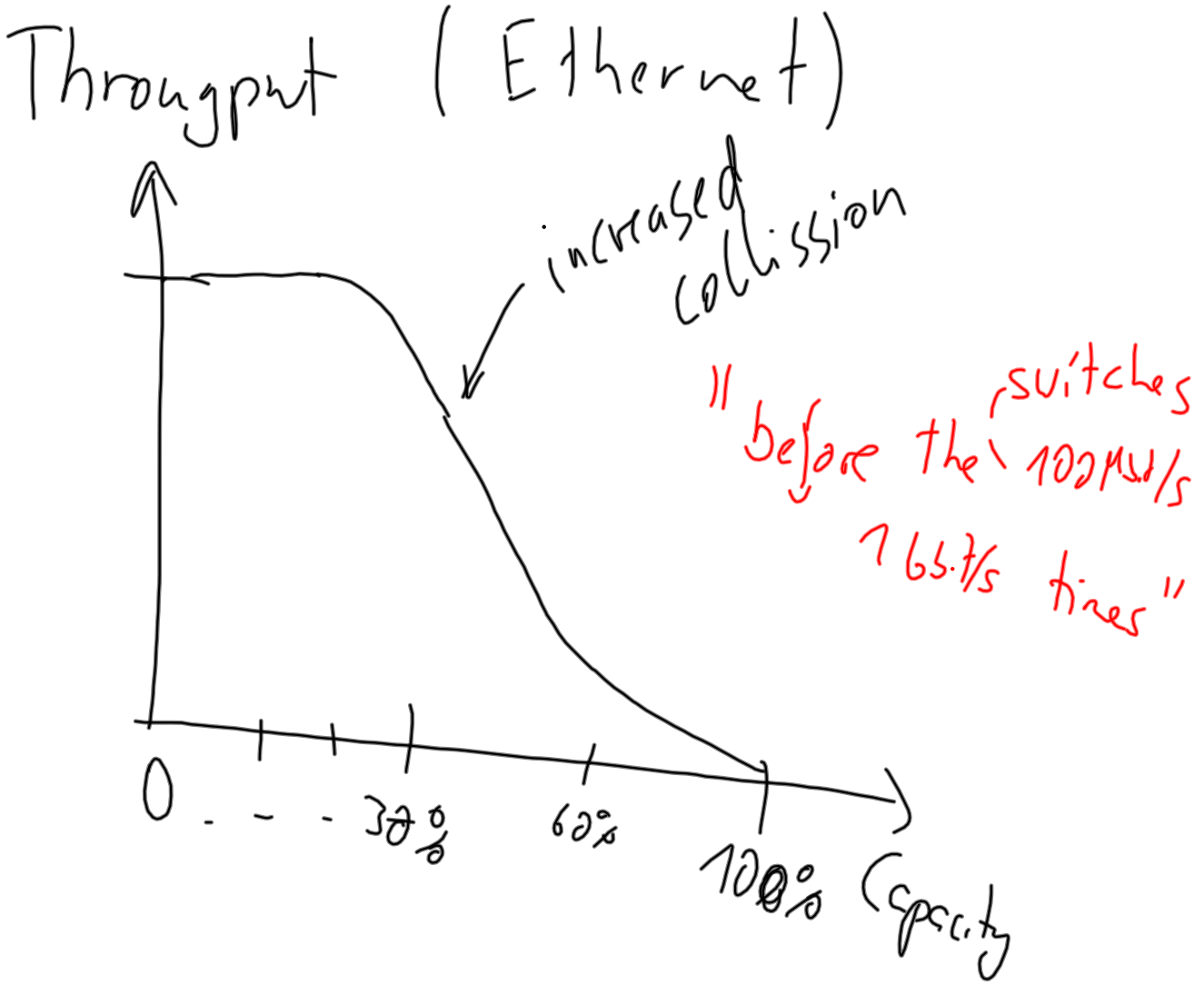

"switches before the 100Mbit/s 765/s times"

Multiple Access in Mobile Systems

When multiple users share same bandwidth, there are four main techniques:

FDMA (Frequency Division Multiple Access)
- Each user is assigned a separate frequency range

TDMA (Time Division Multiple Access)
- Multiple users share the allocated frequency bands, and each user use an allocated time

CDMA (Code Division Multiple Access)
- The bandwidth used by all users simultaneously, which is separated by means of code

OFDMA (Orthogonal Frequency Division Multiple Access)
- The bandwidth is divided to the different users as needed

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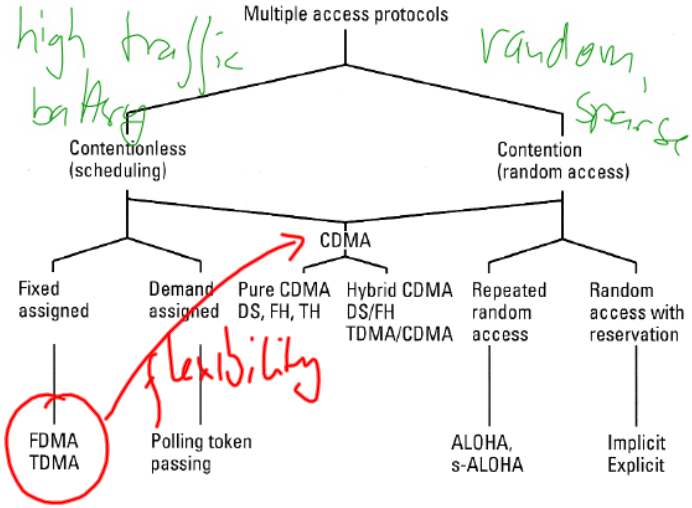
Introduction

Multiple Access is divided in two main types:

- **Contentionless:** "conflict-free" protocol based on scheduling
  - Ensuring a transmission, whenever made is a successful one and not interfered by another transmission.
  - Used in Mobile systems such as GSM, UMTS and LTE



- **Contention:** "Random access" with various means to resolve conflict for simultaneous transmission
  - In principal, transmission is not guaranteed to be successful
  - Used in WLAN/Wi-Fi systems
  - Also used in mobile system for initial connection set-up

