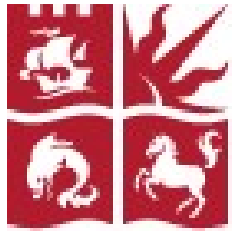
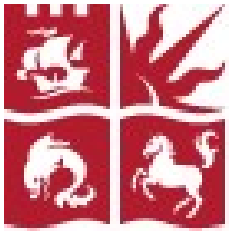


EENGM4221:
Broadband Wireless Communications

Lecture 3: The Wireless Channel

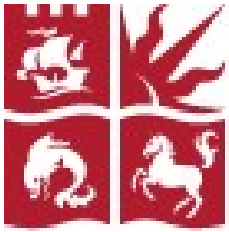
Dr Simon Armour

The Wireless Channel



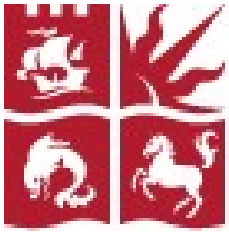
- The Wireless Channel Creates Many Challenges as has been covered in other units:
  - Attenuation (Free Space)
  - Shadowing (Slow Fading)
  - Multipath (Fast Fading)
  - Delay Spread
  - Noise
  - Interference

A Tough Job



- As Wireless Engineers, we have to:
  - Achieve Spectral Efficiency, QoS, Multiple Access, etc
  - Keep costs and power consumption low
- And what are we given to do it?:
  - A channel which, attenuates, fades and adds noise and interference to our already pitifully small signal
- It's a tough job, but someone's got to do it…

Free Space Attenuation

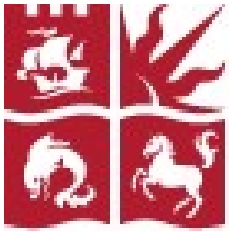


- A well known equation:

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

- So in a WWAN environment we could lose 100dB to free space loss

Shadowing (1)

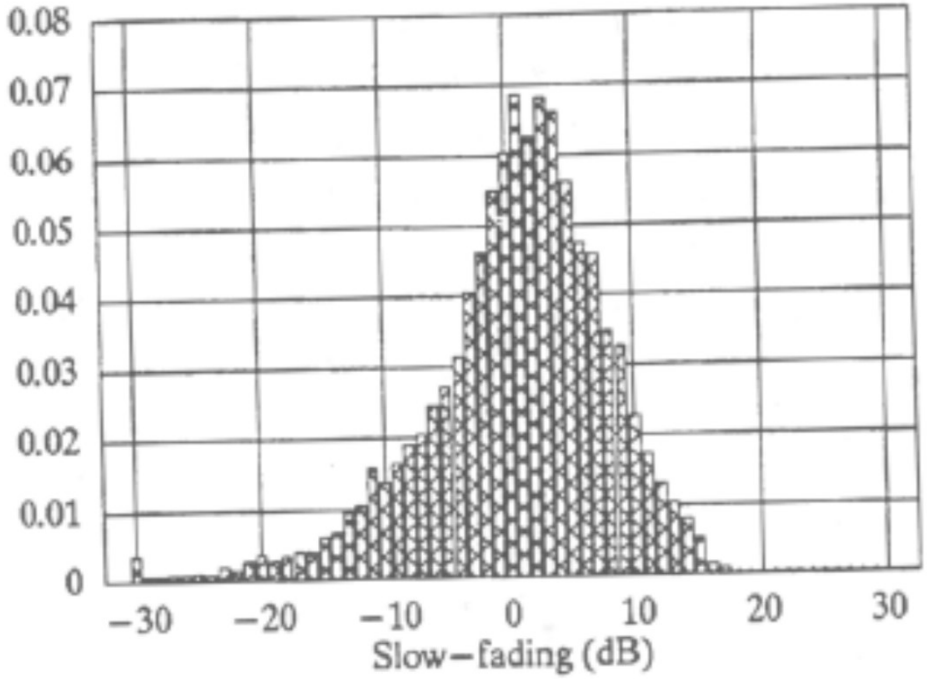


- Shadowing introduces a random component to the loss.
- This may be characterised as a random function or is sometimes modelled as a simple change to the free space loss coefficient
- It is not just the possible additional loss that is a problem – variation of loss is also a problem
  - This variation may also be seen as an opportunity

Shadowing (2)

