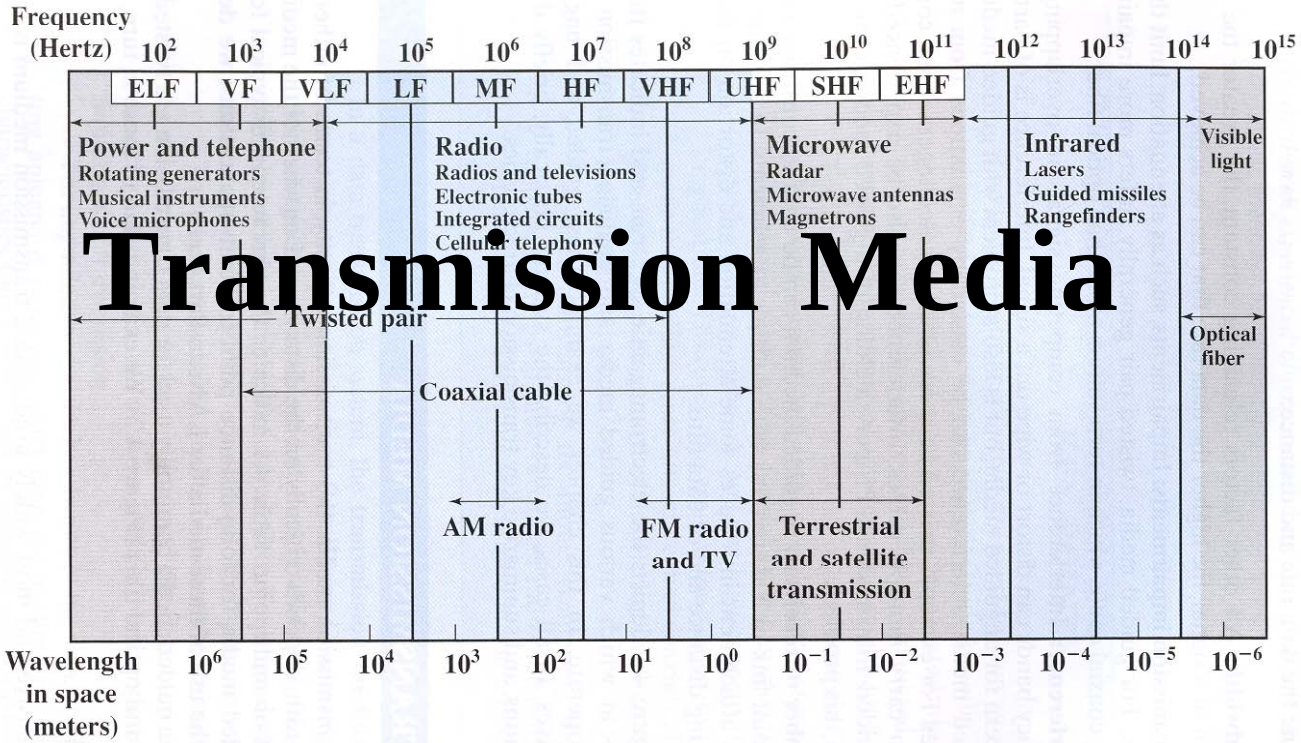
Transmission Media



ELF = Extremely low frequency
VF = Voice frequency
VLF = Very low frequency
LF = Low frequency
MF = Medium frequency
HF = High frequency
VHF = Very high frequency
UHF = Ultra high frequency
SHF = Super high frequency
EHF = Extremely high frequency

