An Interactive Video Course in Multidisciplinarity and Collaborative Design

C. Purdy and H. Carter, Electrical & Computer Engineering and Computer Science, Univ. of Cincinnati
H.S. Abdel-Aty-Zohdy, Oakland University
R. Ewing and G. Lamont, Air Force Institute of Technology
K. Thirunarayan, Wright State University
Y. Zheng, Ohio State University

Abstract

Traditionally, many upper-level engineering courses are centered around a major team project. How can this valuable activity be supported when course participants are not all located at the same institution? We describe an interactive video course involving professors and students at six different sites in Ohio and Michigan. We outline policies and procedures which enable course participants to complete a significant distributed project that makes maximal use of both equipment and faculty skills at the participating sites. This presentation will provide a checklist for successful project definition and completion in similar distributed environments.

Introduction

In many advanced undergraduate and beginning graduate engineering courses today, there is increased emphasis on active student participation through class discussion and intensive course-long team projects. These activities are essential to building important skills for students who are about to enter the workforce or undertake graduate research projects. They are also important components for fulfilling several of the outcomes required by the Accreditation Board for Engineering and Technology (ABET), which is the standard accreditation agency for undergraduate engineering programs. According to ABET evaluation criteria [1], "Engineering programs must demonstrate that their graduates have" eleven separate skills, labeled (a)-(k), including:

(c) an ability to design a system, component, or process to meet desired needs;
(d) an ability to function on multidisciplinary teams;
(g) an ability to communicate effectively;
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

In addition to satisfying ABET criteria, engineering students and faculty are in a constant race to keep up with the many new technological advances which are continuously being made. Today's engineers can no longer rely solely on textbooks or even print journals for up-to-date information but must also keep up with information provided through technical conferences, university web sites, and industry publications and web sites. The need for collaboration across traditional disciplinary boundaries also increases the amount of new technical knowledge which must be assimilated on a regular basis. In addition, the multidisciplinary nature of many of today's leading edge technologies requires collaboration among larger, more diverse, and often more geographically separated research teams.

Course Content

In the fields of electrical and computer engineering and computer science, a concrete manifestation of these trends is the area of "System on a Chip" (SOC) development. A generic SOC is shown in Figure 1. Today's VLSI (Very Large Scale Integration) electrical circuits, or "chips", provide increased functionality and speed in extremely small packages. For example, the Pentium 4, [7] provides a complete powerful computer "system" (minus input/output devices), running at speeds of up to 3 GHz (3 billion clock cycles per second), in a chip which is only 35 mm square. An SOC will also integrate input devices (sensors) and output devices (actuators) with the computational elements of a chip. These devices will typically process analog electrical signals or signals of other types--mechanical, chemical, biological, etc. For example, input "sensors" may directly measure speed, vibrations, temperature, air quality, or biological data, while output "actuators" may produce motion, chemical mixing, medicine dispensing, or other events. The internal processing in such a system will often be computationally intensive and may involve complex algorithms for "intelligent" understanding of the data and decision making. A specific example of a potential SOC, based on a project for the course described here [14], is shown in Figure 2. The project is based on the work described in [4]. Developing an SOC like the one in Figure 2 requires multidisciplinary teams working together and employing multiple tools to make the whole project a success. Because of the multiple types of expertise required, some team members may also need to be recruited from geographically remote sites.

