
وقل رب زدني علما

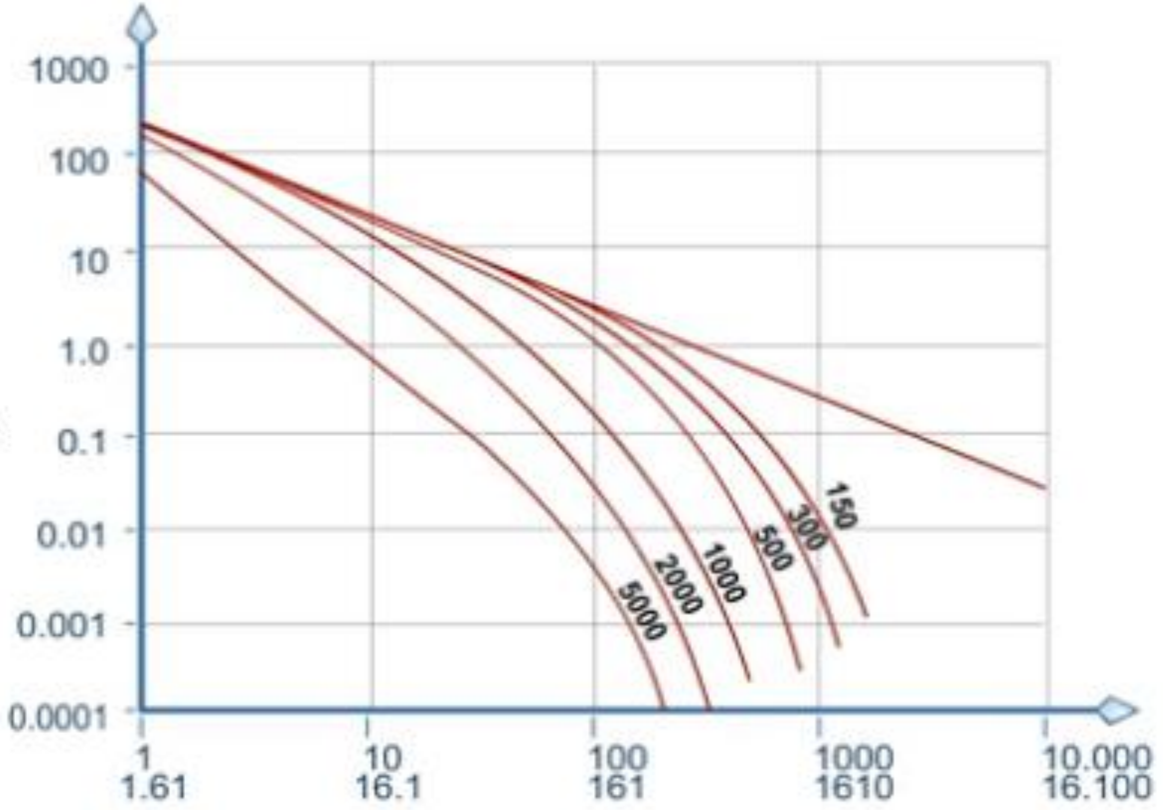
Wireless and Mobile Computing

Dr. Rania Salama

Wireless Link and Network Characteristics

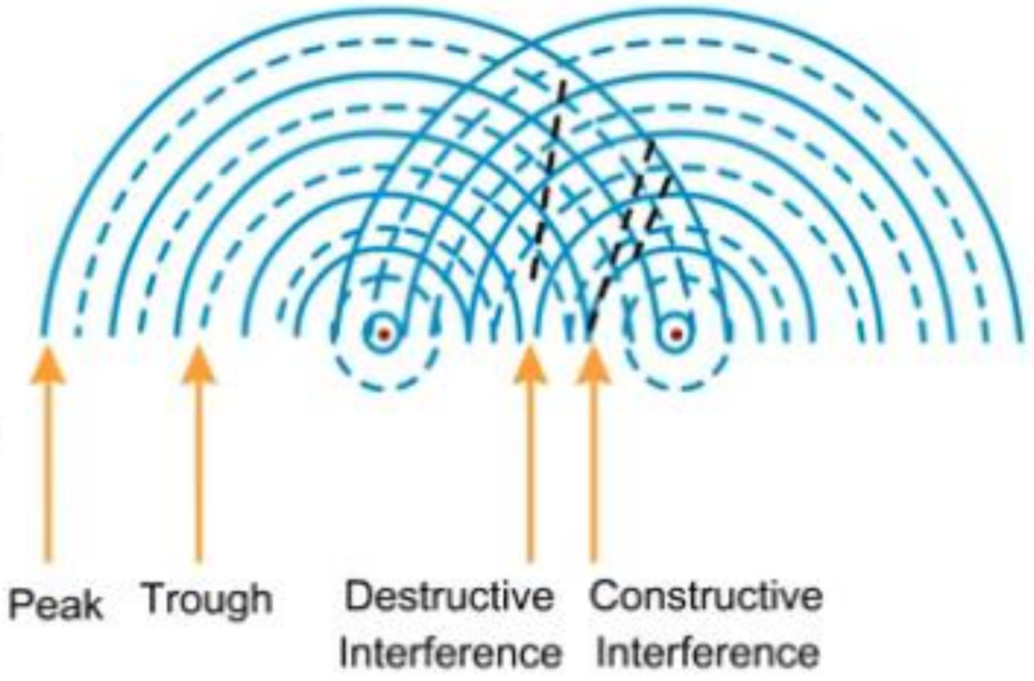
Differences from wired link ….

- Decreasing signal strength. Electromagnetic radiation attenuates as it passes through matter **e.g.**, a radio signal passing through a wall. Even in free space, the signal will disperse, resulting in decreased signal strength, sometimes referred to as path loss as the distance between sender and receiver increases.



