Every lecture is recorded and available at:

> mms://lux.unik.no/UNIK4700-JN/UNIK-20170822.wmv
> mms://lux.unik.no/UNIK4700-JN/UNIK-20170829.wmv
> replace 20170722 with the lecture date

UNIK 4700 recording

if a lecture is missing, ask Kaja Mossend

UNIK 4700/
9700
12 Sep2017

Test yourself, answer these questions

- Convert to dB, dBm: $P_r = P_t \cdot G_t \cdot G_r \cdot L_{free}$. Loss
- What is the exact difference between permeability and permittivity?
- What is Relative permittivity? and Relative Permeability?
- Define Propagation constant

left over from 5Sep2017

dB ↔ 30 dB ↔ 1 W

dBm ↔ 1 mW ↔ 1000

Handset: 2 W ≙ 3 dB = 33 dBm

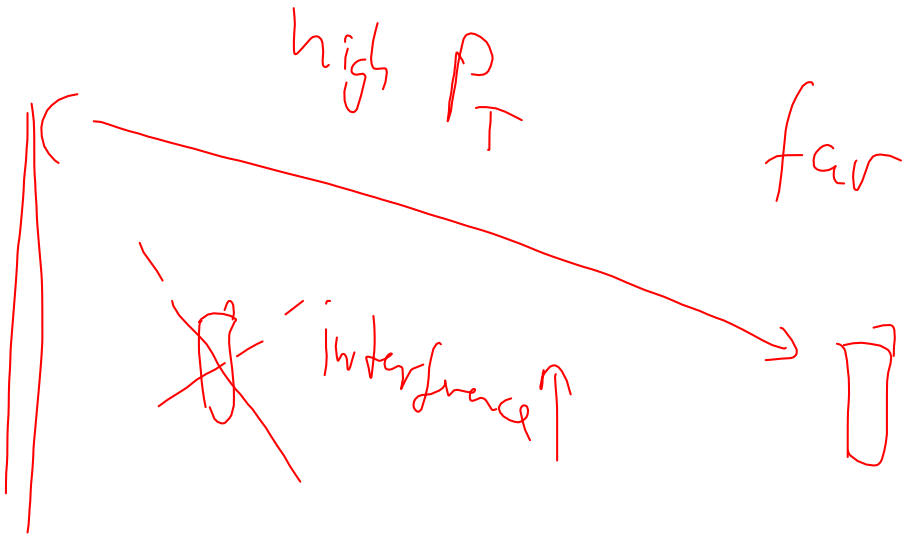
1 W =

$10 \log\left(\frac{P}{1\,W}\right)$

$10 \log 1$

0 dB

Near-far problem



Mobi6: Separate channel Signalling

802.11: min. common BW = 2 Mbit/s

Signalling: 2 Mbit/s

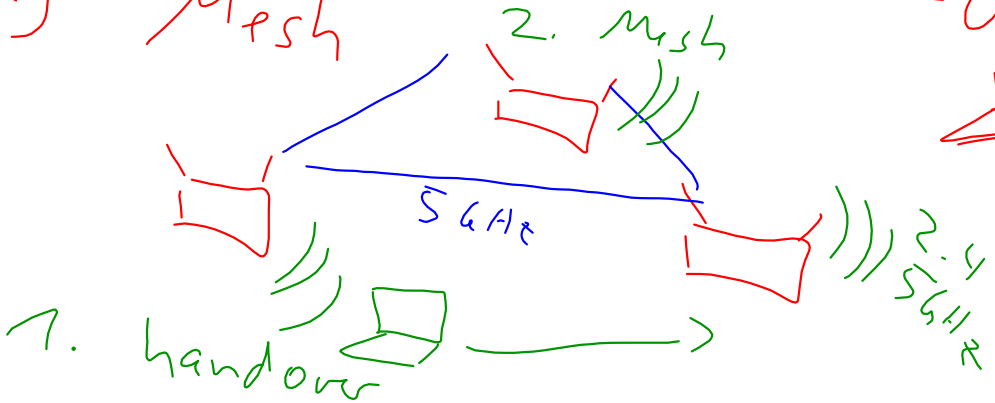
128 Mbit/s

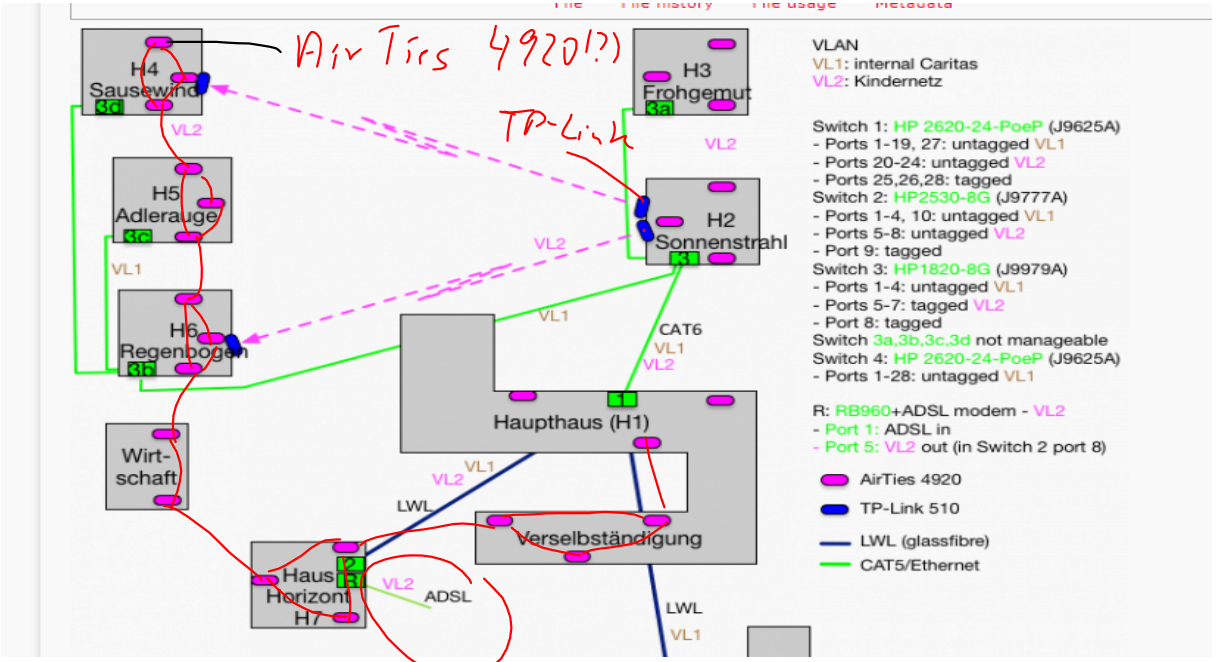
2 Mbit/s

Interference reduction

- mobile network = interference limited
  - Near - far
    - → network operated
  - Wifi: hot spot
    - capacity limited