Figure 4.1 Electromagnetic Spectrum for Telecommunications

Guided/Unguided Media

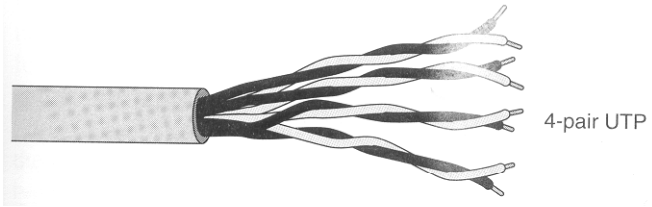
Twisted Pair

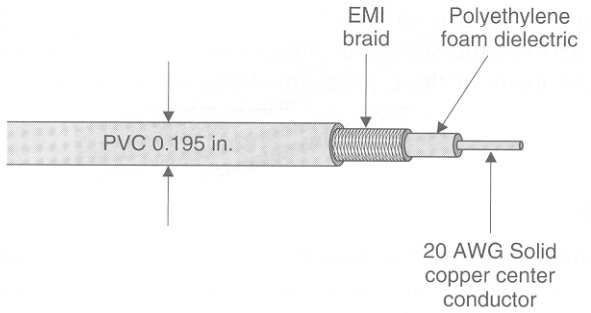
Coaxial cable

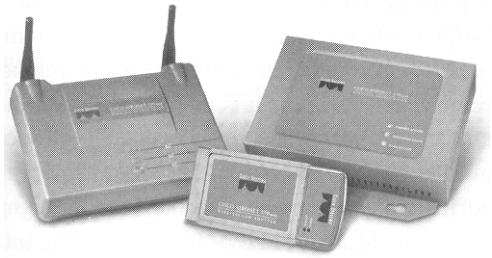
Optical Fiber

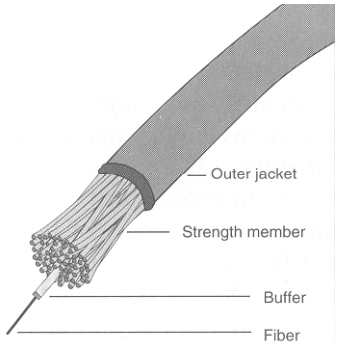
Radio/Micro wave

Guided/Unguided Media









Twisted Pair

Physical description

Consists of two insulated copper wires arranged in a regular spiral pattern

Bundled together into a cable by wrapping them in a tough protective sheath

Twisting of the pairs minimizes electromagnetic interference between the pairs

Thickness: 0.0016 to 0.036 inch

Twisted Pair

Applications

Analog signals

Local loops: individual residential telephone sets connected to the local telephone exchange, central office

Short-haul trunks: 12 or 24 multiplexed voice channels per twisted pair

Digital signals

64 kbps: for connections to a digital data switch or digital PBX within a building

10-100 Mbps: for local-area networks supporting PCs within a building

4 Mbps or more: for long-distance applications

Twisted Pair

Transmission characteristics

Amplfiers: 5-6 km

Repeaters: 2-3 km

Quite susceptible to interference and noise

Measures to reduce impairments

- Interference: shielding the wire with metallic braid or sheathing
- Low-frequency interference: the twisting of the wire
- Crosstalk: the use of different twist lengths in adjacent pairs

Coaxial Cable

Physical description

Consists of a hollow outer cylindrical conductor (copper braid to shield against external unwanted signal, EMI), which surrounds a single inner wire conductor (copper to tx signal)

Applications

TV distribution

LANs

Short-run computer system links

Long-distance telephone transmission

More than 10,000 voice channels can be carried simultaneously using FDM

Coaxial Cable

Transmission characteristics

Transmit both analog and digital signals

Higher frequencies and data rates than twisted pair

Optical Fiber

Physical description

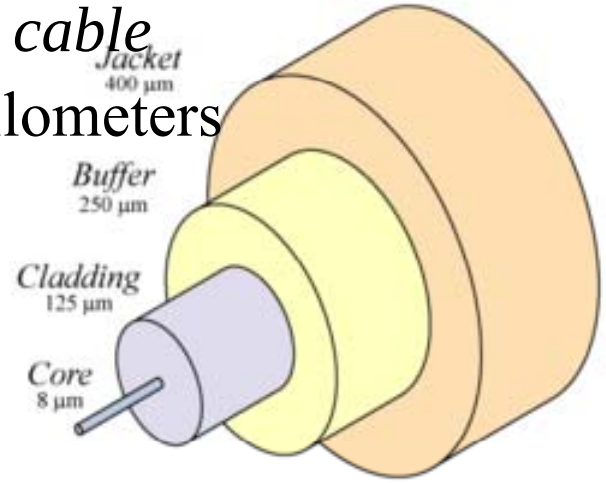
A thin (2-125μm), flexible medium capable of conducting an optical ray

An optical fiber has a cylindrical shape and consists of three concentric sections: core, cladding and jacket

