focus 2015

> Presentation of Slobodan on "Propagation equation"
> Presentation of Marshed on "Radio channels in WPAN"
> also: Shannon, Capacity
> define 2nd presentation

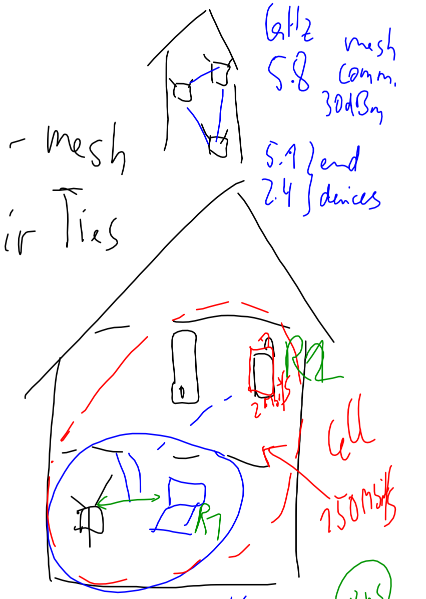
Repeater

Basic Internet.org
.no

- content type filtering
  only compressed text & pictures
- Kinshasa, DRC Congo

Eye SaaS
- admin

- mesh
Air Ties



Multi-user MIMO
Cell breathing
not
- timing
delay
4m → 13ns
upstairs 12m → 40ns
Cell = 600 MBit/s
s = 4m / 3E8 m/s = 13ns
t = c
c = s / t

R2 only 2 Mbit/s
SNR
multipath fading
high power → high noise to R1

for 29Oct

- Slobodan: (I) calculation of receive power and (II) Shanon capacity values

- Marshed: short presentation of paper

- Josef to ask Pedro to present AirTies meas

- agree on 2nd topic

- (Basic Internet) presentation

Exercise:

$$P_R = P_T G_T G_R \left(\frac{\lambda}{4\pi R}\right)^2 \quad L$$

$$P_R[dB] = 10 \log (\ldots\ldots) \quad \text{to do}$$

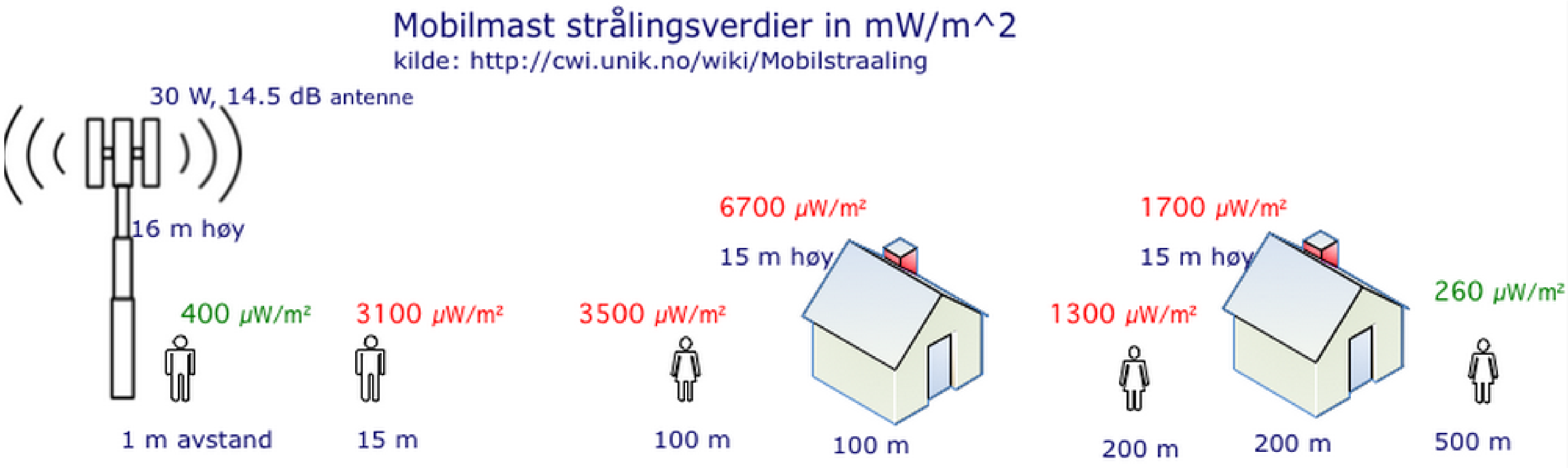
$$= \ldots$$

1 GHz

$$L = 92.4 + 20 \log d[km] + 20 \log f[GHz]$$

(1)