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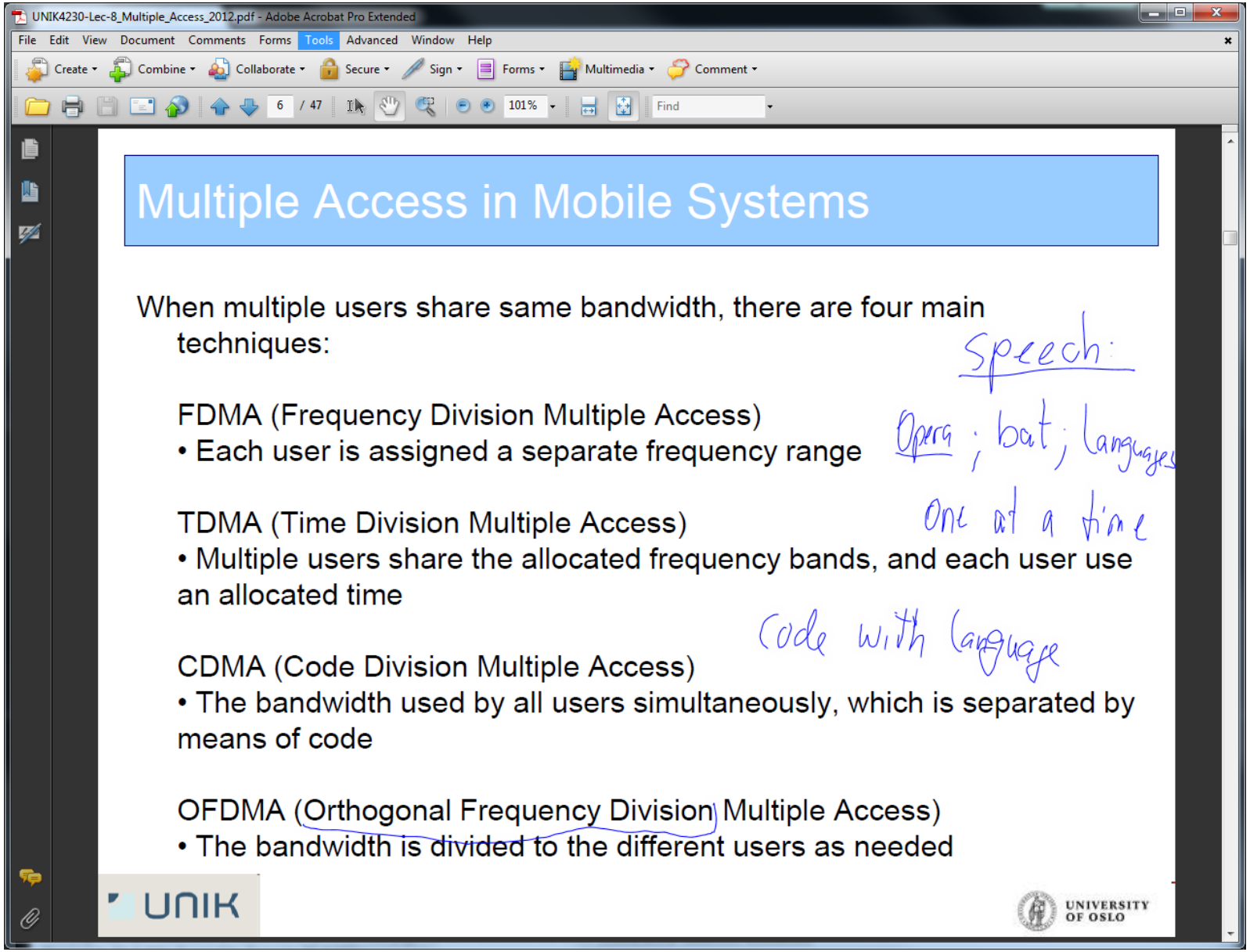
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Find
Multiple Access in Mobile Systems
When multiple users share same bandwidth, there are four main techniques:
FDMA (Frequency Division Multiple Access)
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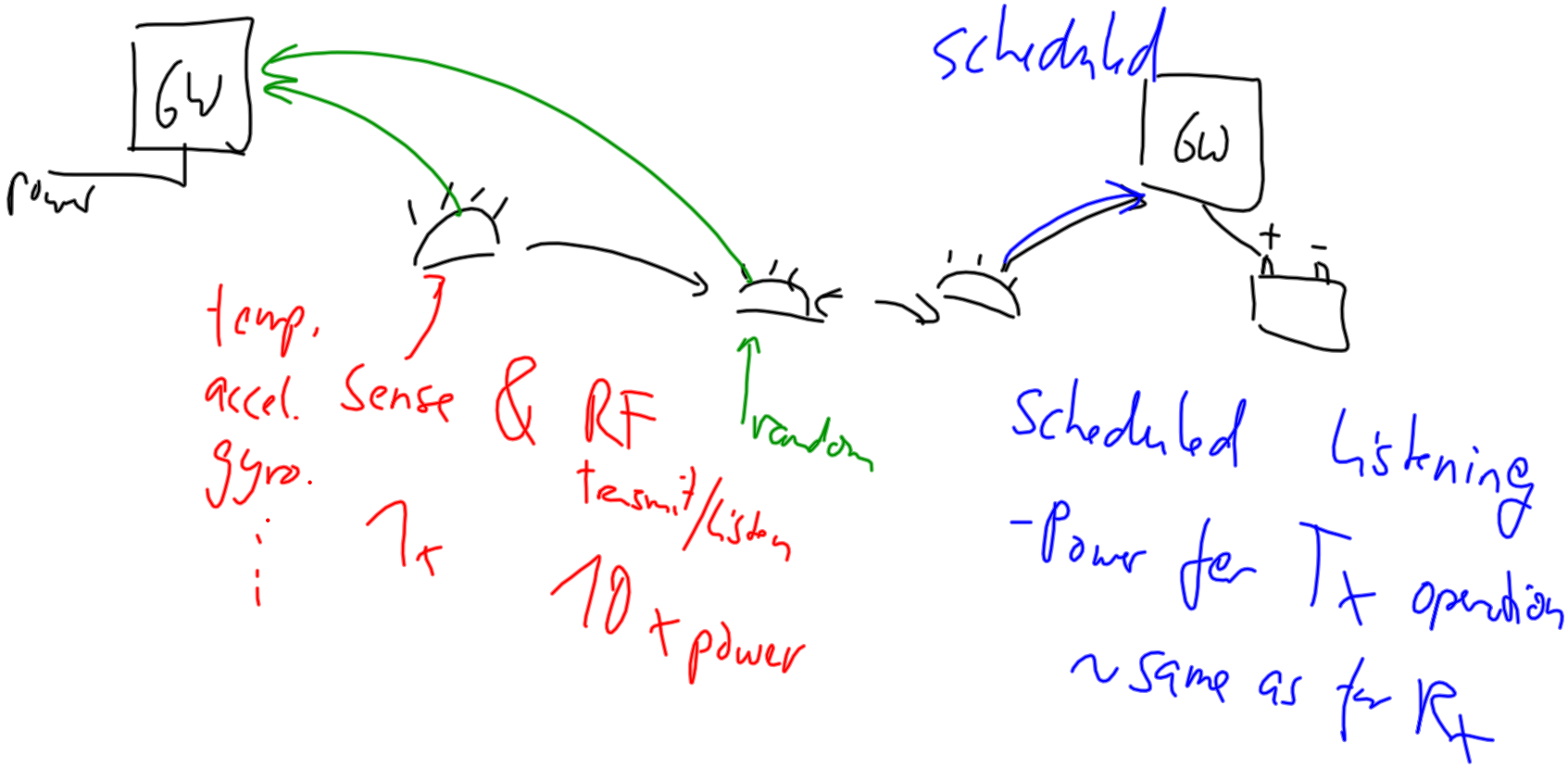
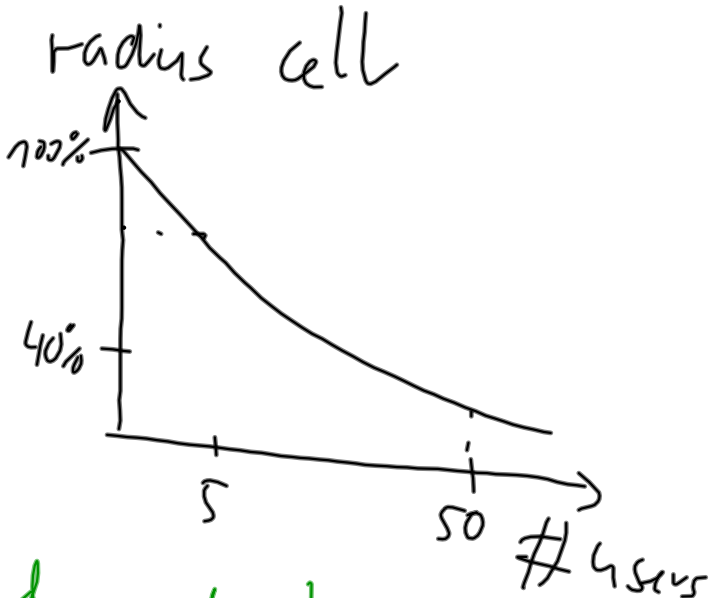
Sensor network



Cell breathing

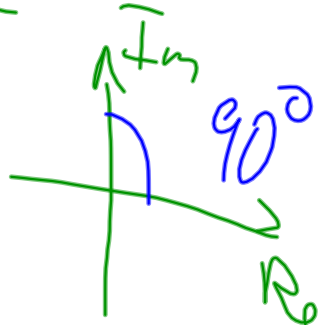
CDMA



codes are not independent

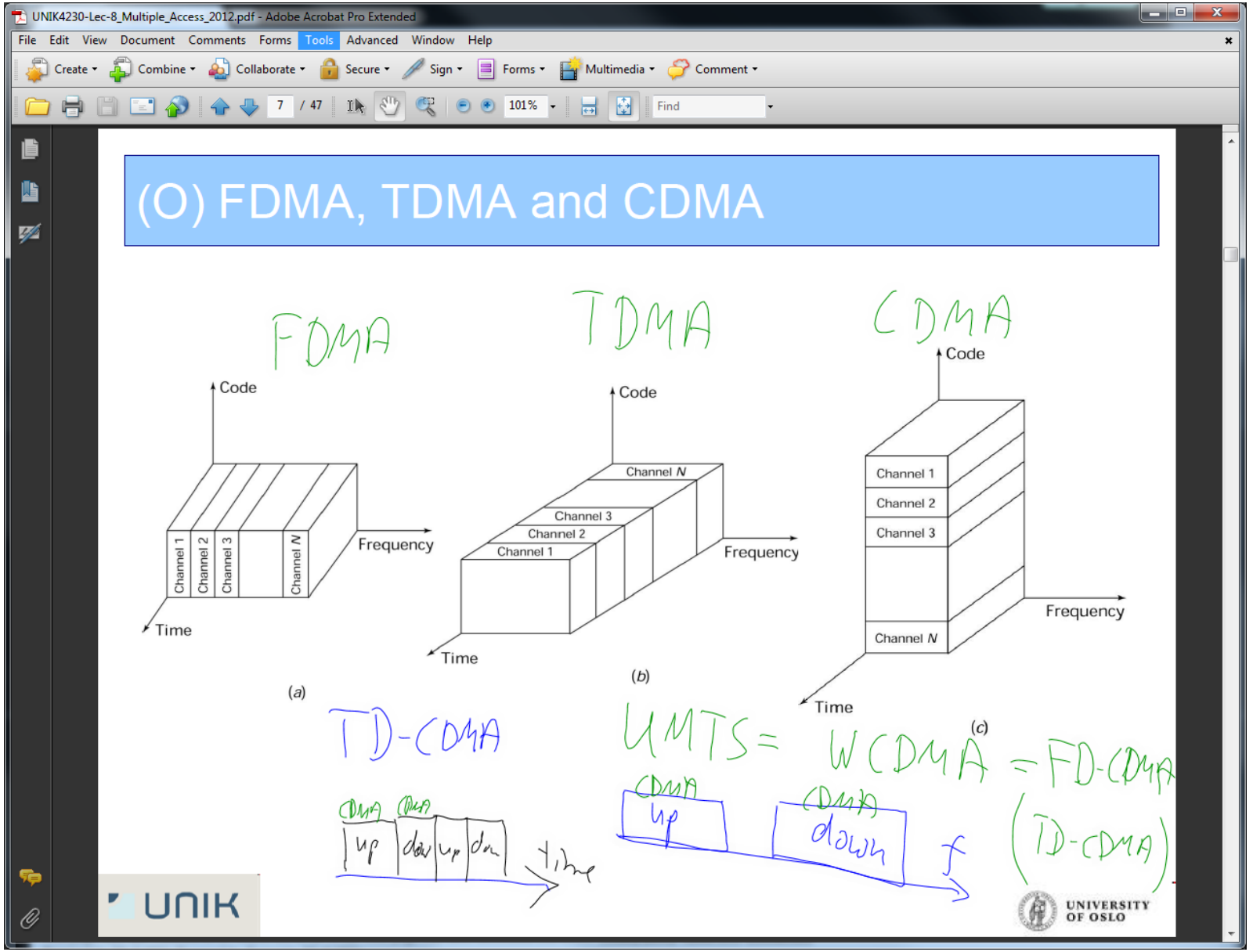
cos, sin

$j = \sqrt{-1}$



I, Q

→ more codes → interference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Find
(O) FDMA, TDMA and CDMA
FDMA
TDMA
CDMA
Code
Frequency
Time
Channel 1
Channel 2
Channel 3
Channel N
(a)
(b)
(c)
TD-CDMA
UMTS = WCDMA = FD-CDMA
up
down
(TD-CDMA)
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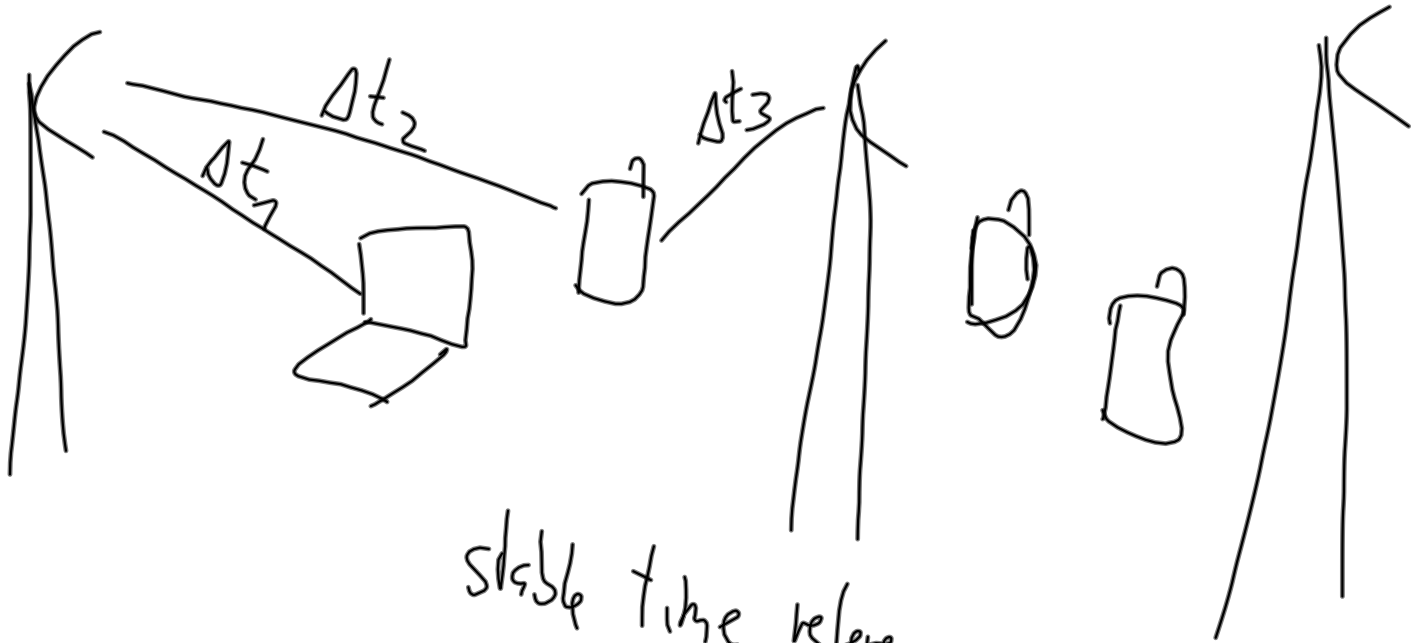
Synchronisation



100 Mbit/s → 50ns ref (?)

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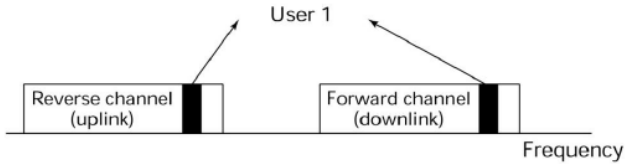
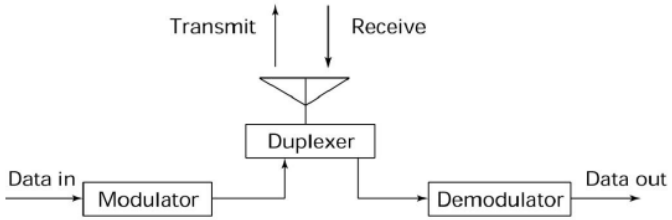
Duplex Transmission

FDD: A duplexer is needed since same antenna is used for both way transmissions

TDD: No duplexer is needed



(a)



(b)

high datarate

⇝ time synchronization

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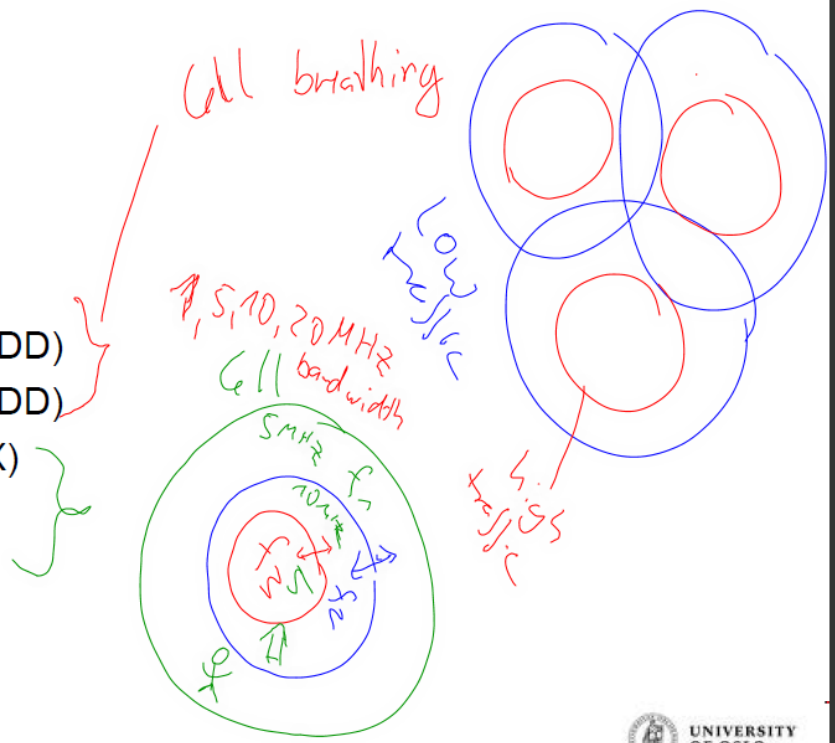
Duplex Techniques and Systems

Systems are characterized both by its method of multiple access and duplex

For example

- FDMA/FDD (e.g. NMT)
- TDMA/FDD (e.g. GSM)
- TDMA/TDD (e.g. DECT)
- CDMA/TDD (e.g. UMTS TDD)
- CDMA/FDD (e.g. UMTS FDD)
- OFDMA/TDD (e.g. WiMAX)
- OFDMA/FDD (e.g. LTE)



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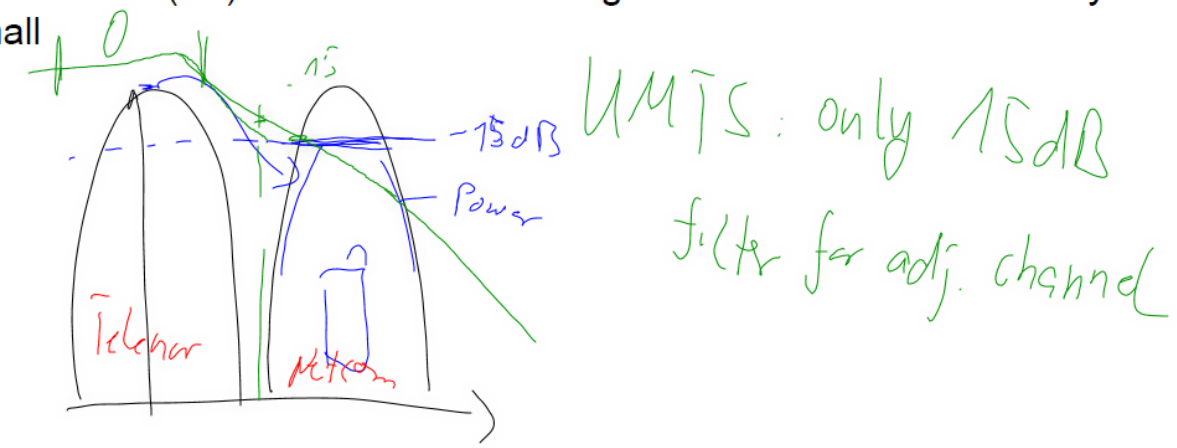
Advantages of FDMA

- The major advantage of FDMA is the "hardware simplicity" since discrimination between users is done by simple bandpass filters.
- No timing information or synchronization is required
- Little problem of frequency-selective fading and Intersymbol Interference (ISI) since bandwidth assigned to each user is relatively small



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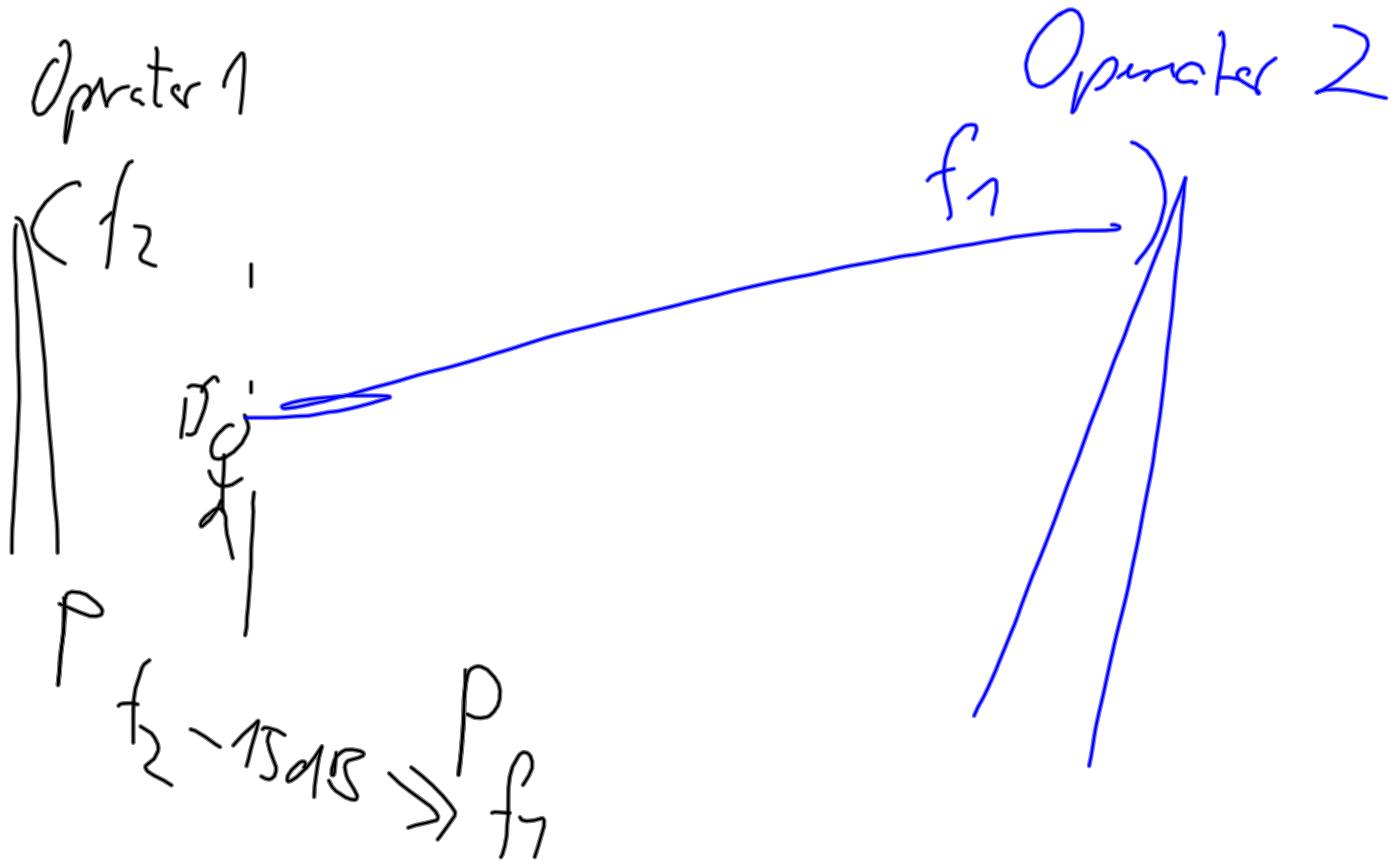
Operator 1
Operator 2
f_2
f_1
P
$f_2 - 15\,\text{dB} \gg P_{f_1}$

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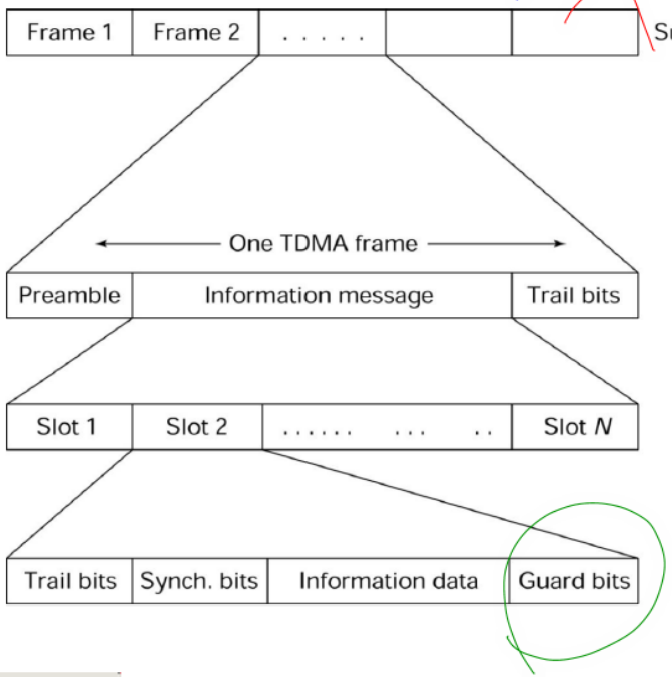
TDMA: Timeslot and Frame



Preamble:

- Address and synchronization information

Guardbits:

- Necessary to allow non-ideal time synchronization between the mobile?

