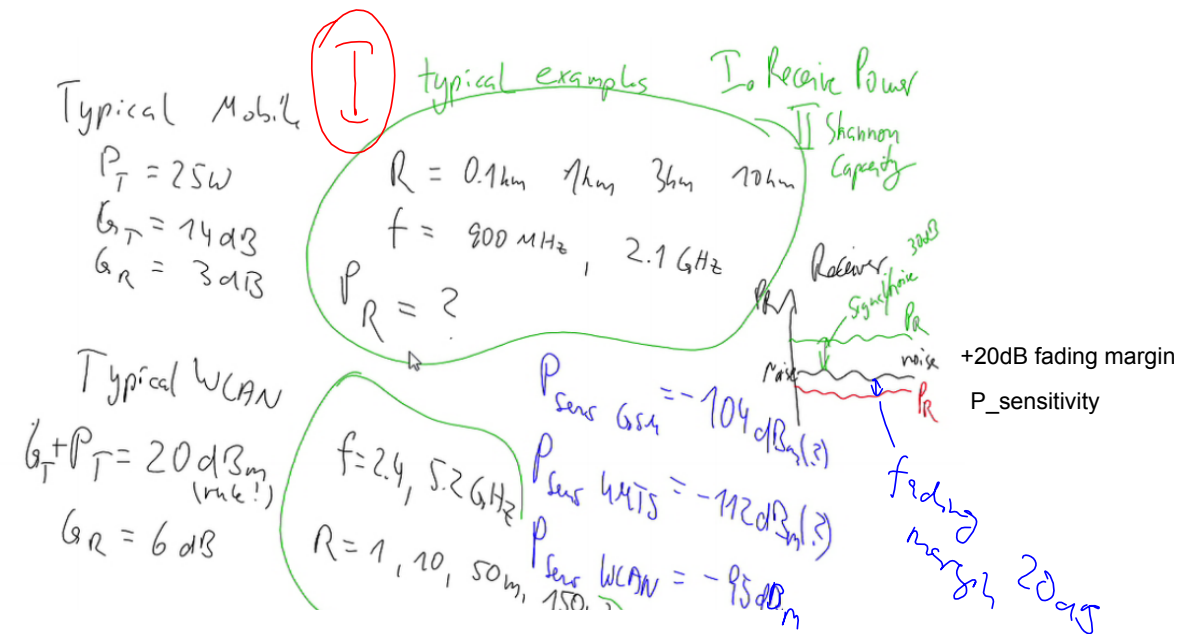


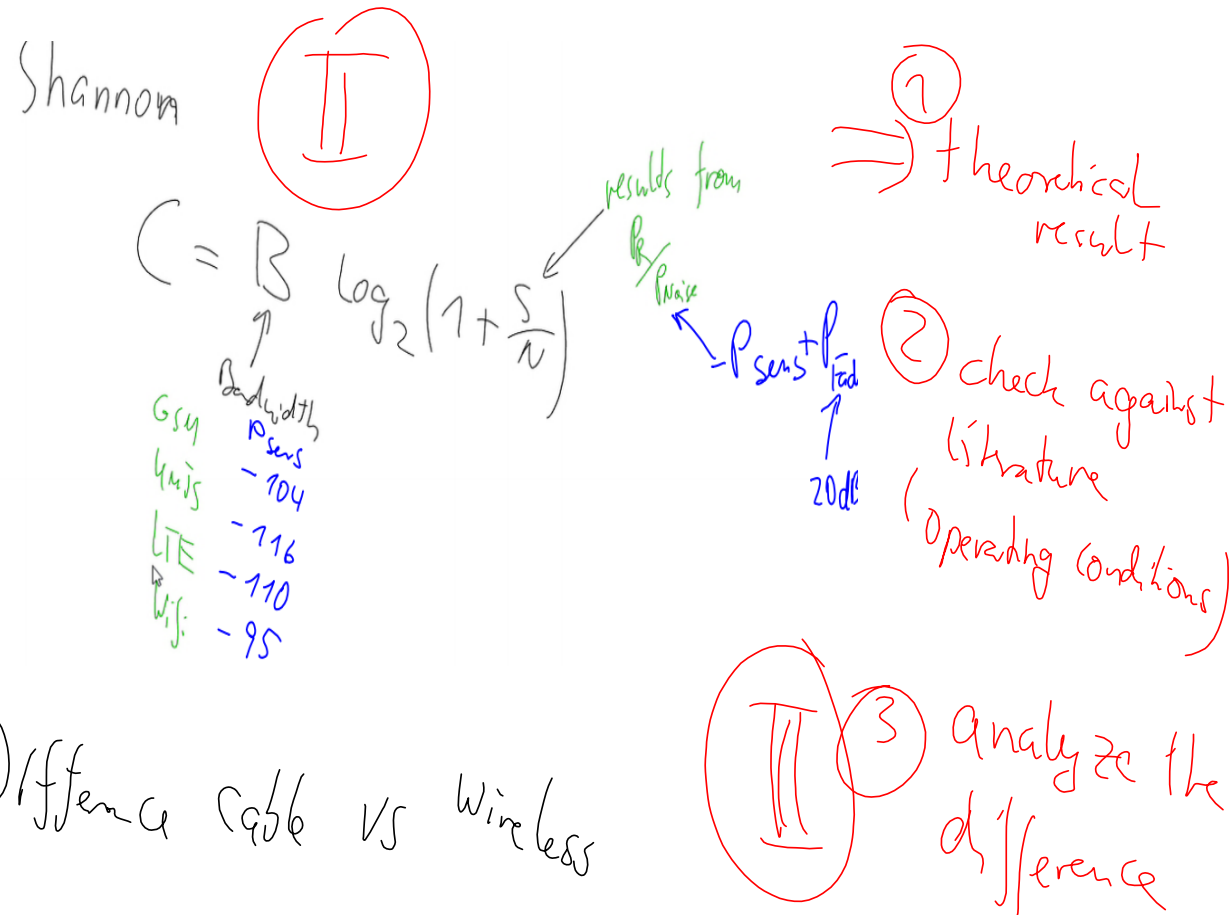


1a: P_{receive}

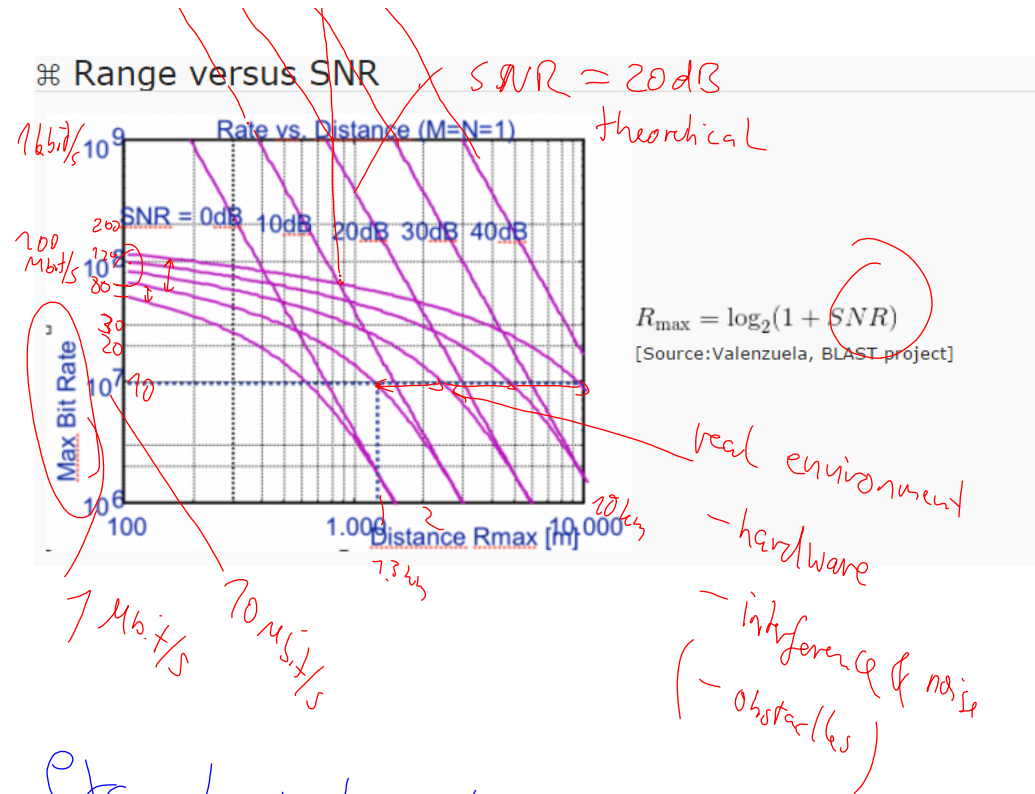
1b: $\text{SNR} (P_r - P_{\text{sen}} - 20\text{dB})$

create a table with R , f , P_r , SNR , Capacity, typical industrial values

calculate Shannon capacity



analyse diff: Shannon versus real systems (check with typical values in Literature)

