Today

- review last lecture "propagation"
- tasks for 2nd pres. & simulation
- from propagation to antennas and comm. parameters

TOC

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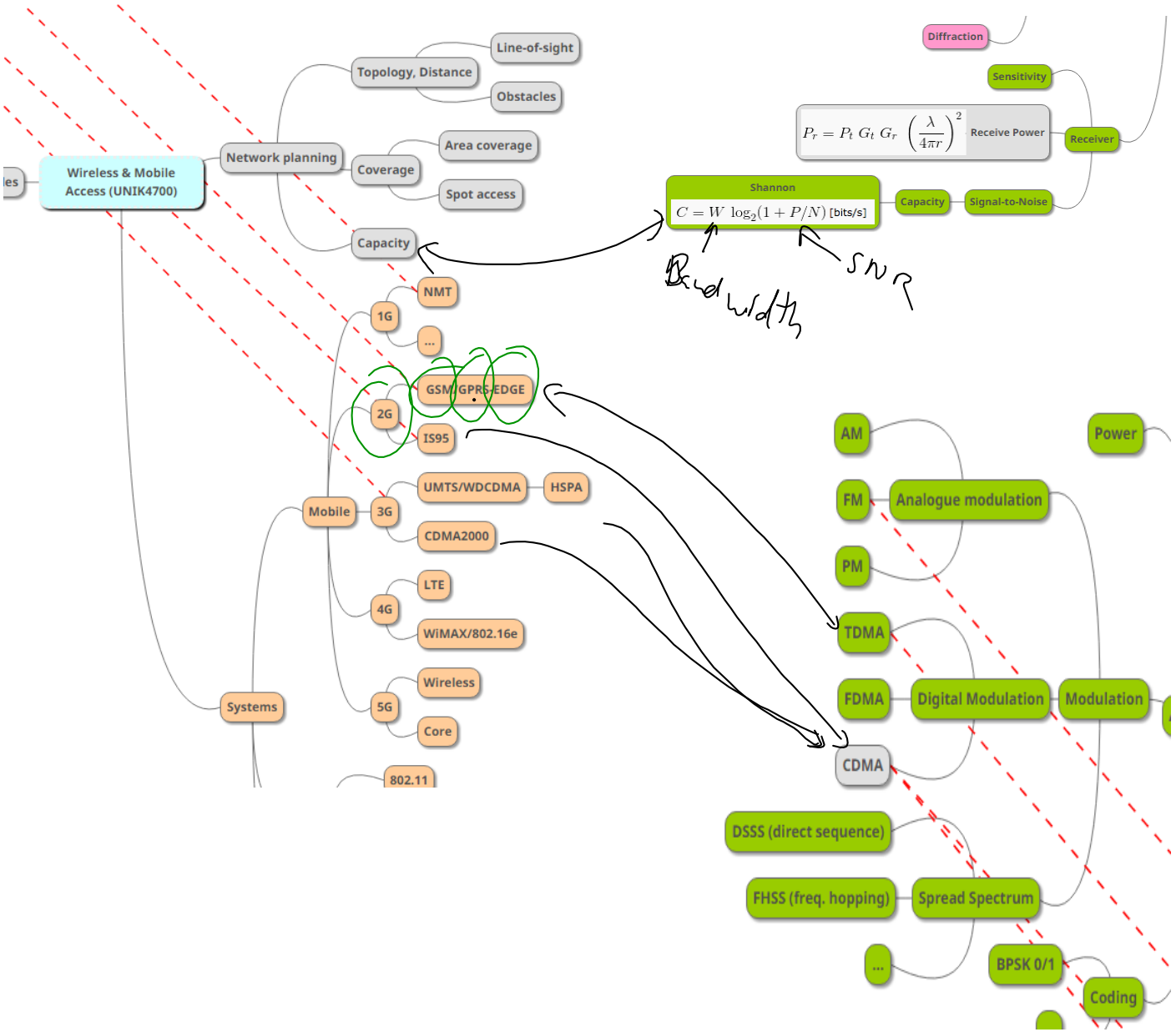
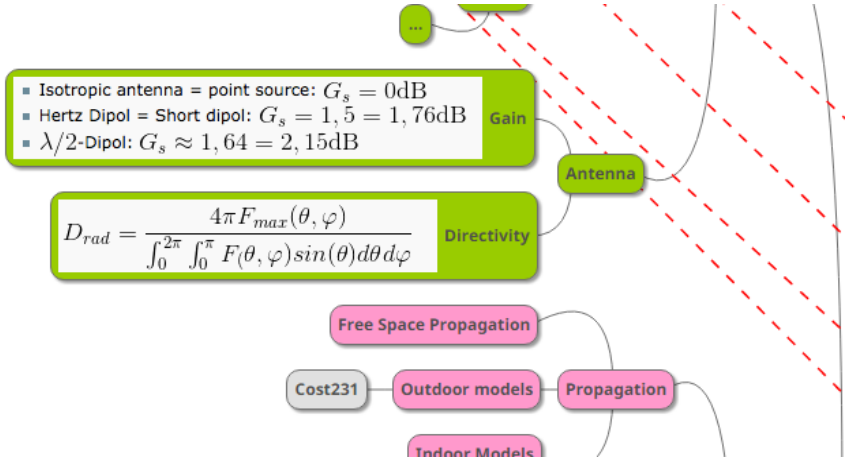
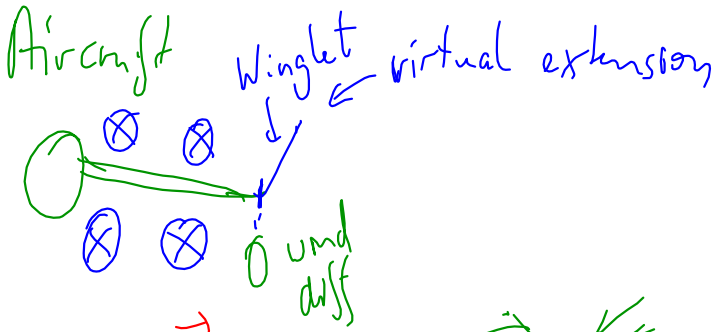

