# WAVE PROPAGATION PARAMETERS

# ELECTROMAGNETIC WAVES

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- How strong?

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# PROPAGATION CONSTANT

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- $\beta$ - Imaginary part: phase constant (*rad/m*)

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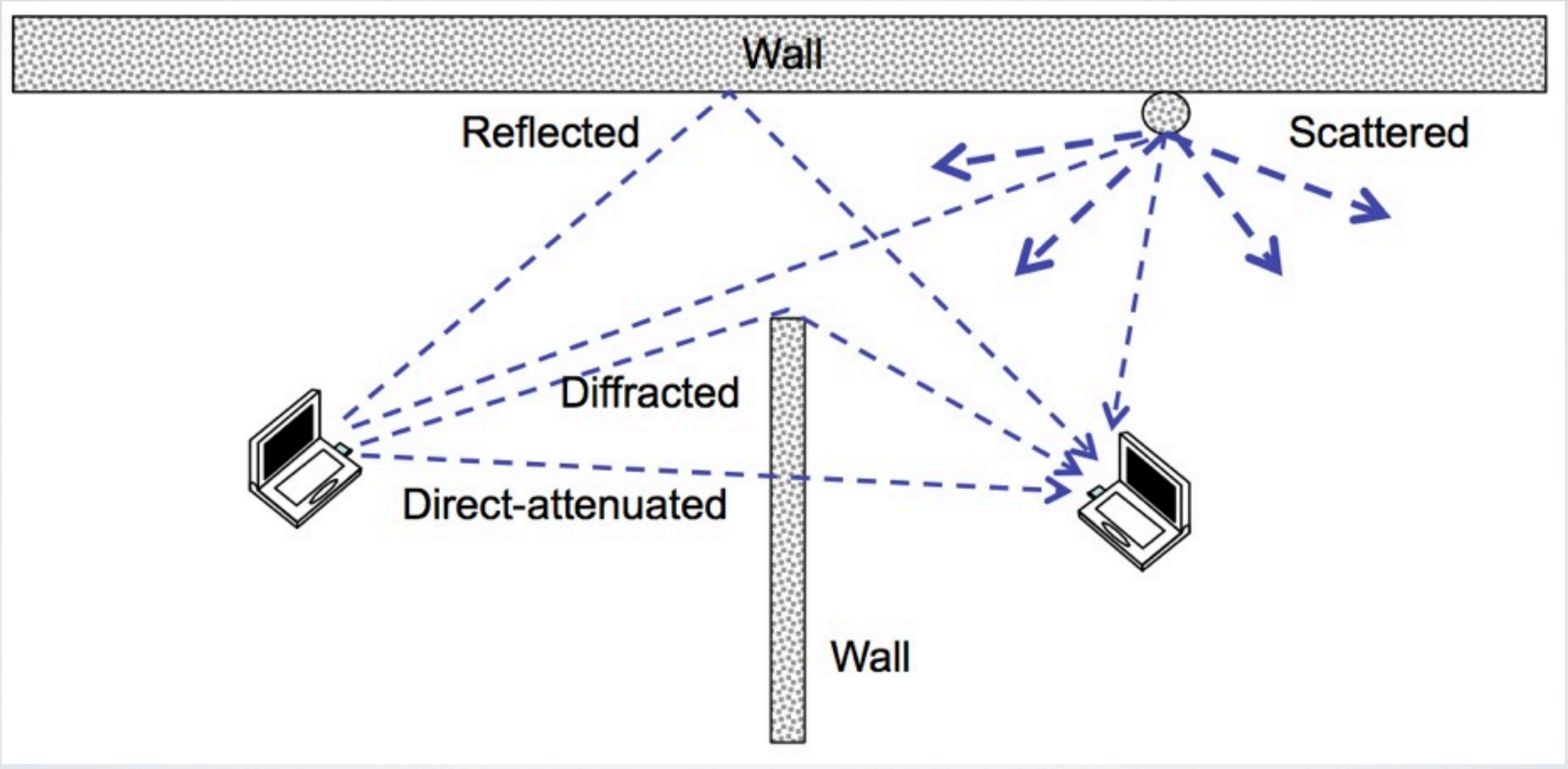
- Ionospheric effects (outdoor)