Applications

Distinction from twisted pair and coaxial cable

- Greater capacity: 2 Gbps over tens of kilometers
- Smaller size and lighter weight
- Lower attenuation
- Electromagnetic isolation
- Greater repeater spacing



Optical Fiber

Five basic applications

Long-haul trunks

Common in telephone network about 900 miles in length and high capacity (typically 20,000 to 60,000 voice channels)

Metropolitan trunks

7-8 miles, 100,000 voice channels in a trunk group

Rural exchange trunks

25-100 miles, fewer than 5,000 voice channels

Local loops

From central exchange to a subscriber

Not only voice and data but also image and video

Local-area network

Optical Fiber

Transmission characteristics

The system operates in the range of about 10^{14} to 10^{15} hertz

Mode of propagation

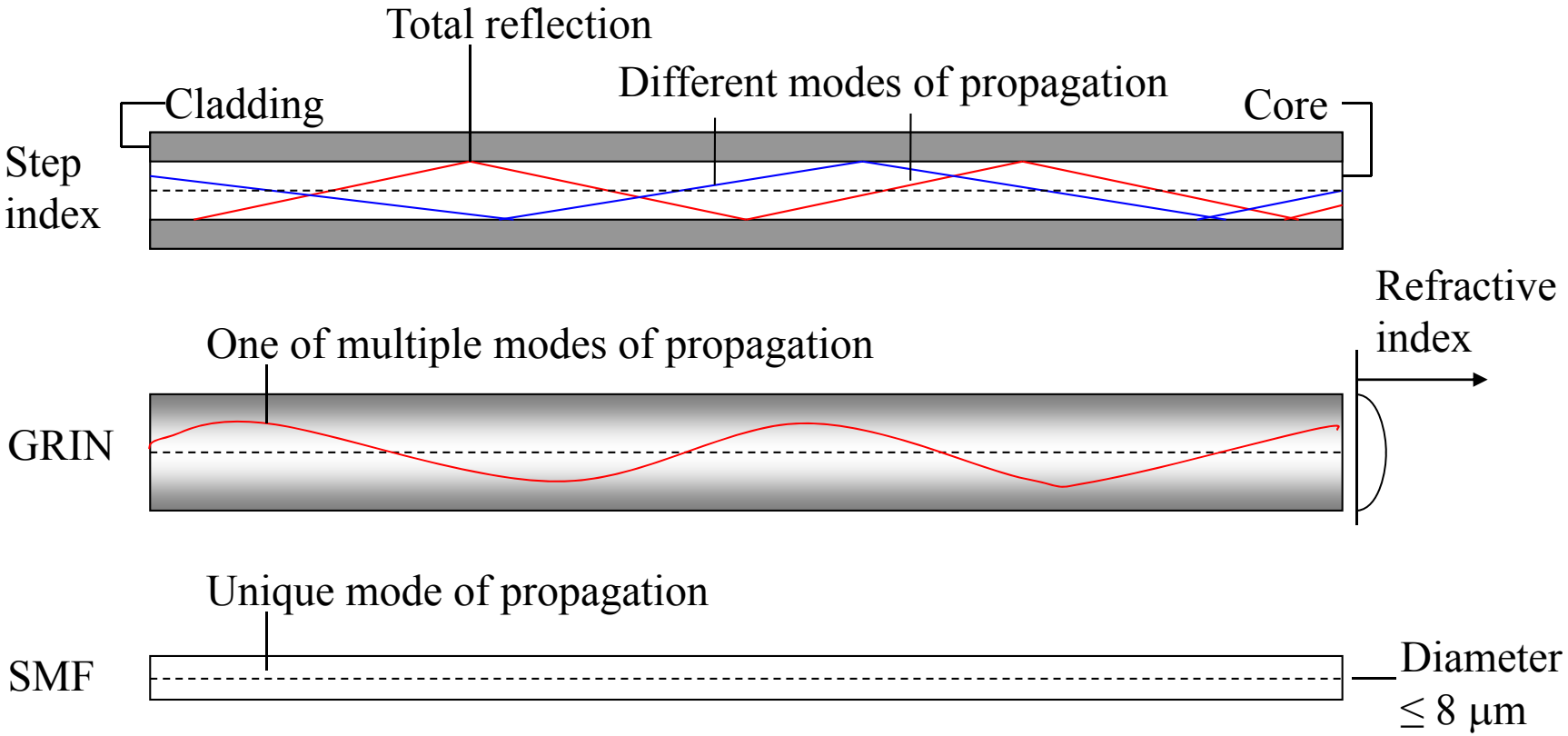
- Multimode (multimode step index) - light
- Single-mode propagation - laser
- Multimode graded index

