UNIK 4700

AI: Slobodan to read 1. lecture

- Q&A 17.9. 1100-1200 @ Ifi 4th edn.'s
- Topics to present (2x) & work on (2x)
- for freq. (p11) which physical objects $\left(\frac{\lambda}{20}\right) \frac{\lambda}{10} < \ell < \lambda\,(2\lambda)$ interfere with the EM wave → blocking

$f = 1\,GHz$, $\lambda = 30\,cm$ } $d = 3 \ldots 30$ cm birds, rocks

- Microwave ⟷ WLAN ? $f = 2.4\,GHz$

lecture plan

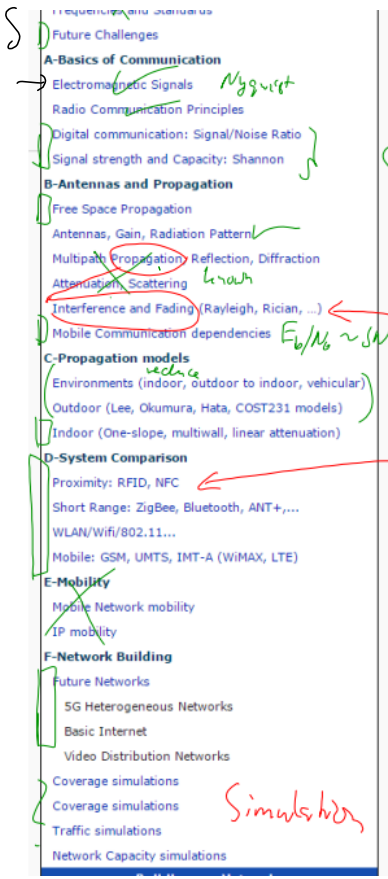
- tentative seminar dates:

28Aug, (10)/11Sep, (8)/9Oct, 29(30)Oct, (26)/27Nov, Exam (10)/11Dec

- phone call: every Friday at 09:15 during

Slobodan, 17 Sep 11004

Topics



Marshed

Sloboday

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

Propagation equation

Presi in "Physics" (open, example: WPAN (Personal Area Networks))

$E_b/N_0 \sim SNR$

Proximity (start from earlier assignments & Literature, Wikipedia)

? chip inside ?

traffic analysis

Basic Internet

free compressed text & pictures

video, games

audio, voice } local

UNIK4700 -> lectures, search:

cwi.unik.no/wiki/B1-Free_Space_Propagation

- Assume a plane wave: E_x, H_y. Show that $\frac{E_x}{H_y} = Z_0 = \sqrt{\mu_0/\varepsilon_0}$

Question: I still don't understand the propagation equation

⌘ Task: Plane wave propagation

Assume a plane wave: E_x, H_y. Show that $\frac{E_x}{H_y} = Z_0 = \sqrt{\mu_0/\varepsilon_0}$

What is the relation between a plane wave and an omnidirectional wave?

⌘ 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

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

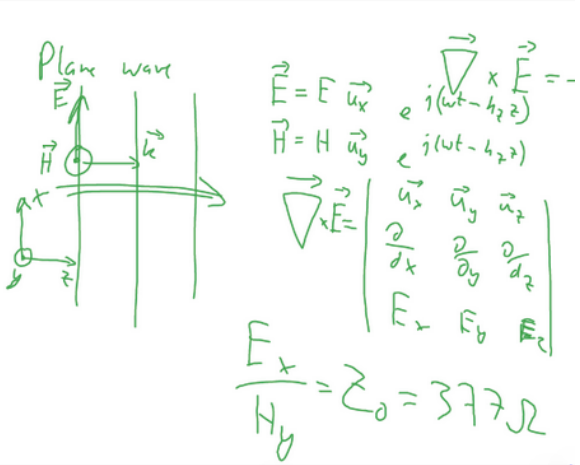
- convert into dB
- provide examples for f = 10 MHz, 1 GHz, 100 GHz
- discuss influences on radiation pattern

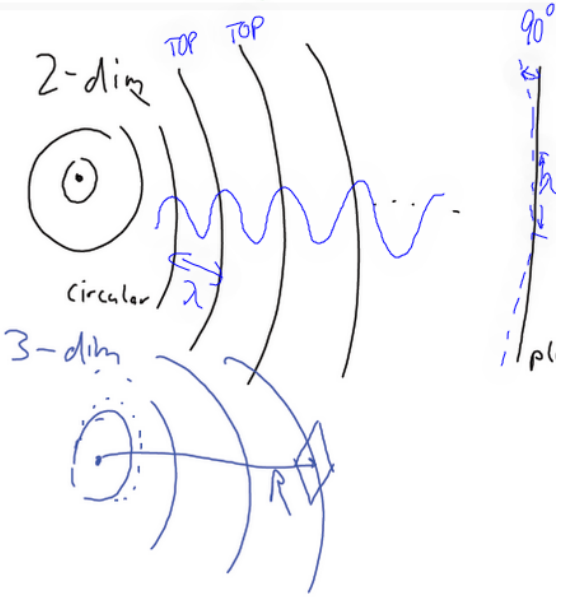
How much is 0 dB_m and 10 dB_m?