Wireless & Mobile Access (UNIK4700)
Network planning
Topology, Distance
Line-of-sight
Obstacles
Coverage
Area coverage
Spot access
Capacity
Diffraction
Sensitivity
$P_r = P_t\ G_t\ G_r \left(\frac{\lambda}{4\pi r}\right)^2$ Receive Power
Receiver
Shannon
$C = W\ \log_2(1 + P/N)$ [bits/s]
Capacity
Signal-to-Noise
Bandwidth
SNR
Mobile
1G
NMT
...
2G
GSM/GPRS-EDGE
IS95
3G
UMTS/WDCMA
HSPA
CDMA2000
4G
LTE
WiMAX/802.16e
5G
Wireless
Core
Systems
802.11
AM
Power
FM
Analogue modulation
PM
TDMA
FDMA
Digital Modulation
Modulation
CDMA
DSSS (direct sequence)
FHSS (freq. hopping)
Spread Spectrum
...
BPSK 0/1
Coding

Antennas





Maxwell

Source free environment and free space:

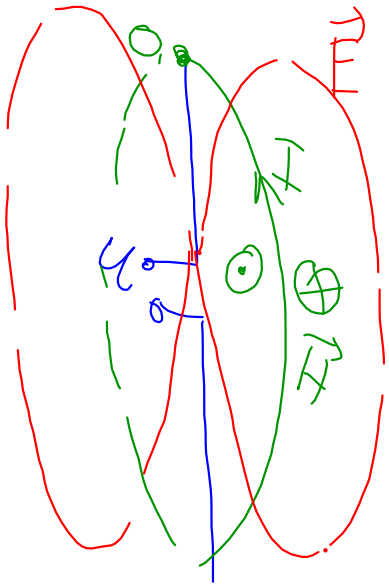
$$\nabla \cdot \vec{E} = 0 \qquad (1)$$

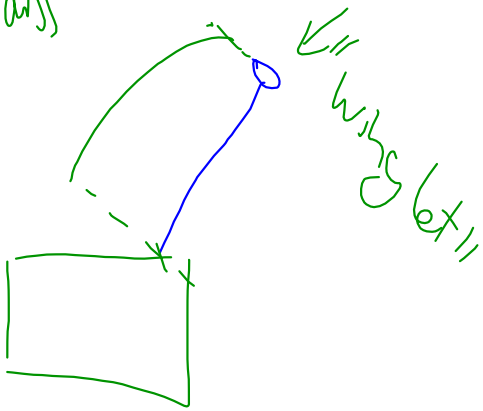
$$\nabla \times \vec{E} = -\frac{\partial}{\partial t}\vec{B} \qquad (2)$$

