CSC8004 Computer Networks

The Physical Layer

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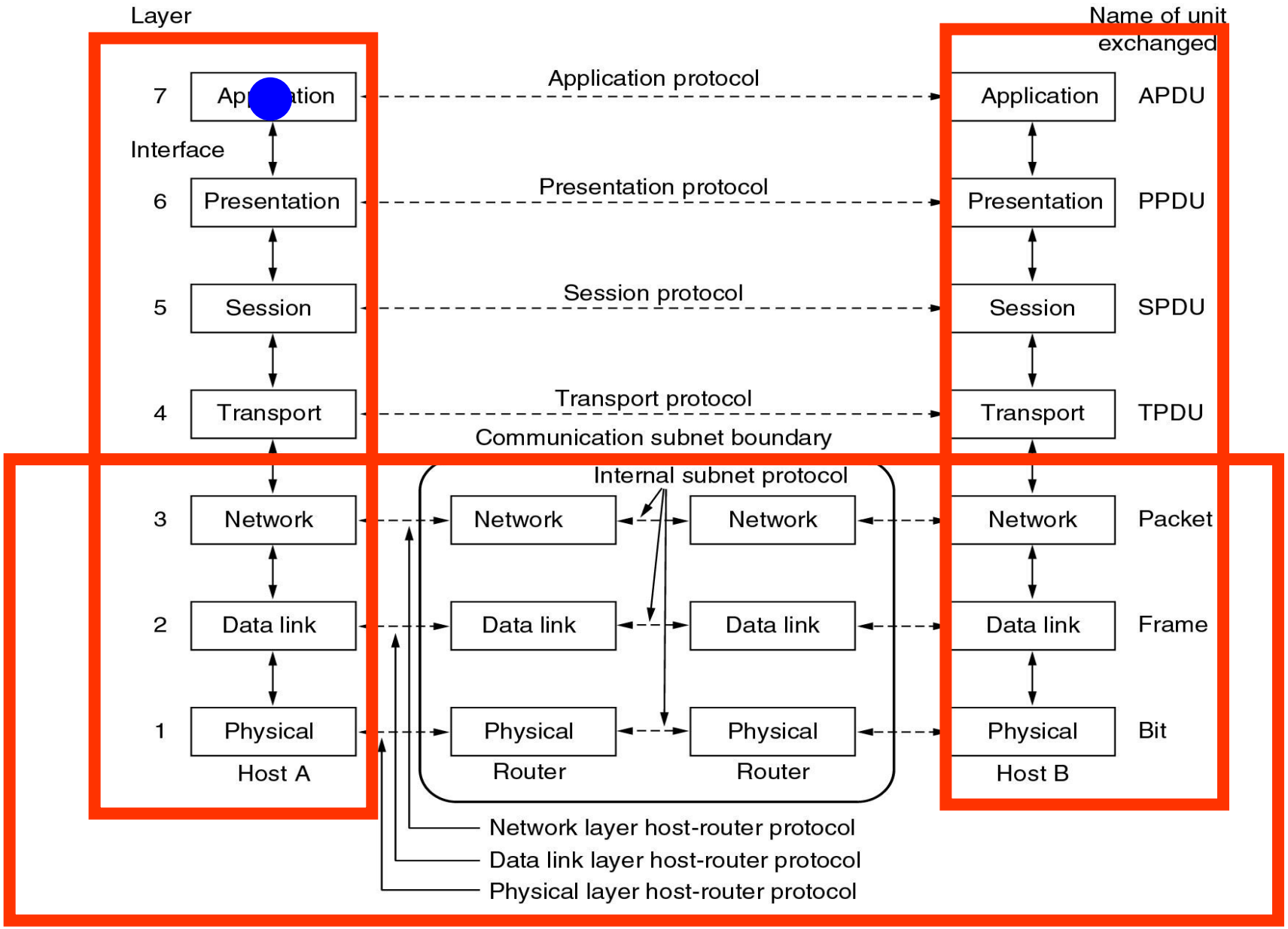
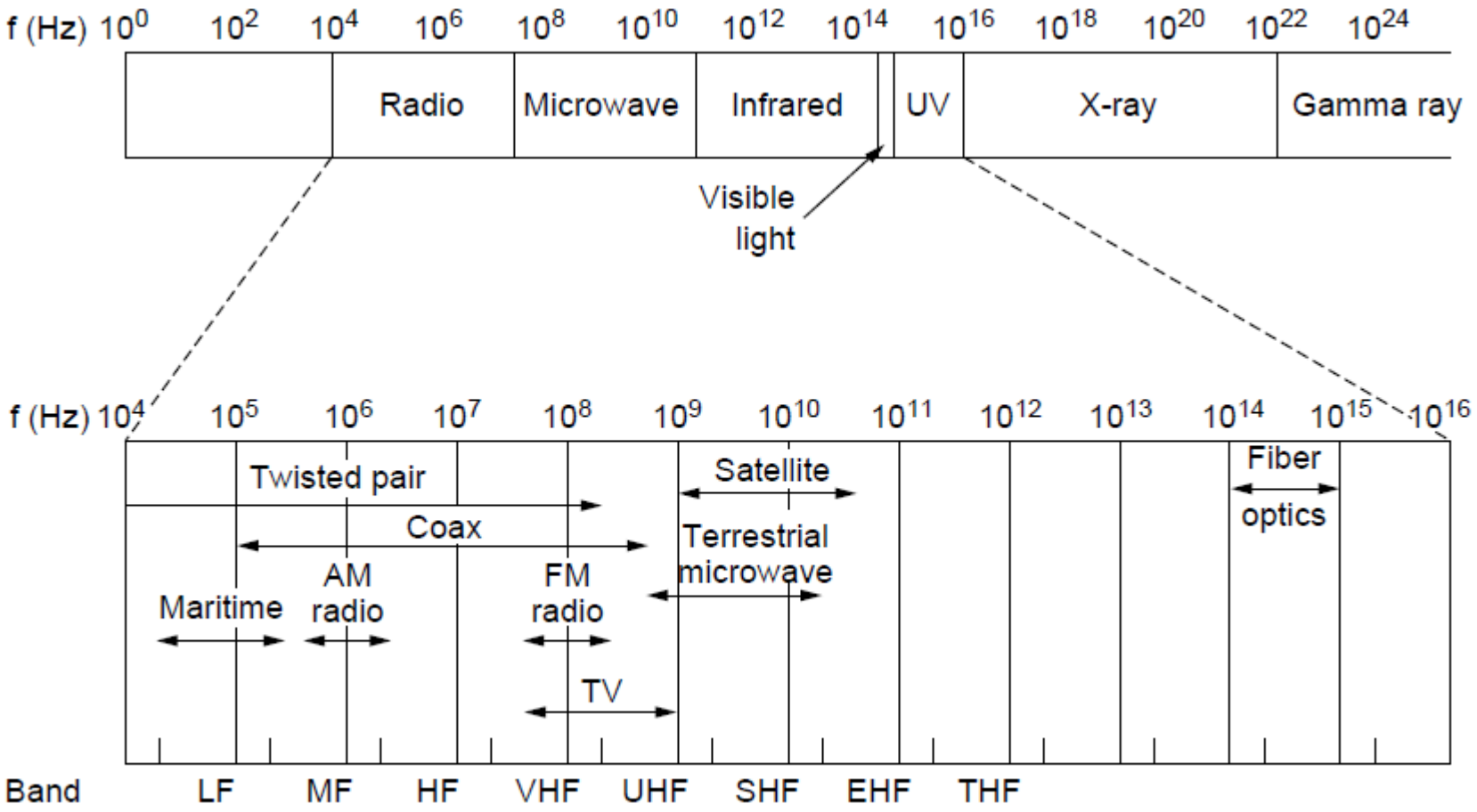
The OSI Reference Model



