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SYSTEM ON CHIP DESIGN: NEW HARMONIZED MASTER STUDIES CURRICULUM IN MACEDONIA AND SERBIA

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Abstract **–The continuous progress of semiconductor technology has made it possible to implement complex systems on a single chip, which has led to new challenges in design methodologies. Driven by these technological forces, the Faculty of Electrical Engineering and Information Technologies (FEIT) – Skopje and Faculty of Electronic Engineering, University of Niš, Serbia with support from TEMPUS JEP_41107_2006 Project have developed an interdisciplinary Master of Science Programme on System-on-Chip design. The programme aims to provide students with competence and skills for designing, analyzing and verifying embedded systems. In this paper, we describe the process of developing the curriculum and the study programme plans.**

Keywords **– Master studies, Curricula harmonization, System on Chip.**

1. INTRODUCTION

The aim of this paper is to announce results of common efforts made at Faculty of Electronic Engineering, University of Niš and Faculty of Electrical Engineering and Information Technologies, "ss Cyril and Methodius" University – Skopje, Macedonia in order to harmonize master level curricula in the field of System on Chip Design (SoC Design). The collaboration was established by support of Tempus project CD_JEP 41107 – 2006 [1]. Tempus Joint Project dedicated to course development helps to non European universities to reach European standards in high education area. Therefore the course development is monitored by our colleagues from Universidad Politécnica de Madrid as grantholder and University of Southempton.

The harmonization is motivated with our desire to create conditions that will make mobility of students and professors in this region, possible. Besides, Faculty of Electronic Engineering, University of Niš, already had course harmonization between some other Universities from Balkan and Europe. Therefore the number of prospective students with similar background increases, enlarging chances for students from Skopje and Niš to continue their education at other universities. Simultaneously this gives chances to Universities in Skopje and Niš to accept students from other universities.

This paper provides data about syllabi in Niš and Skopje giving an overview of knowledge and skills that M.S. students will have after they finish courses on SoC Design. Although we consider these two universities, it is important to emphasis that syllabi in Niš and Skopje at bachelor level have been built on collaboration with other universities from Balkan and European region.

During 2002., another Tempus project CD_JEP-17028-2002 [2, 3] helped synchronization of B.S. education levels in the field of electronics on Universities of Belgrade, Niš and Novi Sad. The project was supported by partners from National Technical University of Athens and Universidad Politécnica de Madrid.

Besides, within the initiative for cooperation in Black Sea Region – organization named Black Sea Economic Collaboration BSEC, funded a project entitled „Networking of IC Design Teaching Centers in Blask Sea Region". The project comprised three integrated circuits design teaching centers from Faculty of Electronic Engineering, University of Niš, State Technical University of Armenia, Yerevan and

Technical University of Sofia. All three institutions harmonized their syllabi in the field of Integrated Circuits Design [4].

The list of international projects that affected articulation of syllabus in the field of Integrated Circuits and Systems Design at Faculty of Electronic Engineering, University of Niš accomplishes project realized under support of World University Service WUS – Austria in 2005 when course Integrated Circuits Design was upgraded according to European standards.

Syllabus related to Integrated Circuits and System Design mainly run the staff engaged with Laboratory for Electronic Design Automation (LEDA) at Faculty of Electronic Engineering, University of Niš. The professors from LEDA have personal contacts with many other education centers in region, teaching courses at University of East Sarajevo and Kosovska Mitrovica. Therefore they have impact on syllabi at these universities as well.

Therefore, sharing experiences of Faculty of Electronic Engineering, University of Niš and Faculty of Electrical Engineering and Information Technologies, "ss Cyril and Methodius" University – Skopje we offer a broad picture of knowledge and skills students from this region got during their undergraduate and graduate education.

Embedded systems give intelligence to many devices that we use in everyday life – they are found in everything from mobile phones and MP3 players, over cars and home appliances, to complex controllers. The continuous progress of semiconductor technology has made it possible to implement complex systems on a single chip, which has led to new challenges in design methodologies. Driven by these technological forces, the Faculty of Electrical Engineering and Information Technologies (FEIT) – Skopje and Faculty of Electronic Engineering, University of Niš with support from TEMPUS JEP_41107_2006 Project has developed an interdisciplinary Master Degree Syllabi on System-on-Chip design. The syllabi couple hardware and embedded software design principles. The syllabi aim to provide students with competence and skills for designing, analyzing and verifying embedded systems. In this paper, we describe the process of developing the curricula and the syllabi.