Wireless Link and Network Characteristics

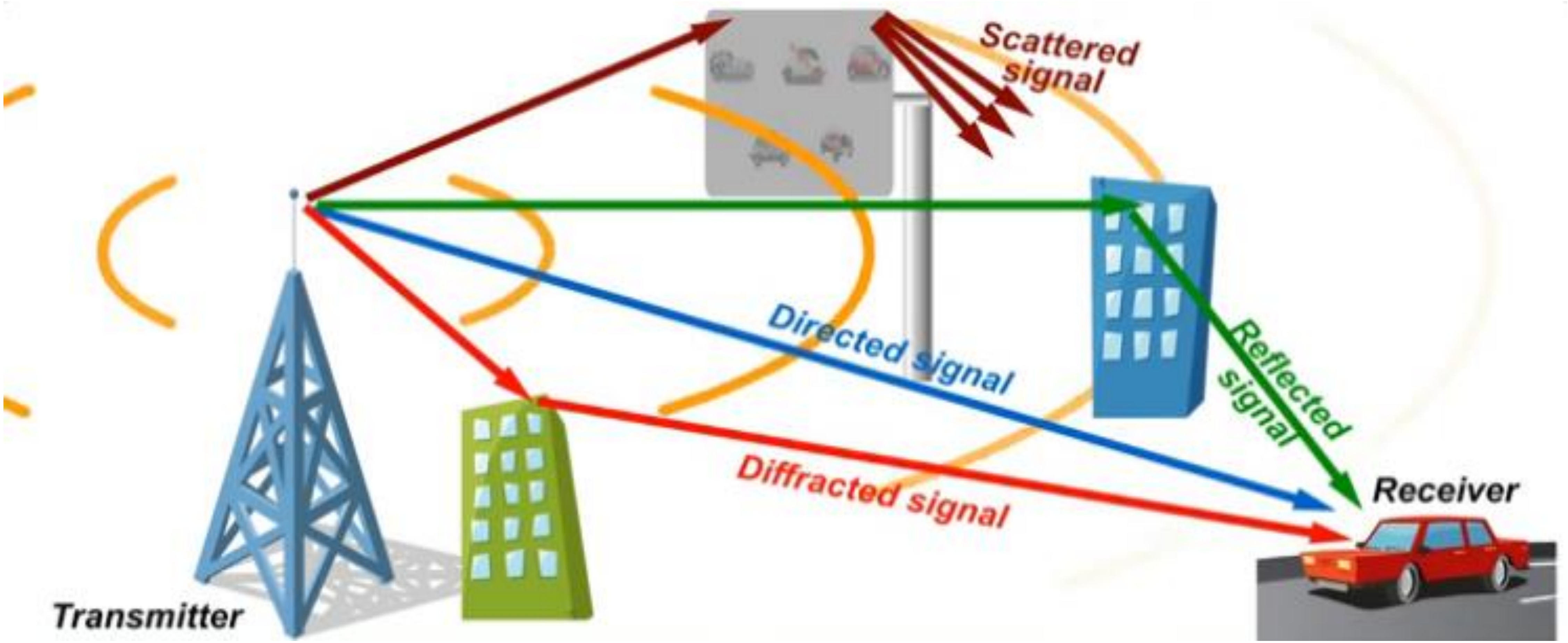
- Interference from other sources. Radio sources transmitting in the same frequency band will interfere with each other. For example, **2.4** GHz wireless phones and **802.1** lb wireless LANs transmit in the same frequency band. Thus, the **802.1** lb wireless LAN user talking on a **2.4** GHz wireless phone can expect that neither the network nor the phone will perform particularly well. In addition to interference from transmitting sources, electromagnetic noise within the environment e.g., a nearby motor, a microwave can result in interference.



Wireless Link and Network Characteristics

- Multipath propagation. Multipath propagation occurs when portions of the electromagnetic wave reflect off objects and the ground, taking paths of different lengths between a sender and receiver. This results in the blurring of the received signal at the receiver. Moving objects between the sender and receiver can cause multipath propagation to change over time.

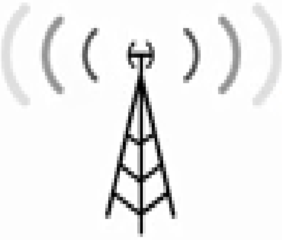
Wireless Link and Network Characteristics



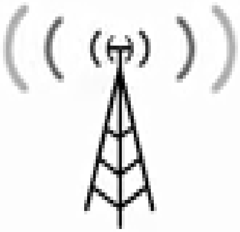
Propagation in free space and without any obstacle is the most ideal situation.

When the radio waves reach close to an obstacle, the following propagation effects do occur to the waves:

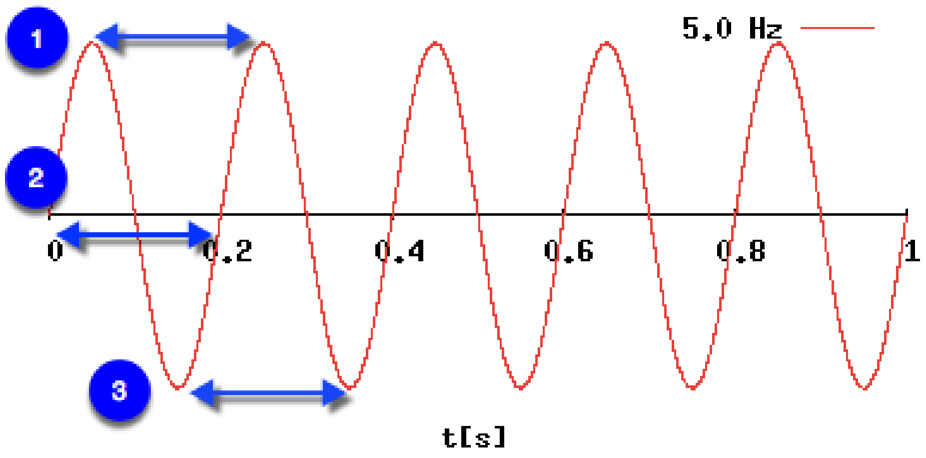
Reflection: Propagating wave impinges on an object that is larger as compared to its wavelength.



Diffraction: Radio path between a transmitter and a receiver is obstructed by a surface with sharp irregular edges.



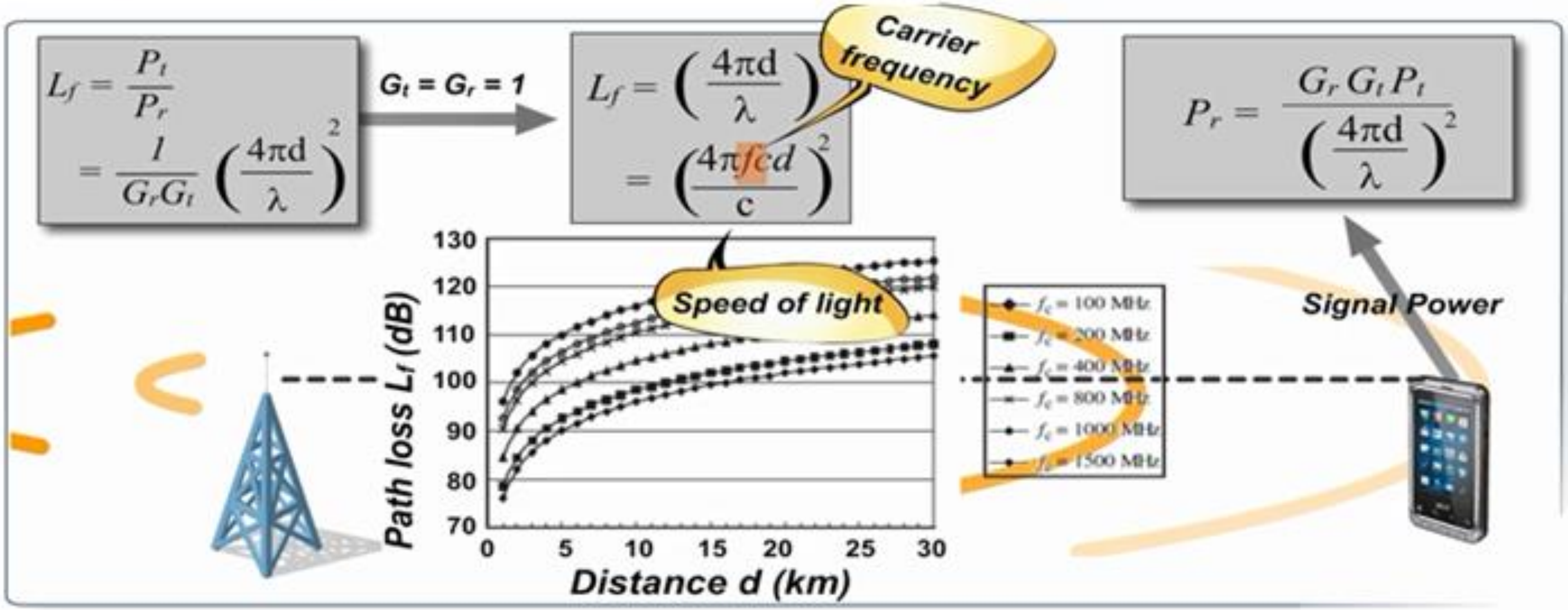
Scattering: When objects are smaller than the wavelength of the propagating wave, incoming signal is scattered into several weaker outgoing signals.