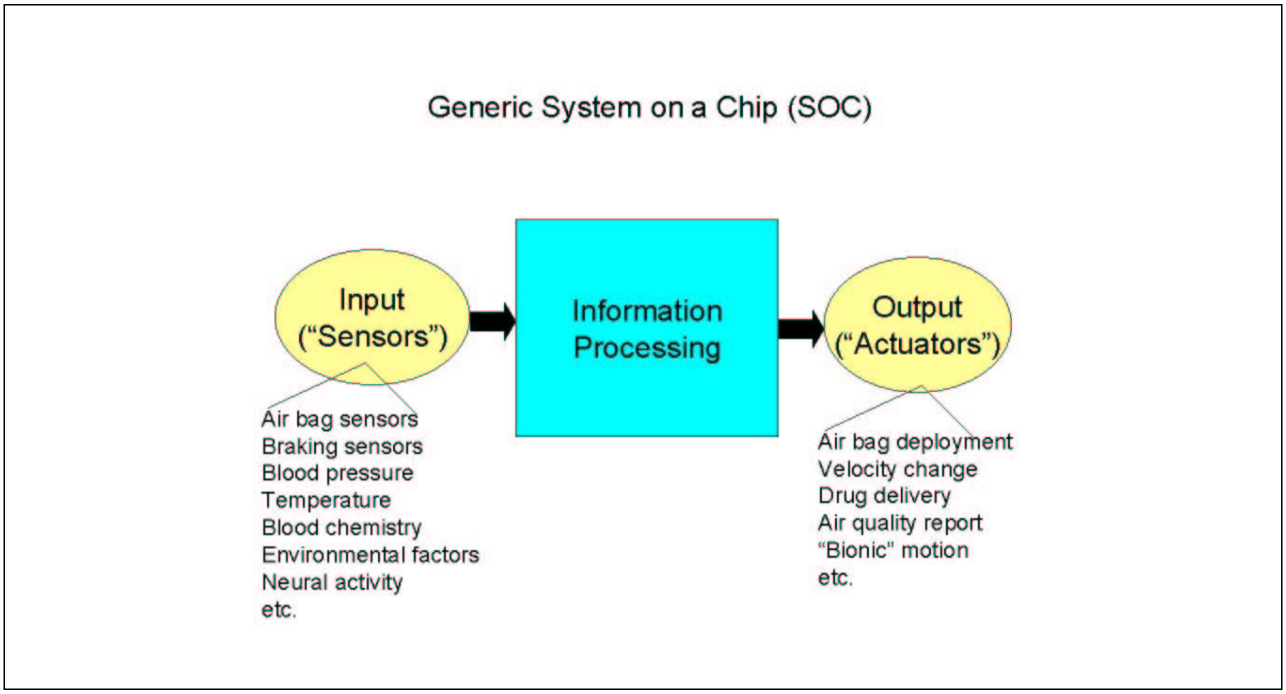

Figure 1. Generic SOC (System on a Chip).

Here we describe an experimental course designed to introduce collaborative design techniques and training in multitechnology design, to leverage available tools and faculty expertise to support this training, and to give students experience in distance collaboration on a typical SOC project. The course addresses the ABET criteria listed above. By drawing on a large group of faculty experts in a range of domains, it also supports efficient dissemination of current information in a broad range of relevant areas. This is a particularly attractive strategy, since a typical university department will likely be very strong in some areas but lack depth in others, and the main foci of research at each institution will also be reflected in the specialized development tools available for use by students. By involving many faculty members, the course also provides opportunities for exploring team teaching techniques. For multidisciplinary projects, team teaching is essential, but it may be difficult or impossible to arrange team teaching opportunities within the course structure of a single department. Our course provides a way for faculty to be involved in a multidisciplinary team teaching effort with only a slight increase in the number of teaching hours.

