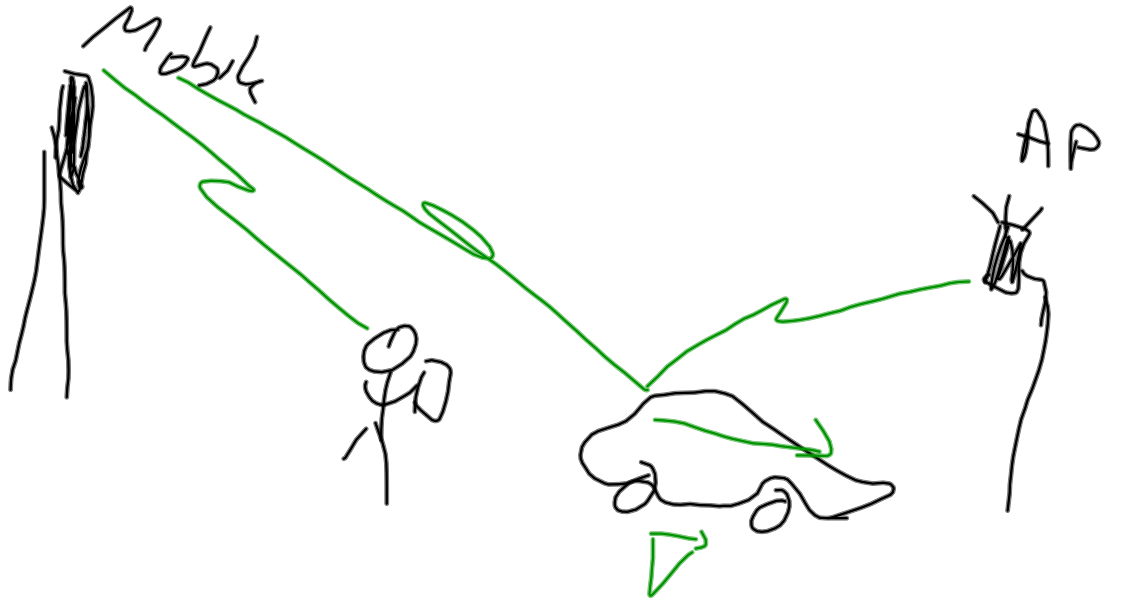
Ultimate goal

Simulation environment for handover



Topics For Programming

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Propagation Models

- indoor (statistical, deterministic), outdoor (rural, city), indoor-outdoor propagation
- comparison to satellite link

Capacity and range

- Propagation equation
- Range, Capacity
- "Real systems" capacity

System parameters

- CDMA-2000, W-CDMA (UMTS), GSM 900, WLAN 802.11b, 802.11a, Bluetooth
- Receiver sensitivity
- Noise factors
-

