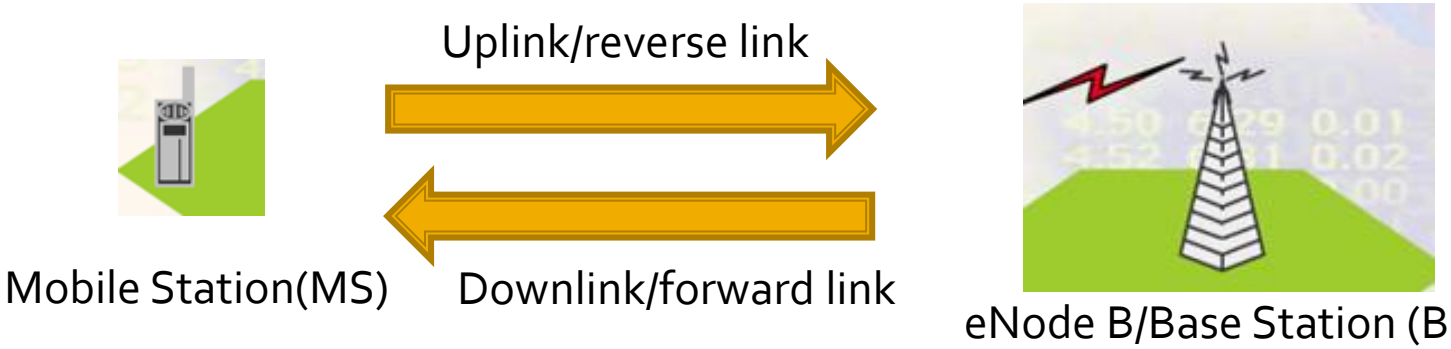
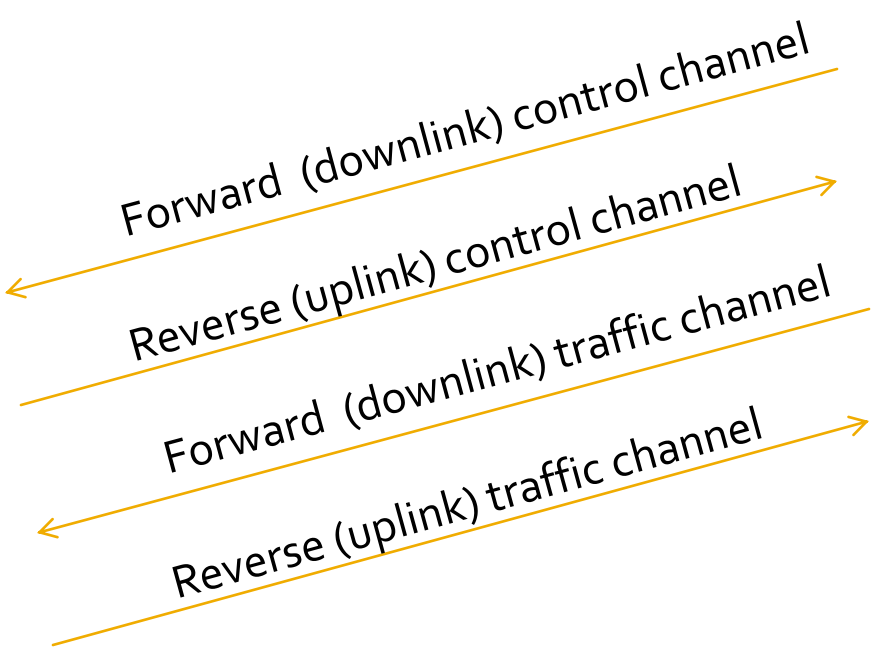
Uplink and Downlink



- Uplink/reverse– Transmission from MS to BS
- Downlink/forward – Transmission from BS to MS

