Wireless Communications Systems:
Lab session 1

Digital modulations

Gilad Yair Nevo

Efi Dvir

Oren Zaharia

Communication Systems Engineering
Ben-Gurion University

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PRELIMINARY

- PSK and ASK are the simplest and basic digital modulations.
- QPSK and QAM using the scheme of PSK and ASK. f
- CDMA - Code-division multiple access
- OFDM - Orthogonal frequency-division multiplexing

CDMA

- A multiple access scheme where several users may share the same physical medium (literally).
- The signals of the individual users are orthogonal.
- The information can be recovered without interference from other users.
- CDMA use pseudorandom sequences are approximately orthogonal to each other, that is they show good correlation properties.
- CDMA is based on spread spectrum, that is, the spectral band is spread by multiplying the signal with such a pseudorandom sequence.

OFDM

- A digital multicarrier transmission technique.
- Digitally encoded symbols over several subcarrier frequencies.
- Clock rate to achieve robustness against long echoes in a multi-path radio channel.
- The information can be completely
- Mathematically, OFDM is a consequence of the orthogonality of the base functions of the Fourier series.

- Capacity: $C = B \log_2 (1 + \text{SINR})$
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-

Feature keys:

- LTE was designed by a collaboration of national and regional telecommunications standards bodies known as the Third Generation Partnership Project (3GPP).
- The successor of the WCDMA, Known as the 4th generation of cellular.
- LTE is using **MIMO** technique (Multiple Inputs, Multiple Outpus).
- OSI Protocols are in use, each UE have an assigned IP address.

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System Architecture Evolution

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The "backbone" of the LTE network.

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eNodeB - Evolved Node B

eNB is a base station that controls the mobiles in one or more cells. The base station that is communicating with a mobile is known as its serving eNB.

- UE

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  The eNB controls the low-level operation of all its mobiles, by sending them signalling messages such as **handover** commands that relate to those radio transmissions.

PRACTICE

UE $\Longleftrightarrow$ eNodeB Connection

- Power on procedure (next slide).
- Wireshark

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Alert block

- Power Headroom reporting
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Example block

Example text.
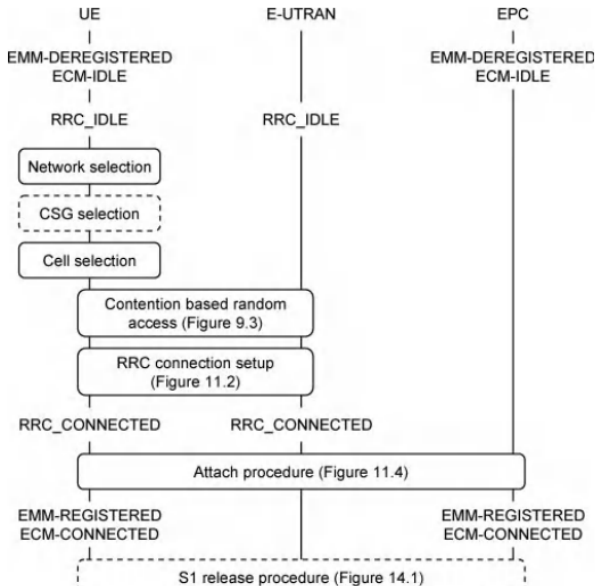
Power On procedure

On power on, the UE (user equipment) begins by running the procedure for network and cell selection, which has three steps.

- The mobile (UE) selects public land mobile network (PLMN).
- The mobile can optionally ask the user to select a closed subscriber group (CSG) for registration.
- The mobile selects a cell that belongs to the selected network and if necessary to the selected CSG.

The mobile then contacts the corresponding base station using the contention based random access, and initiates the procedure for RRC connection establishment.
RRC modes:

- RRC_IDLE
- RRC_CONNECTED

The final step, the mobile uses the attach procedure to contact the EPC (evolved packet core).
The UE accuires an IP address and established a tunnel to communicate out.

The mobile is now in the states RRC_CONNECTED, EMM_REGISTERED and ECM_CONNECTED.

This text appears in the left column and wraps neatly with a margin between columns.

Placeholder
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Image

Lists

Items:

- Item 1
  - ▶ Subitem 1.1
  - ▶ Subitem 1.2
- Item 2
- Item 3

Enumerations:

1. First
2. Second
   2.1 Sub-first
   2.2 Sub-second
3. Third

Descriptions:

First Yes.
Second No.

Discipline	Avg. Salary
Engineering	**$66,521**
Computer Sciences	$60,005
Mathematics and Sciences	$61,867
Business	$56,720
Humanities & Social Sciences	$56,669
Agriculture and Natural Resources	$53,565
Communications	$51,448
Average for All Disciplines	**$58,114**

Table: Table caption

THANKS FOR USING **Focus**!

REFERENCES

📄 CHRISTOPHER COX(AUTH.).
AN INTRODUCTION TO LTE: LTE, LTE-ADVANCED, SAE AND 4G MOBILE COMMUNICATIONS.
2012.

📄 CHRISTIAN LUEDERS HENRIK SCHULZE.
THEORY AND APPLICATIONS OF OFDM AND CDMA: WIDEBAND WIRELESS COMMUNICATIONS.
Wiley, 2005.

📄 LESLIE LAMPORT.
LATEX: A DOCUMENT PREPARATION SYSTEM.
Pearson Education India, 1994.

BACKUP SLIDE

This is a backup slide, useful to include additional materials to answer questions from the audience.

The package `appendixnumberbeamer` is used to refrain from numbering appendix slides.