Type of light source

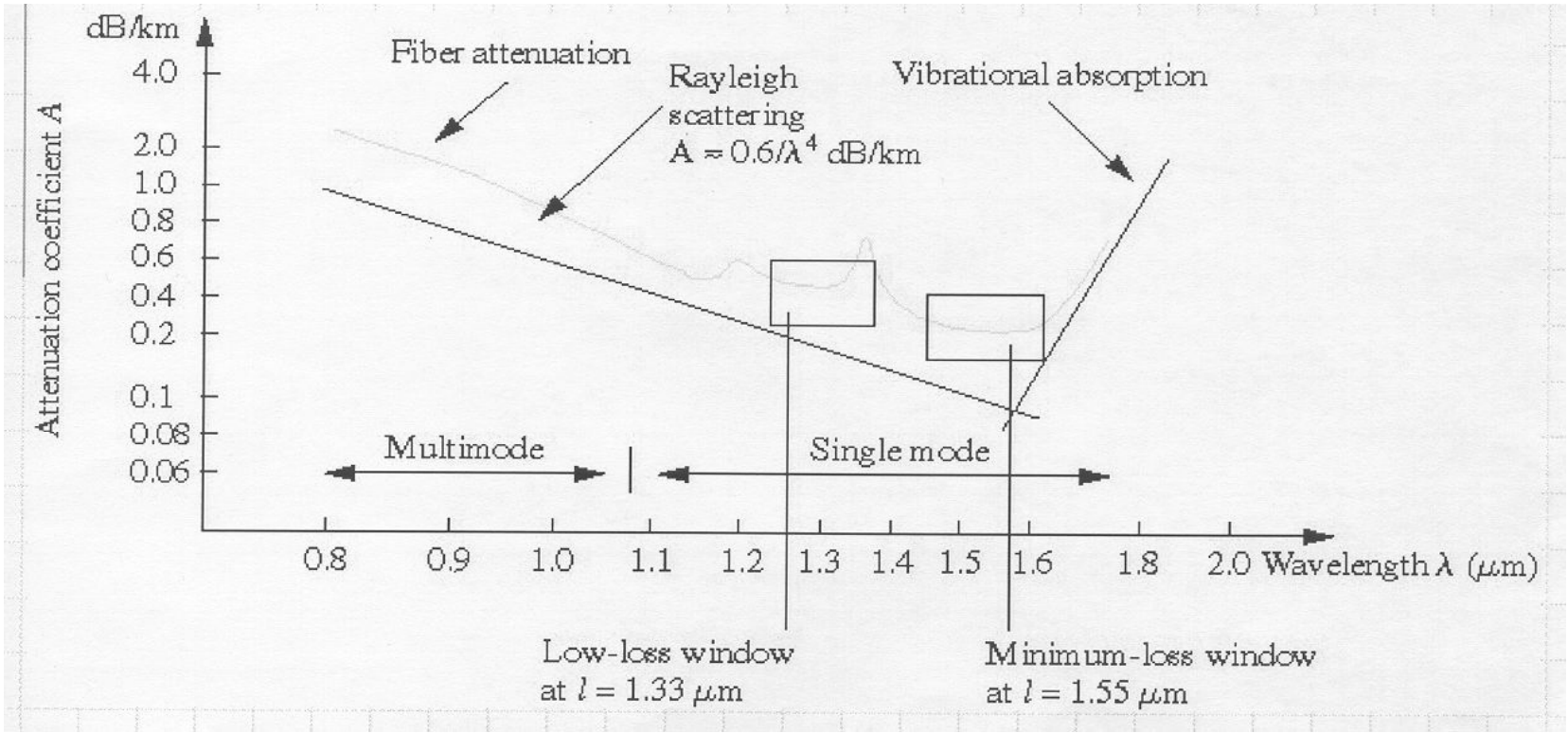
- Light-emitting diode (LED)
- Injection laser diode (ILD)