Mobile/wireless communications

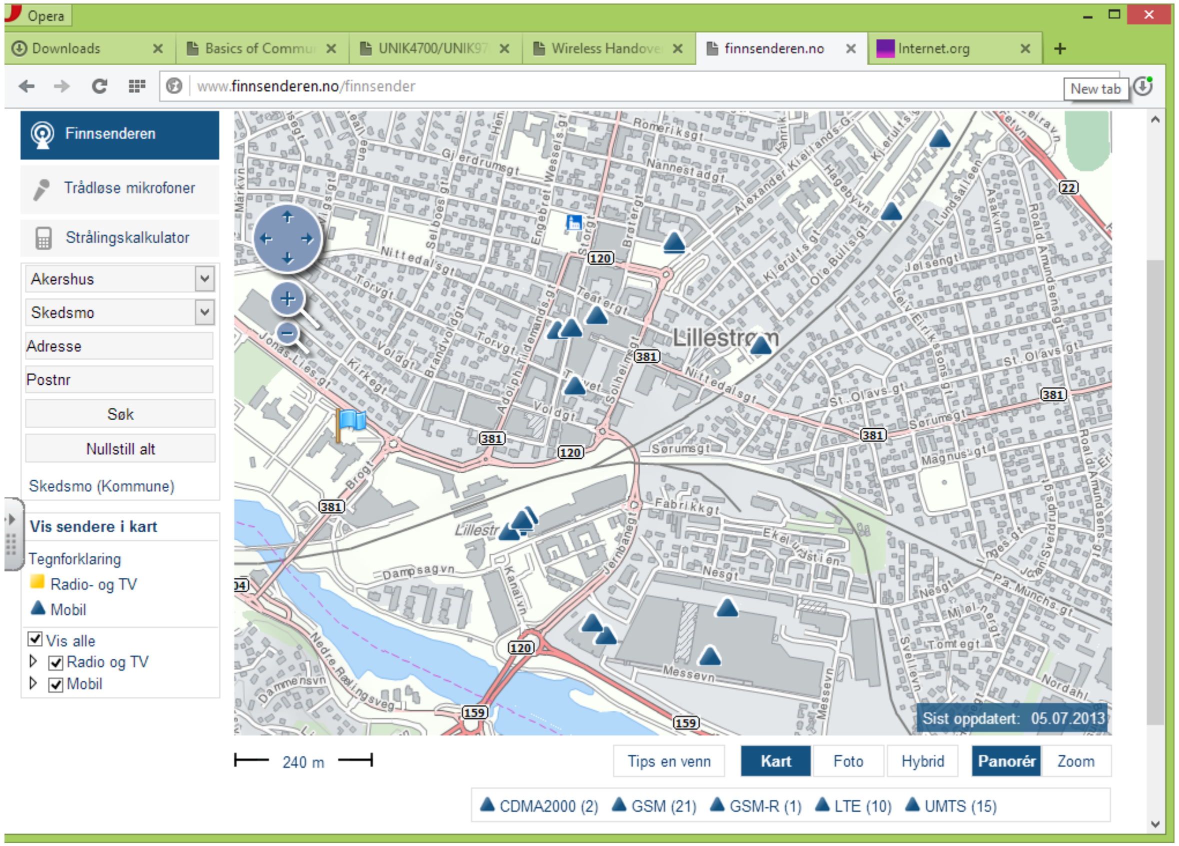
- combine systems and discuss results

http://cwi.unik.no/wiki/Wireless_Handover_Simulations

Current simulation results indicate a cell range of up to 10 km

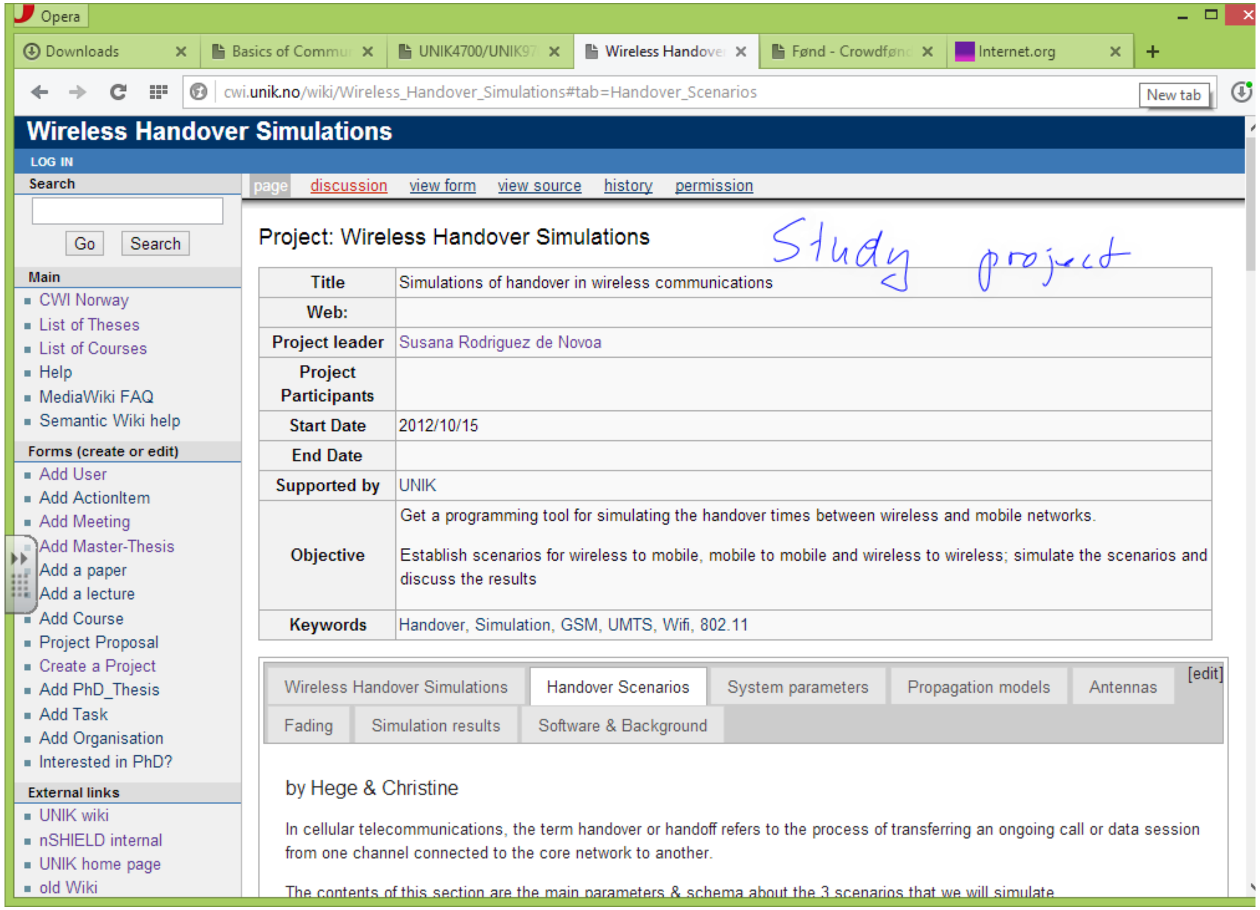
Finnsenderen.no shows that realistic networks have 500-1500 m cell size