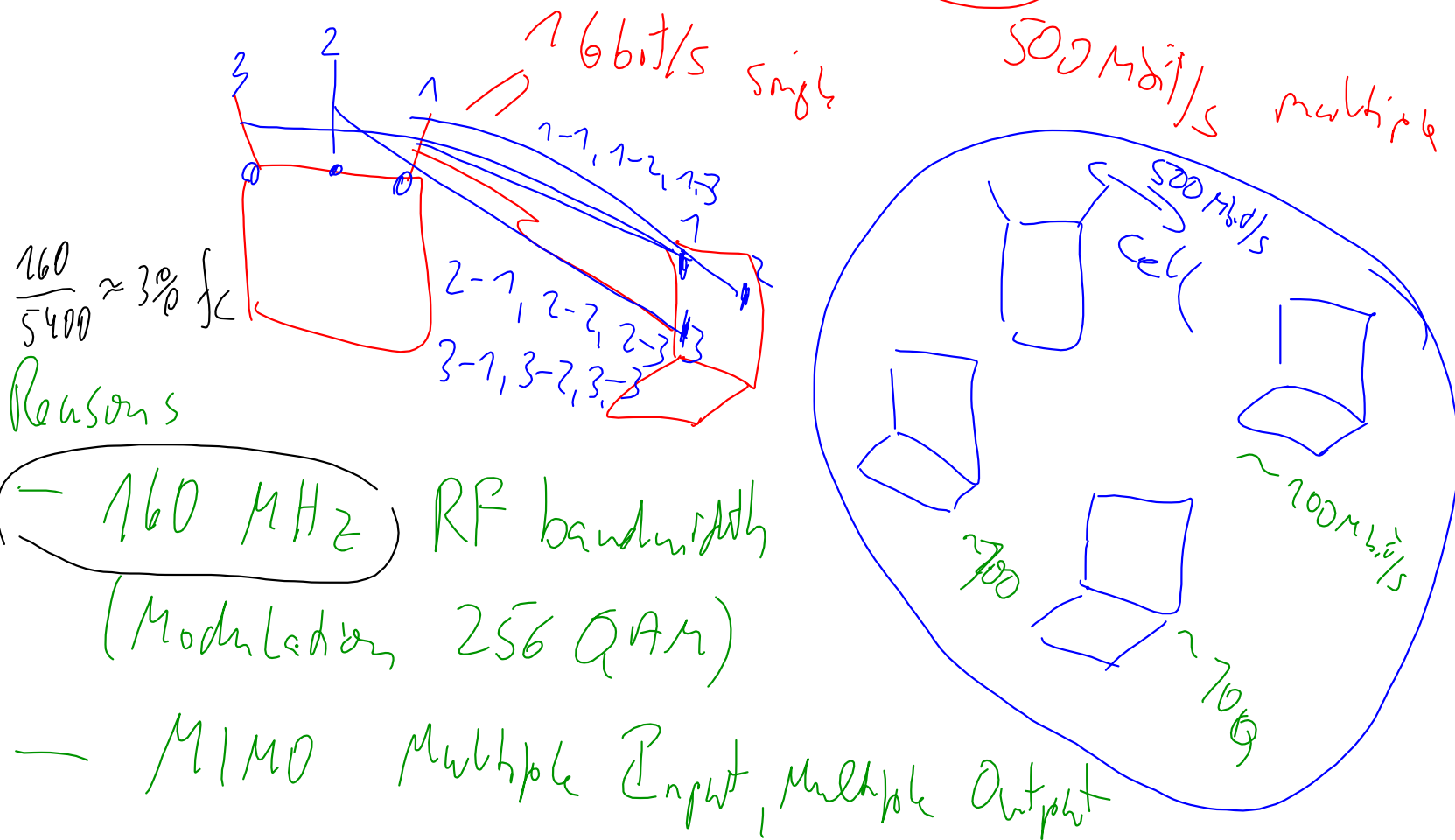


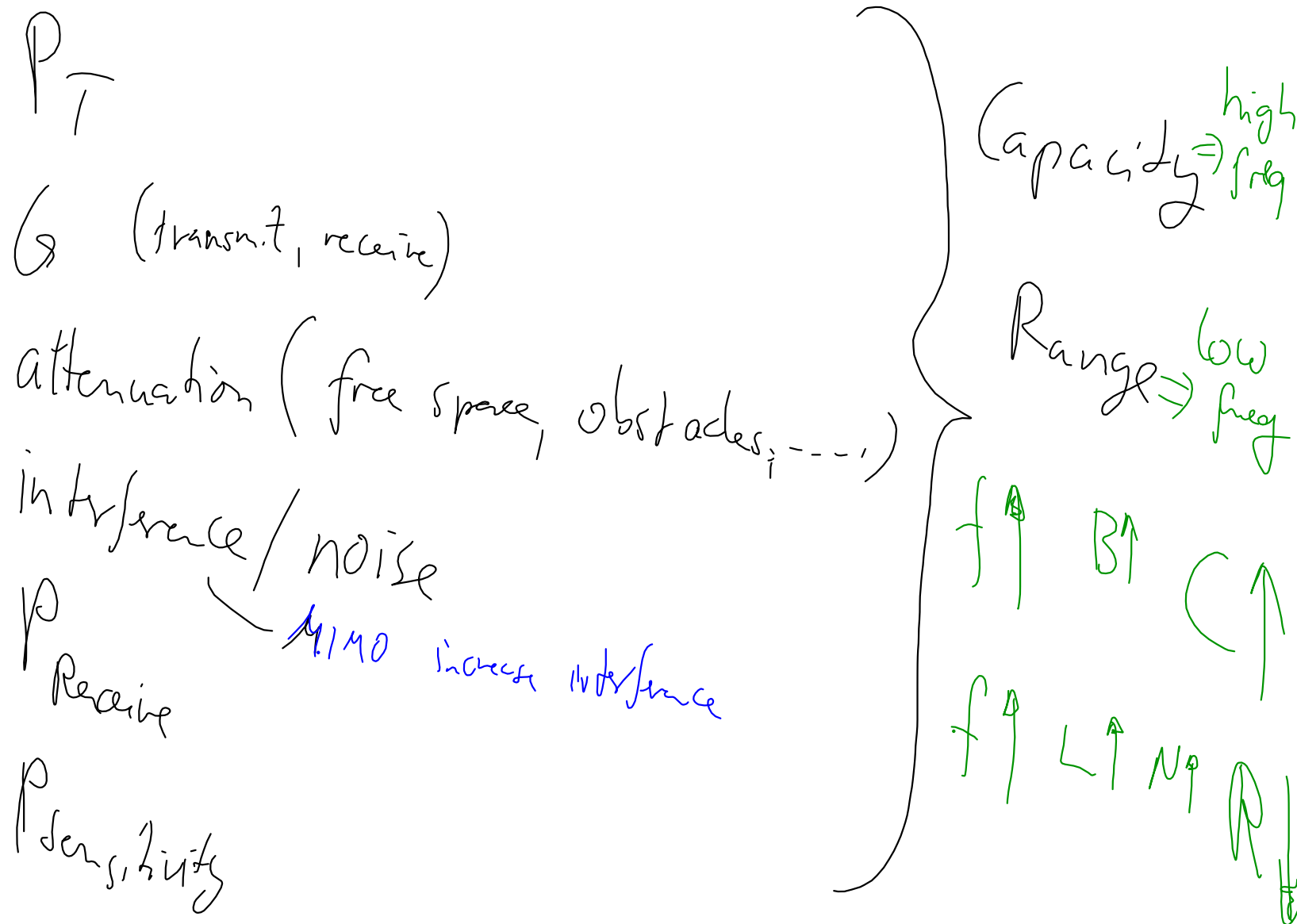
Example real system:

SNR = 30dB ~ Capacity increase 50% / short range
 SNR = 30dB ~ Range increase → 10 + (1.3 → 10 km)