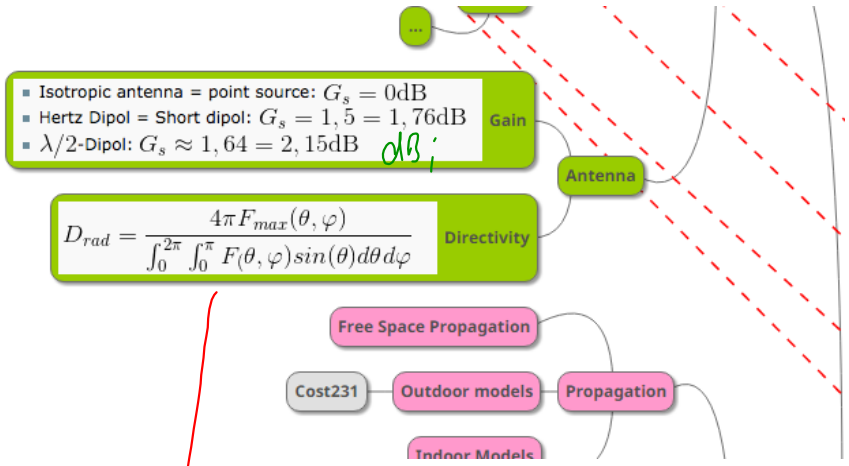
$$\nabla \cdot \vec{B} = 0 \qquad (3)$$

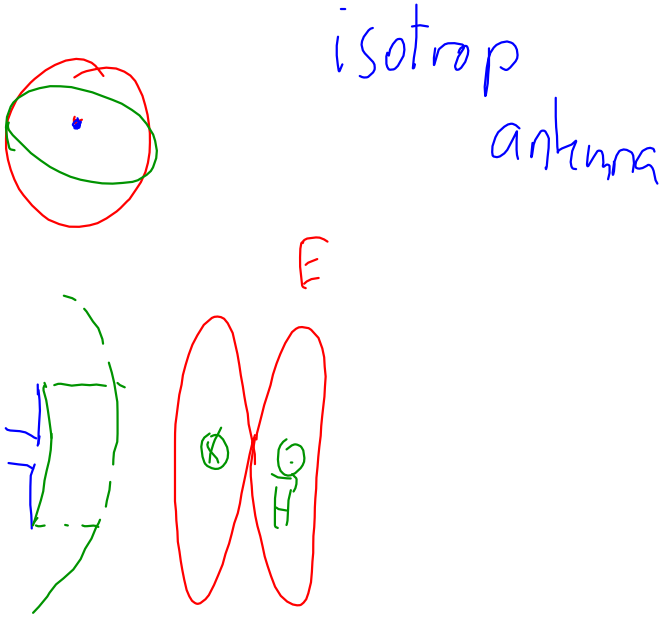
$$\nabla \times \vec{B} = \mu_0\epsilon_0\frac{\partial}{\partial t}\vec{E} \qquad (4)$$