$L =$ 92.4 → 98.4 | 0, 6 | 1 km, 0.3, 2 km, 4 km



Size of this preview: 800 × 244 pixels. Other resolution: 840 × 256 pixels.

Original file (840 × 256 pixels, file size: 56 KB, MIME type: image/png)

Free Space Propagation

develop propagation equation, see (http://www.antenna-theory.com/basics/friis.php)

Power received in an area in a distance R from transmitter:

- area of a sphere is $A_s = 4 * \pi * R^2$
- power transmitted from isotropic antenna is P_t
- antenna area of receiver is $A_r =^2 /4\pi$
- power received in A_r = P_r

$P_r = P_t * A_r / A_s = P_r = P_t * A_r / (4 * \pi * R^2)$

thus

$$P_r = P_t \; G_t \; G_r \; \left(\frac{\lambda}{4\pi r}\right)^2.$$

- convert into dB
- provide examples for f = 10 MHz, 1 GHz, 100 GHz
- discuss influences on radiation pattern

How much is 0 dB_m and 10 dB_m?

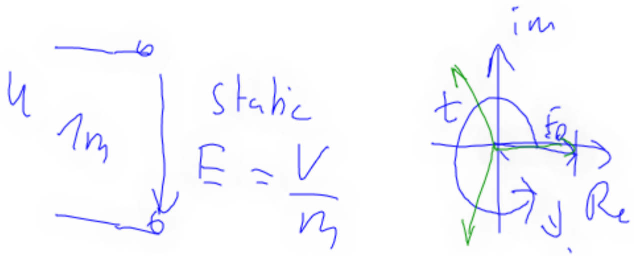
- Convert dBm to mW is: mW = 10^(x/10), x = number of dBm
- Convert mW to dBm is: dBm = 10*log10(y), y = number of mW

So you get:

- 0 dBm = 10^(0/10) = 1 mW
- 10 dBm = 10^(10/10) = 10 mW

Free space attenuation $L = 92,4 + 20\log(d[\mathrm{km}]) + 20\log(f[/\mathrm{GHz}])$

Relation between propagation values



Field strength for a given isotropically transmitted power:

$$E = P_t - 20 \log d + 74.8$$

Isotropically received power for a given field strength:

$$P_r = E - 20 \log f - 167.2$$

Free-space basic transmission loss for a given isotropically transmitted power and field strength:

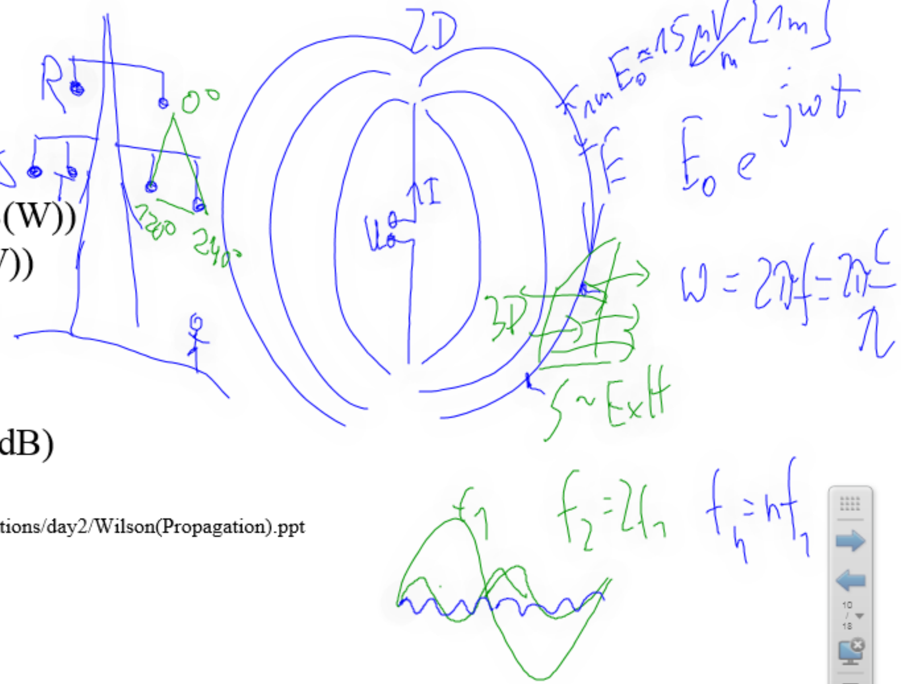
$$L_{bf} = P_t - E + 20 \log f + 167.2$$