# INDOOR PROPAGATION



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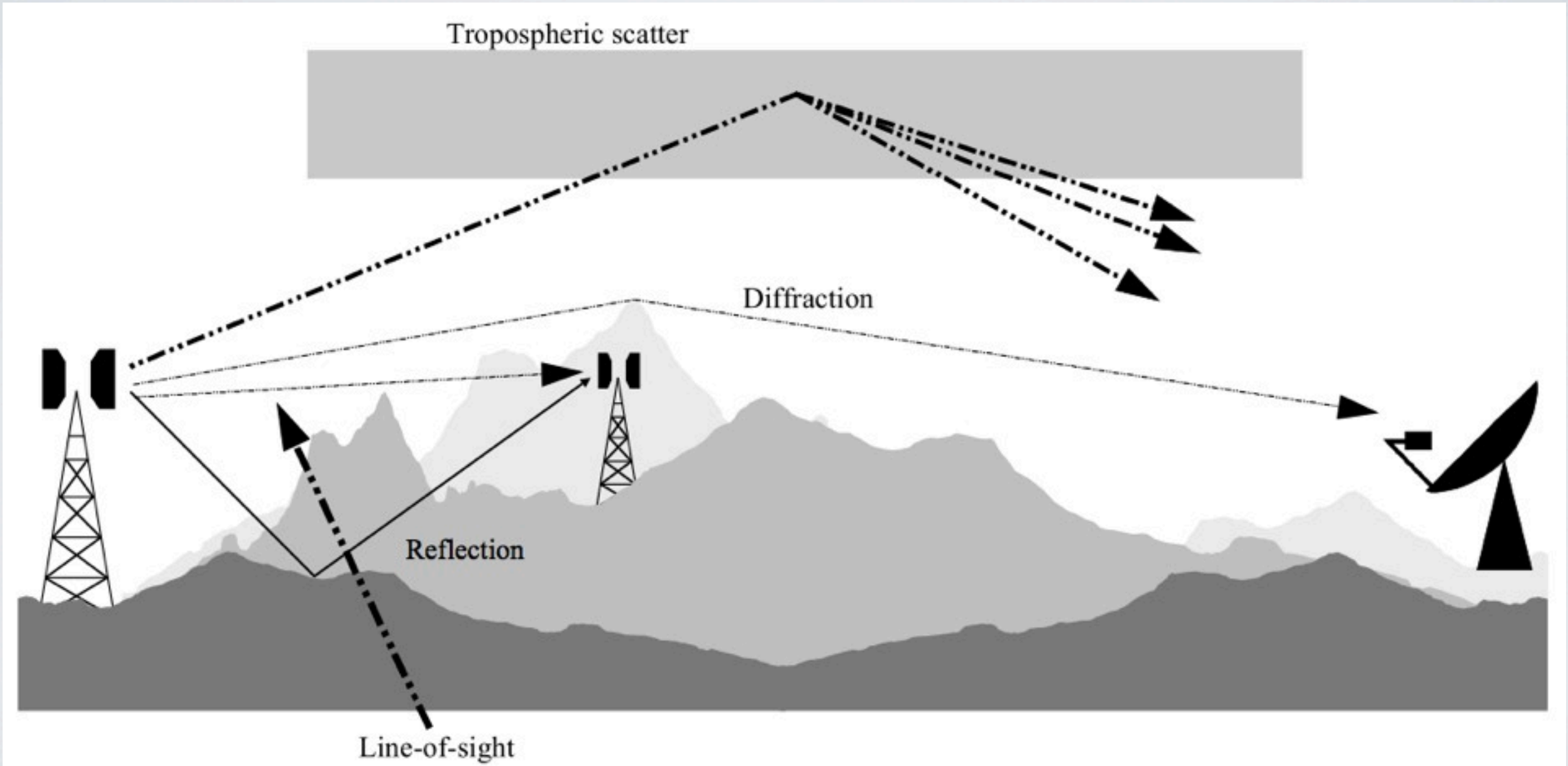

