AN INTERACTIVE VIDEO COURSE IN MULTIDISCIPLINARITY AND COLLABORATIVE DESIGN FOR SYSTEMS ON A CHIP[1]

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ABSTRACT

In 2002 it is estimated that circuits will have a complexity of 150 million transistors and require as many as 1,000 design engineers. As a result, technology is mandating the need both for collaborative design and for multidisciplinary design skills. We describe here a video course taught in Fall 2000 and focusing on developing both multidisciplinary design and collaborative skills.

1. INTRODUCTION

As circuit fabrication technology continues to provide gains in chip density and complexity, the need to develop training in collaborative design for "systems on a chip" (SOC) becomes more pressing. How best to introduce collaborative design techniques and training in multitechnology design, how to leverage available tools to support this training, and how to fit this extra training into already crowded curricula are questions that must be answered. The experimental course described here grew out of a collaborative research project on multitechnology design supported by the Dayton Area Graduate Studies Institute (DAGSI) and involving researchers from universities in Ohio and Michigan, and local industries, along with Air Force Research Labs personnel. The course focuses on transition of expertise developed during this research project to students in graduate programs at participating universities. Course coordinaters were Profs. R. Ewing and G. Lamont (lectures) and Prof. C. Brothers (lab).

2. COURSE GOALS

Major goals of the course were:

1. to exploit available video course technology to deliver lectures from any one of the four sites to all othersites. Students and lecturers were located at four separate sites, linked through the Ohio Aerospace Institute's Interactive Video Network (IVN), providing a true "electronic classroom" during each course session (Figure 1).
2. to use the World Wide Web both as a repository for course materials and as a resource for participants. Web use included a dedicated web site [4], as well as independent sites devoted to SOC design topics ([[1],[5]) and traditional references ([2],[3]).
3. to leverage the extensive combined expertise of participating faculty and available tools to introduce students to areas outside their traditional courses and research. Some of the class was familiar with each topic, but no student was familiar with all topics.
4. to have students design and simulate components for a coordinated multitechnology SOC project based loosely on the related DAGSI research project. To complete the project in one quarter, students were encouraged to explore the availability of standard components (IP) to be used as is or modified to fit project constraints.

The general methodology to be followed was that developed by the Rapid Prototyping for Application Specific Signal Processors (RASSP) project [3]. The final list of student modules included (see Figure 2): overall system design; verification and validation; controller and numeric integrator; 3D (bulk) and 2D (CMOS) MEMS accelerometers; signal conditioner; A/D converter; data compression using wavelets; D/A converter; RF transmitter. Components implementing intelligent processing (neural nets / genetic algorithms) were also explored as an alternative to the signal conditioner, A/D, wavelet compression, and D/A modules. Further integration of evolutionary processing with the more traditional components will be one goal of the course when it is taught again, probably in Winter 2002. Students at each school were assigned one or more components of the overall design, based on enrollment. The goal was to produce a behavioral description of each element, along with test vectors, and a simulation based on data from other teams.

3. COURSE ORGANIZATION

The class met for a two-hour session twice a week. Each participating faculty member presented the lectures is their area of expertise. Topics covered included: RASSP Methodology, Design Issues, Collaborative Web-based Design, Intellectual Property Law, System-level Modeling, FPGA's, ASIC Design, Analog Circuits, MEMS, Intelligent Processing (neural nets and genetic algorithms), Wavelets, Accelerometer Design, Integration, Communication Bus Protocols, SPICE and VHDL-AMS (Very High Speed Integrated Circuit Hardware Description Language with extensions to Analog and Mixed Signals), Reliability,

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Fabrication, and Packaging, Testing, and Verification. In addition, several sessions were devoted to discussion of the course project, and, in the second half of the quarter, to interactive discussions among the student design groups. Also, electronic communication among faculty and students was provided through email. Students gave preliminary and final presentations.

4. TOOLS FOR STUDENT PROJECTS

Students used a variety of tools for their project development, depending both on past experience with tools and availability at each institution, as well as web databases ([1],[5]). Initially, project requirements were deliberately kept flexible, until previous student experience could be evaluated and factored into project plans, Different module component designs were done in tools as low-level as MAGIC and as high-level as MATLAB and Synopsis. For this first offering, students were given a great deal of leeway to experiment with how best to do their design work. In future offerings, a narrower range of choices will likely be permitted, especially as better SOC tools are made available for student use by industry, but the experimentation which occurred proved to be valuable for students struggling to learn many new concepts in a short amount of time. Since no one available tool could handle all the types of design work involved, the choice was made to concentrate on defining the necessary parameters in terms of the tools the students were already familiar with, thus maximizing design time on the specific project at hand. However, a high-level hardware description language approach, especially at the system level, was stressed, with emphasis on VHDL-AMS-type descriptions, especially for interfaces.

5. CONCLUSIONS: "LESSONS LEARNED"

While the collaborative course achieved many of its goals, including the production of a basic set of materials for similar courses, the following "lessons learned" will help us to improve future offerings:

---video technology can be effectively used, especially for the delivery of lectures, but students must be acclimated to it, especially to encourage interactive discussion;

---lectures must be prepared well beforehand to test that video equipment at each site can properly project the accompanying slides. In future slide "templates" with acceptable font types and sizes should be provided. In addition, having the lecture at the central web site well before class time allows students to be better prepared to discuss them;

---in order to maximize the benefit of the project, students need to be given a "common" language in which to work, early on in the course. This can be accomplished by providing online tutorials to enable each student to fill in individual gaps in their knowledge and also by providing a comprehensive description of the quarter project early on, rather than three or four weeks into the course;

---availability of a collaborative electronic work environment, to be used outside regularly scheduled class times, would enhance faculty-student coordination;

---students would benefit from working through some simple practice projects, which build on each student's strengths, before beginning the more challenging quarter project;

---not all faculty expertise can be encompassed in a one-quarter project. But this should not restrict the topics the students are introduced to;

---student access to more and better tools for knitting together the typical components of an SOC design should be made a priority by educators and industry.

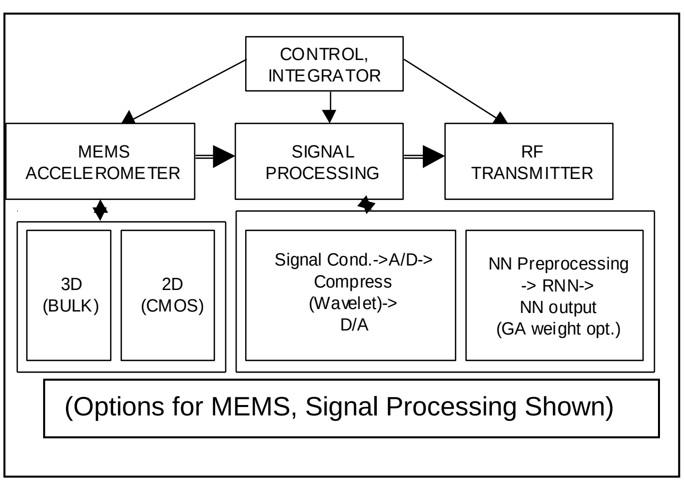

Figure 2: Student Project Modules (Including Options)

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Figure 1: IVN Classroom