Control and Traffic channels

- Control: setting up call
- Traffic: sending data

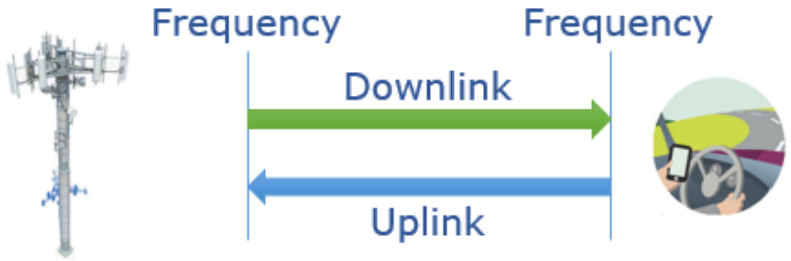


Base Station

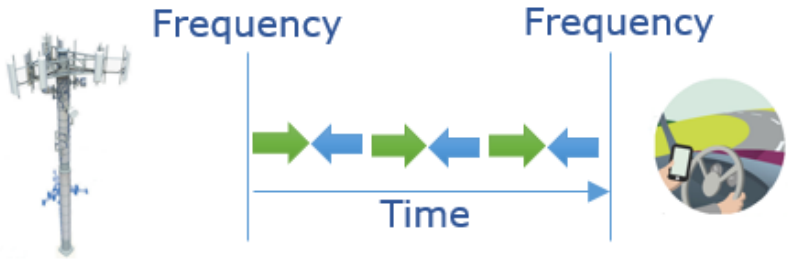
Duplexing Methods: TDD vs FDD

FDD vs TDD

FDD (Frequency Division Duplex) : Uplink and Downlink use different frequency

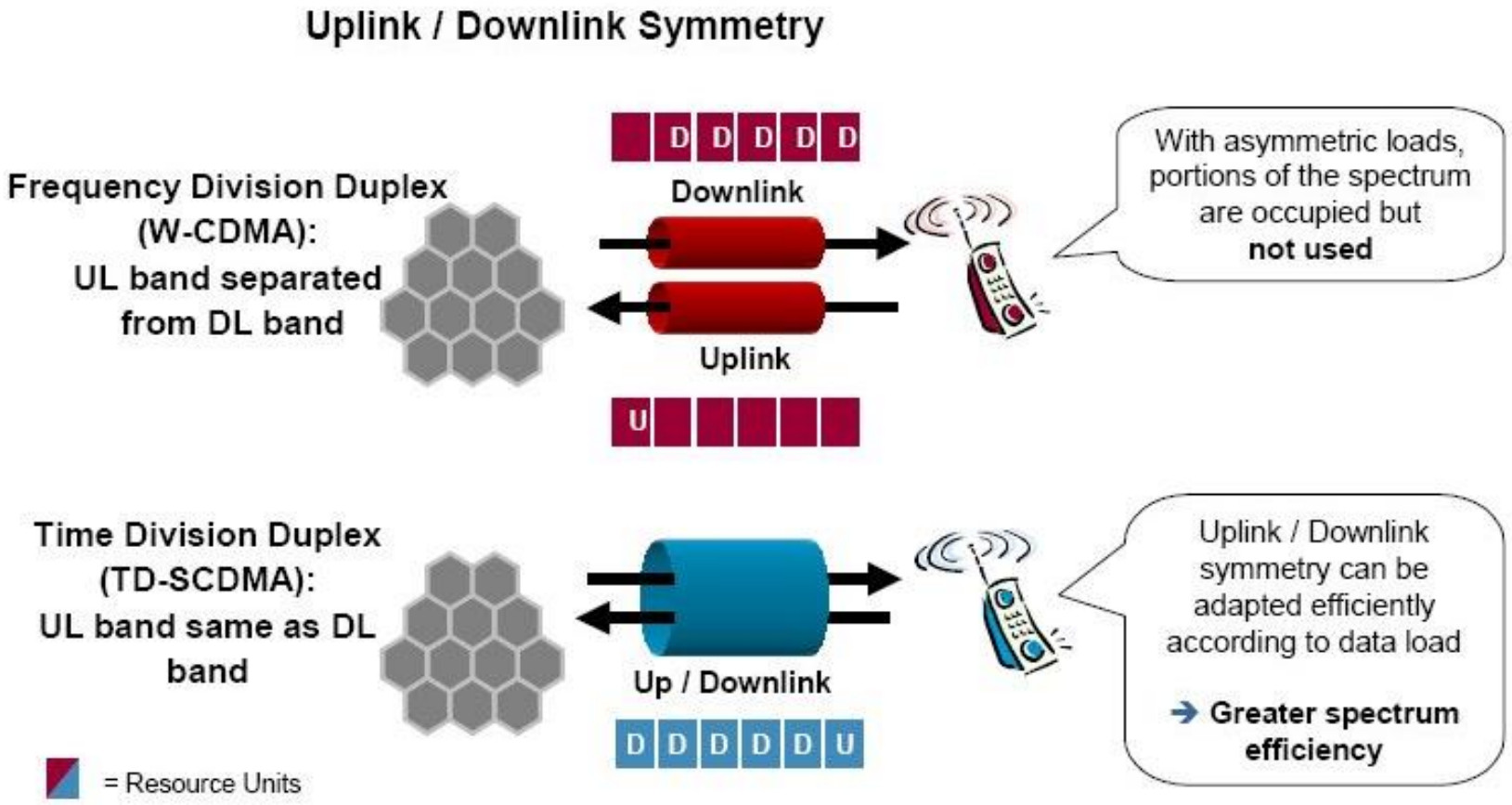


TDD (Time Division Duplex) : Uplink and Downlink use different slots in time, but both operates in the same frequency.

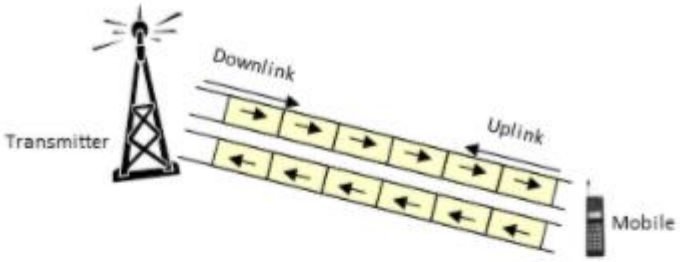


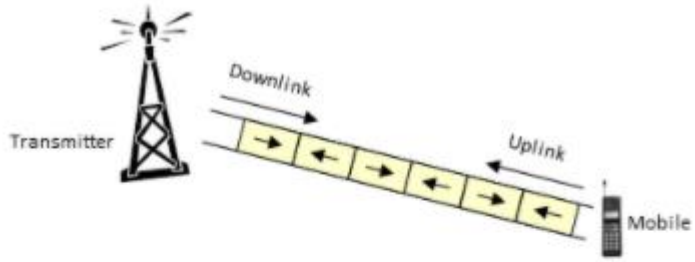
Duplexing Methods: TDD vs FDD

Communication methods between Transmitter and Receiver



Duplexing Methods: TDD vs FDD





Frequency Division Duplex (FDD)

