Wireless Channel and Models

YUN AI

The 'Mobile Age'

Source: http://www.spiegel.de/panorama/bild-889031-473266.html

Agenda

This presentation covers:

- A brief view to wireless channel
- Introduction to important channel parameters
- Introduction to simulation methods

Wireless Channel is Different

- Each cable is a different channel
- No interference
- Low signal attenuation

- One media shared by all
- High signal attenuation and variation
- High interference

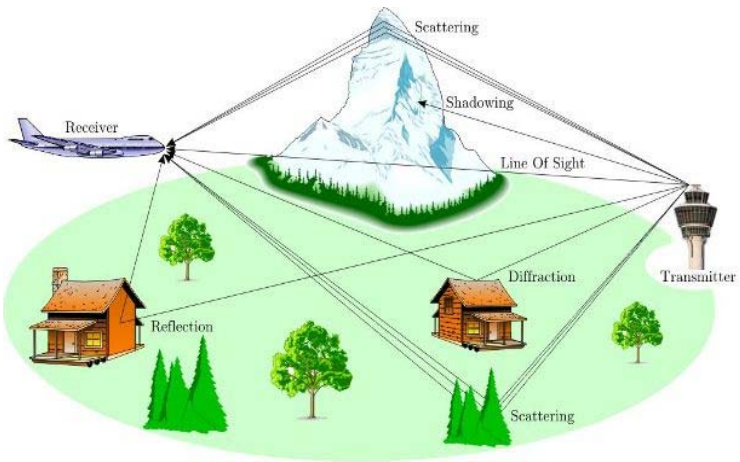
noise, co-channel interference, adjacent interference

WIRED

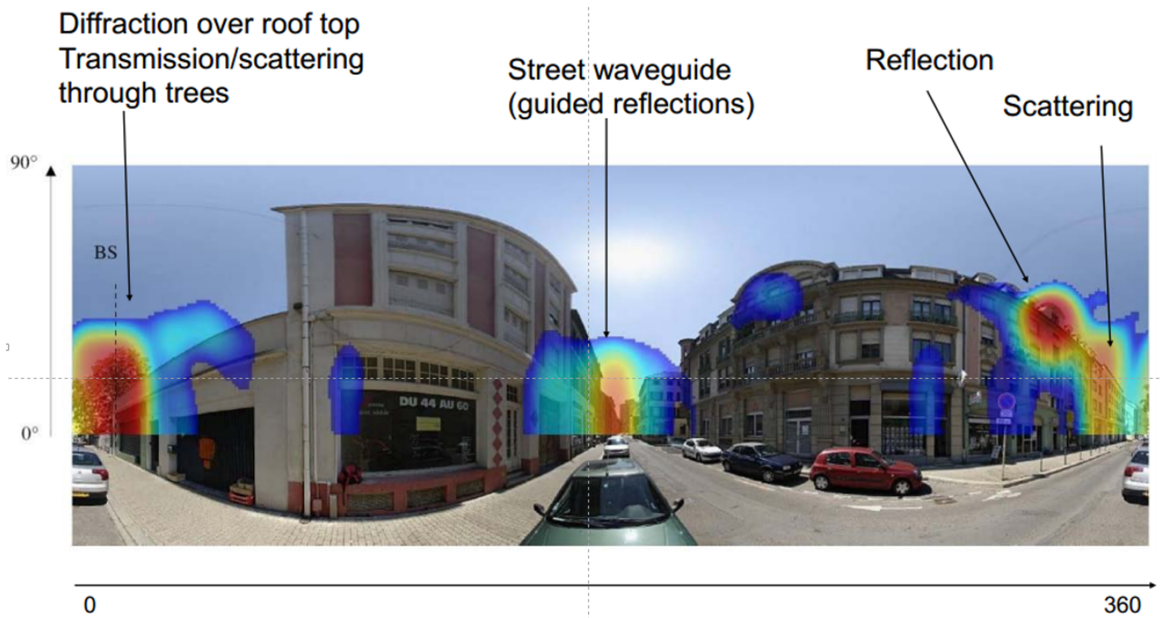
Wireless Multipath Channel

Channel Varies at two spatial scales:

- Large scale fading: path loss, shadowing
- Small scale fading: multi-path fading, doppler



Wireless Channel



Source: Albin Dunand, Jean-Marc Conrat, France Telecom Research & Development,
COST2100 TD(08)406, Carrier freq. 2.2 GHz, bandwidth 62.5 MHz, downtown Mulhouse, France

Various models

- WINNER/IMT-Advanced
- COST 2100
- IEEE 802.11 for 60 GHz
- METIS model
- Various mathematical models

METIS Model requirement

- Broader bandwidth, higher number of antennas, increasing delay and spatial resolution of receiver
- Very large antenna arrays
- High frequencies, from current cellular spectrum up to 86 GHz