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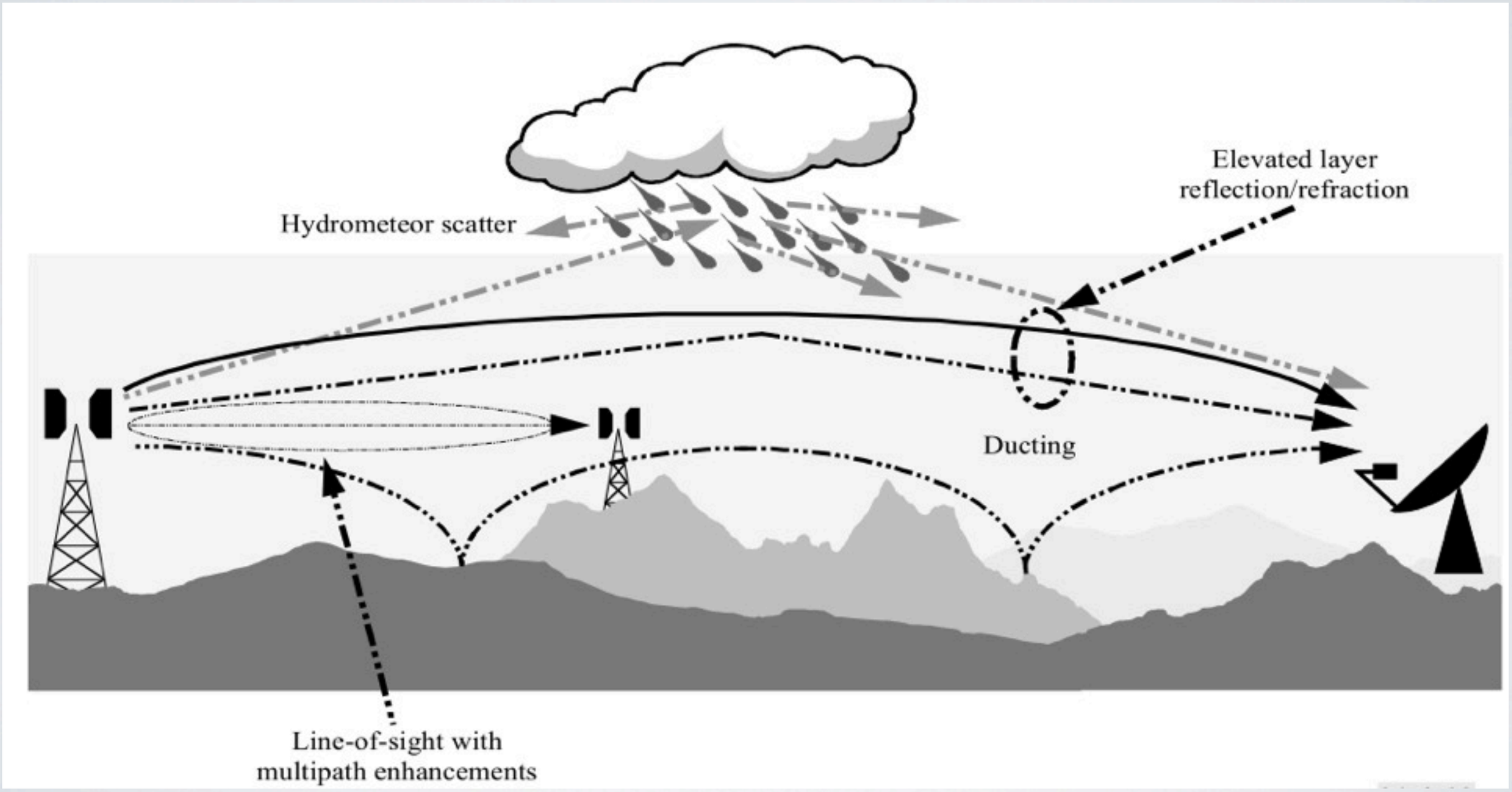