- Simpler to implement
- Simultaneous downlink and uplink transmission
- No need for synchronisation hence simpler implementation
- Needs paired spectrum
- UL/DL ratio is fixed.

Time Division Duplex (TDD)

- Implementation is complex
- Only uplink (UL) or downlink (DL) at any time
- Need for synchronisation within the whole network
- No need for paired spectrum
- Number of UL/DL ratio is changeable

TDD vs FDD

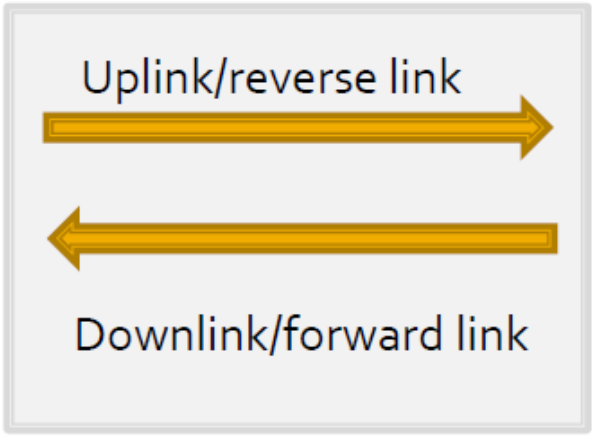
From the video answer the following questions about TDD and FDD

- Definition of Duplexing and types
- How it is implemented in LTE
- List FIVE decision factors to use FDD or TDD
- Compare FDD and TDD based on decision factors
- Which countries implement TDD?

