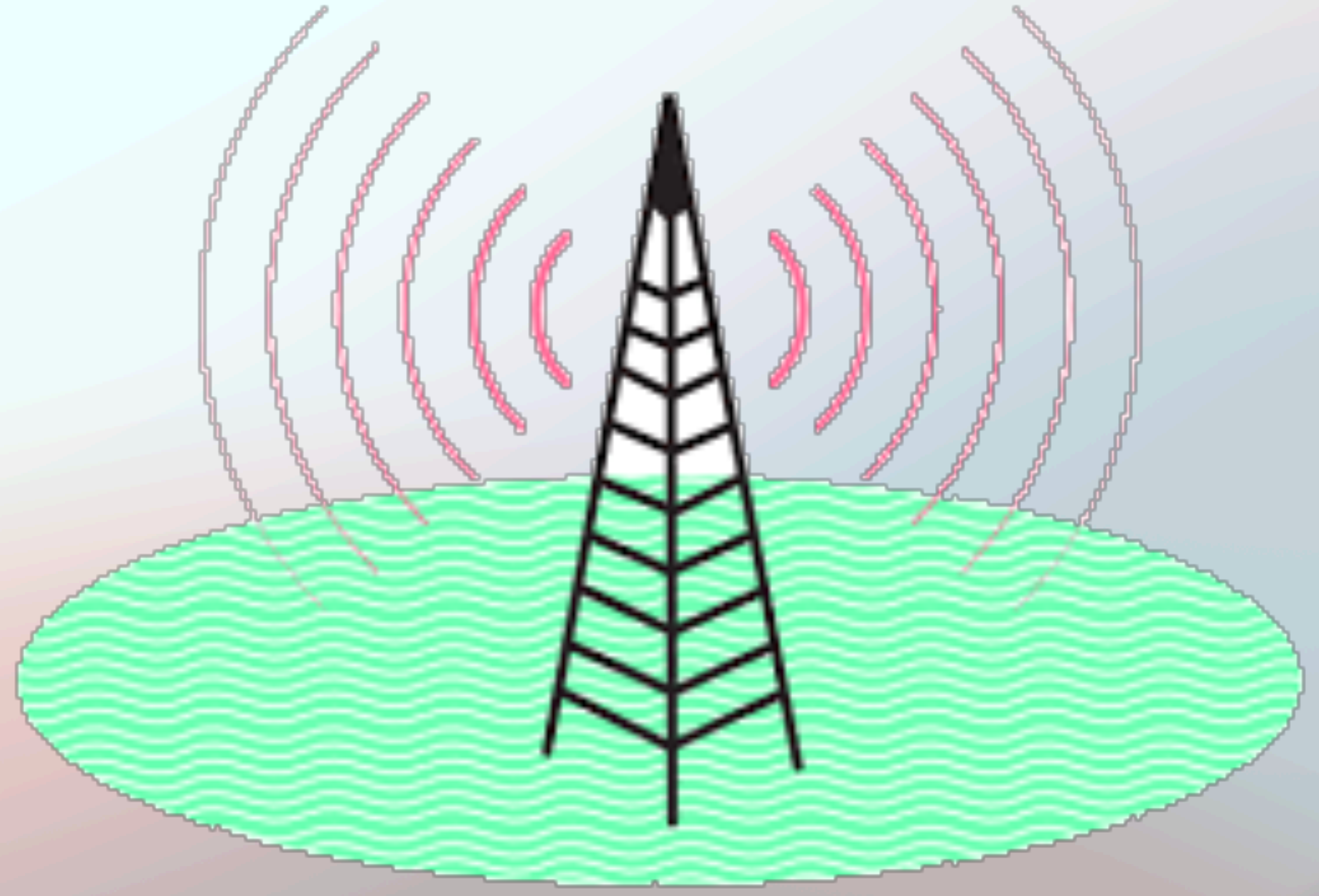
tr4jvgs

Wireless Comm. Fundamentals 2: Radio Propagation

CSE—4128: Wireless Networks



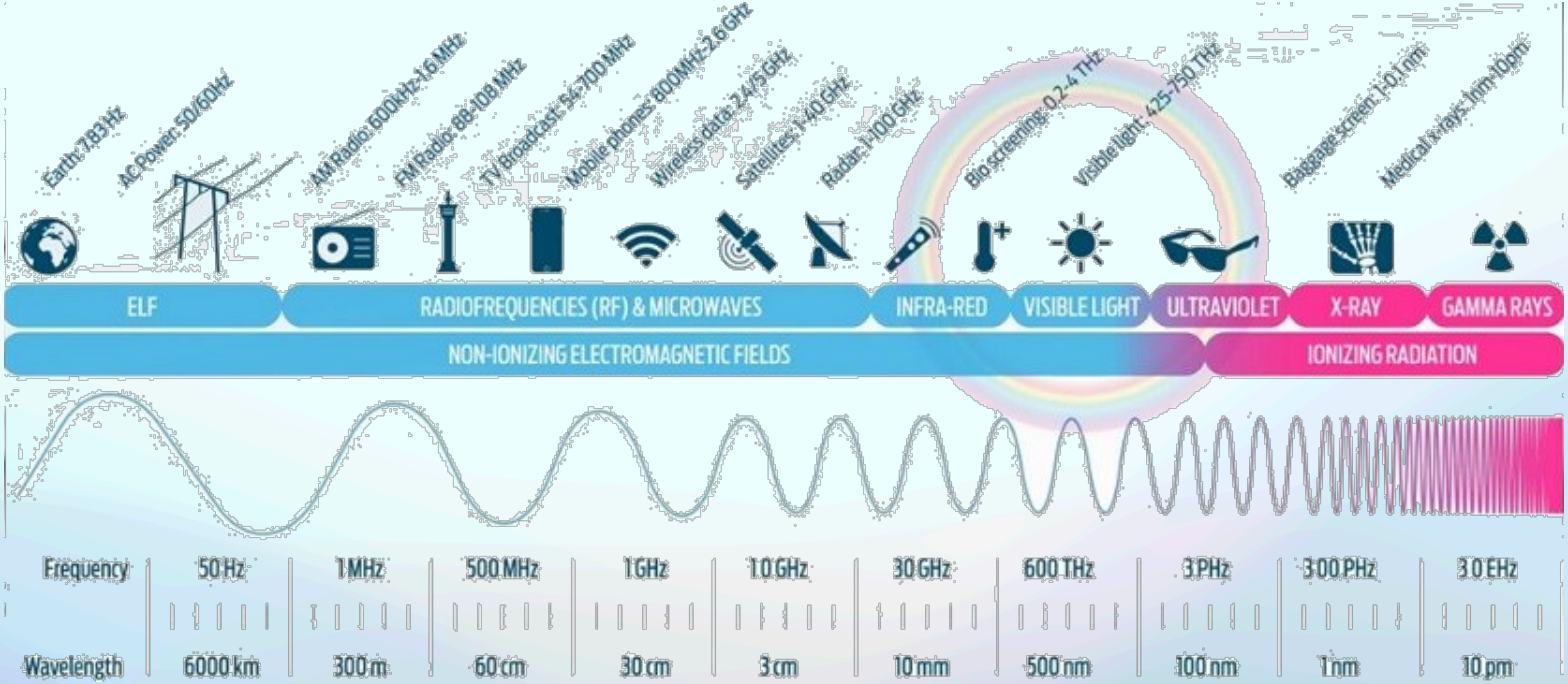
Prof. Md. Mustafizur Rahman
Dept. of Computer Science and Engineering, University of Dhaka

Contents

- Basic Terminologies
  - Frequency Spectrum
  - Radio Propagation
  - Duplex Types: FDD and TDD
  - Antenna Radiation Pattern
- Radio Propagation
  - Wireless Tx-Rx

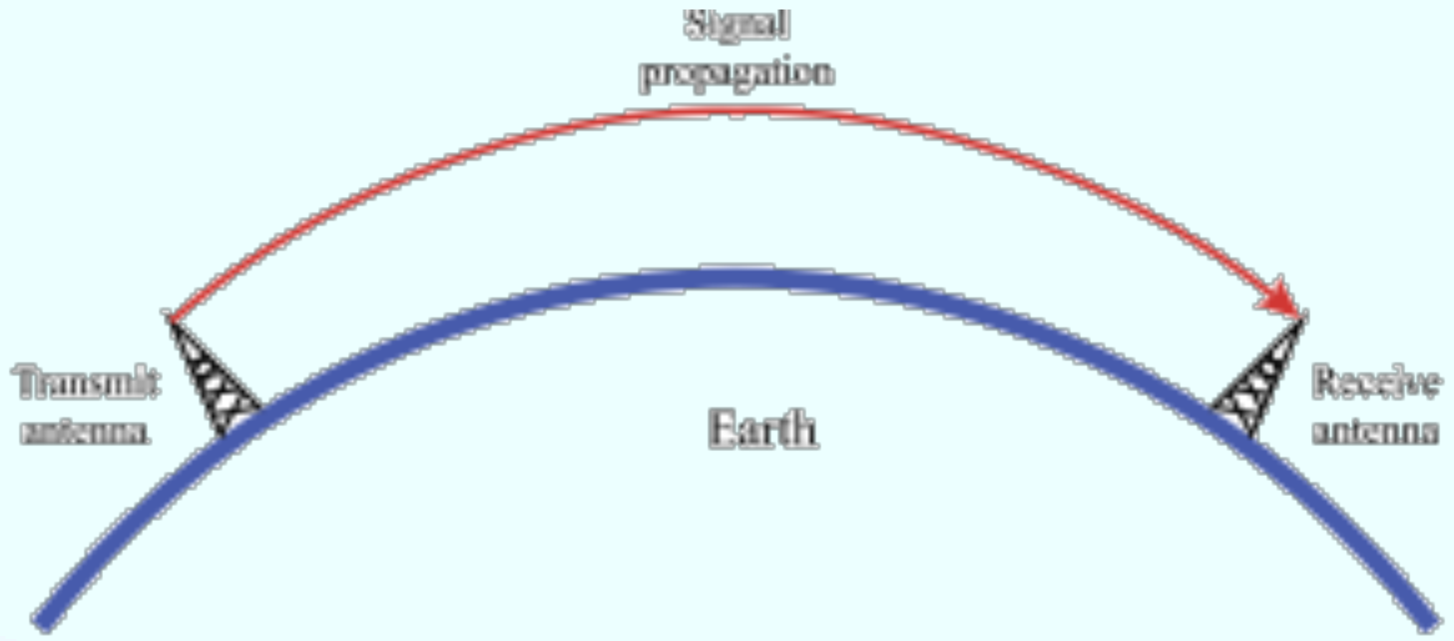
Frequency Spectrum

RadioWave (Electromagnetic Wave)