1) AP coordinated
   - "bad apple"
2) Mesh
   - device operated

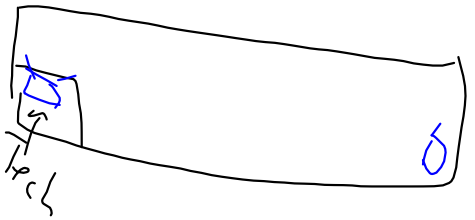


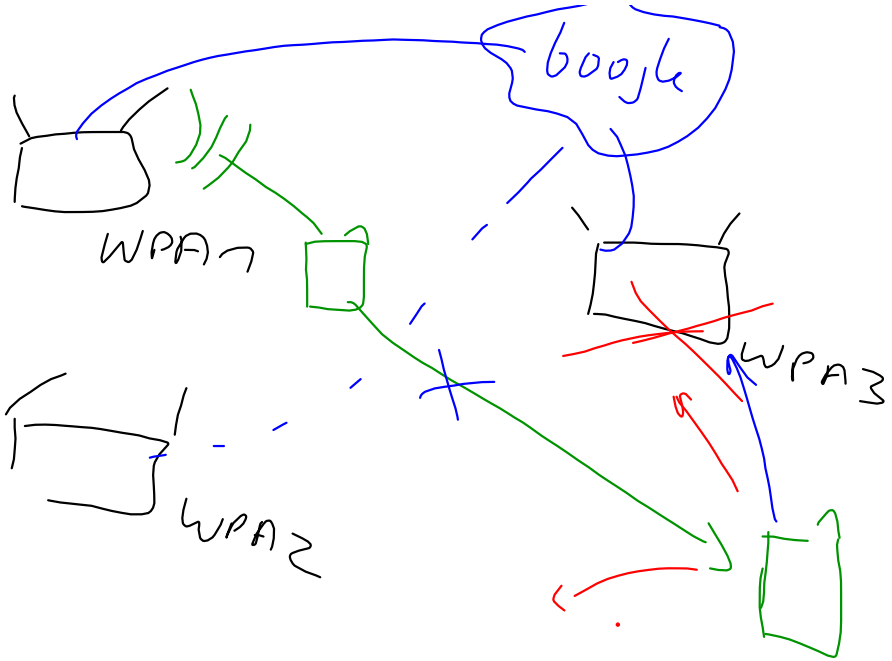


EyeNetworks.no

↳ EyeSaaS.no

Managed W.i.f.





Google AP

information transmission channel with additive white, Gaussian noise. This capacity is given by an expression often known as "Shannon's formula": $C = W \log_2(1 + P/N)$ [bits/s]

with W as system bandwidth, and $P/N = \frac{P}{N_0 W}$ in case of interference free environment, otherwise $N_0 W + N_{\text{interference}}$, where $N_0 = k_B T_K$ with k_B as Boltzmann constant and T_K as temperature in Kelvin.