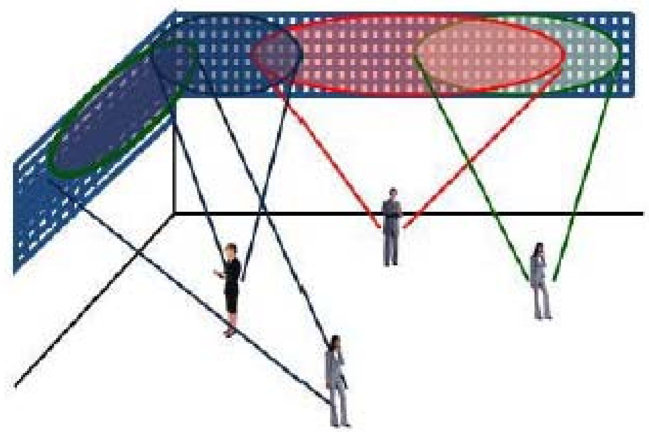


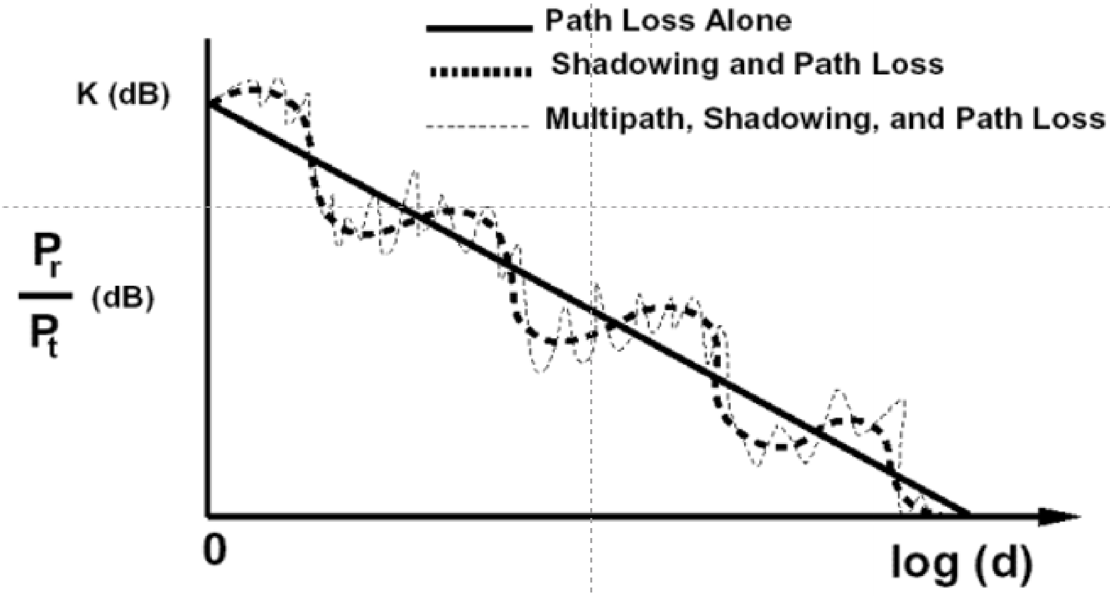
Figure 2-1: Scenario using very large wall mounted antenna arrays.

Source: METIS project

A big and simple picture

Path Loss, Shadowing and fading

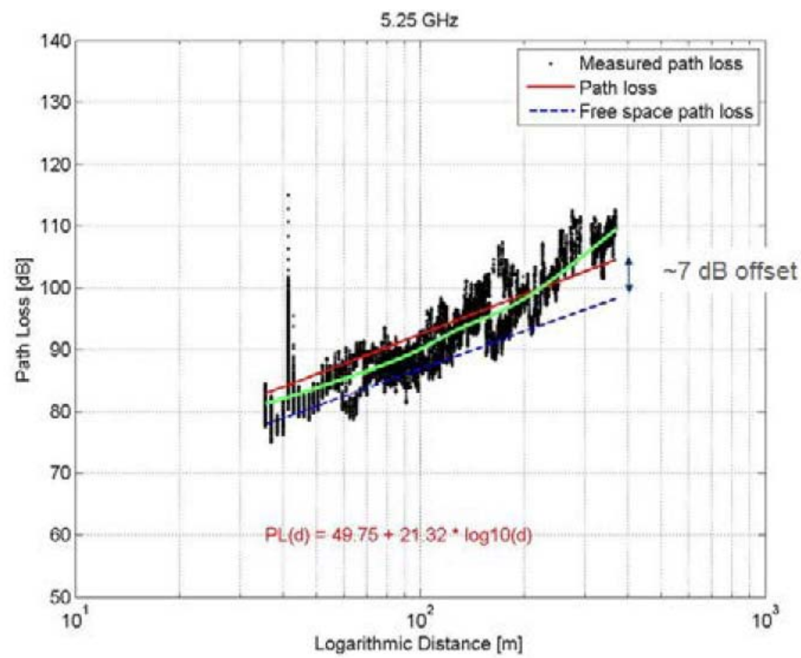
Variable decay of signal due to environment, multipaths, mobility, etc.