- Slow fading statistics have been the subject of many measurement campaigns.
- One example is as shown
- Note, often there is gain rather than attenuation
- Source: Hanzo & Keller, “Single and Multicarrier QAM”

pdf of slow fading



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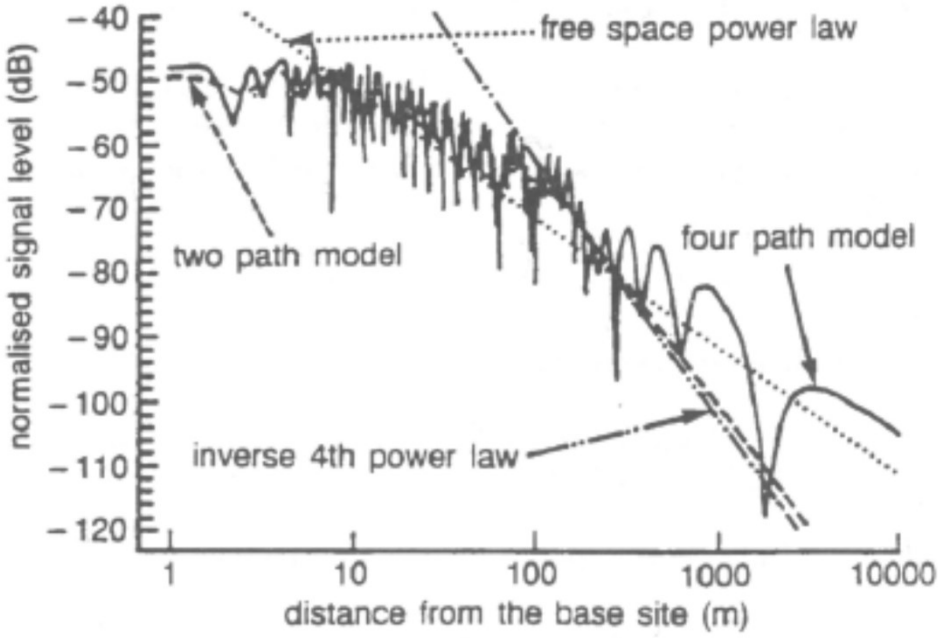
Shadowing (3)

- Slow fading and free space loss effects may be compounded as illustrated here.
- Source: Hanzo & Keller, “Single and Multicarrier QAM”



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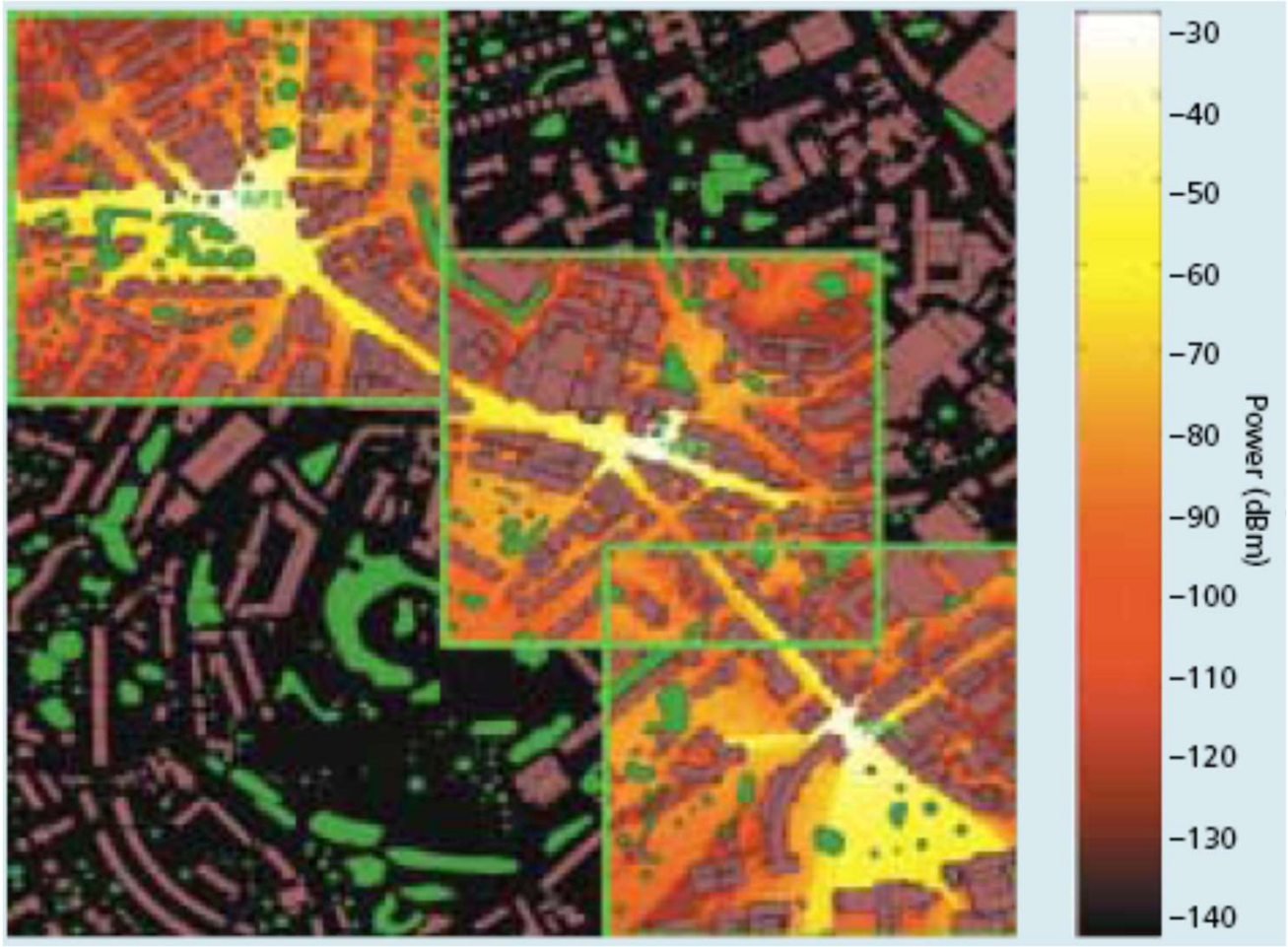
Shadowing (4)

