Wireless Propagation Characteristics

Mobile and Satellite Communication Networks

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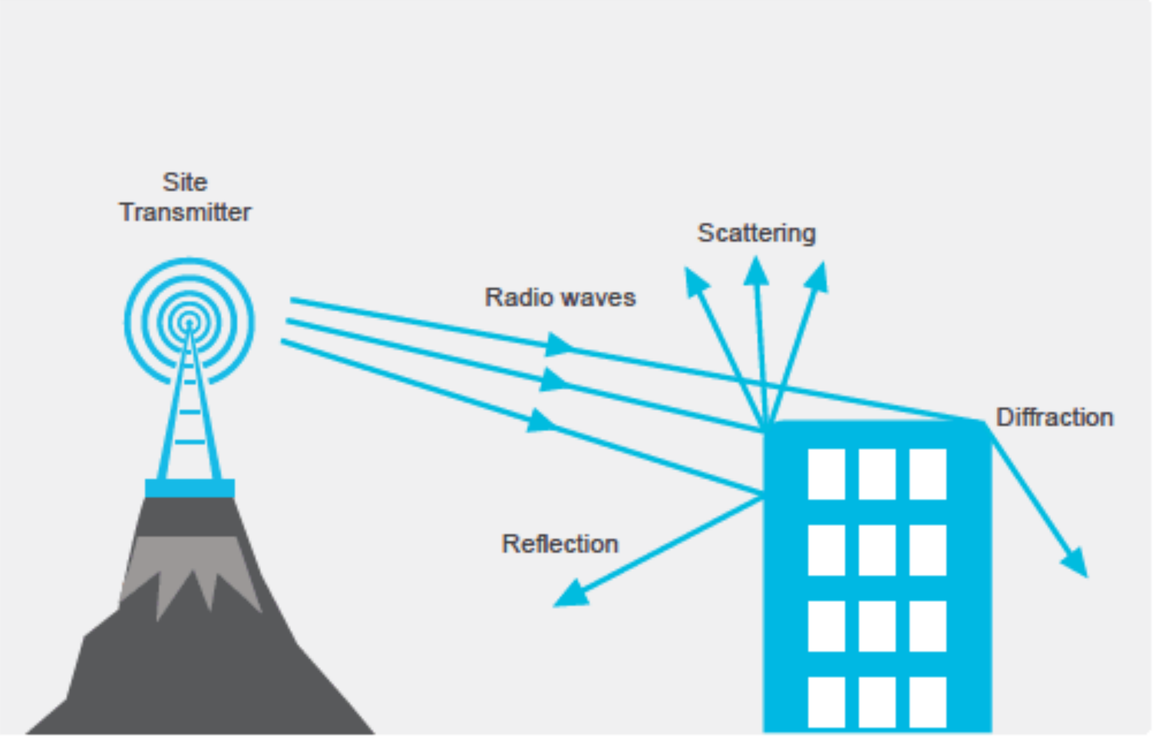
Propagation Mechanisms

Propagation Mechanisms

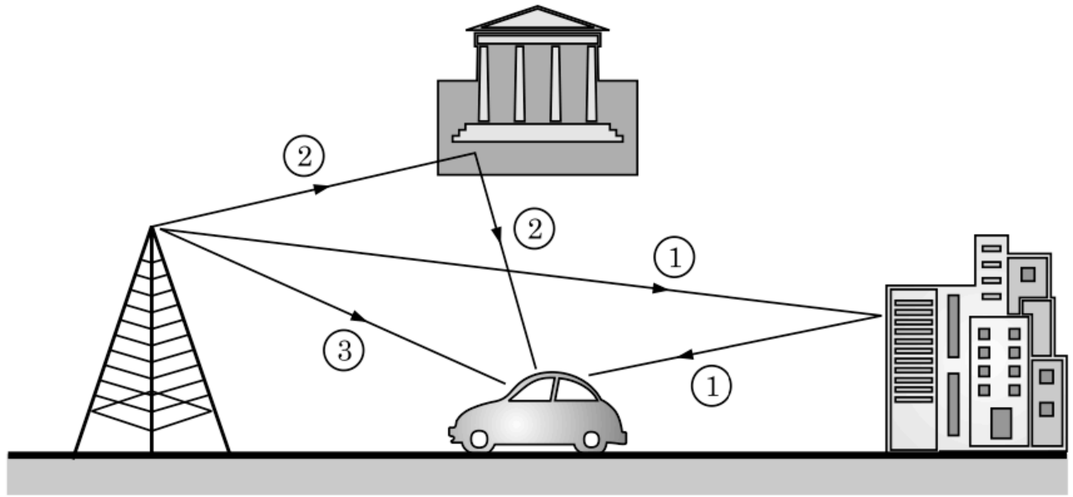
- **Reflection** — when an EM wave encounters a surface or obstacle and bounces back to its source. This causes loss of signal.
- **Diffraction** — Corners and sharp surfaces cause an EM wave just like the one thrown from a router to split into secondary smaller waves.
- **Scattering** — When the signal encounters a surface it dissipates into multiple reflected signals.