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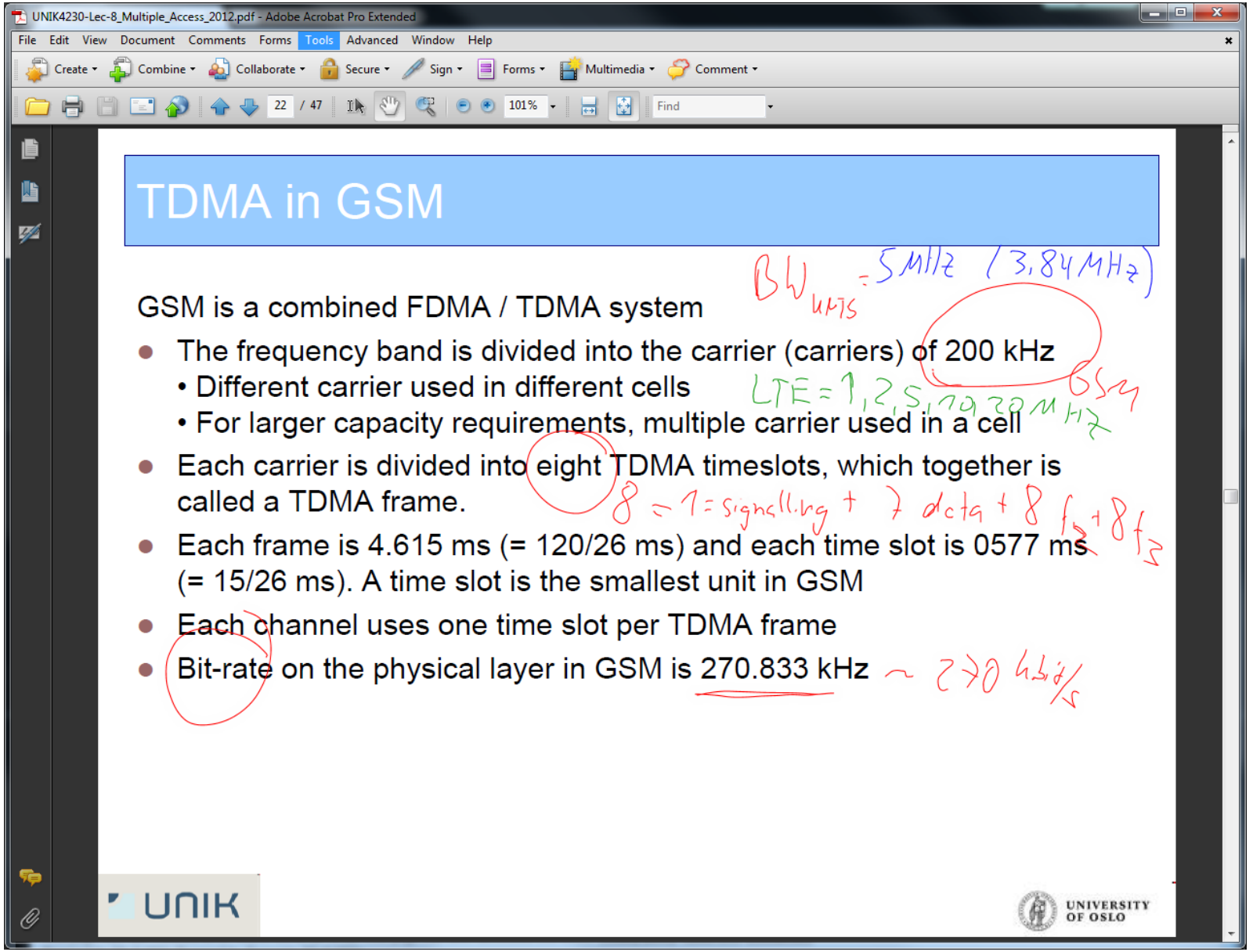
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Find
TDMA in GSM
GSM is a combined FDMA / TDMA system
The frequency band is divided into the carrier (carriers) of 200 kHz
Different carrier used in different cells
For larger capacity requirements, multiple carrier used in a cell
Each carrier is divided into eight TDMA timeslots, which together is called a TDMA frame.
Each frame is 4.615 ms (= 120/26 ms) and each time slot is 0577 ms (= 15/26 ms). A time slot is the smallest unit in GSM
Each channel uses one time slot per TDMA frame
Bit-rate on the physical layer in GSM is 270.833 kHz
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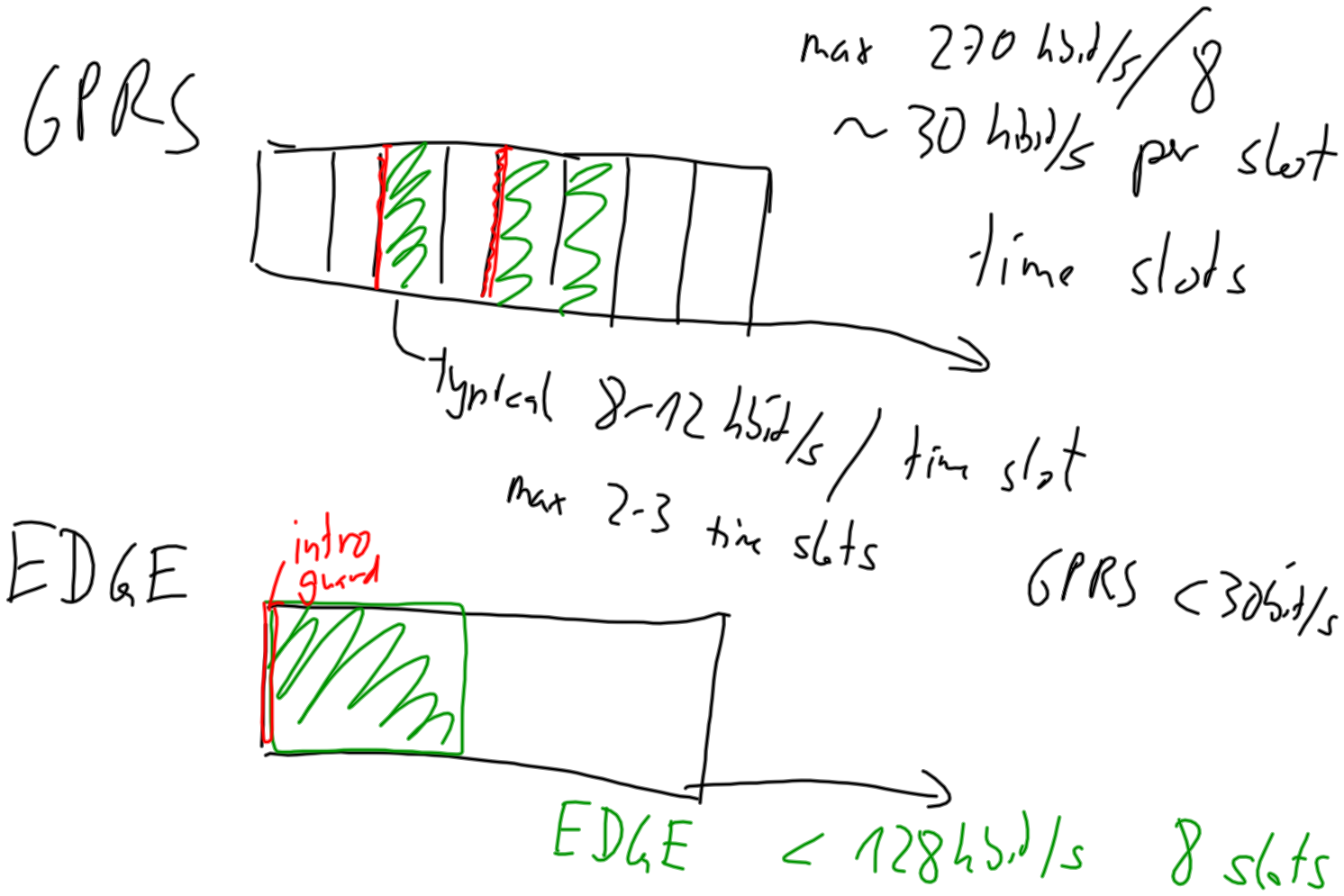
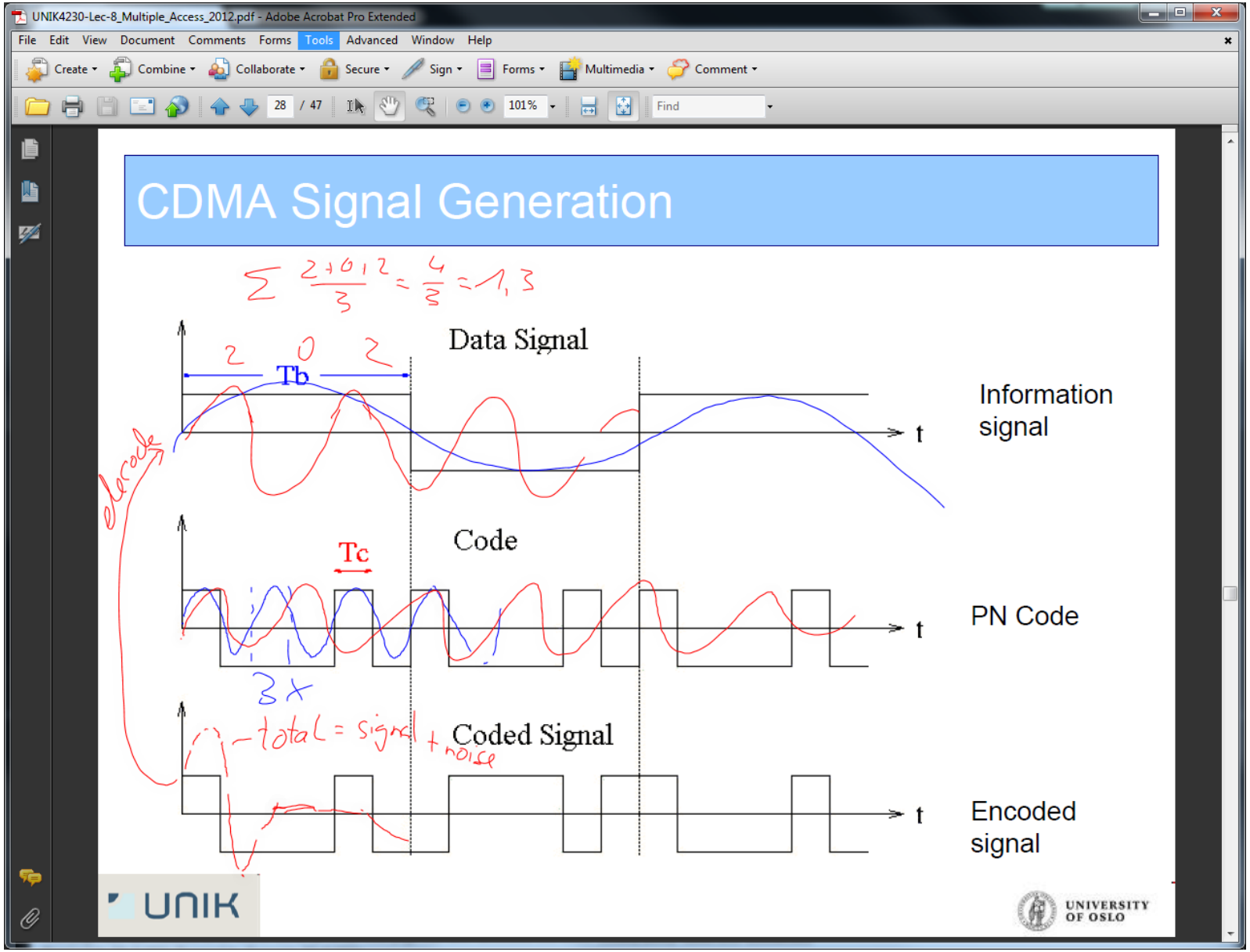

