SoC Curricula at Tallinn Technical University

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Abstract

In year 2002, the Tallinn Technical University is switching to 3+2-year education model reflecting the Bologna declaration [1]. In the Faculty of Information Technology a completely new organization of courses will be introduced that reflects changes in modern silicon technology and achievements in CAD/CASE areas. This paper gives an overview of new and tightly connected sequence of courses covering the fields of System-on-Chip design and diagnostics. The differences in curricula for undergraduate (Bachelor) and graduate (Master and Doctoral) students are provided.

1. Introduction

The Faculty of Information Technology of Tallinn Technical University (TTU) is educating students in a common *study domain* – Information and Communication Technology. The domain includes *study field* Computer and System Engineering, which is focused to digital System-on-Chip (SoC) and SoCWare design, all depict in the Figure 1.

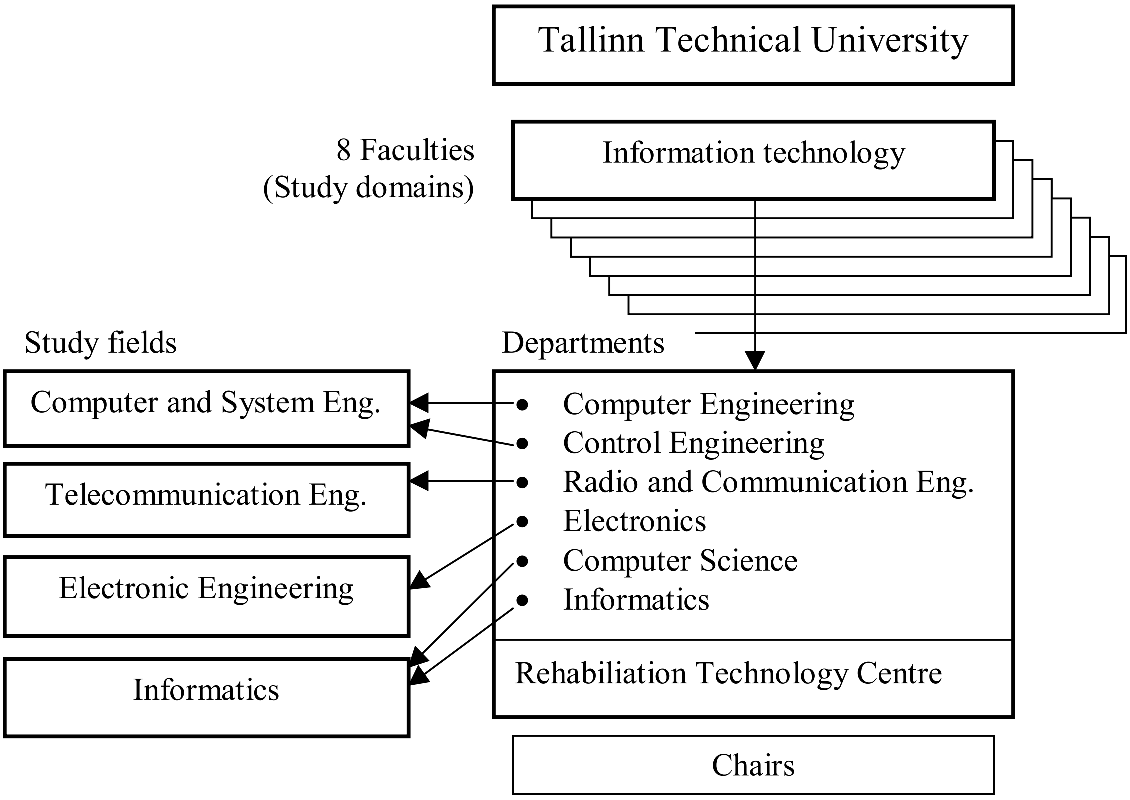

Figure 1. Simplified academic structure of TTU

The aim of the new curriculum in frame of 2+3-year model is to teach and train the students on computer and systems engineering and automation. Depending on the subject of the

graduation work, the students acquire basic knowledge on computer, automation, systems, or software engineering. The study field of computer and systems engineering prepares specialists on design, implementation, application, management, and development of real time technical systems.
Typical above-mentioned systems are bank systems, control and monitoring systems for aviation and shipping, environmental monitoring systems, diagnostic systems, control systems for technological equipment and processes, cash point systems, intelligent sensors, security systems, etc.
The study of computer and systems engineering gives depending on the specialization the following knowledge and skills:

- design and diagnostics of digital equipment and systems;
- design and application of microprocessor systems for special goals;
- configuration and application of computers and computer networks (software and hardware);
- configuration and application of industrial data communication systems (software and hardware);
- hardware based software engineering;
- timing analysis of real time systems;
- real time software engineering;
- analysis of control problems in different applications and systems;
- setting goals for control tasks, design of hardware and software for control systems, analysis, implementation and application of projects;
- automation of technological processes and buildings; and
- design and implementation of real time systems on integrated circuits technology.

The persons with bachelor or master degree will find jobs in companies for development and application of computer systems as computer, automation, systems, or software engineers.
In following chapters, we are going through curricula, conditions of admission and graduation in information and communication technology study domain, focusing on studies leading to SoC or SoCWare designers.
The following chapters describe the Computer and system Engineering study field in detail.

2. Computer and System Engineering study field

The four main education goals of the curriculum are as follows:

- general educational goals;
- occupational goals;
- goals on specialization; and
- professional goals.

Goals on specialization of the curriculum:

- gives knowledge on information and communication technology and related specialities;
- teaches setting problems and goals and solving them; and
- teaches to design projects and plans for their implementation.

Professional goals of the curriculum:

- gives knowledge on business, management and organization of the companies and organizing and planning the work of the engineers; and
- gives skills for teamwork as a subordinate or leader.

Structure of the curriculum

The curriculum in Computer and System Engineering study fields consists of several compulsory and elective parts as shown in Table 1.

Table 1. Structure of curriculum in Computer and System Engineering study field.

Part of the curriculum **Code Type**	**Bachelor(B)** **CP**	**Master (M)** **CP**	**Total B+M** **CP**
1. General studies	13.5	7.0	20.5
2. Basic studies	44.0	0.0	44.0
Total	57.5	7.0	64.5
3. Core studies	41.5	0.0	41.5
4. Special studies	10.5	43.5	54.0
5. Free choice courses	2.5	6.5	9.0
Total classroom studies	112.0	57.0	169.0
including optional common	6.0	28.0	34.0
domain studies	70.5	7.0	77.5
6. Practice	3.0	3.0	6.0
7. Graduation thesis	5.0	20.0	25.0
Total	120.0	80.0	200.0

The amount of Credit Points (CP) is calculated according to normal workload 40 CP per year. It differs form European Credit Transfer System [2], which suggests 60 CP per year.

Specialization list in Computer and System Engineering study field:

- Computer Engineering;
- Automatics and Systems Engineering.

Conditions of completion of basic studies and those of changing stages of studies:

Bachelor studies:

Completion of main courses of basic studies - duration four semesters

Transfer to the completion stage - 80 CP.

Master studies:

Transfer to the completion stage - 40 CP.

At the completion stage, students have two yeas for completing own thesis work.

3. Admission

The admission to Faculty of Information Technology in 2001 is shown in Table 2.

Table 2. Admission to Faculty of Information Technology in 2001.

Speciality	**Bachelor studies**	**Diploma studies**
Computer and Electronic Engineering	**100**	**25**
Informatics	87	50
Telecommunication	30	25
Electrical Engineering	56	-
Business Information Technology	30	-
Total in Information Technology	**303**	**100**

The diploma studies line will be closed for 2002 and the admission numbers to bachelor studies will be increased correspondingly. During the regular admission period, the average number of applications to study places above was 3.0.

4. Courses

The tree year bachelor program gives only basics needed for actual silicon design, i.e., courses about digital logic, general architectures, programming languages, etc. The actual specialization is done at Master program level presented in the Figure 2.