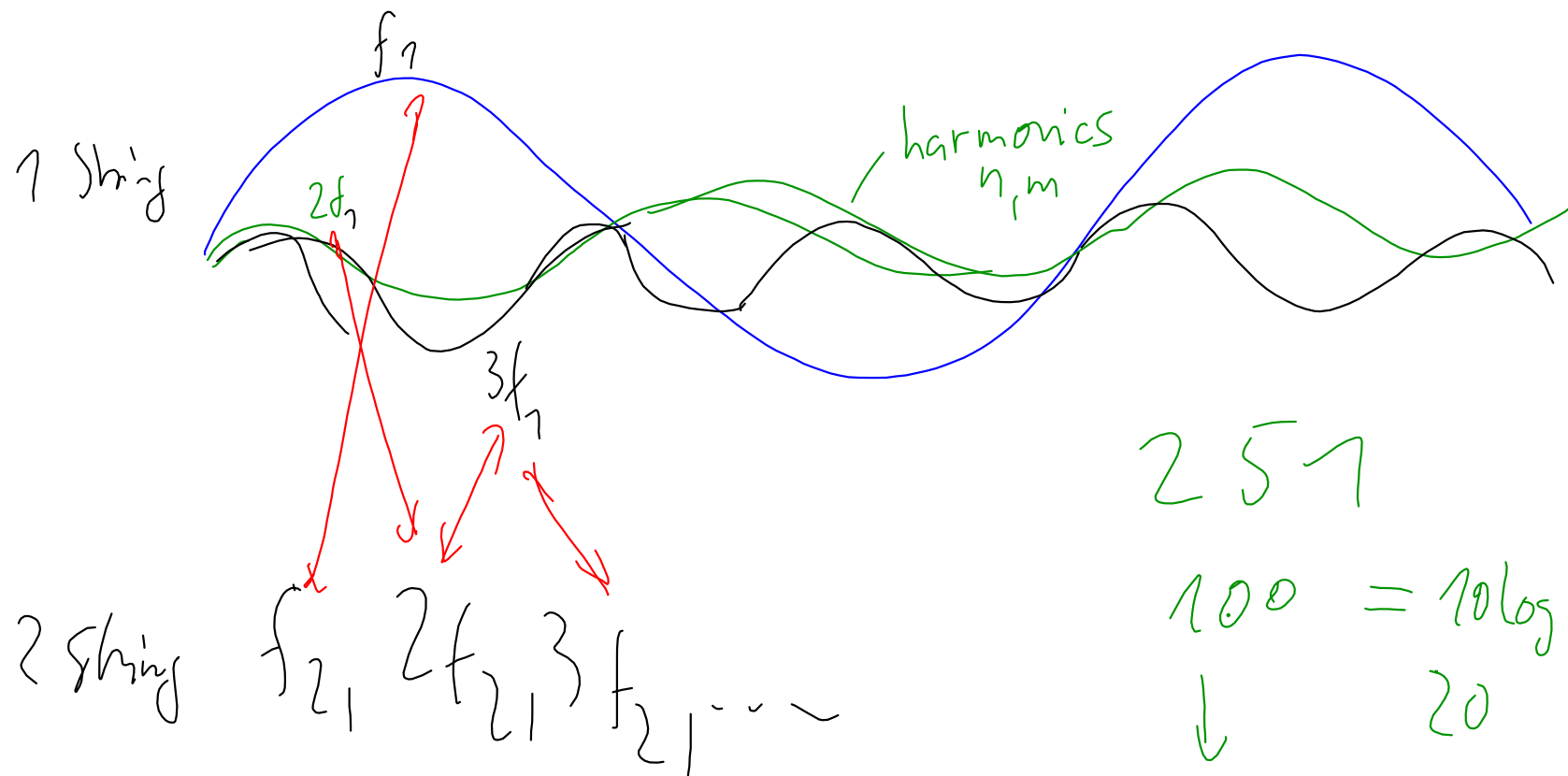
IEEE 802.11ac is a wireless networking standard in the 802.11 family (which is marketed under the brand name Wi-Fi), developed in the IEEE Standards Association process,^[1] providing high-throughput wireless local area networks (WLANs) on the 5 GHz band.^[1] The standard was developed from 2011 through 2013 and approved in January 2014.^{[1][2]}

This specification has expected multi-station WLAN throughput of at least 1 gigabit per second and a single link throughput of at least 500 megabits per second