2. BACKGROUND AND IMPLEMENTATION

Both faculties from Niš and Skopje have reorganized the teaching process according to the Bologna declaration starting in 2004. The contents of the courses, as well as the teaching methodologies for undergraduate and graduate programs are therefore being restructured in order to meet the requirements of the Bologna declaration. The curriculum of System-on-Chip Design (SoCD), was developed as a master degree program, with aims to provide students with practical knowledge through laboratory work and practical student projects. Being developed as a part of the TEMPUS Joint European Project sponsored by the European Commission, the Syllabus has had the support of the European Commission and the partner universities from the EU (School of Telecommunication Engineering at Technical University of Madrid, School of Electronics and Computer Science at University of Southampton) throughout the entire process of the study program development and implementation. The support comes in terms of training teachers, equipping laboratories, student exchange possibilities and providing books for the university's library, as well as creating and publishing new textbooks and laboratory manuals.

The System-on-Chip Master Degree Syllabus at FEIT has been developed with the awareness of the need for a cross-disciplinary educational approach, coupling microelectronics with computer science technologies. In order to create our master programme, we started with analysis of more master programme from different universities across Europe [5] [6] [7] [8]. As result of this analysis we get draft master programme which was sent to our European partners for revision. Also, in our programme we include experiences and knowledge from our partner from University of Niš [9].

According to both Macedonian's [10] and Serbian Low on Higher Education [11], the second cycle academic studies are conducted in the period of one to two years. After graduating the students earn 60 to 120 ECTS credits. The total credits that can be achieved during the first and the second cycle of university studies are 300 ECTS credits. The person that completed the studies with a total of 300 ECTS credits attains a master degree of studies in the given field. At both universities 4+1 years study model are chosen. This means 4 years of undergraduate and one year for graduate studies. Accordingly, the master studies last for one year and bring 60 ECTS.

Starting from this choice, the study plan includes a 20 ECTS compulsory block, which consists of both low-level and system-level design courses, as well as one compulsory non-technical course. The students also choose 4 out of eleven elective courses, two in each semester, which also comprise 20 ECTS in the study plan. Additionally, students can also choose 10% of their courses (in this case one course) from any other programme from our faculty. Finally, the master's thesis combines the acquired knowledge into an individual research project and totals the last 20 ECTS.

This solution is not completely according to the last changes (from March 2008) in Macedonian's Low on Higher Education which state that: The study programs are made up of compulsory and elective courses. The topics of the compulsory courses are from the suitable area of the University unit, i.e. internal organizational unit (institute, department, section). The contribution of the compulsory courses cannot be above 50% of the number of courses on the study program. The rest of the study program is made

up of the elective courses from all of the courses given on the University unit. The students are free to select any of the available elective courses. According to this, our compulsory courses are not above 50% which is complainant with the law, but we will need to change the status of elective course in suggested elective courses, and allow to a student to choose any other courses from our faculty/university.

Both institutions have similar organization. Moreover, within undergraduate studies they offer common background in knowledge and skills measured in ECTS.

At both Universities students get general knowledge on:

- Mathematics,
- Electrics,
- Electronics,
- Electronic circuits design,
- Electronics systems design.

Moreover, they can provide specific knowledge in integrated circuits design choosing elective courses in fields of:

- CMOS process,
- ASIC design,
- FPGA design
- Electronic circuits and systems testing.

Besides, it is expected that students finishing undergraduate level have skills in using:

- SPICE circuit simulator,
- Hardware description languages,
- MATLAB, program package.

3. SoC DESIGN SYLLABUS

The study plan is organized in two semesters. In the first semester of the programme, the student needs to take four compulsory courses, as well as chose two electives. The second semester is reserved for the other two electives, as well as the preparation of the master's thesis. Tables 1 and 2 show lists of the courses, credits and how they are scheduled at Faculty of Electrical Engineering and Information Technologies, "ss Cyril and Methodius" University – Skopje and Faculty of Electronic Engineering, University of Niš. Obviously both study programs have similar structure. However, within elective courses there are possibilities for complement profiles.

In order to make easily choosing and combining the courses and getting exactly the needed 60 ECTS we have standardized the number of credits per course to 5 ECTS. All courses (except the non-technical one) are organized with 2 hours lectures per week, 2 hours laboratory per week and 2 hours per week for student project work. For every course the student must complete a practical work, that enable him to apply the acquired knowledge and develops practical and research skills.

