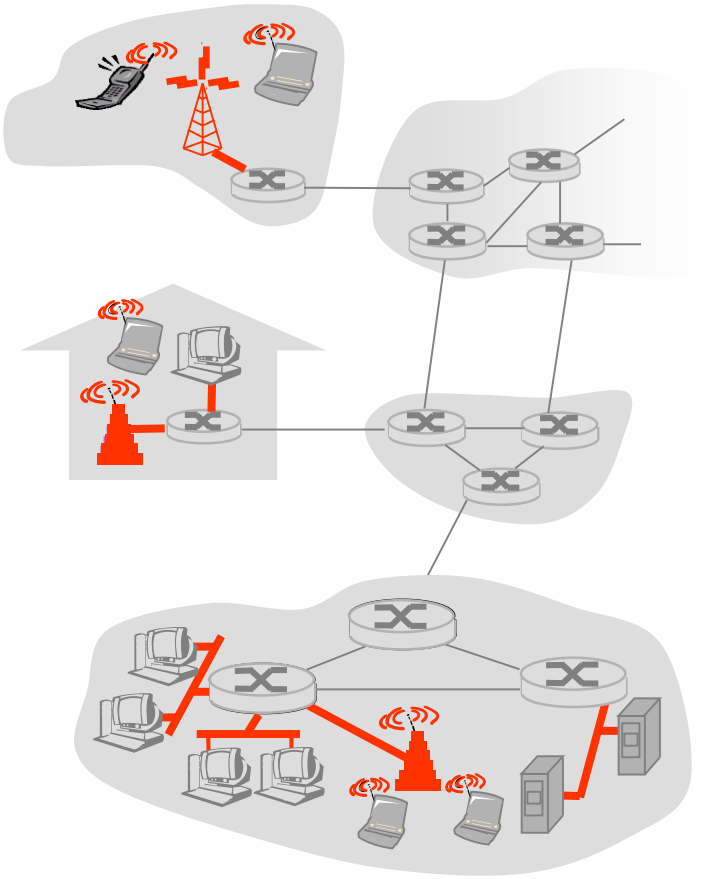
Access networks and physical media

Q: How to connect end systems to edge router?

a) residential access nets

b) institutional access networks (school, company)

c) mobile access networks

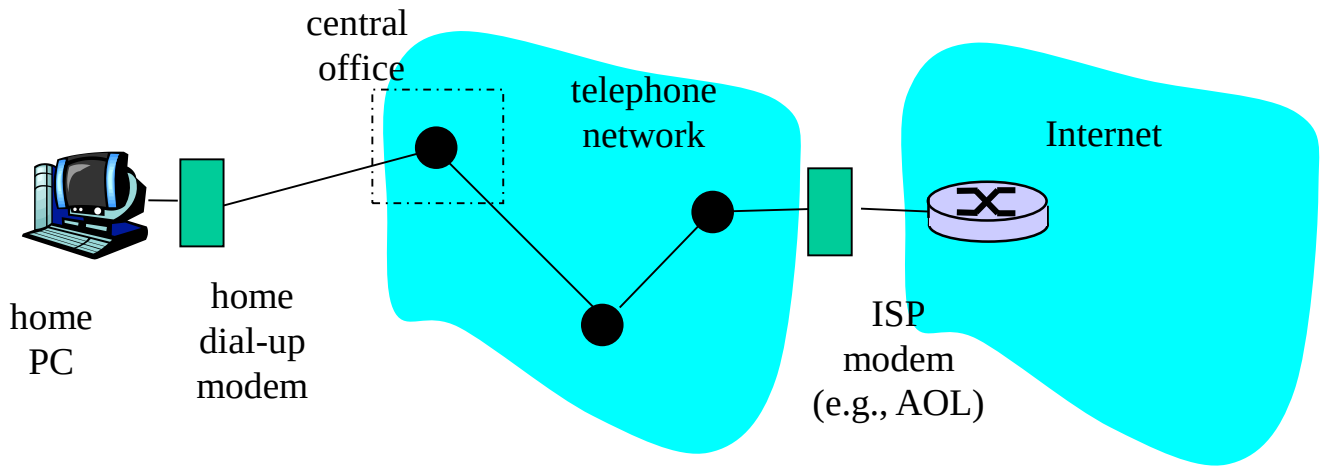


Keep in mind:

a) bandwidth (bits per second) of access network?

b) shared or dedicated?

Dial-up Modem



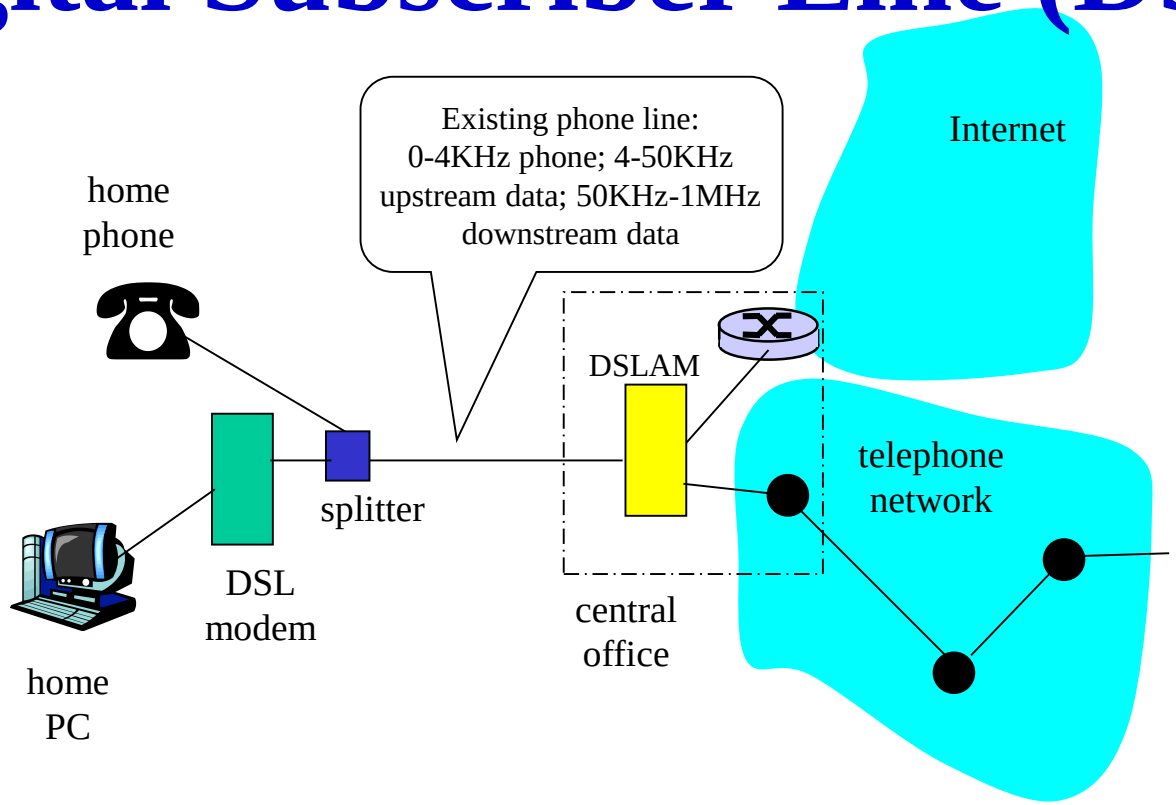
- Uses existing telephony infrastructure
  - Home is connected to central office
- up to 56Kbps direct access to router (often less)
- Can't surf and phone at same time: not "always on"