1
2
3
5.0 Hz
0
0.2
0.4
0.6
0.8
1
t[s]

Free Space Propagation and Path Loss

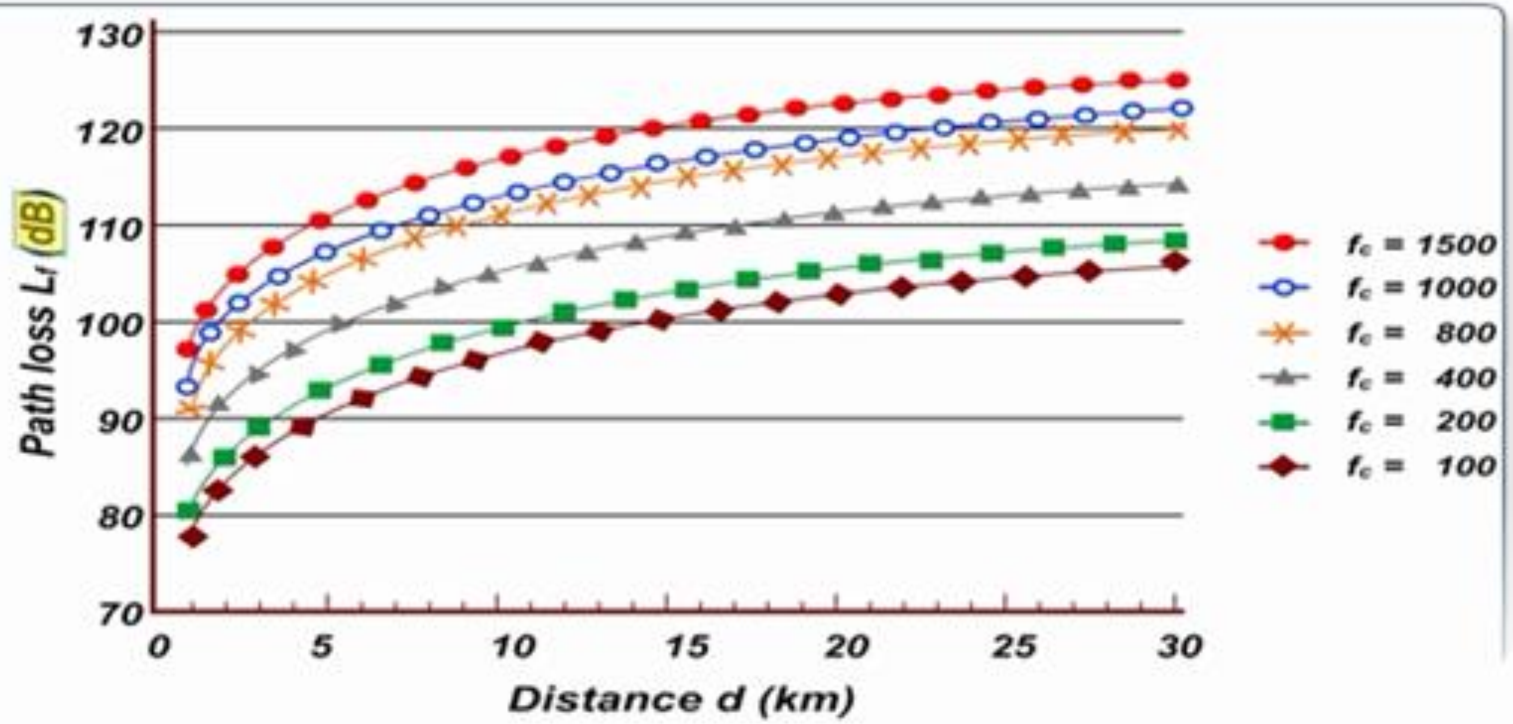
Free space is an ideal propagation medium. Consider a point source fed by a transmitter of P_t watts. At an arbitrary, large distance d from the source, the radiated power is uniformly distributed over the surface area of a sphere.

Free Space Propagation and Path Loss



Free Space Propagation and Path Loss

$$L_f = \frac{P_t}{P_r} = \frac{1}{G_r G_t}\left(\frac{4\pi d}{\lambda}\right)^2$$



Free Space Propagation and Path Loss

- The signal strength and quality of received radio waves vary accordingly, as well as the time to reach the destination changes.
- This implies that the wave propagation in the multipath channel depends on the actual environment, including factors such as the antenna height, the profile of the buildings, roads, and the terrain.
- Therefore, we need to describe the behavior of mobile radio channels using a good and relevant statistical mechanism.

Free Space Propagation and Path Loss

Received signal power

$$P_r = \frac{G_t G_r P_t}{L}$$

Propagation loss in the channel

Aspects of wave propagation:

- Path loss.
- Slow fading (shadowing).
- Fast fading.

$$L = L_P L_S L_F$$

Long-tem fading loss

short-term fading loss

Path loss

Free Space Propagation and Path Loss

- Mathematically, fading is usually modeled as a time-varying random change in the amplitude and phase of the transmitted signal.

The path loss L_P — Is the average propagation loss over a wide area. It is determined by the macroscopic parameters, such as the distance between the transmitter and receiver, the carrier frequency, and the land profile.

The long-term fading loss L_S

The short-term loss L_F

Free Space Propagation and Path Loss

- Mathematically, fading is usually modeled as a time-varying random change in the amplitude and phase of the transmitted signal.

The path loss L_P

The long-term fading loss L_S

The short-term loss L_F

Represents variation of the propagation loss in a local area (several tens of meters). It is caused by the variation in propagation conditions due to buildings, roads, and other obstacles in a relatively small area.

Free Space Propagation and Path Loss

- Mathematically, fading is usually modeled as a time-varying random change in the amplitude and phase of the transmitted signal.