Source: A. Goldsmith book

Path Loss modeling

- Maxwell's equations
  - complex and impractical
- Free space path loss model
  - too simple
- Ray tracing models
  - requires site-specific information
- Empirical models
  - not always generalized to other environments
- Simplified power falloff model

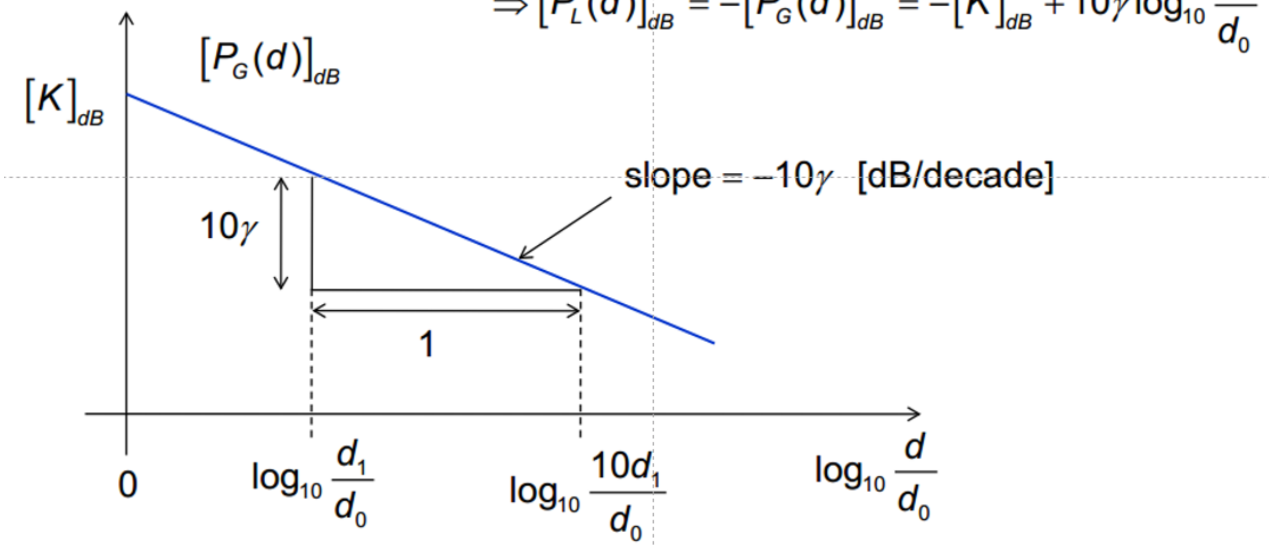


Source: METIS project

Log-distance path loss

$$P_G(d) = K\left(\frac{d}{d_0}\right)^{-\gamma} \Rightarrow [P_G(d)]_{dB} = [K]_{dB} - 10\gamma\log_{10}\frac{d}{d_0} = -[P_L(d)]_{dB}$$

$$\Rightarrow [P_L(d)]_{dB} = -[P_G(d)]_{dB} = -[K]_{dB} + 10\gamma\log_{10}\frac{d}{d_0}$$



Piece-wise log-distance path gain

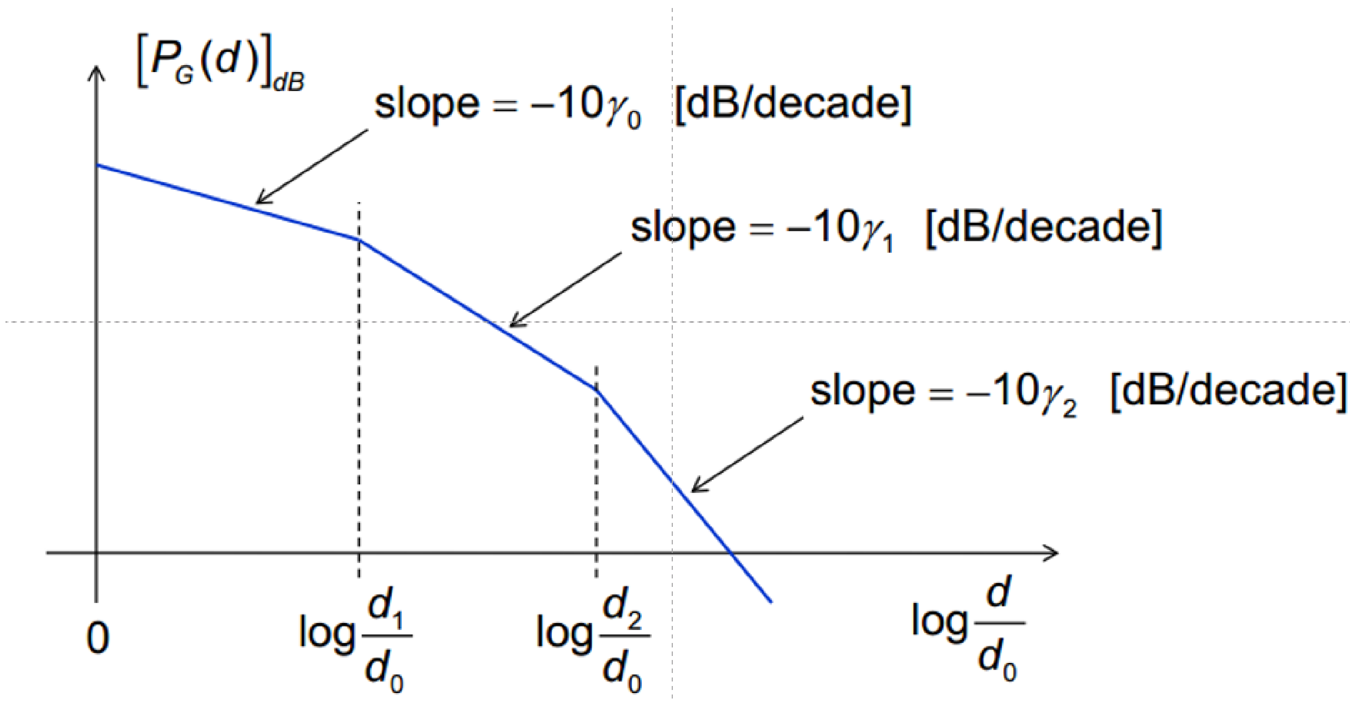
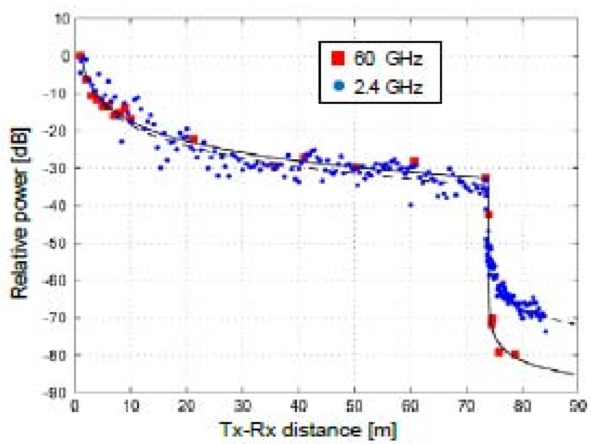