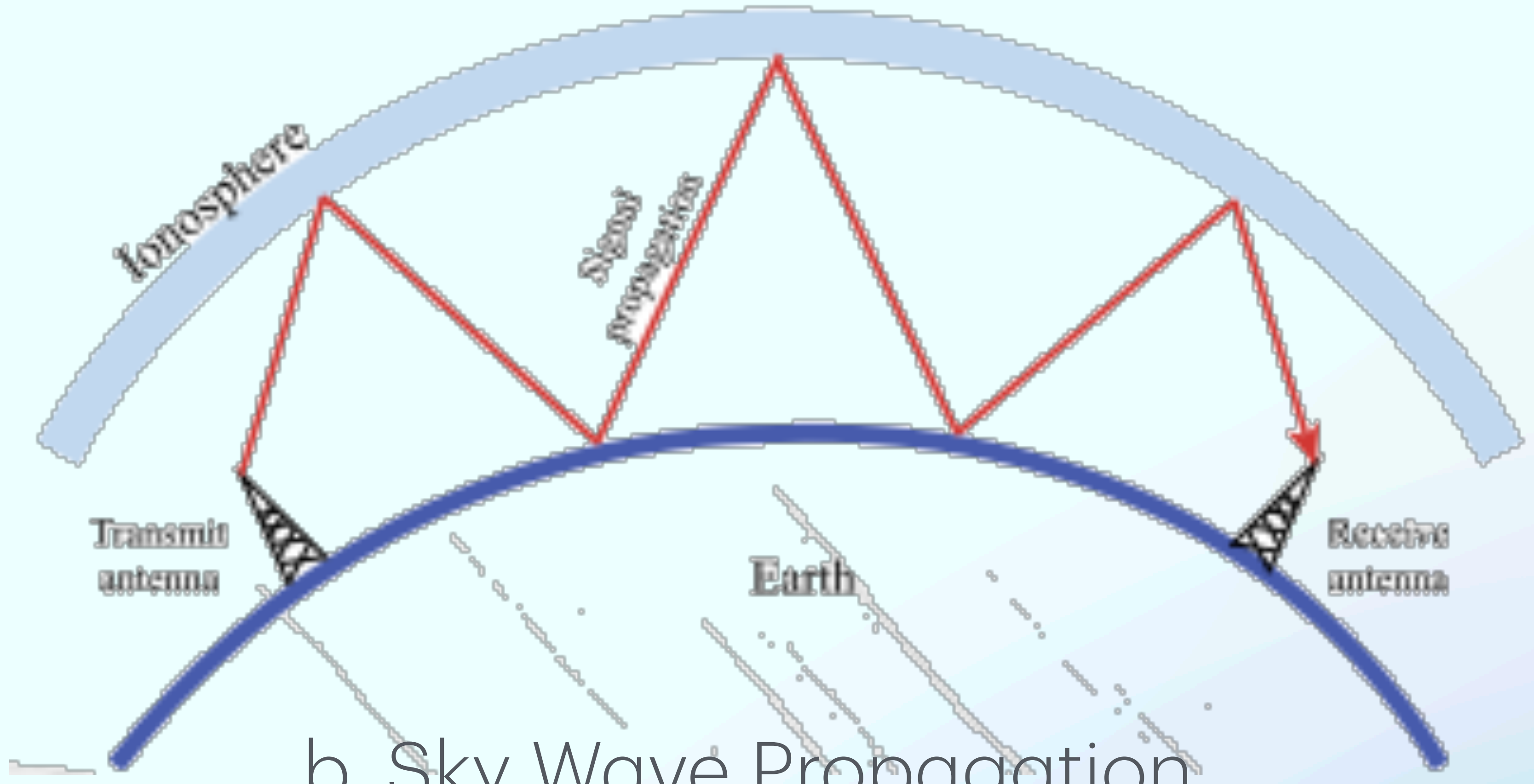


Propagation Mode

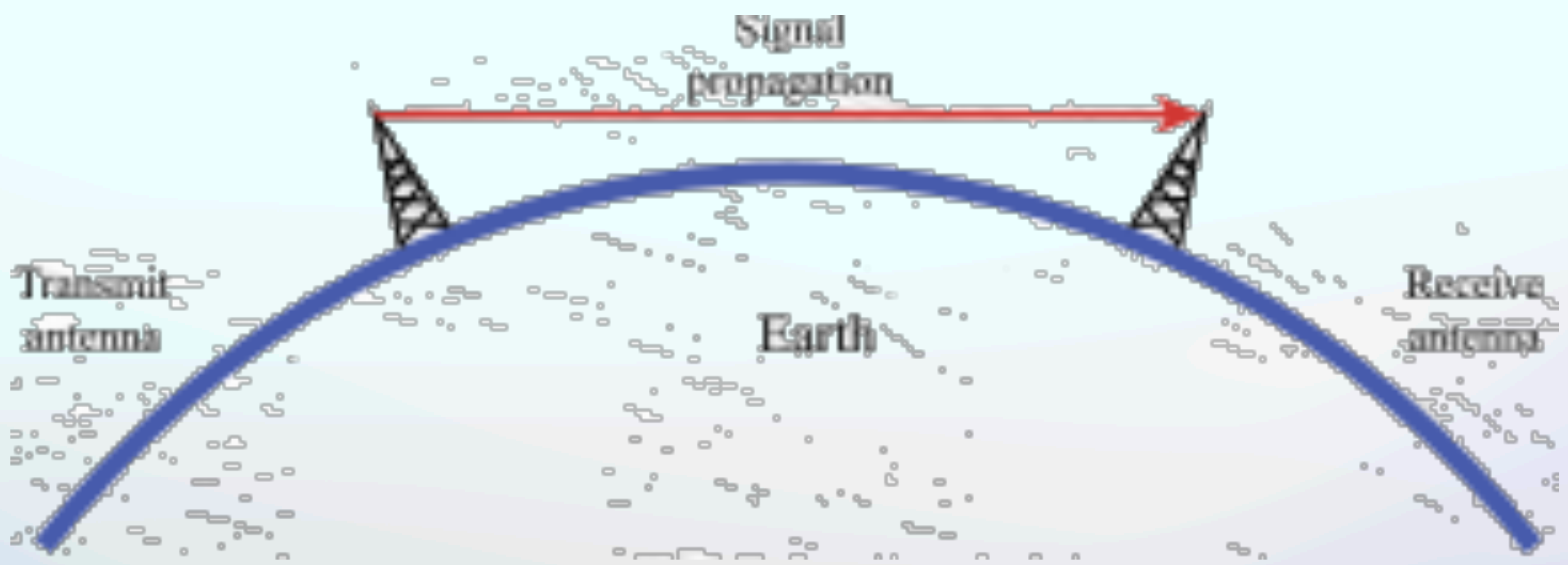
RadioWave (Electromagnetic Wave)