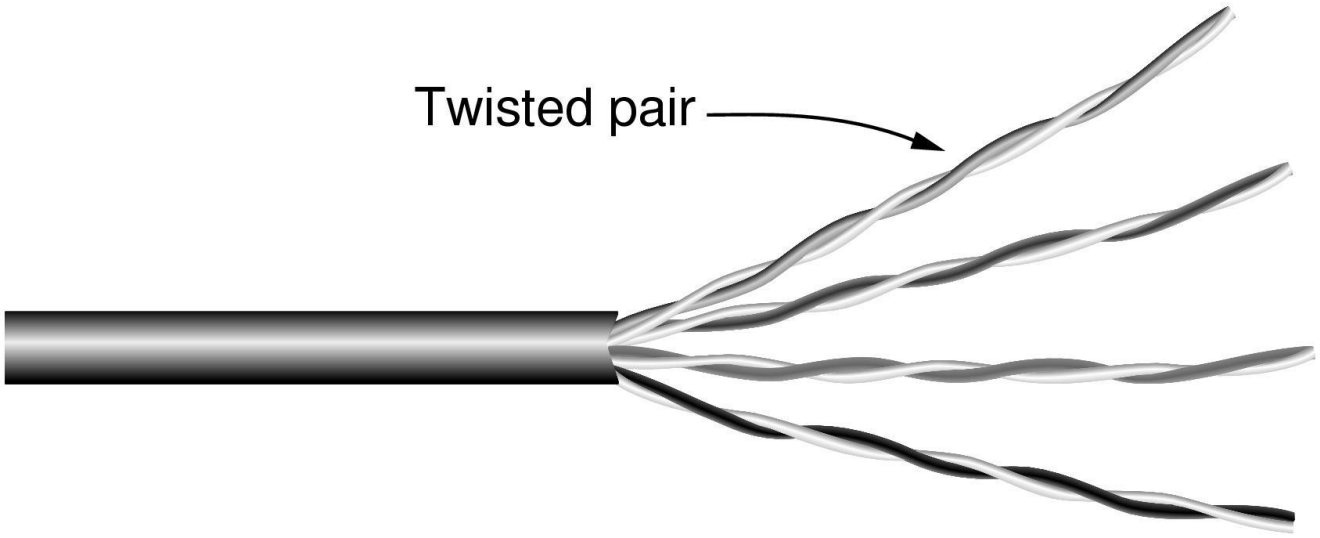
The Physical Layer

- Transmission media
  - The electromagnetic spectrum
  - Twisted pair
  - Coaxial cable
  - Power Lines
  - Fibre Optic Cable
  - Radio
- Transmission methods

The Electromagnetic Spectrum

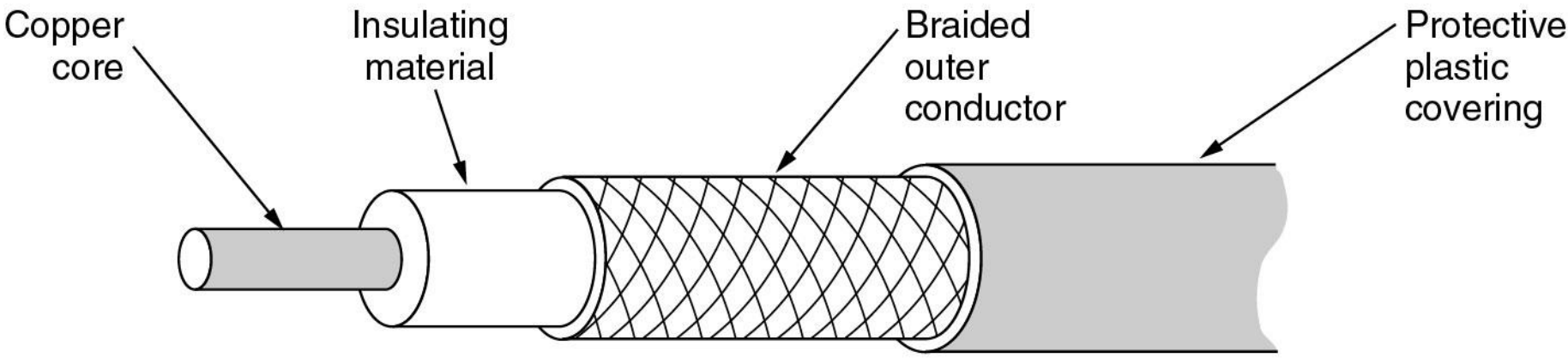


Twisted pair



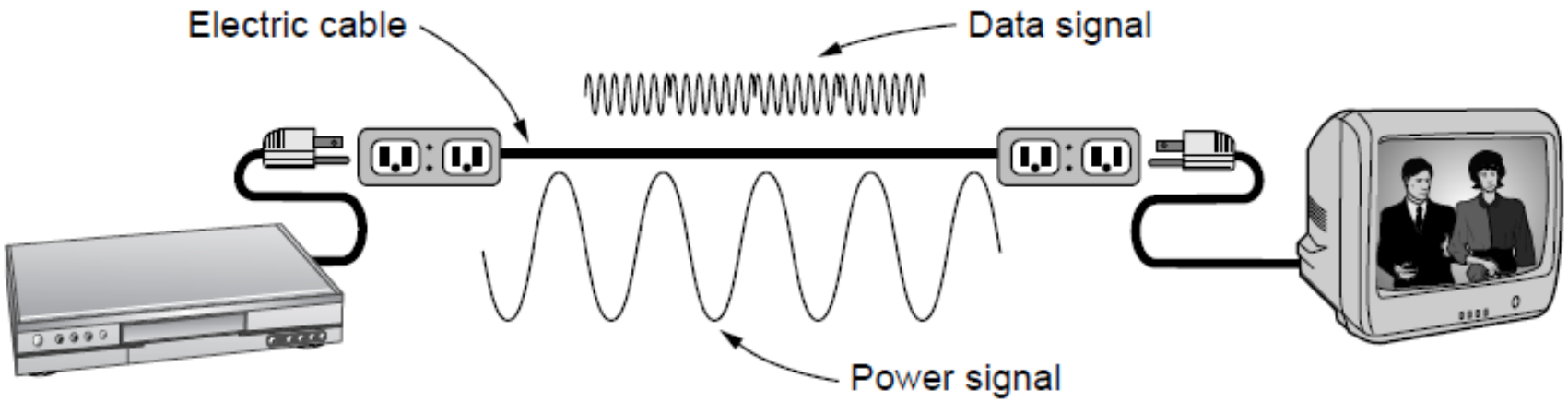
- Twisting reduces noise
  - As magnetic fields induce currents in opposite directions
- Used for printer cables, telephones
- Sometimes used for small office networks
- Can be used with additional shielding

Coaxial cable



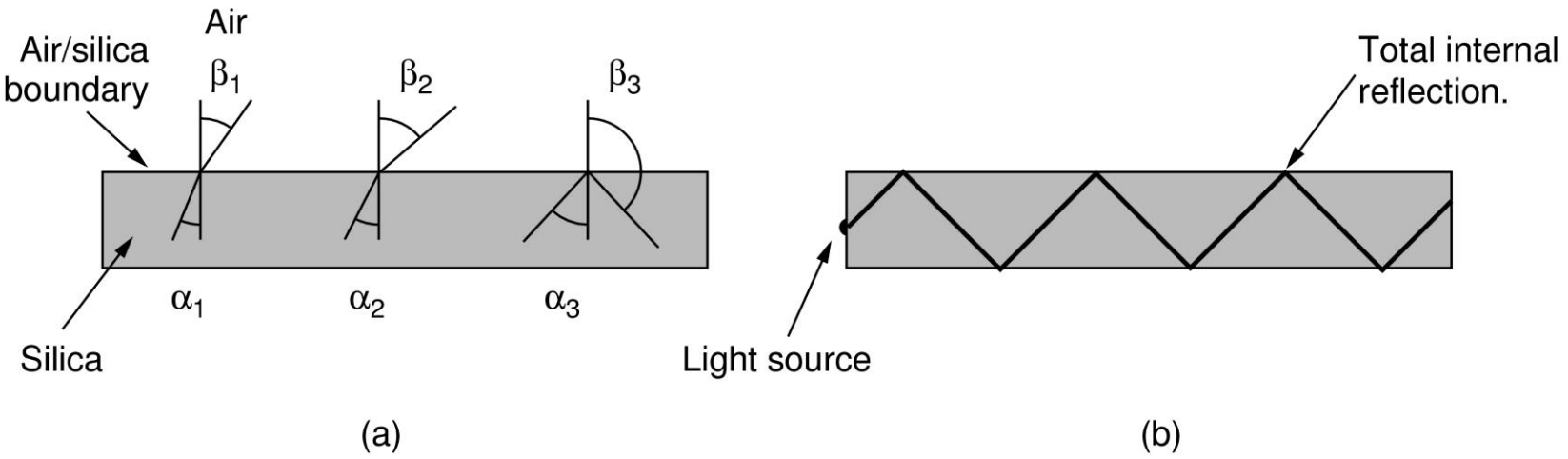
- Good shielding reduces noise
- Traditionally used for Ethernet LANs
- Capable of 1Gbps over 1km

