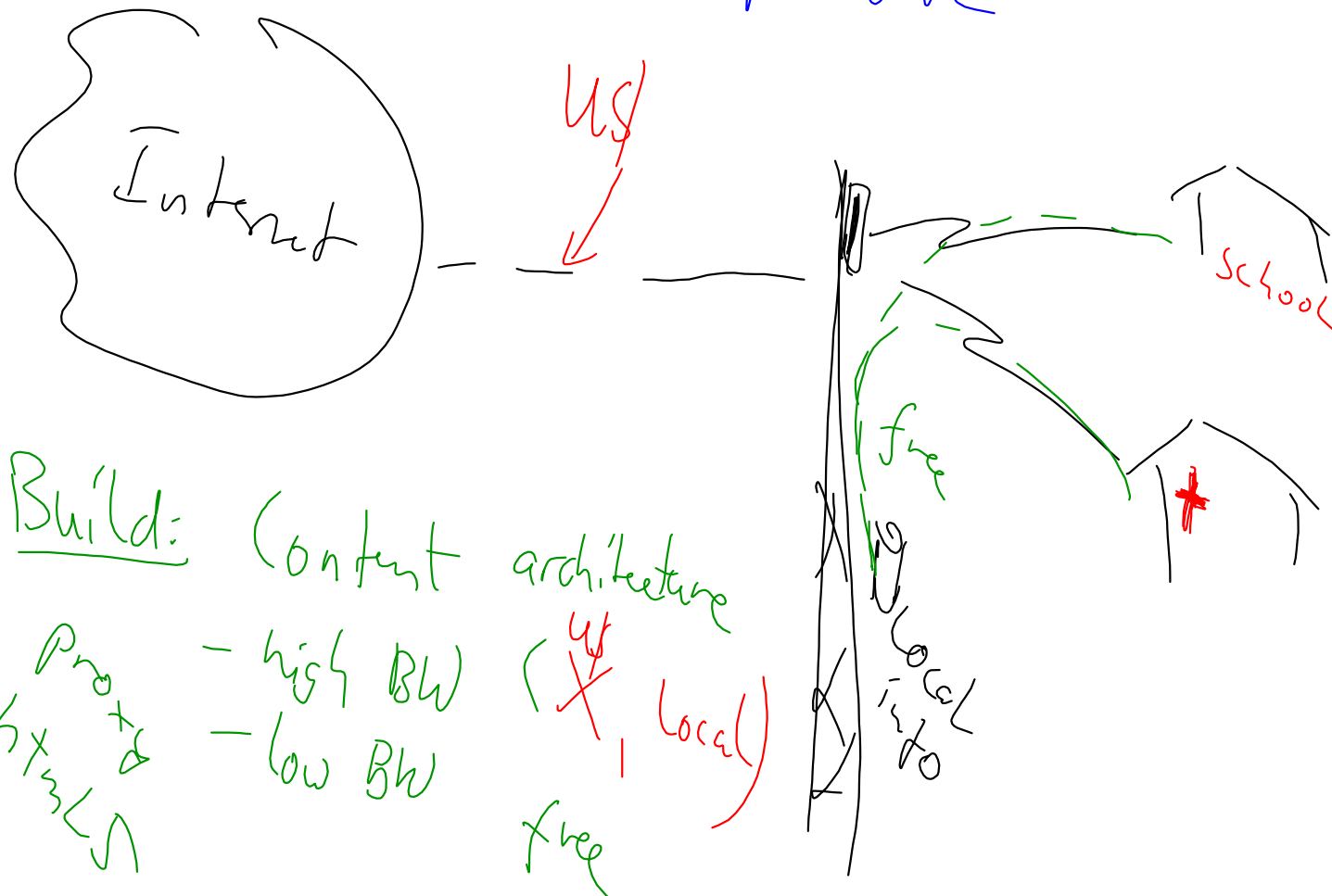
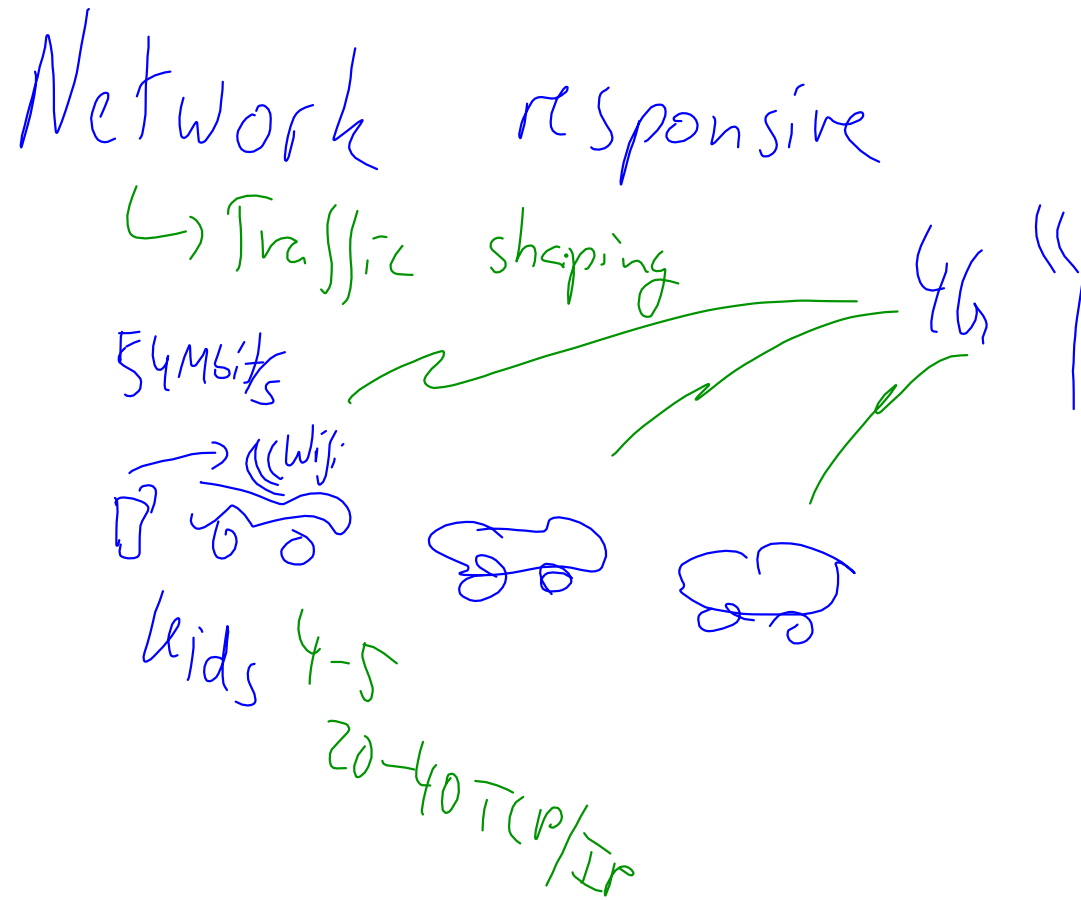