Multipath Propagation

Multipath Propagation

- In multipath propagation, multiple signal paths are established between the base station and the user terminal (mobile phone).
- The fading due to multipath propagation is known as **Multipath fading** or Rayleigh fading.
- These indirect signals can add to or subtract from the direct signal arriving at the antenna.

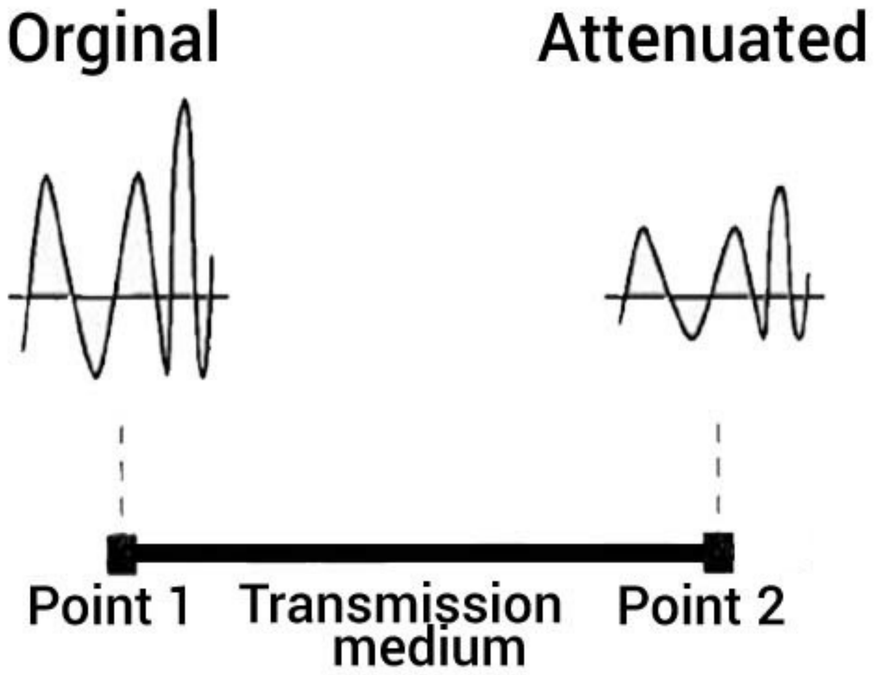


Attenuation & Path Loss

Attenuation

Definition

Attenuation refers to the loss of signal strength with distance over any transmission medium.

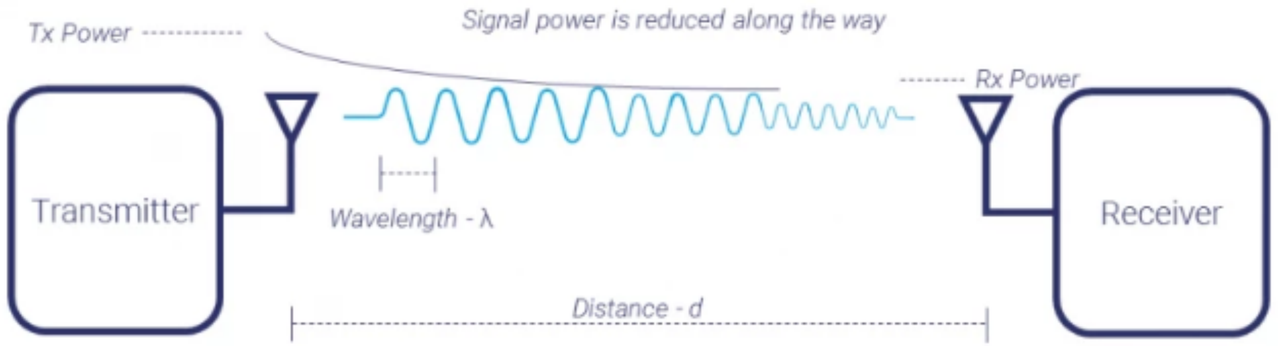


Path Loss

Definition

- Path Loss refers to the loss or attenuation a propagating electromagnetic signal or wave encounters along its path from the transmitter to the receiver.
- Also expressed as the ratio of transmitted power to received power