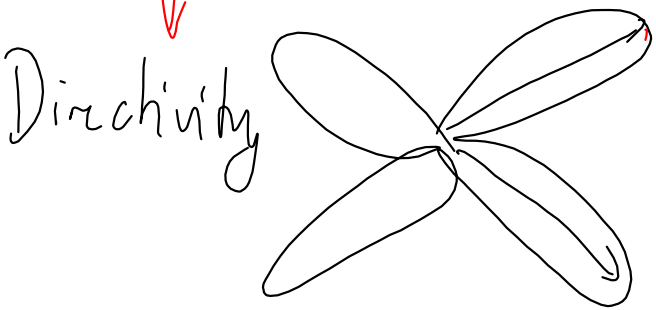
where div is a scalar function

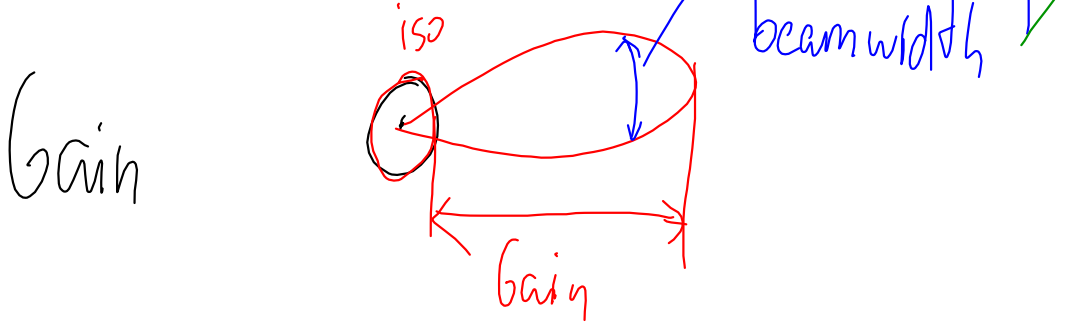





...
Isotropic antenna = point source: $G_s = 0\text{dB}$
Hertz Dipol = Short dipol: $G_s = 1,5 = 1,76\text{dB}$
$\lambda/2$-Dipol: $G_s \approx 1,64 = 2,15\text{dB}$
Gain
dBi
Antenna
$D_{rad} = \frac{4\pi F_{max}(\theta,\varphi)}{\int_0^{2\pi}\int_0^{\pi} F(\theta,\varphi)sin(\theta)d\theta d\varphi}$
Directivity
Free Space Propagation
Cost231
Outdoor models
Propagation
Indoor Models


isotrop
antenna
E
H


Directivity


Gain
iso
3dB
beamwidth
Gain

Wifi
max 20 dB_m EIRP

practical example

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

$-96\,dB_m = 44\,dB_m + 0\,dB + 0\,dB - 140\,dB$

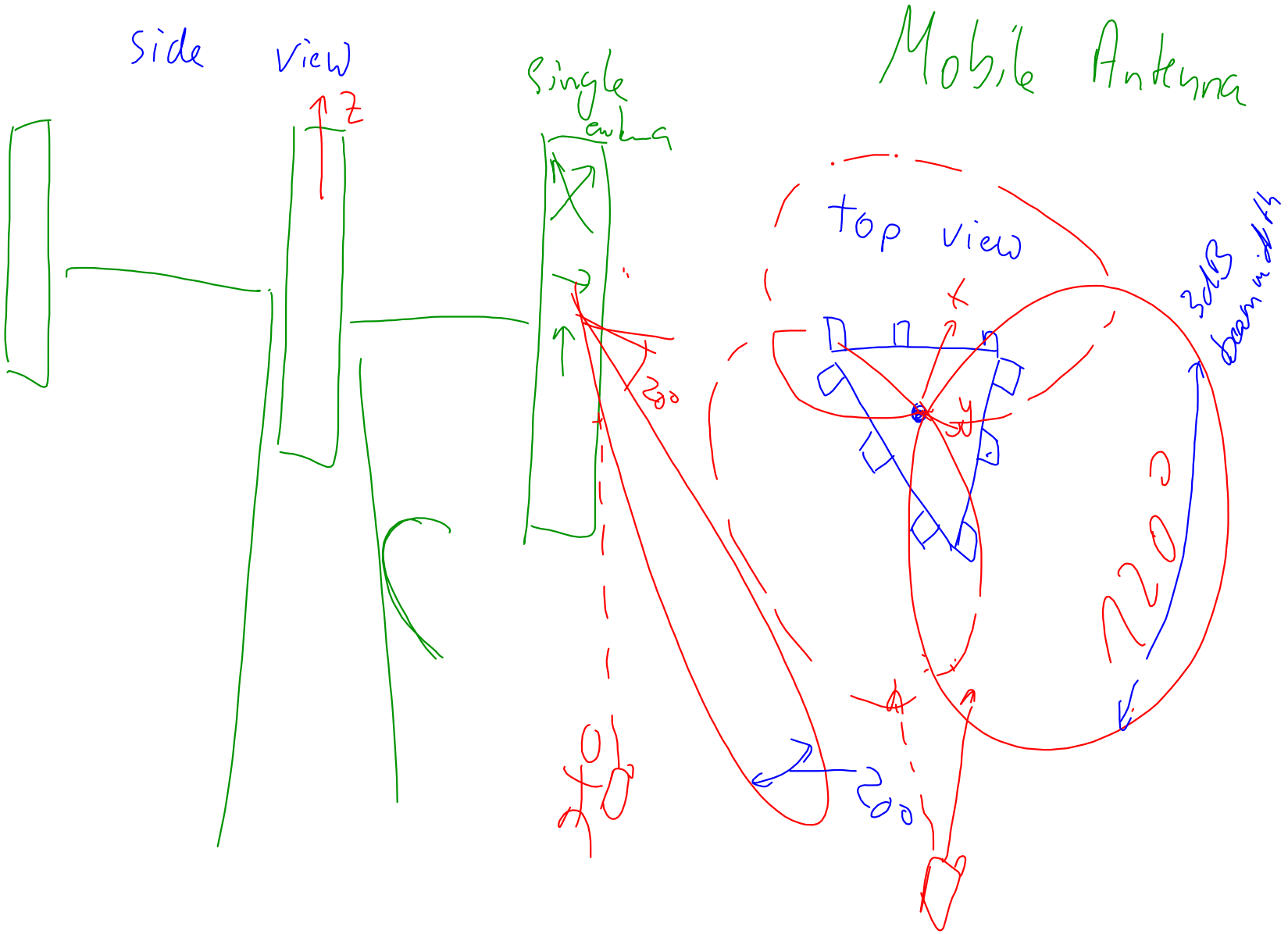
$P_{Sen} = -96\,dB_m \rightsquigarrow SNR = 0$

