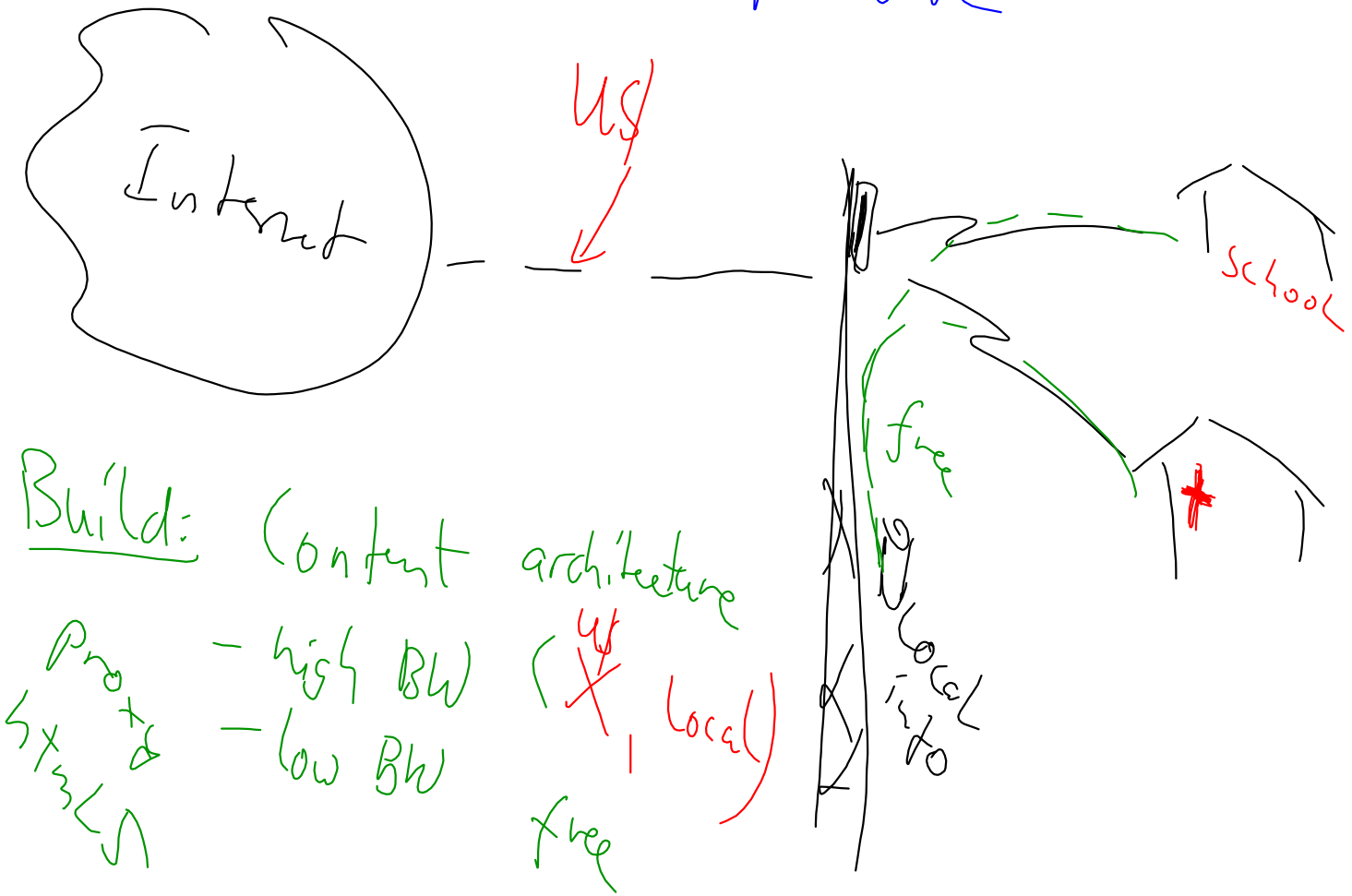
Digital health

- Network responsive



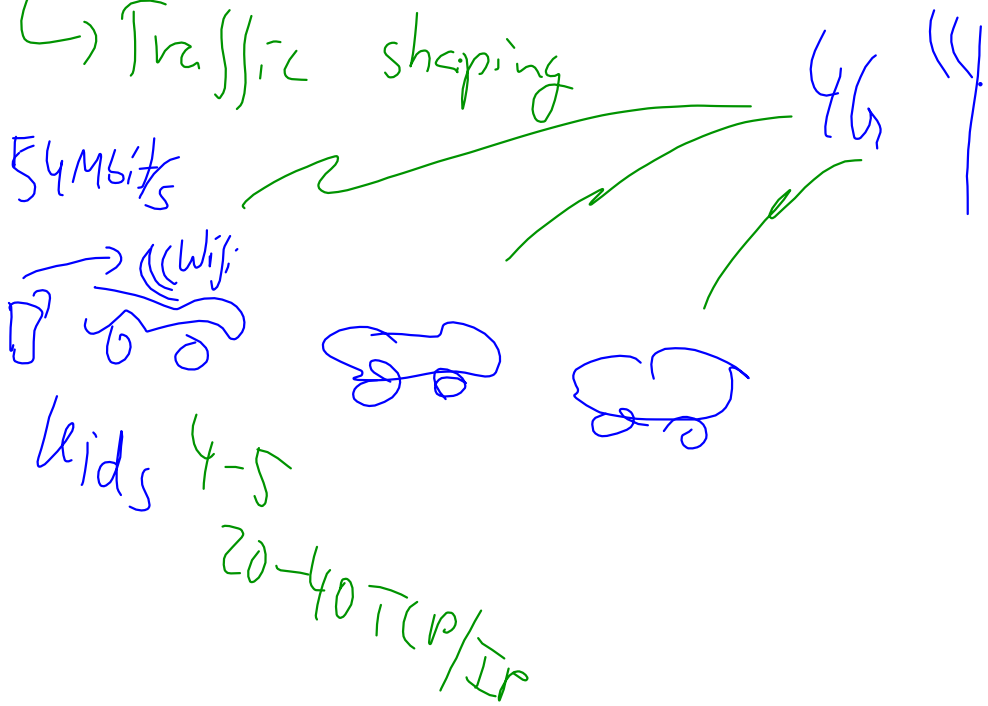
Build: Content architecture

- high BW (Uu, local)
- low BW free

Prod ex

Network responsive

- Traffic shaping



Challenge of Comm.

Frequencies are limited.

↳ Small cell (pico, femto)

↳ re-use

Wifi ← 1 cell

Cellular interference-aware

Test yourself, answer these questions

- What factors affect Wireless signal strength?
- Explain the meaning of the term diffraction
- How is diffraction used for radio communications?
- What is the difference between diffraction and interference?
- What is the difference between Scattering and Diffraction?
- What is non line of sight (NLOS)?
- Does WiMAX possess NLOS capability?
- How is UMTS different from current second generation networks?

FM 88-108 MHz VHF UHF

Very high frequency, VHF	30-300 MHz	10-1 m	Sporadic E propagation Extremely rare F1,F2 lay direct wave.
Ultra high frequency, UHF	300-3000 MHz	100-10 cm	Line-of-sight propagation. Sometimes troposphe
Super high frequency, SHF	3-30 GHz	10-1 cm	Direct wave.
Extremely high frequency, EHF	30-300 GHz	10-1 mm	Direct wave limited by absorption.

