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Extension and Enhancement of a Small Microsystem Program: The Dartmouth/IBM Interaction

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Abstract

This paper explores how a university/industrial interaction based primarily on guest lectures has helped a small program provide much stronger courses. It discusses not only the virtues of such an interaction, but also its potential pitfalls.

Section 1. Introduction

In the Thayer School of Engineering at Dartmouth, we face our share of challenges in teaching VLSI and systems design. The Thayer School is a small, non-departmented engineering school embedded in a liberal arts environment, and does not have a wide range of faculty experts to be resources for course offerings. A big boost to our program comes from industrial interaction.

Our industrial sponsors have been generous in providing essential hardware and software tools for our program. We will always have new equipment needs and we hope to be able to find support for them, but of similar importance now is the support we get from industrial expertise in the form of guest lectures. And none has provided greater support to us than IBM Essex Junction.

IBM's design and fabrication facility in Essex Junction, Vermont is an hour and fifteen minutes from the Dartmouth campus (a short distance by northern New England standards). It is here that IBM has led the world in creating DRAM technology. Random logic and microprocessor chips are also produced at this site, such as those in the recently released System/6000 workstations. The human resources present there are impressive, and it is from this talented pool we draw many guest lecturers for our courses.

Section 2. Our Courses and Guest Lectures

We have offered an advanced VLSI circuits and systems design course taken by graduate students and advanced undergraduates since the mid-1980s. This course, Engineering 130, was originally co-taught by staff from IBM and Thayer, but is now taught primarily by our staff. Although this change reduces somewhat the contact between IBM and Thayer, it has also improved the interaction in the course. Now, guest lecturers are invited to provide supplemental talks on selected special topics instead of the course's core subject matter. In this manner, the material learned from the homework and laboratory assignments are demonstrated in the context of real world problems.

Thayer's interaction with IBM in this course ranges from demonstrations of "industrial strength" design tools during a plant visit to lectures about interfacing differing circuit types. (Field trips to the IBM facility have been used not only for engineering courses, but also for courses that introduce non-science majors to recent trends in technology that are shaping our world.) This past term, IBM engineers and scientists spoke to our students about special problems in SRAM, DRAM, ROM and BiCMOS circuit design.

At Thayer we offer the following sequence of graduate courses in computer engineering:

Engineering 138	Computer Engineering I: Computer Architecture
Engineering 139	Computer Engineering II: Computer Design
Engineering 140	Computer Engineering III: Computer Implementation

These courses are taught in order of increasing emphasis on industrial participation. We have found that industrial contributions are more useful in the design and implementation phases of our computer engineering courses. Engineering 138, for example, will have perhaps one or two speakers from industry, but on the whole is taught from papers and texts.

Our second graduate computer engineering course, ENGG139, introduces students to design challenges. Students design and simulate a non-trivial processor using the Workview CAD package from ViewLogic. This term, students designed Patterson and Hennesey's DLX processor, a RISC microprocessor described in [1]. Toward the end of the term, five visitors from IBM presented short lectures on managing and testing large-scale system designs and they critiqued the students' final presentations.

We have found that students learn from both the similarities and the differences in perpectives that industrial speakers have to offer. In ENGG139, for example, many of the speakers had worked on implenting the IBM System/6000, a workstation based on a RISC microprocessor. It was obvious from both the students questions of IBM employees and IBM critiques of student presentations that there was considerable commonality of interest, including instruction set design, time/space tradeoffs, and performance calculation. Just as informative were the obvious differences between the implementation of a processor as an industrial product versus an academic exercise. Discussions regarding interrupt handling, time constraints, and performance specs were, to say the least, quite lively.

This third part of the graduate computer engineering course sequence emphasizes implementation technology and high-speed system considerations. A guest lecture from an IBM expert on packaging technology has been part of this course, and has been extremely well received. There is nothing like the "show and tell" a packaging expert can provide to interest students in the challenges of packaging and how it has become an essential issue for systems designers. This guest lecture has also extended the course since our faculty could only give limited coverage of this topic. Only now is this critical field being represented by textbooks for the non-specialist.