- 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





why presentation?

"ecosystem"

Company	Revenue	Operating income	Net income	Employe
~~Statoil asa~~	431,112	114,449	39,045	21,213
Norsk Hydro asa	196,234	52,224	17,224	33,218
Telenor asa	91,077	14,721	18,535	31,500
Aker asa	79,892	3,508	3,942	35,816
Orkla asa	52,683	4,480	11,263	28,663
Aker Kværner asa	50,592	0	3,942	22,722
~~Total E&P~~ Norge as	50,577	36,261	8,787	241
~~ExxonMobil~~ Exploration and Production Norway as	49,680	35,546	8,632	0
Yara International asa	48,261	3,352	4,210	7060
~~Esso Norge~~ as	45,408	297	306	890
~~Kommunal Lands~~pensjonskasse	43,581	5,086	5,086	312
NorgesGruppen asa	36,631	1,102	866	9,255
~~Storebrand asa~~	34,074	5,549	1,505	1,305
Norske Skogindustrier asa	28,812	-2,527	-2,809	9,372
DnB NOR asa	28,439	14,066	11,808	11,993
Helse Øst rfh	26,685	-831	-747	0
a/s Norske Shell	26,336	8,663	4,334	673

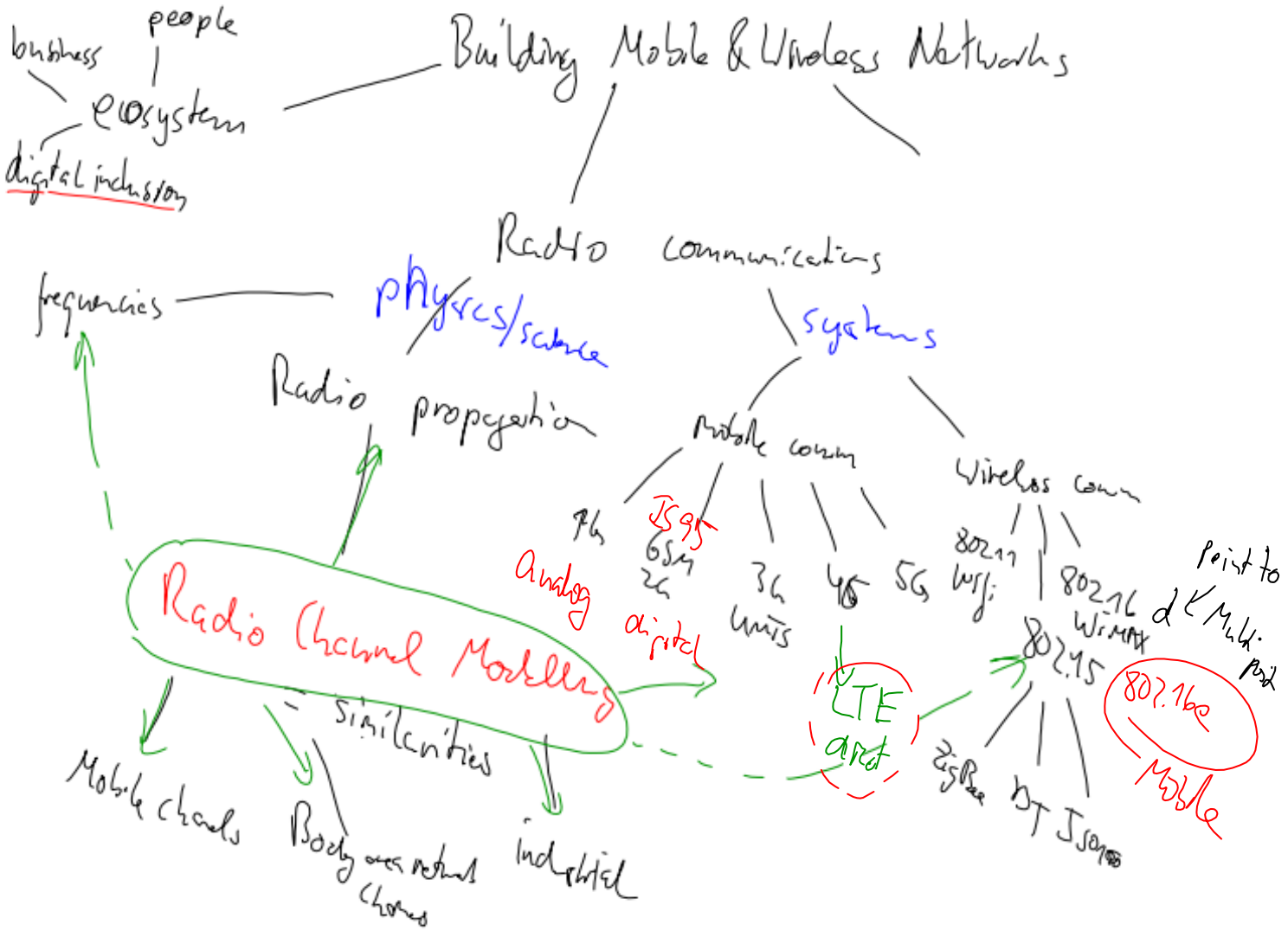
Aluminium
Telecom
yards
Kværner
food
Fertilizer
Pension
food
insurance
forest industry
Liquid
3rd
6-8th
top 5