Broadband residential access

a) DSL – Digital Subscriber Line
   - Provided by telephone company

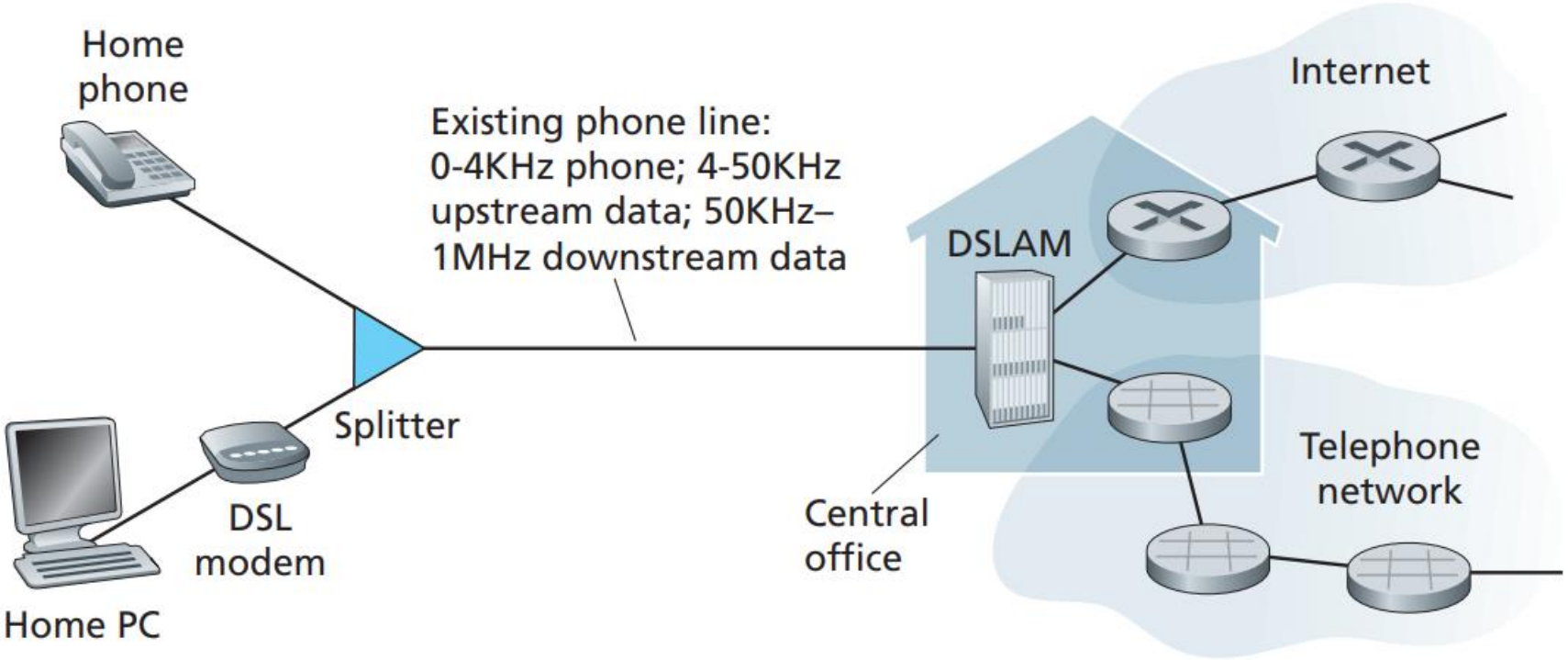
b) HFC – hybrid fiber-coaxial cable
   - Extension of current cable network used for broadcasting cable television

Digital Subscriber Line (DSL)



- Also uses existing telephone infrastructure
- up to 1 Mbps upstream (today typically < 256 kbps)
- up to 8 Mbps downstream (today typically < 1 Mbps)
- dedicated physical line to telephone central office