Engineering 184, Semiconductor Device Theory, has advanced undergraduate and graduate students as an audience. Guest lectures have been given by device experts from IBM over the past several years. The additional perspective provided by someone "in the trenches" on a day-to-day basis enlivens the course and broadens the students' horizons beyond the confines of relatively rural Hanover, New Hampshire. The guest lecturer and the on-site instructor work well together, and are exploring development of an advanced course for presentation at both IBM Essex Junction and Thayer.

Our Semiconductor Materials and Device Fabrication course (Engineering 194) has benefitted from tours of the advanced development facilities in Essex Junction and lectures by (in particular) plasma processing engineers. This latter insight is particularly helpful, since Thayer's solid state device fabrication (clean room) facility does not yet have the capability for plasma processing — a vital component in modern chip manufacture. Again, the touch of the "real world" brings the course material down to earth, making it compelling rather than esoteric.

Section 3. Other Interactions

Our Bachelor of Engineering students, and many of our masters students, are required to take a two quarter design sequence in which they tackle an industrially-sponsored design project in small groups. IBM Essex Junction has sponsored a design problem in this course for the past few years, including problems like trying to spin-coat square wafers. Most recently they sponsored a group to explore more accurate and cost-effective ways of measuring the access time of high-speed SRAMs. Such creative challenges stretch our students, and sometimes provide the sponsors with exciting returns. The design group for this most recent IBM problem came up with an innovative way of producing variable delay ring-oscillators for timing measurement, and the technique is being further explored at IBM.

The interactions between Thayer and IBM are two-way: Thayer faculty have given guest lectures to IBM internal classes. IBM has also contracted with Thayer faculty to perform advanced research in packaging, materials science, and transistor simulation. IBM staff members often serve on thesis committees for these and related research projects. These interactions have reinforced the presence of IBM guest lecturers in Thayer classrooms.

Section 4. The Value and Hazards of Guest Lectures

Guest lectures have extended and enhanced two important facets of our program: expertise and enthusiasm. It is difficult for a book to convey the excitement found in trying to test a million-transistor integrated circuit. It is equally hard for a professor who has never designed a new package to convey with authority the future trends in level 2 interconnection. Our IBM guests have brought with them not only expert knowledge, but also valuable opinions, perspectives, and enthusiasm. They love what they do, and do it well, and that is shared with all our students.

Further, we believe that this sharing has also benefited IBM. Student design projects have provided IBM with some new ideas, as has the research IBM has sponsored at Dartmouth. Guest lectures have certainly exposed our students, potential employees, to the challenges and rewards of working at IBM. Finally, the guest lecturers enjoy taking an afternoon to share their excitement and love of their work with our students.

Inviting industrial guest lecturers is not without its hazards, however. Not all speakers are comfortable or adept at public speaking, and such speakers will be granted little mercy by some students. (After all, someone is paying real money for each and every lecture.) We have avoided such problems by relying on someone "on the inside." Having a primary contact to look out for us, to find good speakers from such a large plant population, and to provide a coordinated interface to us, has been invaluable. Such an ally within IBM Essex Junction has certainly facilitated all of our interactions.

Another hazard can only be avoided by the Dartmouth faculty, and that is to let not only the guest lecturers know how valuable they have been, but also their management, the people who let them visit in the first place. That well-placed letter or phone call has helped to ensure yearly repeat visits from popular speakers.

Section 6. Conclusion (People, People, People)

With limited human resources to teach of microsystem courses, experts from IBM and other companies have extended our ability to bring excitement to all of our courses, and to even offer some of our advanced ones. The microsystem program at Dartmouth benefits from numerous contributions from industrial supporters of essential hardware and software tools. But the contribution of time from technical experts over the wide range of subdisciplines of microsystem design has played a unique role in our curriculum.

Acknowledgements

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References

[1] John L. Hennessy and David A. Patterson. *Computer Architecture: A Quantitative Approach*. Morgan Kaufmann, 1990.