Figure 5-4: Measurement set-up and floor plan of measurement environment.



Source: METIS project (https://www.metis2020.com)

Empirical path loss models

For the models below, the path loss is of the form:

$$P_L(d) = A\log_{10} d + C$$

- Okumura (1960's)

 - Based on extensive measurements

 - Applicable for f: 150 – 1500 MHz, d: 1 - 100 km, ht: 30 - 100 meters, hr: 0 - 10 meters

- Hata

 - Analytical expression to approximate Okumura's model

- COST 231 (1990')

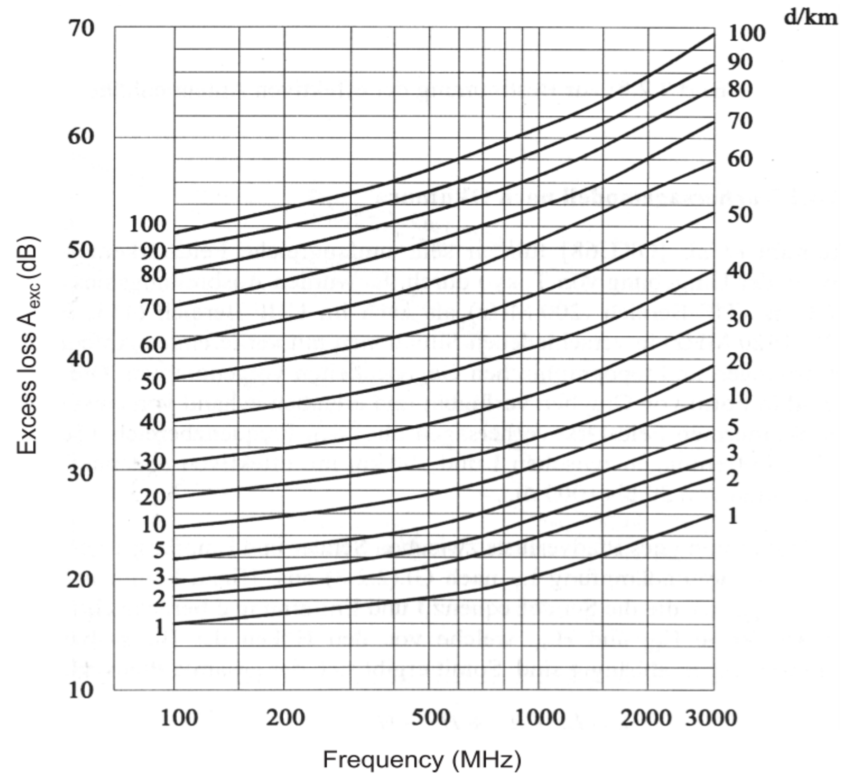
 - Extension to Hata's model

 - Applicable for f: 1.5 - 2 GHz, d: 1 – 20 km, ht: 30 – 200 m, hr: 1 - 10 m

Path loss according to the Okumura-Hata model

Path loss vs. Frequency

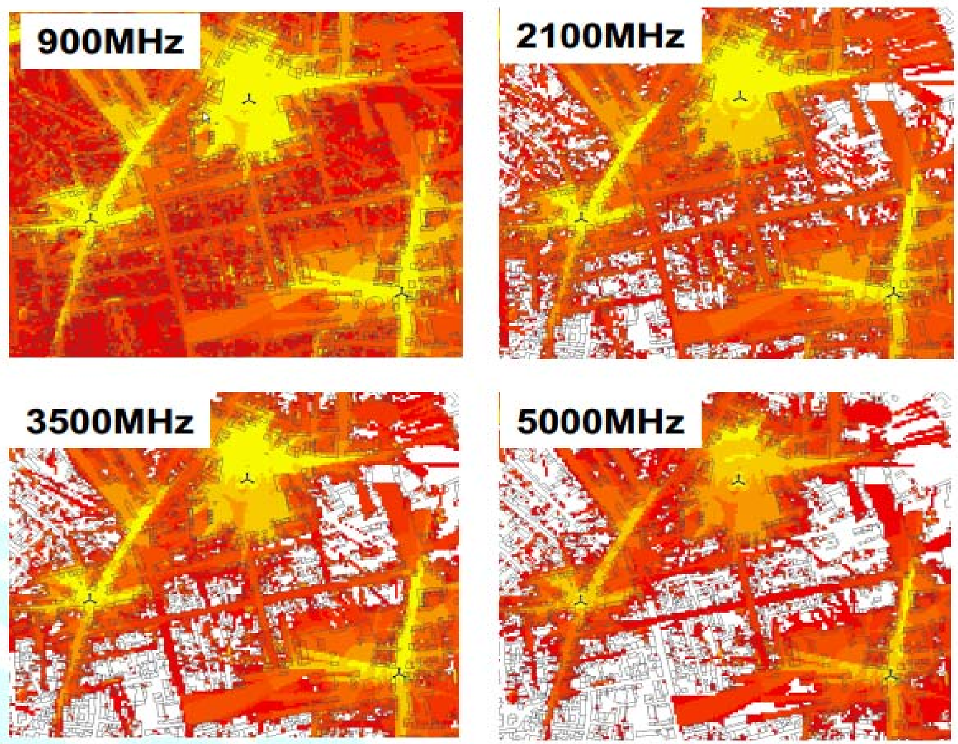
Path loss vs. distance



Source: A. Molisch book

Coverage vs frequency

Higher the frequency bands provide
- the more spectrum
- but lower the coverage



Source: Vodafone

Shadowing

- The received signal is shadowed by obstructions such as hills and buildings

Outdoor model, Indoor model, Outdoor – Indoor model,

- This results in variation in the local mean received signal power

Pr(dB) = E[Pr(dB)] + X, X ~ N(0, δ)