$R' = 2R$

$3\,dB \rightsquigarrow SNR = 3\,dB$

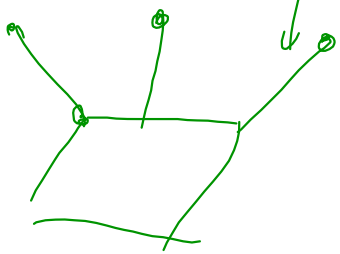
$-3\,dB \rightsquigarrow SNR = 0\,dB$

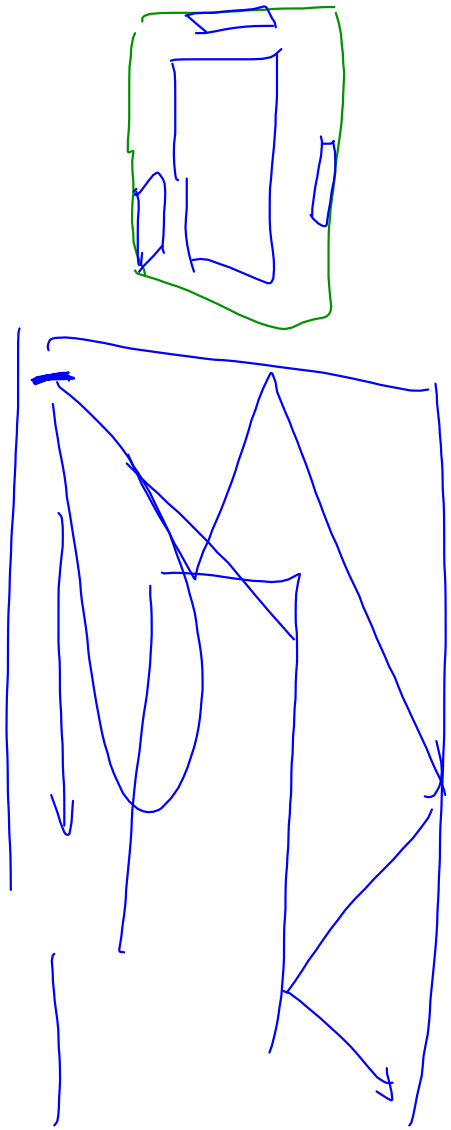
$25 + 25\,dB \rightsquigarrow SNR = 50\,dB$