$$P_L = \frac{P_t}{P_r} = \left(\frac{4\pi d}{\lambda}\right)^2$$



Path Loss

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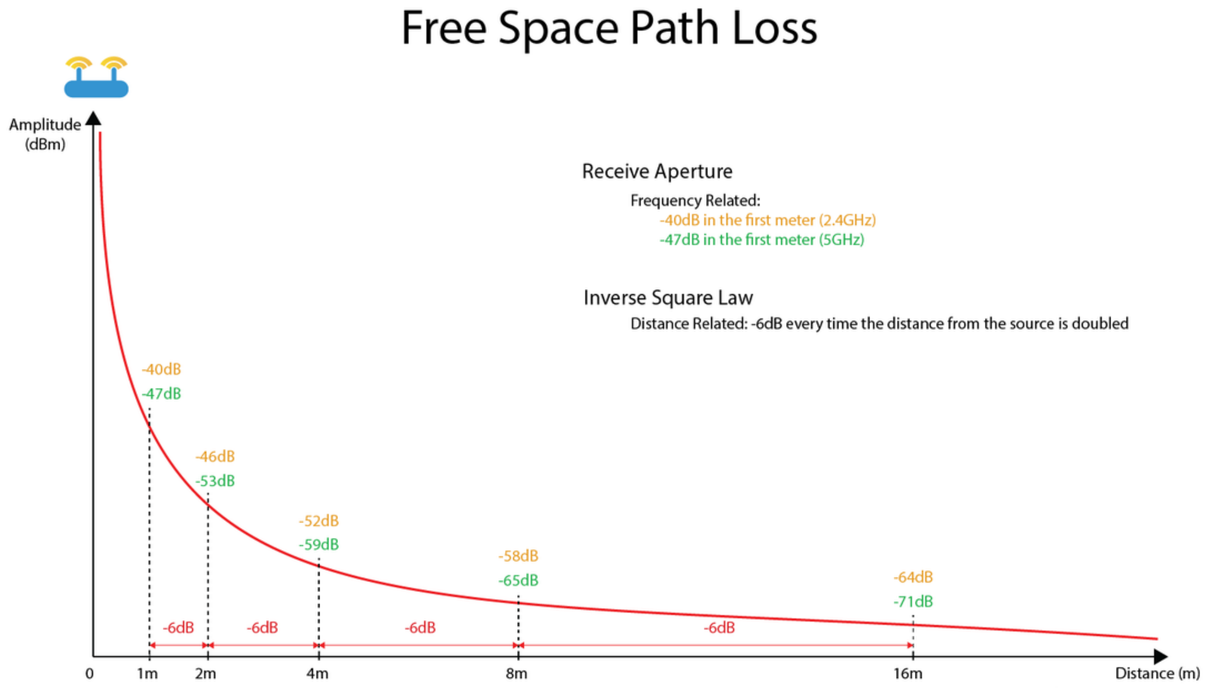

Path Loss

in decibels

Path Loss, in decibels can be expressed as:

$$L_{\text{dB}} = 10 \log \frac{P_t}{P_r} = 20 \log \left(\frac{4\pi d}{\lambda} \right)$$

Fading

Fading

Definition

Fading refers to the **fluctuations** in signal strength when received at the **receiver**. These are basically unwanted variations introduced at the time when the signal propagates from an end to another by taking multiple paths. Fading can be classified into two types:

1. Fast Fading
2. Slow Fading

Fast Fading

Definition

- Fast Fading refers to the rapid fluctuations in the amplitude, phase or multi path delays of the received signals, due to the interference between multiple versions of the same transmitted signal arriving at the receiver at slightly different times.

- The multiple signal paths may sometimes add constructively or sometimes destructively at the receiver causing a variation in the power level of the received signal.

Slow Fading

Definition

- The name Slow Fading itself implies that the signal fades away slowly.
- Slow fading occurs when objects that partially absorb the transmission lie between the transmitter and receiver.
- Slow fading is also referred to as **shadow fading** since the objects that cause the fade, which may be large buildings or other structures, block the direct transmission path from the transmitter to the receiver.

Fast Fading vs Slow Fading