Why?



1. Assignment

- Understand Scenario
- point out challenges
- indicate areas of little knowledge



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Wireless Handover Simulations

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External links

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Project: Wireless Handover Simulations

Study project

Title	Simulations of handover in wireless communications
Web:	
Project leader	Susana Rodriguez de Novoa
Project Participants	
Start Date	2012/10/15
End Date	
Supported by	UNIK
Objective	Get a programming tool for simulating the handover times between wireless and mobile networks. Establish scenarios for wireless to mobile, mobile to mobile and wireless to wireless; simulate the scenarios and discuss the results
Keywords	Handover, Simulation, GSM, UMTS, Wifi, 802.11

Wireless Handover Simulations | Handover Scenarios | System parameters | Propagation models | Antennas | Fading | Simulation results | Software & Background [edit]

by Hege & Christine

In cellular telecommunications, the term handover or handoff refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another.

The contents of this section are the main parameters & schema about the 3 scenarios that we will simulate

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Heinrich Hertz - Radiowave Propagation

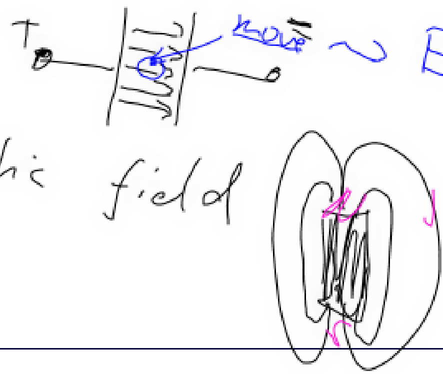
Basics of wave propagation:

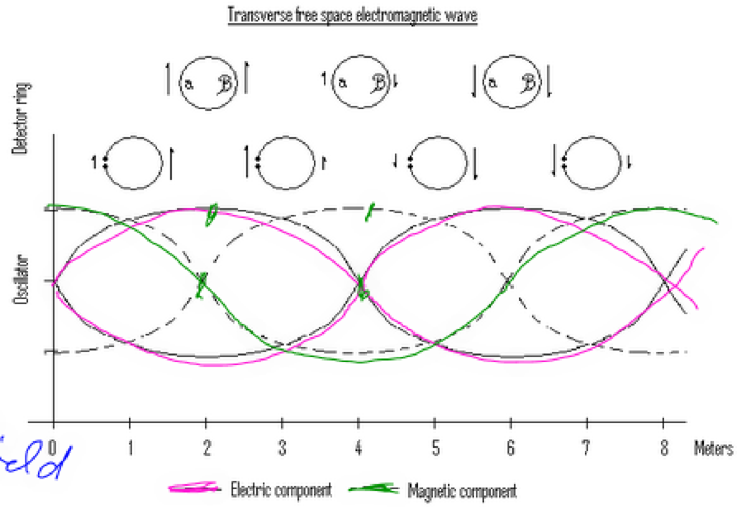
- The variation of an electrical field creates a magnetic field
- The variation of a magnetic field creates an electrical field