Fast Search → Microsoft Bing

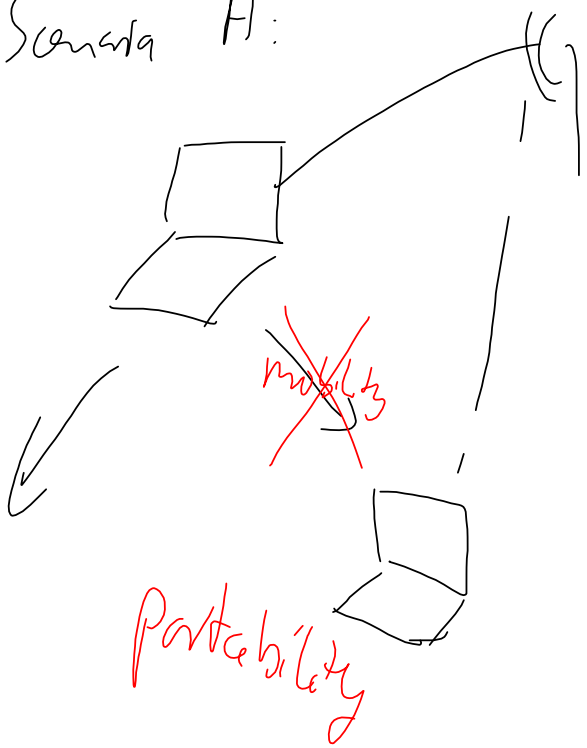
Opera Software → ??

Trolltech → Qt → Nokia → Microsoft

Scandinavian Banks
Linux
php
Skype
Spotify ...


Building Mobile & Wireless Networks
people
business
ecosystem
digital inclusion
Radio communications
frequencies
physics/science
systems
Radio propagation
Mobile comm
Wireless comm
2G
GSM
3G
UMTS
4G
5G
802.11
WiFi
802.16
WiMAX
Point to
Multi.
Radio Channel Modelling
analog
digital
similarities
LTE
and
802.15
802.16e
mobile
ZigBee
BT
Mobile channels
Body area network
channels
Industrial

Scenario A:



Scenario B

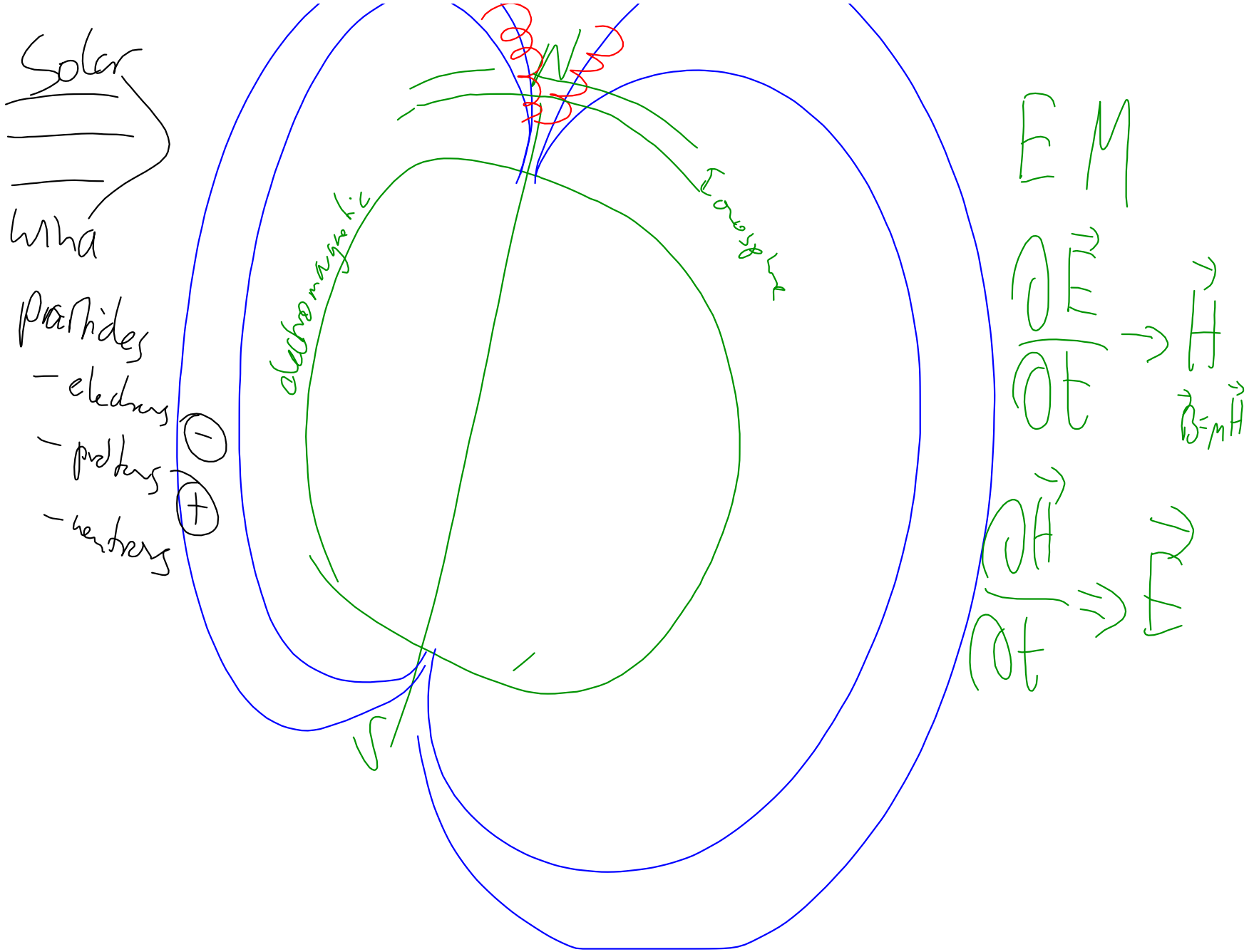
"mobile"