Power Lines



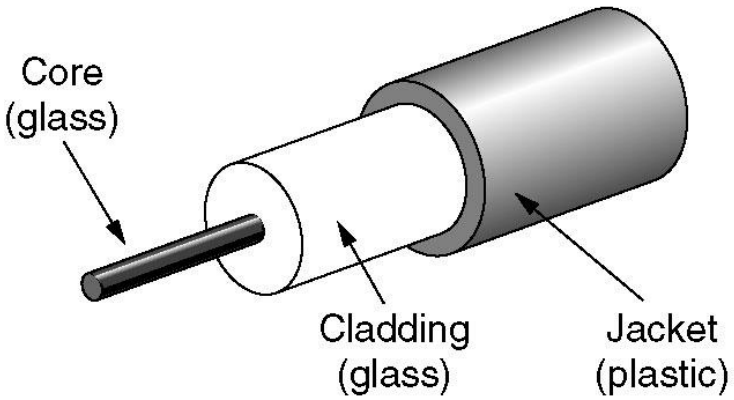
A network that uses household electrical wiring.

Fibre Optics

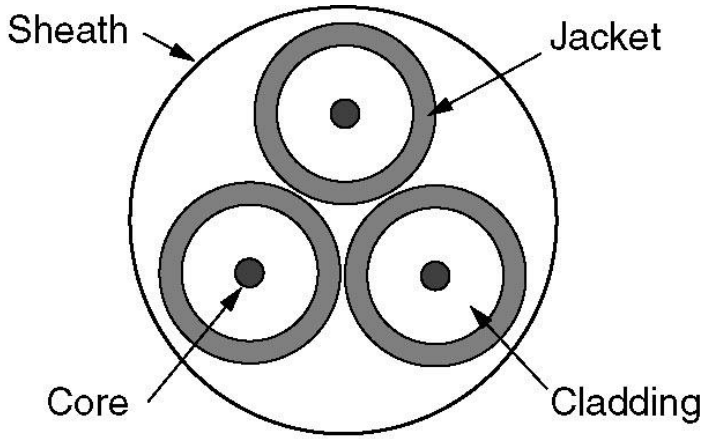


Light trapped by total internal reflection.

Fibre Optic Cable



(a)



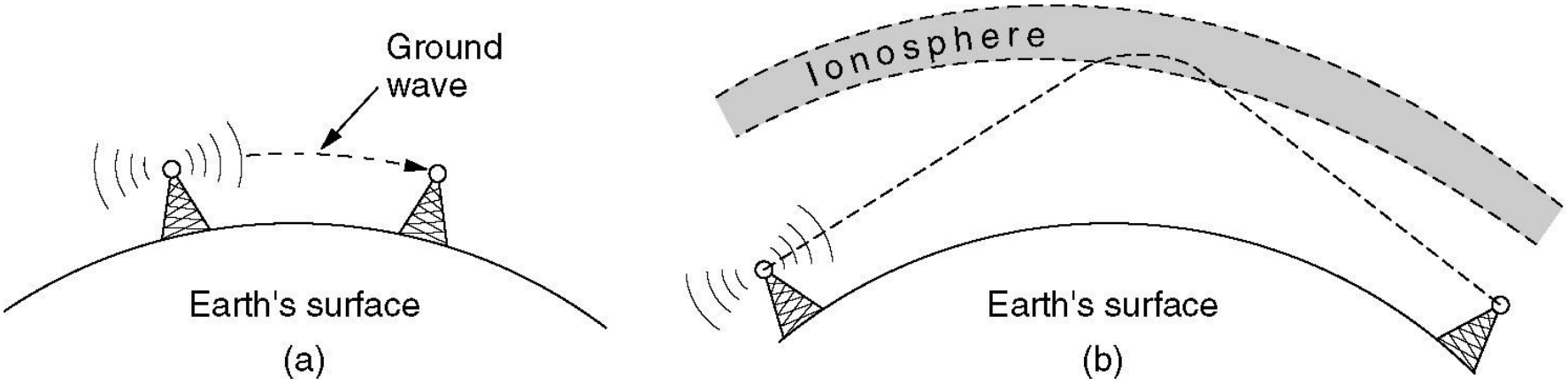
(b)