In optical fiber, light propagates best in three distinct wavelength “windows”, centered on 850, 1300, 1550 nm

Optical Fiber: Three modes



Optical Fiber



Wavelength-Division Multiplexing (WDM)

The potential of fiber is fully exploited with WDM

Multiple beams of light at different frequencies are transmitted on the same fiber

A form of FDM

Each wavelength carries a separate channel of data

Commercial systems with 80 channels each of 10 Gbps are now available

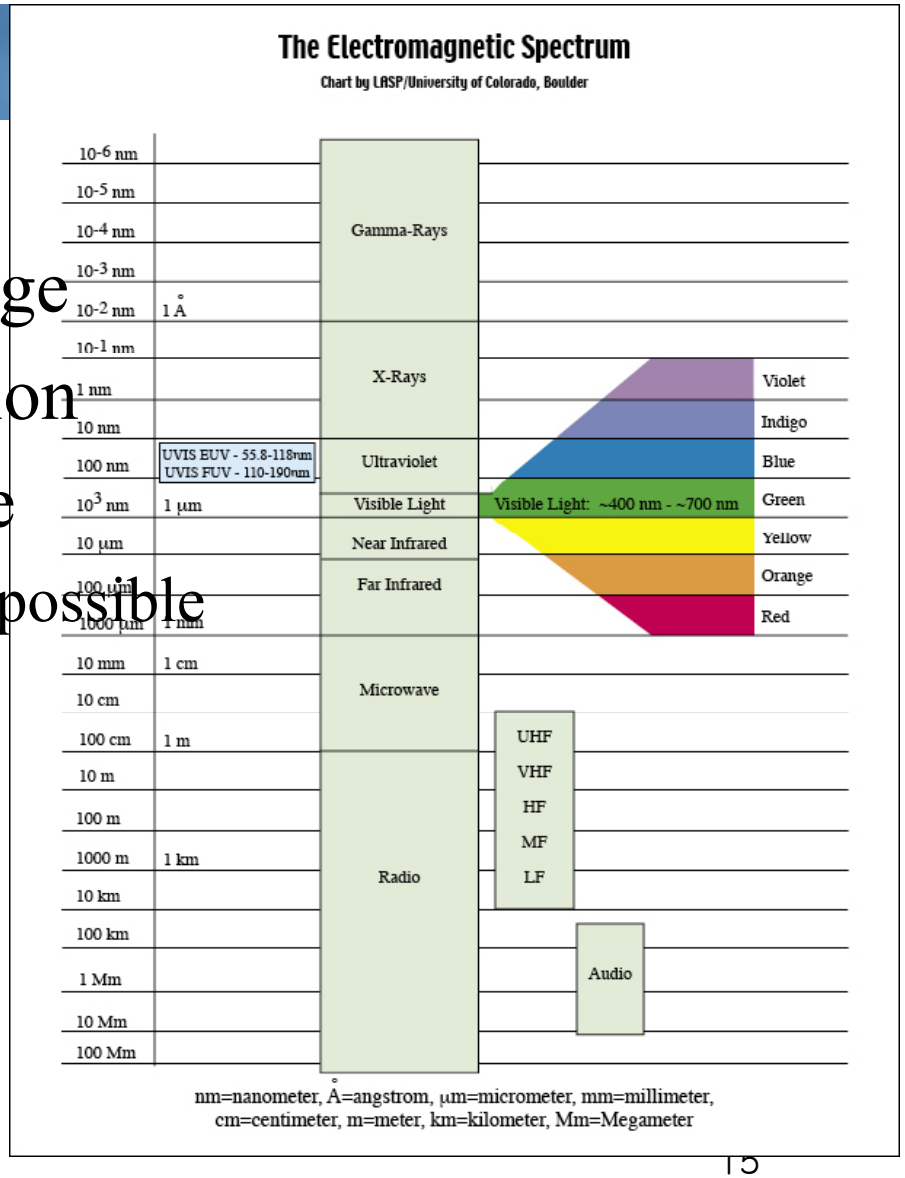
Wireless Transmission

30 MHz – 1GHz: Radio range

- Omnidirectional application

1GHz – 40GHz: Microwave

- Highly directional beams are possible
- Point-to-point transmission
- Satellite communication