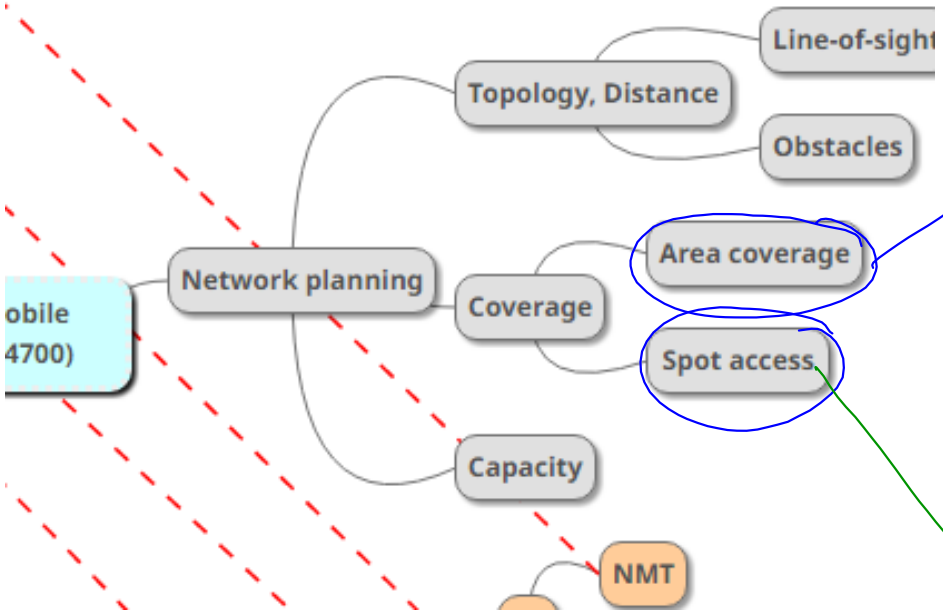

Side view
z
Single element
Mobile Antenna
top view
3dB beam width
30°
120°
20°

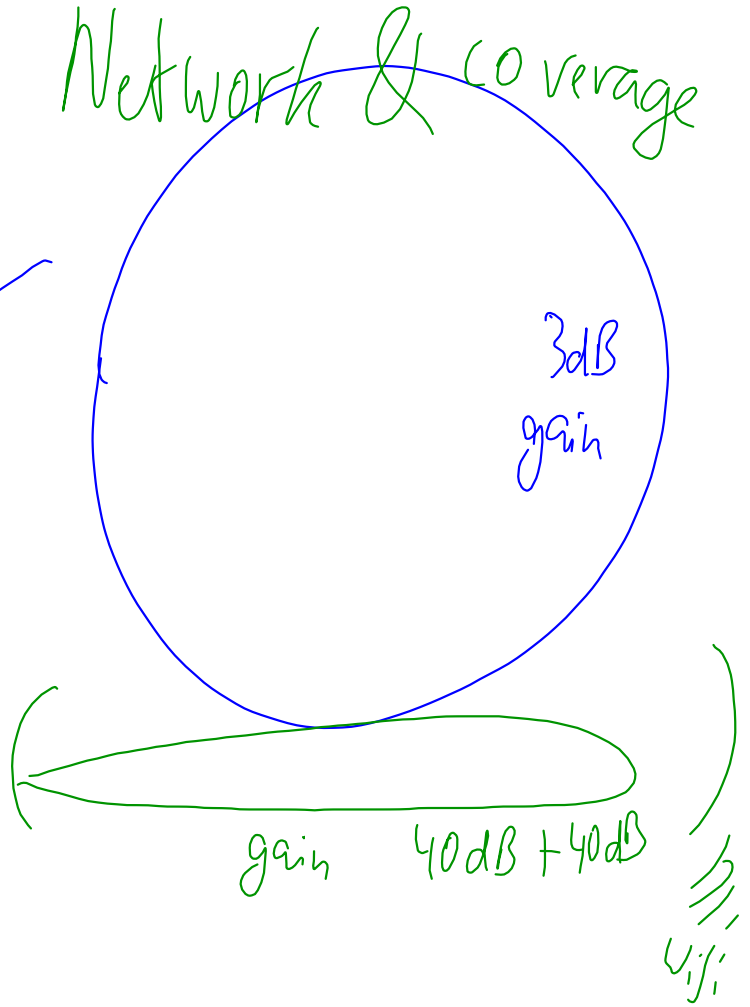
Wifi antennas

el dipol






Line-of-sight
Topology, Distance
Obstacles
Area coverage
Network planning
Coverage
obile
4700)
Spot access
Capacity
NMT