800/900 MHz GSM 25MHz BW

1800 GSM

2.1 GHz UMTS

2.4 WiFi

2.6 GHz LTE → 5.X

3.3 GHz ....

10% of carrier freq is "easy" BW

f = 900 MHz ~ 90 MHz BW

2.4 GHz ~ 240 MHz BW ⇒ 85 MHz

$f \rightsquigarrow \lambda = \frac{c}{f}$ $3E8\ m/s$

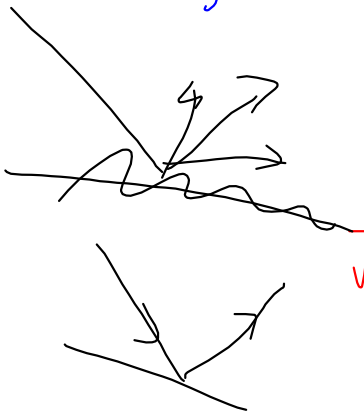
Obstacle

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

$\frac{\lambda}{10} < d < 2\text{-}3\lambda$

Scattering

reflection

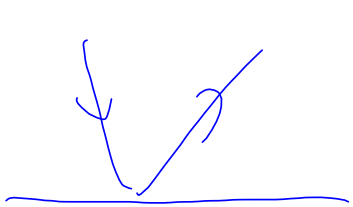


d. ffraction → edge

refraction → atmosphere

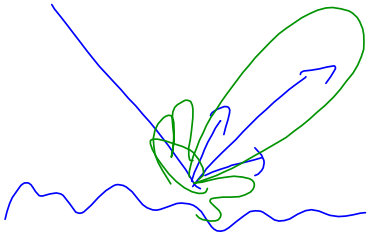
$f = 1GHz$ $\frac{30cm}{10} = 3cm < d < 2 \cdot \lambda$ $f = 1GHz$ $60cm$

$5GHz$ $\frac{6cm}{10} = 6mm < d < 12cm$



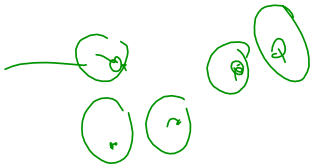
reflection

flat $\delta \ll \lambda$



slightly undulated $\delta \leq \lambda$

rough surface scattering $\delta > \lambda$



diffraction $d \ll \lambda$

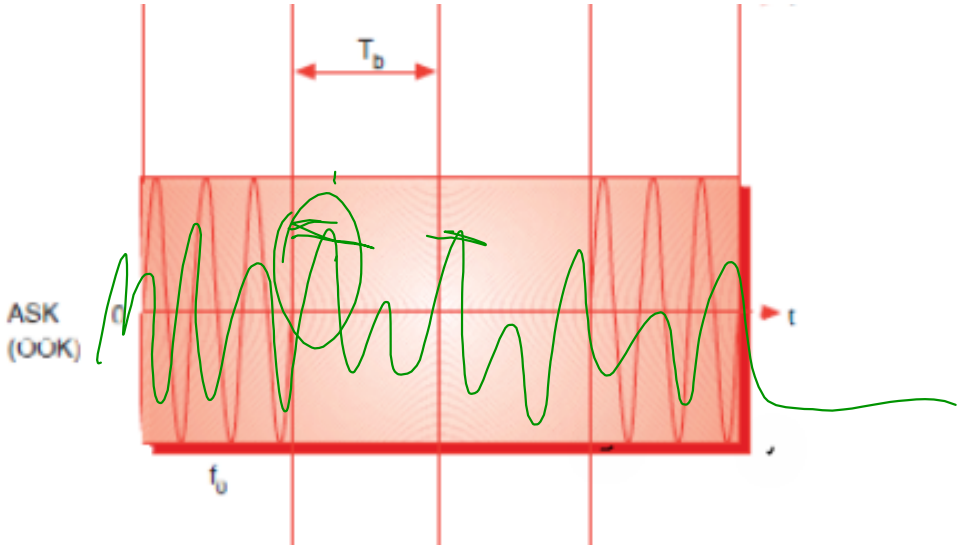
Received signal

~~LOS~~ direct

NLOS

- 20-30 dB
- 30-40dB
+(-5dB)

reflection
scattering
edge d.ffraction
d.ffraction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ime Division Multiplexing