DSL Internet Access



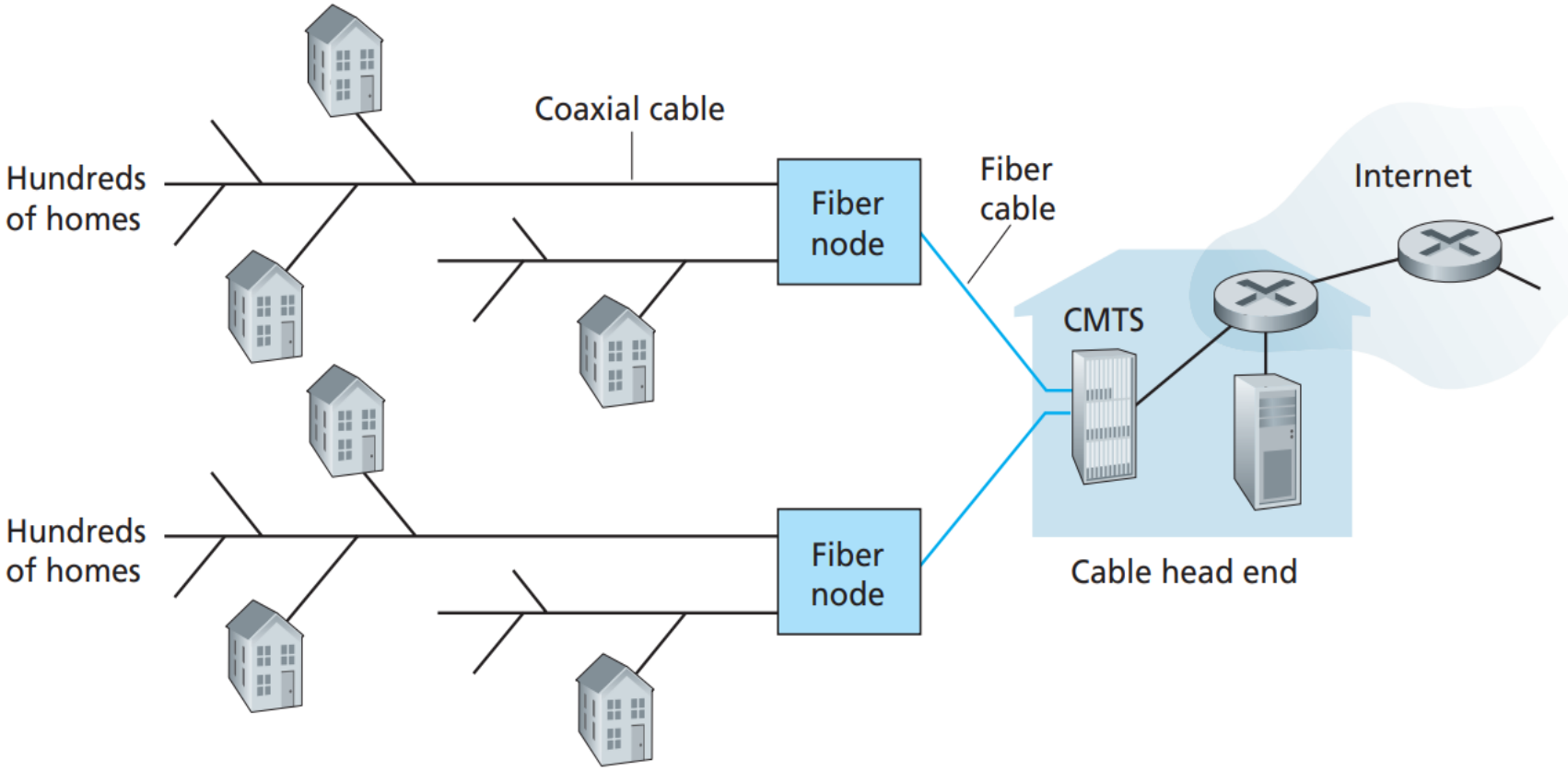
Residential access: cable modems

a) Does not use telephone infrastructure
   - Instead uses cable TV infrastructure

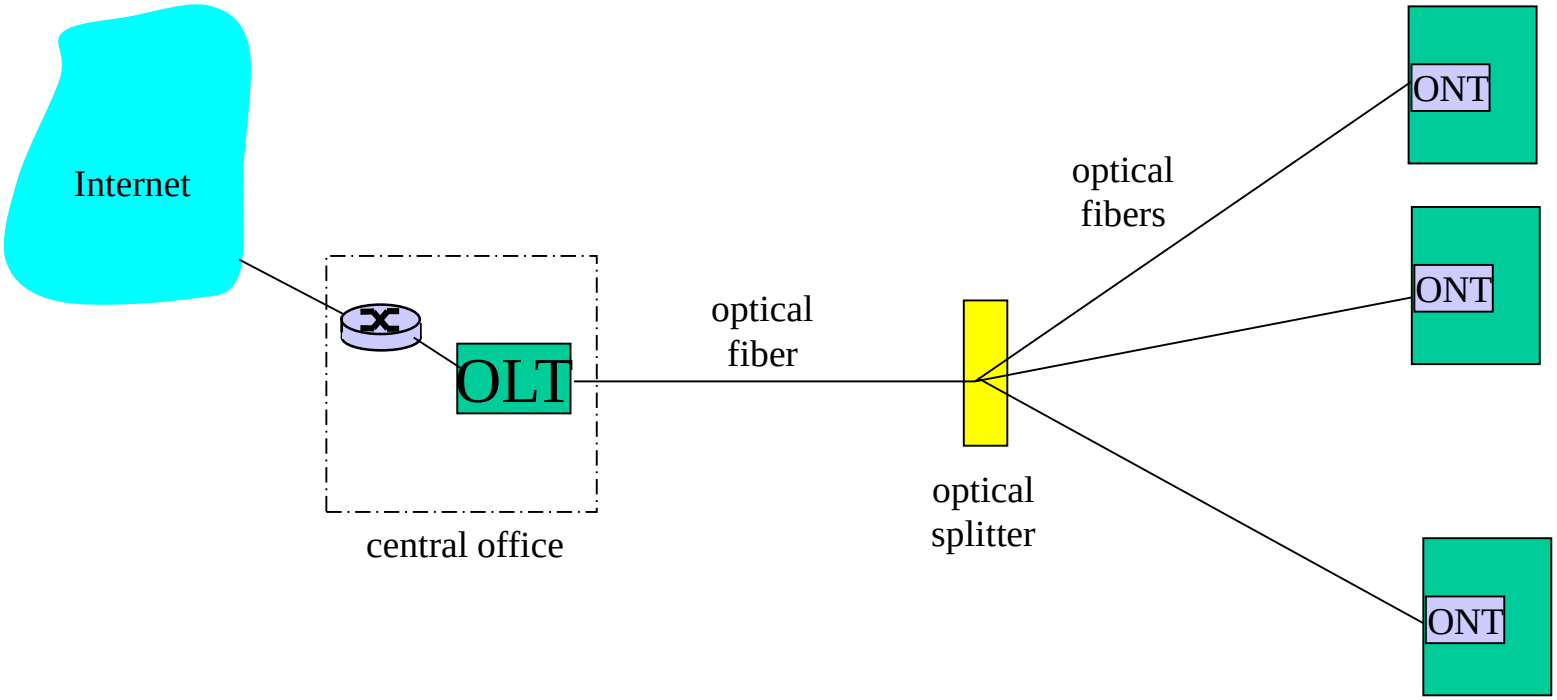
b) HFC: hybrid fiber coax
   - asymmetric: up to 30Mbps downstream, 2 Mbps upstream

c) network of cable and fiber attaches homes to ISP router
   - homes share access to router
   - unlike DSL, which has dedicated access