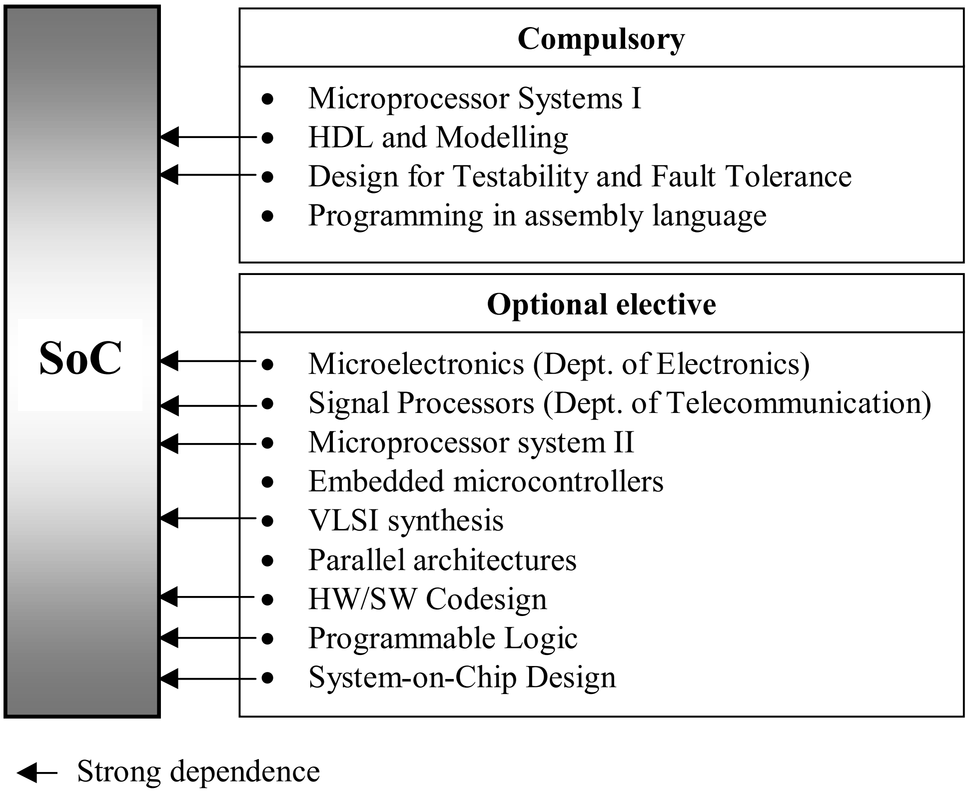

Figure 2. SoC oriented courses of Master studies

5. Annotations of SoC Master courses in the Dept. of CE

The courses below are given with the code, name, and amount of credit points.

IAY0040 HDL and Modeling 4.0 CP

Modeling concepts for digital and analog hardware. Hardware description languages - VHDL, Verilog, HandelC. Description levels in VHDL - behavioral/functional, structural and data-flow levels. VHDL simulation engine. Synthesizable VHDL. Verilog and HandelC - description levels and simulation engines. Description languages for analog hardware - Spice, VHDL-AMS. Simulation and modeling in modern design tools.

IAF0010 Design for Testability and Fault Tolerance 3.5 CP

Design criteria: testability, reliability, fault-tolerance, dependability, and availability. Design for testability economics. Testability measures: controllability and observability. Probabilistic estimation of testability: McCluskey method, cutting method and method of conditional probabilities. *Ad hoc* methods of design for testability. Design for testability rules and restrictions. Scan based design. Linear feedback shift registers. Pseudo-random test generation. Signature analysis. Built-in Self-Test. BIST architectures: LOCST, STUMPS, CSTP, BILBO. Boundary scan standards. SoC testing methodologies. Basic concepts of self-checking design. On-line testing. Fault-tolerant systems. Introduction to the coding theory for fault tolerance.

IAY0022 Microprocessor systems II 2.5 CP

Microprocessor system development main technical and economical principles; design team; teamwork; project specification; hardware/software division; hardware development; software development; documentation; development tools; traditional troubleshooting instruments (multimeter, logic probe, advanced logic probe, logic pulser, current tracer, multichannel oscilloscope) and their application; signature analyzer; logic analyzers (timing and state analyzer); hardware and software debugging with analyzers; evaluation and development systems; in-circuit emulator; hardware and software integration; modern development system types and characteristics; built-in development support; microprocessor system design for testability; EMC problems in microprocessor systems.