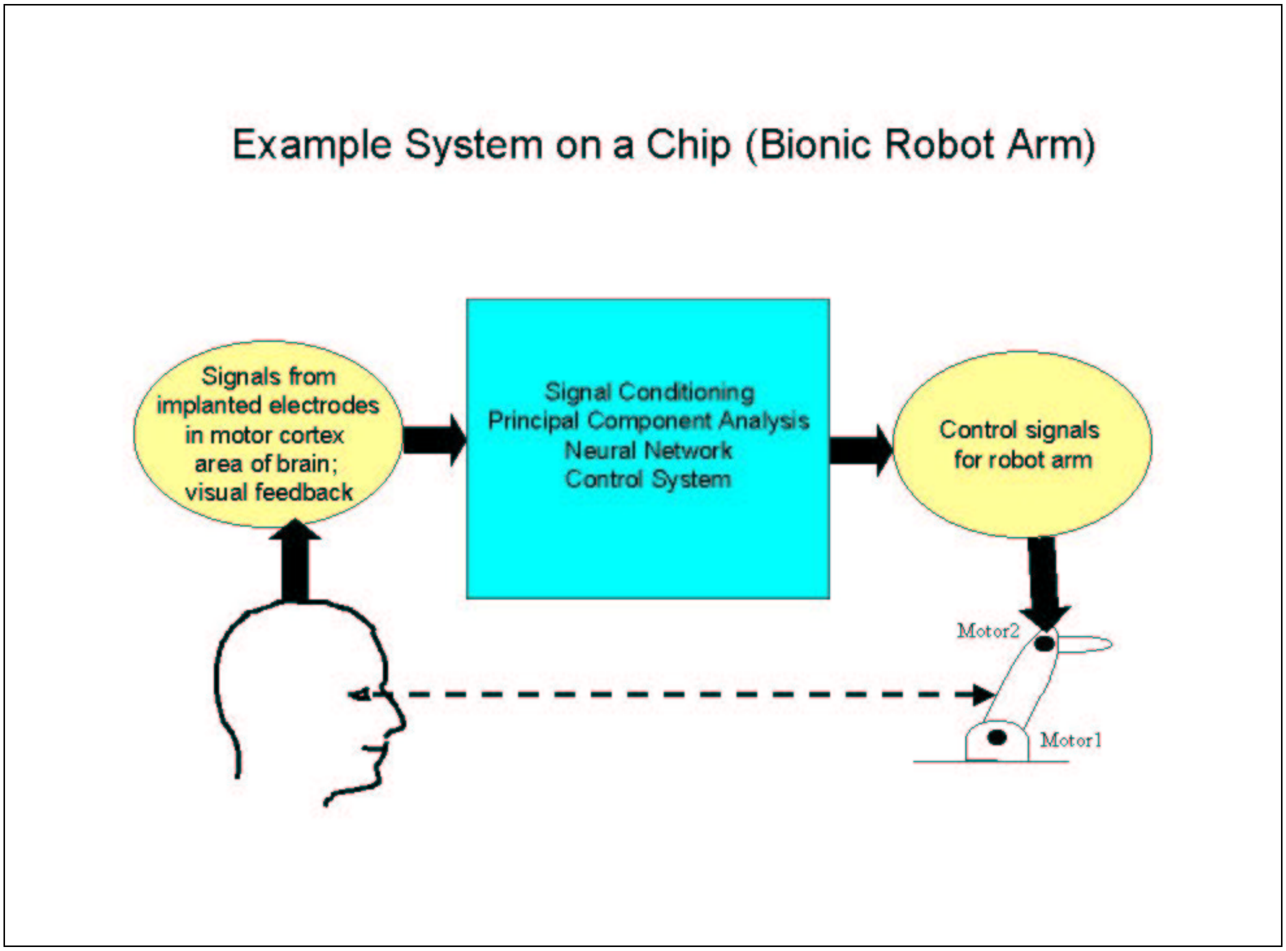

Figure 2. Specific SOC ("Bionic Arm").

The experimental course described here is based on a collaborative research project supported by the Dayton Area Graduate Studies Institute (DAGSI). The project draws on the expertise of researchers from the Air Force Institute of Technology, Ohio State University, University of Cincinnati, University of Dayton, Wright State University, Oakland University in Rochester, Michigan, local industries, and the Air Force Research Lab (Wright-Patterson Air Force Base). In the course the focus is on transition of expertise developed during this research to graduate students at the participating universities. A technical description of the course is available on the course website [13]. The technical content of the course has been described in [6]. Here we concentrate on the educational aspects of the course.

Classroom Environment

Each of the participating institutions must have access to a video classroom, which permits bidirectional audio and video communication. A typical classroom (at the University of Cincinnati) is shown in Figure 3. Equipment includes two cameras, one facing the instructor, and one facing the students, four monitors for viewing local and remote sites, document camera, VCR, slide projector, PC with Internet connection, whiteboards, a portable easel, a FAX machine, a speaker phone, and an automatic tracking camera that follows the presenter as he or she moves about the room. Available communication protocols are supported via T1, Integrated Services Digital Network (ISDN), or Multiple Control Unit (MCU) bridging technologies. Each site also provides a facilitator to assist participants during the presentation and to deal with any communication glitches which arise during the session.