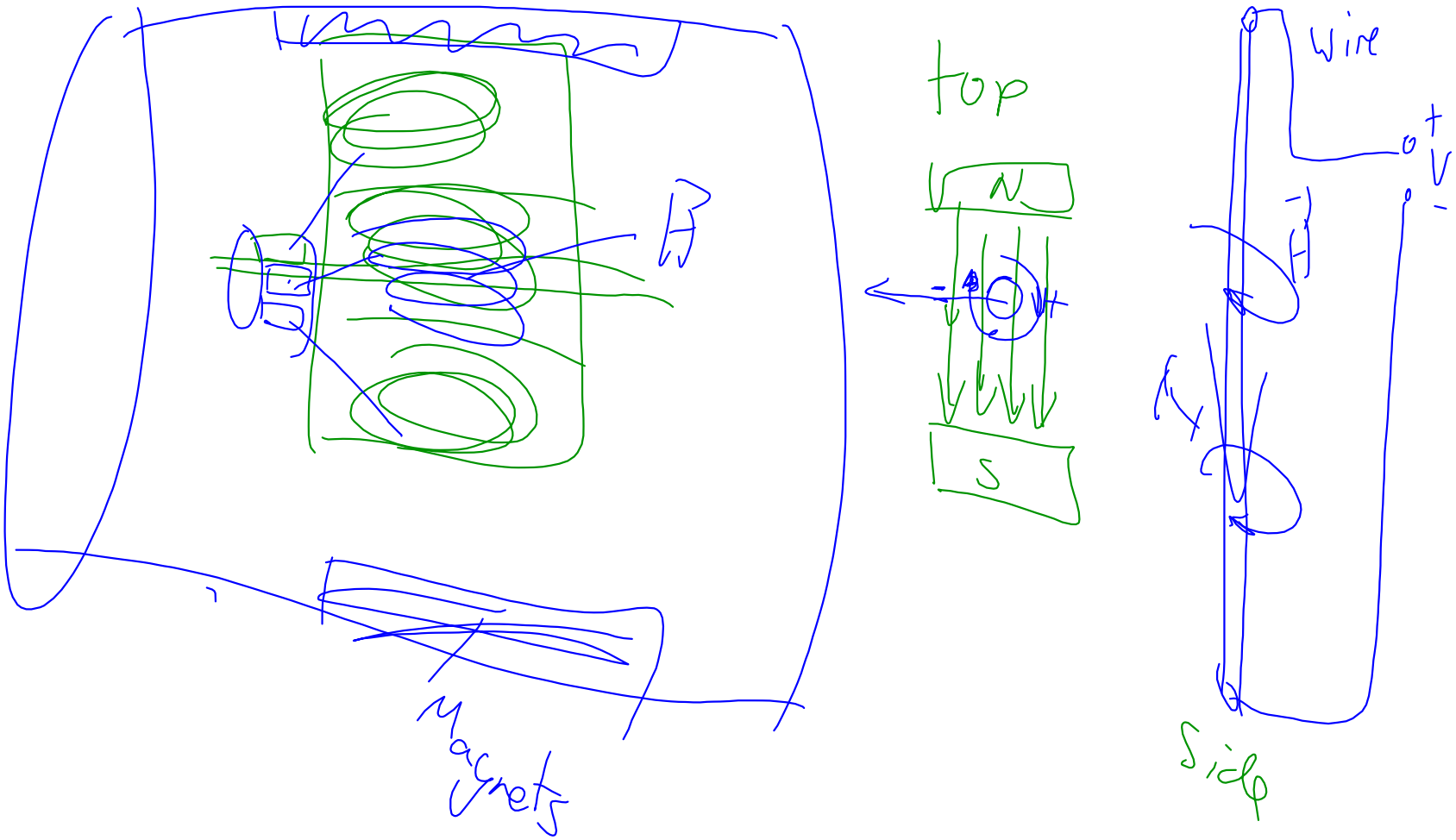
$V > 5$ km/h

"signalling" (100 - 250 km/h)

Signalling (allocation)