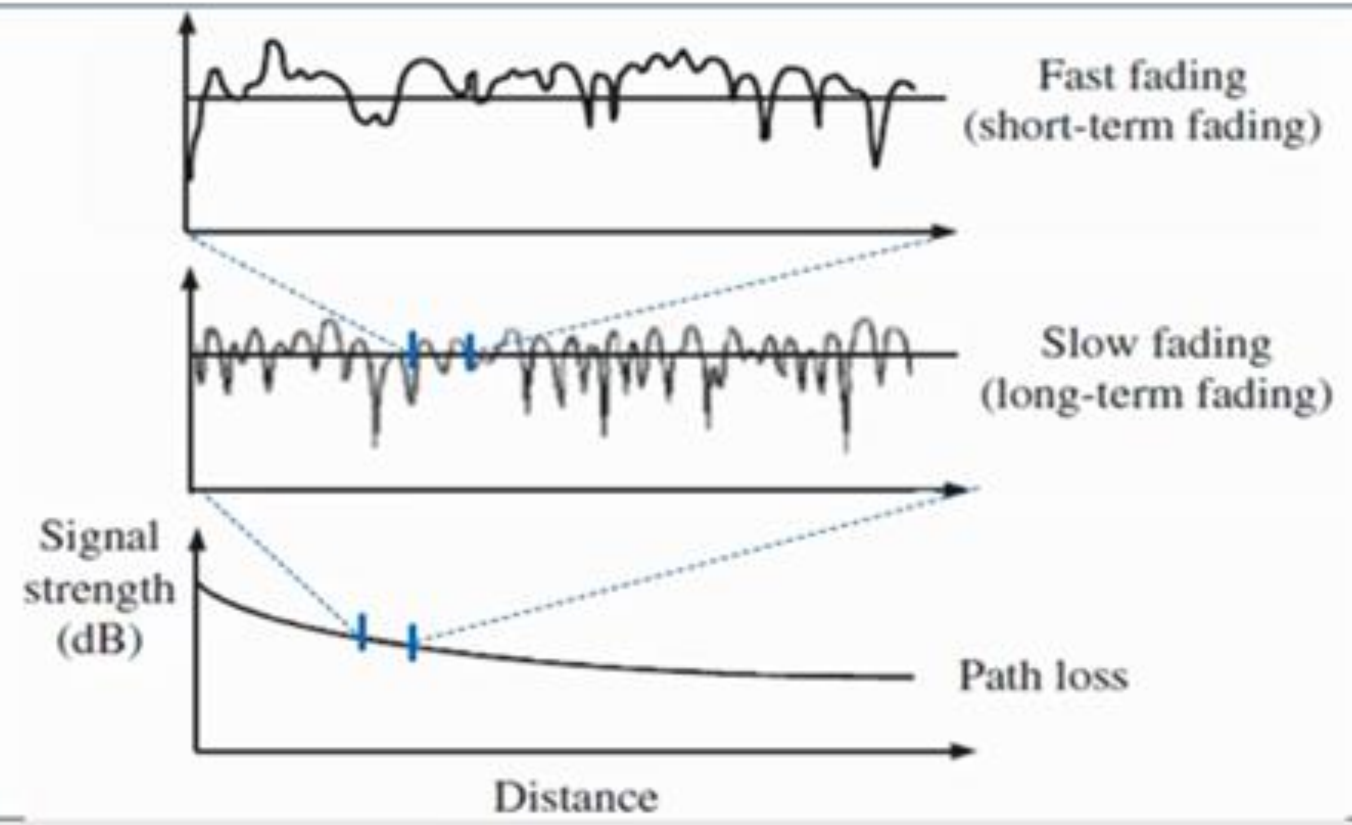
The path loss L_P

The long-term fading loss L_S

The short-term loss L_F

Is due to the motion of the MS that consists of many diffracted waves, representing the microscopic aspect of the channel as shown in last figure.

Free Space Propagation and Path Loss



Free Space Propagation and Path Loss

- The simplest formula for path loss of land propagation is:

$$L_P = A d^{\alpha}$$

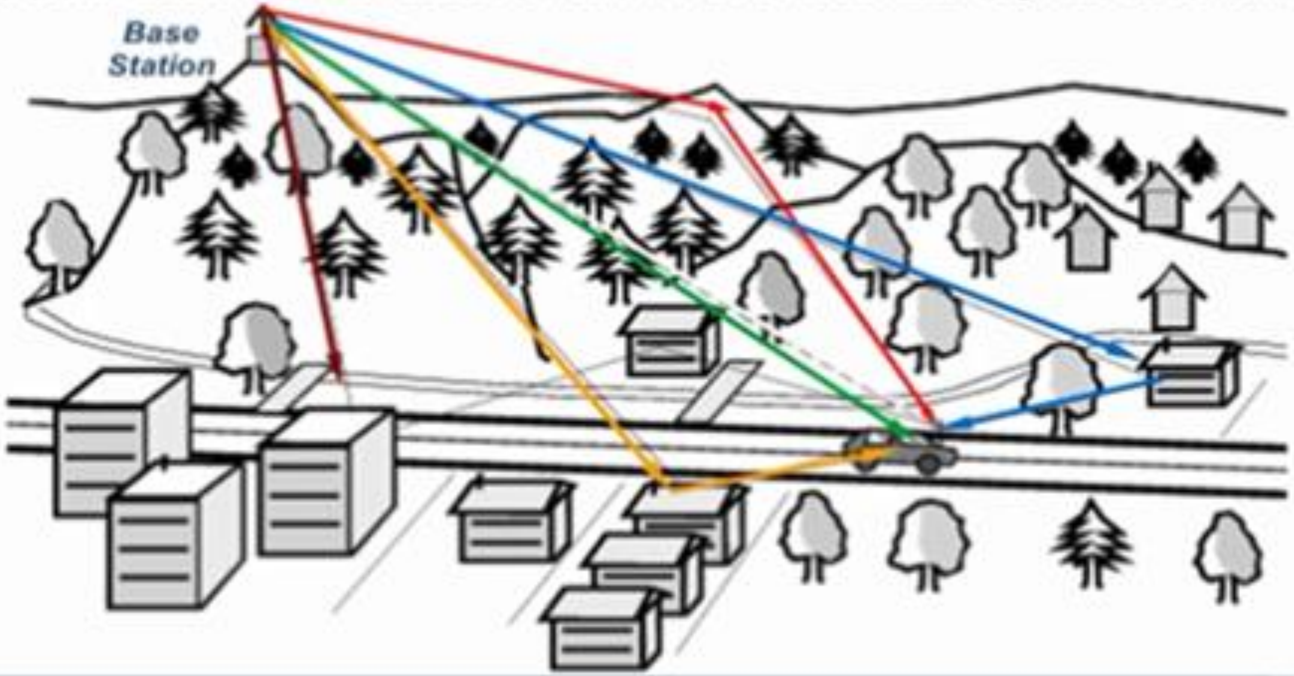
Where

- ***A*** and α are propagation constants and
- ***d*** is the distance between the transmitter and the receiver.

Usually, α takes a value of ***3*** □ ***4*** in a typical urban area.