Intermodulation $= n f_1 \pm m f_2$



257

$$100 = 10 \log E_2$$

$$\downarrow \quad 20$$

$$200 + 2 \quad + 3$$

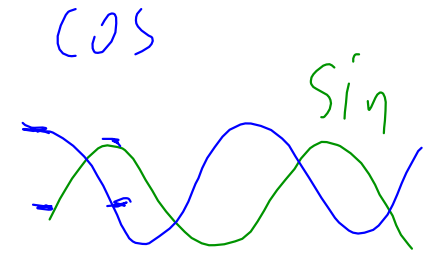
$$\sim 24 \text{ dB}$$

512 steps

Power/Voltage



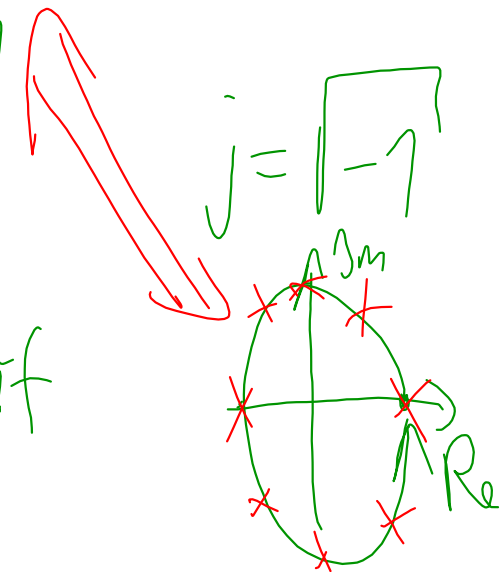
1V	1	1V
0V	0.5	0.9
	0	0.2
		0.1



Electromagnetics

$$\vec{E} = E_0 e^{-j\omega t}$$

$2\pi f$



Challenge

$$f_c = 4.5 \text{ MHz} \quad B = 3 \text{ MHz}$$

unrealistic for
real system



$$\frac{B}{f_c} = 0.75$$

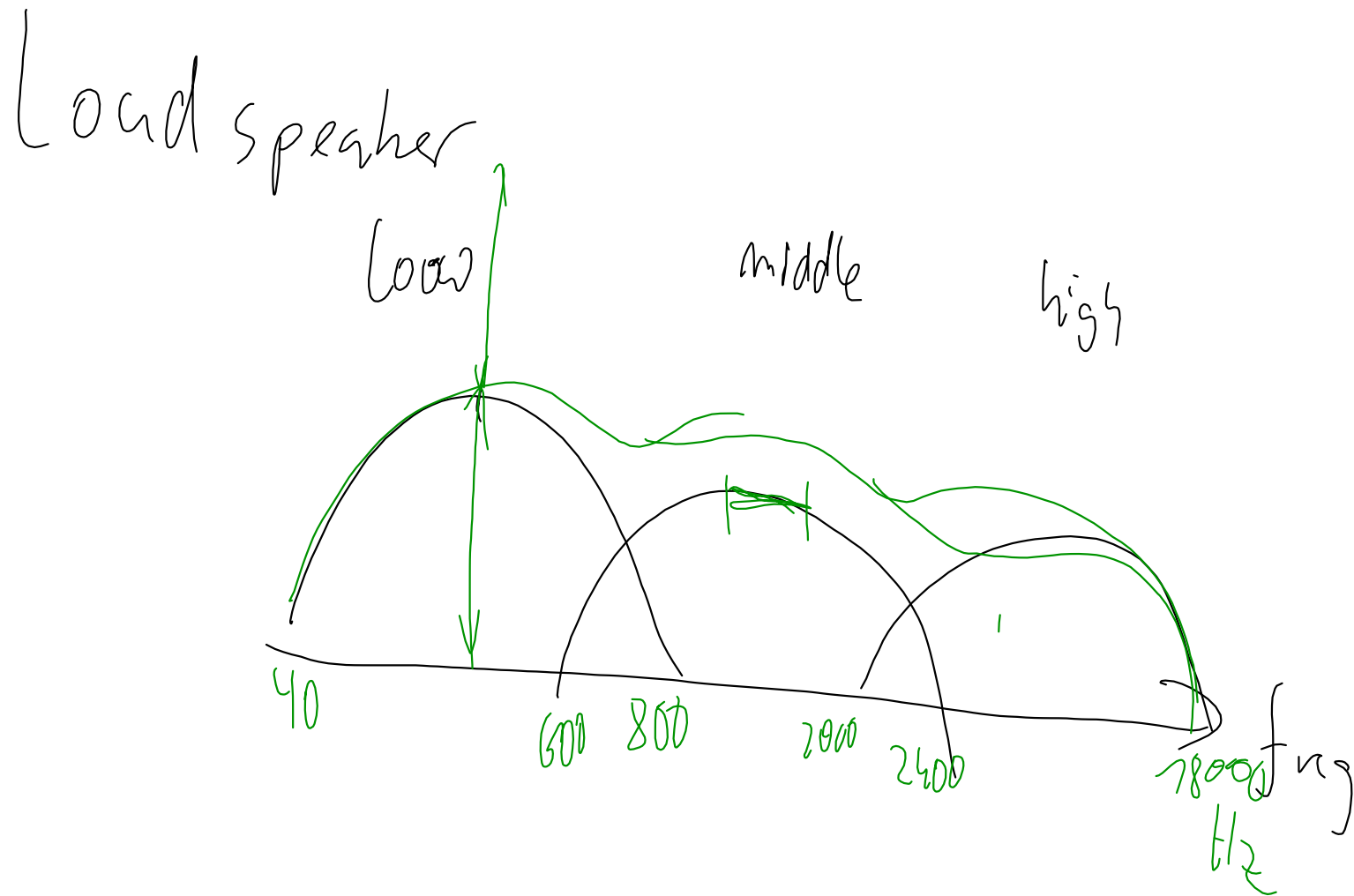
Real system: filter, amplifier, receiver linearity