Digital health

Network responsive





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 tropospheric
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.

Handwritten notes in red:

- 800-900 MHz GSM
- 1800 GSM
- 2.1 GHz UMTS
- 2.6 GHz LTE
- 3.3 GHz
- 25 MHz BW
- 2.4 Wifi
- 5.X

10% of carrier freq is "easy" BW

$f = 900 \text{ MHz} \sim 90 \text{ MHz BW}$

$2.4 \text{ GHz} \sim 240 \text{ MHz BW} \Rightarrow 85 \text{ MHz}$

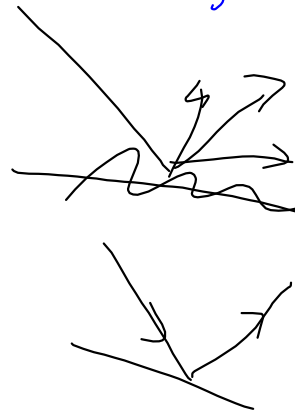
$$f \leadsto \lambda = \frac{c}{f} \quad 3E8 \frac{m}{s}$$

Obstacle

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

$$\frac{\lambda}{10} < d < 2 \cdot \lambda$$

Scattering
reflection



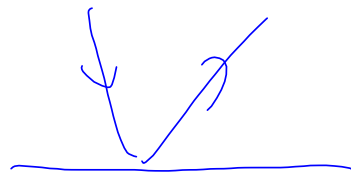
$$f = 16 GHz$$

$$\frac{30 cm}{10} = 3 cm < d < 2 \cdot \lambda$$

$f = 16 GHz$ $\underline{60 cm}$

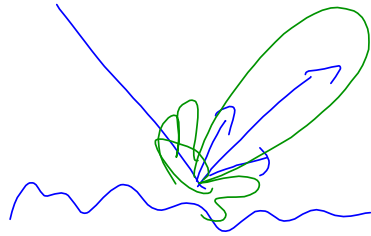
d. fraction $\rightarrow$ edge
refraction $\rightarrow$ atmosphere