Table 1. System on Chip Design Curriculum Structure in Skopje

	Title	Semester		Credits		Classes
1	**System on chip design techniques**	IX		5		2+0+2+2
2	**Integrated circuits design**	IX		5		2+0+2+2
3	**Embedded computer systems software development**	IX		5		2+0+2+2
4	**Compulsory non-technical course**	IX		5		2+0+0+4
5	Specialization elective course	IX		5		2+0+2+2
6	Specialization elective course	IX		5		2+0+2+2
7	Specialization elective course		X		5	2+0+2+2
8	Specialization elective course		X		5	2+0+2+2
9	***Master's thesis***		X		20	
	Total			30	30	

The first course, System on chip design techniques, aims to provide students with conceptual knowledge about System-on-chip (SoC) design methodologies. The course introduces the basic principles and problems of designing complete SoCs, focusing on hardware, as well as embedded software design principles simultaneously. It also gives an introduction to hardware description languages (Verilog HDL, VHDL and system C), and addresses the problems of testing and verifying SoC designs. Students will also learn how to use Intellectual property (IP) cores for the purpose of designing SoCs. Embedded computer systems software development concentrates on tools and techniques for developing embedded systems software and introduces embedded operating systems. Students should acquire good programming practice in an embedded context, using the appropriate software techniques and tools, as well as hardware interfaces. The aim of the Integrated circuits design course is to provide students with the knowledge for analysing and designing integrated circuits in CMOS technology. It covers the basic characteristics of the CMOS technology and the principles of designing small digital systems.

The engineers of today are not only required to have professional technical knowledge, but also show some additional skills in order to be competitive for employers: whether it is about how to market a product or to write its technical description. Therefore, the last compulsory course in the SoC Master's programme is non-technical and two different courses are offered as an alternative for the students. The first alternative is *Project management*, where students learn to effectively plan and control projects, identify and deal with risks and write project documentation. *Technical writing and research*

methodologies is the second alternative course and the objectives of the course are to prepare students for autonomous research and argumentative, persuasive writing of technical reports and documentation.

The electives courses give students the opportunity of customizing the study programme according to their interests. Therefore, the programme offers a broad spectrum of elective courses, either providing background for nanotechnology and digital system design, introducing cryptographic techniques or covering networking techniques and methods for network analysis. We present the full list of the elective courses, without additional course descriptions, which are beyond the scope of this paper:

- Wireless and ad hoc computer networks
- Contemporary methods for network analysis
- Digital system design using HDL
- System reliability
- Collaborative computer systems
- Digital electronic system design
- Custom purpose networks
- Cryptography
- Process computers
- Nanotechnology
- Analogue and mixed signals design

The studies from the second cycle are concluded by taking exams for every course and defending a master's thesis in accordance to the study program. The students can choose their supervisor for master thesis between professors from which they get at least one course. The defending of the master thesis is done in front of a commission made up of three members that have higher science degrees. Two of the members need to have science degrees in the appropriate subject matter that coincides with the topic of the master thesis.

Students that successfully graduate on the SoCD master's programme can find potential employers in Macedonia in a variety of industries. In addition, there are more companies that are involved in outsourcing embedded software development, and also in creating and developing new embedded devices and software. Alternatively, students can continue with doctoral studies in the same field at the home university.

At Faculty of Electronic Engineering, University of Niš, the structure of the program is similar. There are two compulsory courses in first semester. Namely *Systems on Chip Design* and *Microsensors and Microsystems*. Besides, students are compulsory to have *Study Research Work* for 7 hours per week. In the first semester there are two elective courses. Table 2 presents case when courses *Mixed Signal IC Design* and *RF IC Design* are chosen. The subsequent semester comprise of two elective courses, each valued with 4 ECTS, *Study Research Work* valued with 7 ECTS and Diploma thesis work valued with 18 ECTS. For illustration in Table 2 elective courses are *Simulation and Optimization of Electronic Circuits* and *Modeling of Electronics Circuits and Systems.*

Table 2. System on Chip Design Curriculum Structure in Niš

	Title	Sem	Elect	Credits	Classes
1	**System on chip**	1	C	4	2+2+1+0
2	**Microsensors and microsystems**	1	C	4	2+1+0+0
3	**Research and Study Work**	1	C	7	0+0+0+10
4	Mixed Signal IC Design	1	E	4	2+0+1+3
5	RF IC Design	1	E	4	2+2+0+2
6	Intelligent Machines	1	E	4	2+2+0+0
7	Simulation and Optimization of Electronic Circuits	2	E	4	2+2+1+0
8	Modeling of Electronics Circuits and Systems	2	E	4	2+1+0+3
	Research and Study Work	2	C	7	0+0+0+10
9	***Master's thesis***		C	18	
	Total			60	

4. CONCLUSION

In this paper, the new harmonized master studies curriculum in System on chip design that was created in Macedonia and Serbia. The studies are harmonized in two ways, the first is their harmonization with the leading EU universities, and the second one is harmonization of the studies between Faculty of Electrical Engineering and Information Technologies in Skopje and Elektronski fakultet in Nis. This second harmonization effort is maybe more interesting, and it is giving additional value to the whole project through enabling easily student exchange between two neighboring faculties.

The created master studies are also good base for PhD studies in System on Chip Design, and both faculties are working on creation of the PhD studies.

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