# PROPAGATION MECHANISMS

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- Direct wave

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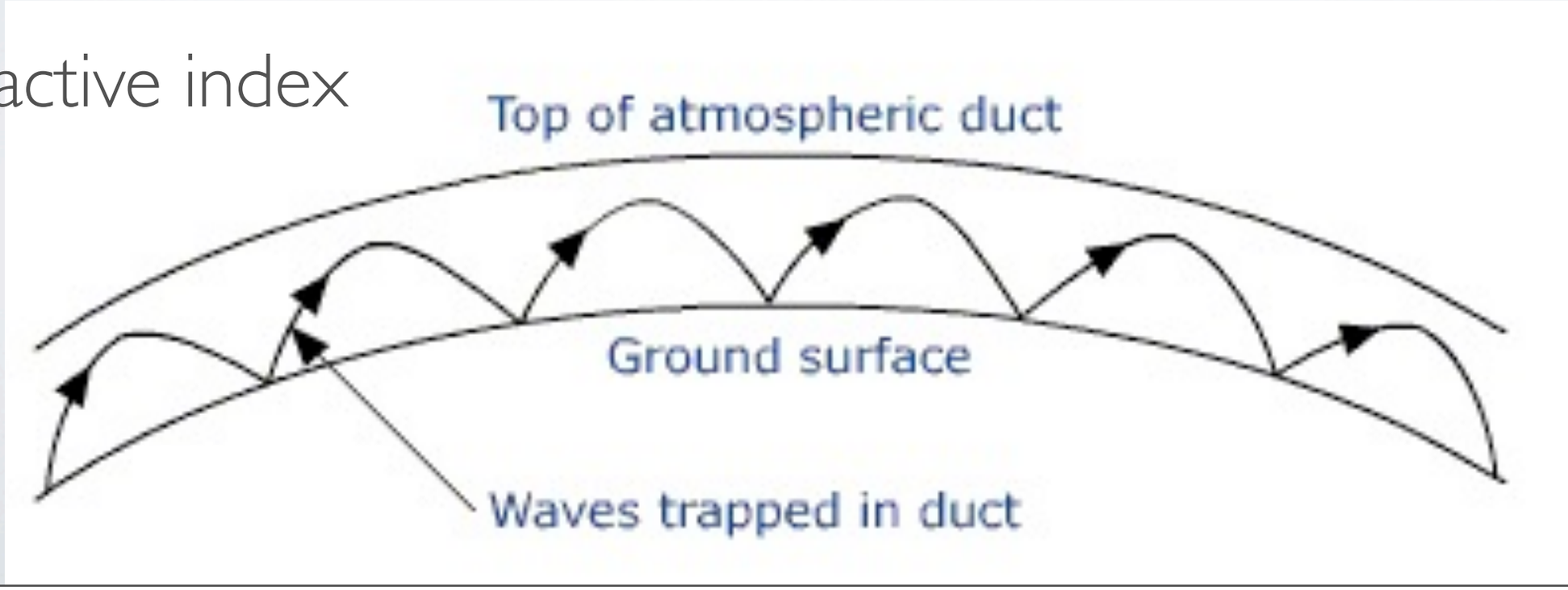

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- Empirical mathematical formulation
- Used to define wave propagation (path loss)
- A function of frequency, distance, and other conditions
- Usually one single model for propagation for all similar links under similar circumstances
- Many different models: various propagation mechanisms, different environments (indoor, outdoor, land, sea, space, etc), different applications, different frequencies, etc.

