581305-6

Computer Organization I
(Tietokoneen toiminta)

Teemu Kerola

University of Helsinki

Department of Computer Science

Spring 2010

Computer Organization I

- Course area and goals
- Course learning methods
  - Study circle course
  - Web course
  - Learning methods used in this course
- Ttk-91 example computer
  - Titokone simulator
  - TitoTrainer environment
- Computer Organization I vs. II

Learning Goals

- To understand basic features of a computer system, from the point of view of the executing program
- To understand, how a computer systems executes the program given to it
- To understand the storage methods and locations of the program code and data
- To understand the execution time program presentation
- To understand the role and basic functionalities of the operating system

- **The goal is learning**, not credit units, or passing
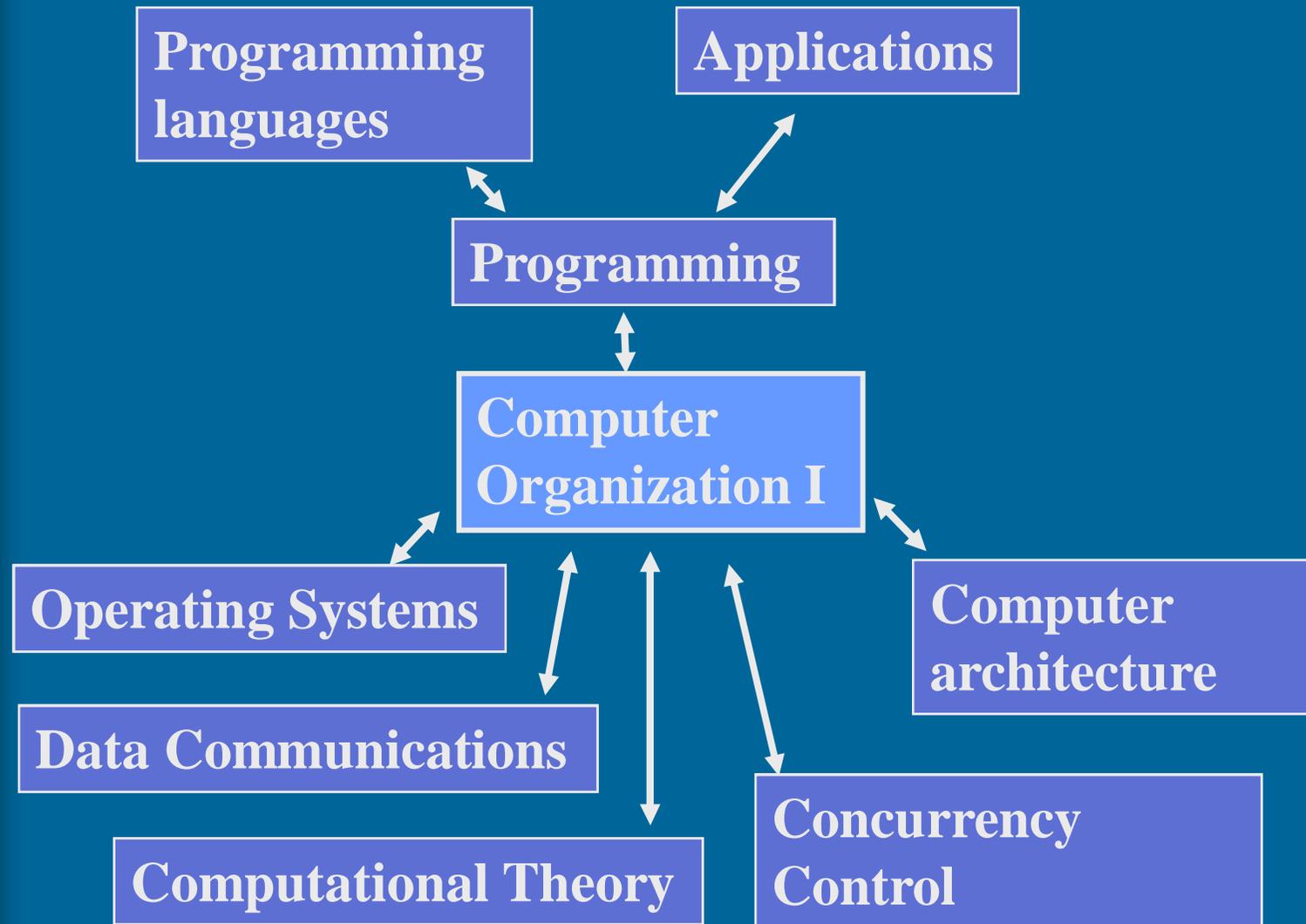 - Start preparing for the course exam now!