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



reflection

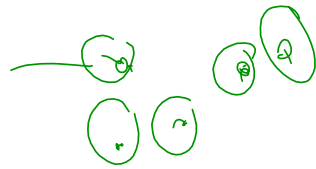
flat $\rho \ll \lambda$



slightly undulated $\rho \leq \lambda$



rough surface scattering $\rho > \lambda$



diffraction $d \ll \lambda$

Received signal
~~LOS~~ direct

NLOS

-20-30dB

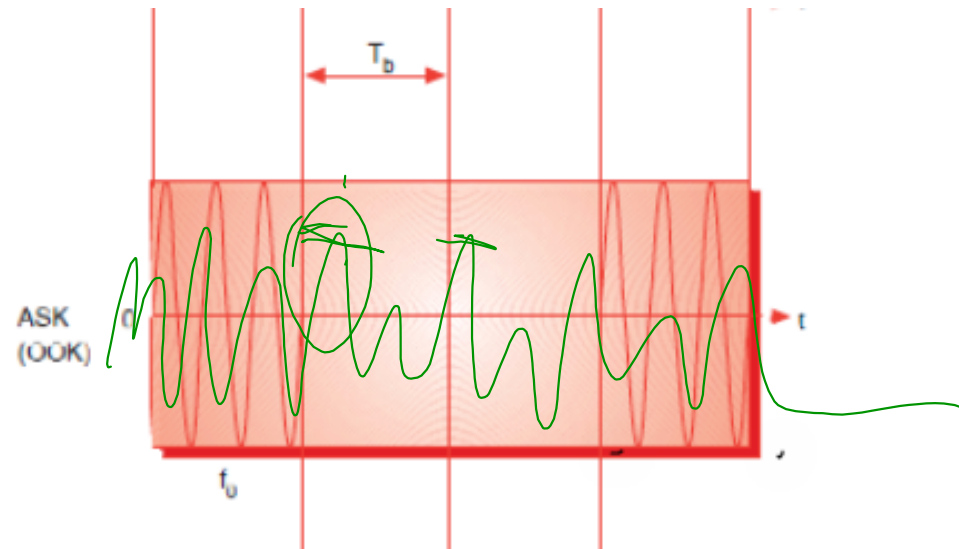
reflection

-30-40dB

← scattering

edge diffraction

+ (-5dB) diffraction



Σ

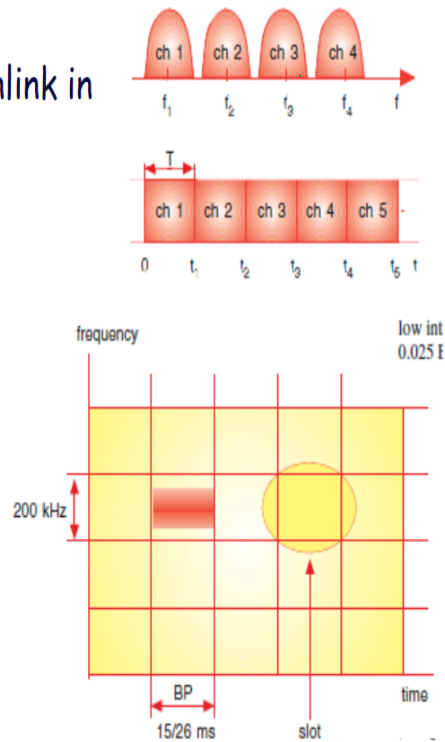
Time Division Multiplexing

ts in GSM

up- and downlink in

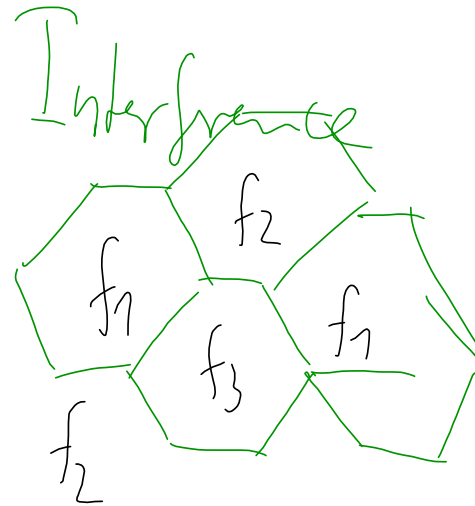
specific codes

of Mobile