$$B \sim \frac{1}{70} f_c$$

$$900 \text{ kHz} \sim B \sim 90 \text{ MHz}$$

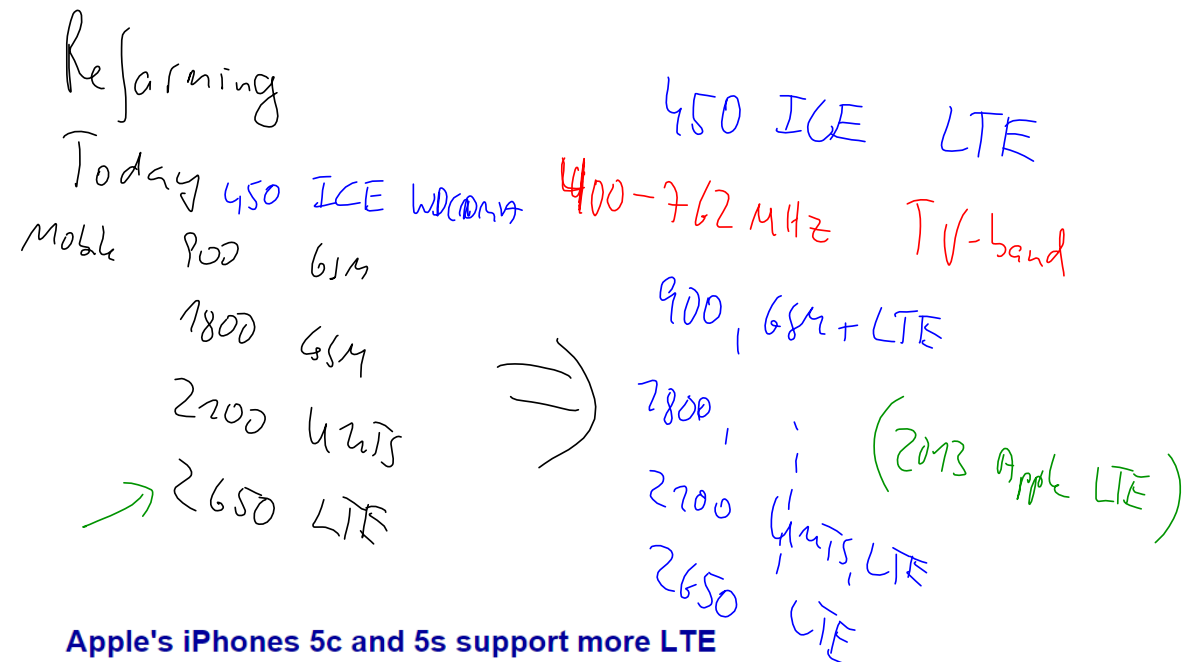
$$802.11a \xrightarrow{5.4 \text{ GHz}} B \sim 540 \text{ MHz}$$

ac



Future Networks

- refarming: LTE at 800 MHz
- Digital Divide (TV frequencies)
- Basic Internet - Business model of information



Apple's iPhones 5c and 5s support more LTE bands in Europe

September 10, 2013 | By Anne Morris

SHARE

Email

Apple unveiled two new iPhones to replace the iPhone 5 on Tuesday, the lower-cost iPhone 5c and higher-end iPhone 5s, and to the relief of Apple fans across Europe the new smartphones will now support LTE Bands 7 (2.6 GHz) and 20 (800 MHz), as well as LTE Band 3 (1800 MHz).

8 antenna

Apple: easy rec. update

-(USA) network provision

- already used (3G)

typical

R C

total
avail.
bandwidthCoverage 450
outdoor $\rightarrow$ indoorCoverage 900
outdoor $\rightarrow$ indoor

Capacity 1800

Capacity 2700

hot-spot 2650

$$6 \text{ MHz ops} = 5 \text{ MHz LTE} + 1 \text{ MHz GSM}$$

$$12 \text{ MHz ops (25 MHz carrier 3 ops)} = 2 \times 5 \text{ MHz LTE} + 2 \times 10 \text{ MHz LTE}$$

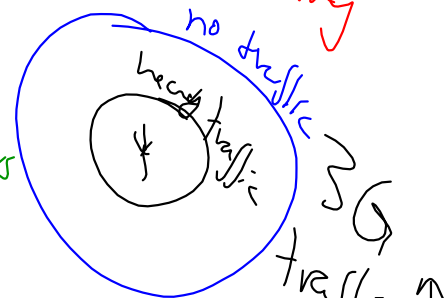
25 MHz

4 operations
no

LTE flexibility

 $B = 2, 5, 10, 20, 40 \text{ MHz}$

cell-breathing

3G
traffic $\uparrow$ noise $\uparrow$
 $P_{\text{cell}}, P_{\text{avg}} \downarrow$