  http://www.cs.helsinki.fi/u/kerola/tito/kurssikuvaukset/2008_8/oppimistavoitteetE.pdf
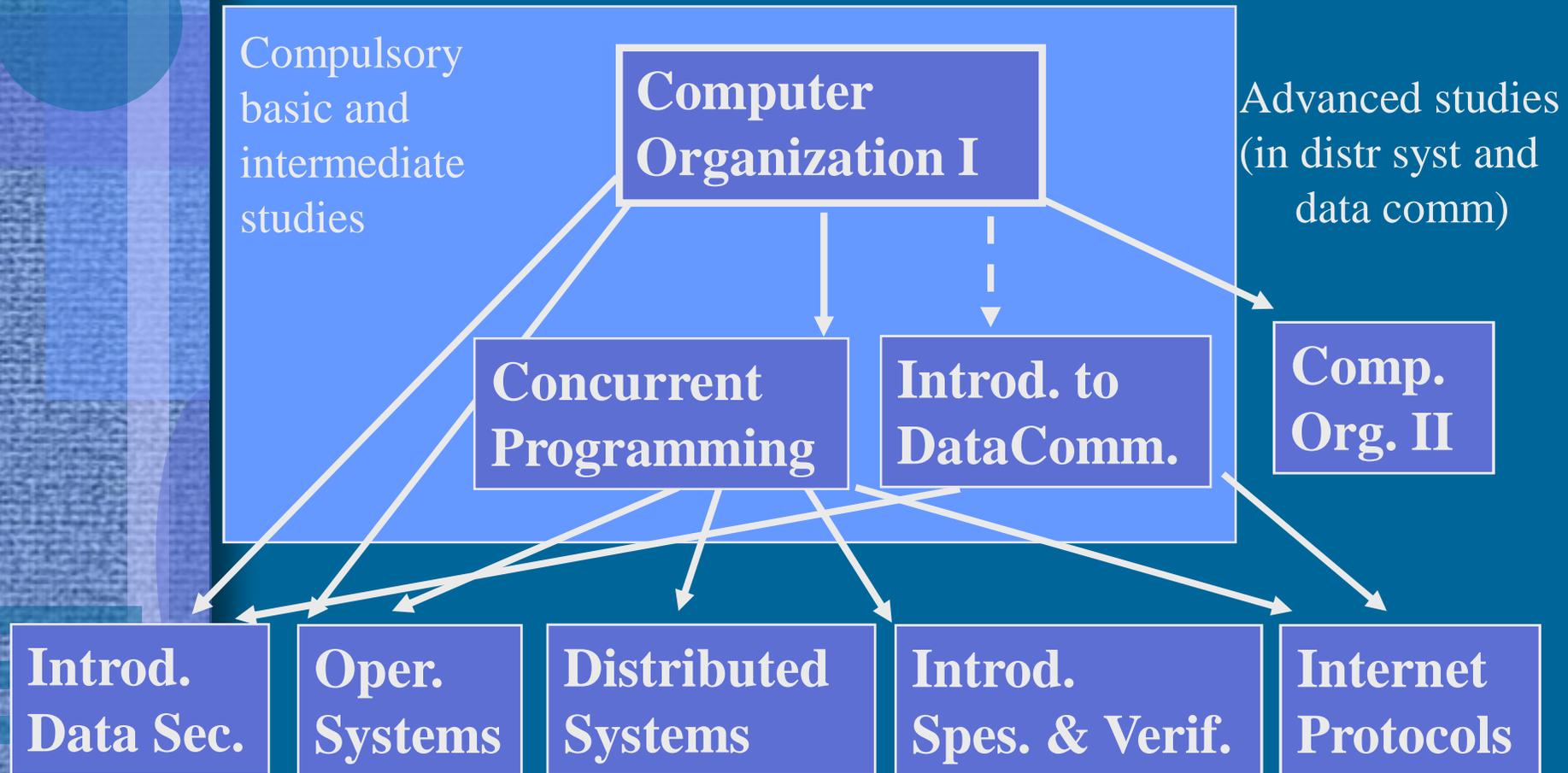
What good is it for?