(a) Side view of a single fibre

(b) End view of a sheath with three fibres

Capable of carrying 100s of Gbps over 100s of kilometers

Radio Transmission

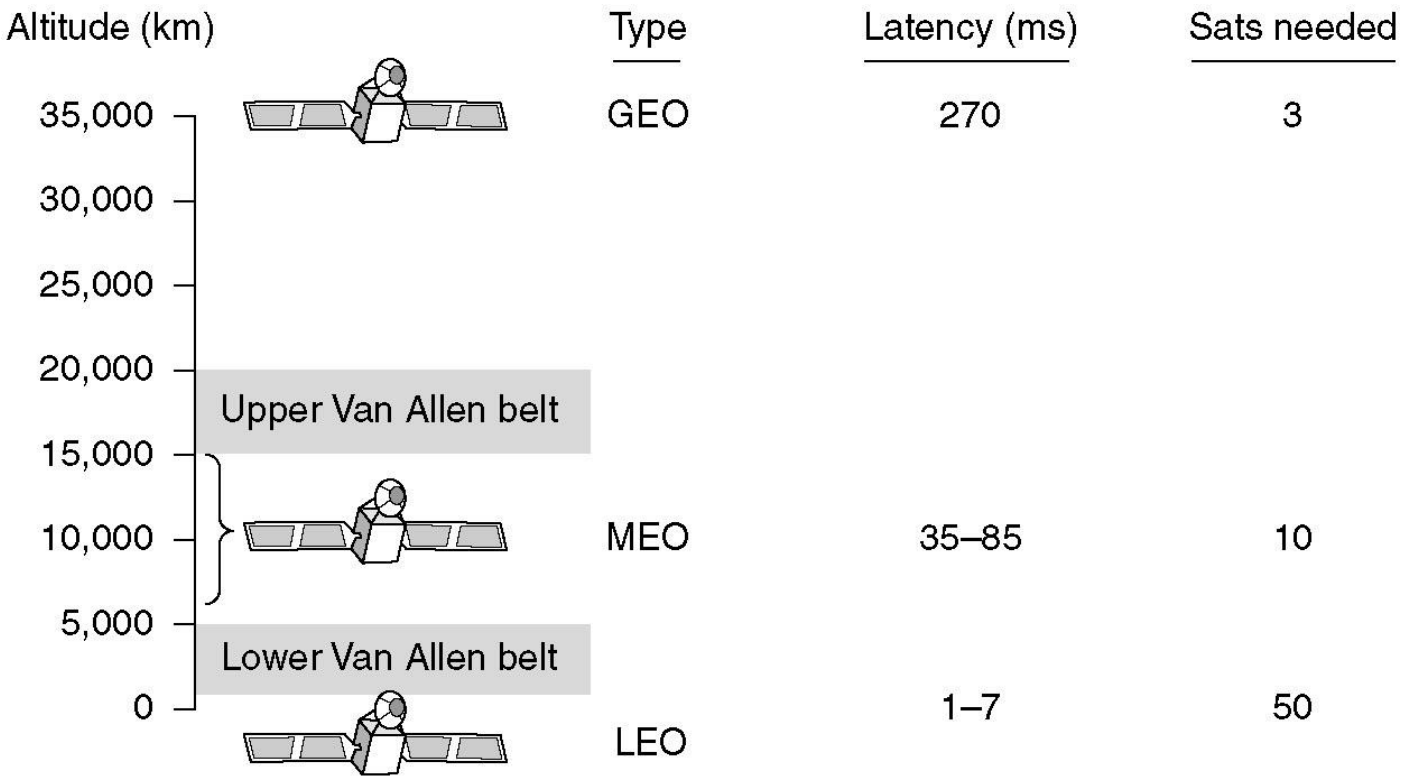


(a) In the VLF, LF, and MF bands, radio waves follow the curvature of the earth

(b) In the HF (short wave) band, they bounce off the ionosphere

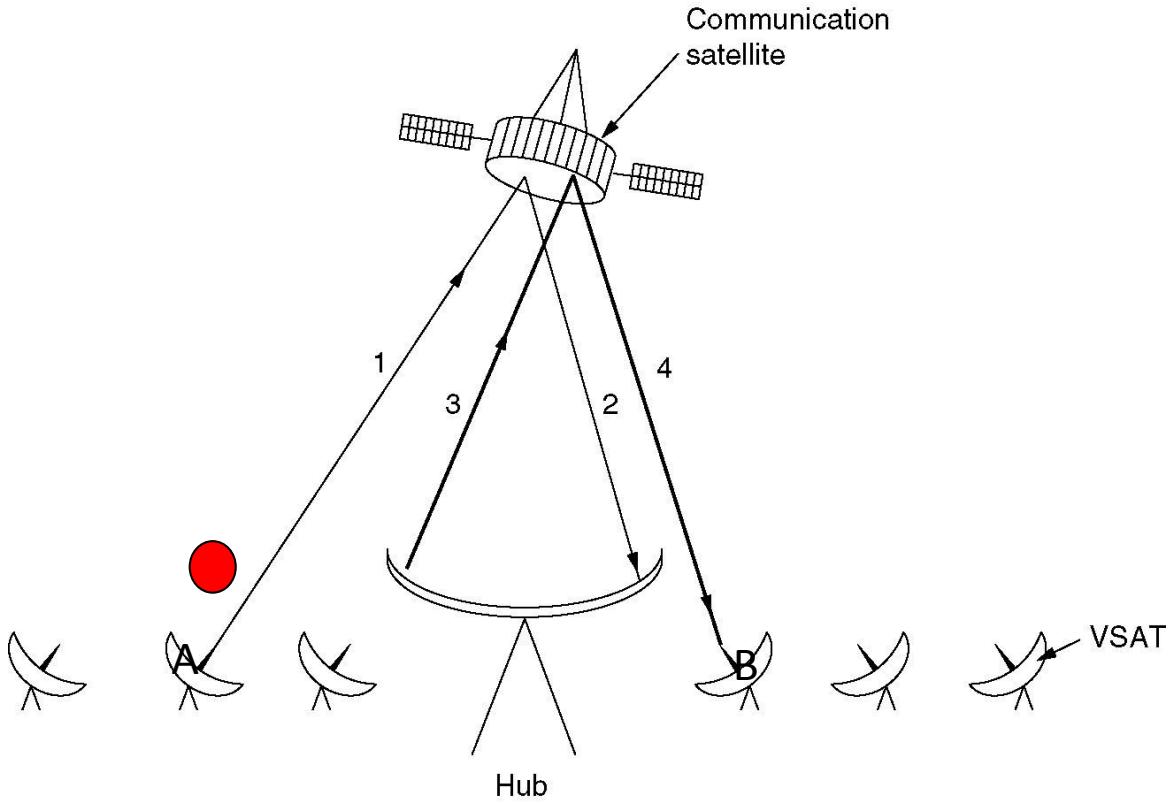
- Radio enthusiasts use this phenomenon to communicate over great distances.
- http://en.wikipedia.org/wiki/Shortwave_radio

Communication Satellites



Communication satellites and some of their properties, including altitude above the earth, round-trip delay time and number of satellites needed for global coverage

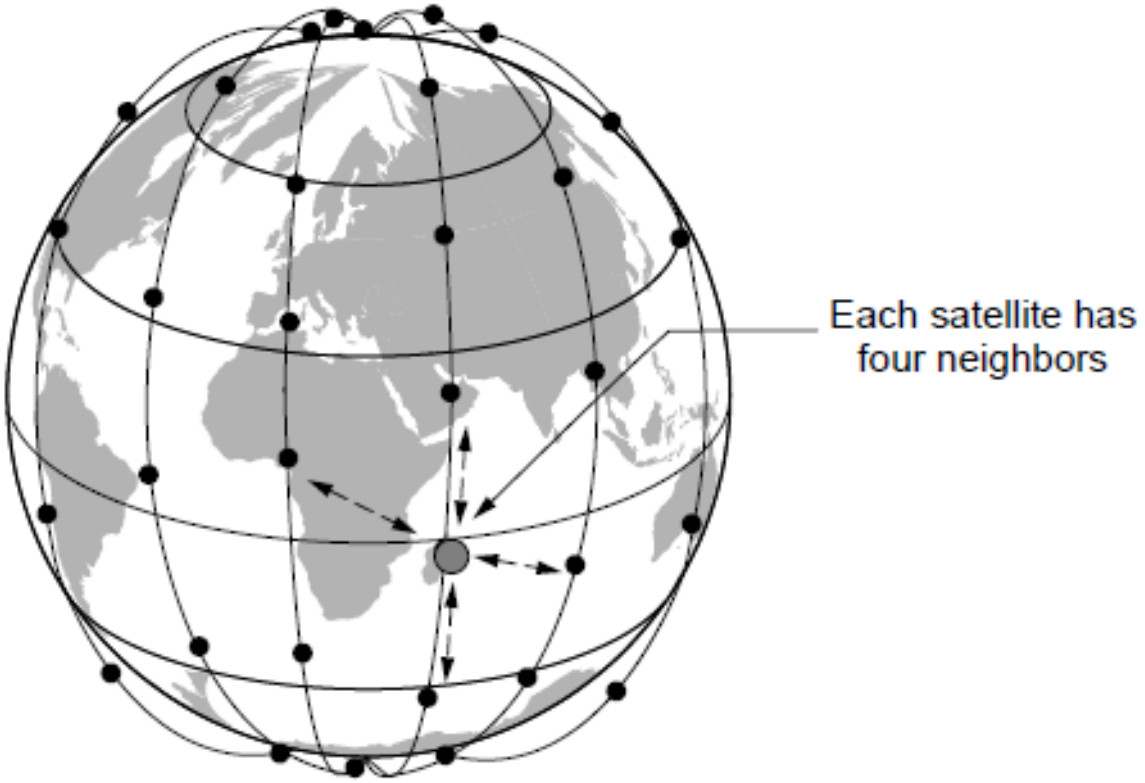
Geostationary satellites



Geostationary satellite at high altitude requires high power transmitters

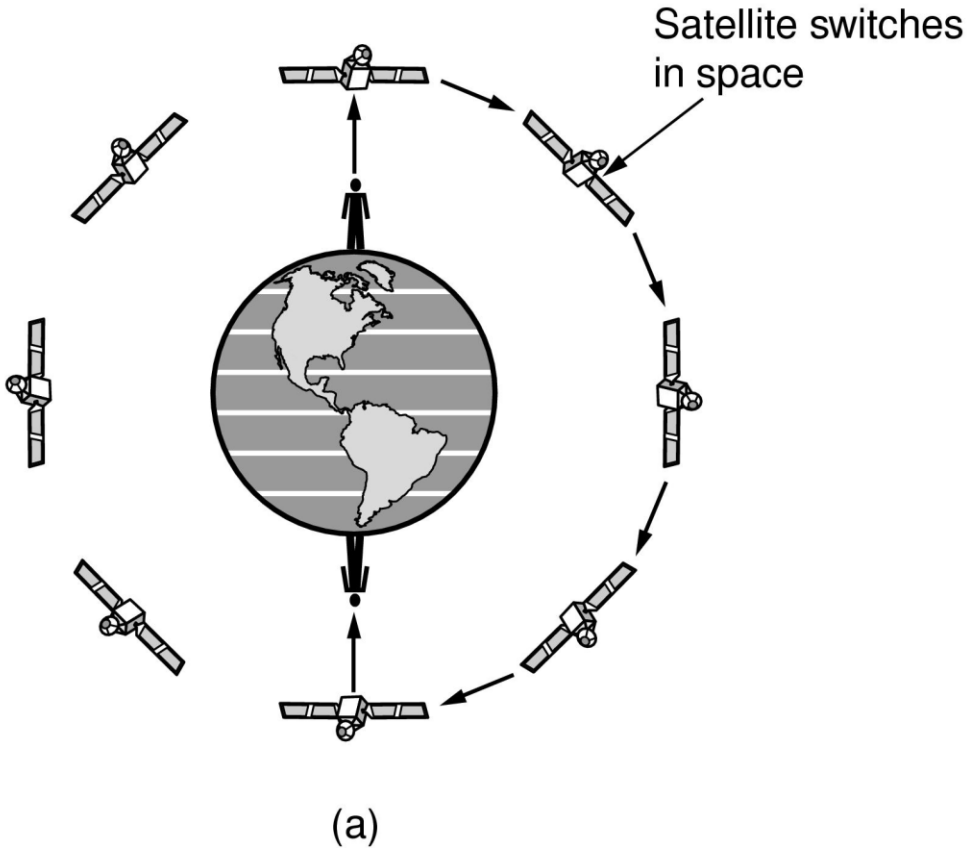
- Require few satellites for global coverage
- Good for broadcast networks such as TV
- Transmission between terminals requires double-hop through hub (if router not in satellite)