Mobile Radio Propagation

Mobile Station(MS)

Transceiver



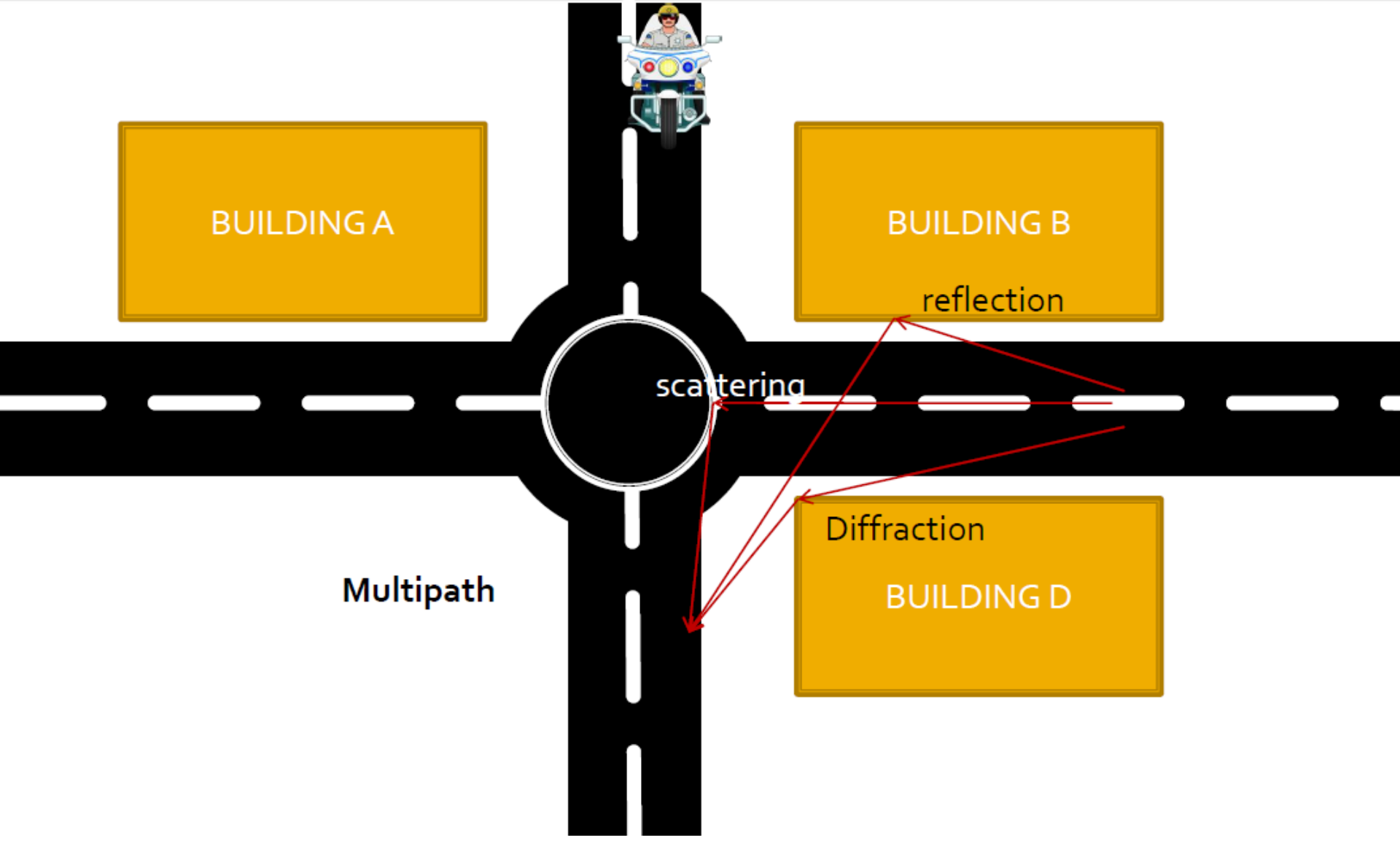
Channel – Radio Frequency

eNode B/Base Station (BS)

