Computer Architecture Development Courses in Toulouse Universities

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Introduction:

Computer architecture is a key topic for both computer science education, located at the edge of those two fields. It has been teached in Toulouse, France, from the beginning of the computers in the fiftees, at the Paul Sabatier University (UPS) and then at the ENSEEIHT-INPT engineer school. The postgraduate advanced courses are common for both ENSEEIHT and UPS.

We are presenting in this paper the content and the experience in delivering the computer architecture courses in these two institutions. The first part is about the undergraduate courses organized in two years. The second part is about the one year postgraduate advanced courses.

Undergraduate and graduate courses:

The curricula presented in this first part is from the computer science department of the ENSEEIHT engineer school and from the Paul Sabatier University (UPS). The courses are divided each year in three parts: the lessons teached with all the students, the courses work teached with a class of about 24 students and the practical work with small groups of about 12 students.

The first year (undergraduate) is dedicated to basic topics such as synchronous and asynchronous digital functions analysis and synthesis, MC68000 assembler language, computer structure, microprocessors basics, memory hierachies, peripherical components, bus protocols, bipolar and CMOS technologies [8] [9]. The 80 hours of lessons (60 hours at UPS) are spread during all the year. The 48 hours of directed work (32 hours at UPS) and 64 hours of practical work (64 hours at UPS) are about basic digital design and assembler programmation. The tools used are logical simulators and 68000 based micro-computers with assembler/debugger.

The second year (graduate) lessons are about supercomputing and parallel architectures and programming (16 hours) [6] [7], RISC/CISC and superscalar processor architecture (32 hours), and VHDL language (8 hours). The courses work and practical work are organized with two hours of directed work followed by two hours of practical work each week, for a total of 72 hours. All the materiel teached in these 72 hours are publicated in a book "Principes et méthodologie de conception des systèmes électroniques en VHDL" by Dominique Houzet, which will be edited by Cépadues editions, Toulouse France [1]. The second book used is Chang's book [5]. This work is divided in two parts.

The first part (24 hours at ENSEEIHT and 16 hours at UPS) corresponds to typical exercises with CAD tools, that is logical simulators and VHDL simulators. We use libraries of real component models to build small exemples of architecture systems such as interfaces (UART, Centronics), MMU, timers, control units, microprogrammed units and so no. The VHDL language is introduced in order to illustrate the behaviour of architectural parts of the computers. It is thus a good solution to teach both electronic design and computer architecture.

The second part (24 hours) concerns the design of a small project. A typical subject is to design a small calculator with 4 integer operations. Several solutions have been studied: microprogrammed or bit-serial hardwired, with Polish mechanism or not. An other exemple is the control unit of the DLX processor [2] [3]. Several solutions have been developped : a pipelined and a superscalar control unit. The aim is to practice both computer architecture and electronic design methodology. It is thus possible to practice effectivelly computer architecture concepts with hardware high level language and simulator tools. The student can manipulate architecture concepts and mechanisms in details by simulations, and participate to the design of such components.

Postgraduate advanced courses:

The computer architecture advanced courses are common with ENSEEIHT and Paul Sabatier University since 1989. They are attended by 15 to 20 students, from both computer science and electrical engineering origin. This last year curricula is divided in two main parts. The first semester is intended to give a solid specialization in computer architecture and design. The students take theoretical and practical courses on special topics in computer architecture and VLSI design. The second semester is developped with active feedback from industry, and is quite aggressive in its goals. Students carry out training course in industry in order to achieve solid experiences in real surroundings. The curricula of the first semester is divided in two main parts :

- VLSI design :

The first one is about VLSI circuits design, that is VHDL, test, micro-systems, CMOS technologie, fault tolerency, ASIC, FPGA, CAD tools and so on. All these courses, with practical works, are focused on all the aspects of VLSI. A real project is proposed during the first semester to illustrate the courses. The purpose is to design a CMOS standard cell VLSI used by a research project on parallel computer [4]. This ASIC is divided in several parts designed each one by two students. All the parts are grouped at the end of the first semester to obtain the final circuit. It is then fabricated by a European foundry. The circuits are received at the end of the second semester. The second semester is dedicated to full time work in a French company. One or two students can do their second semester in our research laboratory to prepare the receipt of the ASIC and design the test board and the software part of the project. This year, the subject was the design of a high speed interconnection network between PCI motherboards in order to build a scalable parallel shared memory machine. The ASIC function was to generate and route messages in the network through FIFOs and 1.2 Gbits/s serial links. All the ASIC has been designed in VHDL, simulated and synthesized with Cadence and Compass CAD tools.

- Computer architecture :

The second main part is about computer architecture [2]. 32 hours of courses are intended to give and complete the knowledge of the students on advanced concepts in architecture design. The main topics are the design of systems like RISC and superscalar processors (datapath and control path, pipelining, dependency detection mechanisms, forwarding mechanisms...), memory systems and DRAM controllers, I/O controllers, cache controllers, graphic display controllers ... The last 110 hours are used to design a significant project . The students work together in teams of two or three. These courses are illustrated with the design of a full 32-bits RISC processor, that is the MIPS R3000, with schematic CAD tools. All the courses are developped around this design. Each couple of students has to design the whole processor to make architectural choices and tradeoffs.

Conclusion:

The computer architecture education is a basic topic of both computer science and electrical engineering. The use of VHDL and schematic CAD tools is a good solution to teach both computer design and architecture. The students can study and practice computer architecture with real architecture examples. VHDL high level modeling is a good way to manipulate effectivelly and easilly complex mechanisms to experiment their tradeoffs and behaviours.

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