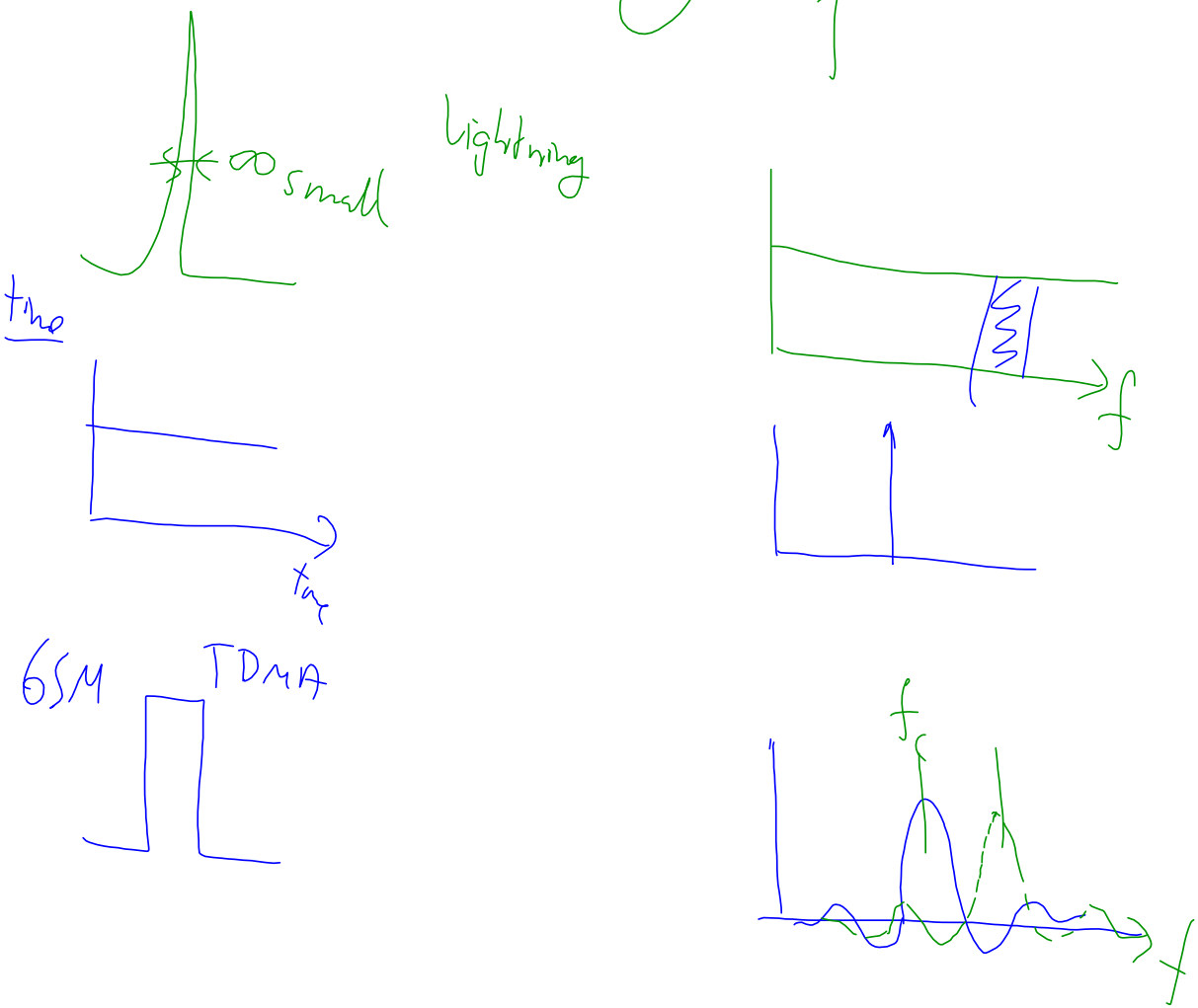
Data


Solar
wind
particles
- electrons
- protons
- neutrons
electromagnetic
energy
E M
$\frac{\partial \vec{E}}{\partial t} \rightarrow \vec{H}$
$\vec{B} = \mu \vec{H}$
$\frac{\partial \vec{H}}{\partial t} \Rightarrow \vec{E}$

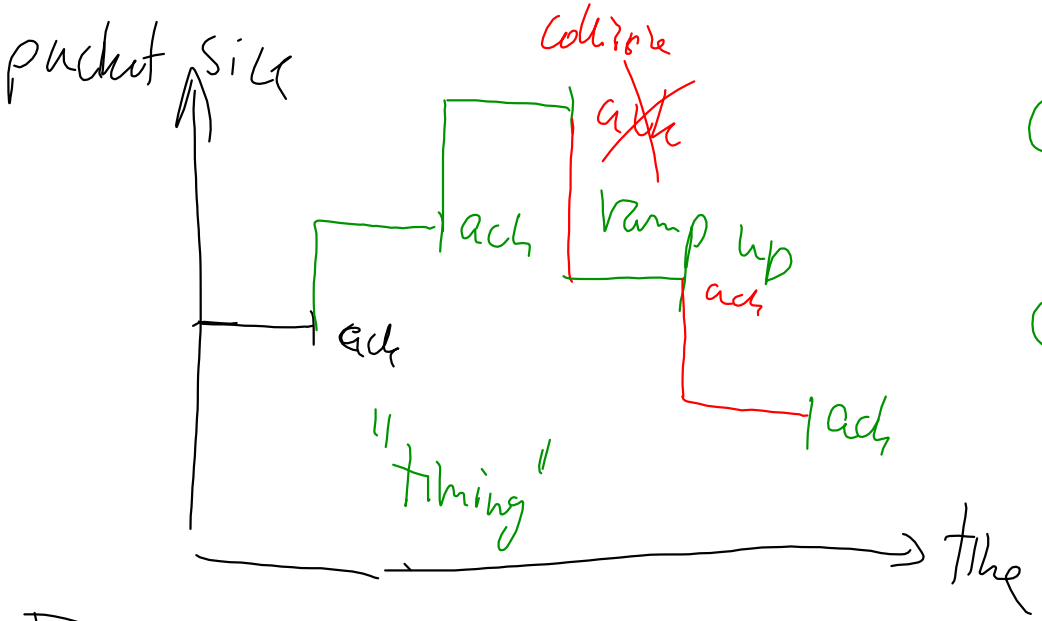

top
N
S
Wire
Side
Magnets

Fourier transform

t ⟷ f



TCP/IP ack packet size



cable: packet collision

air: bit error

Bit Error Rate 10^{-3}

party ok

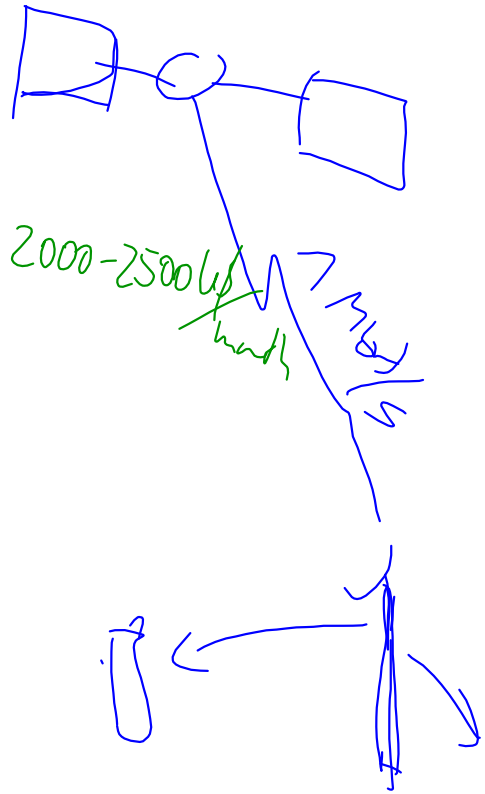
100/100/1 → 10^{-6}

TCP/IP over "air" behave badly as compared to cable

Cost model of an operator

- amount < 16 GByte

- Speed base < 1 MBit/s



Antennas:

- gain, $g \sim \left(\frac{D}{\lambda}\right)^2$ max as compared to isotropic
- directivity $\Theta_{3dB} \sim \frac{\lambda}{D}$

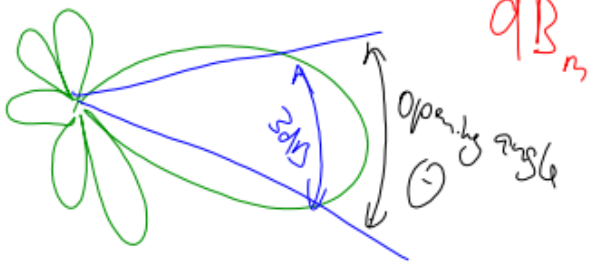
$10 \log\left(\frac{P}{P_0}\right)$

$20 \log\left(\frac{E}{E_0}\right)$

30 dB $\frac{P}{1W}$

dB_m $\frac{P}{1mW}$

$\frac{D}{\lambda}$ = dimension

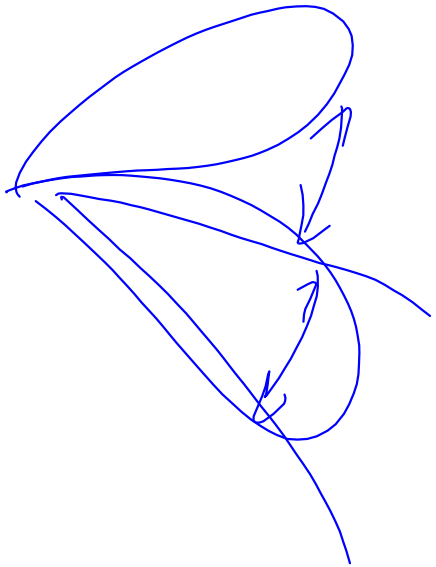


E, H directional antenna

Typical values

Type	Gain	
mobile phone	~3dB	microstrip
Base station	~14-20dB	magnetic gap
dish directivity	~25-40dB	

antenna
beamforming



power P

receiver sensitivity

SNR

signal to
noise ratio

0 – 60 dB

Capacity

60 Gbit/s

range r

outdoor ~ 200m (f=60GHz)

MIMO

Multiple Input
Multiple Output

T_x 2 x 2 R_x antennas

3 x 3

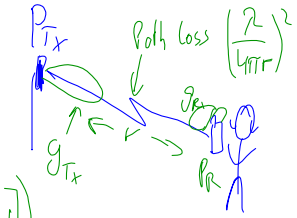
frequency f

wavelength λ

- physical interaction $\frac{\lambda}{20} < d < 2\lambda$ antennas $\sim \frac{\lambda}{2} \dots \lambda$

f[GHz]	0,1 (radio)	1	2	2.5	5	10 (TV satelita)	60	GHz
$\lambda[cm] = \frac{30}{f[GHz]}$	3m	30cm	15	12 (WiFi)	6	3	0.5cm	

- notation dB, dBm
  Decibel $P[dB] = 10 \log_{10}(P[W])$
  $P[dBm] = 10 \log_{10}(P[mW])$



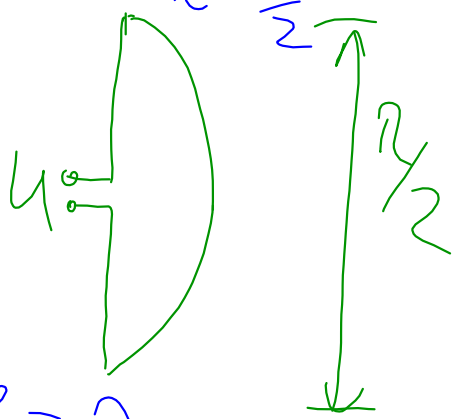
- Power equation: $P_{Rx} = P_{Tx} \cdot g_{Tx} \cdot g_R \cdot \left(\frac{\lambda}{4\pi r}\right)^2$
  ↳ transfer in dB, dBm
- Capacity eqn (Shannon) $C = B \log_2(1 + SNR)$ (B: bandwidth)

https://www.youtube.com/watch?v=sosHAgSpXWk
iPhone 4G antenna: the effect of the bumper