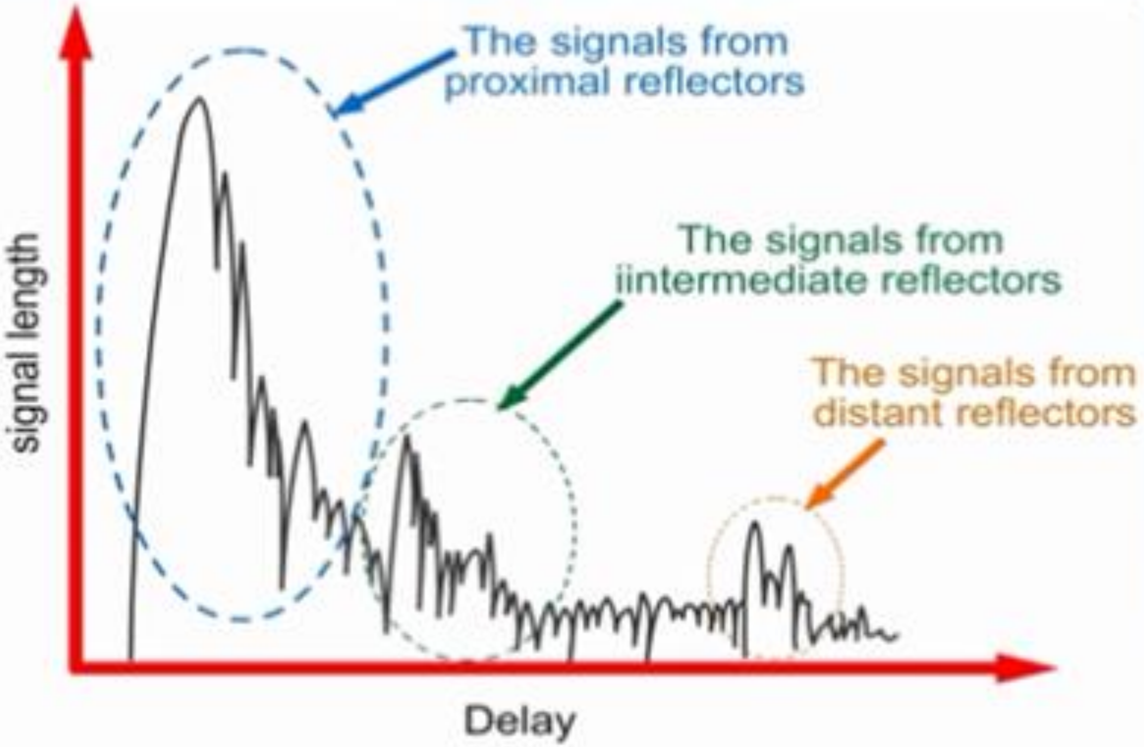
Frequency and Time Selectivity

- In many cases, when a signal propagates from a transmitter to a receiver, the signal suffers one or more reflections so that the path becomes indirect as shown. This forces radio signals to follow different paths.



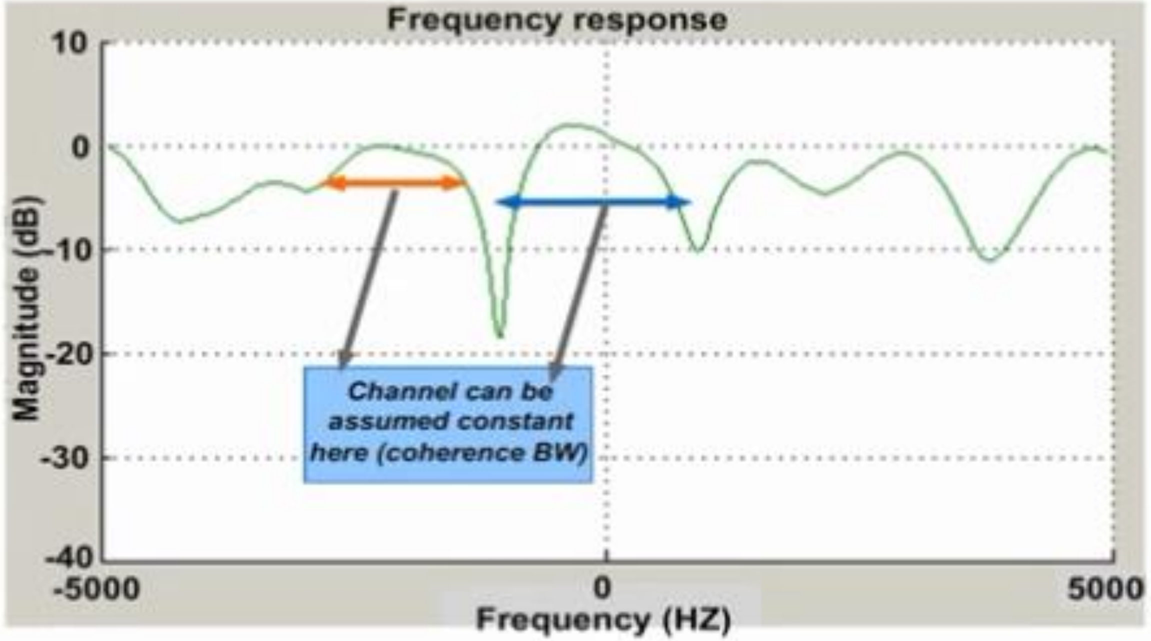
Frequency and Time Selectivity

- Figure shows the received signal due to the different multipath. Since each path has a different path length, the time of arrival for each path is different. The smearing or spreading out effect of the signal is called ***"delay spread."***



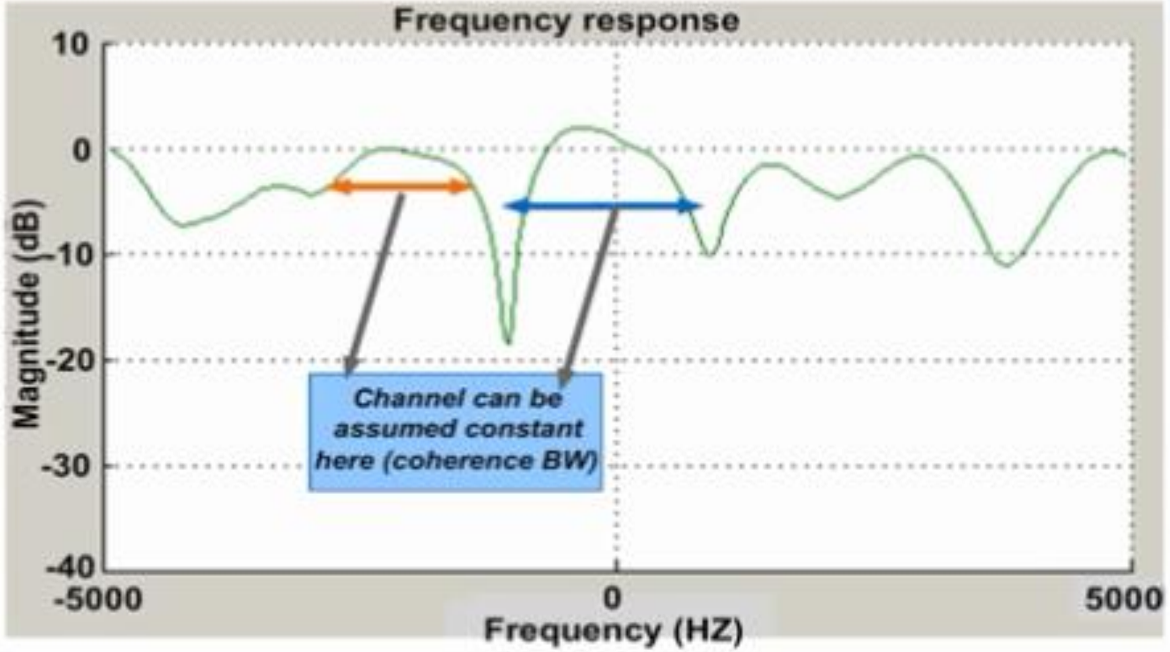
1.3 Frequency and Time Selectivity

- In the frequency domain, this means that the overall channel response will not be constant and will suffer from what is called ***"Frequency selectivity"*** as shown.