Low-Earth Orbit Satellites



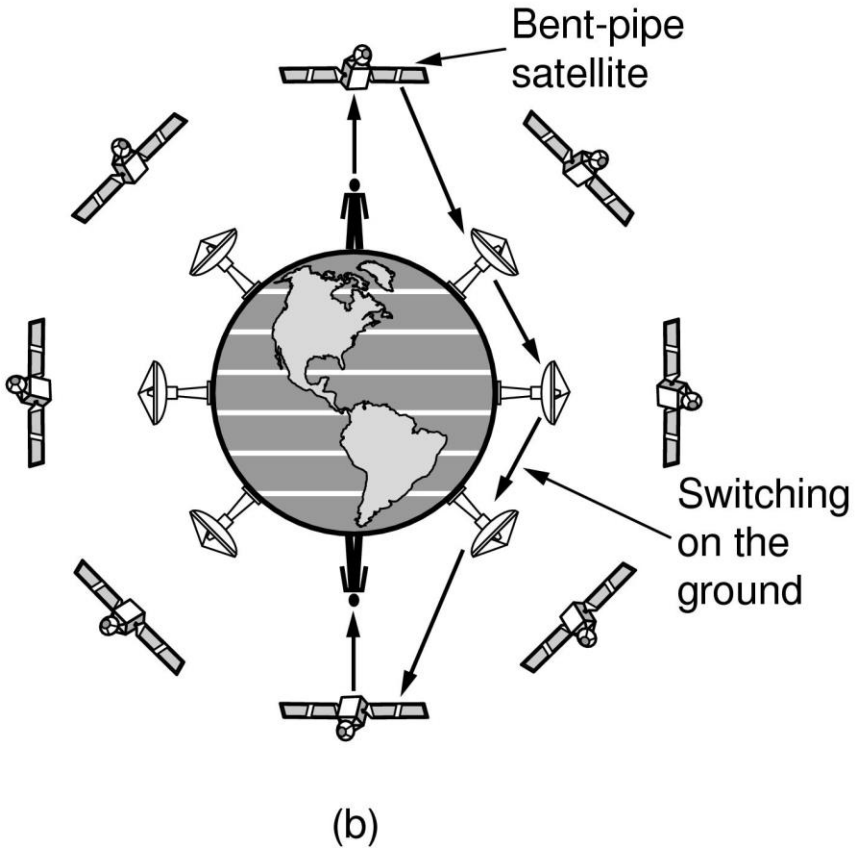
The Iridium satellites form six necklaces around the earth.

Low-Earth Orbit Satellites



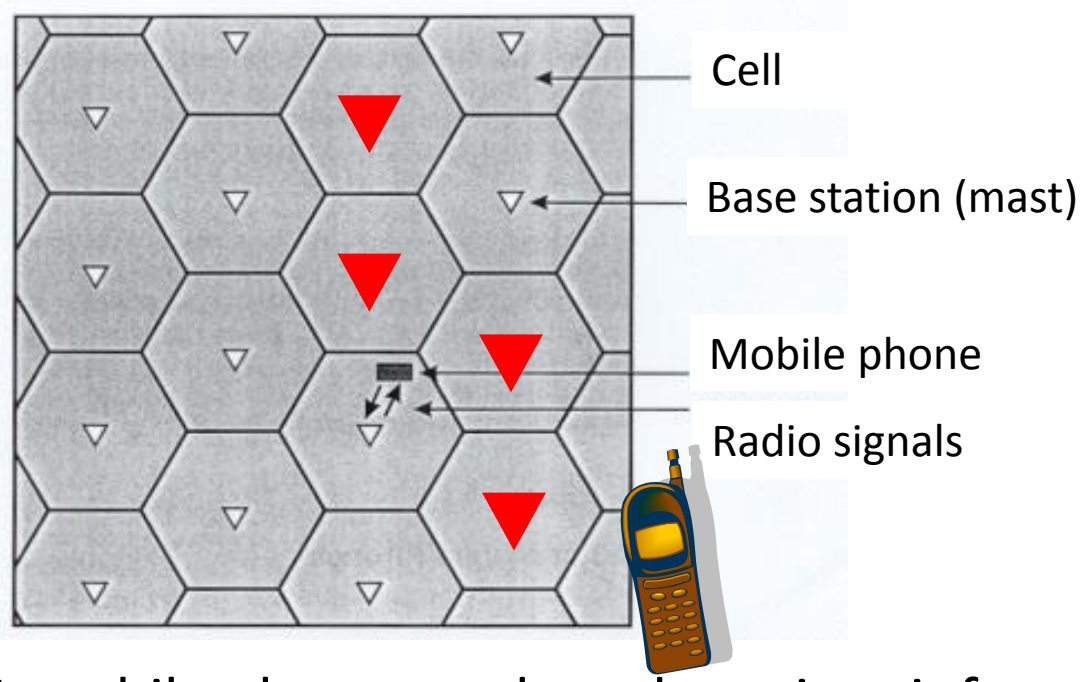
Relaying in space.

Low-Earth Orbit Satellites



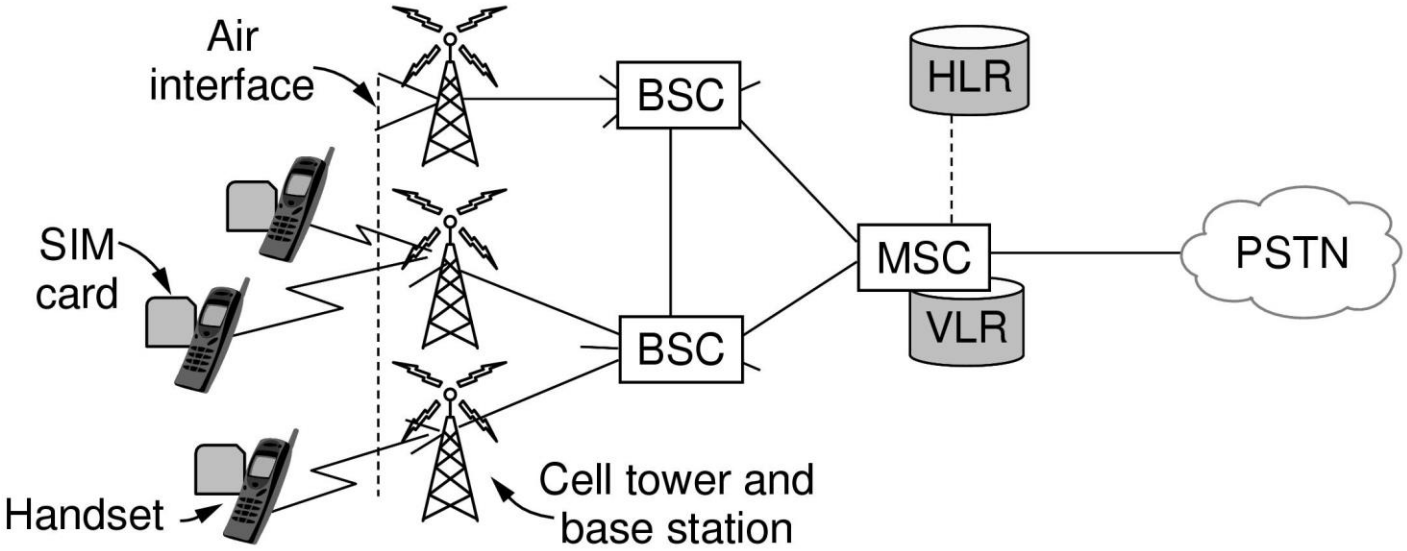
Relaying on the ground

Mobile phone networks



- A mobile phone sends and receives information by radio communication. Radio frequency signals are transmitted from the phone to the nearest base station
- If a person with a mobile phone moves out of one cell and into another, the controlling network hands over communications to the adjacent base station