# FREE-SPACE

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- No hardware predictions (antenna gain, etc)

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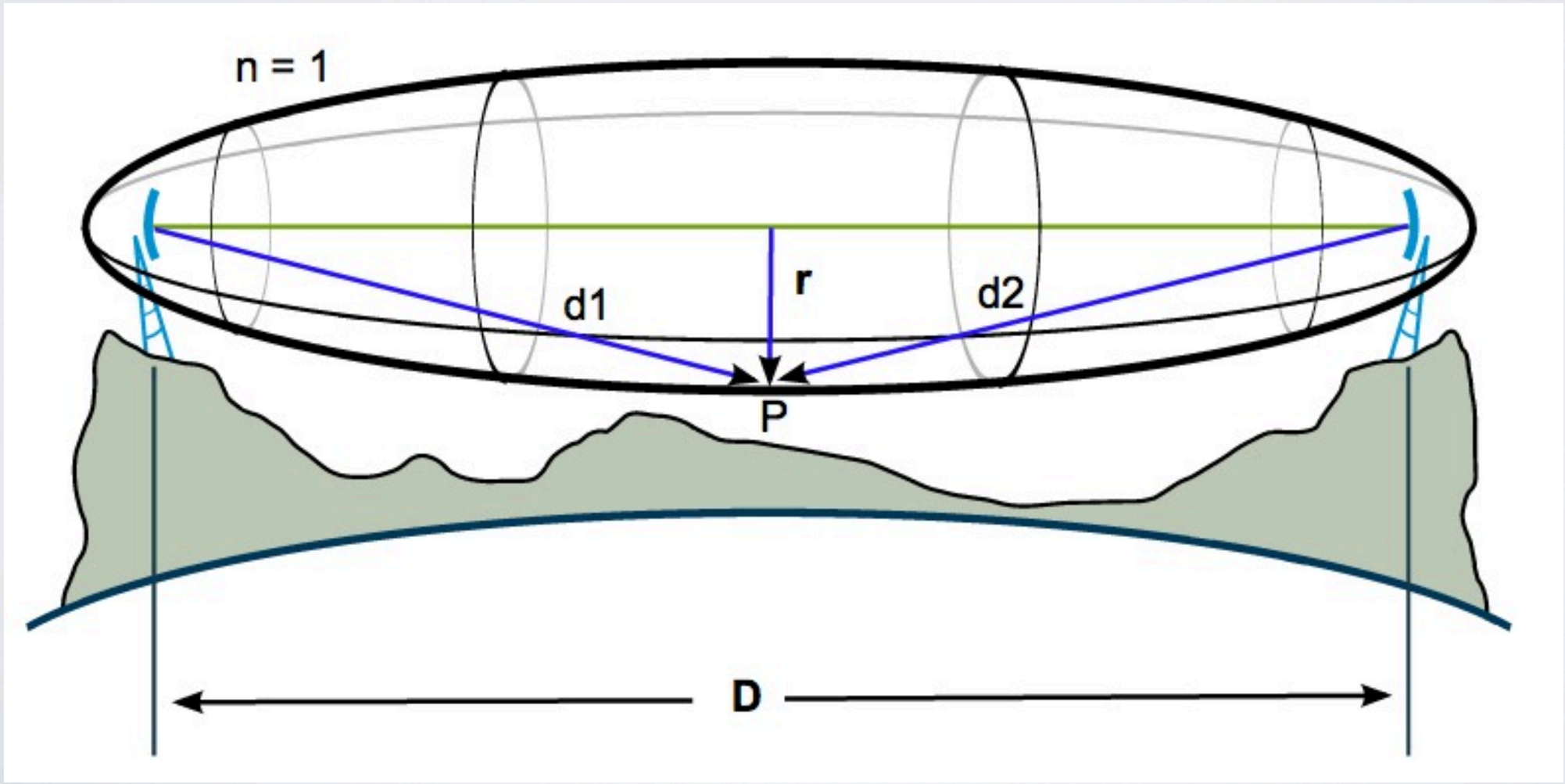

# OKUMURA-HATA

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- Three varieties of it:
  - Urban areas
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  - Open areas

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  - Obstacles not entering the first zone, can be ignored
- And/or if signal reaches the receiver due to reflection, refraction, diffraction, etc
- Obstructions can be located to either sides of the path, or above/below.