A hybrid fiber-coaxial access network



Fiber to the Home

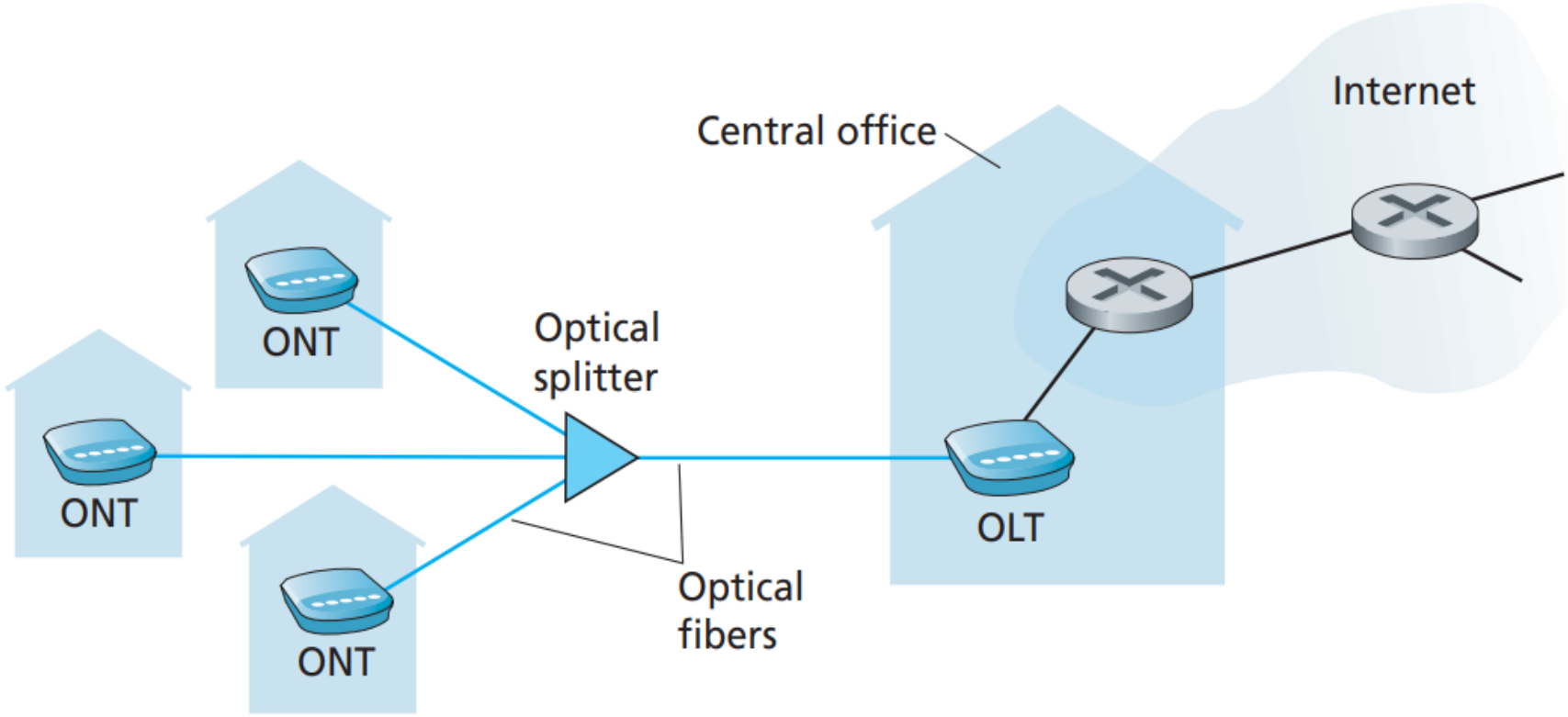


a) Optical links from central office to the home

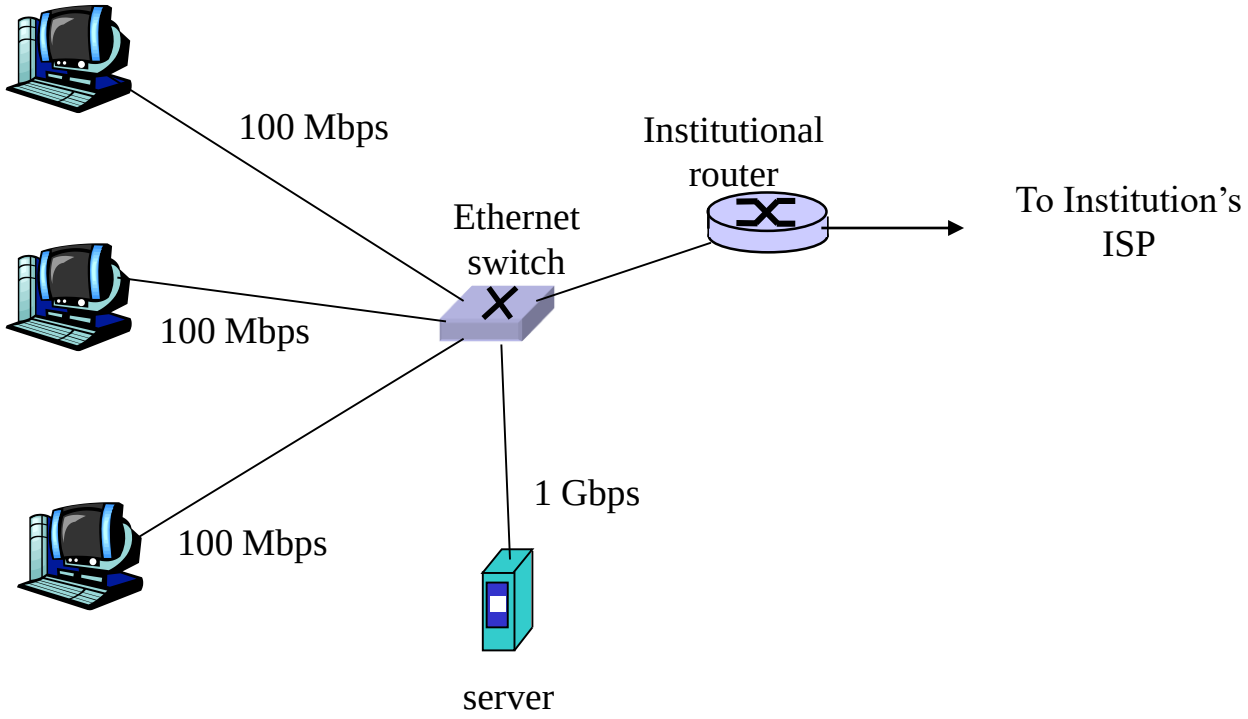
b) Two competing optical technologies:
   - Passive Optical network (PON)
   - Active Optical Network (PAN)

c) Much higher Internet rates; fiber also carries television and phone services

FTTH Internet access



Ethernet Internet access



a) Typically used in companies, universities, etc

- 10 Mbs, 100Mbps, 1Gbps, 10Gbps Ethernet
- Today, end systems typically connect into Ethernet switch