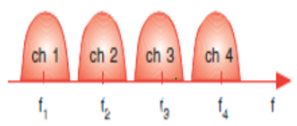
Mobile Network

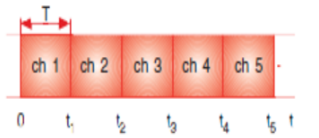
ts in GSM

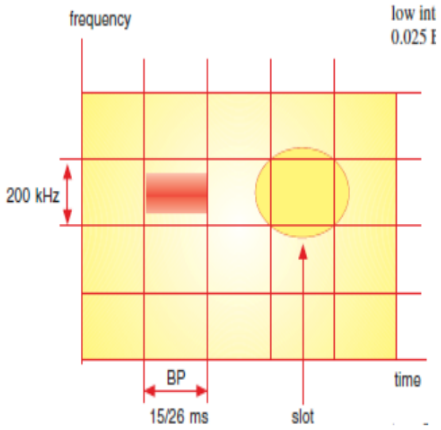
up- and downlink in

ecific codes

of Mobile

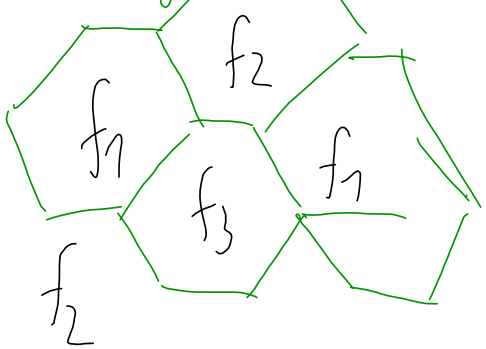




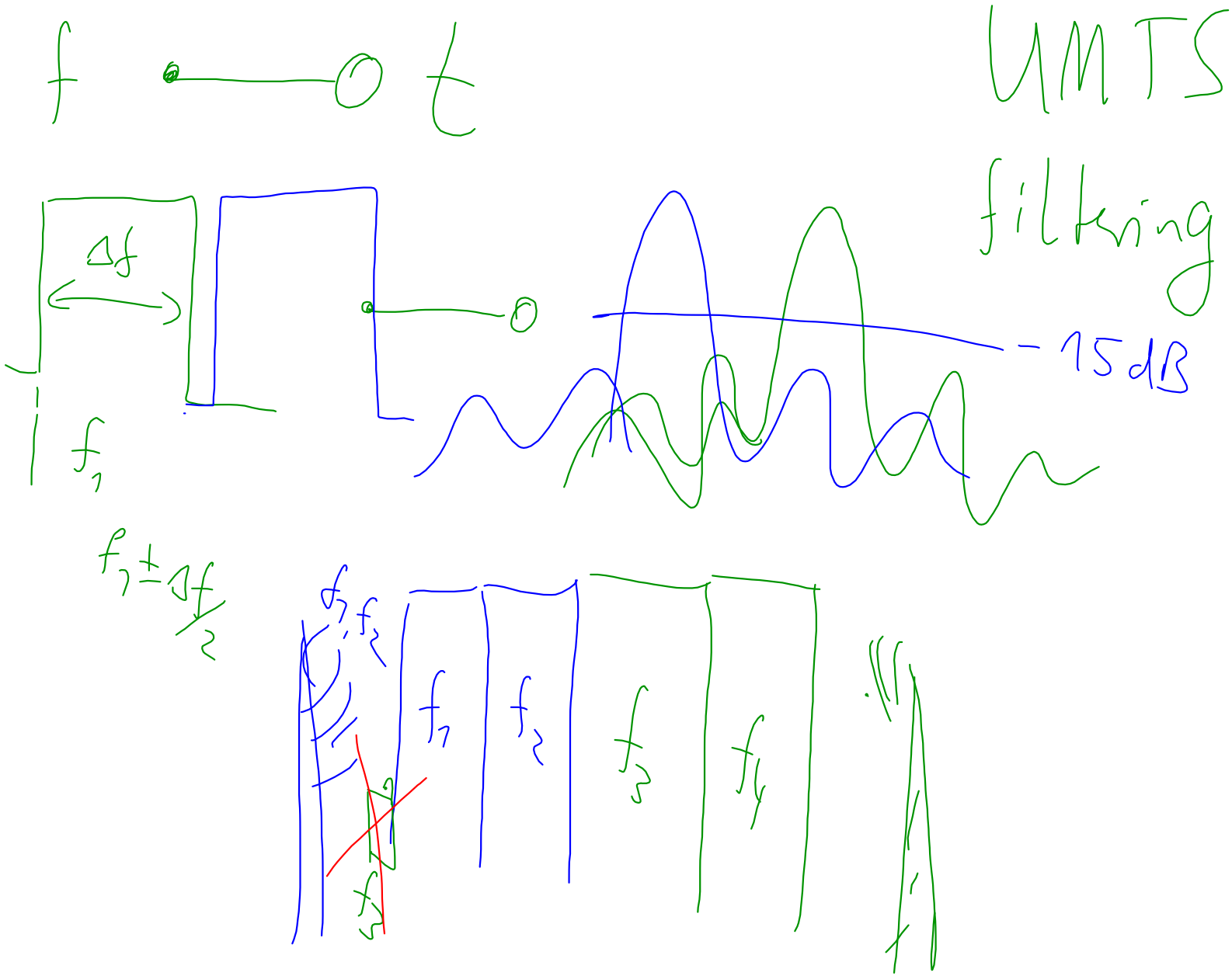


A1-123

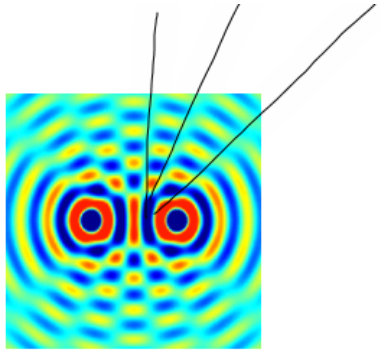
Interference



graph colouring


f
t
UMTS
filtring
Δf
f1
-15dB
f1±Δf/2
f1
f2
f3
f4

Sources Of Noise



* Electronic parts of transmitter and receiver (components)
- Spurious electromagnetics (lines radiating on the chip)
- Fluctuations in power (switching CMOS circuits)

Radio

- In-band interference
- out-of band interference, e.g. GSM/NMT interference
- radio channel, e.g. scattering, multi-path

[Source:Wikipedia, "interference"]

Noise floor in receiver

$N = \text{Boltzmann} \times \text{Bandwith} \times \text{Temperature [K]}$

GSM 200 kHz

UMTS 3800 kHz

