CS/EE Online – Lessons Learned in Planning, Developing, and Operating a Joint, Web-Based Master's Program

Bill D. Carroll, William P. Osborne, Behrooz Shirazi, C. D. Cantrell, Saibun Tjuatja
UT-Arlington/UT-Dallas/UT-Arlington/UT-Dallas/UT-Arlington

Introduction

CS/EE Online is a web-based master's degree program being jointly developed by The University of Texas at Arlington (UT-Arlington) and The University of Texas at Dallas (UT-Dallas) with funding from The University of Texas TeleCampus. Students may choose to major in computer science, computer science and engineering, or electrical engineering and must designate either UT-Arlington or UT-Dallas as their home institution. Students receive the degree from the home institution but take courses from both. The program was conceived in the spring of 1999, and course development began in the fall of that year. The first courses were available online in fall 2000 with the full complement of 24 courses planned for the 2002 academic year. *US News and World Report*[1] recently selected *CS/EE Online* as one of the best online graduate programs in engineering.

The following two sections will provide the context in which the program was conceived and developed and program details, respectively. Course development related issues are then discussed. The final two sections of the paper describe administrative issues that had to be solved and lessons learned.

Background

The UT TeleCampus is an administrative unit of The University of Texas System with a mission to develop and support distance-learning programs across the 15 campuses of the System. Central to the core design of the UT TeleCampus is service, and the necessity to provide increased access to education without compromising the quality and integrity of the educational offerings, their tradition or the educational mission of the universities within the System.

The UT TeleCampus was launched in May 1998, with a website designated to serve as a central support system for the online educational initiatives of the 15 component campuses and research facilities that comprise the UT System. Utilizing a unique model, the UT TeleCampus spent its entire first year building student services, digital libraries, conferencing and chat capabilities, and compiling hundreds of links to education resources that could be utilized by the general public. These links provide educational support for K-16 and beyond, thus creating a backbone of Internet-based support to the lifelong learner. The goal of the UT TeleCampus in placing programs online is the creation of collaborative degrees, utilizing the best resources in faculty expertise from all campuses. Programs currently offered via the UT TeleCampus are listed in Table 1. More information on the UT TeleCampus can be found on their web site[2].

Table 1 Current UT TeleCampus Programs

Program	Degree Granting UT Campuses	Campuses Only Providing Courses
MBA Online	Arlington, Brownsville, Dallas, El Paso, Pan American, Permian Basin, San Antonio, Tyler	None
MEd in Educational Technology	Austin, Brownsville, El Paso, Permian Basin, Galveston	None
MEd in Curriculum and Instruction With Reading specialization	Arlington	None
Master's in Kinesiology	El Paso, Pan American, Permian Basin, Tyler	Arlington, San Antonio
CS/EE Online	Arlington, Dallas	None
Bachelor's Completion in Criminology And Criminal Justice Online	Arlington, Brownsville, Permian Basin	Dallas
First Year Online	Arlington, Austin, Brownsville, Dallas, El Paso, Pan American, Permian Basin, San Antonio, Tyler	None
Chess in Education Online	Dallas	None
ESL Supplement Certificate Program	Arlington	None

To support the development of these degree programs, the UT TeleCampus returned over half of its operating budget to the campuses in 1999. This provided funding for course development ranging from approximately $25,000 - $40,000 per course. *CS/EE Online* was funded at $35,000 per course. Additionally, extensive support services are provided by the UT TeleCampus staff in the way of instructional design and course development, as well as faculty training in bringing courses from the lecture-based classroom to the Web-based classroom. Technological support, policy, marketing research and external communications are among the other essential support services provided to the campus from the TeleCampus.

The University of Texas at Arlington, classified as Doctoral/Research University-Extensive by the Carnegie Foundation, is located between the cities of Dallas and Fort Worth. UT-Arlington is the second largest component of the University of Texas System enrolling 16,329 undergraduate and 4,851 graduate students in the fall 2001 semester. UT-Arlington consists of nine colleges or schools offering 61 baccalaureate, 64 master's, and 22 Ph.D. programs. The UT-Arlington faculty numbers more than 1,200.

The College of Engineering (COE) is the most comprehensive in the Dallas/Fort Worth area and enrolled nearly 3,500 students in the fall 2001 semester in eight baccalaureate, 12 master's, and 10 Ph.D. programs. The COE enjoys strong relationships with numerous companies in the Dallas/Fort Worth area ranging from small consulting and manufacturing firms to large multinational corporations such as Lockheed Martin, National Semiconductor, Sabre, and Nokia.

In addition to *CS/EE Online* offered through the UT TeleCampus, the COE offers a wide range of courses and programs through the Engineering Center for Distance Education (ECDE).