- Program execution speed is based on <u>machine instructions</u> executed by the processor (CPU), and not in the program presentation in high level language (C, Pascal, Java)

- Understanding higher level topics is easier, once one first understands what happens at lower levels of the system

Why should one compile Java programs (byte code)?
What does it mean to compile Java programs?
What does it mean to execute Java programs?
What does it mean to execute C programs?
Why does one need operating systems (OS)?
What does the OS do? How is it structured?

Topic Dependencies

Programming languages

Applications

Programming

Computer Organization I

Operating Systems

Computer architecture

Data Communications

Computational Theory

Concurrency Control

Dependencies Between Courses

Compulsory basic and intermediate studies

Computer Organization I

Advanced studies (in distr syst and data comm)

Concurrent Programming

Introd. to DataComm.

Comp. Org. II

Introd. Data Sec.

Oper. Systems

Distributed Systems

Introd. Spes. & Verif.

Internet Protocols

CO-I (4 op), Credit options

- Web course based on study circles
  - starting lecture, summary lecture   ”Ordinary course”
  - Web lectures, text books, practice problems
  - Titokone, Titotrainer
  - In study circles
    - Homeworks, discussion problems, projects
    - Group meetings (with instructors and others),
    - Web discussions, chats (peer students, instructors)
  - Course exam
  - Makeup exam
    - 1st final exam after the course exam
- Final exam
  - Text books [Stal10 ja Tane10]
  - Programming with ttk-91 symbolic assembly language
    - Titokone, TitoTrainer
  - Based on material used in previous course

Study circles

- Group work, team work
  - It is better to study in a team than alone
  - Peer student support
  - Study circles formed in the first group meeting
- Student centred learning
  - The student has responsibility on learning
  - Instructor facilitate learning
  - Instructors give good environment for learning
- Different types of team work
  - Solving homework problems independently and then discussing them in study circles
  - Projects
  - Any other co-operative work for this course

Creation of Study Circles

- Possibly the largest problem in study circle courses
  - "Jack promised, but did not do and he was not accessible. And then Mary did most of it. This is not right! Boohoo!"
- Study circles are formed in the 1st group meeting
  - Goals should be similar
    - Easy in real life: "you will finish it or …"
  - Think about your goals before the 1st group meeting
    - Do I want to make the extra project?
    - Do I want to learn a lot, or just pass the course?
  - Discuss and agree on common goals before agreeing on forming a study circle
    - Finally, sign the "Study Circle Contract"
    - Email the lecturer the names of students in your study circle
- Keep up with your agreement
  - Inform the study circle immediately, if you will not continue
  - Get quickly rid of students who do not work as agreed on

http://www.cs.helsinki.fi/u/kerola/tito/k2010/opintopiiri_sopimusE.html

Web course

- Significant part of the course is in web
  - Web lectures, practice problems, TitoTrainer problems
  - Information, slide copies, problems, results
- Web course ≠ distance learning
  - Starting lecture and final lecture in lecture hall
  - Weekly group meetings at the CS dept
  - Other study circle meetings at the CS dept
  - Some learning modules can be done remotely via web

Web lectures

- Self study material in web, just for learning
  - Like a lecture, but own pace
  - Like a book, but with sound and animations
  - No bookkeeping on material use
  - No direct credit for course grade
- Lectures 1-4 also in English
  - Lectures 5-11 only in Finnish
- Material production
  - Teemu Kerola 2004-2005
  - Macromedia Authorware software
- Use   https://www.cs.helsinki.fi/i/kerola/tito/verkkoluennot/lu01e/lu01e.htm
  - Browser plug-in in Windows
    - CS dept, home
  - Windows-server in Linux environments at CS dept

Summary and discussion lectures

- Only in Finnish, sorry!

- Summary of topics for previous week
- Group discussions on some topics

Practice Problems

- Practice problems
  - Self evaluation
    - Do it only after you think you know the material
    - Do I understand it now?
    - Check only some part of the material, no guarantees!
  - Use of it does not directly affect your grade
    - No bookkeeping on material use
    - No credit toward course grade

  https://www.cs.helsinki.fi/i/kerola/tito/kertaus/pract.html

Homework problems

- Just like normal homework problems
- Learning happens when you solve the problems and discuss them
  - Study topic area first before trying out the problems
  - Work on the problems independently before discussing them
  - Reading a complete solution or giving one to peer student is wasting a good problem!
- Affect your grade
  - You get homework points (hwp) for completed problems
  - Only for those present in practice sessions (group meetings)

http://www.cs.helsinki.fi/u/kerola/tito/k2010/harjoitukset/lh1E.html

Practice Session

- Students are split into "tables"
  - Each table should have for each problem at least one student who has solved it
- Discuss all homeworks in tables
  - There are no common presentations for all
  - You may assume that each student has familiarized themselves to the problems and at least tried to solve them
  - Assistant helps when needed
- Model solutions are available later in the meeting
  - Including extra discussion items
- Everybody is present until the end
- In the English speaking practice session all students may end up in an English speaking table
  - Some of the tables may still be in Finnish