power amplifier

noise factor = 10

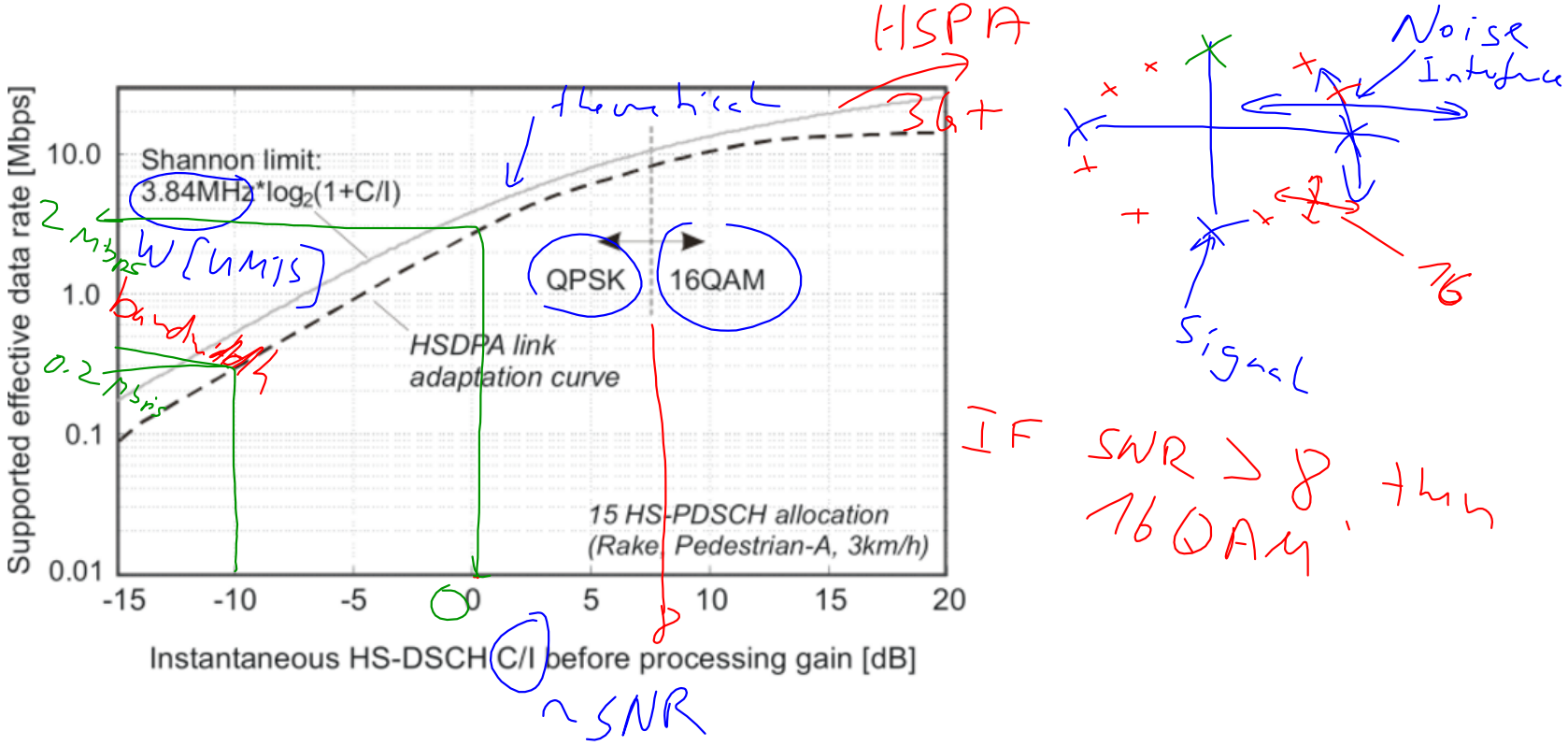
1) Capacity ~ Band width

2) Capacity ~ log(SNR)

$P_{\text{Sensitivity}}$ ~ -95 dB_m WLAN

-104 dB_m GSM

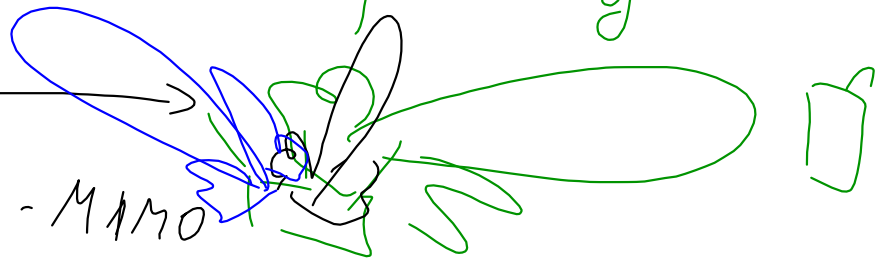
-116 dB_m UMTS


Supported effective data rate [Mbps]
10.0
1.0
0.1
0.01
Shannon limit:
3.84MHz*log2(1+C/I)
HSDPA link
adaptation curve
QPSK
16QAM
15 HS-PDSCH allocation
(Rake, Pedestrian-A, 3km/h)
-15
-10
-5
0
5
10
15
20
Instantaneous HS-DSCH C/I before processing gain [dB]
HSPA
IF
SNR
Noise
Signal
16