Currently, ECDE supports program in Aerospace Engineering, Computer Science & Engineering, Electrical Engineering, and Mechanical Engineering. ECDE is the oldest continually operating distance education facility at UT-Arlington, having begun the delivery of graduate courses to local industry via a closed-circuit educational television network known as TAGER in 1977 (along with UT-Dallas, Southern Methodist University and other Dallas-area universities). Today, ECDE delivers graduate and undergraduate courses to students electronically through videotape, streamed video, and the Internet. The two largest units within the COE, Computer Science and Engineering and Electrical Engineering, participate in the *CS/EE Online* program. The UT-Arlington Center for Distance Education (CDE) is UT-Arlington's newest electronic courseware production and delivery facility. Founded in June 1997, CDE produces and delivers Internet courses and degree programs adding new dimensions and value to the university education experience.

The University of Texas at Dallas, which is located at the convergence of Richardson, Plano and Dallas in the heart of the complex of major multinational technology corporations known as the Telecom Corridor©, enrolls approximately 7,000 undergraduate and 5,000 graduate students. UT-Dallas, which is classified as a Doctoral/Research University Intensive by the Carnegie Foundation, was created when the founders of Texas Instruments - Erik Jonsson, Cecil Green, and Eugene McDermott - offered their private research/teaching institute to the state of Texas to become part of the University of Texas System. Seventeen years later, the Texas Higher Education Coordinating Board authorized the creation of UT-Dallas' Erik Jonsson School of Engineering and Computer Science to prepare students to tackle the rapidly changing world of technology and communications. UT-Dallas is the most rapidly growing component institution in the University of Texas System.

As the Erik Jonsson School's enrollment and programs have expanded, so have its relationships with corporations such as Alcatel, Nortel, Ericsson, Nokia, WorldCom/MCI, Lucent, and many others. The Erik Jonsson School was recently named one of five worldwide research partners in Alcatel's Preferred Partner program. Industry leaders have joined with UT-Dallas and the Erik Jonsson School to conduct research, share resources, enhance educational opportunities, and develop new technologies. The School of Engineering and Computer Science is composed of two departments, Electrical Engineering and Computer Science. The total enrollment for these two departments in the fall of 2001 was 3600 students.

UT-Dallas offers a wide variety of program through its various schools and programs. These schools include the Schools of Engineering and Computer Science, Management, Art and Humanities, Human Development, Natural Science and Mathematics, Social Science, and General Studies. The university supports 20 doctoral programs, 40 masters programs, and 40 undergraduate degree programs. The university has over 300 tenured/tenure-track faculty and senior lecturers, and a student population of over 12,000.

The target audience for *CS/EE Online* is telecommunications professionals in Texas who seek a master's level degree that encompasses the systems engineering skills of Electrical Engineering coupled with software engineering skills of Computer Science/Engineering. It interests professionals who demand the convenience of acquiring this education at any time, from anywhere.

This focus was chosen because of the growing importance of telecommunications research and education to the State of Texas and the nation. North Texas alone is home to over 600 telecommunications companies (with 80,000 technology workers) and numerous other industries including microelectronics, aerospace, and defense corporations. The distance delivery of a Master's degree in EE or CSE with an emphasis on telecommunications engineering serves the educational needs of the telecommunication technical community in Texas and the nation. The demands of the workplace at telecommunications companies are such that the traditional commute to campus is often not a practical option.

Program Description

The *CS/EE Online* Program is comprised of three degree options. Based on past experience and current career goals, a student can select which of the three will best serve his/her educational needs. Choices include master's degrees in Electrical Engineering, Computer Science, or Computer Science and Engineering. To emphasize the multidisciplinary nature of this program, students in one department will be required to take at least two major courses from the other department. All three degrees are conferred with the Graduate Telecommunications Engineering Certificate. Entrance requirements for the online programs are the same as for traditional campus-based programs. Degree requirements are summarized in Table 2.

Table 2 *CS/EE Online* Degree Requirements

Institution	Discipline	Degree	Hours Required	Thesis Required
UT-Arlington	CSE	MSCSE	36	None
	CS	MSCS	36	None
	EE	MSEE	36	None
UT-Dallas	CS	MSCS	33	None
	EE	MSEE	33	None

CS/EE Online is predominantly offered using the Internet, but may include supplemental materials such as video/audio tapes and CD-ROM. Students are not required to attend the campuses at any time. However, some courses require proctored examinations that can be arranged at locations near the student.