- Source: A. Goldsmith book

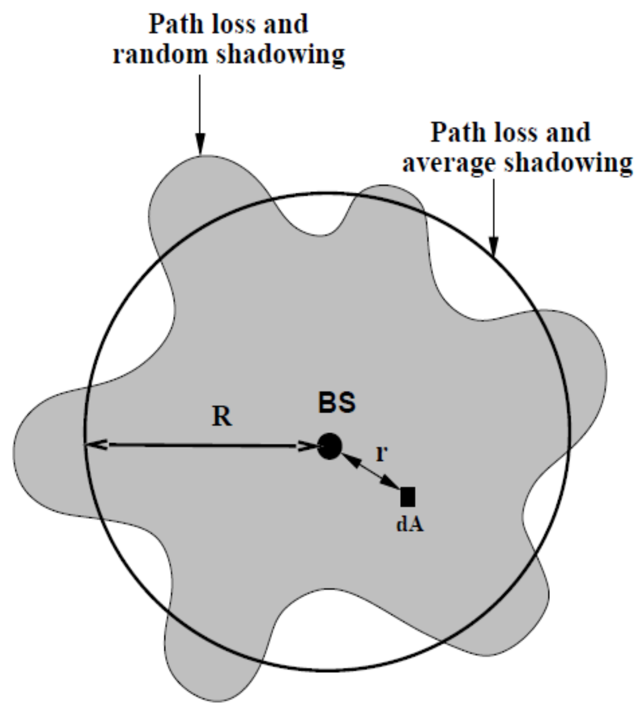
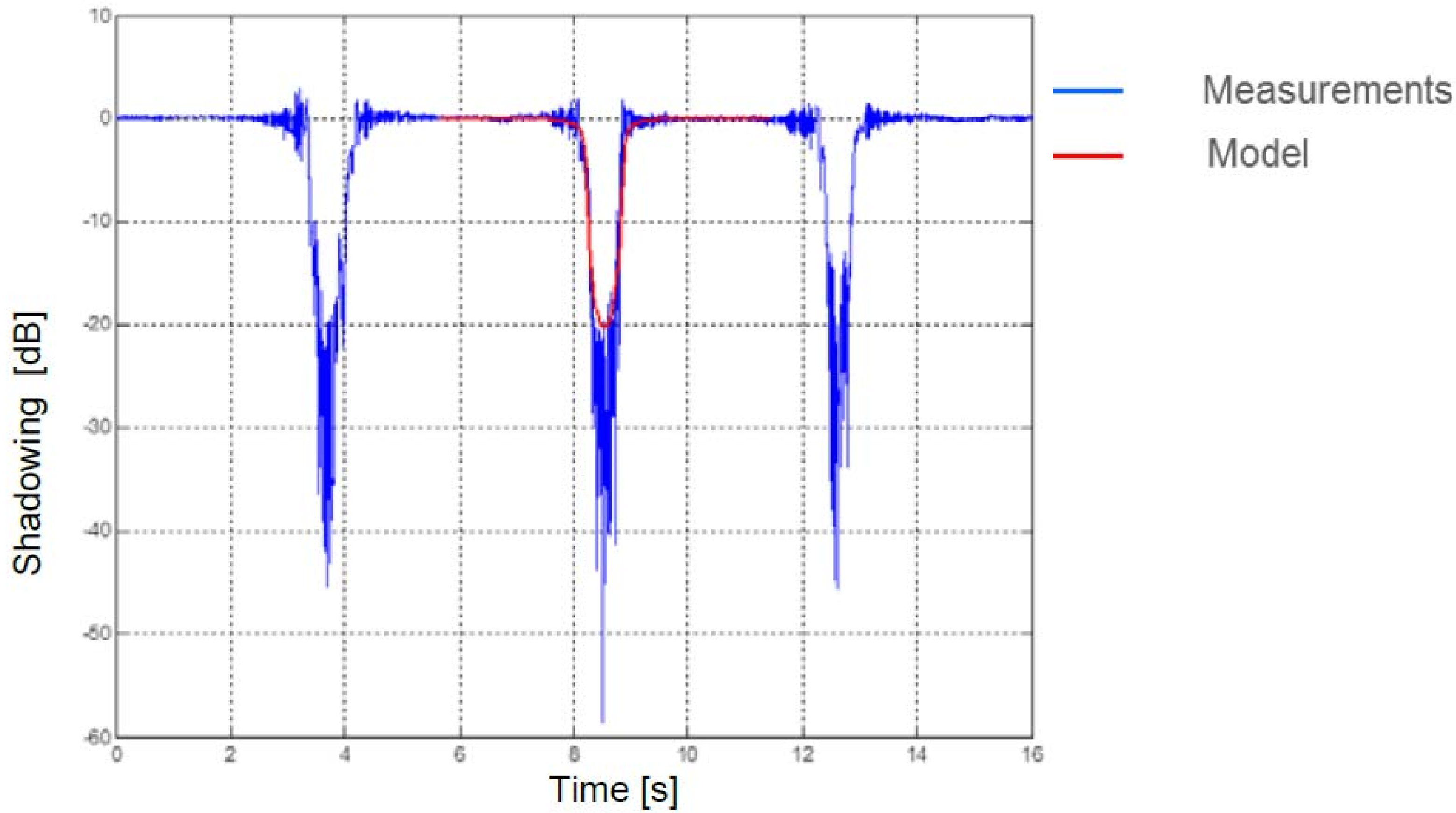


Figure 2.10: Contours of Constant Received Power.

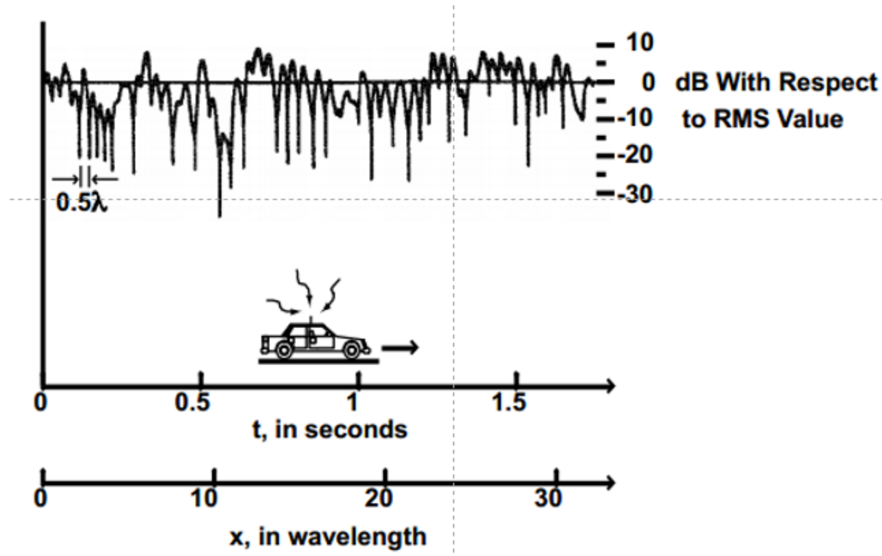


Body blocking loss for a LOS link (4 meter distance) at 60 GHz

Source: METIS project (https://www.metis2020.com)