Power flux-density for a given field strength:

$$S = E - 145.8$$

where:

- P_t : isotropically transmitted power (dB(W))
- P_r : isotropically received power (dB(W))
- E : electric field strength (dB(μV/m))
- f : frequency (GHz)
- d : radio path length (km)
- L_{bf} : free-space basic transmission loss (dB)
- S : power flux-density (dB(W/m²)).



Taken from International Council for Science - www.iucaf.org/SSS2010/presentations/day2/Wilson(Propagation).ppt

$$P_{dB} = 10 \log_{10} \frac{P}{1W}$$

$P = 20W$

$\log(\ )$ ← no unit

$$P_{dBm} = 10 \log_{10} \frac{P}{1mW}$$

Typical Mobile

$P_T = 25W$

$G_T = 14\,dB$

$G_R = 3\,dB$

typical examples

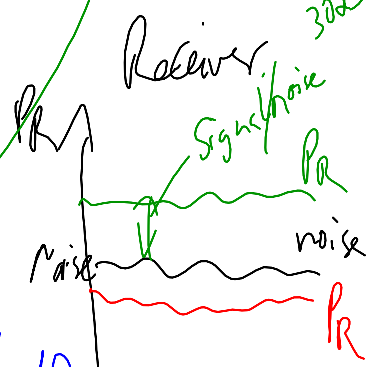
I. Receive Power

II. Shannon Capacity

$R = 0.1km \quad 1km \quad 3km \quad 10km$

$f = 900\,MHz, \; 2.1\,GHz$

$P_R = ?$



Typical WLAN

$G_T + P_T = 20\,dBm$ (rule!)

$G_R = 6\,dB$

$f = 2.4, \; 5.2\,GHz$

$R = 1, 10, 50m, 150m?$

$P_{sens\,GSM} = -104\,dBm$ (?)

$P_{sens\,UMTS} = -112\,dBm$ (?)