802.11 b 26.000 kHz

Receiver: - temperature

- noise factor

$P_{\text{Sensitivity}} = -90\,(-95)$ [dB]

-106 GSM

-114 3G

- further explanations: Telektronikk 4/95, Rækken and Løvnes, Multipath propagation

Basics of Communication (A1-193)

Propagation equation

$$P_R = P_T \, g_T \, g_R \cdot L_{free\ space} \cdot L_{loss}$$

f ↑ ↑ ↑ $L_{free\ space}$ ↓ L_{loss} increase ↓

TV Sat 10 GHz wet snow heavy rain

dB 1 W $\Rightarrow$ 0dB $= 10 \log \frac{1\,W}{1\,W}$

10 W 10dB

dB_m mW

1W $\Rightarrow$ 30dB$_m$ $= 10 \log \frac{1\,W}{1\,mW}$

Wi-fi: max 20 dB_m

Bluetooth: 0: 0 dB_m
1: 4 dB_m
2: 20 dB_m

Signal/Noise Ratio

$$\mathrm{SNR} = \frac{P_{\mathrm{signal}}}{P_{\mathrm{noise}}}$$

$$\mathrm{SNR(dB)} = 10 \log_{10} \left(\frac{P_{\mathrm{signal}}}{P_{\mathrm{noise}}} \right),$$

where *P* is average power

- why talking about noise?
- dB, dB_m, dB_a
- near-far problem

[source: Wikipedia]