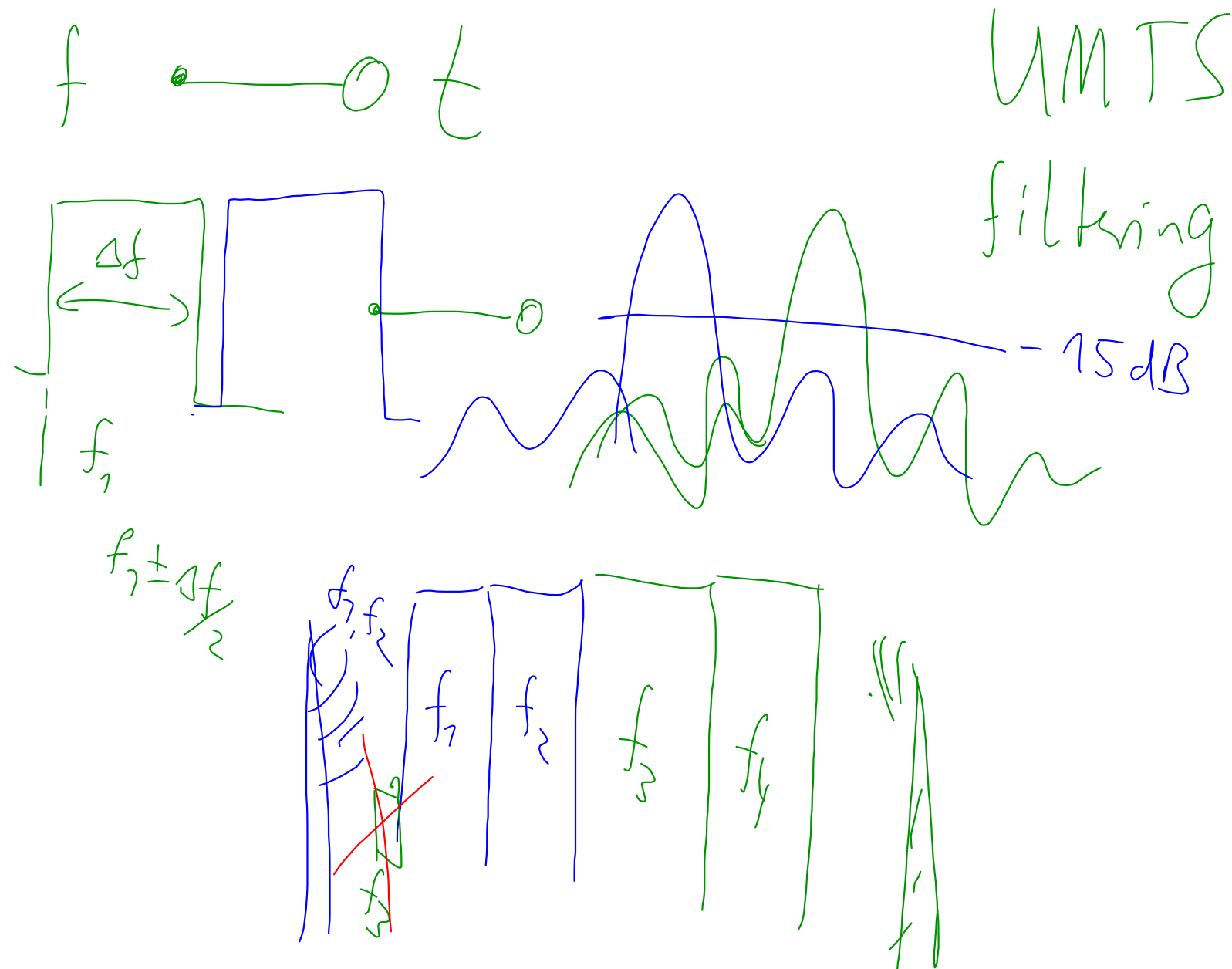
A1-1231

Mobile Network



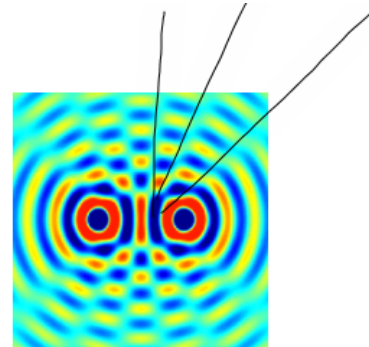
graph colouring





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

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

GSM	200 kHz
NMTS	3800 kHz
802.11b	26.000 kHz

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

Basics of Communication (A1-193)

Receiver: - temperature

- noise factor

$$P_{\text{Sensitivity}} = -90(-45) \text{ W/t}$$

-106 GSM
 -114 3G

Propagation
equation

$$P_R = P_T \cdot G_T \cdot G_R \cdot \frac{1}{L_{\text{free space}}} \cdot \frac{1}{L_{\text{atmos}}}$$