a. Ground Wave Propagation



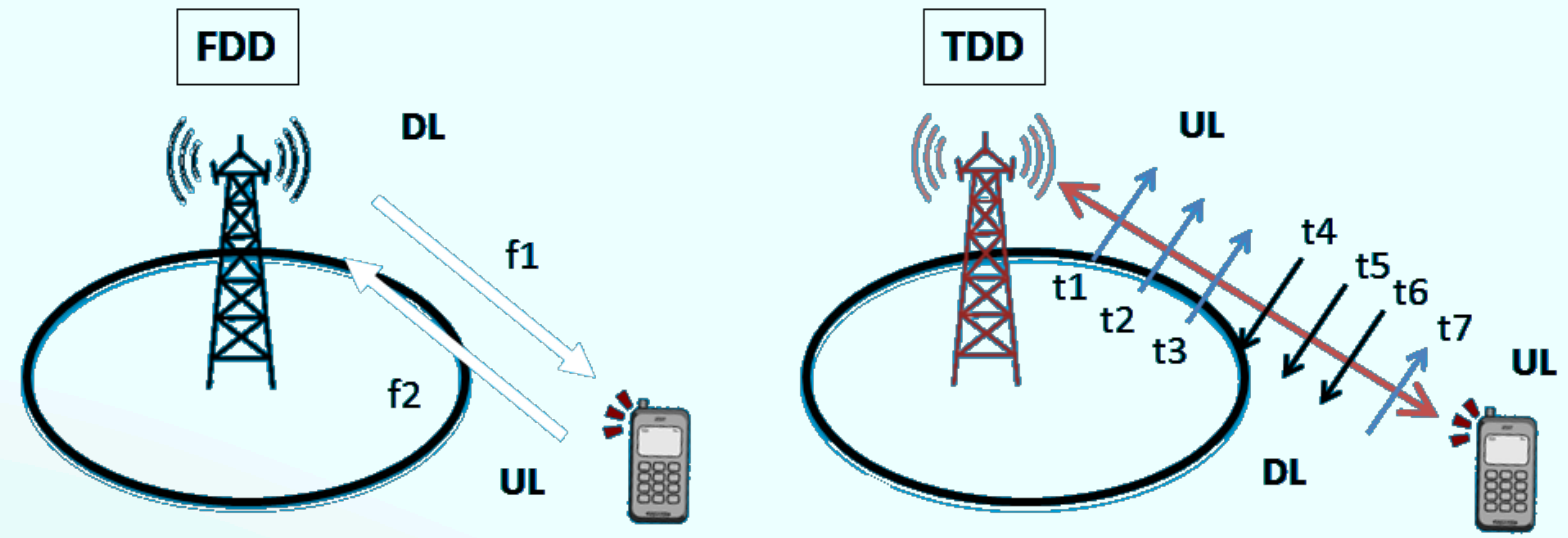
b. Sky Wave Propagation

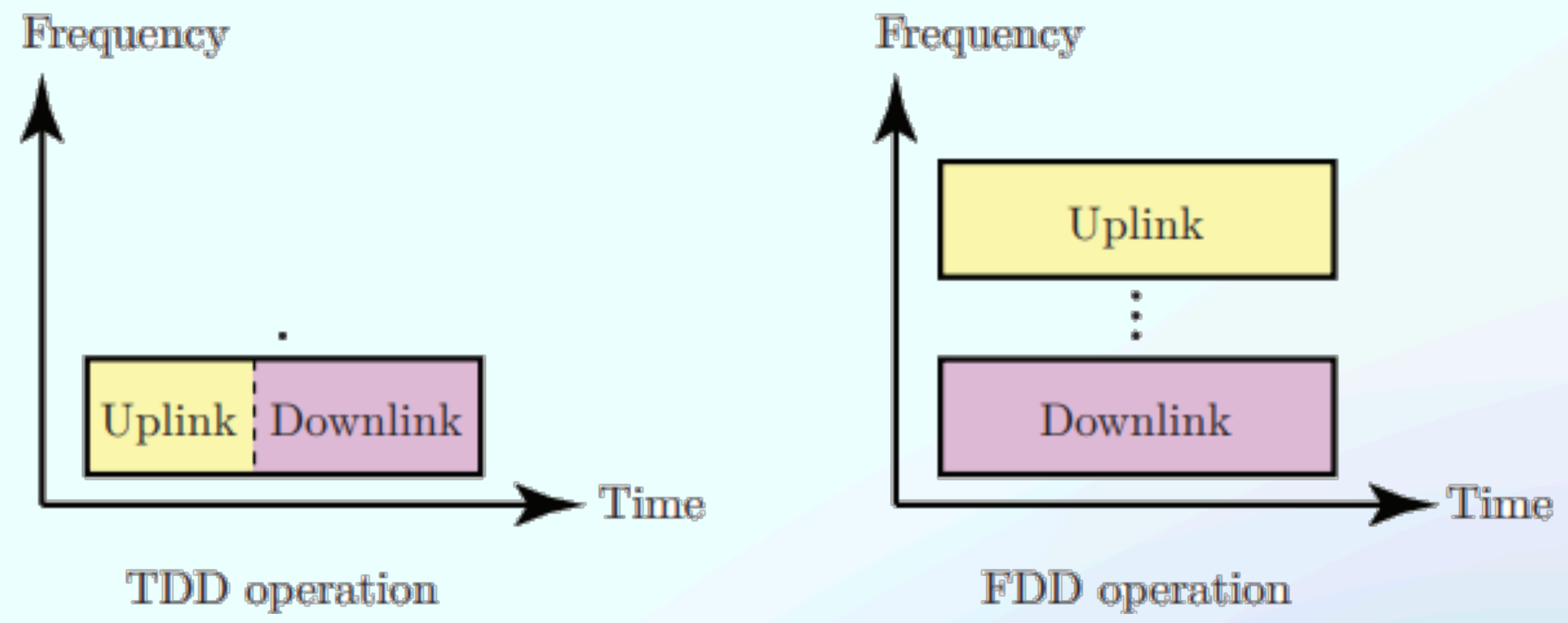


c. Line of Sight (LOS) Wave Propagation

Duplex Types

Frequency Division Duplex and Time Division Duplex



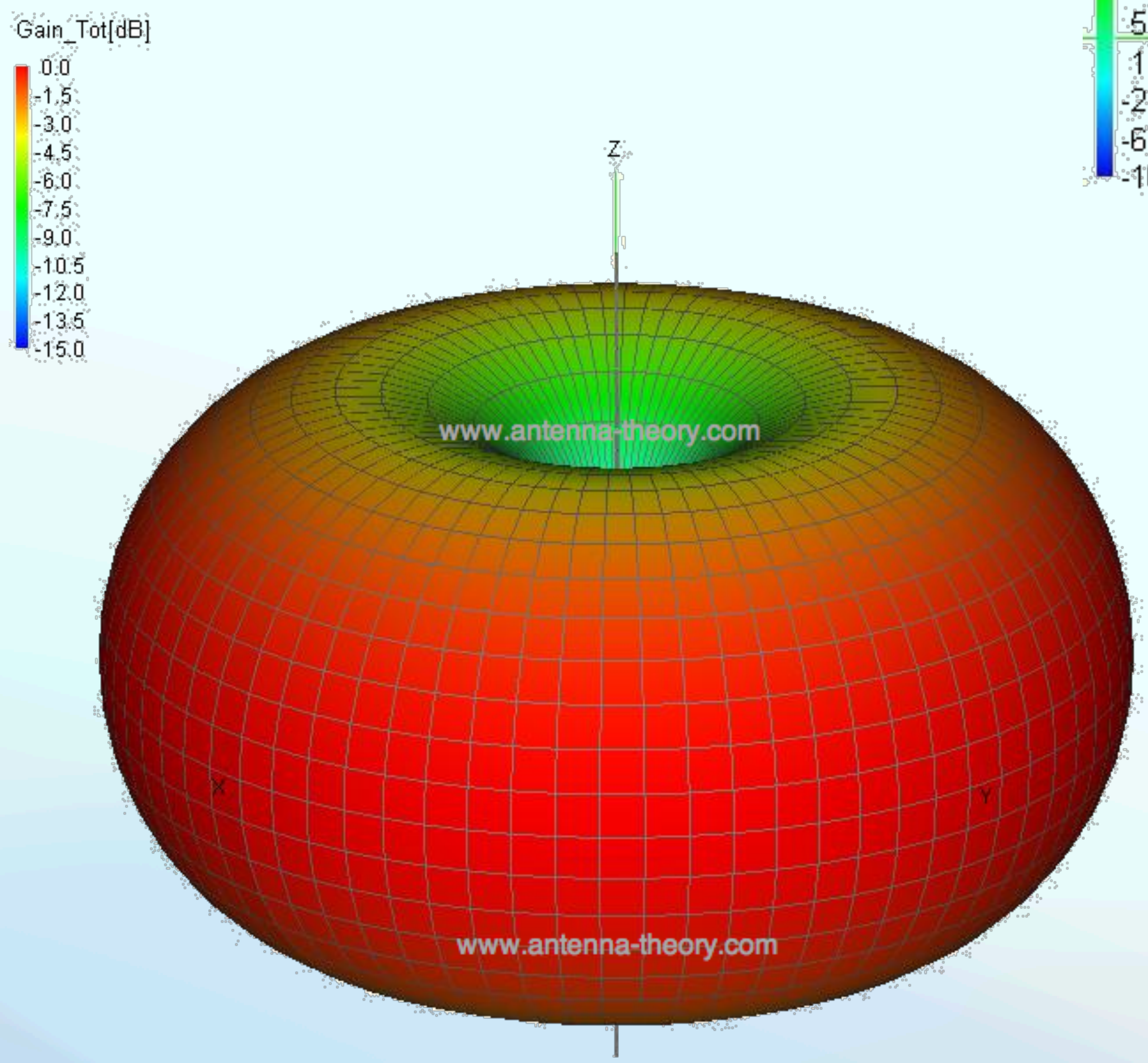


Frequency Division Duplex (FDD) implies that downlink and uplink transmission take place in different, sufficiently separated frequency bands.

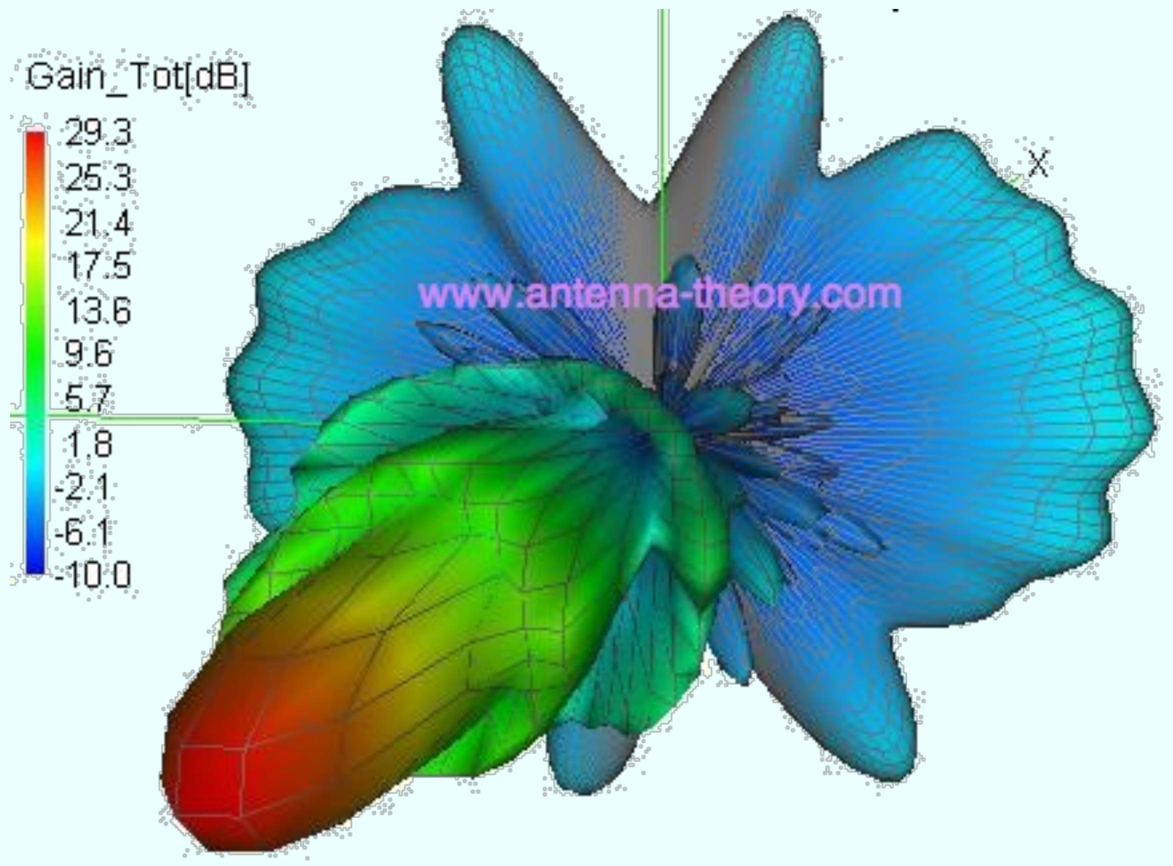
Time Division Duplex (TDD) implies that downlink and uplink transmission take place in different, non-overlapping time slots.

Antenna Radiation Pattern

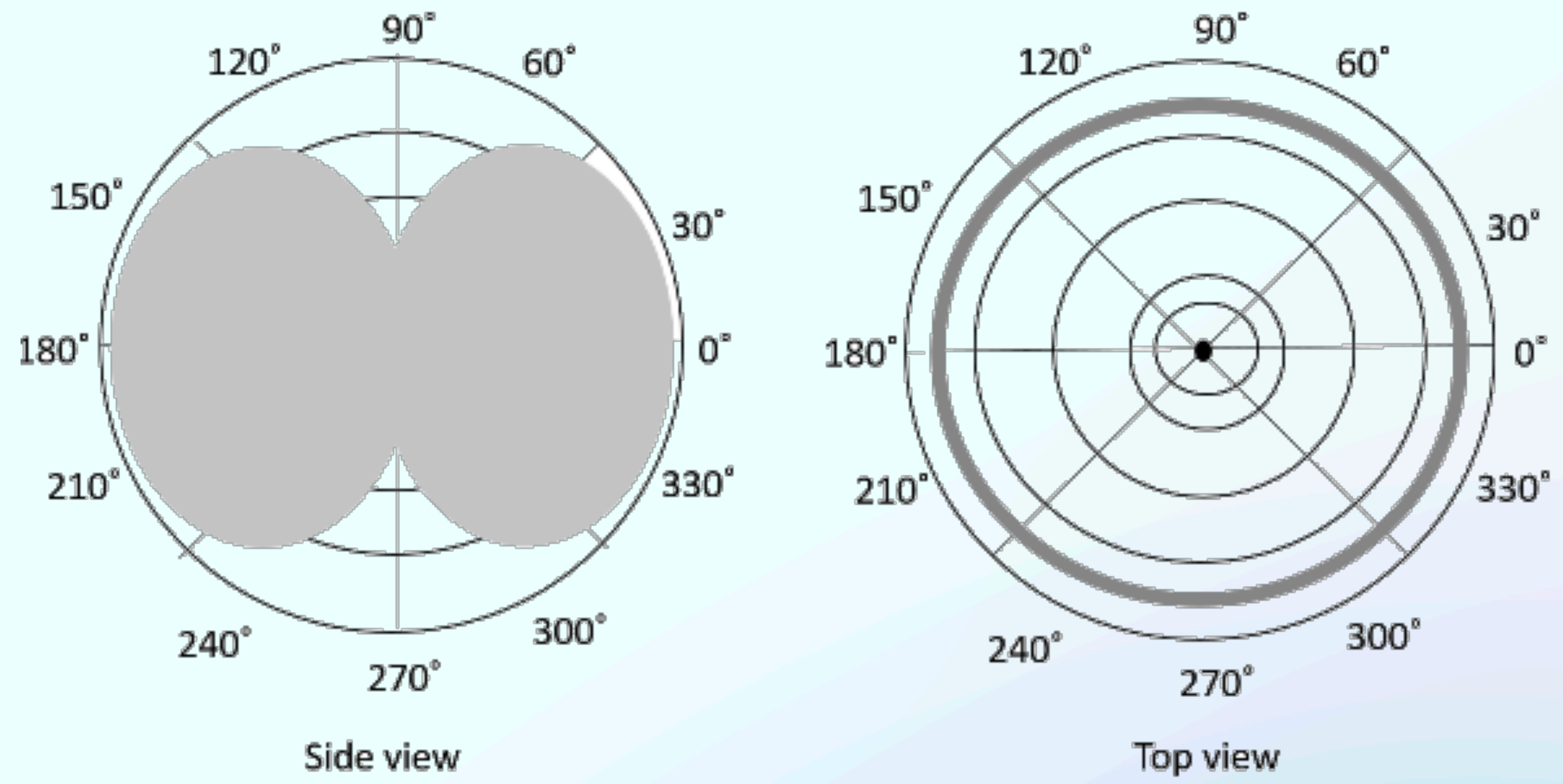
Signal Power at any direction and distance