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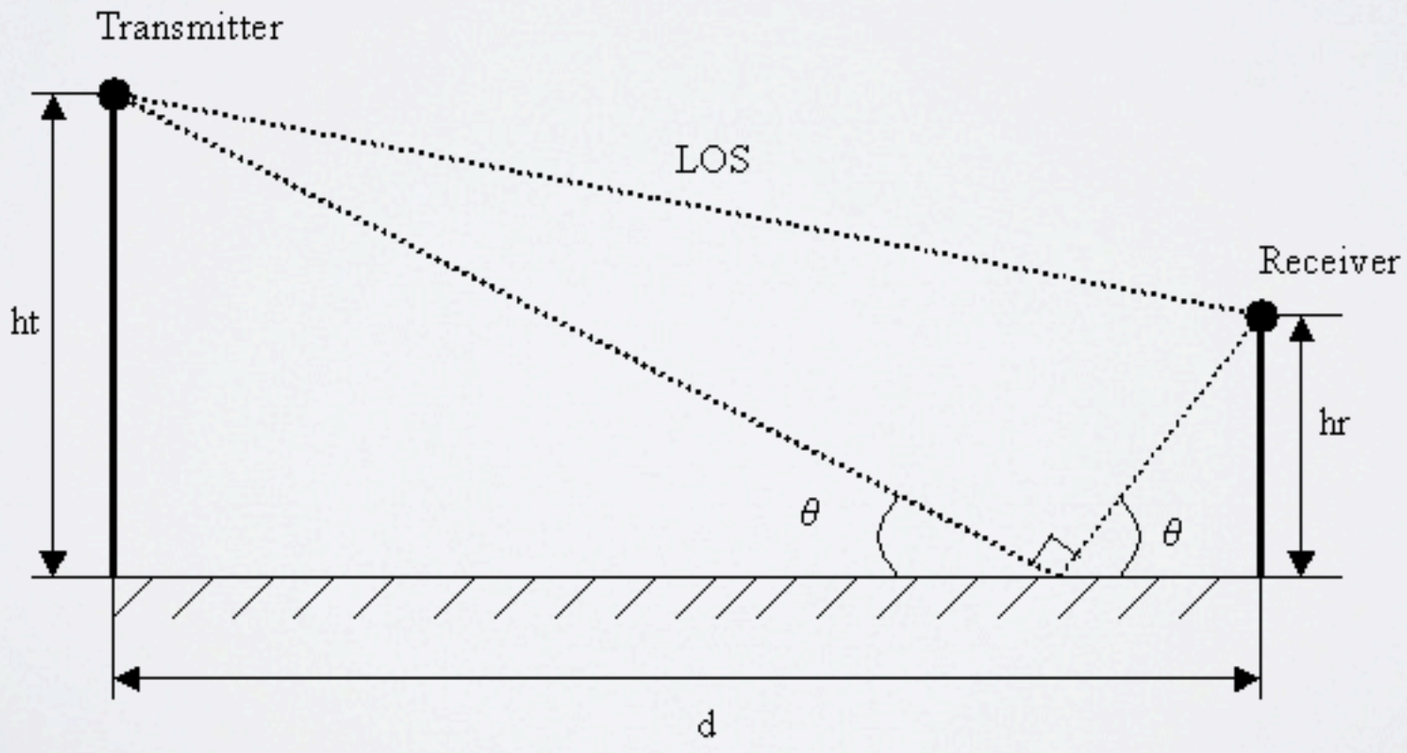