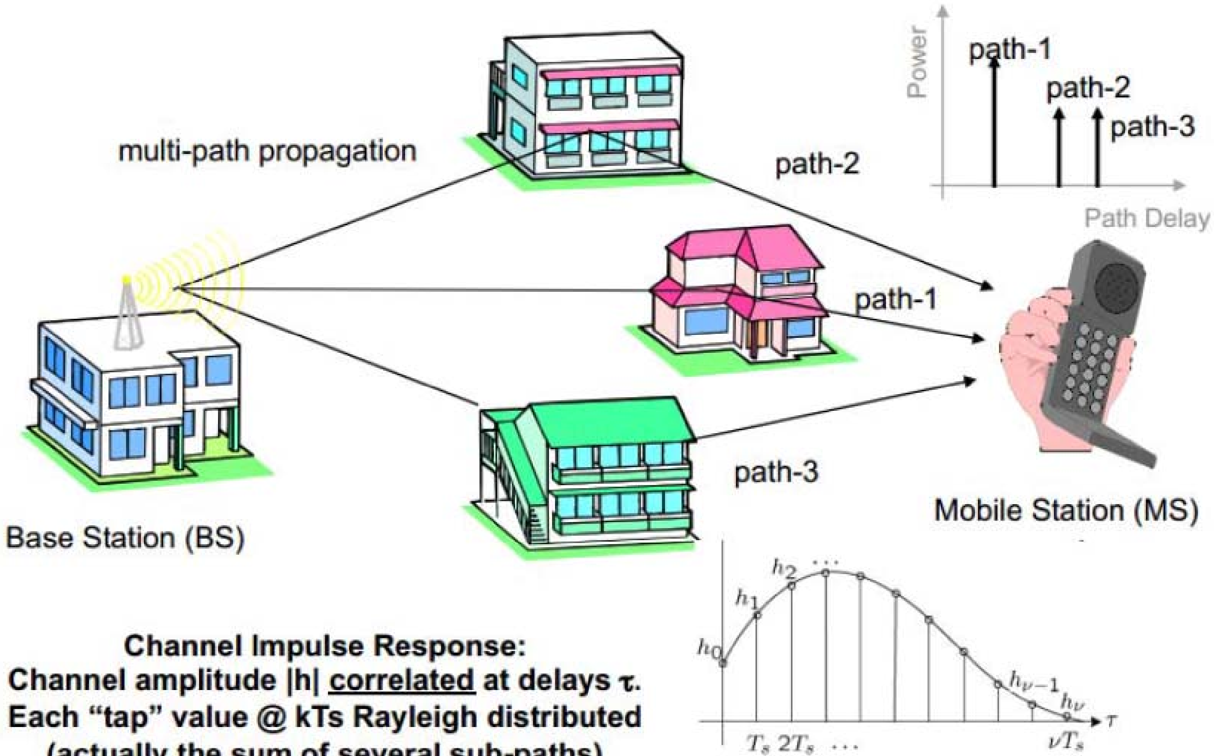
Small-scale multipath fading

- Multipath fading due to constructive and destructive interference of the transmitted waves