GSM—The Global System for Mobile Communications



GSM mobile network architecture.

http://www.mastdata.com/

Mobile Telephone System

1G (1981) Mobiles with Analog Voice

2G (1992) Mobiles with Digital Voice

3G (2001) Mobiles with Digital Voice and Data

4G (2011) Mobiles with Digital Voice and lots of Data

5G (?) ? http://en.wikipedia.org/wiki/5G

- 1980s advert:
  - https://www.youtube.com/watch?v=ZJoEPWVJqFw

The Physical Layer

- Transmission media
- Transmission methods
  - Simplex v duplex
  - Multiplexing
  - Bit encoding

Simplex/duplex

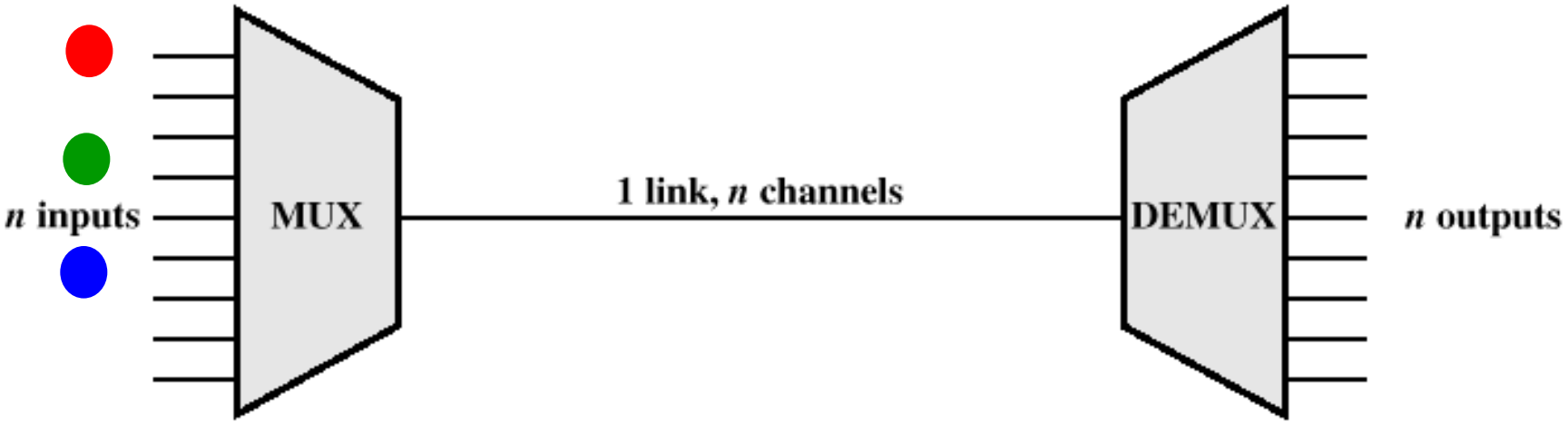
Circuits can be designed to permit data to flow in one or both directions. There are three ways to transmit:

a) Simplex - One way communication. Example: keyboard to computer

b) Half-duplex -Two way communications link, but only one system can talk at a time. Example: walkie-talkie

c) Full duplex -Transmit in both directions simultaneously. Example: telephone. Most communications systems work full-duplex (the extra cost is marginal)

Multiplexing



- Multiplexing allows the carrying of multiple signals on a single medium. This allows more efficient use of the transmission medium

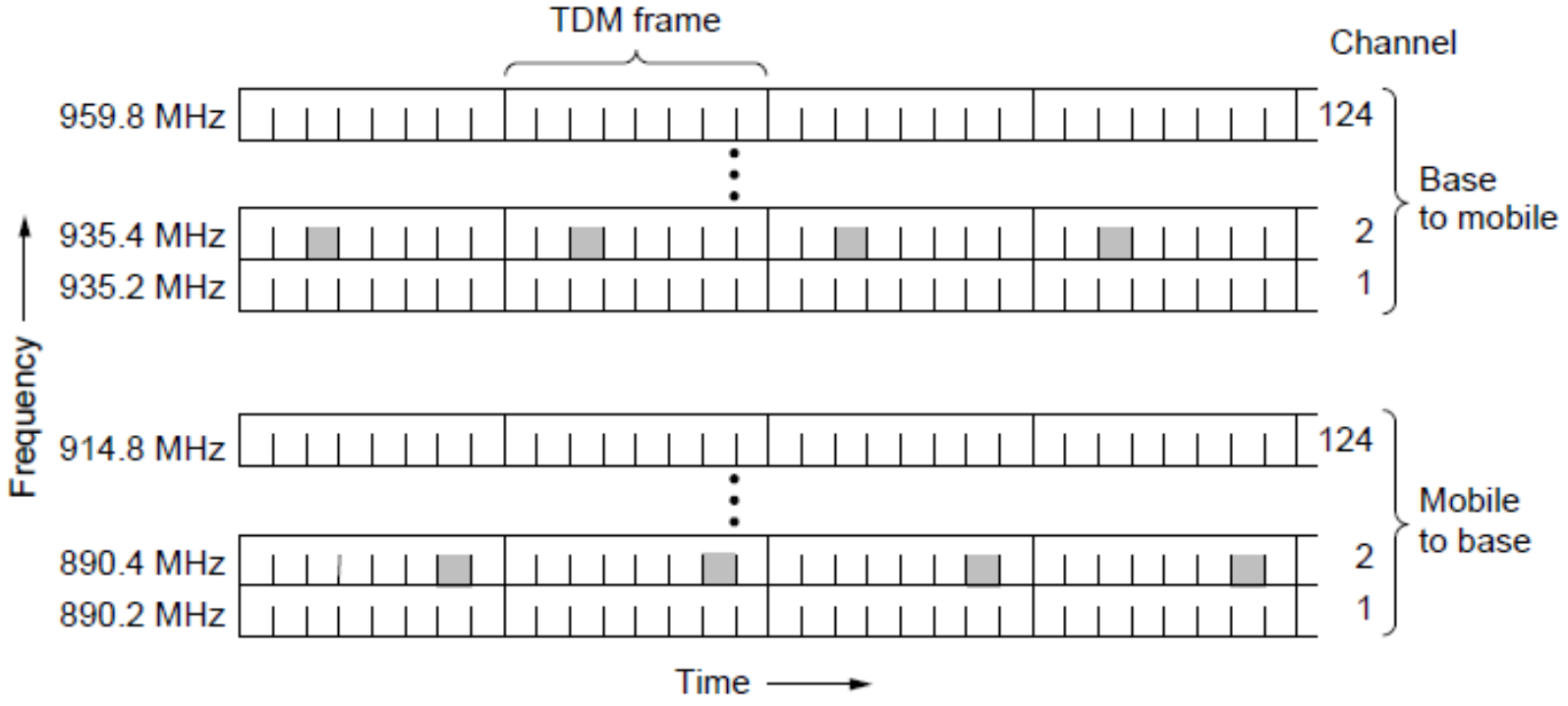
Multiplexing (2)