- Source: CCR



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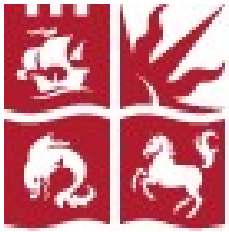
Multipath (Fast Fading)



- Multipath effects may further attenuate the signal according to Rayleigh or Rician statistics
  - E.g. 20dB fade 1% of the time or 10dB fade 10% of the time under Rayleigh conditions
- Multipath fading may be wideband in which case:
  - It creates complications for modem design
    - We will not consider this further (See EENGM2510 re wideband modems)
  - It can also be seen as a source of diversity – not all of the signal will be attenuated at any one time.

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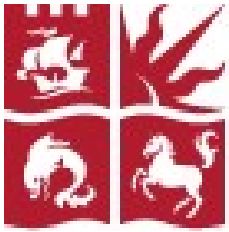
Noise and Interference



- After being faded, a wireless signal is subject to noise and interference
- Noise, whilst random, typically conforms to a reliable statistical model
  - Its ever present but at least we can expect it to have a consistent effect
- Interference is a bit more of an unknown:
  - It may vary with the band of operation
  - It may be bursty in nature

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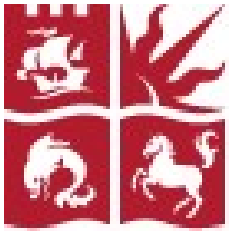
The Design Problem



- Often as Engineers we must resign ourselves to having to deal with the compound effects of fading, noise and interference
- There is an engineering trade-off to consider here. Do we:
  - Design for the worst case and accept that we don't get the best out of our channel sometimes
  - Design for the best case and accept that communication fails sometimes
  - Or more likely, find a compromise somewhere in the middle?
- OR do we consider an adaptive system…. more later!

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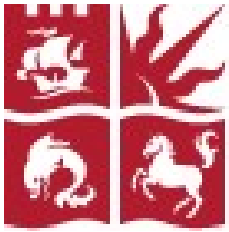
Review of Lecture 3



- We have reviewed and revised various aspects of wireless propagation that challenge us as communication engineers
  - Loss, slow fading, multipath and fast fading, dispersion, noise, etc
- There were nothing really new here but we juxtaposed the challenges from this lecture and the last; QoS and wireless propagation and set out the motivation for ‘adaptivity’

Ref: