

UNIK 4700

Agenda

- open issues $\left(\frac{\lambda}{4\pi r}\right)^2$; $Z_0 = 377 \Omega = \sqrt{\frac{\mu_0}{\epsilon_0}}$

- Compendium \rightarrow Question: $\left\{ \begin{array}{l} \text{Wiki:} \\ \text{UNIK4700 Google Plus} \end{array} \right.$

- Raul: freq range & transm. rate

- Yuk Ai: propagation model

Propagation equation

$$P_r = P_t \cdot G_t \cdot G_R \cdot \frac{1}{4\pi R^2} \cdot \frac{\lambda^2}{4\pi}$$

Sphere
↓

Antenne

↪ see Compendium

Antenna interaction:

Free space

$$\left(\frac{\lambda}{4\pi R} \right)^2$$

path loss

$$L \approx \frac{\lambda}{z}$$

15 cm for 654 at 2.7 GHz

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

Free space path loss

$$L_p \approx \left(\frac{\lambda}{4\pi R}\right)^2 \rightsquigarrow L_p = 10 \log \left(\frac{\lambda}{4\pi R}\right)^2$$

$$= 20 \log \frac{\lambda}{4\pi R} \quad *2$$

Analogous:

$$U = R \cdot I$$

resistance [Ω]

$$\vec{P} = \vec{E} \times \vec{H}$$

$$P = E \cdot H = Z \cdot H^2$$

$$\hookrightarrow E = Z \cdot H$$

$E, H \rightsquigarrow 20 \log$

free space $Z_0 = 377 \Omega$ impedance

convert to

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

$$L_p = \text{const.} + 20 \log(f [\text{MHz}]) + 20 \log(R [\text{km}])$$

course [Master](#)

Edit the page by [Special:FormEdit/Course/UNIK4700](#).

Lecture overview

	<i>Date</i>
LTE and Voice over LTE	17 October 2014
Wifi WiMax and Security in NFC	10 October 2014
- Autumn holidays - no lecture	3 October 2014
Frequency Ranges and Propagation Models for Communications	26 September 2014
Antennas and their communication parameters	19 September 2014
Radio propagation equation	12 September 2014
Basics of Communication	5 September 2014
UNIK4700/9700-Introduction	27 August 2014

To add new lectures, use: [Add a lecture](#)

For **assignments to be presented** during the course, please visit typical topics at [UNIK4700:Assignme](#)

Lot's of course material is still on our old [wiki.unik.no](#), [Courses](#), [UNIK4700](#)

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ilding_Mobile_and_Wireless_Networks_Compedium

UNIK wiki WNaS@UNIK Master/PhD Courses Master Thesis Research Areas

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Building Mobile and Wireless Networks Compendium

Disclaimer: This compendium provides information on aspects of radio wave propagation, antennas, system aspects, and handover schemes for mobile and wireless systems. The compendium is foreseen for the UNIK4700 course on [Building Mobile and Wireless Networks](#), and is kept on the system aspects level. UNIK has several courses on Radio and Network technologies as part of the [Wireless Networks and Security \(WNaS\)](#) research area.

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 - 4.1 What have we learned?
- 5 ¶ TOC - Propagation models
- 6 ¶ TOC System Comparison
- 7 ¶ TOC - Mobility
- 8 ¶ TOC - Network Building

UNIK 4700 Building Mobile and Wireless Networks

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Building Mobile and Wireless Networks

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Author
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Building Mobile and Wireless Networks Compendium

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Building ... Networks

History, Now and Future

- History
- Pioneers: Maxwell, Hertz,...
- 1G, 2G,... 5G networks
- Frequencies and Standards
- Future Challenges

A-Basics of Communication

- Electromagnetic Signals
- Radio Communication Principles
- Digital communication: Signal/Noise Ratio
- Signal strength and Capacity: Shannon

B-Antennas and Propagation

- Free Space Propagation
- Antennas, Gain, Radiation Pattern
- Multipath Propagation, Reflection, Diffraction
- Attenuation, Scattering
- Interference and Fading (Rayleigh, Rician, ...)
- Mobile Communication dependencies

C-Propagation models

- Environments (indoor, outdoor to indoor, vehicular)
- Outdoor (Lee, Okumura, Hata, COST231 models)
- Indoor (One-slope, multiwall, linear attenuation)

D-System Comparison

- Proximity: RFID, NFC
- Short Range: ZigBee, Bluetooth, ANT+,...
- WLAN/Wifi/802.11...
- Mobile: GSM, UMTS, IMT-A (WIMAX, LTE)

E-Mobility

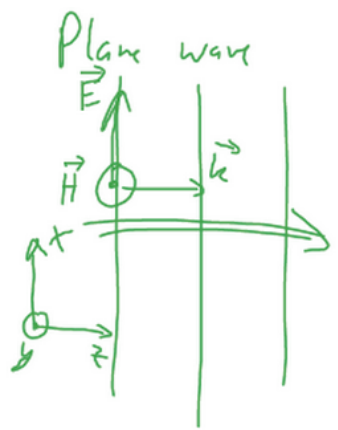
- Mobile Network mobility
- IP mobility

F-Network Building

- Future Networks
- 5G Heterogeneous Networks
- Basic Internet
- Video Distribution Networks

$t=0 \quad \vec{H} = H \vec{u}_y e^{-j k_z z} \quad k_z = \frac{2\pi}{\lambda}$

wave number $\vec{k} = (k_x, k_y, k_z)$



$$\vec{E} = E \vec{u}_x e^{j(\omega t - k_z z)}$$

$$\vec{H} = H \vec{u}_y e^{j(\omega t - k_z z)}$$

$$\nabla \times \vec{E} = \begin{vmatrix} \vec{u}_x & \vec{u}_y & \vec{u}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ E_x & E_y & E_z \end{vmatrix}$$

$$\nabla \times \vec{E} = -\mu_0 \frac{\partial \vec{H}}{\partial t}$$

$$\frac{E_x}{H_y} = Z_0 = 377 \Omega = \sqrt{\frac{\mu_0}{\epsilon_0}}$$

$$\begin{aligned} *1 &= -\mu_0 \frac{dH}{dt} = -\mu_0 \frac{d(H_y u_y e^{-j(\omega t - k_z z)})}{dt} \end{aligned}$$

$$\mu_0 c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = \sqrt{\frac{\mu_0}{\epsilon_0}}$$

Advertisable throughput is obtained by " sending and receiving " pure payload without any overhead

Throughput varies based on a number of different factors. We can roughly approximate Wi - Fi throughput to be about half advertised throughput in the best case : LOS close to transmitter, no interferences and multipath ways.

MAX



P.L.
I.
Number
MP.

Conclusions

- trans rate $\sim \frac{1}{r^2}$; $\sim \frac{1}{f^2}$
- typical trans. rate $\sim 50\%$ at most best

Reasons

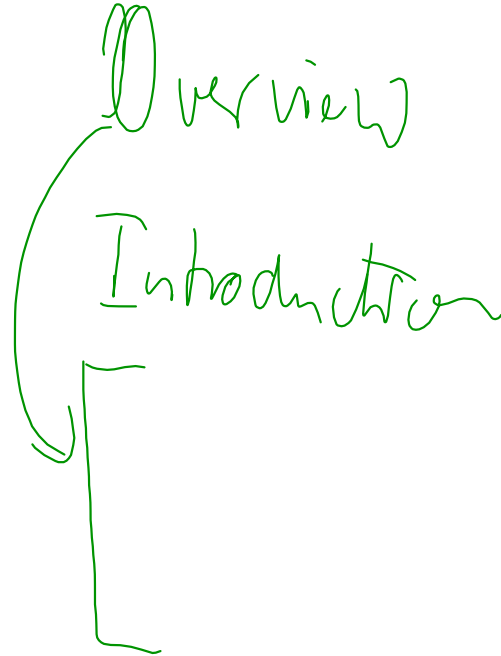
- path loss
- interference
- number of users
- multipath

Titel

Overview

Introduction

Conclusion



Summary

"My take"

- Wireless Channel

path loss

fading

shadowing

multipath

etc

es. 1-20 dB } impact
f outdoor, fr-----
types of models

400 - 1006 MHz

1 - 2 GHz

5 GHz

20, 80 GHz

- Wireless Channel Models

modeling approaches

different scenarios

: 3 main directions





NPT.NO OM TJENESTEN ORDBOK OM STRÅLING KONTAKTINFORMASJON HJELP

Finnsenderen

- Trådløse mikrofoner
- Strålingskalkulator

Akershus
Skedsmo

Adresse
2027

Søk

Nullstill alt

Skedsmo (Kommune)

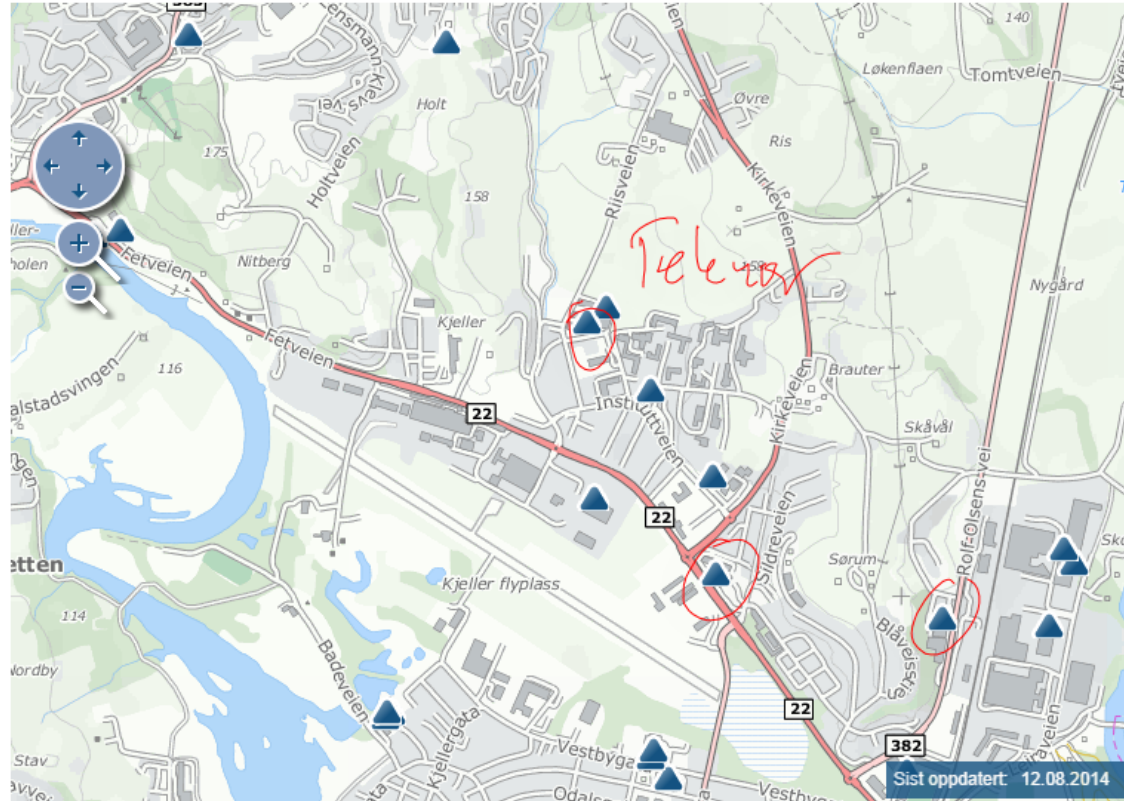
Vis sendere i kart

Tegnforklaring

- Radio- og TV
- Mobil

Vis alle

- Radio og TV
- Mobil



less Mobility
more Building
Networks

480 m

Tips en venn **Kart** Foto Hybrid **Panorér** Zoom

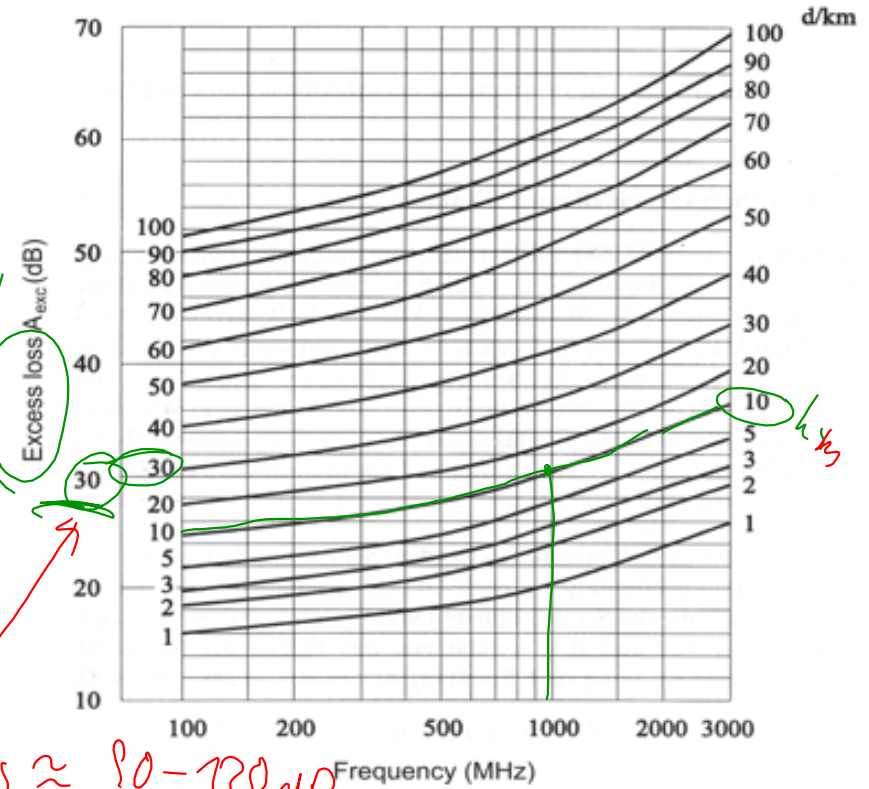
▲ GSM (19) ▲ LTE (20) ▲ UMTS (21)

Path loss according to the Okumura-Hata model

Path loss vs. Frequency

Path loss vs. distance

Source: A. Molisch book



??
"does not fit!"

Andreas
free space additional path loss

total path loss \approx 90-120 dB

provides a good indication