Terrestrial Microwave

Physical description

The parabolic "dish" antenna (about 3m in diameter) focuses a narrow beam for line-of-sight transmission to the receiving antenna

Applications

Long-haul telecommunication services as an alternative to coaxial cable or optical fiber

Both voice and television transmission

Point-to-point links between buildings

Transmission characteristics

2-40 GHz

Attenuation is proportionally less than twisted pair or coaxial cable but increased with rainfall

Satellite Microwave

Physical description

A communication satellite is a microwave relay station

- Links two or more transmitter/receivers
- Uplink/downlink (different frequency)
- Transponder channels: a single satellite operates on a number of frequency bands

Two common configuration for satellite communication

- Point-to-point
- Broadcast link

Stationary satellite: 35,784km

The number of possible satellite is quite limited due to the interference

Satellite Microwave

Applications

Television distribution
- Program distribution to Cable TV stations
- DBS (Direct Broadcast Satellite) directly to the home users

Long-distance telephone transmission

Private business networks
- Satellite provider leases channels to individual business users
- VSAT (Very Small Aperture Terminal)

Satellite Microwave

Transmission characteristics

- Below 1 GHz: significant noise
- Above 10 GHz: attenuation

Optimum frequency range: 1 to 10 GHz Frequency bandwidth

4/6 GHz band

- uplink: 5.924 ~ 6.425 GHz
- downlink: 3.7 ~ 4.2 GHz

Satellite Microwave

12/14 GHz band

uplink: 14 ~ 14.5 GHz

downlink: 11.7 ~ 12.2 GHz

Attenuation problems must be overcome

Smaller and cheaper earth station receivers can be used

19/29 GHz band

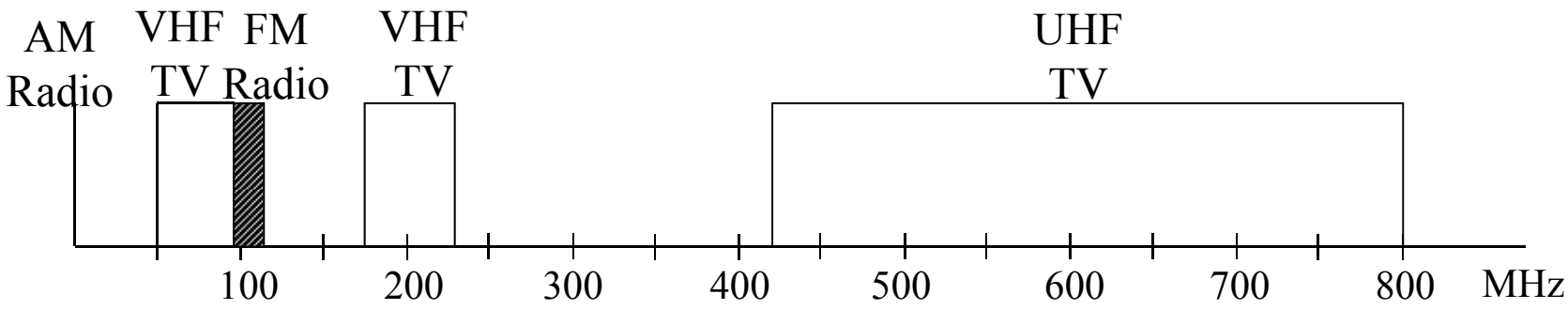
uplink: 27.5 ~ 31.0 GHz

downlink: 17.7 ~ 21.2 GHz

Even greater attenuation problems

Greater bandwidth, even smaller and cheaper receivers

Broadcast Radio



30MHz - 1GHz band: FM radio, VHF/UHF TV
Omnidirectional/directional antenna

Summary

Twisted pair: local loop, short-haul trunk, LAN

Coaxial cable: TV distribution, LAN

Optical Fiber: long-haul, metropolitan trunks, FTTH, LAN

Radio: AM, FM, TV broadcast

Microwave: point-to-point, Satellite