$P_{sens\,WLAN} = -95\,dBm$

Shannon

$$C = B \log_2\left(1 + \frac{S}{N}\right)$$

B ↑ Bandwidth

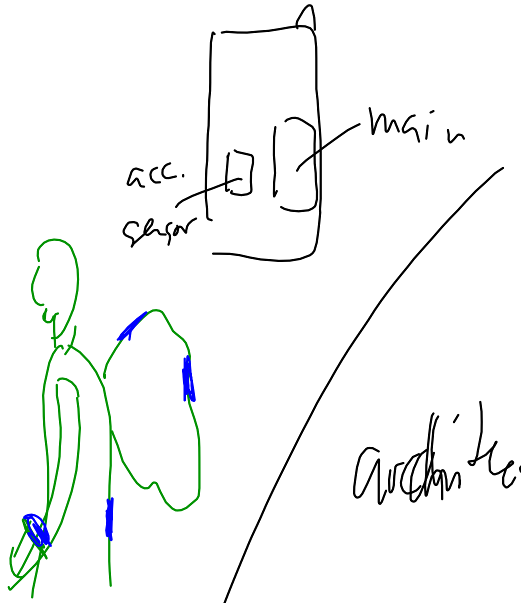
S/N ← results from P_R / P_{Noise}

GSM

4MiS

LTE

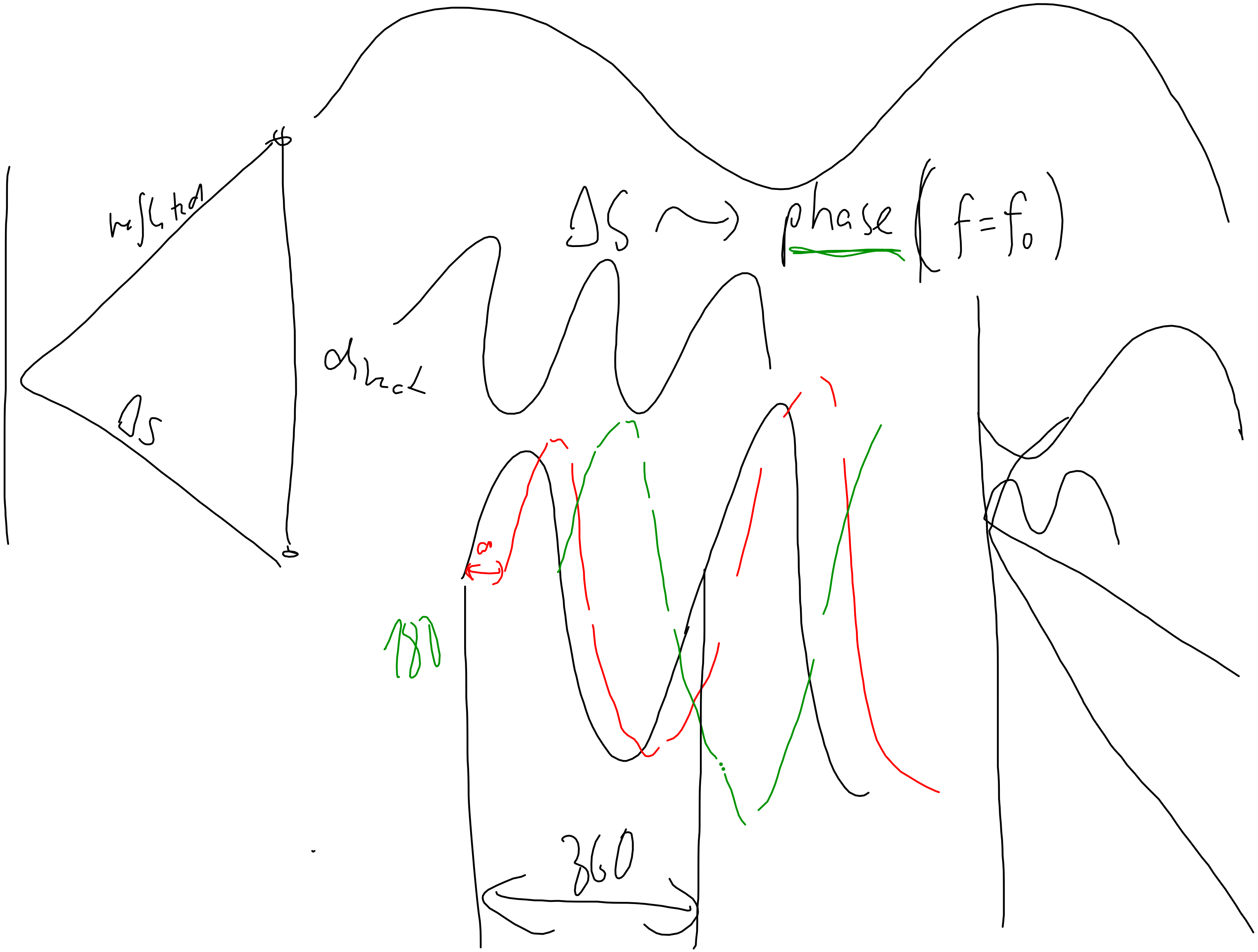
WiFi

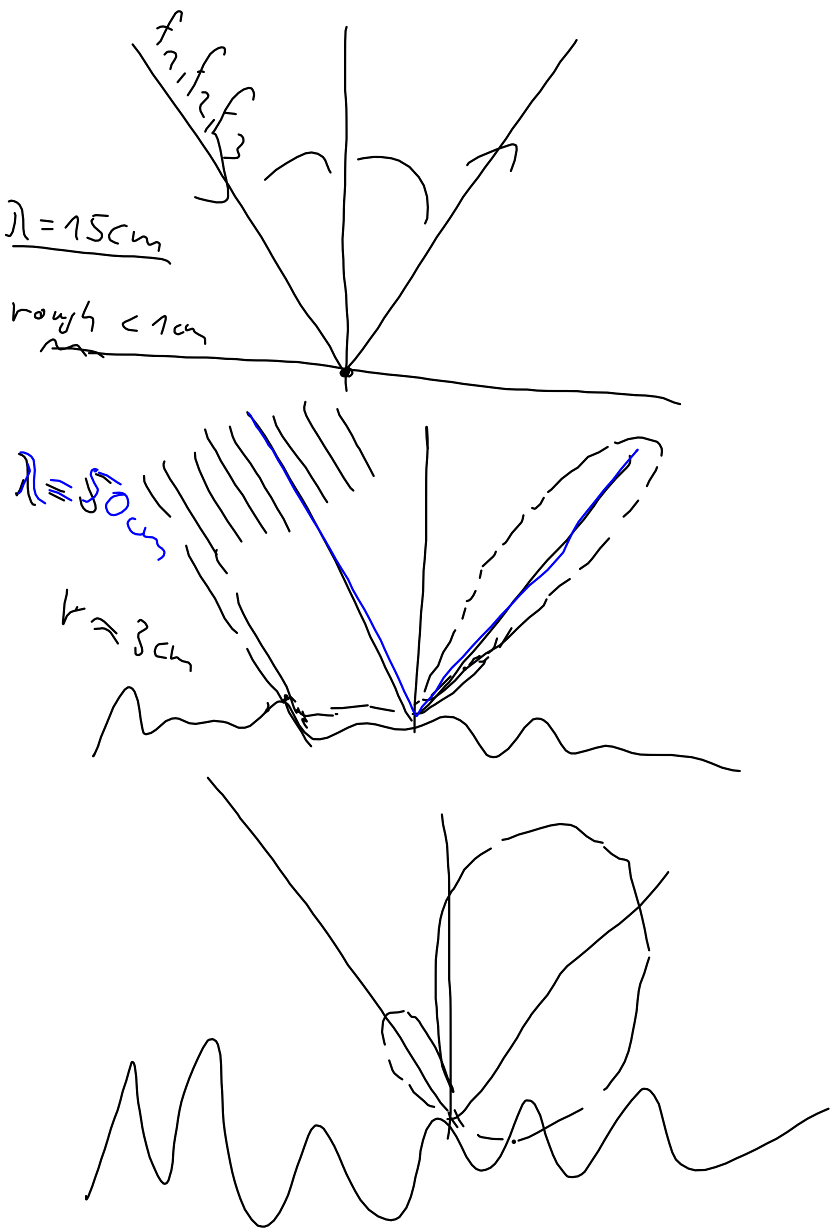