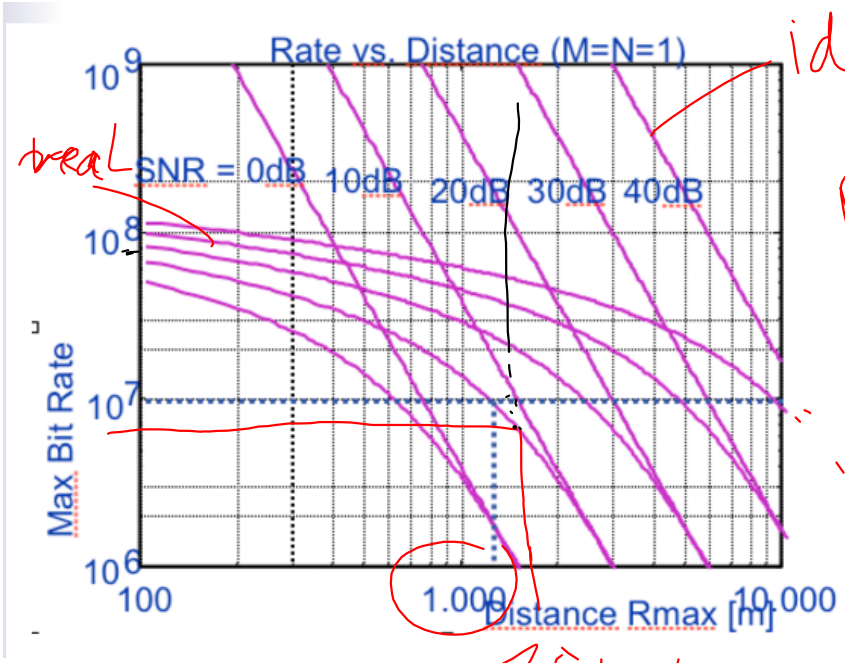
MIMO → beam forming

802.11 n

new: Multi-MIMO



→ "real MIMO" analyse & combine multiple path



ideal

real

$R_{max} = \log_2(1 + SNR)$

$R_{\max} = \log_2$

[Source:

SNR = 10 dB

$R_{max} = 7.5\,km \rightarrow 2\,Mbit/s$

SNR = 40 dB $R_{max} = 7.5\,km$

Bitrate < 100 Mbit/s

7,5 km UMTS typical cell size

yields the wave equation:

$$\frac{\partial^2 \vec{E}}{\partial t^2} - {c_0}^2 \cdot \nabla^2 \vec{E} = 0$$

$$\frac{\partial^2 \vec{B}}{\partial t^2} - {c_0}^2 \cdot \nabla^2 \vec{B} = 0$$

with $c_0 = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 2.99792458 \times 10^8$ m/s

[Source: Wikipedia]

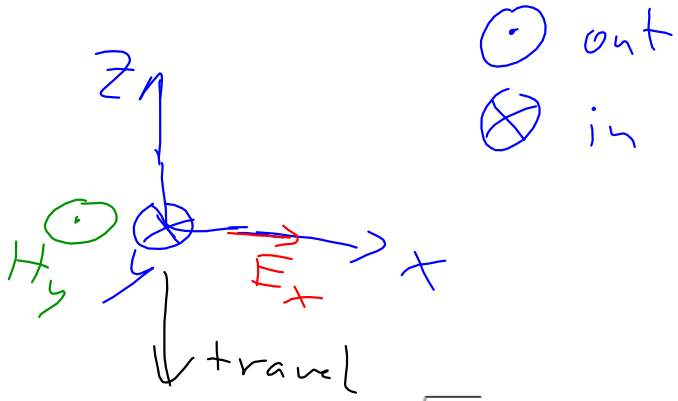
speed of light

$c \sim 3 \cdot 10^8 \frac{m}{s}$

Medium $v_{speed} = \frac{1}{\sqrt{\mu \varepsilon}}$ $\mu = \mu_0 \cdot \mu_r$ $\varepsilon = \varepsilon_0 \cdot \varepsilon_r$

voice: scalar

Wave: E_x - H_y



where direction

→ $\vec{r} = (x, y, z)$ and $\vec{k} = (k_x, k_y, k_z)$ so?

- j is the imaginary unit
- $\omega = 2\pi f$ is the angular frequency, [rad/s]
- f is the frequency [1/s]
- $e^{j\omega t} = \cos(\omega t) + j\sin(\omega t)$ is Euler's formula

with the group velocity (free space = speed of light) $c = \frac{c_0}{n} = \frac{1}{\sqrt{\mu\varepsilon}}$ and the refraction index $n = \sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}}$

free space resistance

$Z_0 = \frac{E}{H} \sim 377\,\Omega$

antenna cable

50Ω, 75Ω

Free space propagation next week

Presentation

30 min slot : 20 min pres + 10 min discussion

> Internet of Things & cognitive Radio

Questions / Open Issues

Topics

- > 5G security and mobility challenges : Haroon
- > Device to device communication challenges and opportunity : Magnus
- > Location variability in satellite communication : Hani
- > Modelling wireless propagation : Maxime
- > Mobile broadband performance measurements : Cise
- > 5G network slicing : Georgios

heterogeneity

1320 – 1400

1400 – 1430

1745 – 1515

19 Sep 2017

19 Sep 2017

15:15 – 15:45

13:30 – 14:00

break 14:30 – 14:45

For scientific literature search: http://its-wiki.no/wiki/Search_for_literature

and use https://vpn.uio.no for full access to ACM and IEEE