1.3 Frequency and Time Selectivity

- As can be seen from Figure the channel cannot be assumed constant over different frequencies. A transmitted signal with a specific bandwidth will undergo a different channel gain at different frequencies. If you look closely at the figure, we can assume that the channel is almost constant over certain ranges of frequencies. This range (or band) of frequencies, over which the channel is considered constant is referred to as the "coherence bandwidth" of the channel. It is worth mentioning here that the coherence bandwidth is inversely proportional to the delay spread of the channel.

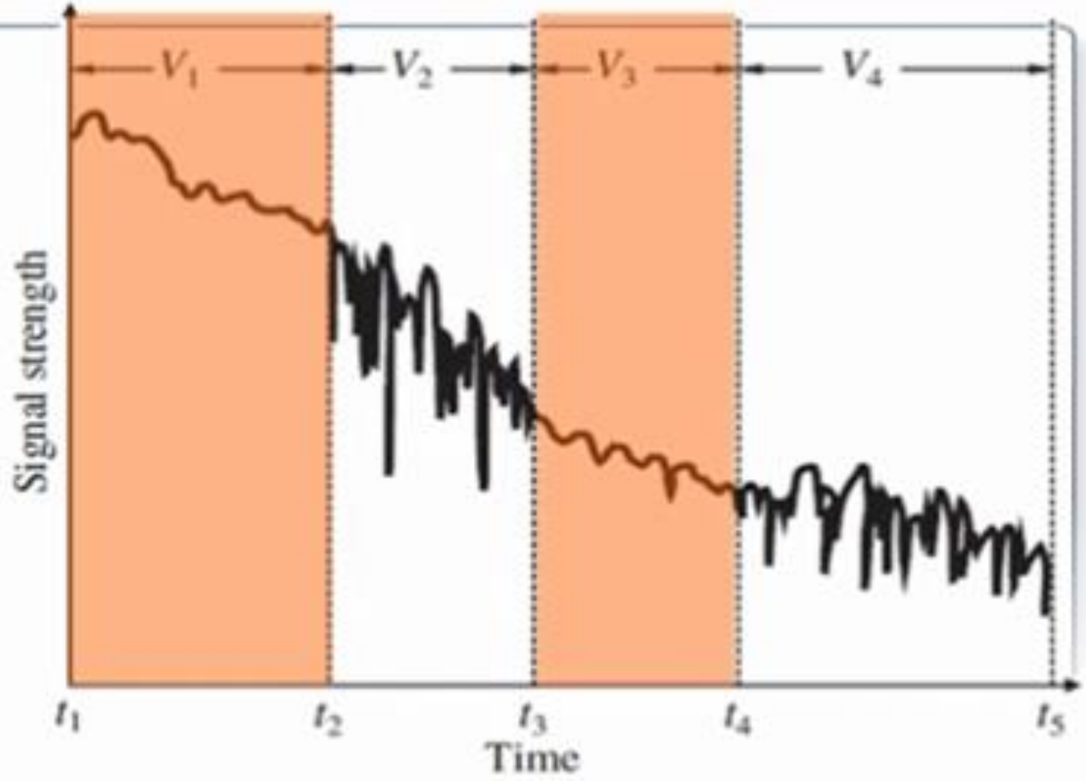


Frequency and Time Selectivity

- In a wireless and mobile system, the location of the BS is fixed while the MSs are mobile. Therefore, as the receiver is moving with respect to the wave source, the frequency of the received signal will not be the same as the source.

Frequency and Time Selectivity

- V1, V2, V3, and V4 are different moving speeds of the receiver. When they are moving toward each other, the frequency of the received signal is higher than that of the source.
- When they are moving away from each other, the received frequency decreases.



Frequency and Time Selectivity

Frequency of the received signal → $f_r = f_c - f_d$

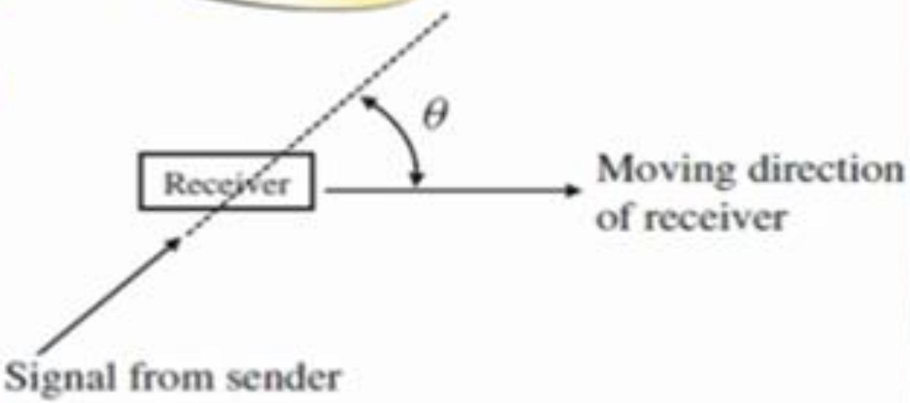
Frequency of source

Doppler frequency

Moving speed

Doppler shift → $fd = \frac{\upsilon}{\lambda} \cos \theta$

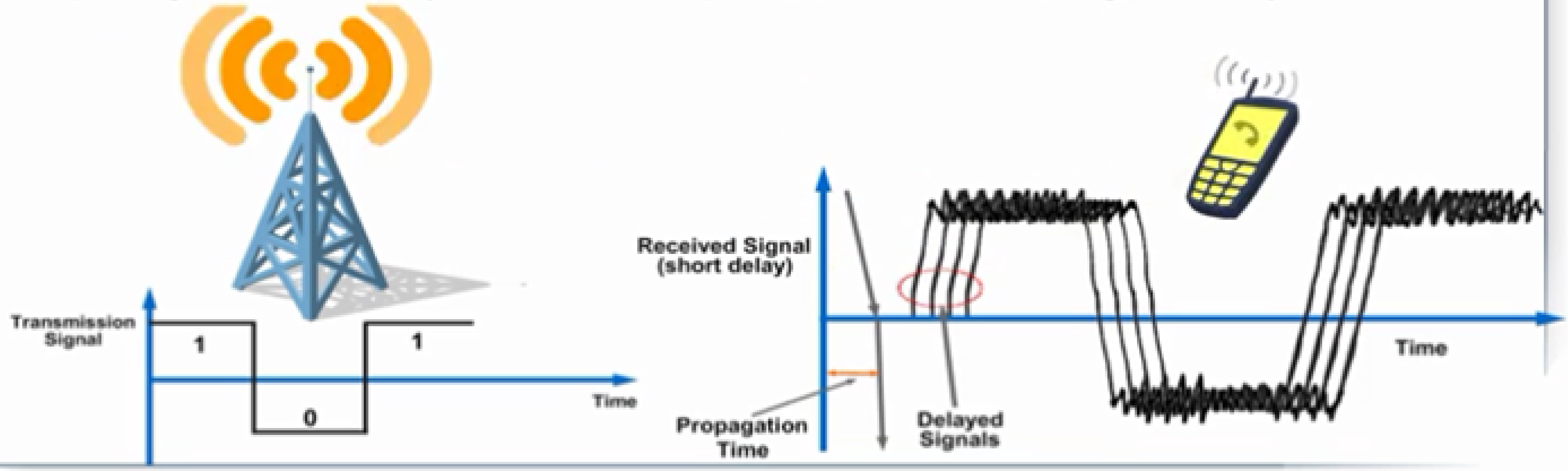
Wavelength of carrier



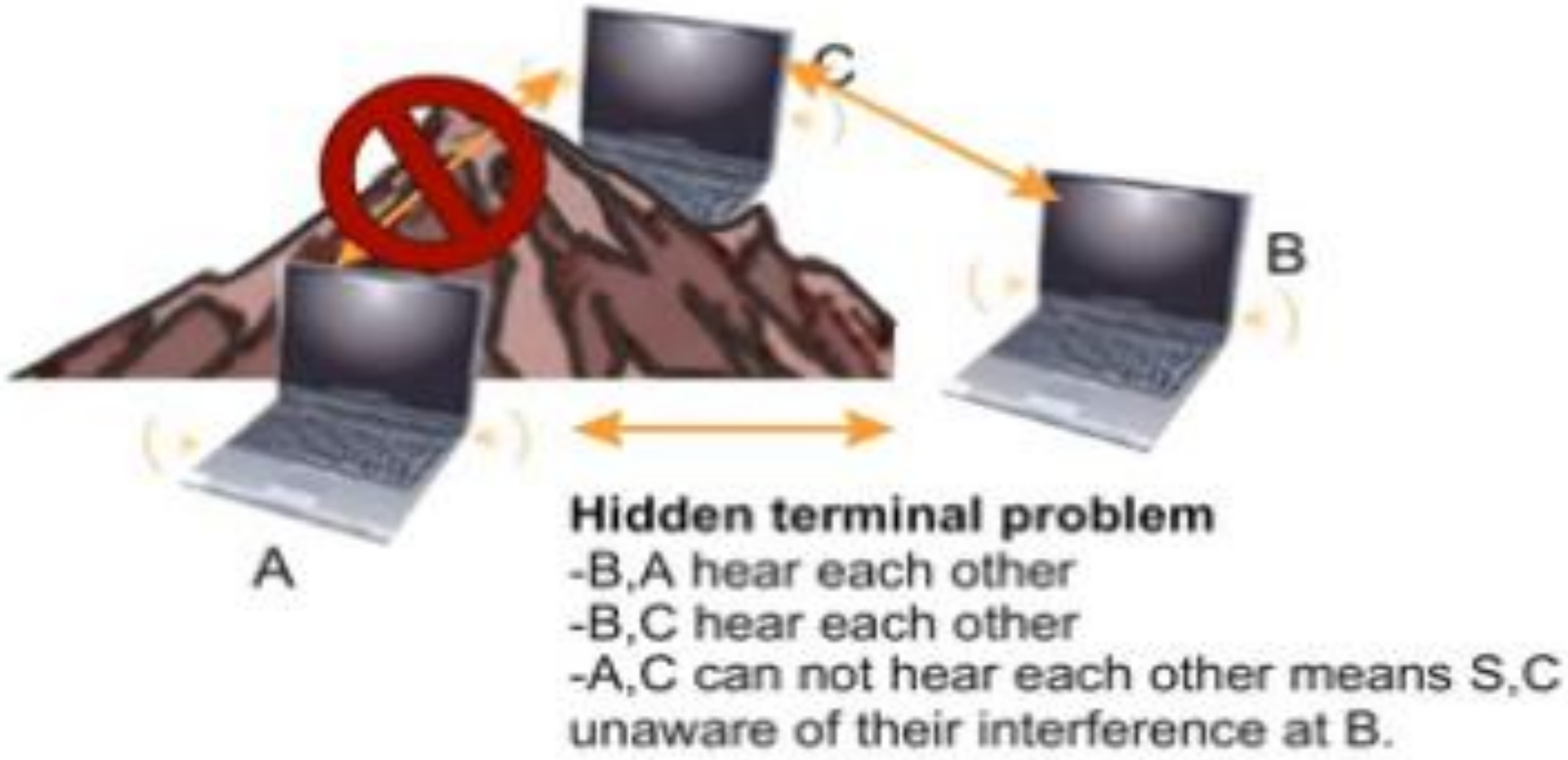
Velocity component of the receiver in the direction of the sender.

Inter-symbol Interference

Inter-Symbol interference (ISI) is caused by time-delayed multipath signals.
ISI also has an impact on the burst error rate of the channel. Such an effect is illustrated in figure where the second multipath signal could be delayed so much that a part could be received during the next symbol interval.

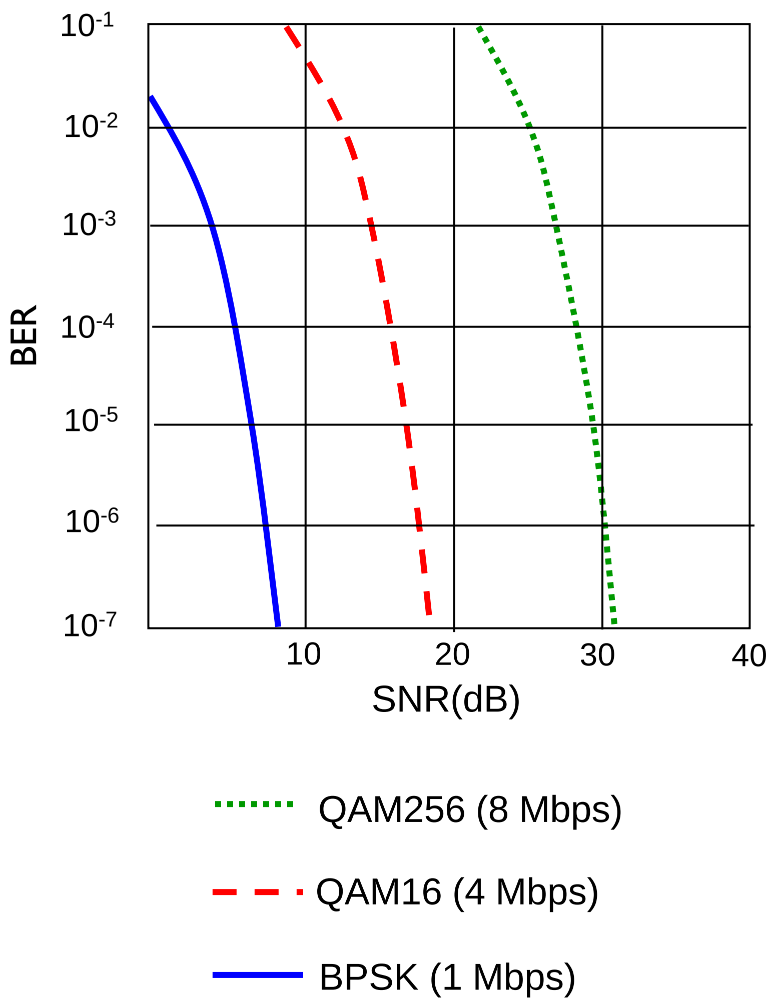


Wireless Network Characteristics



Wireless Link Performance Evaluation

- SNR: signal-to-noise ratio
  - larger SNR – easier to extract signal from noise (a "good thing")
- *SNR versus BER tradeoffs*
  - *given physical layer:* increase power -> increase SNR->decrease BER
  - *given SNR:* choose physical layer that meets BER requirement, giving highest throuput
    - SNR may change with mobility: dynamically adapt physical layer (modulation technique)



802.11: advanced capabilities

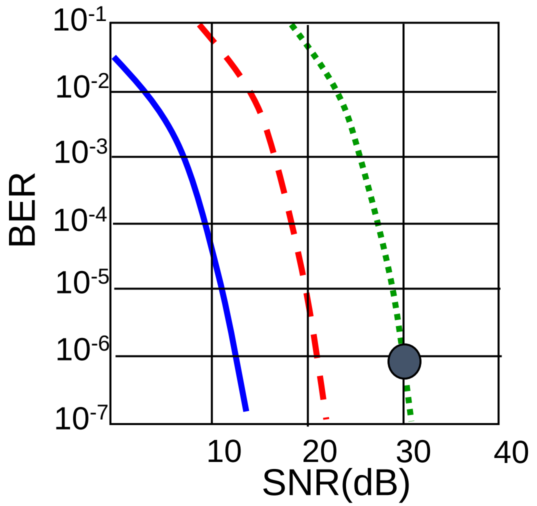
power management

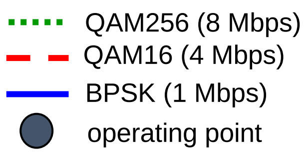
- node-to-AP: "I am going to sleep until next beacon frame"
  - AP knows not to transmit frames to this node
  - node wakes up before next beacon frame
- beacon frame: contains list of mobiles with AP-to-mobile frames waiting to be sent
  - node will stay awake if AP-to-mobile frames to be sent; otherwise sleep again until next beacon frame

802.11: advanced capabilities

Rate adaptation

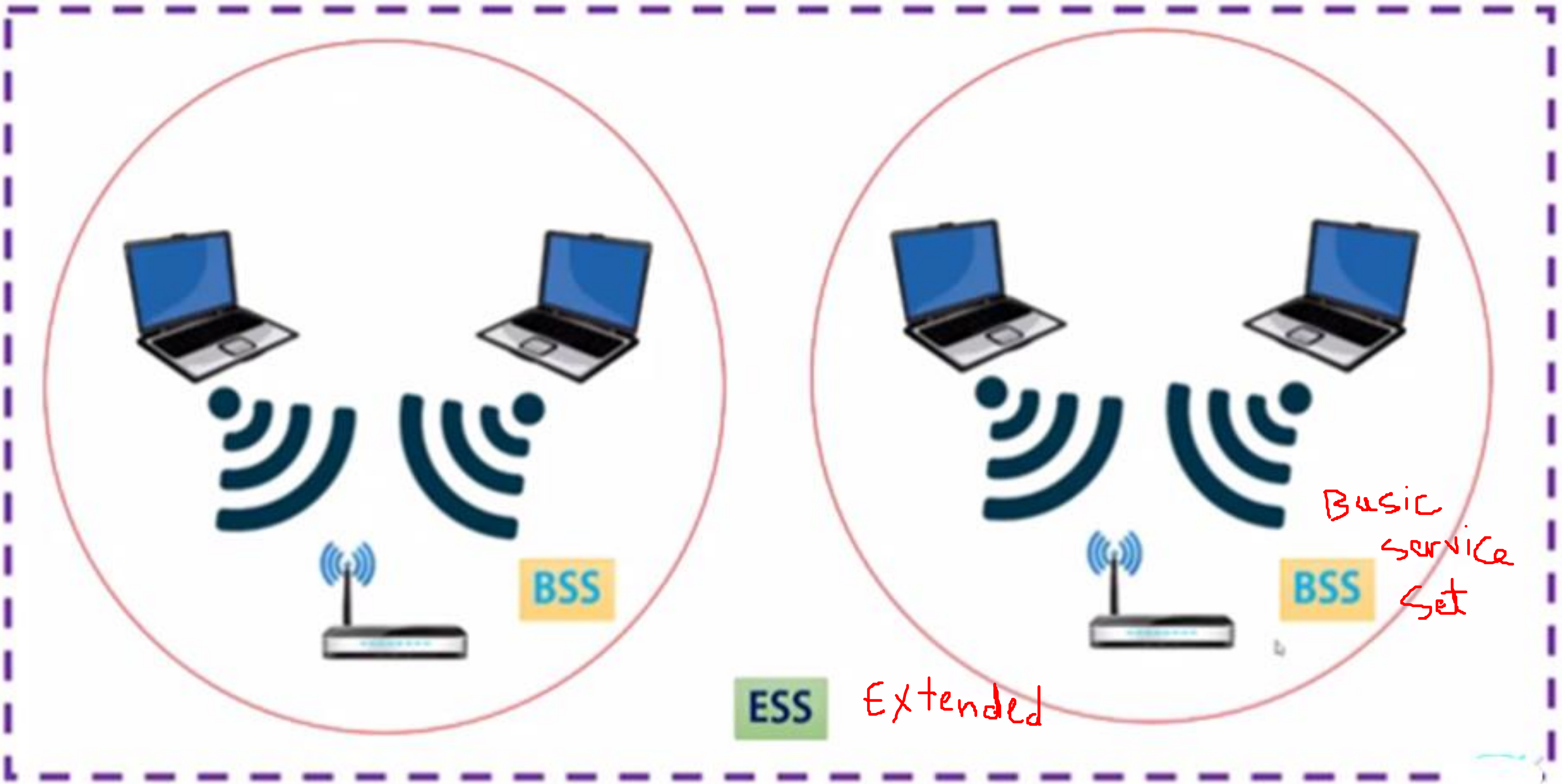
- base station, mobile dynamically change transmission rate (physical layer modulation technique) as mobile moves, SNR varies





1. SNR decreases, BER increase as node moves away from base station

2. When BER becomes too high, switch to lower transmission rate but with lower BER


BSS
BSS
Basic
service
Set
ESS
Extended

802.11: mobility within same subnet

- H1 remains in same IP subnet: IP address can remain same
- switch: which AP is associated with H1?
  - self-learning switch will see frame from H1 and “remember” which switch port can be used to reach H1