

Outline



- A preliminary overview
- **Propagation characteristics**
- ISO-OSI Model
- Physical layer: modulation
- MAC layer:
 - Fixed resource assignment
 - Random access
 - Ethernet (CSMA/CD)
 - WiFi (CSMA/CA)
- Personal Area Networks
 - Bluetooth
 - Zigbee
- Cellular network dimensioning
- Cellular networks
 - From GSM (2G) to UMTS (3G)
 - LTE (4G)

Propagation characteristics



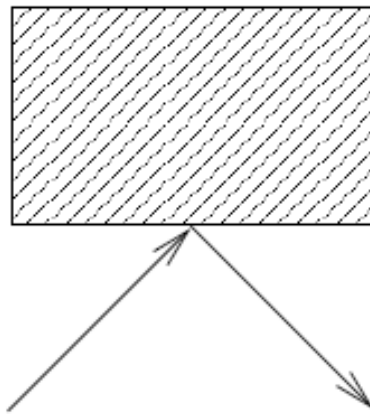
- Alla lavagna:
 - Power gain
 - Transmission loss and repeaters
 - Radio transmission

A. B. Carlson e P. B. Crilly, *Communication Systems: an Introduction to Signals and Noise in Electrical Communication*, McGraw Hill Higher Education, 5th edition, 2009. ISBN-13: 978-0071263320.

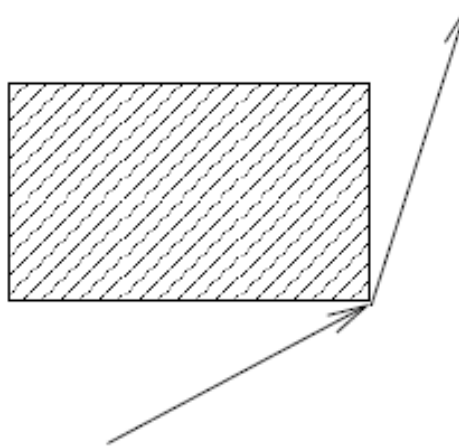
Propagation modes



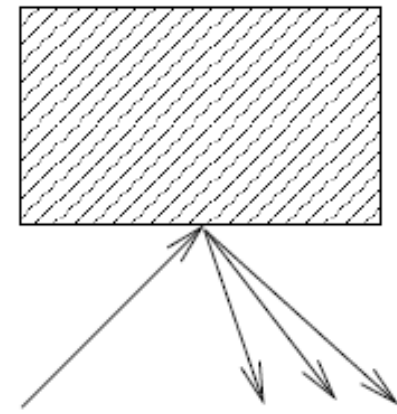
- Line-Of-Sight (**LOS**): there is a direct path between source and destination (typical of countryside).
- Non-Line-Of-Sight (**N-LOS**): there is no direct path between source and destination (typical of urban).



REFLECTION



DIFFRACTION



SCATTERING

Effects in N-LOS Environments

- **Attenuation**: becomes remarkable at long distances (e.g., 10 km).