There are two major multiplexing techniques:

a) Frequency-division multiplexing (FDM)
   - Takes advantage of the fact that useful bandwidth of the medium exceeds the required bandwidth of a given signal
   - Different frequencies used to transmit several signals simultaneously

b) Time-division multiplexing (TDM)
   - Takes advantage of the fact that achievable bit rate of the medium exceeds the required data rate of a digital signal
   - Each signal takes up the transmission medium for a little "time slice"

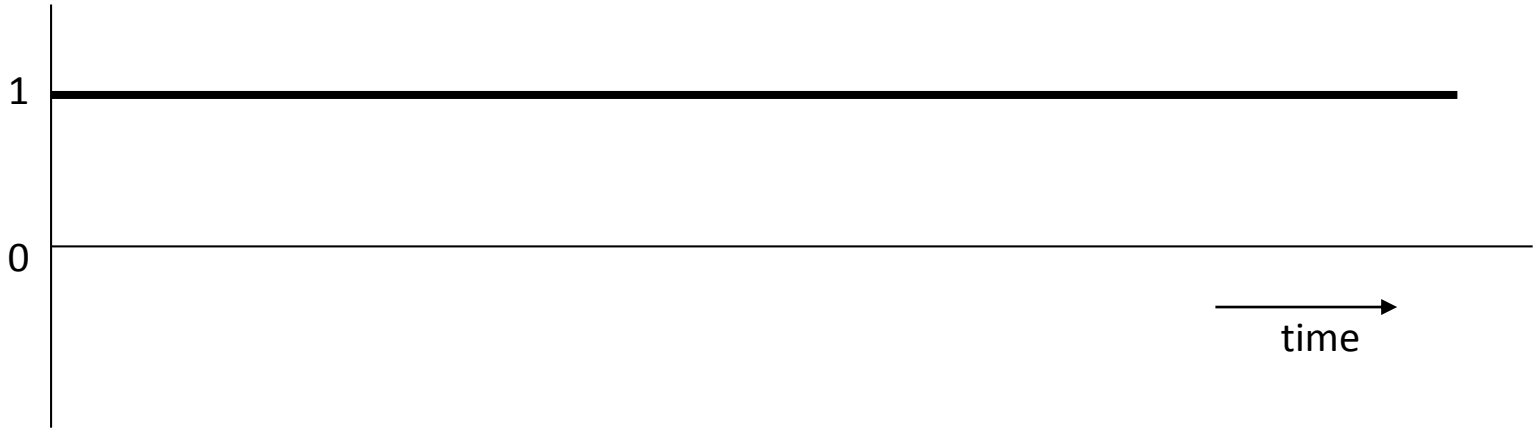
GSM—The Global System for Mobile Communications



GSM uses 124 frequency channels, each of which uses an eight-slot TDM system.

Bit encoding

Transferring a long stream of bits introduces a synchronisation problem. The clocks of the sender and receiver never run exactly at the same speed. How is the receiver going to tell where the bit boundaries are? How many ‘1’ bits are in the picture below?

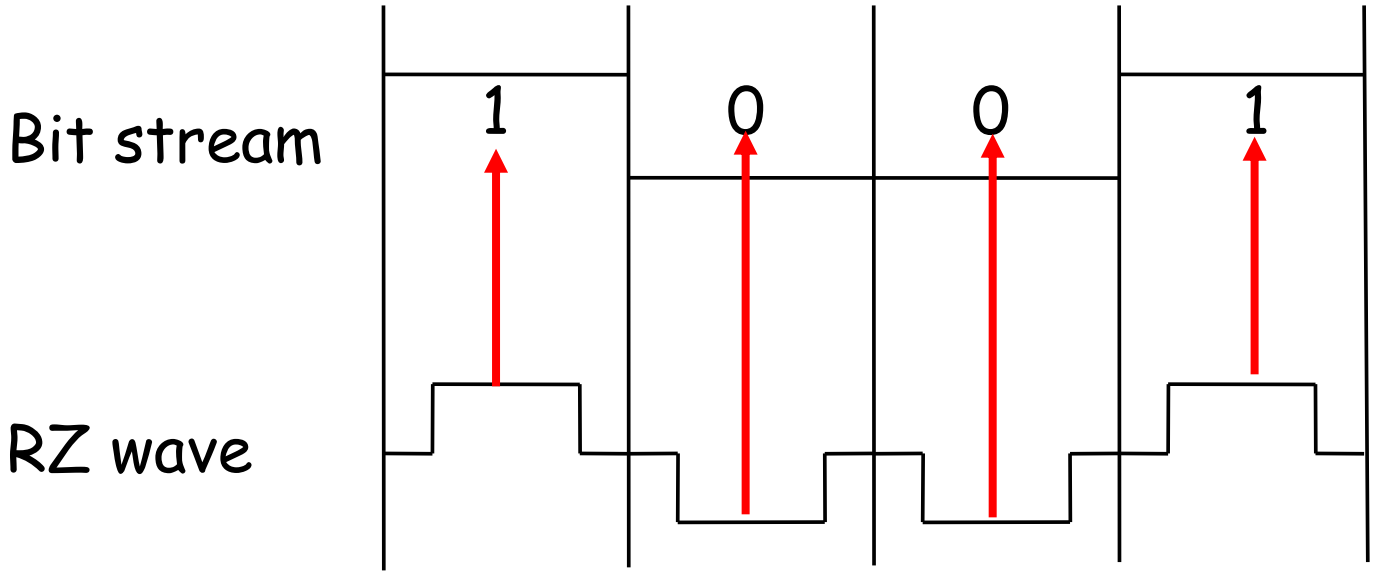


Bit encoding - synchronization

1. Use a separate clock wire. This is only feasible over very short distances
2. Ensure that the clock signal is embedded into the bit stream. Data is encoded in such a way that there is always a signal transition present for every bit of data (RZ/Manchester)
3. Use the bit stream to synchronise the receiver clock occasionally. This requires the guaranteed occasional presence of signal transitions (NRZI)

Bit encoding - RZ

return-to-zero (RZ)

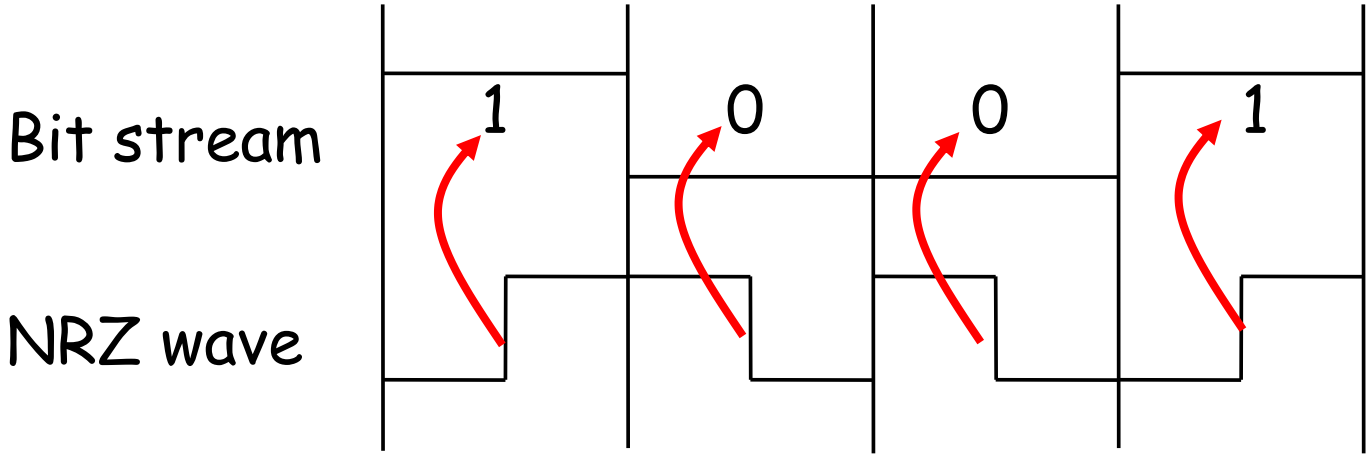


Positive pulse is logical 1

Negative pulse is logical 0

Key point is that there are three voltage levels

Bit encoding - Manchester



Positive edge in the middle of the bit is logical 1

Negative edge in the middle of the bit is logical 0

There are two voltage levels

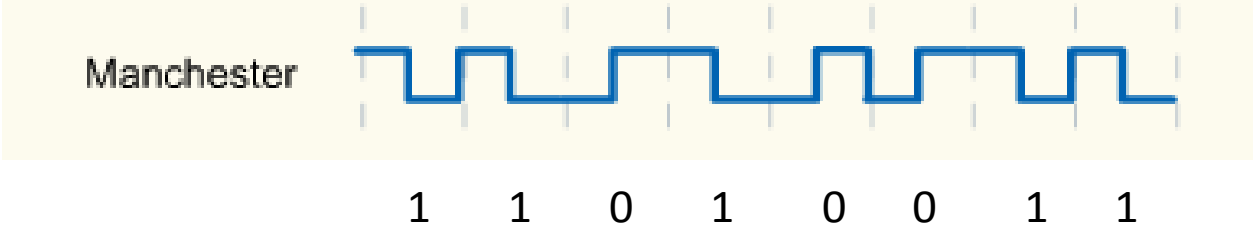
Sometimes shown inverted by text books but key point is that it is the direction of change that indicates polarity (0/1)