GPRS
max 270 kbit/s / 8
~ 30 kbit/s per slot
time slots
typical 8-12 kbit/s / time slot
max 2-3 time slots
EDGE
intro
guard
GPRS < 30 kbit/s
EDGE < 128 kbit/s 8 slots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Find
CDMA Signal Generation
Data Signal
Tb
t
Information signal
Code
Tc
t
PN Code
Coded Signal
t
Encoded signal
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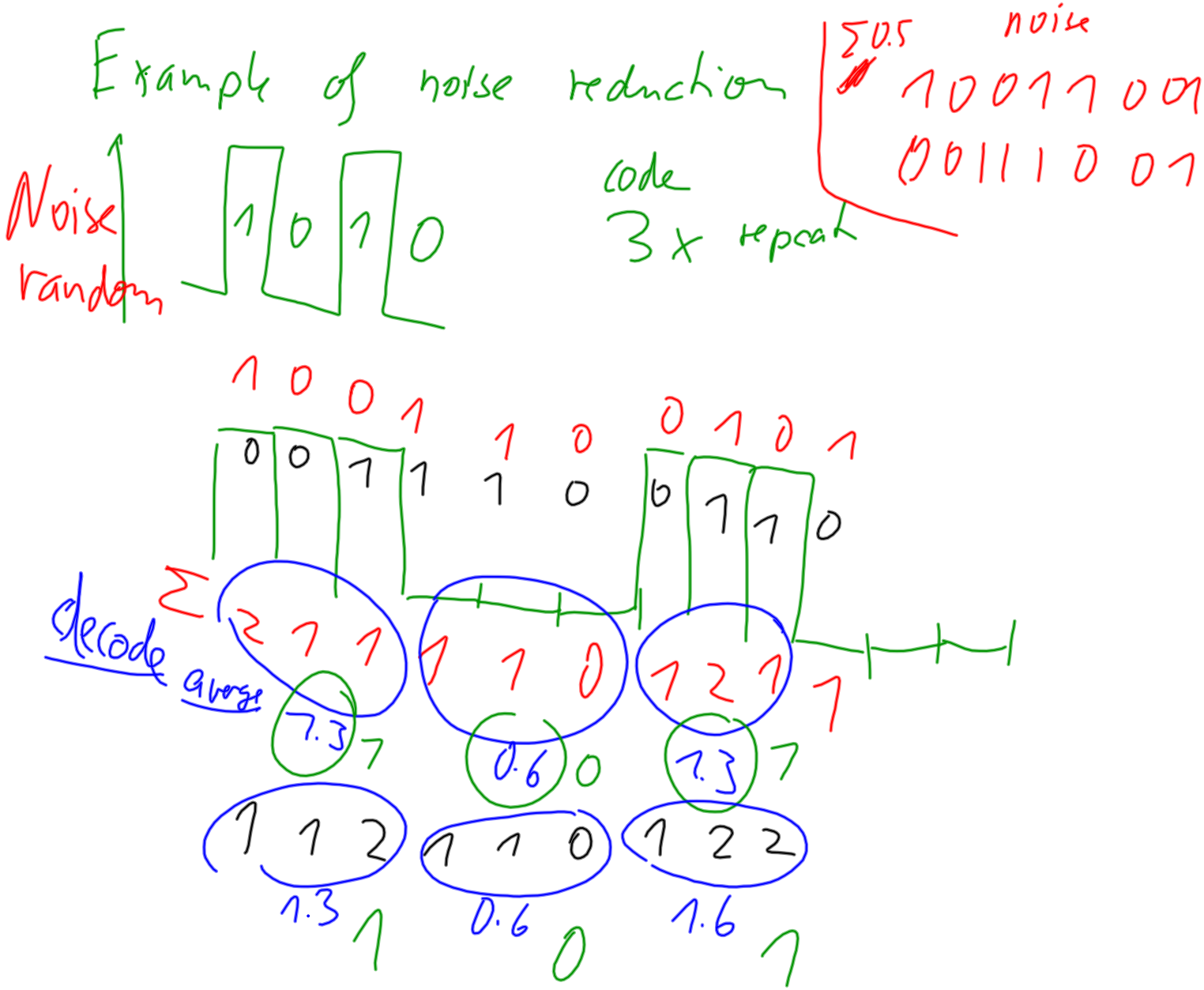
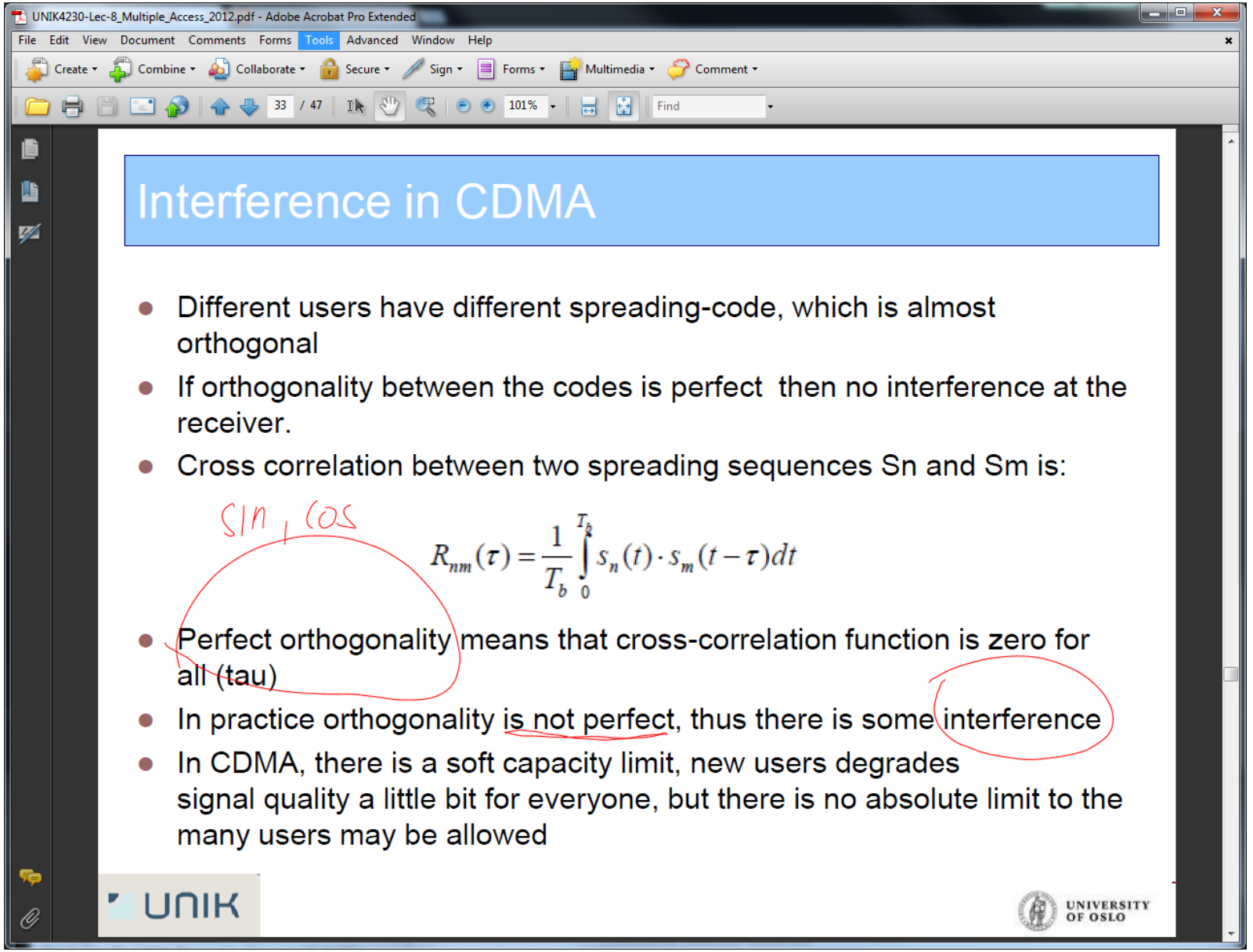

Example of noise reduction
Noise
random
1 0 1 0
code
3 x repeat
Σ0.5
noise
1 0 0 1 1 0 0 1
0 0 1 1 1 0 0 1
1 0 0 1
0 0 1 1
1 0
0 1 1 0
Σ
decode
average
2 1 1
1 1 0
1 2 1
1.3
0.6
1.3
1 1 2
1 1 0
1 2 2
1.3
0.6
1.6
1
0
1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Find
Interference in CDMA
Different users have different spreading-code, which is almost orthogonal
If orthogonality between the codes is perfect then no interference at the receiver.
Cross correlation between two spreading sequences Sn and Sm is:
$R_{nm}(\tau) = \frac{1}{T_b}\int_0^{T_b} s_n(t)\cdot s_m(t-\tau)dt$
Perfect orthogonality means that cross-correlation function is zero for all (tau)
In practice orthogonality is not perfect, thus there is some interference
In CDMA, there is a soft capacity limit, new users degrades signal quality a little bit for everyone, but there is no absolute limit to the many users may be allowed
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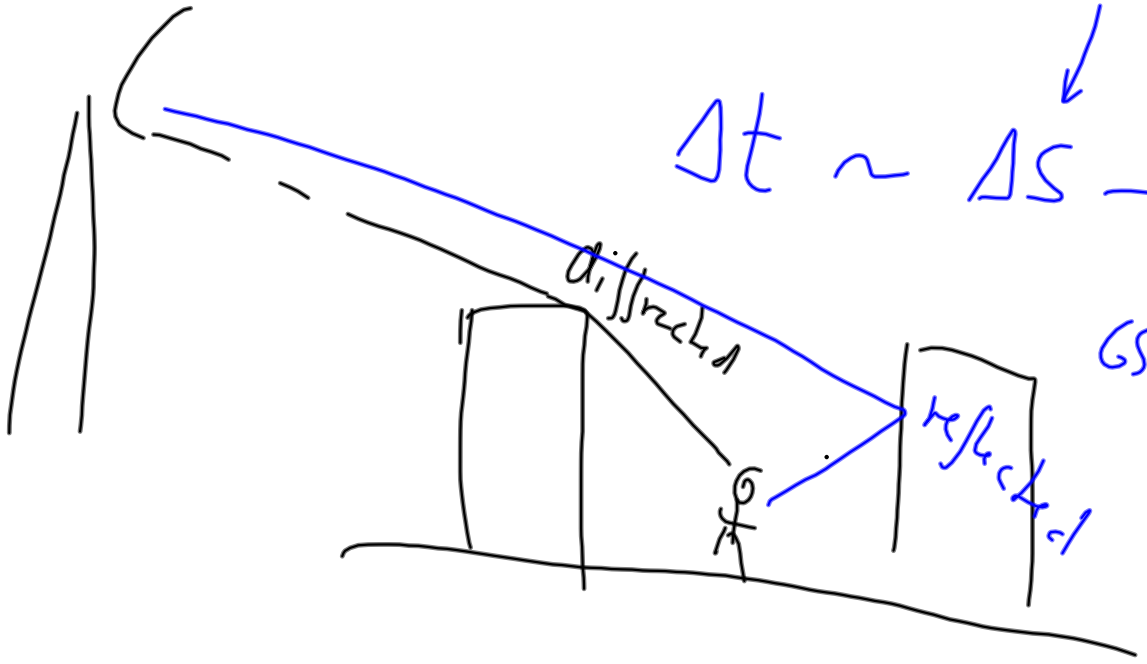
Spread Spectrum



path length

$\Delta t \sim \Delta s \rightarrow \varphi$

I, Q angle

$\varphi(f)$

GSM:

760 ... 780°

Spread spectrum

90 ... 270°

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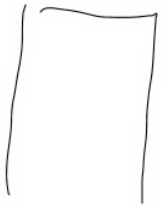
Spread Spectrum

- Spread spectrum is a generic term for techniques that spread the information over a wide frequency range (broadband)
- Can be various reasons for this, for example:
  - Avoid fast fading
  - Avoid jamming (especially in military applications)



- Available in two main types of spread spectrum:
  - Direct-Sequence
  - Frequency Hopping
- CDMA uses direct sequence spread spectrum to achieve multiple access

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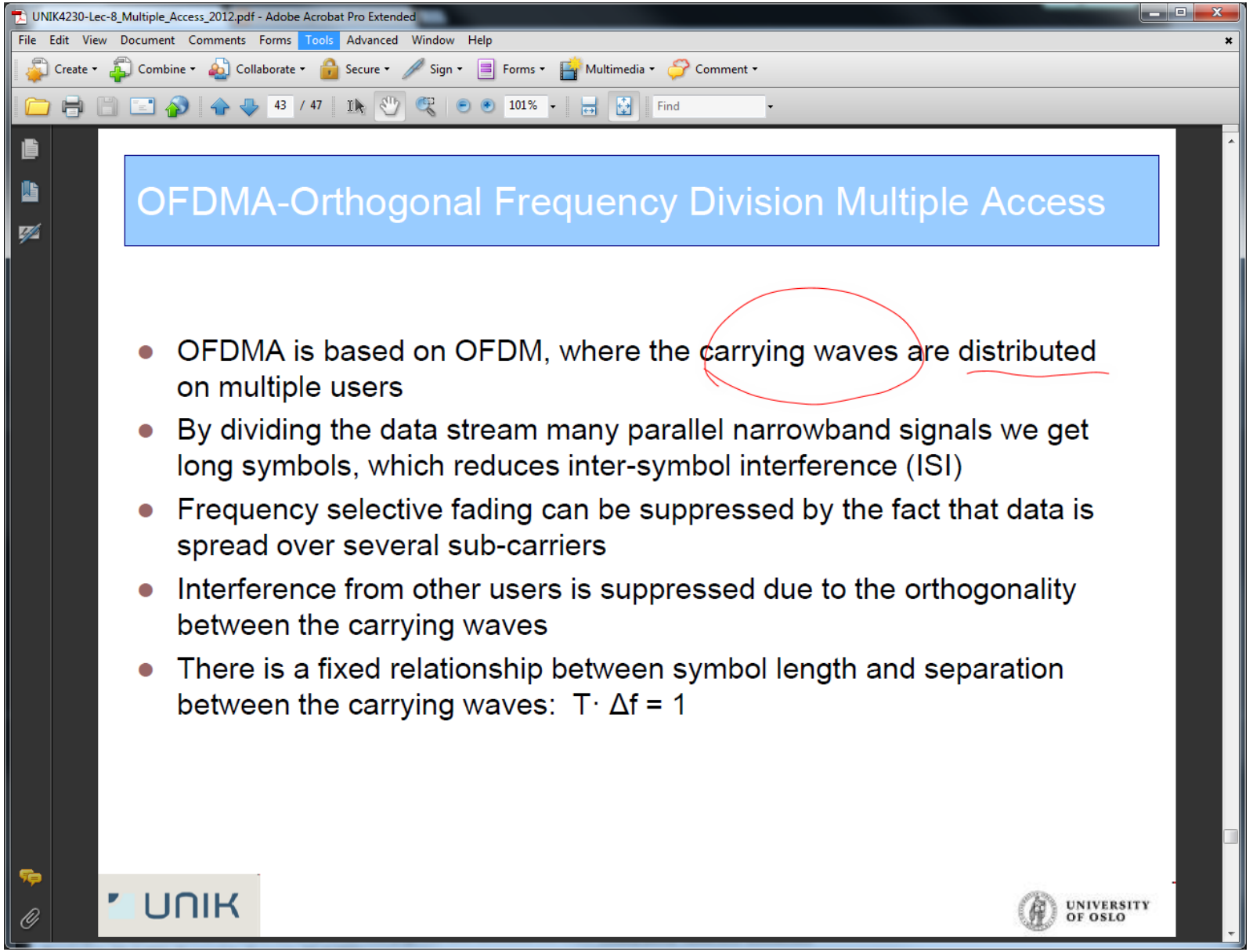
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Find
OFDMA-Orthogonal Frequency Division Multiple Access
OFDMA is based on OFDM, where the carrying waves are distributed on multiple users
By dividing the data stream many parallel narrowband signals we get long symbols, which reduces inter-symbol interference (ISI)
Frequency selective fading can be suppressed by the fact that data is spread over several sub-carriers
Interference from other users is suppressed due to the orthogonality between the carrying waves
There is a fixed relationship between symbol length and separation between the carrying waves: T· Δf = 1
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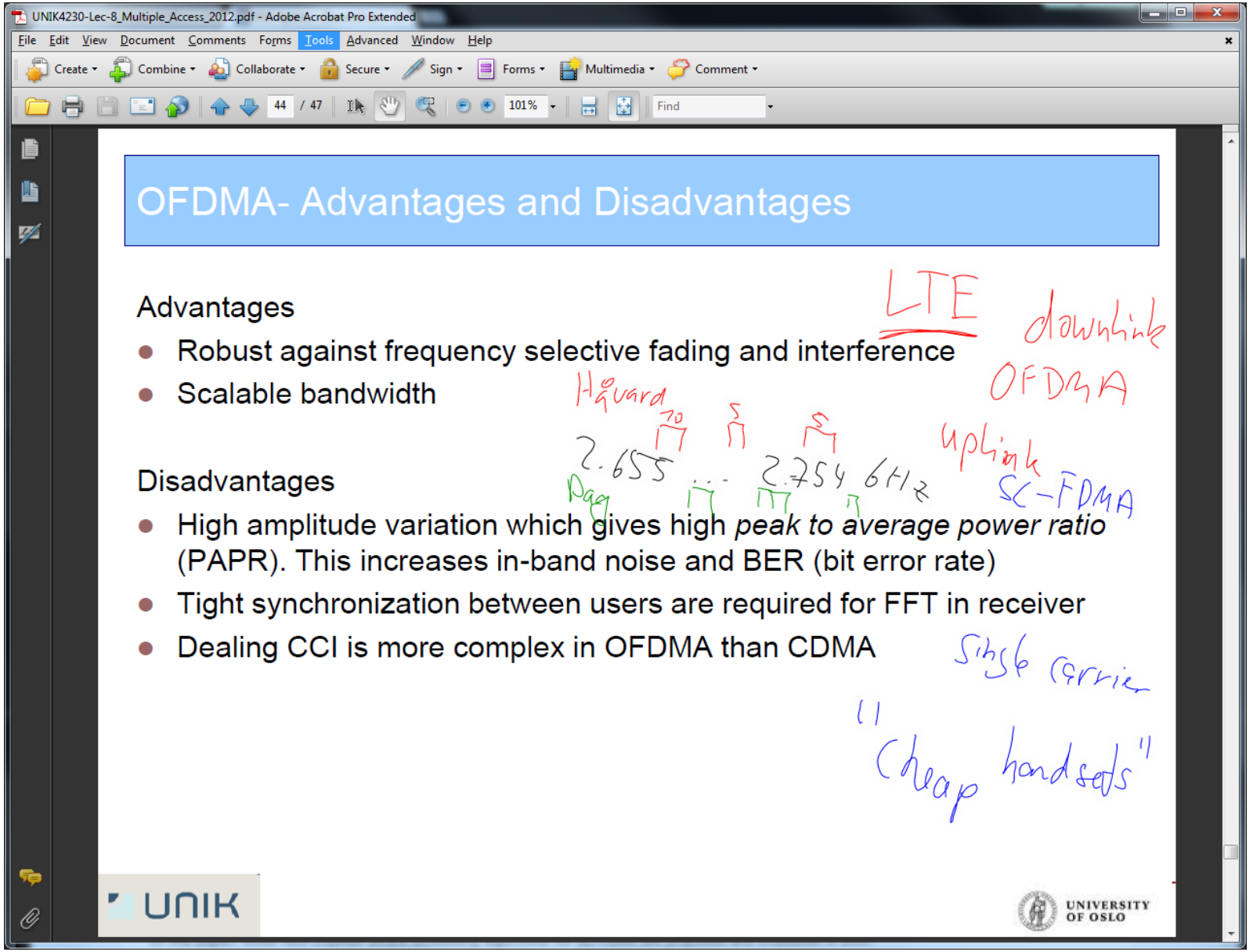
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Find
OFDMA- Advantages and Disadvantages
Advantages
Robust against frequency selective fading and interference
Scalable bandwidth
Disadvantages
High amplitude variation which gives high peak to average power ratio (PAPR). This increases in-band noise and BER (bit error rate)
Tight synchronization between users are required for FFT in receiver
Dealing CCI is more complex in OFDMA than CDMA
LTE
downlink
OFDMA
uplink
SC-FDMA
Single carrier
"Cheap handsets"
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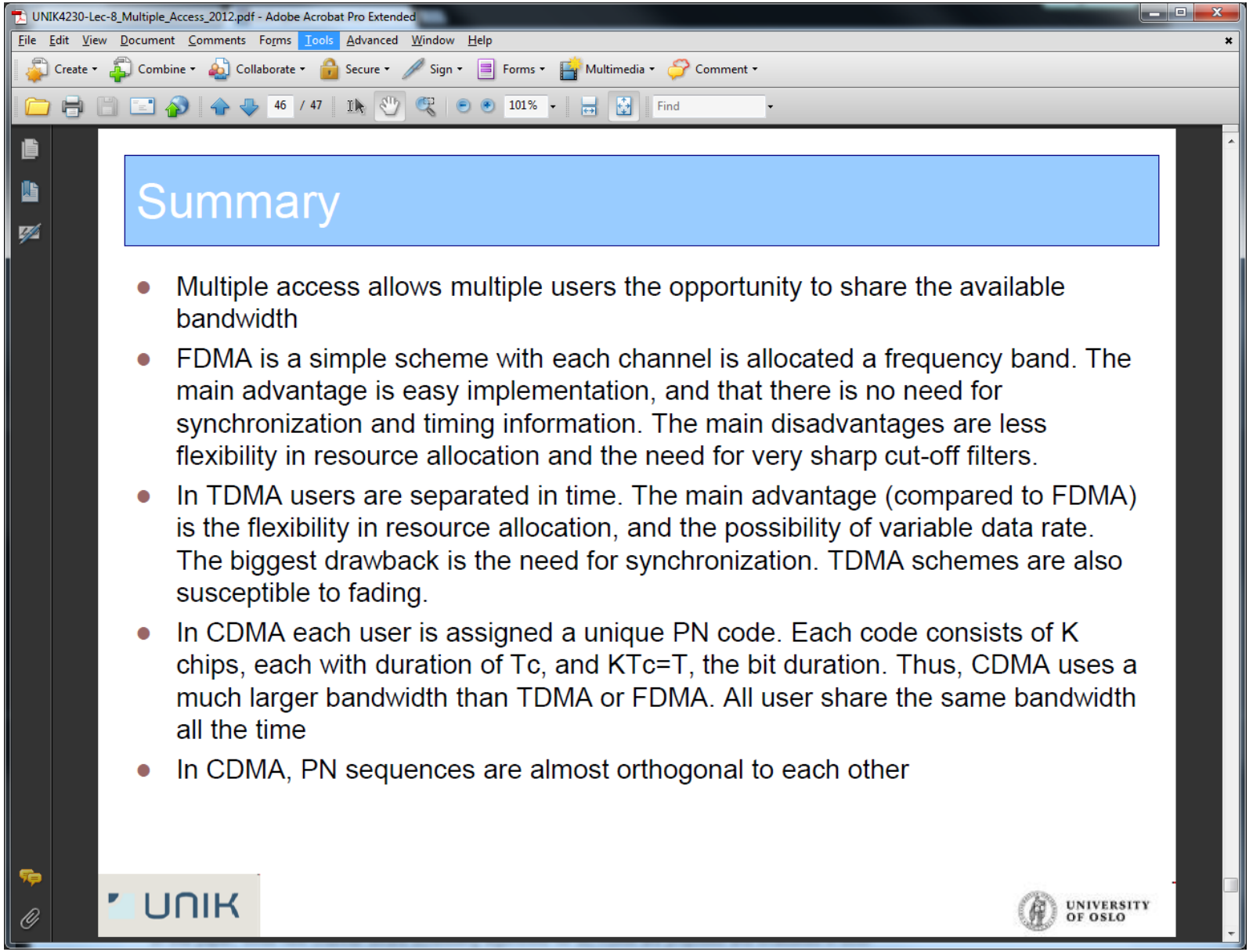
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Summary
Multiple access allows multiple users the opportunity to share the available bandwidth
FDMA is a simple scheme with each channel is allocated a frequency band. The main advantage is easy implementation, and that there is no need for synchronization and timing information. The main disadvantages are less flexibility in resource allocation and the need for very sharp cut-off filters.
In TDMA users are separated in time. The main advantage (compared to FDMA) is the flexibility in resource allocation, and the possibility of variable data rate. The biggest drawback is the need for synchronization. TDMA schemes are also susceptible to fading.
In CDMA each user is assigned a unique PN code. Each code consists of K chips, each with duration of Tc, and KTc=T, the bit duration. Thus, CDMA uses a much larger bandwidth than TDMA or FDMA. All user share the same bandwidth all the time
In CDMA, PN sequences are almost orthogonal to each other
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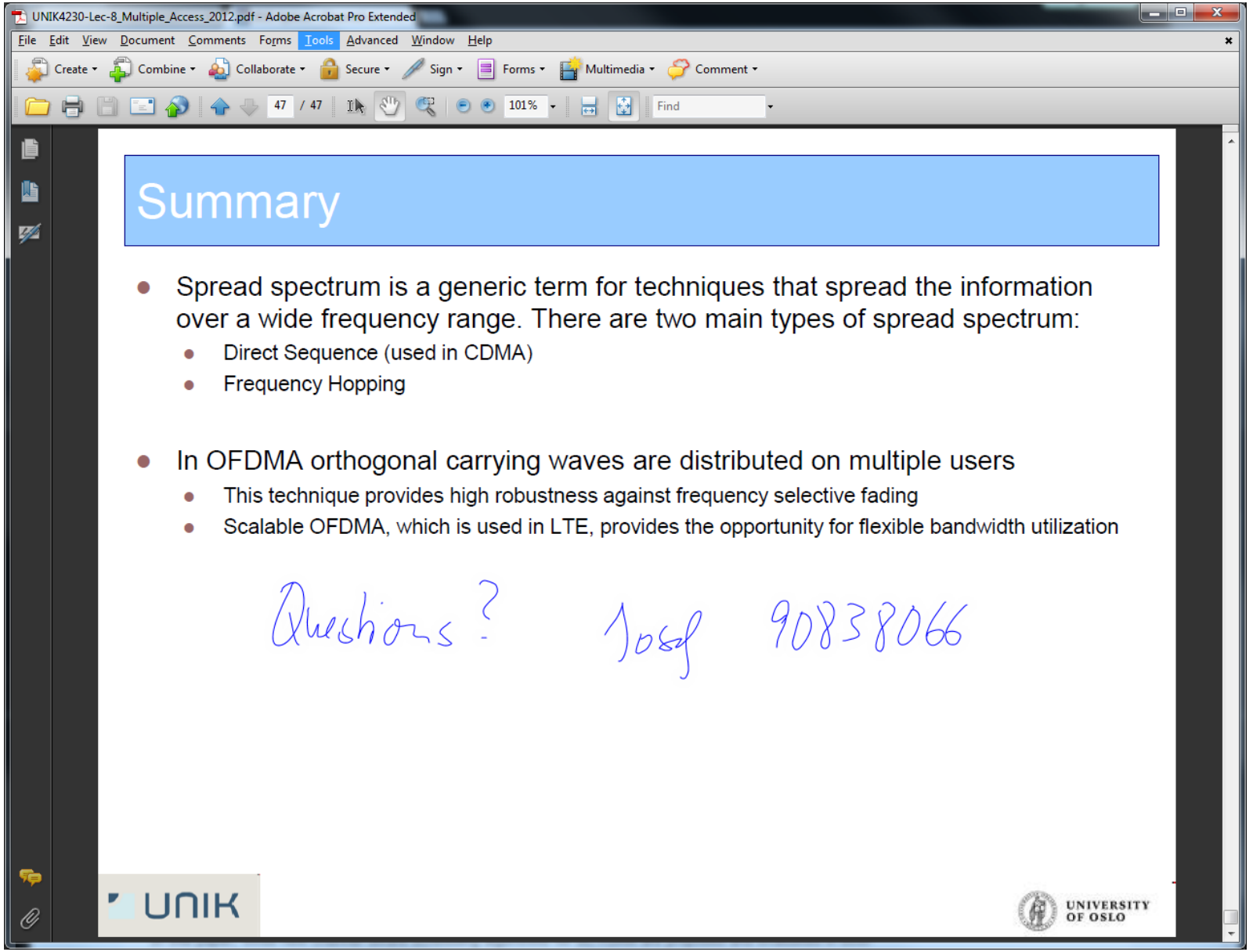
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Find
Summary
Spread spectrum is a generic term for techniques that spread the information over a wide frequency range. There are two main types of spread spectrum:
Direct Sequence (used in CDMA)
Frequency Hopping
In OFDMA orthogonal carrying waves are distributed on multiple users
This technique provides high robustness against frequency selective fading
Scalable OFDMA, which is used in LTE, provides the opportunity for flexible bandwidth utilization
Questions? Josef 90838066
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