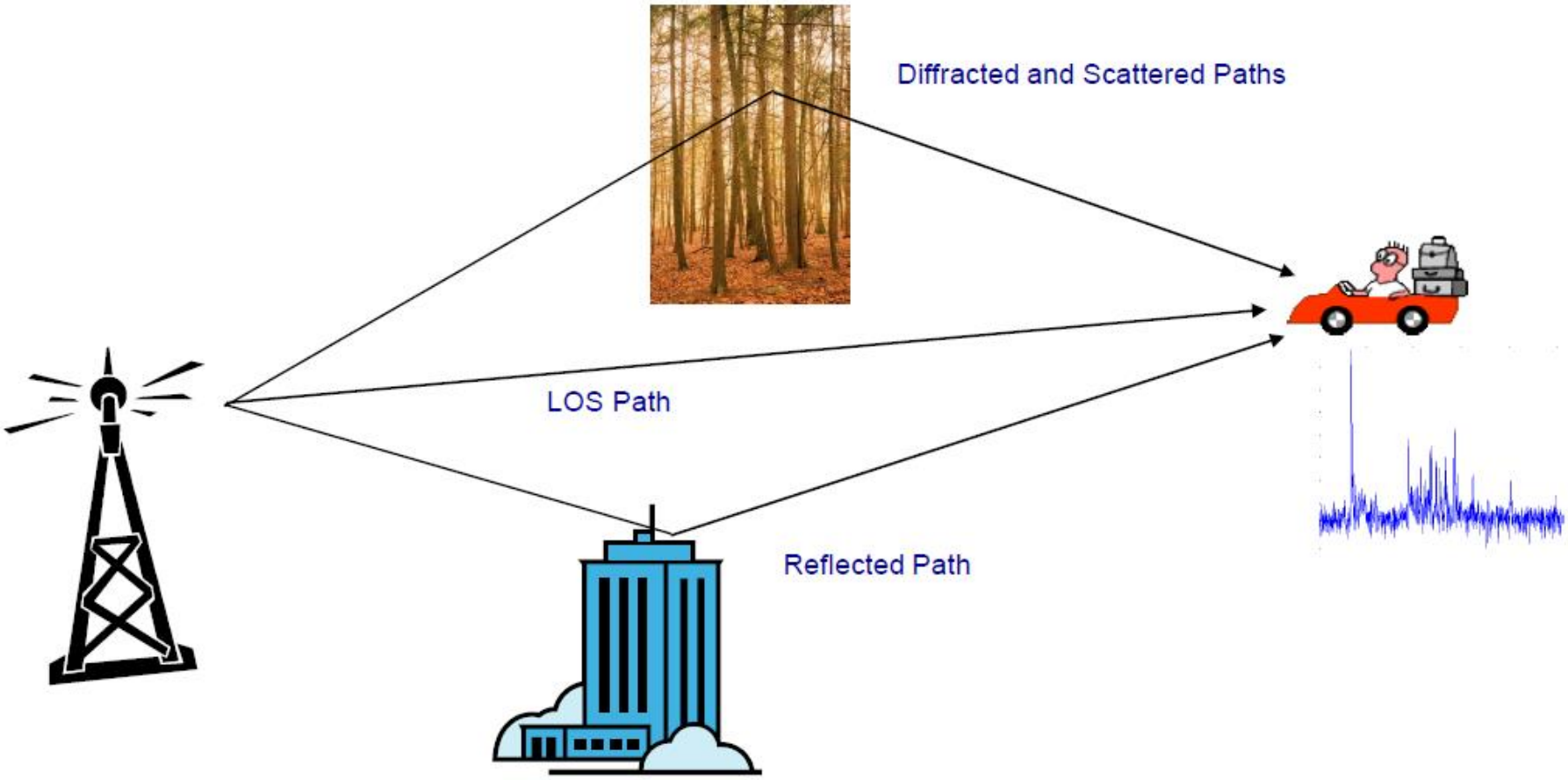
Transceiver

- Data is sent through Radio Frequency
- Important: To know Radio frequency characteristic, weakness to ensure high quality data transmission with low bit error rate (BER)
- We need to understand mobile radio propagation characteristic and how it influences the cellular performance.

Multipath Phenomena

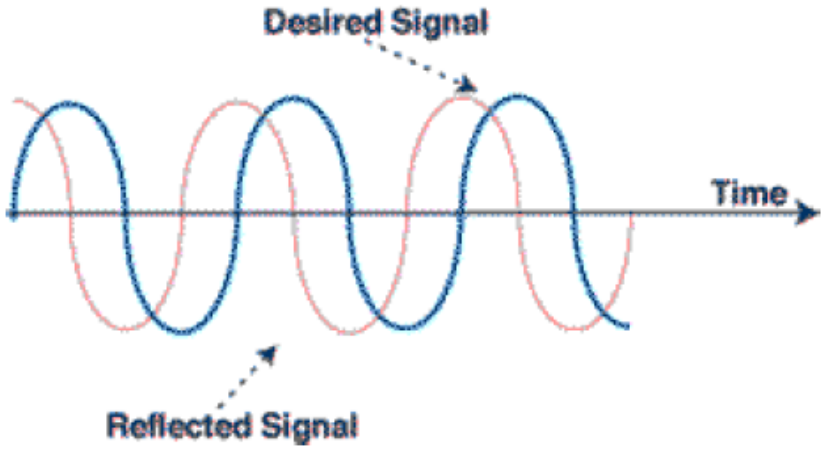


Multipath channel



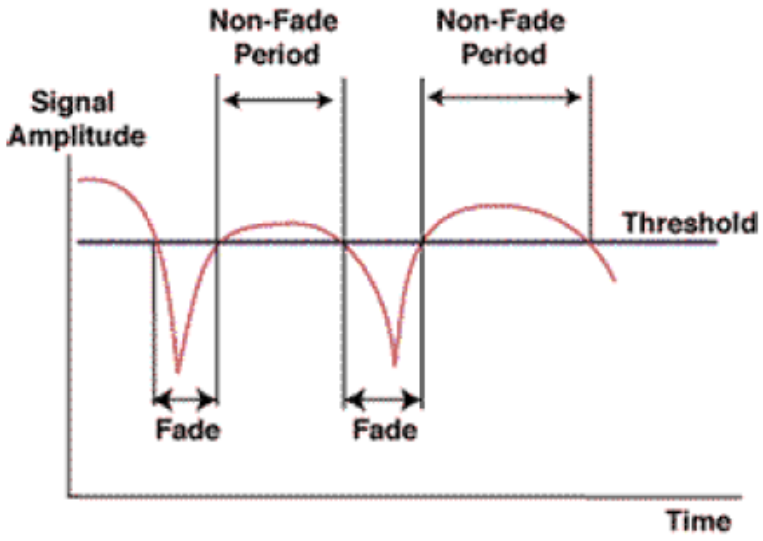
Multipath: How it Occurs

- Transmitted radio signal is reflected by physical features/structures, creating multiple signal paths between the base station and the mobile user.
- Resulting from having unwanted reflected signals.
- Often, the reflected signals do not match with the original transmitted signals.



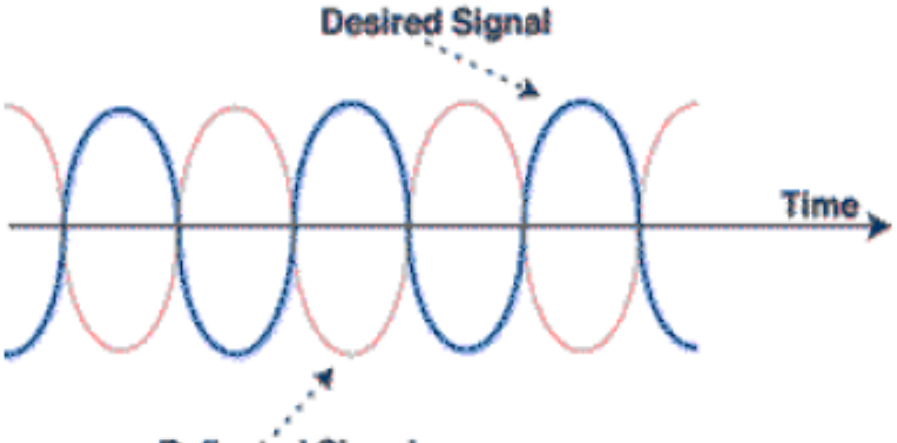
Multipath Problem: Fading

- **Fading:** the received signal strength will fluctuate downward, causing a momentary, but periodic, degradation in quality