IAY0050 VLSI Synthesis 2.5 CP

Using CAD systems for VLSI design. VHDL basics. Design methodology of VLSI and ASIC, design phases and teamwork. Hardware description levels - system, high, register transfer, logic, and physical levels. System level description languages. Synthesis tasks at different description levels. Scheduling, allocation and binding in high level synthesis. Using field programmable logic for prototyping. VLSI synthesis with modern design tools.

IAY0070 Hardware and Software Codesign 2.5 CP

Hardware and software mixed system design topics: specification, design space exploration, design quality and cost estimation, partitioning source description into different implementation domains, target code generation, interface synthesis and coverification. Partitioning algorithms. Specification refinement. Coverification methods for heterogeneous systems. System design methodology. Commercial and academic codesign packages.

IAF0020 Programmable Logic 3.0 CP

Evolution of Programmable Devices. Applications of programmable logic. Classification. Economics of programmable logic. Programming technologies. Different programmable logic devices: ROM, simply programmable array structures (PLA, PAL), Field Programmable Gate Arrays (FPGA) and Mask Programmable Gate Arrays (MPGA), Complex Programmable Logic Devices (CPLD). CAD systems for FPGA: Technology mapping, Placement and Routing. Commercially available FPGAs. Testing for Programmable Logic.

IAY0080 SoC Design 3.0 CP

System-on-a-Chip (SoC), technological reasons, methodological impacts on the design process. Components of SoC, heterogeneous multi-processor and multi-memory systems. Bus architectures, synchronous and asynchronous data transfer. Clock generation and distribution. Low power systems. Network on a chip. Mixed systems - analog and digital components on the same chip.

6. International contacts and internationalization

Several faculty members have been involved in SoC Master teaching programs at Royal Institute of Technology (Peeter Ellervee, Alexander Sudnitsyn, and Kalle Tammemäe). The cooperation continues on 2001/2002 academic year. Tallinn Technical University and Helsinki Technical University, only 80 km apart over Finnish bay, have signed a preliminary contract to combine resources to set up a twin-university in selected study fields, especially in information technology and electronic engineering.

The bachelor and master studies at TTU are available for foreign students already now although the interest has been modest.

7. Resources

The hardware and software resources used by Department of Computer Engineering are obtained mainly through EUROPRACTICE, through different educational programs or donations.

Specialized hardware resources (quantity and description):

- **14** Sun Blade 100 workstations
- **12** Sun Ultra 10 workstations
- **9** Windows 2000/Linux RedHat workstations

Software resources:

- **9** licenses Synopsys SECP
- **15** licenses Cadence (14 IC + 1 Full package)
- **5** licenses Xilinx Foundation Express
- **6** licenses Celoxica HandelC

Original locally developed software:

- Turbo-Tester and Decider

Development boards:

- **6** XECC development boards with Xilinx XC4000 series FPGA-s
- **1** Celoxica RC1000 development board with Xilinx XCV2000E FPGA

Agilent mixed signal measurement equipment.

8. Conclusion

We presented an overview of new courses in Computer and System Engineering study field at Faculty of Information Technology of Tallinn Technical University. The focus is on the new set of courses introduced with a goal to recruit the graduates in contemporary silicon design, i.e., SoC field, starting at 2002. The knowledge, skills, and resources available, combined with excellence centers and academic institutions in neighbor countries, enable us to consider the new education model matching needs of information technology era.

Currently, there are two successful companies active in ASIC and SoC design field in Estonia – ArsMicro and Artec Design Group. Both companies have strong TTU background and they are cooperating actively with several departments of Faculty of Information Technology. The expectations are high to have some new spin-off companies arising in coming years.

References

1. Bologna Declaration. http://www.unige.ch/cre/activities/Bologna%20Forum/Bologna_welcome.htm
2. European Credit Transfer System. http://europa.eu.int/comm/education/socrates/ects.html