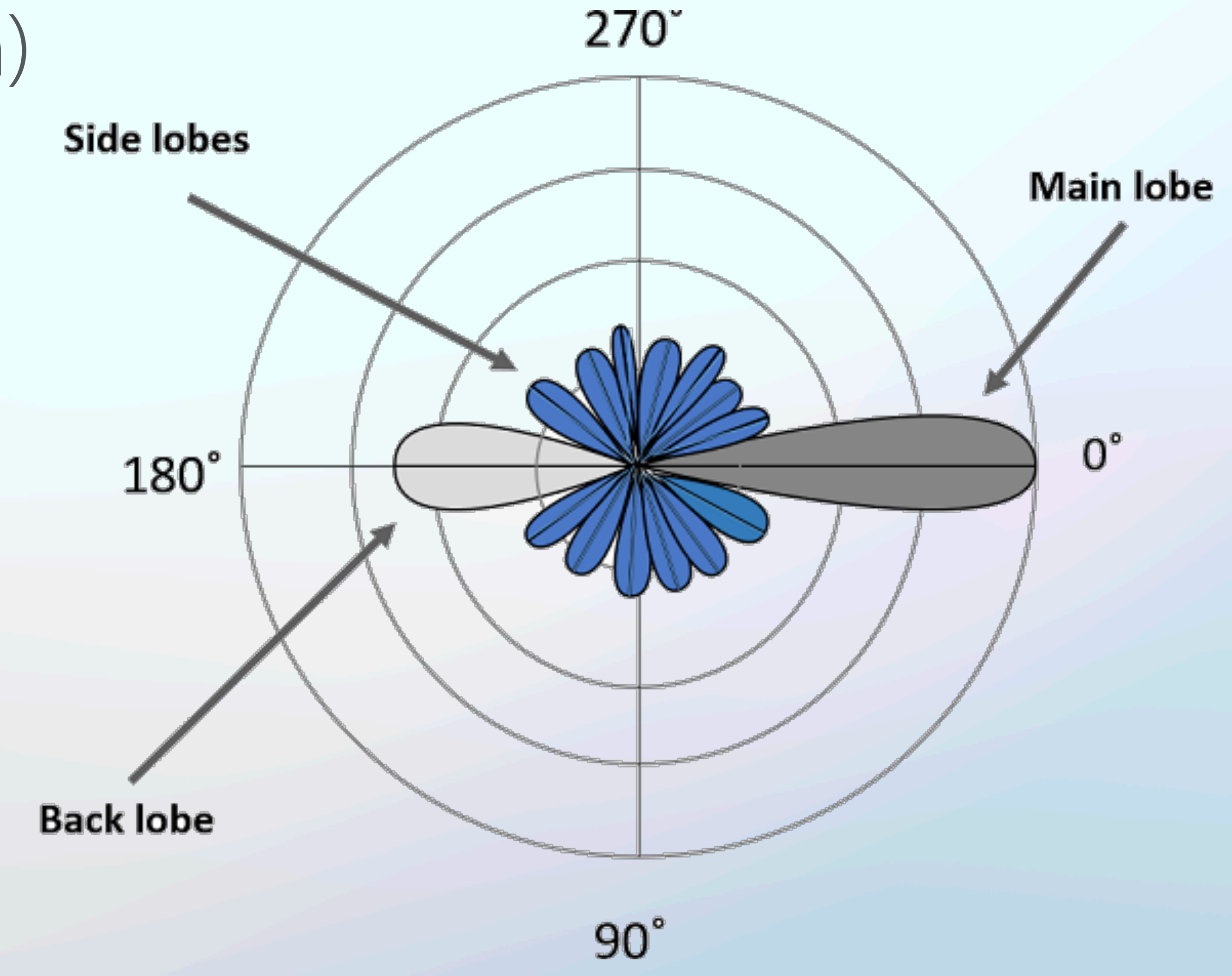
a. Omnidirectional (ideal)



b. Directional (Dish)



c. Dipole Antenna

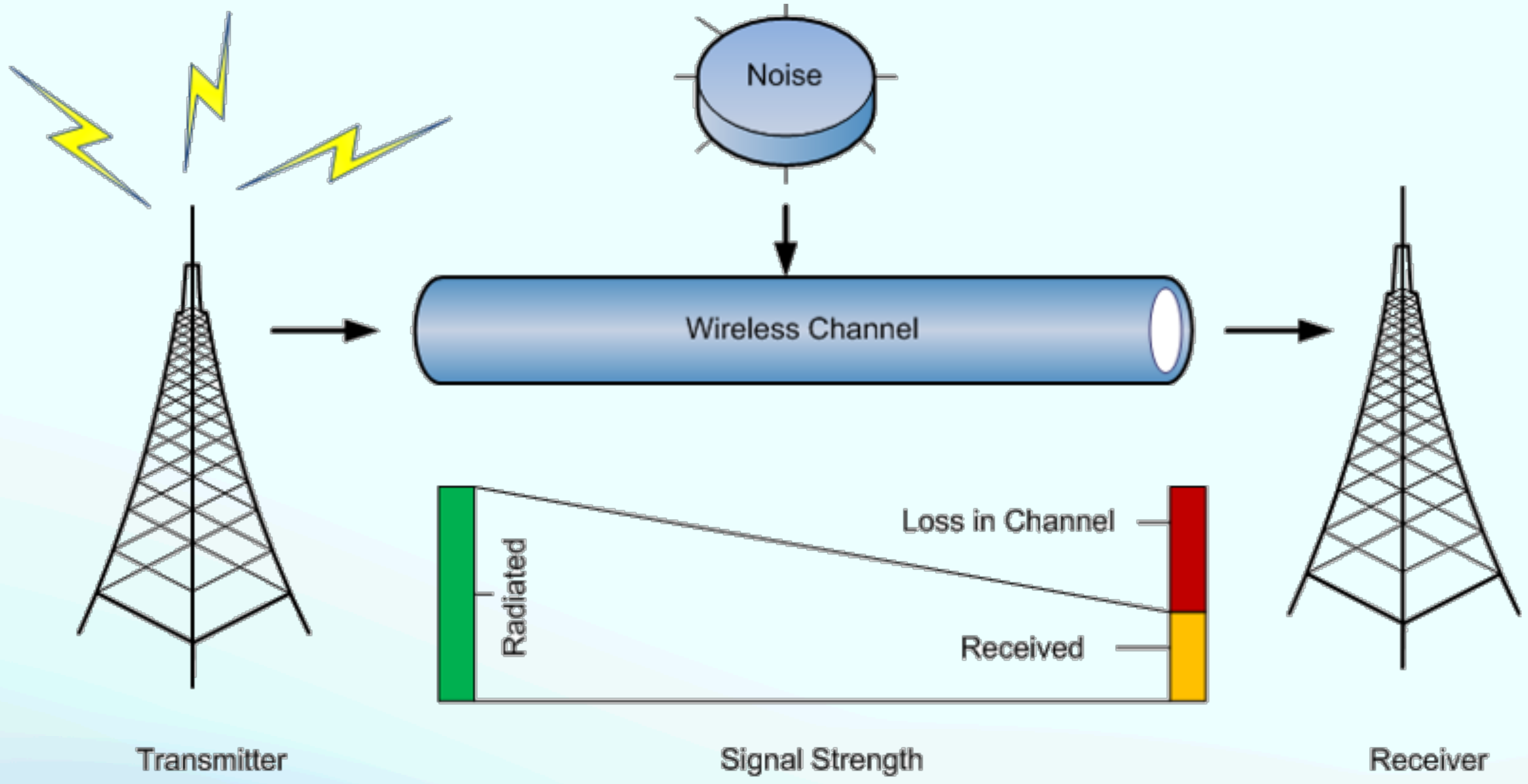


d. Signal Lobes

Radiowave Propagation

Wireless Tx-Rx

Tx-Rx



- One STA acts as Transmitter, one or more STAs receives
- Transmitter injects the electro-magnetic signal into the wireless channel
- The signal follows radio propagation rules and attenuates over distance
- If the signal strength at a receiver is high enough to receive and decode, the packet is received by the receiver.
-

Wireless Tx-Rx

Tx-Rx

Tx Signal Power

Signal Passes Through Medium

Rx Signal Power????

- The signal follows radio propagation rules and attenuates over distance
- If the signal strength at a receiver is high enough to receive and decode, the packet is received by the receiver.

Wireless Tx-Rx

Tx-Rx

Tx Signal Power

Amount of soft drink

Initial Amount

$(steps)^5 ml$

$(steps)^{10} ml$

$(steps)^{25} ml$

Different Rate of attenuation at different medium

Medium's Property

- high enough to receive and decode?

Rx Signal Power????

Are you satisfied with the received Amount of the soft drink?

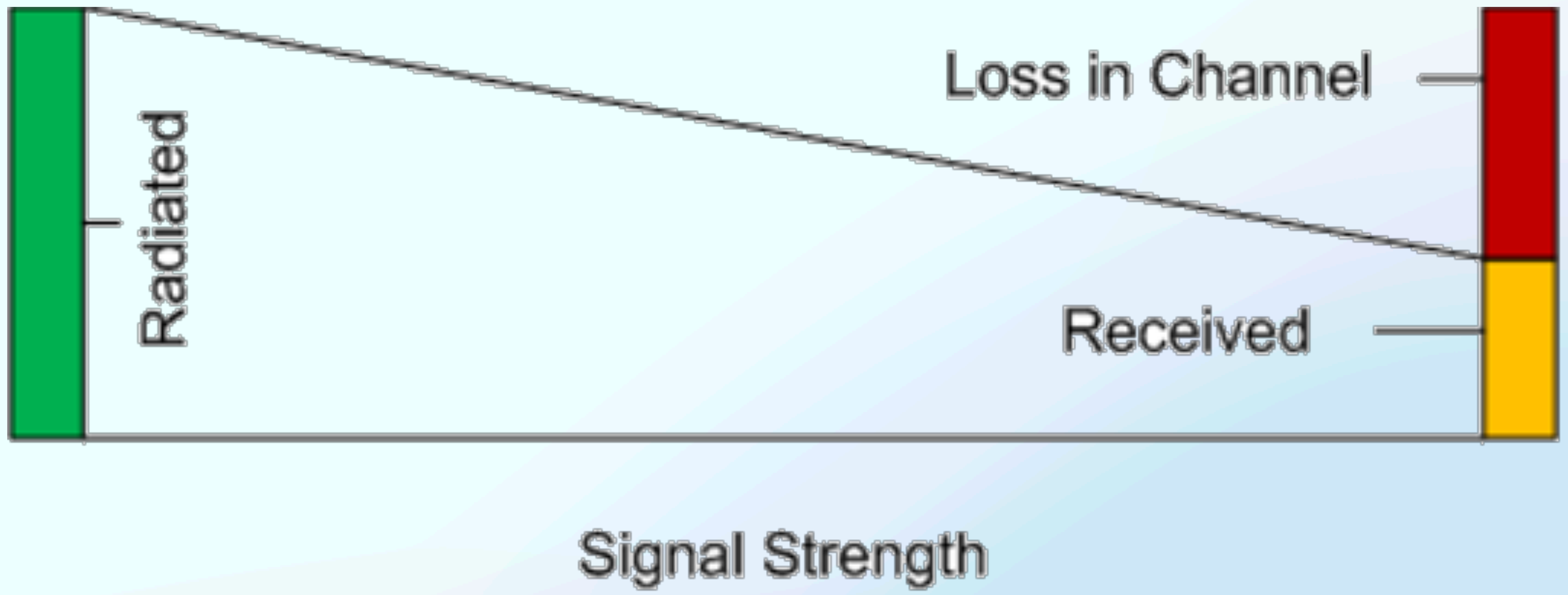
Your (Receiver's) Property

Wireless Communications

Wireless Tx-Rx (Contd..)