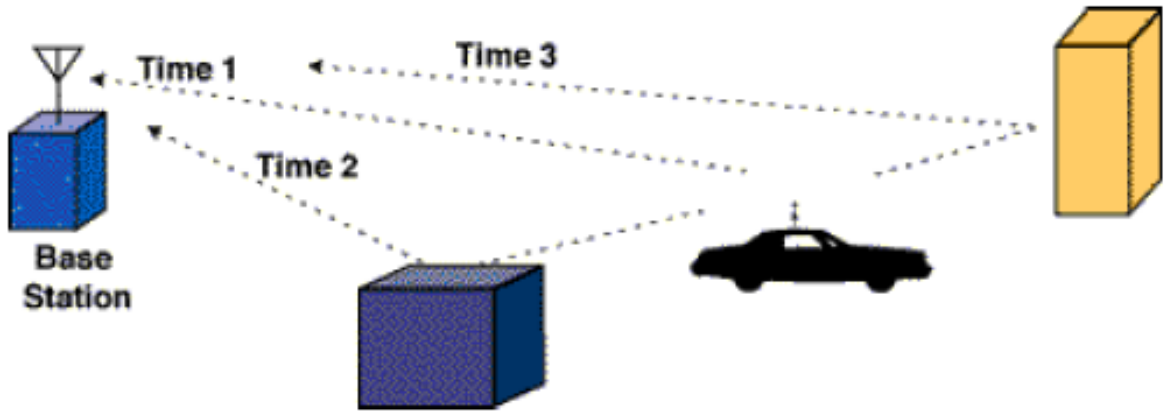
Multipath Problem: Phase Cancelation

- **Phase cancellation**: When waves of two multipath signals are rotated to exactly 180° out of phase, the signals will cancel each other.
  - The effect is of more concern when the control channel signal is canceled out, resulting in a black hole, a service area in which call set-ups will fail



Multipath Problem: Delay Spread

- **Delay spread:** multiple reflections of the same signal may arrive at the receiver at different times. This can result in intersymbol interference (or bits crashing into one another) that the receiver cannot sort out.
  - bit error rate rises and eventually causes noticeable degradation in signal quality



Antenna Concepts

- Directionality
  - Omni (360° coverage) directional
  - Directional (limited range of coverage)
- Gain
  - Measured in dBi and dBd (0 dBd = 2.14 dBi)
  - More gain means more coverage - in certain directions
- Polarization
  - Antennas are used in the vertical polarization

Directional Antenna

- Antenna that shapes and projects a beam of radio energy in a specific direction and receives radio energy only from a specific direction.
- Directional antennas are effectively omni directional antennas that use a reflecting element which directs/ focuses the RF over a specific beamwidth.
- Most popular beamwidth used is the 120° beamwidth.
- Allows sectorization for effective capacity increase.
- Directional antenna produce more gain than omni-directional antenna.
  - Omni-directional antenna radiates energy 360° while directional antenna radiates energy to a certain direction.

Omni-directional

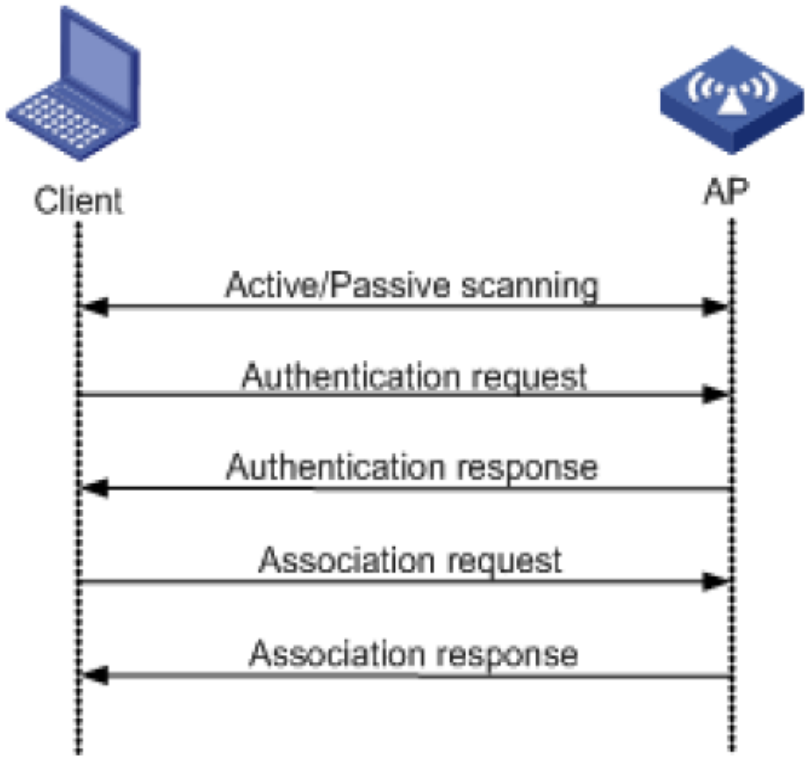
Directional

Directional Antenna (cont.)