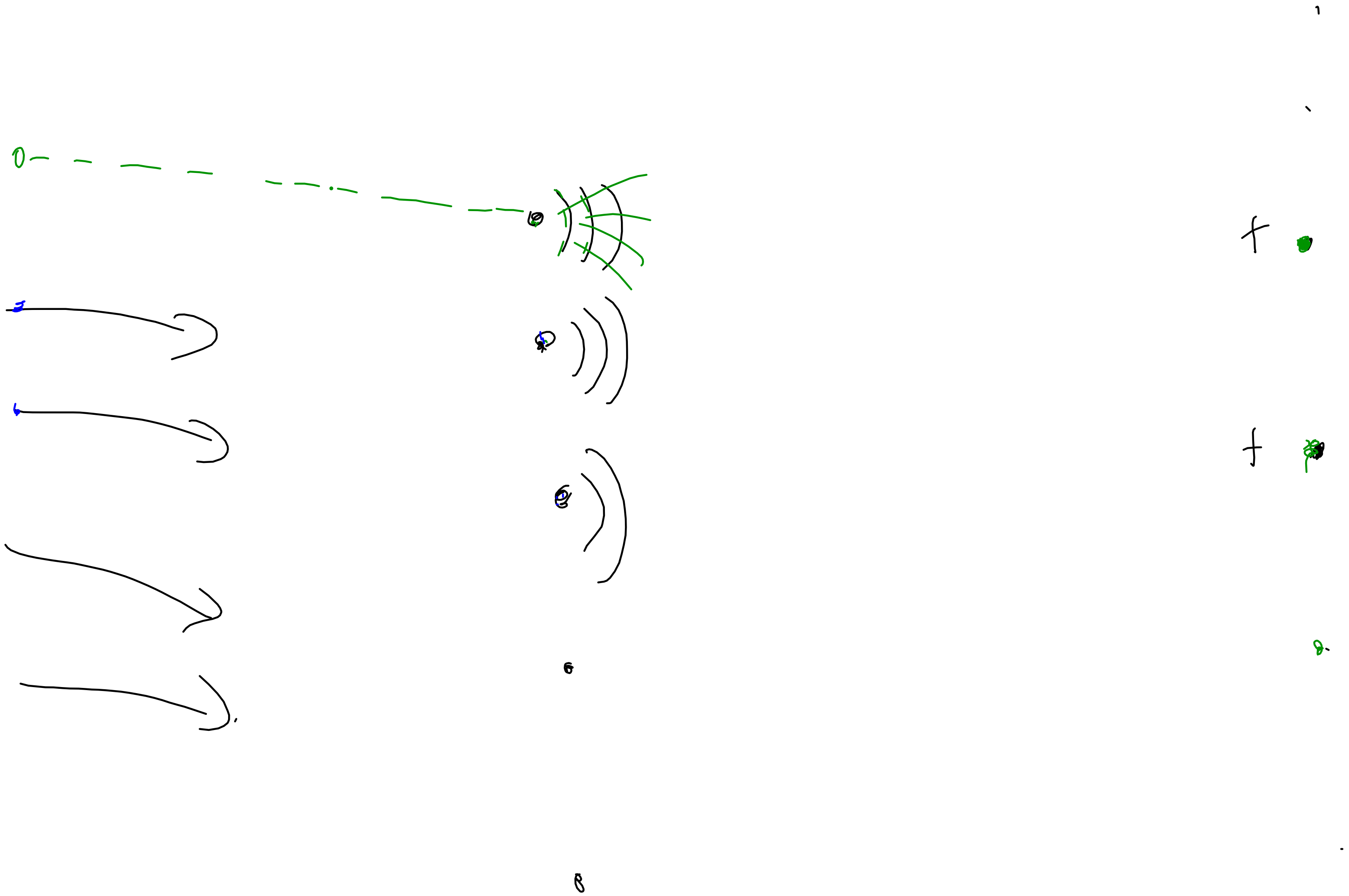
architecture

Mac

Channel models/adapt

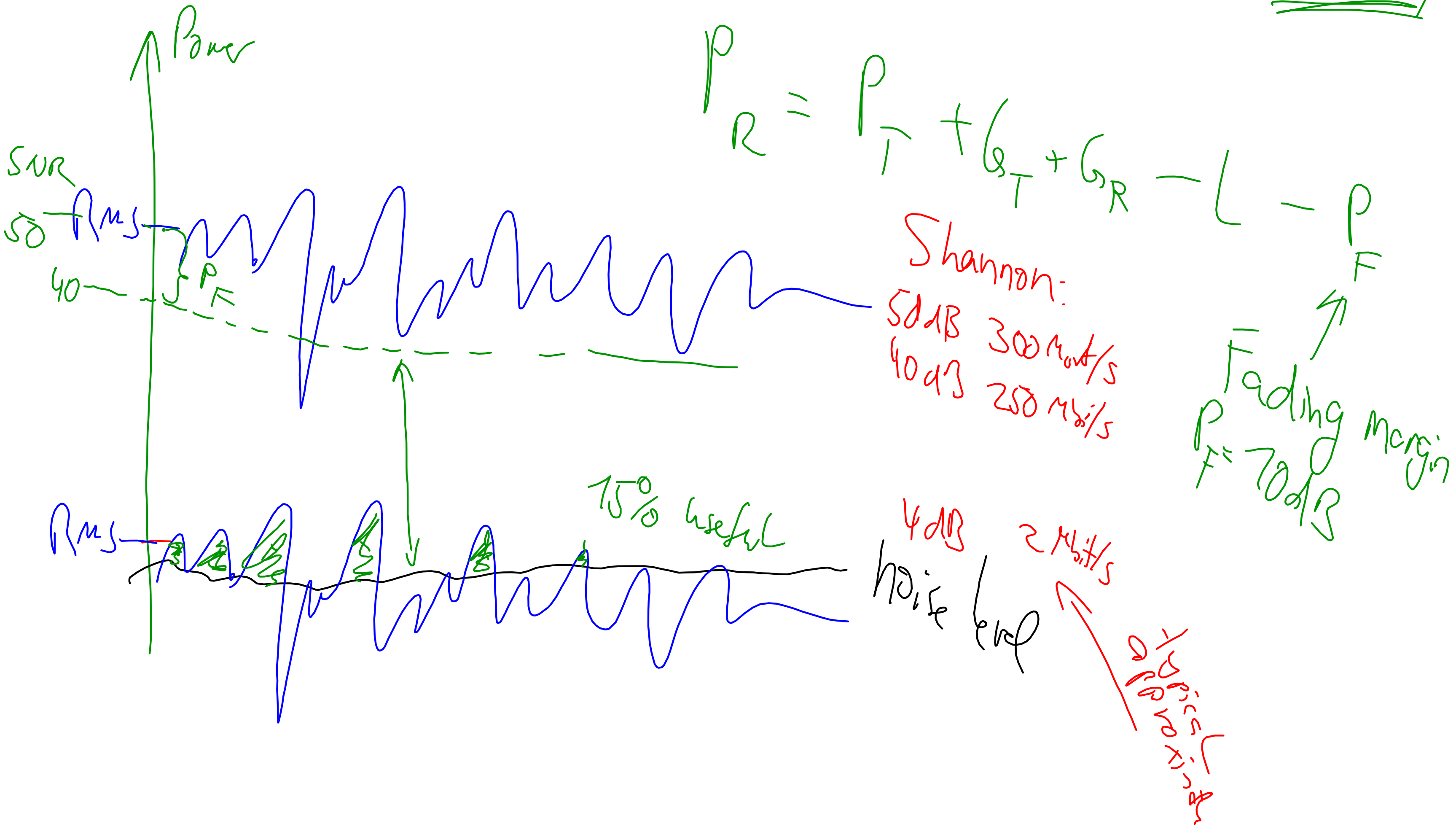

Δs ~> phase (f = f₀)
360
180


f1, f2, f3
λ = 15cm
rough < 1cm
λ = 50cm
r ≈ 3cm



Effect of Signal to Noise (SWR)

$$P_R = P_T + G_T + G_R - L - P_F$$



Shannon

$$C = B \log_2 (1 + SNR)$$

dominant

watt ratio

→ 28 Oct

SNR, capacity ↓

B: Bandwidth

Q: Capacity increase

		P_{sens}	P_T	G_T dB	G_R
80 kbit/s GSM/GPRS	8 · 10 kbit/s (8 slots) 200 kHz	−104 dBm	2W	3	14
~1.6 Mbit/s UMTS (Edge 8 slots)	3.8 MHz	−116 dBm	25W	14	3
~2 ... 16 Mbps LTE	2, 5, 10, 20, 40 MHz	−116 dBm ?	25W	14	3
~8 Mbps WLAN b,g	20 MHz	−95 dBm	100 mW		3
~16 Mbps WLAN c	20+20	−95 dBm	100 mW		3

simplification = P_{noise}, no traffic

Q1: Given a constant SNR, increase of capacity C from GSM to ....