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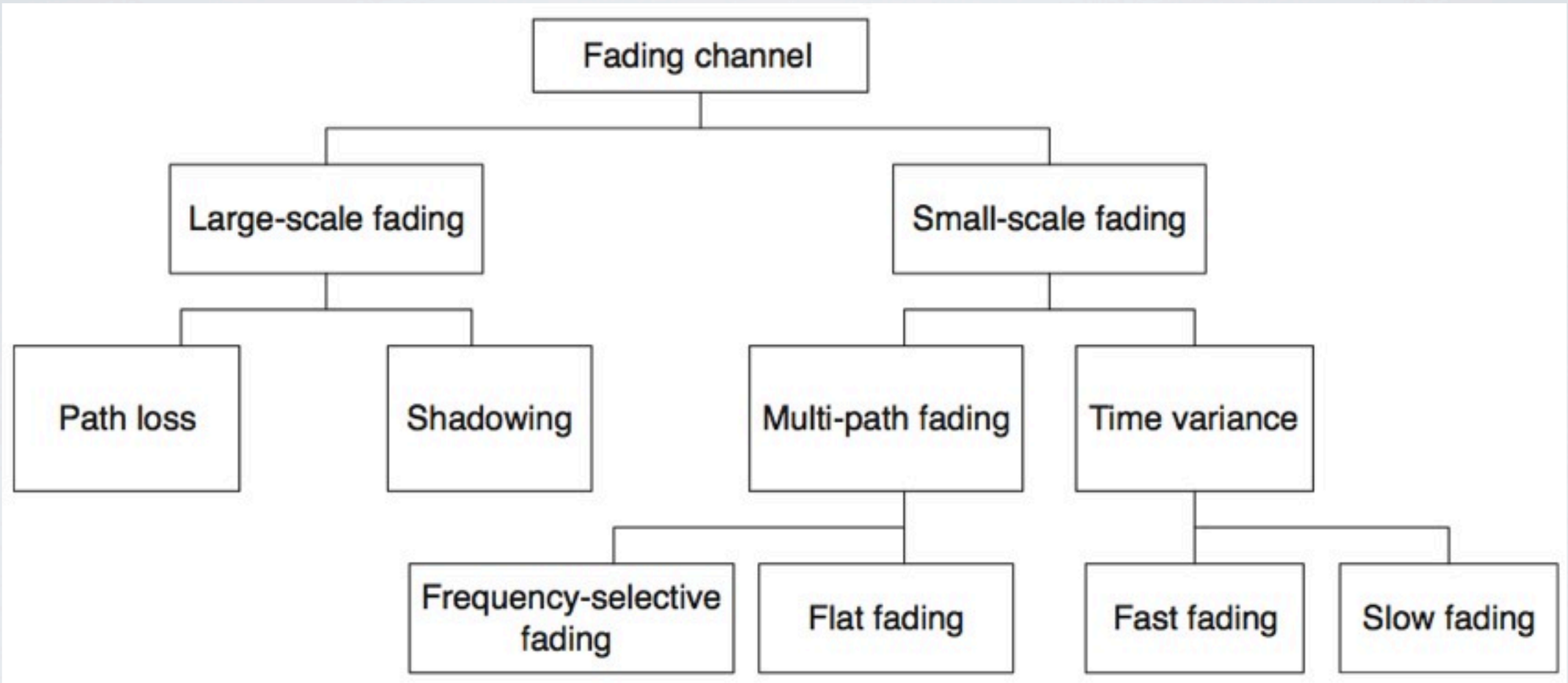
Fading channel
Large-scale fading
Small-scale fading
Path loss
Shadowing
Multi-path fading
Time variance
Frequency-selective fading
Flat fading
Fast fading
Slow fading

# LARGE-SCALE FADING

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- Often a distance of the order of a cell size

- Mean path loss, that decreases with distance
- Shadowing that varies along the mean path loss