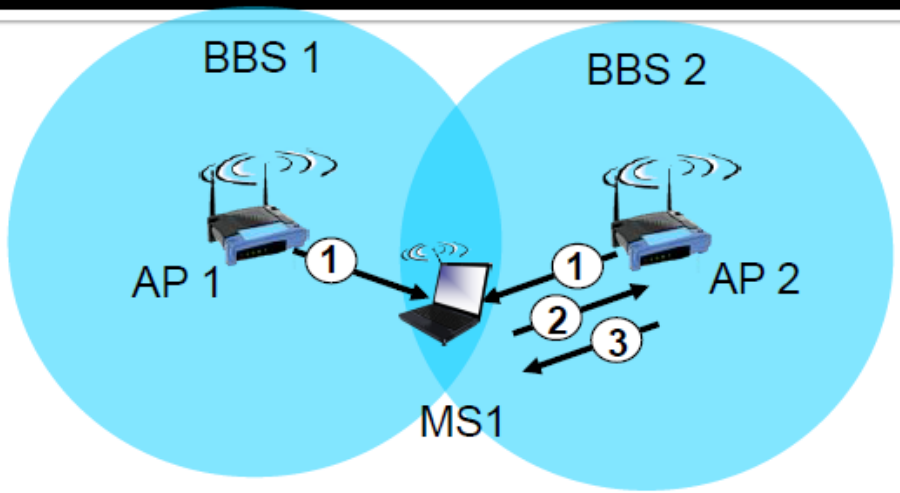
- Using directional antenna, gain is developed by inserting a **reflecting element** behind an omni-directional antenna.
- The reflector distorts and compresses the horizontal radiation pattern at the sides causing it to bulge forward and produce directional gain.
- Example: 10 dB gain antenna could be modified with a V-shaped reflector to produce 60° horizontal radiation pattern and 17 dB gain. Therefore, the directional antenna produced 7 dB more gain.

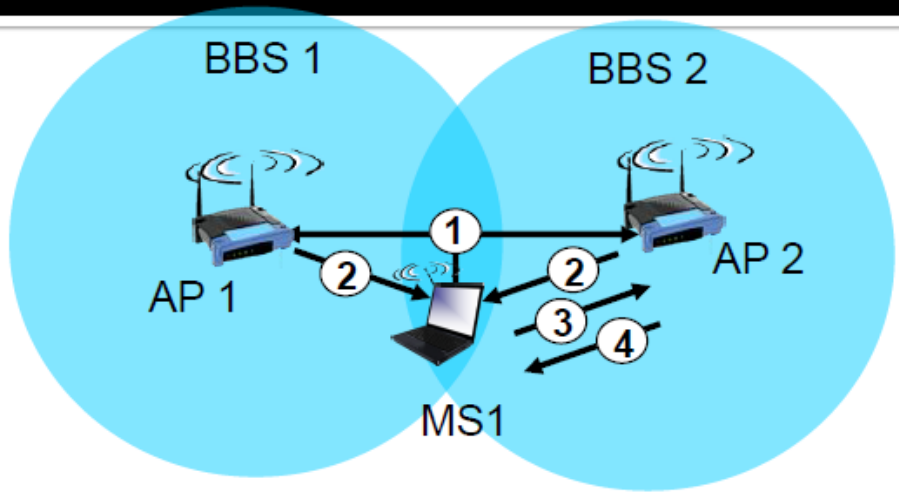
Wireless Client Access

- Scanning
- Authentication
- Association



802.11: passive/active scanning





passive scanning:

(1) beacon frames sent from APs
(2) association Request frame sent: MS1 to selected AP
(3) association Response frame sent from selected AP to MS1

active scanning:

(1) Probe Request frame broadcast from MS1
(2) Probe Response frames sent from APs
(3) Association Request frame sent: MS1 to selected AP
(4) Association Response frame sent from selected AP to MS1

Factors Affecting Wireless LAN Performance

- Intel and IBM suggested six factors affecting wireless LAN performance:
  - Interference
    - Likely to occur in the 2.4GHz RF environment
    - Interference from devices using the same RF: Bluetooth, microwave oven, cordless phones.
    - Will significantly lower the Signal to Noise Ratio (SNR)
    - Signal/Noise (SNR)

Factors Affecting Wireless LAN Performance

- Antenna
  - Determines the amount of radio frequency energy being transmitted or received and the direction of the wave being directed.
  - the attributes of the antenna are the antenna gain, diversity and cable length
- Scattering and Multipath Fading
  - refers to the signal being scattered and goes indirectly towards the intended receiver through multipath routes.
  - Increases time difference of the client receiving parts of packets

Satellite Communications