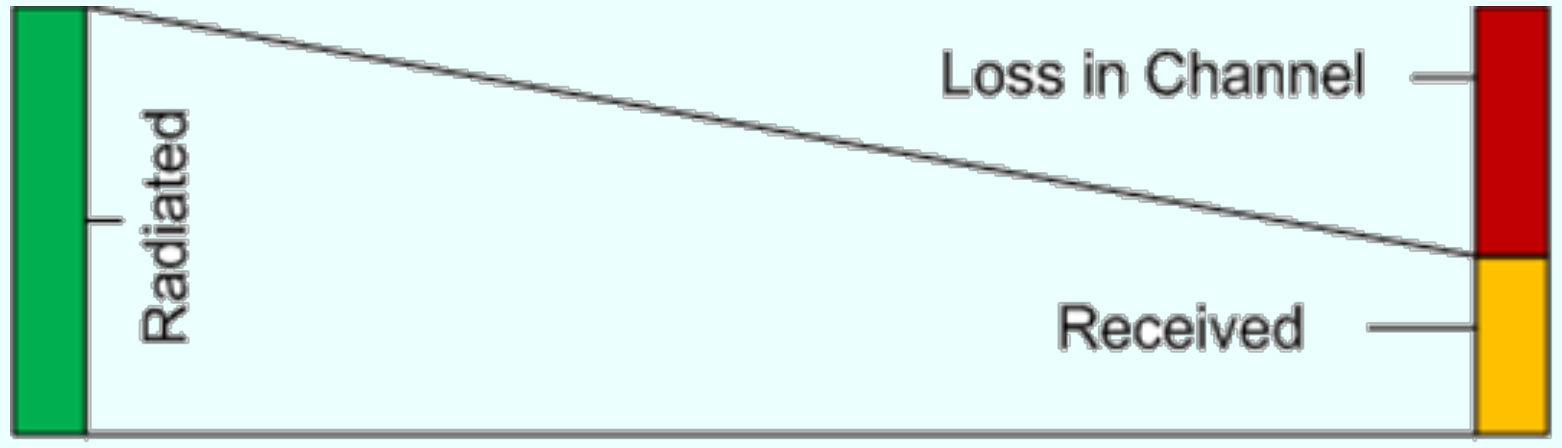
- Signal Level at Receiver
  - Radiated (Transmitted) Signal Strength
  - Channel Quality (Attenuation Factor)
  - Distance between the Transmitting and Receiving STAs

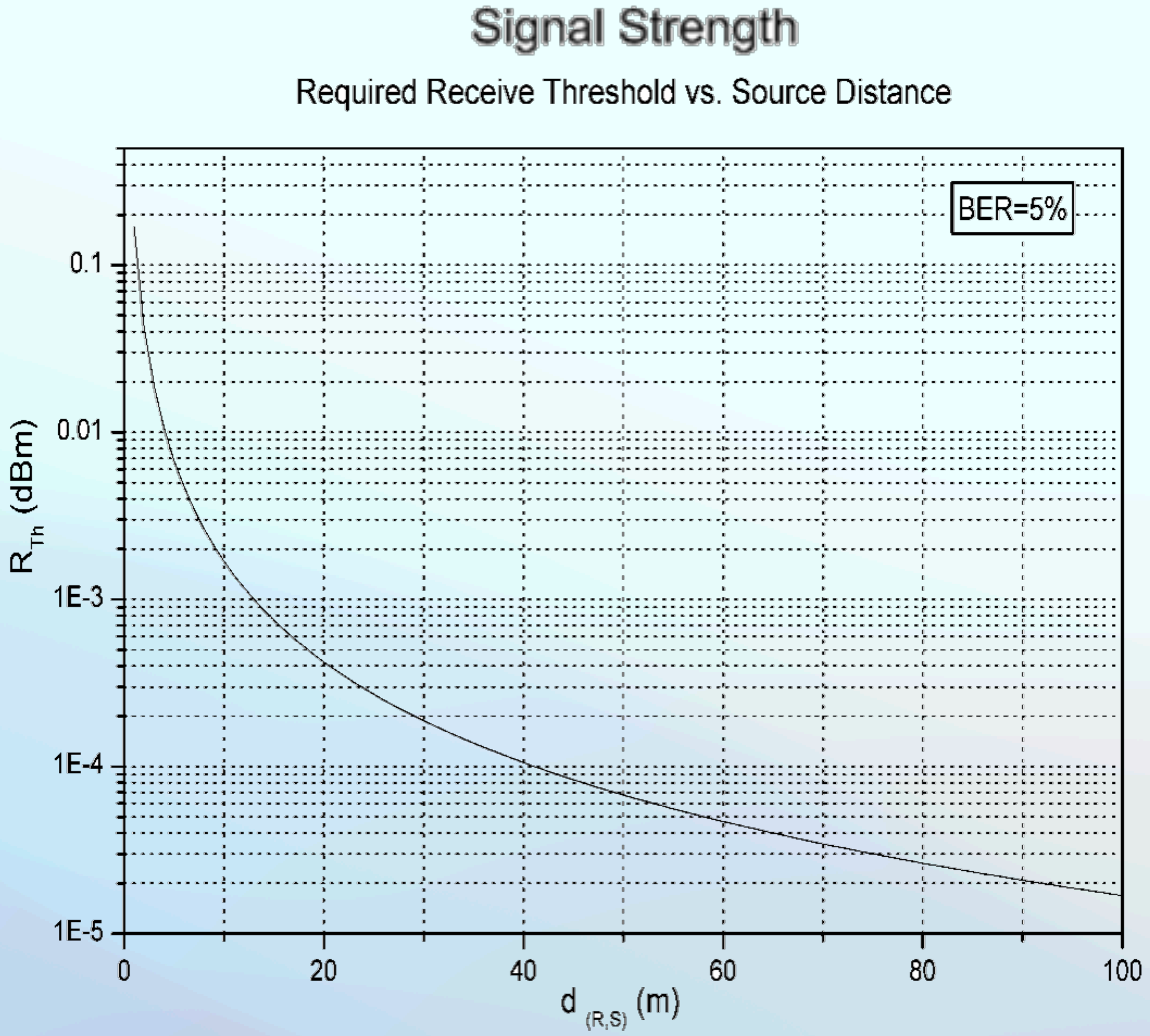
- Receiver Sensitivity
  - The minimum level of the signal strength for receiving a packet
  - Receiver cannot receive and extract a packet if the received signal is below this level



Wireless Communications

Wireless Tx-Rx (Contd..) : Pathloss



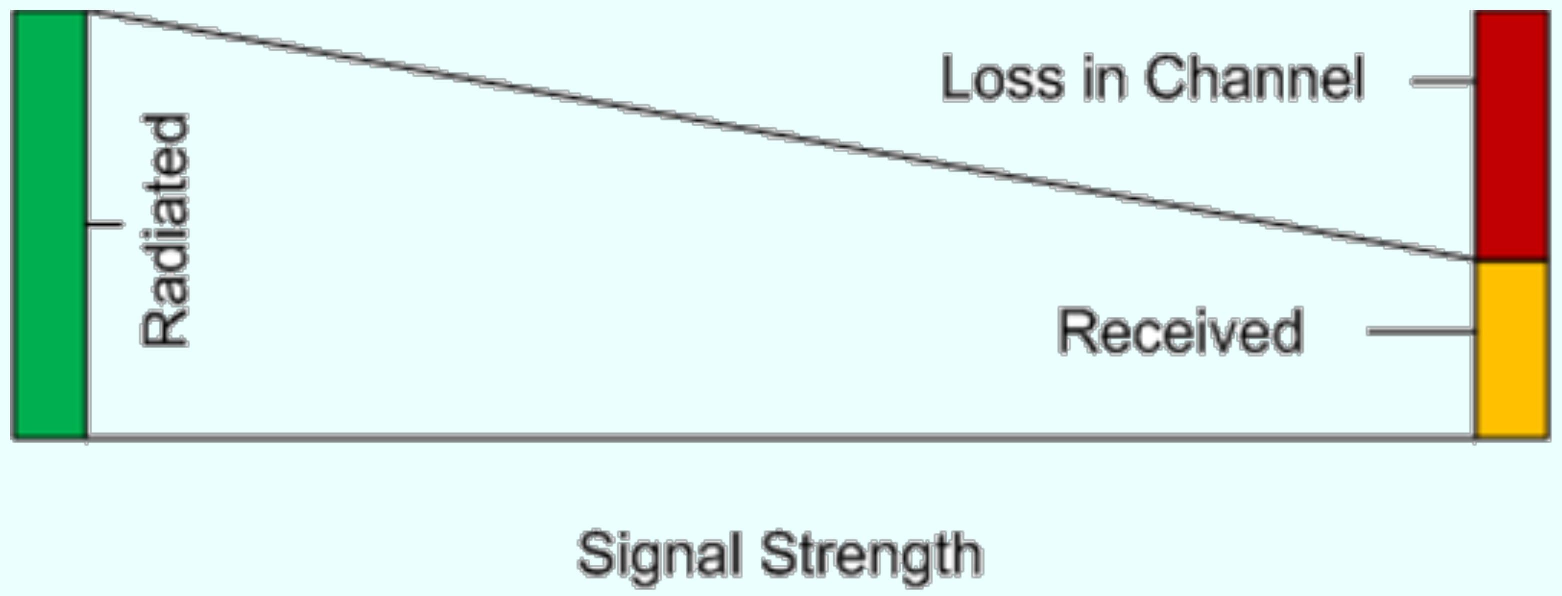


$$P_r(d) = P_t - PL(d_0) - 10\gamma(\log_{10}\left(\frac{d}{d_0}\right) + \mathcal{N}(0,\sigma_n)$$

- where,
  - $P_r(d)$ is the Signal Strength at distance d from the Transmitter
  - $P(t)$ is the Radiated/Transmitted Signal Strength from the Transmitter
  - $PL(d_0)$ is the Power Loss at a reference distance $d_0; here, (0 < d_0 \leq 1)$
  - γ is the Channel Quality (Attenuation Factor)
  - d is the distance between the Transmitter and Receiver
  - $\mathcal{N}(0,\sigma_n)$ is the noise

Wireless Communications

Pathloss Models..