Network & coverage
3dB
gain
gain
40dB + 40dB
Wifi

gain

$f = 2.4\ GHz$ } $2\times \rightsquigarrow 2\times G$
↳ $f = 5.1\ GHz$

gain considerations

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

$$L[dB] = 92.4\ ? + 20\log(R[km]) + 20\log(f[GHz])$$

$$P_R[dB_m] = P_T[dB_m] + G_T + G_R - L$$

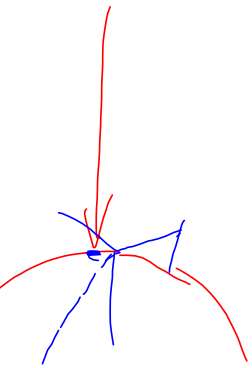
$f = 2.4 \rightarrow 4.8\ GHz$ $+3dB$ $+3dB$ $-3dB$ $= +3dB$

Sat: Thuraya

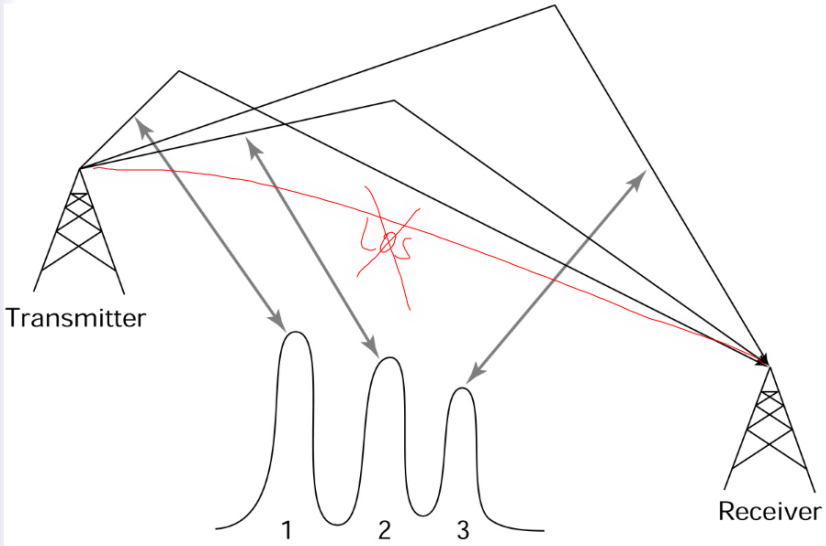
freq: 1.5 GHz

attenuation from Earth?

- obstacles
- (antenna)



Multipath And How To Use It



Multipath propagation can be used through

1.) specific receivers (rake receivers)
2.) Multiple-input, multiple-output antenna systems (MIMO)

Note: The mobile phone users will typically not have a direct link between the mobile phone and the antennas of the base station in a typical environment. Such a situation, where the mobile communication has to go "around a building" or "around the corner" are called **NLOS**, non Line-of-Sight connection. As compared to a Line-of-Sight **LOS** connection the signal is typically reduced by some 20-30 dB.

$L[dB] = 92.4 + 20\log(R[km]) + 20\log(f[GHz])$

NLOS ~ 30dB

R → R' L

2x 3dB

10x 20dB

16x ~ 29dB

Mobile coverage: 5 km (NLOS)

direct link: 5+76 ~ 90 km? LOS

Topics & time plan

- ~~Simulation~~ math/matlab/.XLs analysis & presentation

3-4 weeks

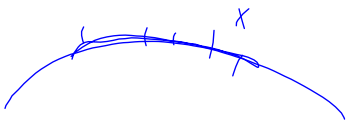
4k camera mobile coverage

Comparison Spot-network VS coverage network

Solar-powered relay 5.8 GHz point-to-point link

ICT & SDGs final report, May - Ericsson
https://www.ericsson.com/res/docs/2016/ict-sdg.pdf