Friis Formula

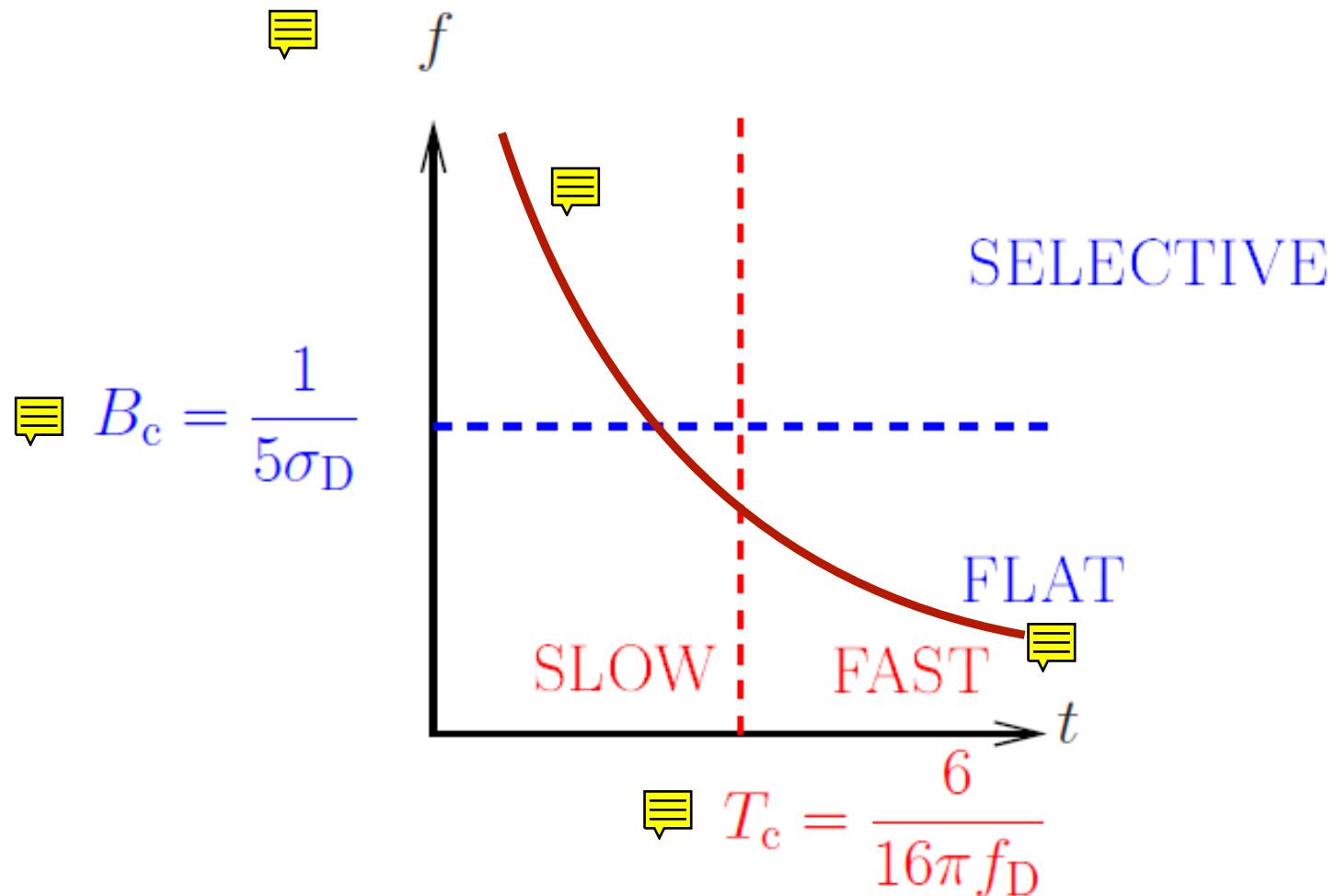
$$P_r(d) = P_t G_t G_r \left(\frac{\lambda}{4\pi d} \right)^\nu = P_t G_t G_r \left(\frac{c}{4\pi d f_c} \right)^\nu$$


with $\nu = 2 \div 4$.

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- **Shadowing**: becomes remarkable at medium distances (e.g., 1 km). It is a fluctuation of the received power around a mean value and it can be described by a lognormal distribution. 
 - **Short-term fading**: becomes remarkable at short distances (e.g., 100 m). It is a rapid fluctuation of the received power around the mean value (with also negative spikes) and it can be described by a Rayleigh distribution. 

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Fading Characterization



Fading Counter-acts



- **Diversity**: in time (rake receiver), frequency (frequency hopping), space (multiple antennas, space-time codes, polarization diversity, etc.). 
- **Smart Antennas**: antennas' lobes are properly modulated according to the direction they transmit $\Rightarrow$ a lot of problems in the presence of mobility!!!