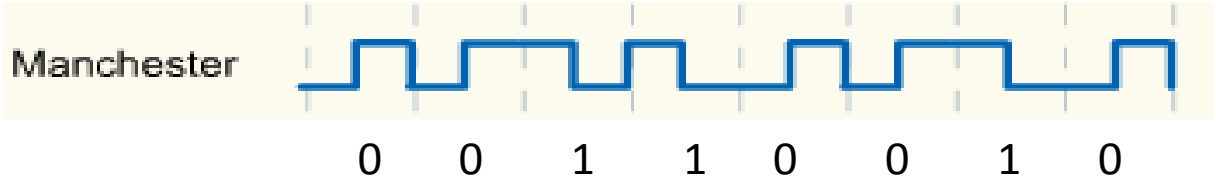
Manchester encoding examples

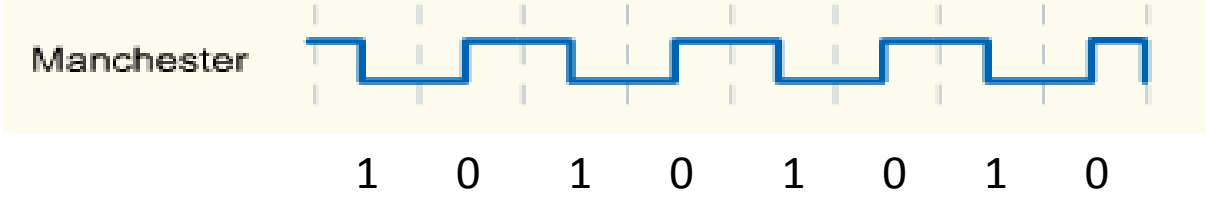
In the following examples:

Positive edge in the middle of the bit is logical 0

Negative edge in the middle of the bit is logical 1





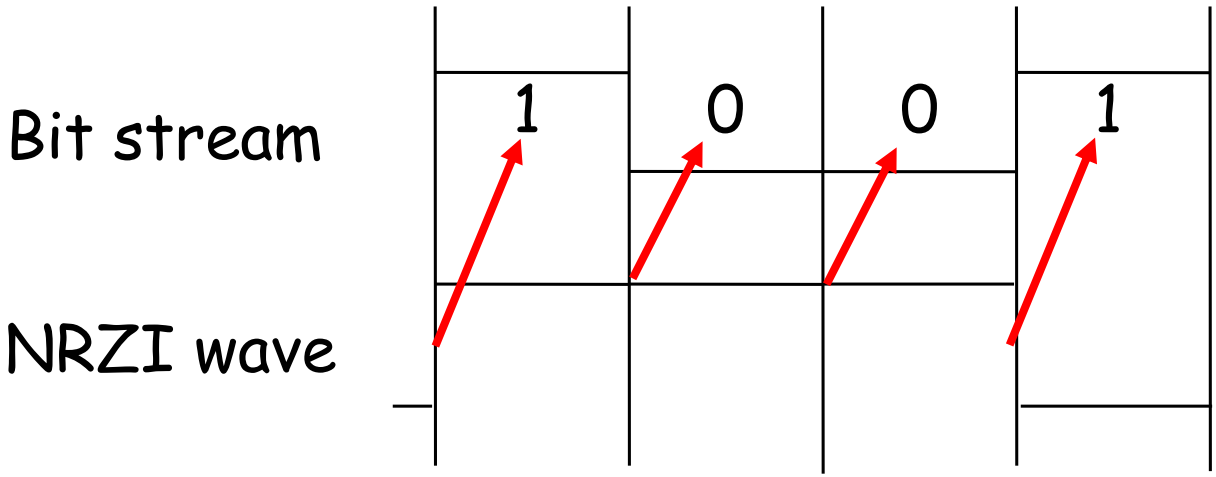


Bit encoding - NRZI

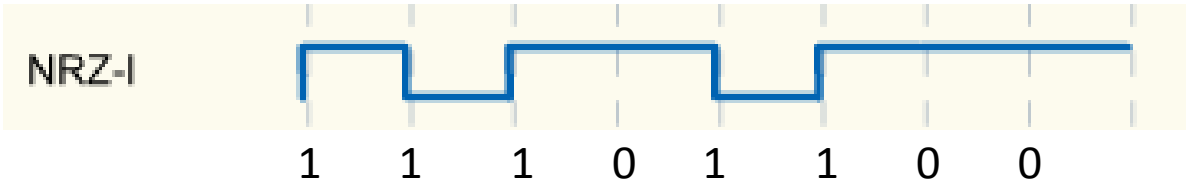
Another popular method is non-return-to-zero-inverted (NRZI). Means invert on 1.

A change at the bit boundary means logical “1”. No change means logical “0”

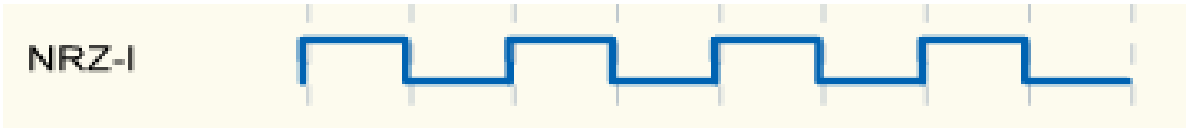
Sometimes shown inverted by text books but key point is that it is the presence or absence of change that indicates polarity (0/1)



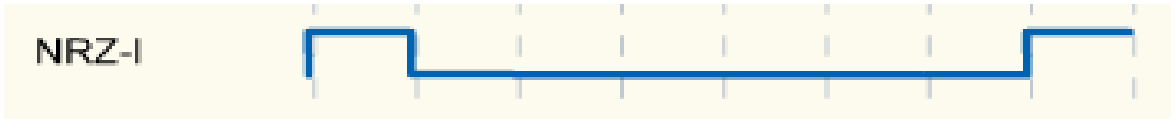
Bit encoding – NRZI Examples



1 1 1 0 1 1 0 0



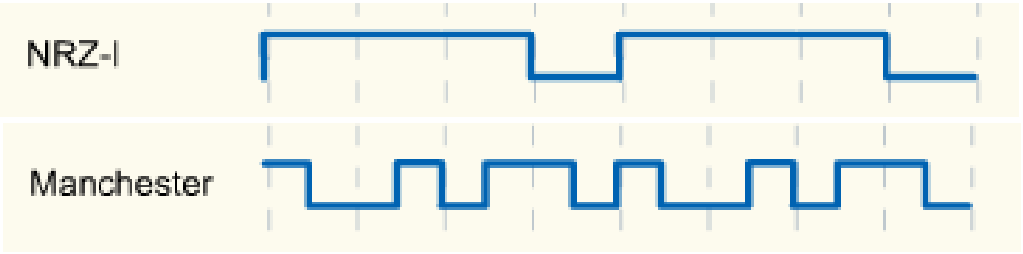
1 1 1 1 1 1 1 1



1 1 0 0 0 0 0 1

Draw the square waves for the following binary numbers using NRZI encoding and then Manchester encoding

1 0 0 1 1 0 0 1



0 0 0 1 0 0 0 1