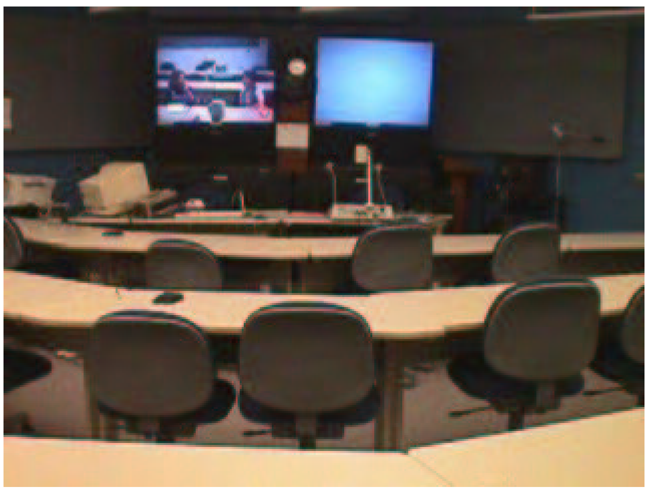

Figure 3. The University of Cincinnati Video Classroom.

Challenges

The major challenges of a successful implementation of this course fall into three main categories:

- challenges of teaching any project and team-based course;
- challenges of coordinating participant and institution schedules;
- challenges arising from the technology.

The general challenges of teaching project-based courses are discussed, for example, in [9]. Projects must be carefully defined, with specific milestones set out at the beginning, and with requirements for student progress reports on a regular basis. Similarly, successful strategies for setting up and managing student teams are described in [8]. As with projects, successful student team efforts involve clear definitions of goals and milestones. In addition, an understanding of team dynamics and of how to recognize and deal with common problems, which arise in teamwork improves the success rate for student teams. The instructor also needs to provide teams with regular opportunities to report on how the team is functioning and to get help to get back on track if interpersonal frictions have arisen. Finally, specific grading policies must be established at the beginning of the team project and adhered to thereafter.

The challenges of coordinating participant and institution schedules involve determining start and stop dates, as well as vacation dates, for each school, setting up student policies and presentation schedules to take into account whether each institution is on a quarter or semester schedule, and preemptive planning for potential problems such as technology failure, illness of a presenter, or, as in Winter 2003, a series of "snow days" at some participating institutions.

The challenges of distance learning in general are being addressed in many forums and many strategies for delivering education on line are being developed (see [12], e.g.). But delivering education through videoconferencing has its own unique challenges. Challenges arising from the technology include classroom equipment failure and communication failures. Certainly the possibility of such events needs to be factored into course planning. In addition, lecturers need to become familiar with the various tools for presenting material and with the special requirements for each type of presentation necessitated by the video classroom environment. For example, Microsoft Powerpoint presentations containing mathematical equations, which have been developed for use with a single classroom projection system, may not be easily readable on the classroom video screens. A speaker also needs to be sufficiently close to a microphone to be heard clearly. A further challenge may arise because of the mismatch of transmission rates among institutions. This can cause questions and responses from the "slow" site to be delayed, so that participants at that site may face difficulties in actively contributing to discussions.

The biggest challenge, however, is fostering student participation and discussion. In a video classroom environment with two-way communication, there is the possibility of interaction, but it is not the same as in a traditional classroom. While two-way visual and audio communication are provided, at any time during a class session, participants at a given site will only see two sites, typically the site of whoever is speaking and their own site. This reduces the potential for informal interaction and removes many visual cues which discussion participants typically rely on. Also, only one speaker at a time can be heard clearly. The succession of speakers must be better managed than in a traditional classroom, since participants desiring to speak may not be able to see who else is also waiting to speak. In addition, even if a site is being televised, some participant at that site may not be within the area being televised. Participants, especially students, need practice and encouragement to overcome the psychological barriers to contributing to the discussion which these environmental features induce. This is important not only for facilitating project discussions, but also during lecture portions of the class. Research has shown [10] that even in a traditional lecture students tend to become inattentive after about 20 minutes at most. Although we have not collected data on this, it is likely that, in the video classroom environment, attention spans are even shorter. The effect of this phenomenon on student learning is one of the factors which are contributing to an increased emphasis on "active learning [2] in engineering education, sometimes summarized as the professor changing from "the sage on the stage" to the "guide on the side"[3]. Achieving active learning in a video classroom environment is not automatic, even for teachers who regularly use active learning techniques in a traditional classroom.

Checklist for Course Coordinators

We are currently offering our video course for the second time. With experience, we are gradually developing a checklist for organizers of similar courses. The list is a work in progress, and we welcome additional suggestions.