Ttk-91 Example Computer

- Auvo Häkkinen, 1991
  - Tietokoneen toiminta –kurssi 1991 (CO-I 1991)
- Simple computer architecture
  - Specification level just perfect for this course
- Simple (symbolic) assembly language
  - Easy to learn, not too many machine instructions
  - Good for the course goals
- Goals
  - Understand, what type of code the processor uses
  - Understand, how the system executes programs

Titokone

- Java program, that simulates the ttk-91 computer and its operating system
  - Works the same way as a real hardware implementation of a ttk-91 architecture and its operating system
  - Original design and implementation
    - Software development project Koski, Spring 2004
- Contains
  - Ttk-91 symbolic assembly language assembler (compiler)
  - Ttk-91 emulator, that can execute assembled ttk-91 programs
  - Integrated software debugger
  - Animator that visualizes ttk-91 instruction execution
  - Graphical user interface

http://www.cs.helsinki.fi/u/kerola/tito/titokone/asennus/asennusE.html

http://www.cs.helsinki.fi/u/kerola/tito/titokone/kayttoohje/manual.html

TitoTrainer

http://db.cs.helsinki.fi/titotrainer2/

- Software built "on top" of Titokone
- Implement ttk-91 programs or parts of them
  - Same programs run also directly in Titokone
- Program correctness is checked automatically
- Affects your grade
  - You get points toward your grade for completed problems
    - A few problems as homeworks
    - More problems in project pr1

Project pr1 (12 pp)

- Solve as many TitoTrainer problems as you can
  - Solve some problems each week
    - Problems at the same level as in homeworks?
- Grading
  - 1 pp, when 22 problems solved
    - Includes problems solved as homeworks
  - 7 pp, when 40 problems solved
  - 12 pp, when 50 problems solved

http://www.cs.helsinki.fi/u/kerola/tito/k2010/projektit/proj1E.html

Project pr2 (16 pp)

- Come up with a new practice problems
  - In two parts, each with one practice problem (8 pp)
- Goal is deeper understanding on some topics
  - Other course components may be needed as background knowledge
    - Web lectures, text books, homeworks, discussion problems
- Grading
  - Instructor evaluates based on the report and functionality
  - You get project points (pp, e.g. 8 pp) in three parts
    - Basic points (2 pp) for just completing the project
    - Grade (0-6 pp) depending on the quality of work
    - Participation points (max ± 2 pp) based on you participation
      - Study circle determines this part!

http://www.cs.helsinki.fi/u/kerola/tito/k2010/projektit/proj2E.html

Univ of Helsinki Moodle

https://moodle.helsinki.fi/

- Common
  - Shared discussion groups
  - A discussion group to coordinate doing homeworks (and other studies) together
- Study Circle Groups
  - Own closed discussion group
  - Wiki?
  - What else?

Completing a web course based on study circles

- Study weekly topics

  read   hear   think

  - Self study with web lectures
    - Learn the basics well from lectures
  - Read the text book the same topics, with different approach   read
  - Deepen your knowledge with summary lectures   discuss
- Check your learning with self evaluation   do   evaluate
  - Do practice problems, homeworks, TitoTrainer problems   do
- Participate in study circle
  - Discuss homeworks   discuss
  - Weekly group meeting   do   think
  - Continue projects
  - Study circle meet face-to-face or in the web   discuss
- Take course exam   read   evaluate

Evaluation

- Self evaluation
  - Practice problem after each topic
    - Do not affect your grade
  - Homeworks and TitoTrainer problems every week
    - Do I understand or not?
    - What is there still to learn and how do I do it??
    - Affect your grade
- Course exam
  - Gives a fixed time goal for learning
  - Covers all topics given in course description
    - Topics learned in independent study as well as in study circle work using various learning methods
  - Evaluates learning
    - Most of the grade based on this
    - Must reach certain level (50%) to pass the course