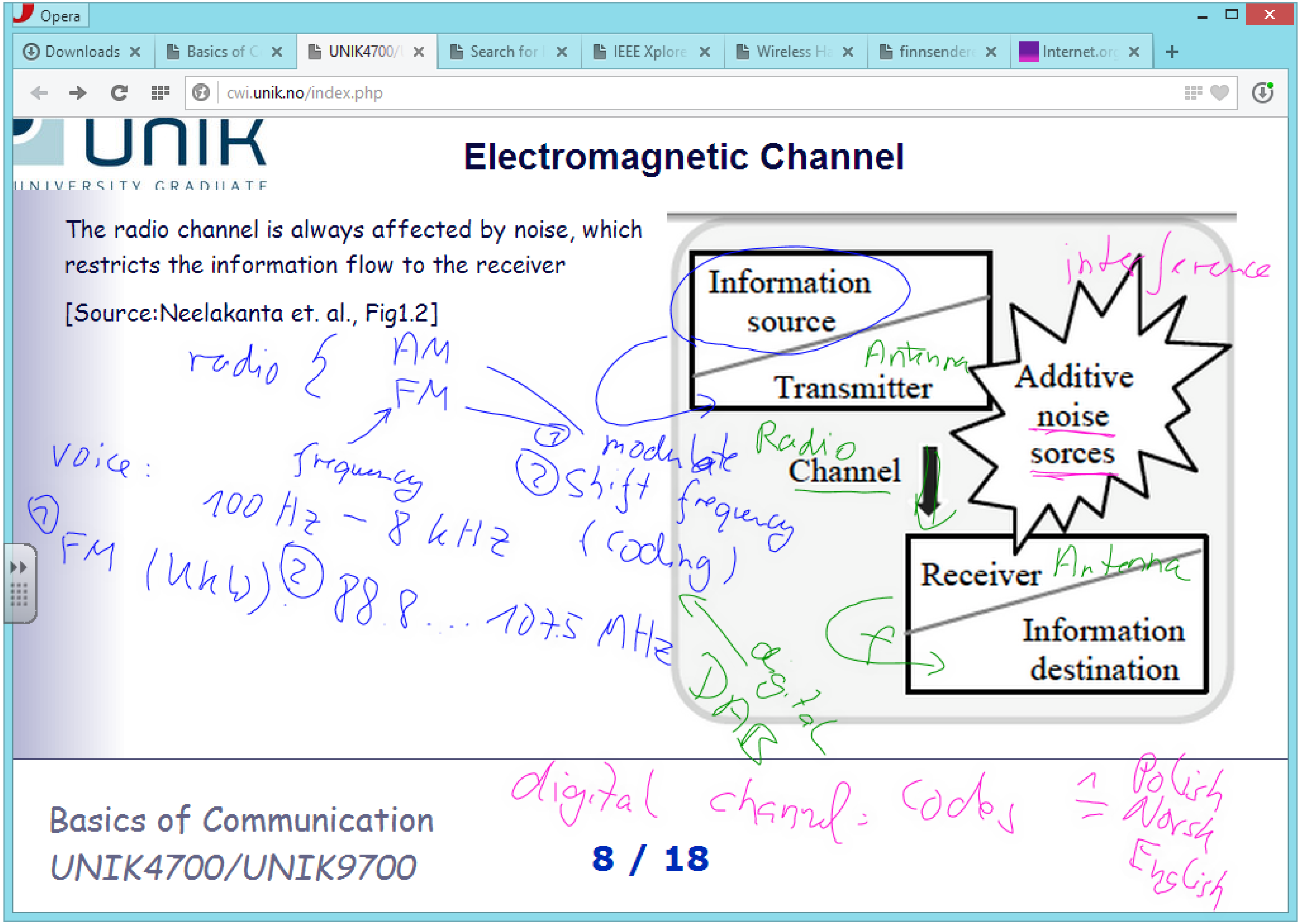
Electric field

~ EM-field

Magnetic field



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Electromagnetic Channel
The radio channel is always affected by noise, which restricts the information flow to the receiver
[Source:Neelakanta et. al., Fig1.2]
Information source
Transmitter
Additive noise sorces
Radio
Channel