2 — satellite
— radio links



Examples:

Wifi: theoretical vs measured

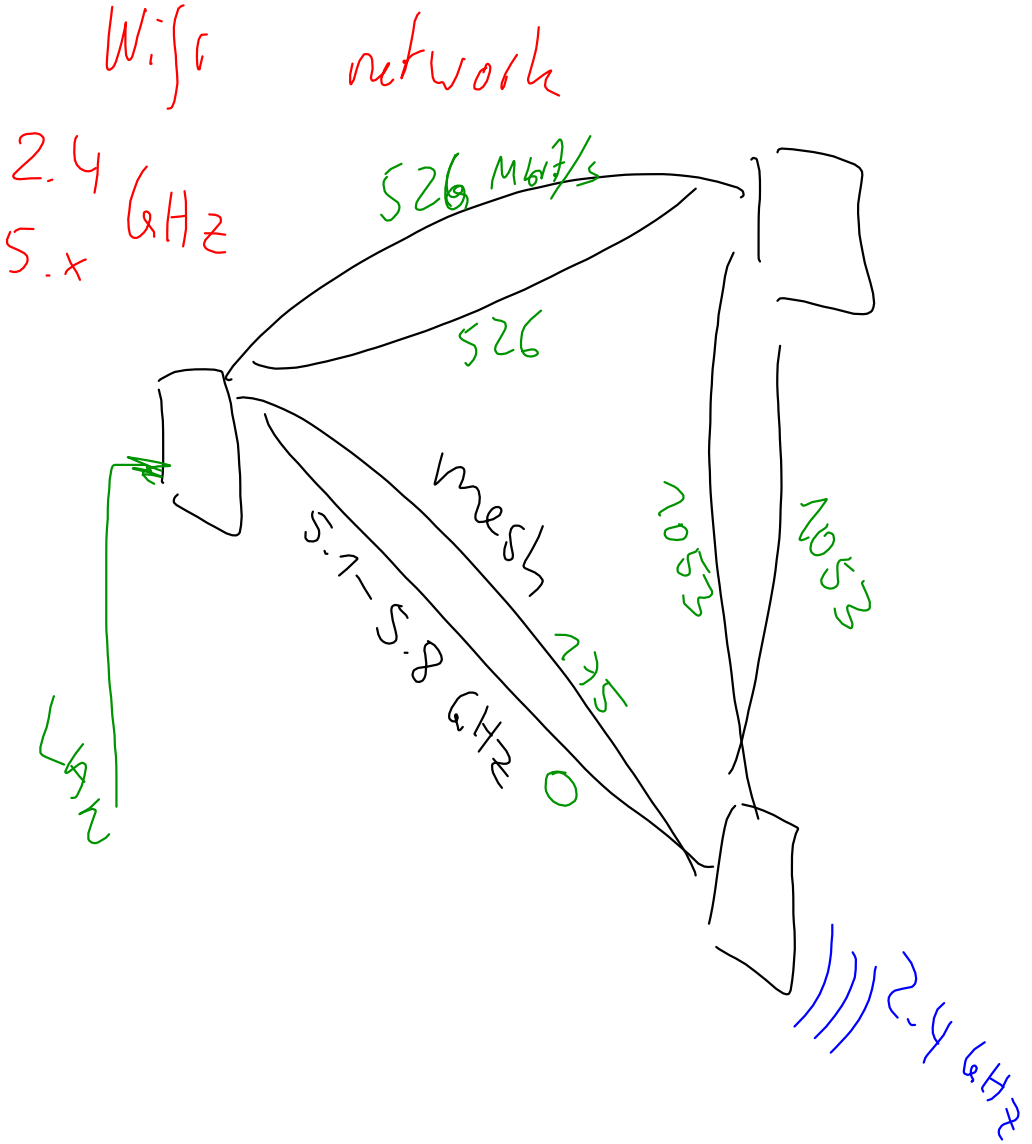
distance calculations

village coverage

body networks

effect of body/hand

capacity of WSN


Wifi network
2.4 GHz
5.x
526 Mbit/s
526
mesh
5.1-5.8 GHz
735
702
1053
LAN
2.4 GHz

Air 4920