Grading

- Good work is awarded
- Diligence and knowledge is awarded
- Course component maximum grade points

Homeworks *minimum requirement **1 p***	**6 p**
Projects TitoTrainer problems (pr1: 12 pp) Make Practice problems (pr1: 16 pp) (super-diligent participation +4p) *minimum requirement **1 p***	**14 p** (16 p)
Course exam, make-up exam *minimum requirement **20 p***	**40 p**
Total *minimum requirement **30 p***	**60 p**

Learning material

- Lectures
  - Lecture notes pdf's
- Web lectures and 1-4 in English (in web)
- Text books
  - Stallings: Computer Org. and Architecture, 9th Ed., 2010
  - Tanenbaum: Structured Computer Organization, 5th Ed, 2010
- Practice problems (in web)
- Titokone simulator (in web)
- TitoTrainer (in web)
- Homeworks and projects (in web)
- Moodle
- Schedule page (in web)
- Course exam (results in web)

WWW Information

- Course home page   http://www.cs.helsinki.fi/u/kerola/tito/
- Course schedule
  - Everything is found linked to here

    http://www.cs.helsinki.fi/u/kerola/tito/k2010/aikatauluE.html

- Part of material is in CS departmental Intranet
  - Web lectures (Authorware)
  - Practice problems
  - Course statistics (hwp, pp, exam points)
  - Everyone need CS dept id's
    - Those minoring in CS must first have the UNIX-id (so called cc-id) from the University IT department, obtained from your own department

Course contents

- Lecture 0:   Course contents, structure, and organization
- Web lecture 1: System structure
- Web lecture 2: Ttk-91 and the simulator for it
- Web lecture 3: Assembly language programming
- Summary lecture   (in Finnish)
- Web lecture 4: Assembly language subroutine implementation
- Web lecture 5: CPU and bus   (in Finnish)
- Web lecture 6: Data presentation   (in Finnish)
- Summary lecture   (in Finnish)
- Web lecture 7: Error recovery and internal memory   (in Finnish)
- Web lecture 8: Program implementation in the system (in Finnish)
- Summary lecture   (in Finnish)
- Web lecture 9: External memory, I/O   (in Finnish)
- Web lecture 10: Compilation, linking and loading   (in Finnish)
- Summary lecture   (in Finnish)
- Web lecture 11: Interpretation and emulation   (in Finnish)
- Lecture 12: Summary

CO-I vs. CO-II

Memory   CPU

Bus

Cntrl   Disk
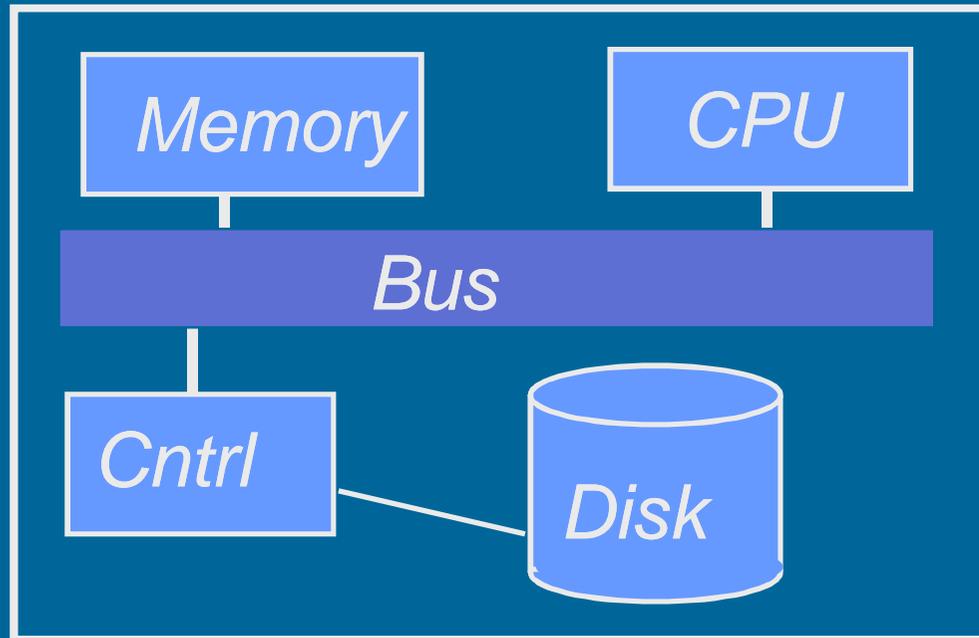
CO-I: What happens in the system?
   What does OS do??

CO-II: How is CPU and memory implemented?
         How does the clock pulse cause execution?

Processor Implementation Hierarchy (2)

- Machine lang. architecture
  - ADD R1, R2

- Modules
  - Adder, register, ALU

- Logical gates
  - AND, OR, NOR

- Circuit design
  - Power consumption, timing, wiring

- Implementation device
  - Tubes, transistors, microcircuits

CO-II

CO-I

G18_8BIT_ADDER

X[7..0]   SUM[7..0]
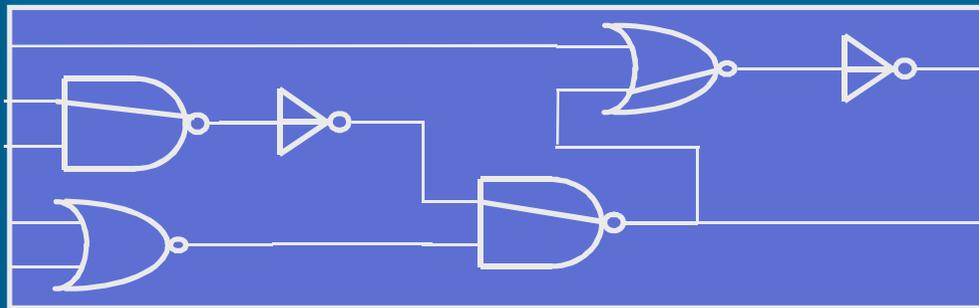
Y[7..0]   COUT

1
0   0
AND
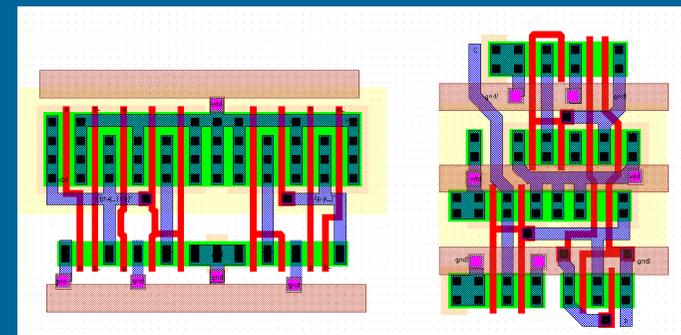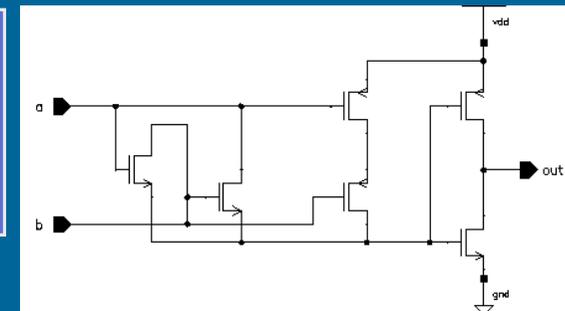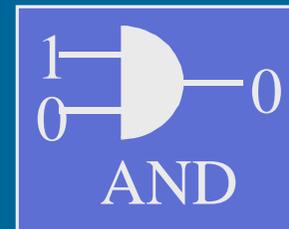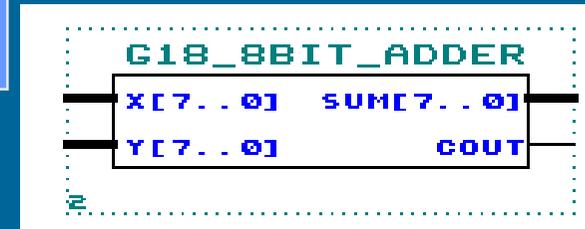
Program Execution Level

Comp. Org. I

A := B + C;
high level language

MOV AX, B
ADD AX, C
MOV A, AX

machine lang.

Comp. Org. II

Logical circuits (at gate level)

Motto

- "It is not good exercise, if you do not sweat"
- However, this is not a marathon!
- Altogether some 12 h / week (?)
  + exam preparation + exam
  – Before: Total some 80 h / 2 sw course (2 work weeks)
  – Now: Total some 107 t / 4 cu course

5 yrs / 300 cu = 1 yr / 60 cu = 1600 h / 60 cu
= 26.67 h / 1 cu = 107 h / 4 cu

Copyright Teemu Kerola 2010