$\uparrow$ $\uparrow$ $\downarrow$ $\downarrow$
 f free space loss increase

TV sat 10 GHz

wet snow
heavy rain

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

10 W 10dB

$$dB_m \quad mW$$

1W $\Rightarrow$ 30dB_m = 10 $\log \frac{1W}{1mW}$

Wifi : max
20dB_m

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

Signal/Noise Ratio

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

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

where P is average power

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

[source: Wikipedia]

$$P_t = (10 \text{ dB}) =$$

$$= 10 \text{ W}$$

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

acoustic 120 dB_a ears

antennas

isotropic

1. Assignment

Idea

Scenario / Use case

Challenges

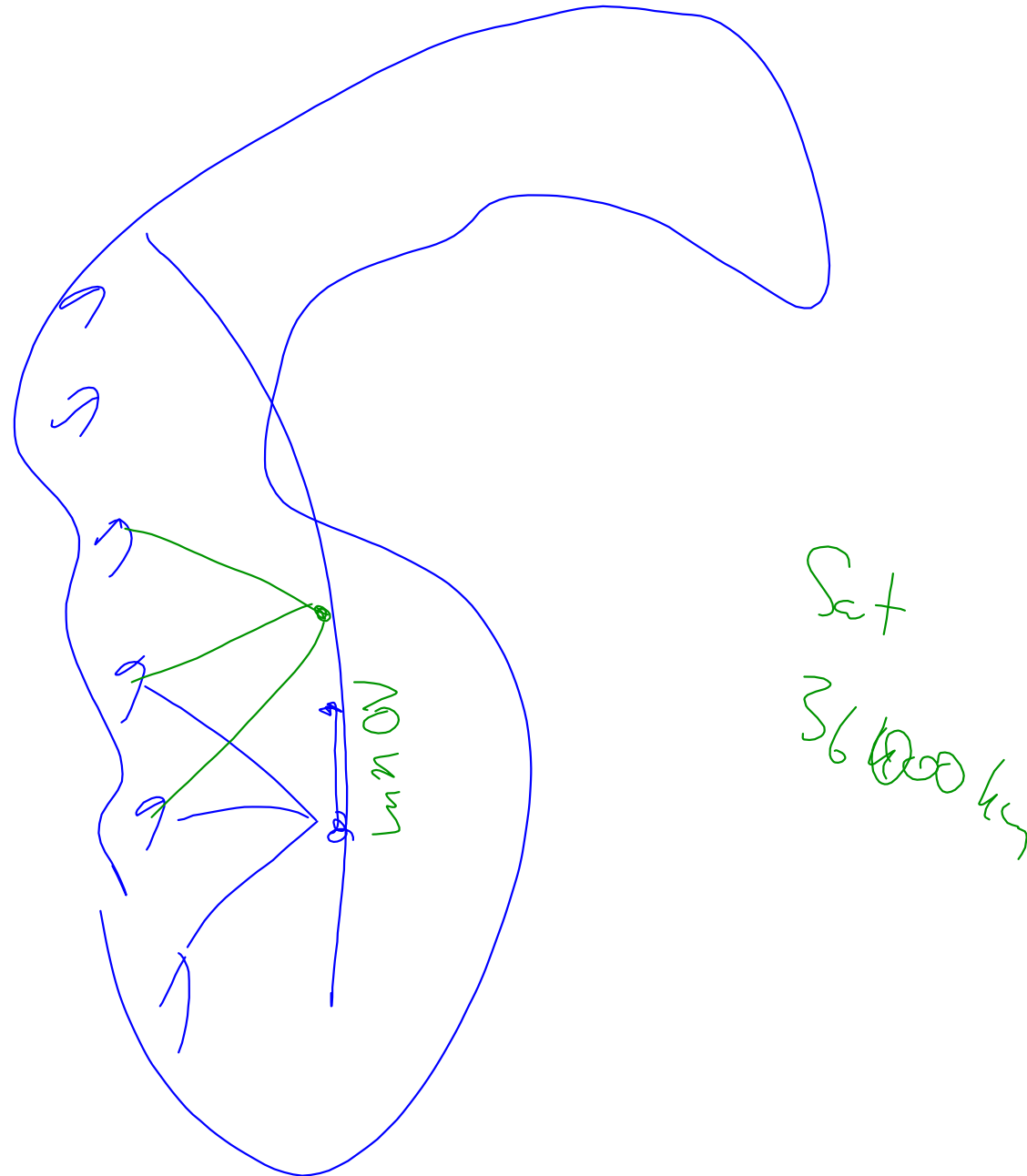
Discussion

2. Assignment

→ Elaborate

TOPIC

Method, Evaluate



Assignment too early, give us a month
before assignment

Alternatives: a) selected papers Choose
or b) own topic