# SMALL-SCALE FADING

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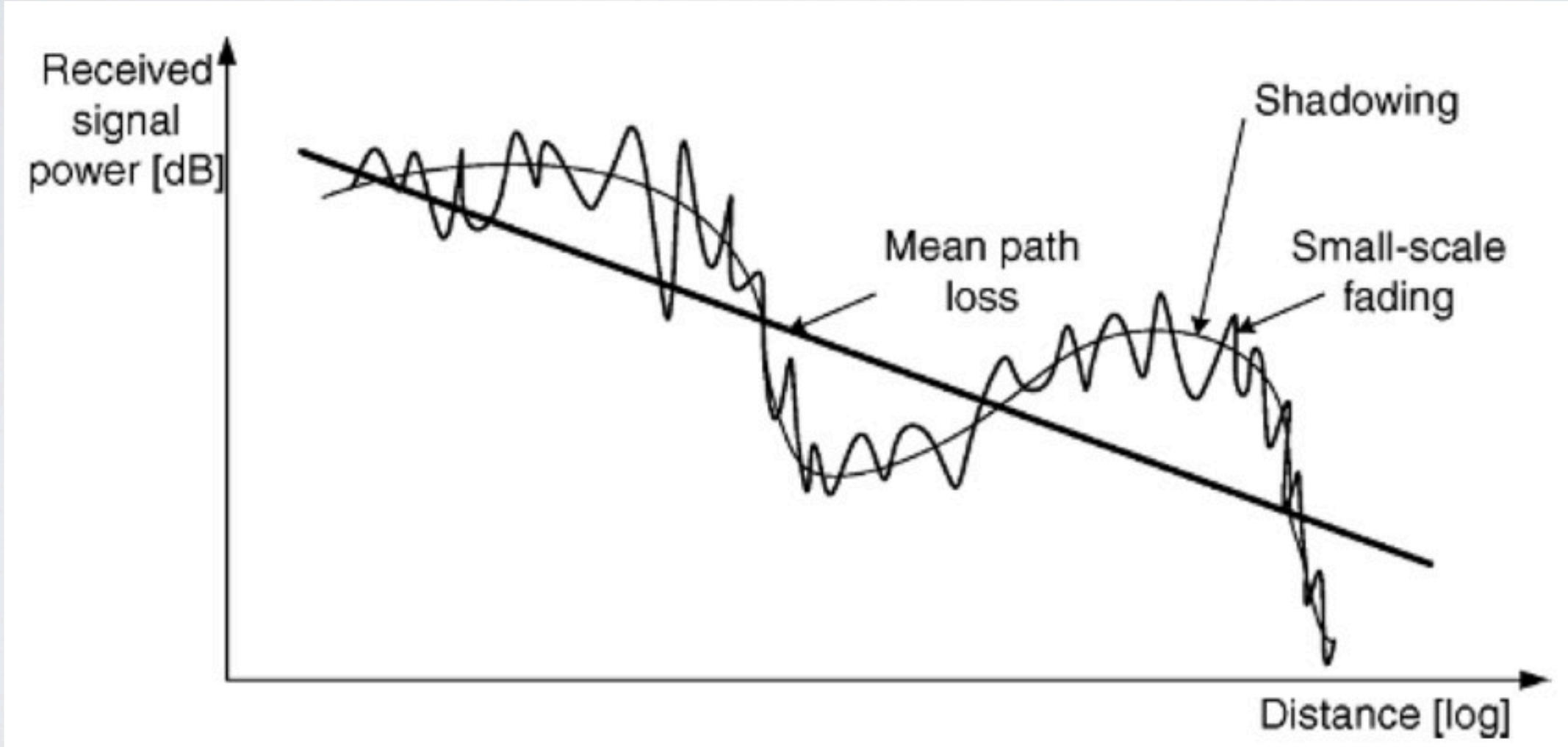
- Doppler effect

# LARGE- VS SMALL-SCALE



# QUESTIONS?

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GOOD NEWS! WE WON THE BID TO BUILD A NATIONWIDE WIRELESS NETWORK!
BAD NEWS! WE DON'T KNOW HOW TO BUILD A NATIONWIDE WIRELESS NETWORK!
IT'S WIRELESS. HOW HARD COULD IT BE TO NOT INSTALL WIRES?
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