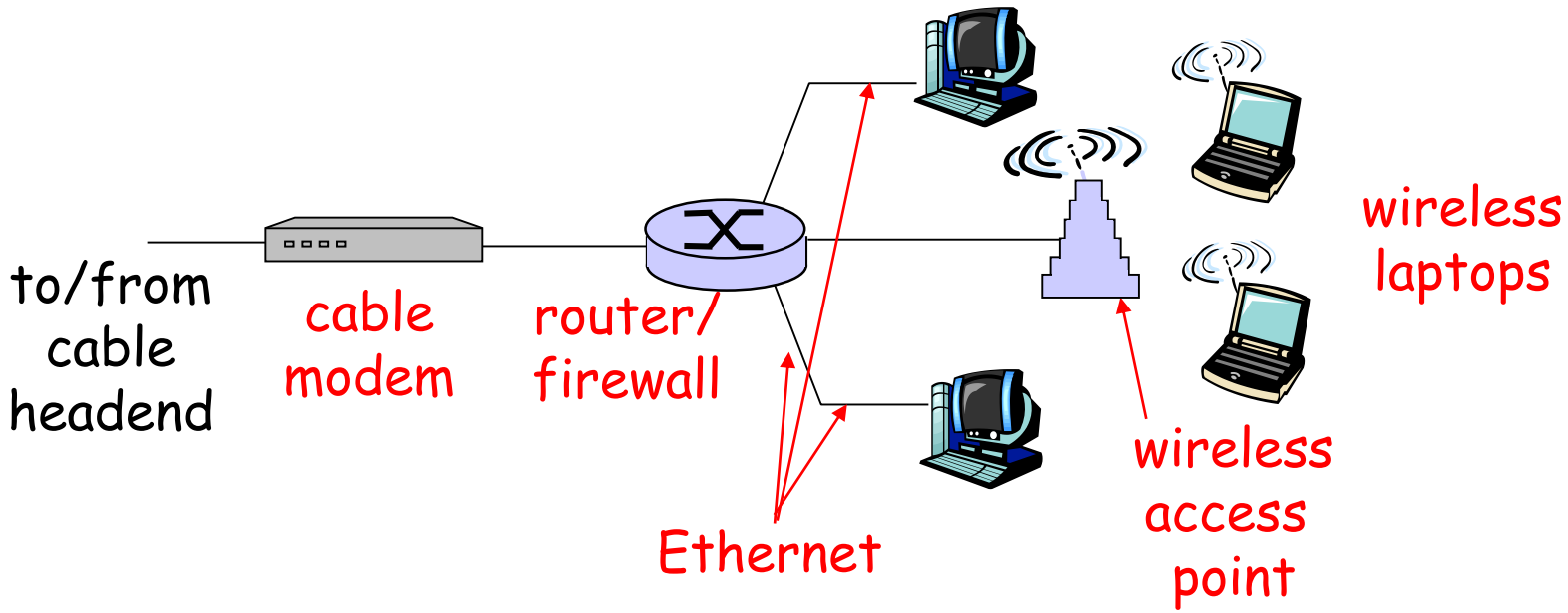
Home networks

Typical home network components:

a) DSL or cable modem

b) Ethernet

c) wireless access point



Physical Media

a) Bit: propagates between transmitter/rcvr pairs

b) physical link: what lies between transmitter & receiver

c) guided media:
   - signals propagate in solid media: copper, fiber, coax

d) unguided media:
   - signals propagate freely, e.g., radio

Twisted Pair (TP)

a) two insulated copper wires
   - Category 3: traditional phone wires, 10 Mbps Ethernet
   - Category 5: 100Mbps Ethernet

Physical Media: coax, fiber

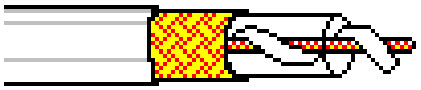
Coaxial cable:

a) two concentric copper conductors

b) bidirectional

c) baseband:
   - single channel on cable
   - legacy Ethernet

d) broadband:
   - multiple channels on cable
   - HFC



Fiber optic cable:

- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
  - high-speed point-to-point transmission (e.g., 10's-100's Gps)
- low error rate: repeaters spaced far apart ; immune to electromagnetic noise

Guided Transmission Data

- Magnetic Media
- Twisted Pair
- Coaxial Cable
- Fiber Optics

Twisted Pair

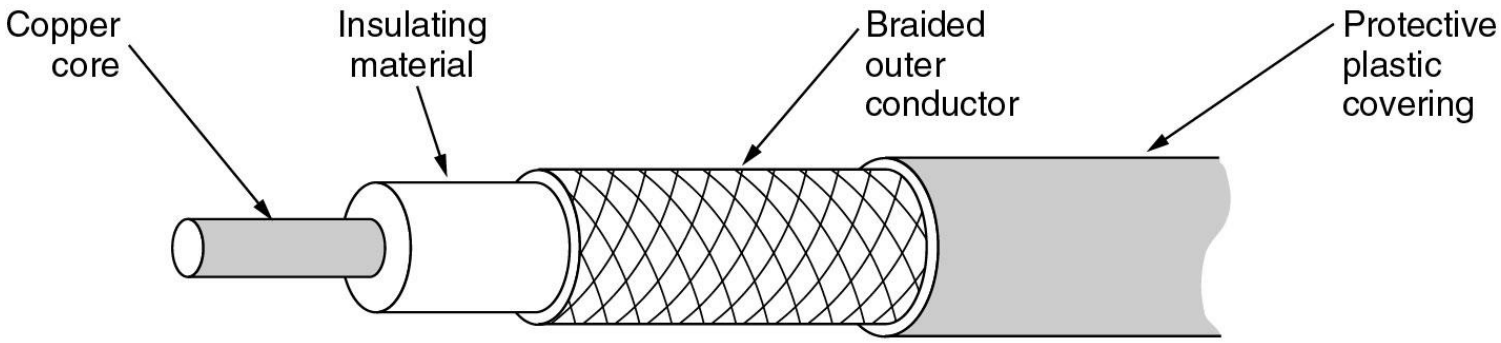
(a)