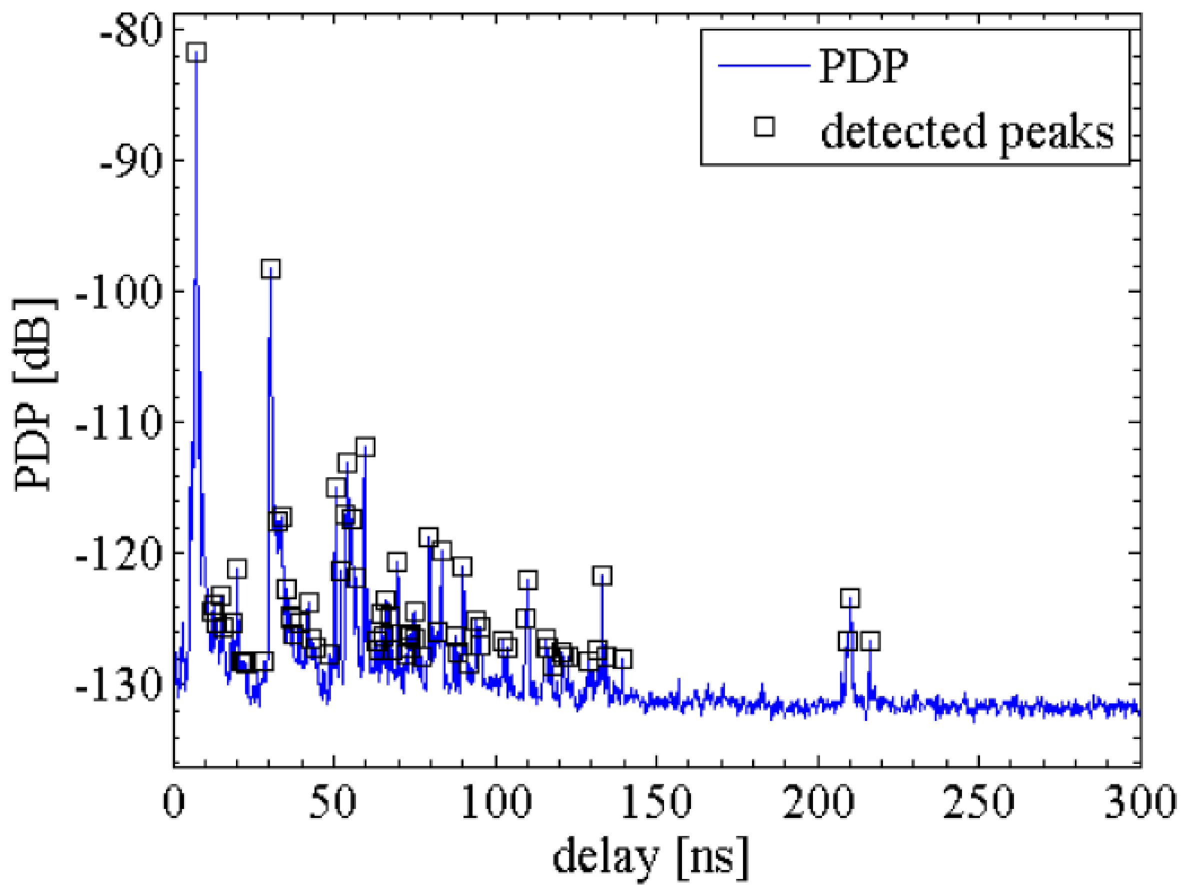
Source: A. Goldsmith book

Multipath: power delay profile



Channel Impulse Response:
Channel amplitude |h| correlated at delays τ.
Each "tap" value @ kTs Rayleigh distributed
(actually the sum of several sub-paths)

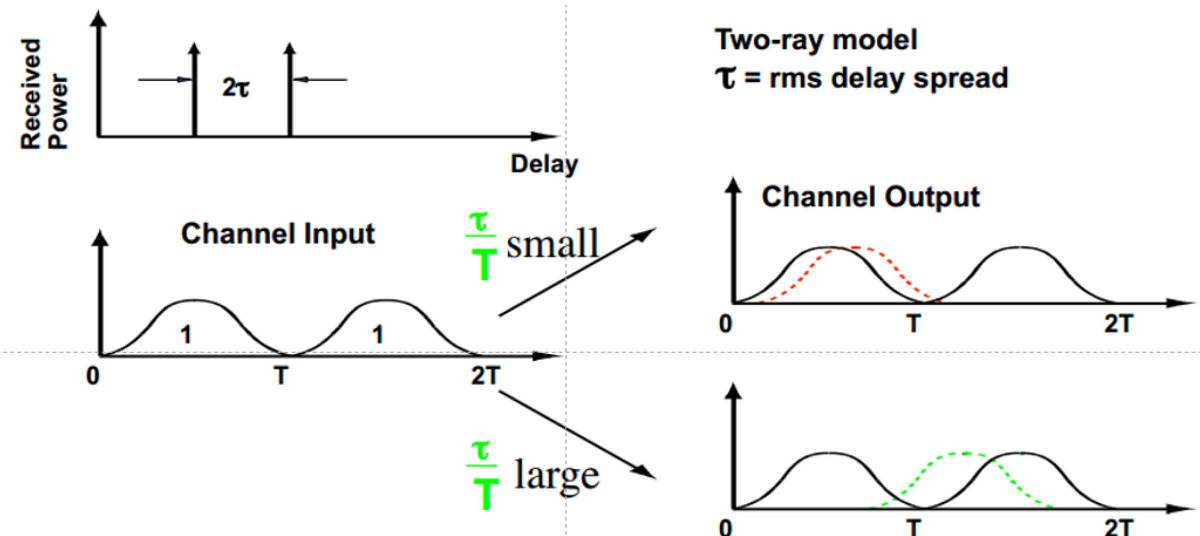
Source: David Tse book



Example of LoS PDP with detected peaks

Source: METIS project (https://www.metis2020.com)

Delay spread



- $\frac{\tau}{T}$ small ⟹ negligible intersymbol interference
- $\frac{\tau}{T}$ large ⟹ significant intersymbol interference, which causes an irreducible error floor

Summary

- Wireless Channel
  - path loss
  - fading
  - shadowing
  - multipath
  - etc
- Wireless Channel Models
  - modeling approaches
  - different scenarios


Thank
You
Merci
Gracias
Danke
Spacibo
Arigatô
Hvala
TerimaKasih
KamSahHamnida
Xièxie
Mèsi
Grazie
Chokrane
Kiitos
Dziakuju
aDank
BarakAllahuFik
Takk
Koszönöm
Murakoze
TapadhLeat
WaadMahadsantahay
Buznyg
ThintKo
Blagodaram
Rahmat
Matondo
Mercé
Taiku
Dakujem
Grácies
Faleminderit
Efharisto
NajisTuke
Grandmercé
Tanemirt
Tenki
Nirringrazzjak
Bayarlalaa
Obrigado
Salamat
Saha
Multumesc
CámOn
Gracie
GratiasAgo
KopKhunKha
Motashakkeram
Sagolun
Tak
Dankie
Aciú
TanánVága
GratiasAgimus
Mauruuru
Barkal
Chnorakaloutioun
Aabhar
Dhanyavaad
Grazzi
Gratzias