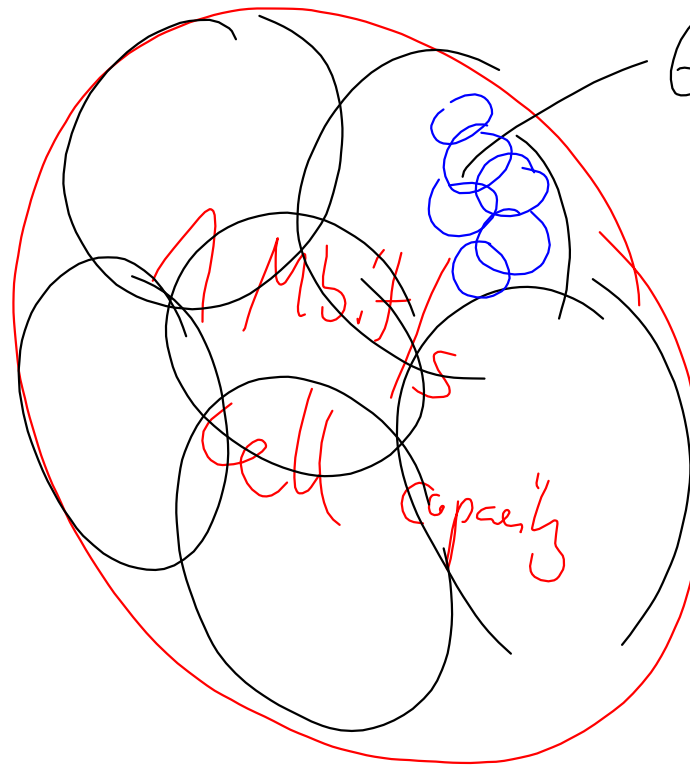
UMTS

 $B = 5 \text{ MHz}$
(3.8 MHz)

Typical Cell

UMTS

3 x 5 MHz
(3.8 MHz)



6x capacity

100x capacity

- cost

(-interference)

- Mobility
handover

Basic Internet.org

35 min pres

5 min pause

58% mobile coverage in Africa

- Why Universities, not rural

- Tanzania

- DR Congo - no Internet

not affordable

↳ funding

Questions understanding

Questions challenges

Buz

Investment

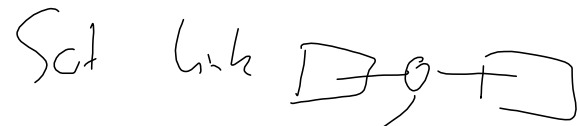
CAPEX

Operational

OPEX

Return of Investment ROI

- free basic ~ 5% BW
 - funding "infrastructure" ^{CAPEX} ← not proven
 - ← "tax"
- vouchers ~ 95% BW ← income
- users:
 - 80% smartphones
 - 75% males
 - 75% women
 - Smartphone ← Oper Mini
 - ? tablets
 - ? PC/laptop
- Information
 - Univ. → PC ← India buy health centre, schools
 - sell stuff 77-78k\$
 - network admin's responsible
- hotspots
- health centre
 - tablet
 - PC



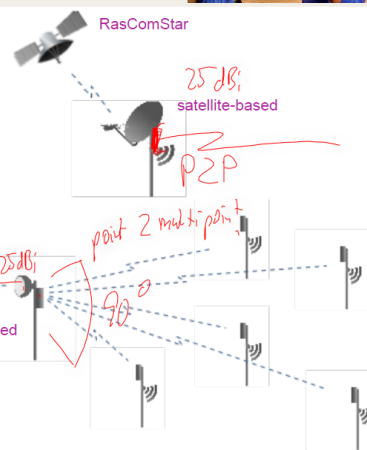
$$1 \text{ mp3} = \sim 3-5 \text{ KB}$$

low

$$2500 \text{ kbit/month} \\ 7 \text{ Mbit/s} = 777 \text{ kByte/s} \\ \sim 7 \text{ MByte/month}$$

Basic Internet provision through Partners

- Satellite, radio or mobile link
 - local roll-out
 - with partners in Africa
- Mobile Operators: extend the reach, prepare the market
- CSR: increase innovation
- Own deployment: hot-spot owner
- AID organisations: education, health information
- Sponsored access
- Higher education: educate teachers



Firefox - Browser -> proxy?

- ?? (filter by IP)

off-line vs online content