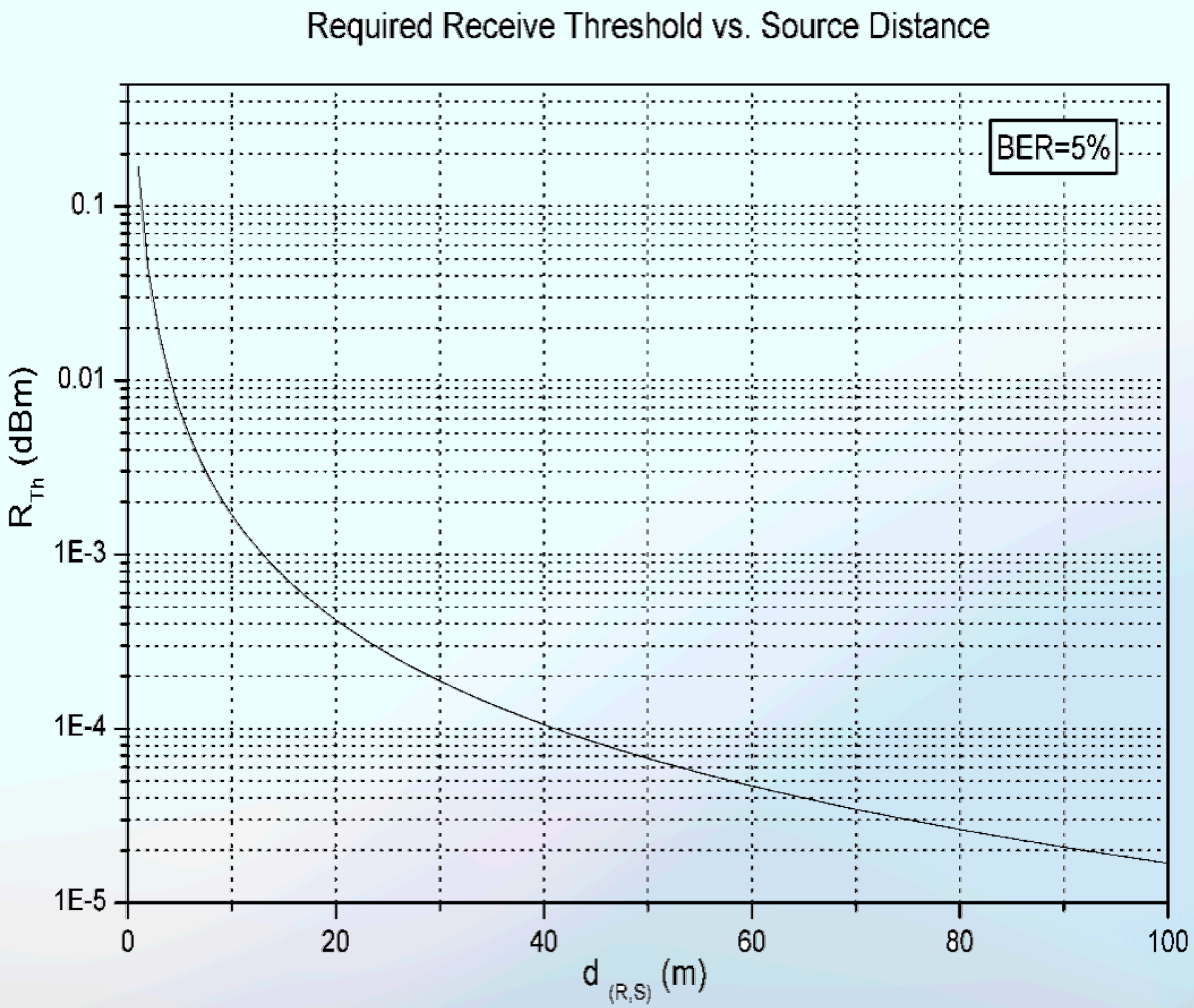
$$P_r(d) = P_t - PL(d_0) - 10\gamma \log_{10}\left(\frac{d}{d_0}\right) + \mathcal{N}(0, \sigma_n)$$

Simple Form (Noiseless)

$$P_r(d) = P(d_0) - 10\gamma \log_{10}\left(\frac{d}{d_0}\right)$$

$$P(d_0) = P_t - PL(d_0)$$

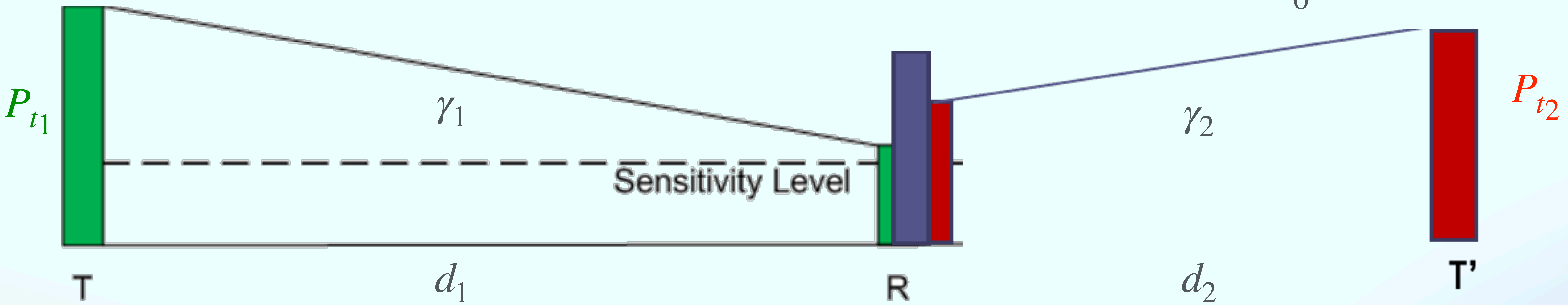
$$PL(d_0) = 20 \log_{10}\left(\frac{4\pi d_0 f}{c}\right)$$



Wireless Communications

Collisions

$$P_r(d) = P_t - PL(d_0) - 10\gamma \log_{10}\left(\frac{d}{d_0}\right) + \mathcal{N}(0,\sigma_n)$$



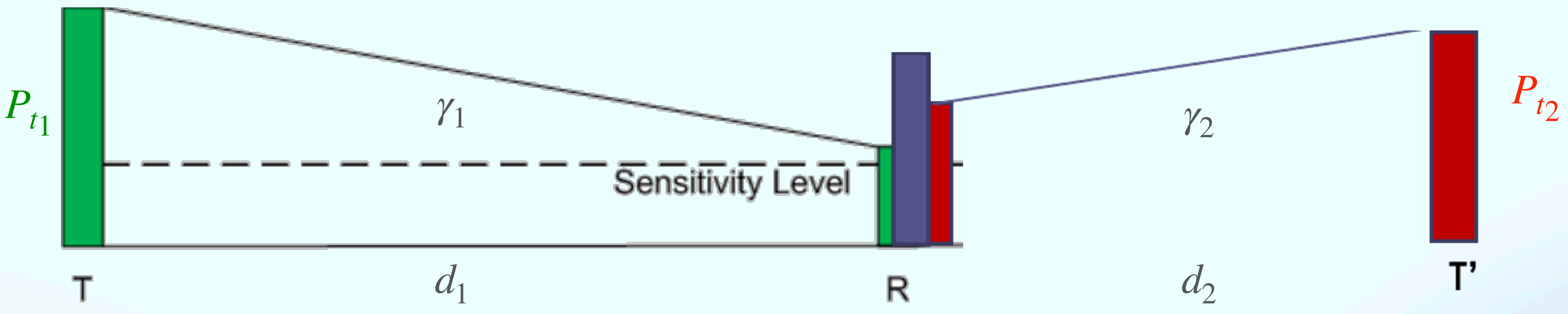
$$P_r(d_1) = P_{t_1} - PL(d_0) - 10\gamma_1 \log_{10}\left(\frac{d_1}{d_0}\right) + \mathcal{N}(0,\sigma_n)$$

$$P_r(d_2) = P_{t_2} - PL(d_0) - 10\gamma_2 \log_{10}\left(\frac{d_2}{d_0}\right) + \mathcal{N}(0,\sigma_n)$$

$$PL(d_0) = 20 \log_{10}\left(\frac{4\pi d_0 f}{c}\right)$$

Wireless Communications

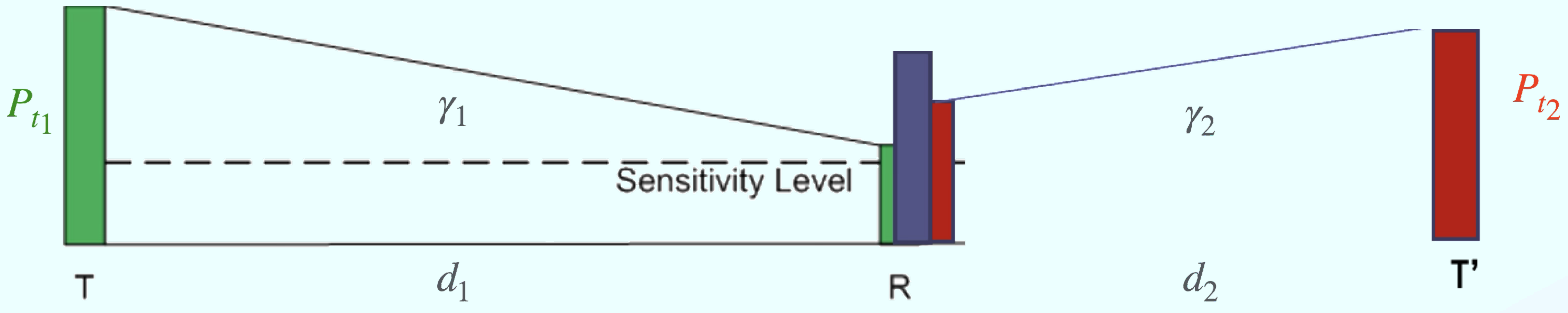
Collisions



- Receiver R is supposed to receive signal from T as the received signal is above the threshold
- Receiver R can/cannot receive from T′ depending on signal strength
- When they arrive simultaneously at R, the combined level is also above the sensitivity, however, R cannot receive either