(b)

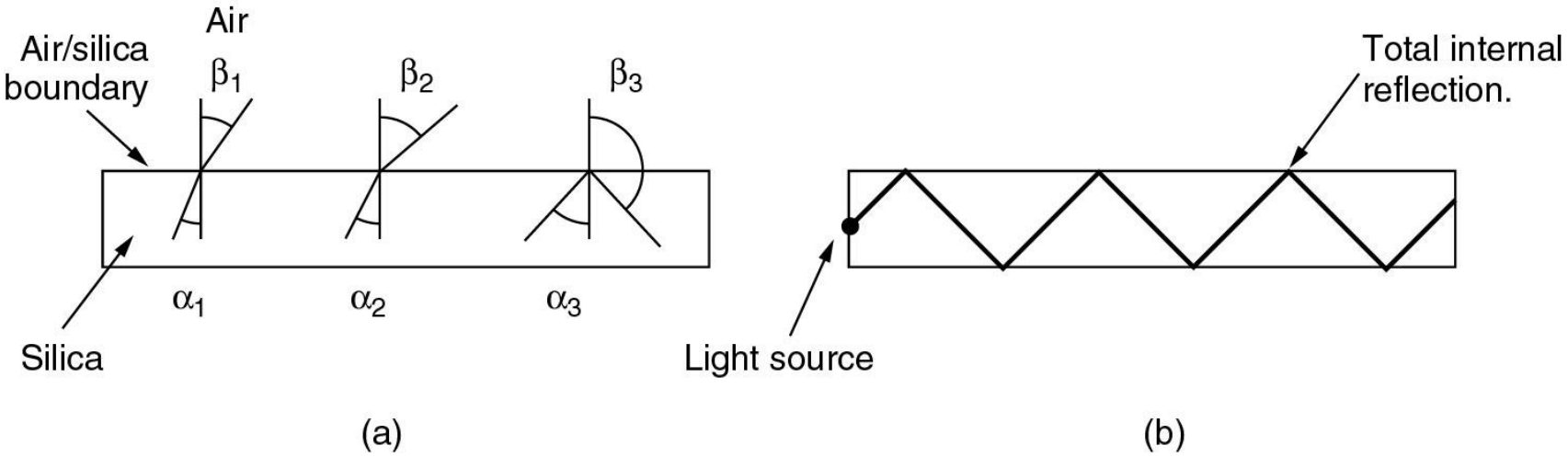
(a) Category 3 UTP.
(b) Category 5 UTP.

Coaxial Cable

A coaxial cable.



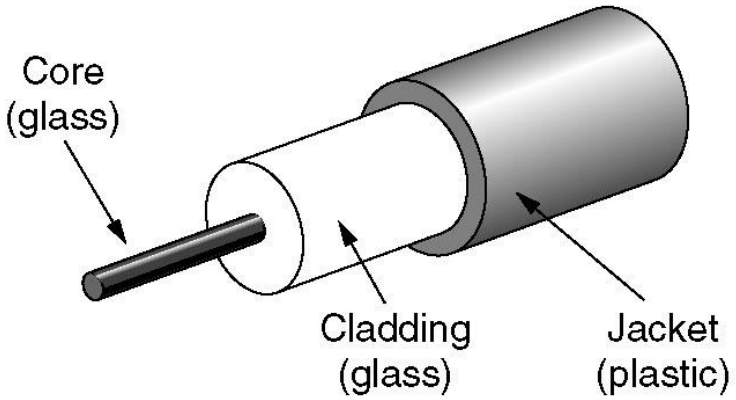
Fiber Optics



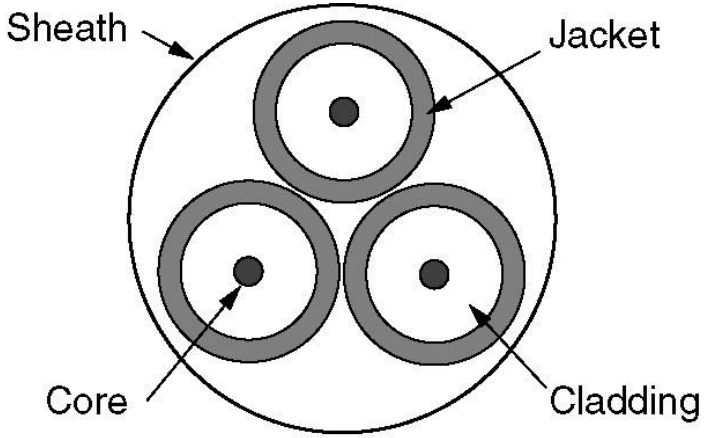
(a) Three examples of a light ray from inside a silica fiber impinging on the air/silica boundary at different angles.

(b) Light trapped by total internal reflection.

Fiber Cables



(a)



(b)

(a) Side view of a single fiber.

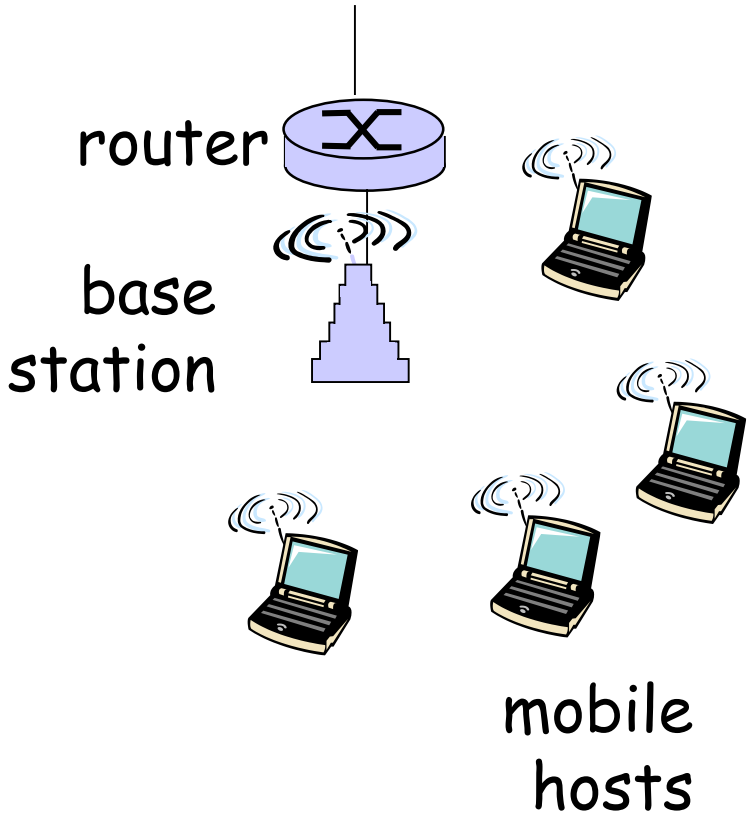
(b) End view of a sheath with three fibers.