1. Assignment

Idea

Scenario / Use case

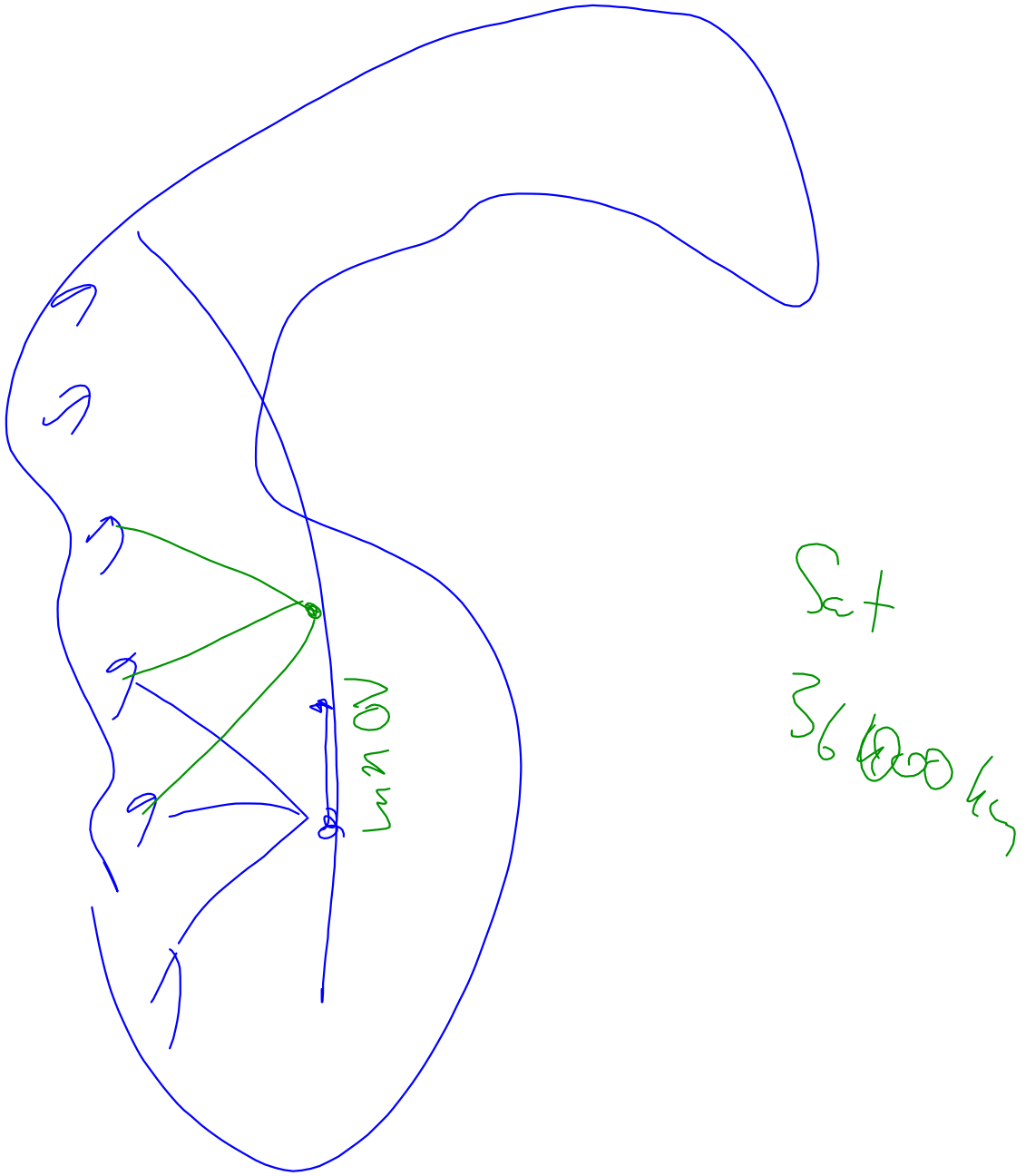
Challenges

Discussion

2. Assignment → Elaborate

TOPIC

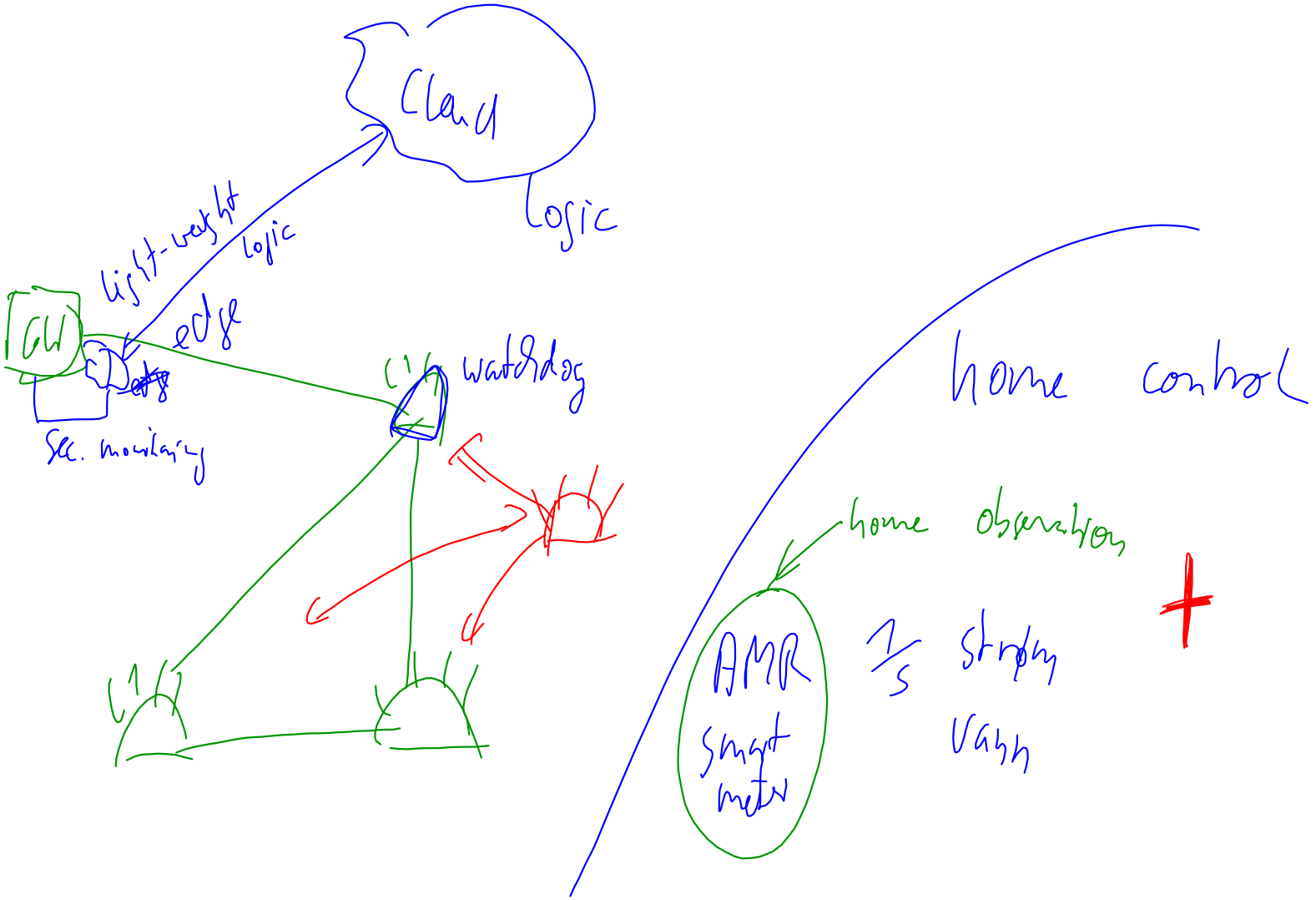
Method, Evaluate


Sat
36000 km

Assignment too early, give us a month before assignment

Alternatives: a) selected papers Choose

or b) own topic


Cloud
logic
light-weight
logic
edge
GW
Data
Sec. monitoring
watchdog
home control
home observation
AMR
smart
meter
1/s
strøm
vann