Wireless Communications

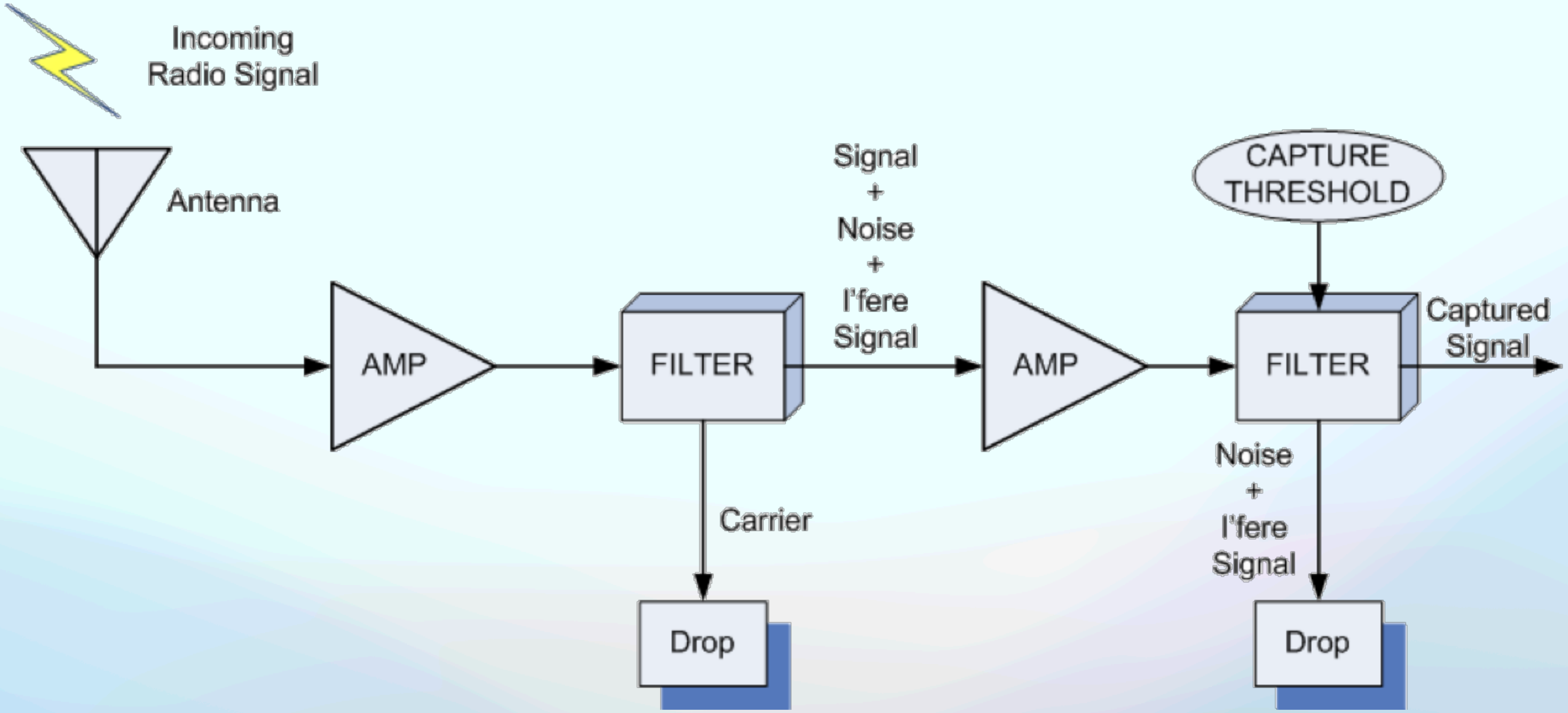
Received Signal Capturing



- In practice, wireless channel state varies over time, and it consists of a number of noise sources that add noise
- Transmitted signals from other STAs are also added with intended signal
- Capture means Extracting information from received signal from superposed received signal having noise and signals from other STAs (**completely depends on receiver circuitry**)
- **Capture Threshold** (Receiving Circuitry Property): The minimum required ratio of intended signal to noise and interference at which the receiver can capture intended signal

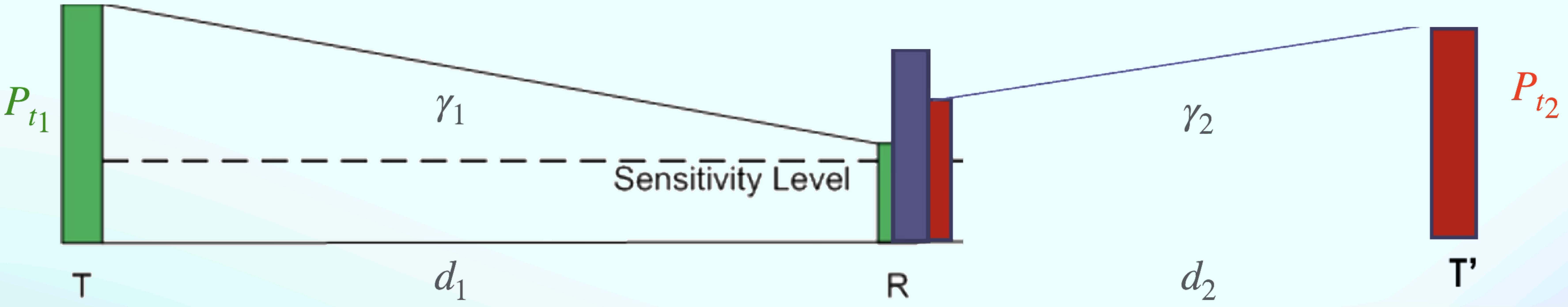
Wireless Communications

Receiver Operation (Rx)



Wireless Communications

Received Signal Capturing



$$\frac{r_i}{\sum_{i \neq j} r_j + N} \geq \beta_0$$

$r_i \equiv$ intended signal from STA i

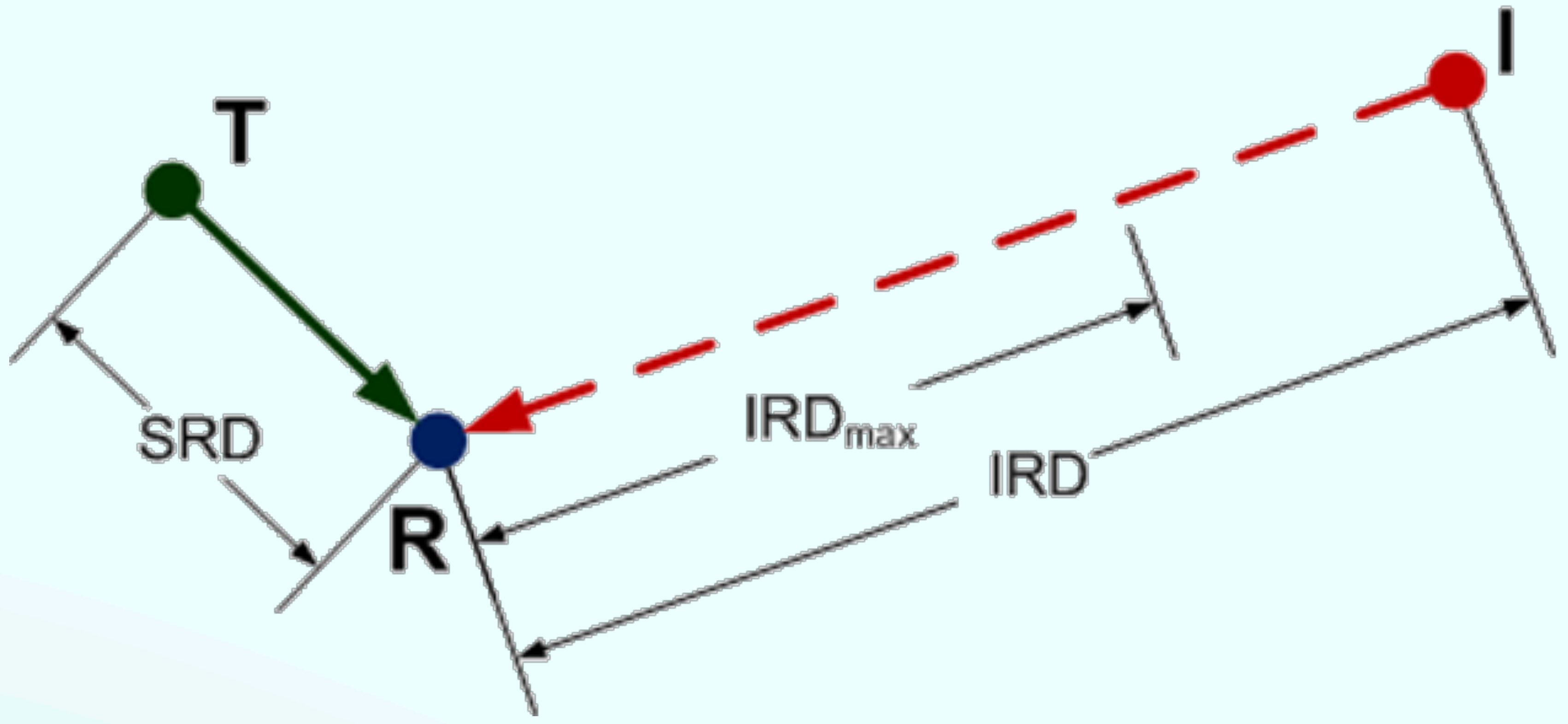
$r_j \equiv$ signal from other STAs

$N \equiv$ Ambient White Noise

$\beta_0 \equiv$ Capture Threshold

Wireless Communications

Simple Interference Model



$$IRD \leq \left(\frac{r(SRD)}{r(IRD) + N}\right)^{\frac{1}{\gamma}}$$

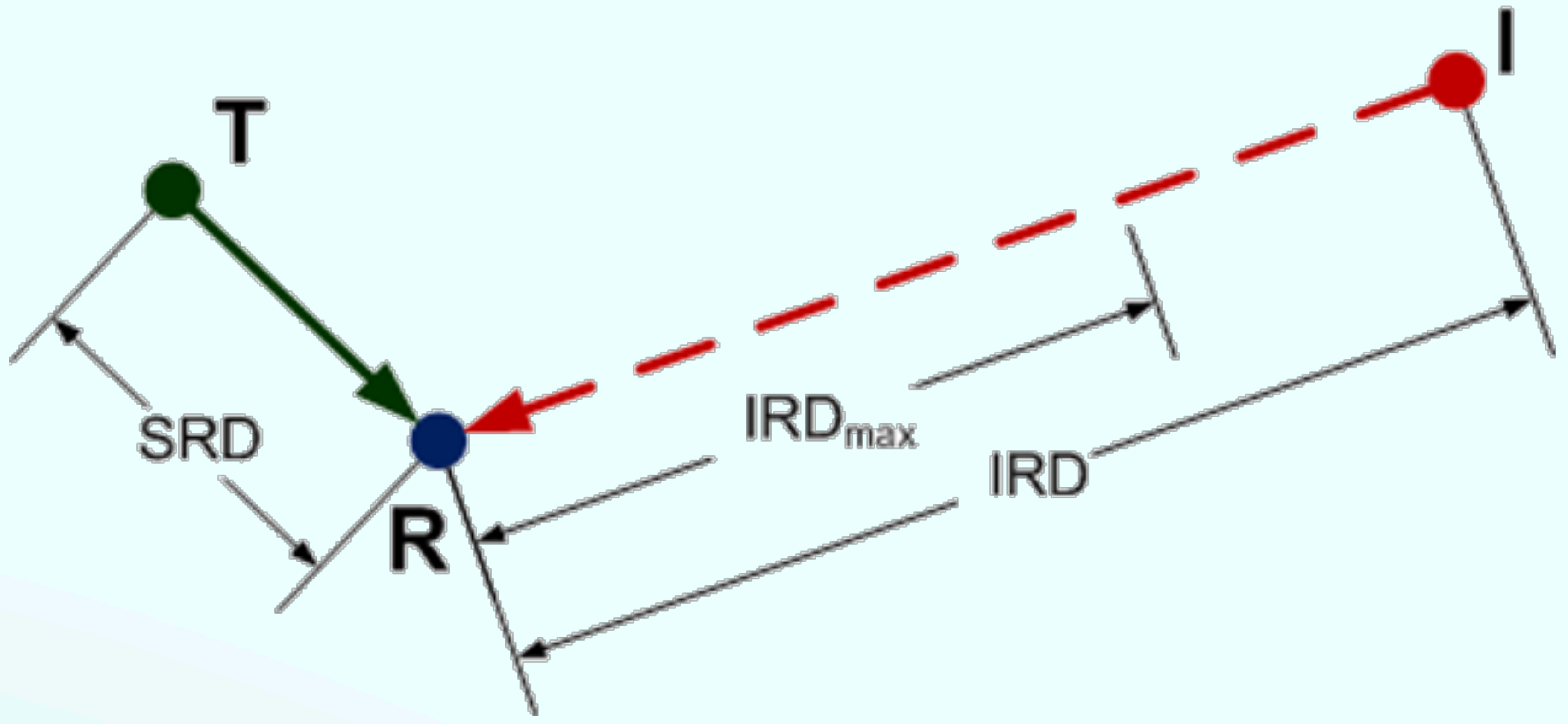
$$IRD \leq SRD \times \beta^{\frac{1}{\gamma}}$$

Interferer 'I' would interfere at 'R' and disrupt the reception of signals transmitted from 'T' if..