Planning

Six months before the course is to be offered:

- Identify a general course coordinator and a project coordinator.
- Identify a local coordinator for each institution which will participate.
- Appoint a webmaster.
- Set up an email list for all coordinators and the webmaster.
- Choose a class time, both days of the week and beginning and end times.
- Each local coordinator will arrange for the course to be scheduled and the video conferencing room to be reserved.
- As a group, the general coordinators will write a course description and arrange for publicity at each institution.
- Determine each institution's schedule, including beginning and end dates and any holidays or vacations.
- Set up a tentative preliminary schedule and begin to identify potential faculty speakers; contact each one to determine interest.
- Begin to investigate possible textbooks and supplementary material.

Three months before the course is to be offered:

- Revise the preliminary schedule and begin scheduling speakers.
- Provide speakers with a list of available classroom resources and templates for common data. formats (e.g., Microsoft Powerpoint); templates should have been tested for readability in the actual classroom environment.
- Define one or more course projects to be completed and investigate resources needed for each.
- Confirm the course time and room reservations.
- Order textbooks.

One month before the course is to be offered:

- Prepare a final schedule; the schedule should contain specific days for students to present initial, in-progress, and final project reports. Some flexibility for technology failures can be built in to the schedule (in general the technology has been very reliable. Most problems that have arisen have been due to misunderstandings about scheduling).
- Confirm that technical facilitators will be available as needed at each site.
- Determine the grading scheme (overall plan for the course, with modifications for each institution).

- Prepare detailed project descriptions.
- Prepare a timeline, with milestones, for the project.
- Choose a project process model (such as the Rapid Prototyping Model in [11]) which stresses modular development and will coordinate well with the distributed nature of the course.
- Hold an orientation session for the instructors; this should be held online in the video classrooms. For our course, instructors are, for the most part, already familiar with the basic classroom equipment (computer, overhead projector, etc.), but in general instructors may need experience with one or more of these tools. Most instructors, however, will not be familiar with the video classroom. This session will give instructors an opportunity to use the equipment, to see how their lecture materials appear on it, to try out the sound system, and to become comfortable with interacting with other sites. An experienced user can also suggest techniques based on active learning activities [2] which can help to facilitate discussion. For example, the "wait time" [5] for students to answer a question may need to be increased.
- Encourage all instructors to provide handouts of technical material to coordinators for distribution to students before their presentations if the materials do not show up well on the video screens.
- Share the best presentation materials from previous years with instructors so they can see what is effective.

Just before the course is offered:

- Confirm all instructors, facilitators, and schedule.
- Make sure instructors know how to submit materials to the web page.
- Check that project descriptions and timelines are complete.

Ongoing Course Management

During the first week of the course:

- Ask each student to introduce himself or herself and describe their technical interests and background; this gives the students some experience with communicating in the video classroom and also will allow student groups to begin to form for the projects.
- Provide each instructor with the names, pictures, and short biographies of all the students, so that they can interact more effectively with them during class.

During the second week of the course:

- Make sure that all students have organized themselves into groups of 2-4 people, based on interests and skills.
- Assign a short "miniproject", such as exploring and reporting on specific reference materials, with a short time frame, to get student groups, especially those which span several institutions, communicating electronically and working together.
- Schedule a project discussion to encourage student input and questions.
- Make sure students know the project schedule and milestones.
- Make sure students can access the web site.

- Make sure students have contact information for all instructors and coordinators, in case they have any questions, and encourage them to use this contact information
- Schedule weekly project reports and also schedule discussion sessions if needed. Outside of class, students will only have email contact with their peers at other sites. Thus it is important to make sure that students have sufficient opportunity for interaction during the class periods.

Throughout the course:

- Adhere to the project schedule, with short oral (and written) project reports for each milestone.
- Each local coordinator will survey local students periodically to make sure group work is going smoothly.
- Coordinators can also provide discussion questions during the lectures to increase student participation.

Wrap-up

After the course ends:

- Survey students and instructors for suggestions on how to improve the course next time.
- Record suggestions to be considered for possible implementation the next time the course is offered.

Conclusions

We have offered some suggestions, based on our experiences and student and faculty feedback, to facilitate effective teaching, project-based assignments, and active learning in courses taught through video conferencing. Effective use of video conferencing technology in project-based courses remains an important area of study for the future.

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