Wireless access networks

a) shared *wireless* access network connects end system to router
   - via base station aka “access point”

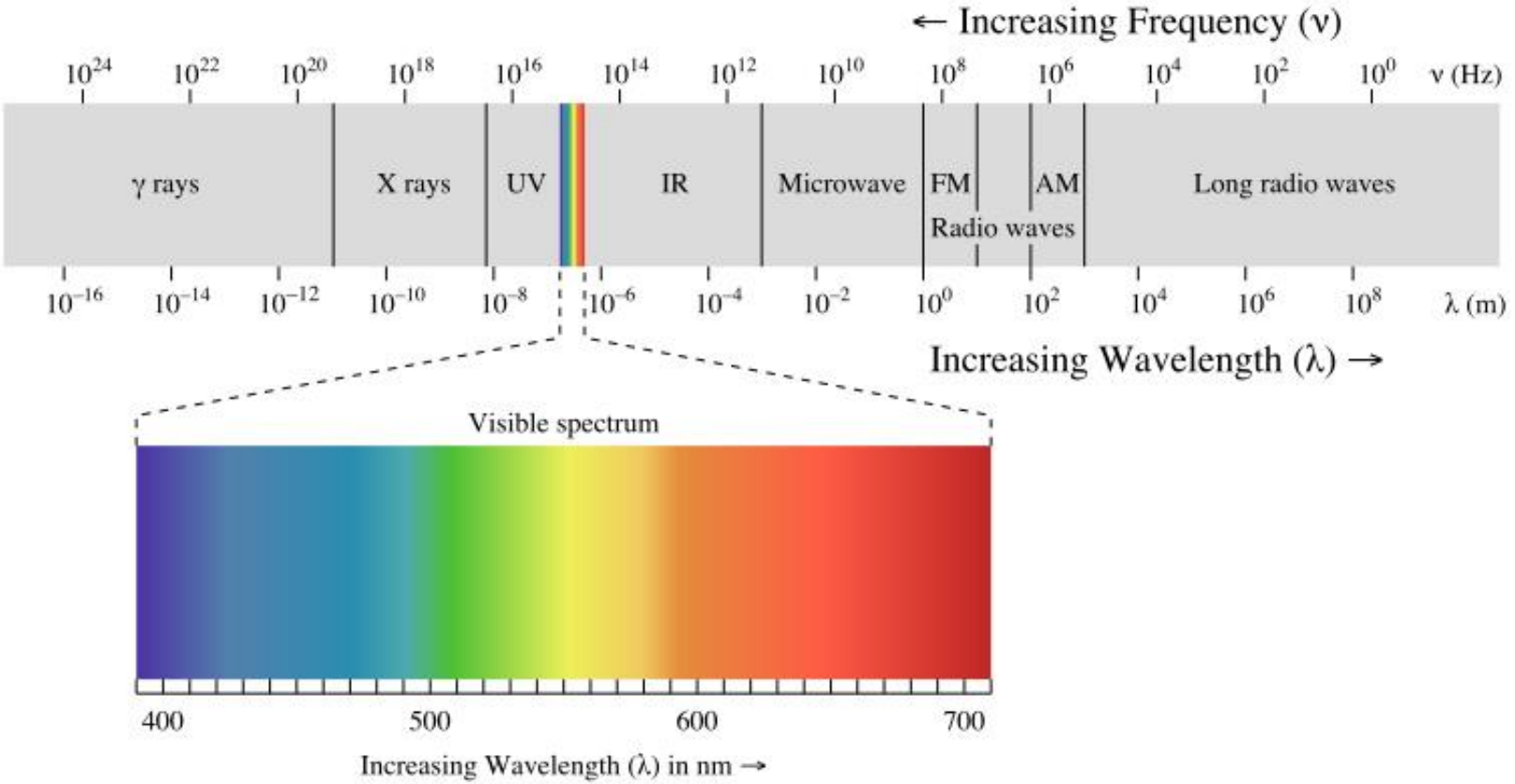
b) wireless LANs:
   - 802.11b/g (WiFi): 11 or 54 Mbps

c) wider-area wireless access
   - provided by telco operator
   - ~1Mbps over cellular system (EVDO, HSDPA)
   - next up (?): WiMAX (10’s Mbps) over wide area