Angle of arrival is not important (except the mobility condition)

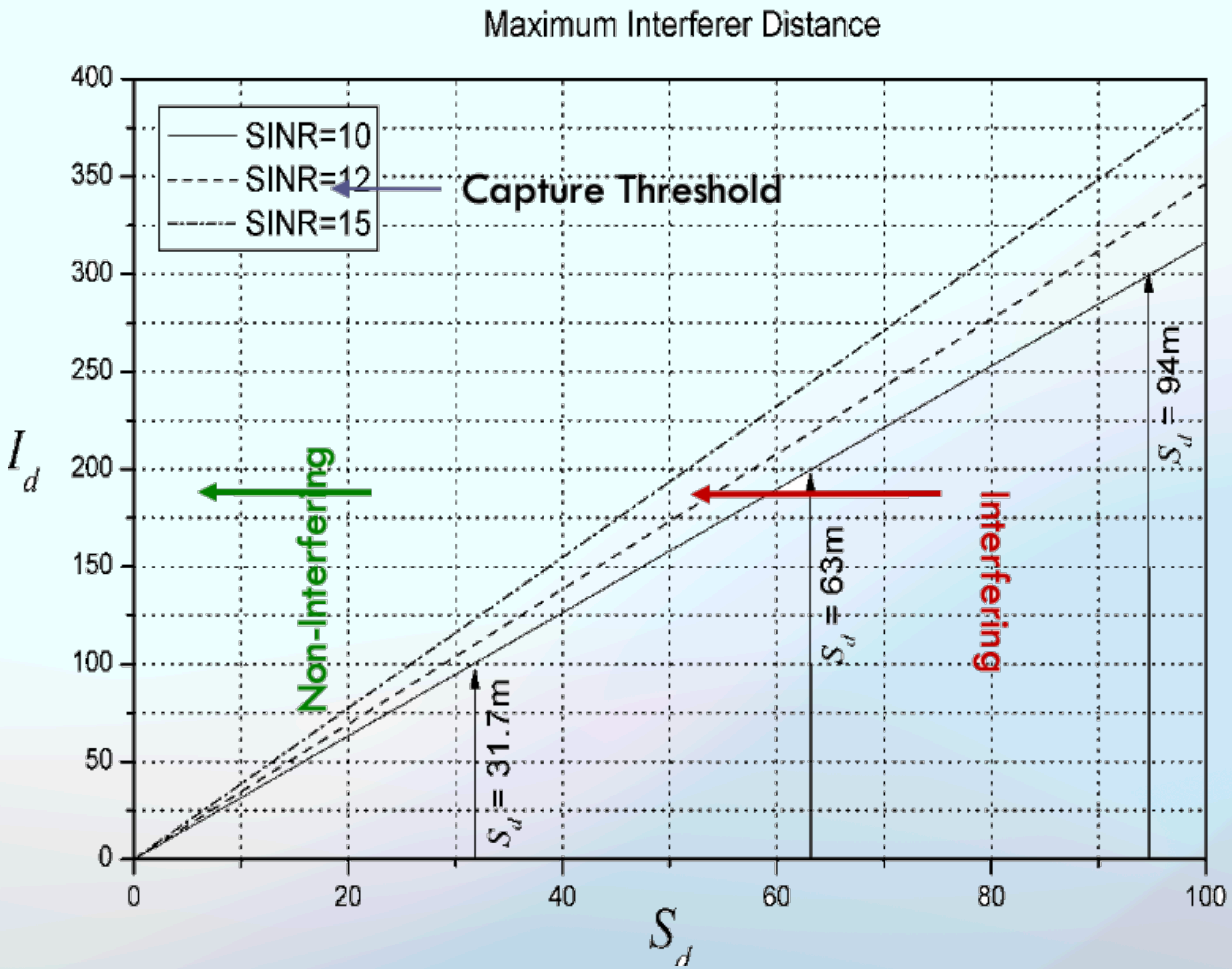
Wireless Communications

Simple Interference Model



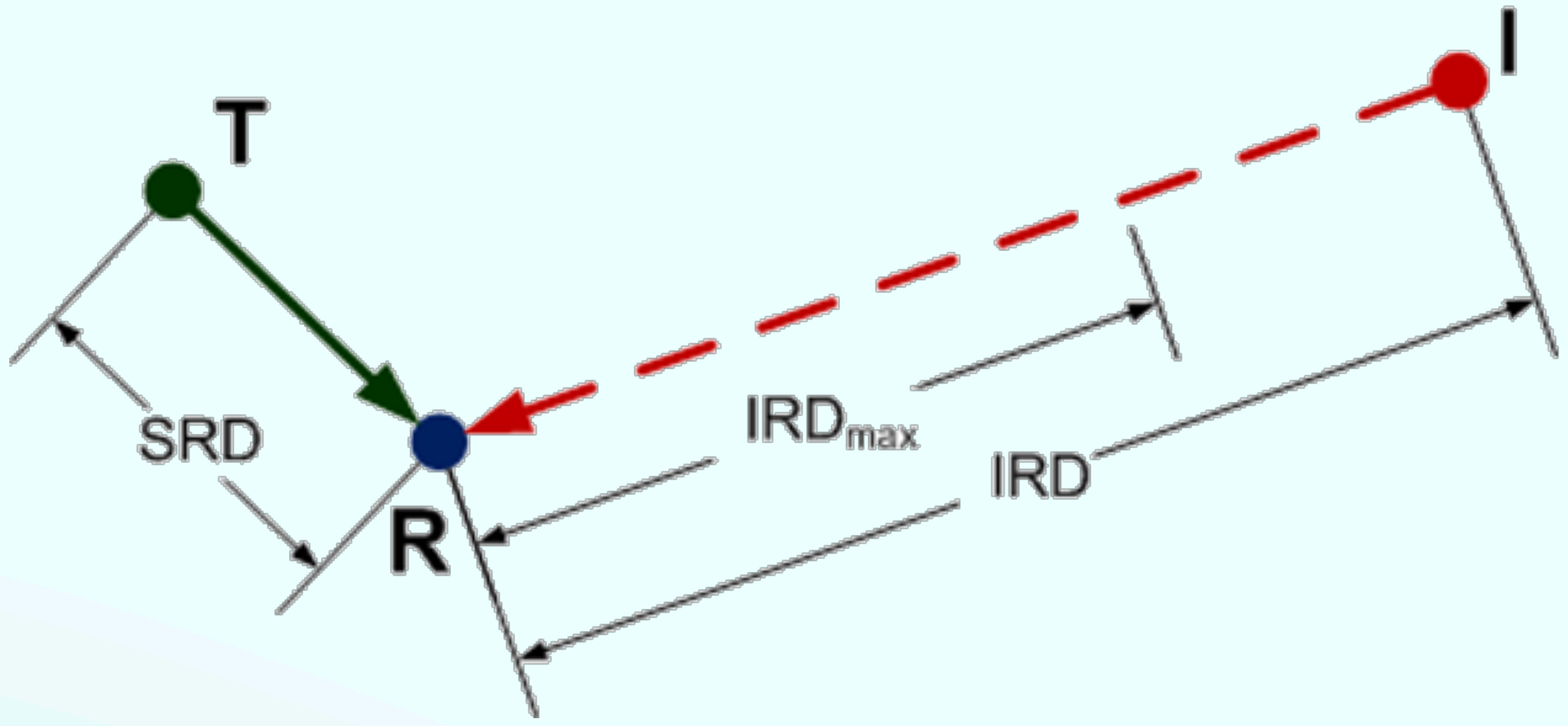
$$IRD \leq \left(\frac{r(SRD)}{r(IRD) + N} \right)^{\frac{1}{\gamma}}$$

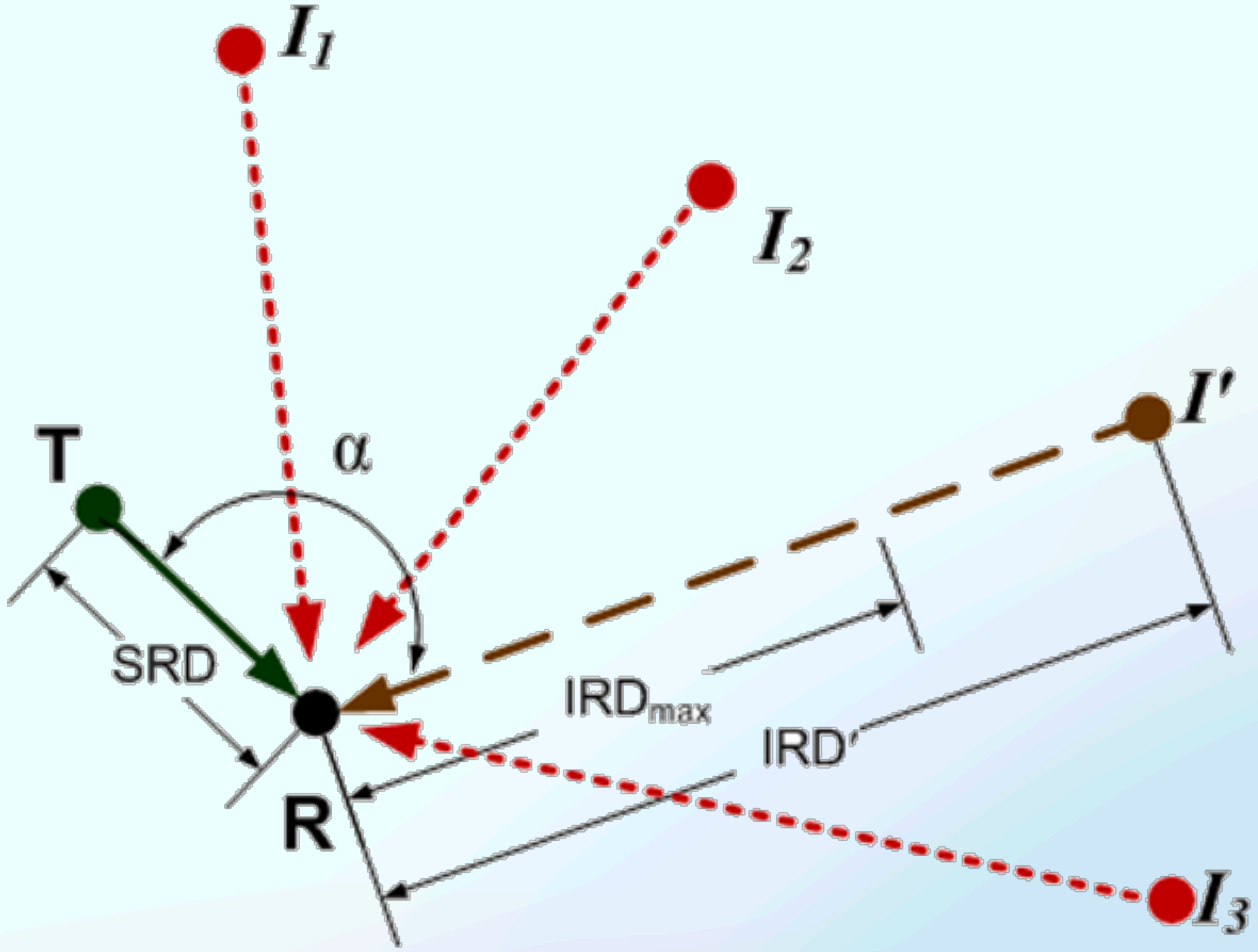
$$IRD \leq SRD \times \beta^{\frac{1}{\gamma}}$$



Wireless Communications

General Interference Model





$$IRD \leq \left(\frac{r(SRD)}{r(IRD)+N}\right)^{\frac{1}{\gamma}}$$

$$IRD \leq SRD \times \beta^{\frac{1}{\gamma}}$$

tr4jvgs

Questions?