Receiver
Information destination
Antenna
interference
radio
AM
FM
frequency
modulate
shift frequency
(coding)
voice:
100 Hz – 8 kHz
FM (UKW)
88.8 ... 107.5 MHz
digital
DAB
digital channel: codes
Polish
Norsk
English
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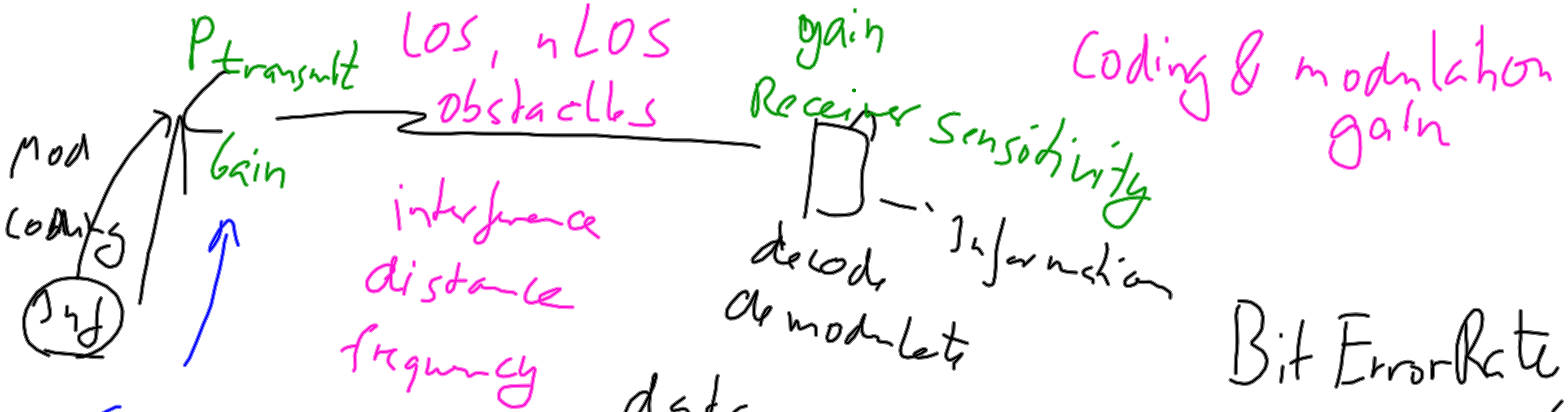
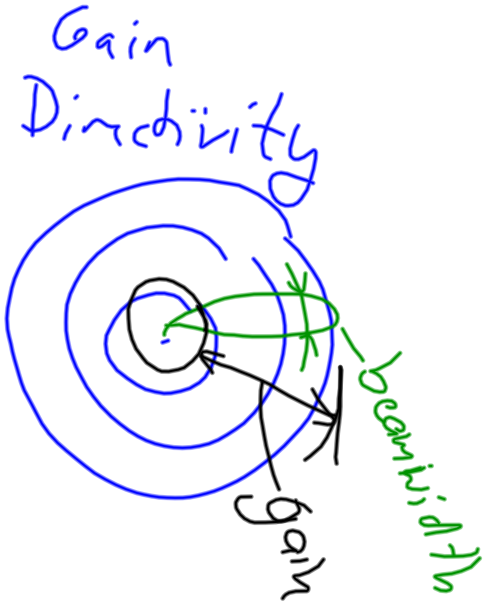




data package:

- header
- data
- parity bit
- FEC error control

Bit Error Rate

$BER = 10^{-6}$

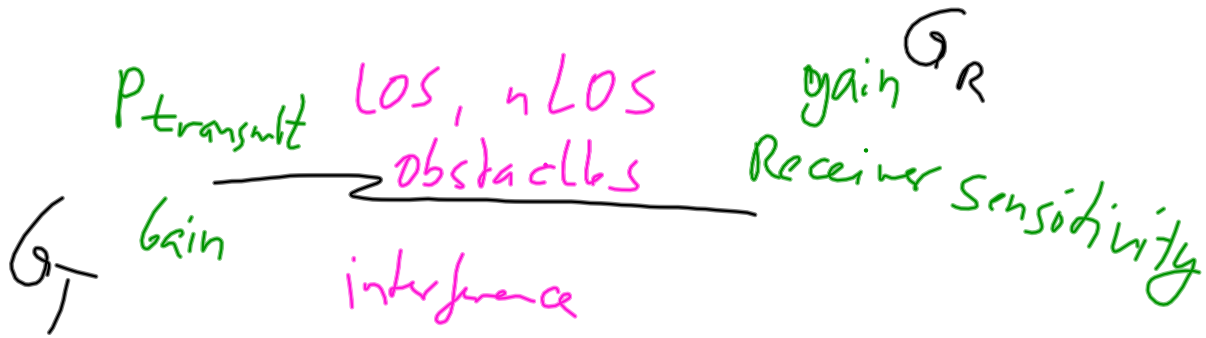
voice $\sim 10^{-3}$

data $< 10^{-6}$

$$P_{received} = P_{transmit} \cdot G_T \cdot G_R \cdot \underset{\text{(free space)}}{\text{attenuation}}$$

- others
  - obstacles
  - coding gain (+)

$$P_{received} > P_{sensitivity}$$



$P_{dB} = 10 \log \frac{P}{1W}$ $P_{dBm} = 10 \log \frac{P}{1mW}$

$P_{received} = P_{transmit} \cdot G_T \cdot G_R \cdot$ attenuation (free space

in dBm

$P_r = P_t [dBm] + G_T [dB] + G_R - L_{free\ space}$

mobile networks
good −75 dBm
acc −90 dBm
sens. −115 dBm

60 dBm + 14 dB + 6-8 dB − 130-150 dB

WiFi 2.4 GHz in dB

max power incl. antenna = 20 dBm

P_r ~ −60 dBm good
−80 dBm accept
−90 (95) dBm sensitivity

Sound ~ dB_A

$\frac{Power}{1W}$ ~ dB

$\frac{Power}{1mW}$ ~ dBm

Comparison: Δ ~ 25 dB 10 log(P)
Mobile ≈ 40 times more sensitive

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Maxwell's Equation In A Source Free Environm

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

$$\operatorname{div} \vec{v} = \frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} + \frac{\partial v_z}{\partial z} = \nabla \cdot \vec{v}$$

and curl is a vector function

$$\operatorname{curl} \vec{v} = \left(\frac{\partial v_z}{\partial y} - \frac{\partial v_y}{\partial z}\right)\mathbf{i} + \left(\frac{\partial v_x}{\partial z} - \frac{\partial v_z}{\partial x}\right)\mathbf{j} + \left(\frac{\partial v_y}{\partial x} - \frac{\partial v_x}{\partial y}\right)\mathbf{k} = \nabla \times \vec{v}$$

[Source: Wikipedia]

electrical field
direction vector

$$\vec{E} = E_0 e^{-i(\vec{k}\vec{r} - \omega t)}$$

in a material $\lambda = \lambda_0 \cdot \sqrt{\varepsilon_r}$

$\vec{k}$ propagation vector

$k = \frac{2\pi}{\lambda}$

$\lambda_0 = \frac{c}{f}$

$\omega = 2\pi f$ frequency vector

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Homogeneous Electromagnetic Wave

single frequency

$$\vec{E}(\vec{r}) = E_0 e^{j(\omega t - \vec{k}\cdot\vec{r})},$$

$$\vec{B}(\vec{r}) = B_0 e^{j(\omega t - \vec{k}\cdot\vec{r})},$$

[Source: Wikipedia]

where

- $\vec{r} = (x, y, z)$ and $\vec{k} = (k_x, k_y, k_z)$ so? radial
- j is the imaginary unit
- $\omega = 2\pi f$ is the angular frequency, [rad/s]
- f is the frequency [1/s] time
- $e^{j\omega t} = \cos(\omega t) + j\sin(\omega t)$ is Euler's formula

with $c = \frac{c_0}{n} = \frac{1}{\sqrt{\mu\varepsilon}}$ and $n = \sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}}$

P_{dBm} ... P $\qquad 10 \log \left(\frac{P}{1mW} \right)$

30 dBm — 1 W = 1000 mW = 10^3 mW

33 dBm — 2 W $\qquad 10 \log(2 \cdot 10^3) = 30 + 10 \log 2$; $10 \cdot 0.3$ → 3 dB

27 dBm — 0.5 W $\qquad 30 + 10 \log(0.5)$ → −0.3

WiFi = 20 dBm — 100 mW

100 mW

0 dBm — 1 mW Bluetooth Class 0, 1, 2

−10 dBm — 0.1 mW $\qquad 10^{-1}$ W … 0 dBm … 4 dBm … 20 dBm

Vision of NextLeap