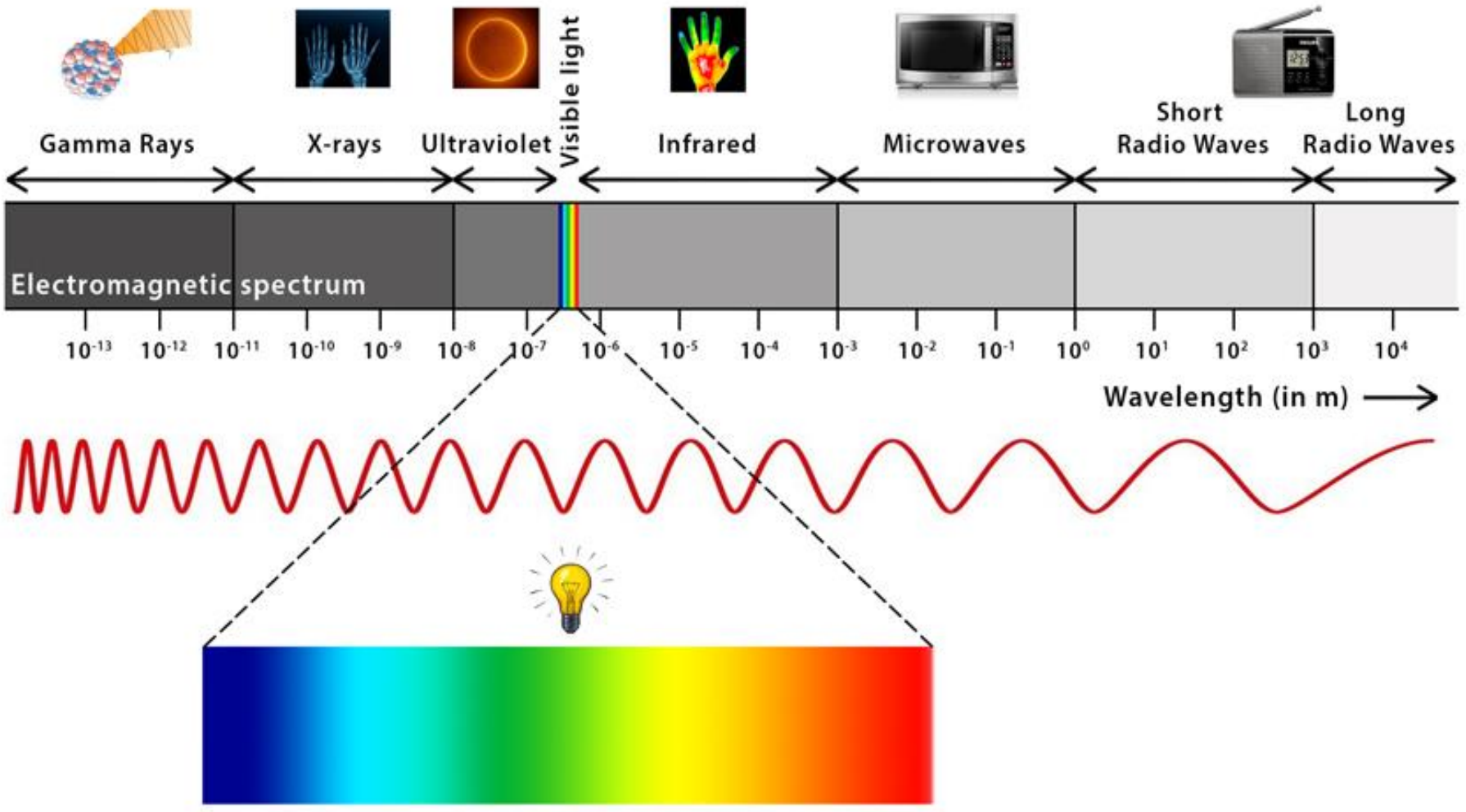


Wireless Transmission

Electromagnetic Spectrum

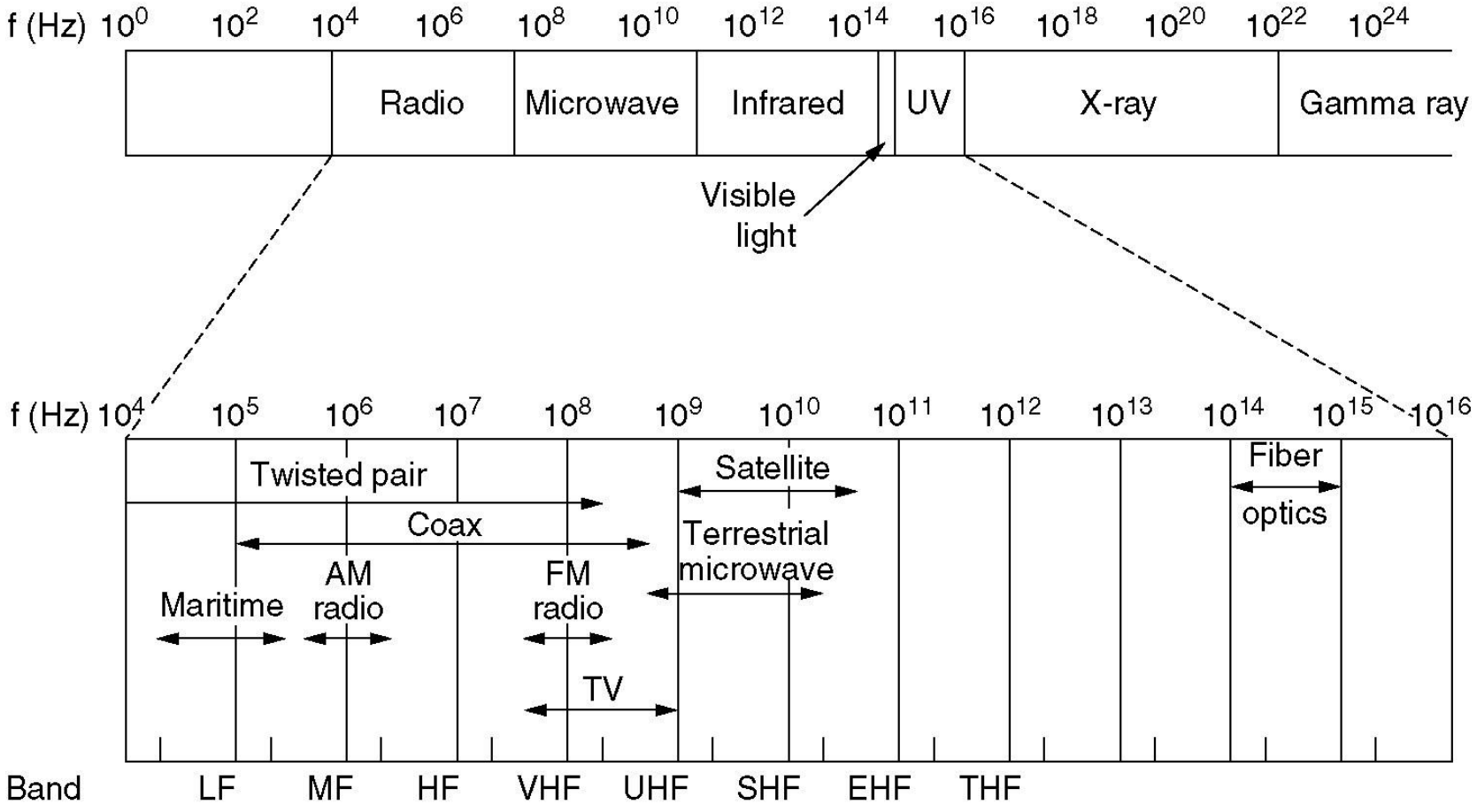


Electromagnetic Spectrum – Types



The Electromagnetic Spectrum

The electromagnetic spectrum and its uses for communication.



Thank You!