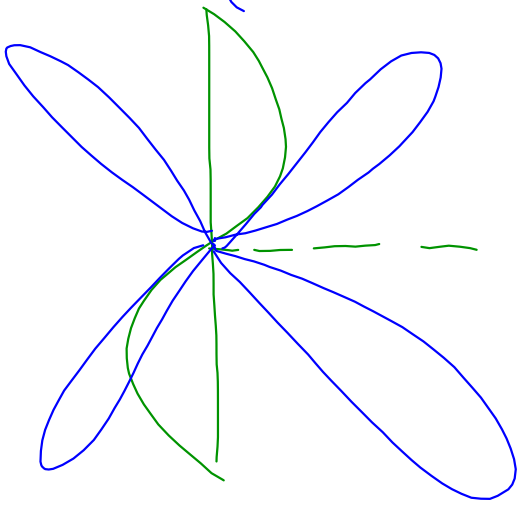
Others: attenuation loss $\sim e^{-\alpha d}$ (d: thickness)
dielectric const. $\sim \varepsilon_r$
attn. coeff.: air 1, tap 3-5, water 80

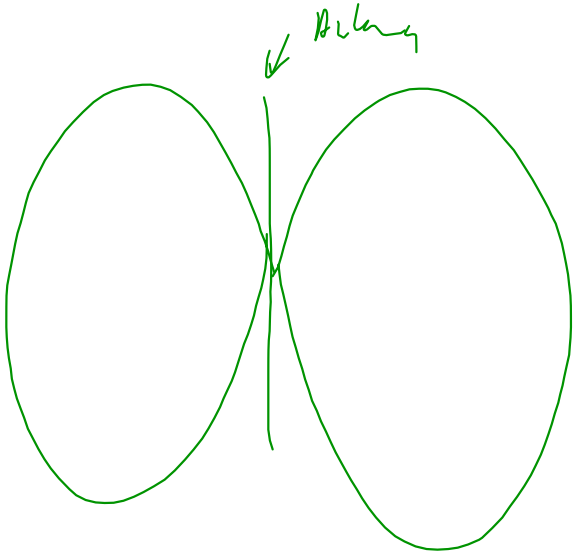
Isfjord radio, Svalbard (Spitzbergen)

el $\ell = \frac{\lambda}{2}$

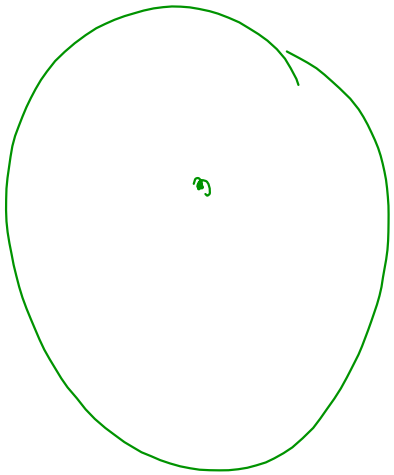


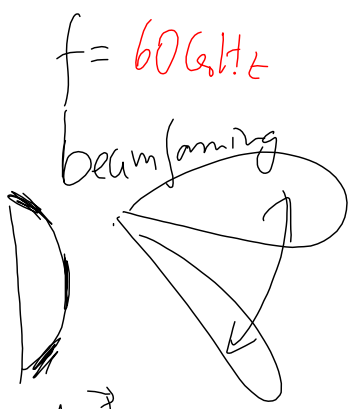
$\ell = \lambda$





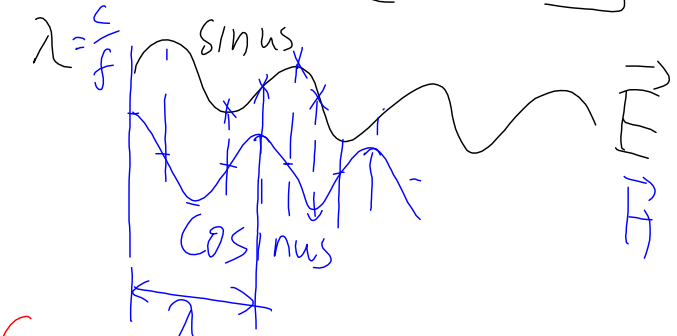
top





$c = 3\,E8\ \frac{m}{s} \quad 3 \cdot 10^8$

$f\,[GHz] = \{1000 \cdot MHz\}_{E6} = E9\left[\frac{1}{s}\right]$



$\frac{d\vec{E}}{dt} \Rightarrow \vec{H}$

$\lambda = \frac{c}{f} = \frac{3E8\ m/s}{*E9\ \frac{1}{s}} = \frac{30\ cm}{f\,[GHz]} =$

$\lambda\,[cm] = \frac{30}{f\,[GHz]} \qquad \lambda\ 0.5\,cm$

f 60 5 2.4 2 900/800 GHz

802.11a 802.11b/g UMTS GSM

Mobil 850/900 1800/1900 2100 2650

trad: GSM GSM/UMTS UMTS LTE/4G

L08 L18 L26

iPhone 5