The Master of Science in Electrical Engineering (MSEE) is designed for today's telecommunications professional. Students with bachelor's work in Electrical Engineering are encouraged to apply for this program to better prepare them for the dynamic changes facing their industry. The field of Electrical Engineering has evolved rapidly over the past 25 years. To understand the current and next generations of telecommunications technologies, and to design systems that use these technologies, requires many hours beyond the bachelor's degree. Engineers must learn the basics of random processes, digital signal processing and digital communications, as well as applications such as packet networking. The MSEE curriculum consists of 18 hours of core/foundation courses and 15 to 18 hours of electives from EE and CS/CSE. The program covers both the hardware and software aspects of telecommunications engineering with an emphasis on the physical, data link, and network layers.

The Master of Science in Computer Science or the Master of Science in Computer Science and Engineering are a necessary part of the life-long learning required of telecommunications professionals. Computer Science is a relatively new and evolving discipline and, as a result, students majoring in computer science must go through a life-long learning process to stay up-to-date and effective. Fields such as nano-fabrication, molecular technology and mobile computing didn't even exist ten years ago. The successful graduate will achieve several educational outcomes including software engineering principles, design and analysis of telecommunications systems and networks, network routing and protocols, network mobile IP, and wireless Internet concepts.

Students with an undergraduate engineering degree are eligible to apply for the Master of Science in Computer Science and Engineering program from UT-Arlington. Both engineering and non-engineering students have the option of receiving a Master of Science in Computer Science degree from UT-Dallas or UT-Arlington.

Degree plans for each of the programs are given below. Course descriptions are given in Appendix A.

UT-Arlington Electrical Engineering Online Degree Plan

- Required Courses:

  UTA EE 5301 Advanced Engineering Analysis
  UTA EE 5302 Random Signals and Noises
  UTA EE 5350 Digital Signal Processing
  UTA CSE 5324 Software Engineering
  UTD EE 6340 Introduction to Telecommunications Networks
  UTD EE 6352 Digital Communications Systems

- Three courses from the following EE list:

  UTA EE 5361 Fundamentals of Telecommunication Systems
  UTA EE 5367 Wireless and Cellular Propagation
  UTA EE 6364 Advanced Data Networks
  UTD EE 6310 Optical Communication Systems
  UTD EE 6344 Coding Theory
  UTD EE 6345 Broadband Packet Networks
  UTD EE 6390 Introduction to Wireless Communications

- Two courses from the following CS/CSE list:

  UTA CSE 5311 Design and Analysis of Algorithms
  UTA CSE 5330 Database Systems I
  UTA CSE 5348 Multimedia Systems
  UTA CSE 5350 Computer Architecture II

UTA CSE 6345 Mobile Computing Systems
UTD CS 6352 Performance of Computer Systems and Networks
UTD CS 6359 Object-Oriented Analysis and Design
UTD CS 6378 Advanced Operating Systems
UTD CS 6385 Telecommunication Networks
UTD CS 6386 Telecommunication Software Design
UTD CS 6390 Advanced Computer Networks

- One course from either the above EE list or CS/CSE list.

UT-Dallas Electrical Engineering Online Degree Plan

- Core courses in Electrical Engineering:

  UTA EE 5302, Random Signals and Noise
  UTD EE 6340, Introduction to Telecommunication Networks
  UTD EE 6352, Digital Communication Systems
  UTD EE 6360, Digital Signal Processing I

- Three CS/EE Online courses in Electrical Engineering

- Four CS/EE Online elective courses, which may be chosen from either Electrical Engineering or Computer Science

UT-Arlington Computer Science and Engineering Online Degree Plan

- Required Courses:

  Four Core courses:

  UTA CSE 5311 Design and Analysis of Algorithms
  UTA EE 5361 Fundamentals of Telecommunication Systems
  UTD CS 6386 Telecommunications Software Design

  Either of these (the other may be used as an elective):

  UTA CSE 5350 Computer Architecture II
  UTD CS 6378 Advanced Operating Systems

  One Breadth Course chosen from below with remaining available as electives:

  UTA CSE 5324 Software Engineering Analysis, Design & Testing
  UTA CSE 5330 Database I
  UTD CS 6352 Performance of Computer Systems and Networks
  UTD CS 6390 Advanced Computer Networks

- Electives:

  Four courses, at least two from EE.

Note: A concentration (3 courses) should be designed to fit a student's goals. Topics such as signals, wireless, mobile, network-based computing, or telecommunications software engineering would be typical.

UT-Dallas Computer Science Online Degree Plan

- Five CS/EE Online core courses in Computer Science, plus one prerequisite:

  UTA CSE 5311, Design and Analysis of Algorithms
  UTD CS 6352, Performance of Computer Systems and Networks
  UTD CS 6378, Advanced Operating Systems
  UTD CS 6385, Telecommunication Networks
  UTD CS 6390, Advanced Computer Networks
  UTD EE 6340, Introduction to Telecommunication Networks
  (prerequisite for EE 6390)

- Three CS/EE Online courses in Computer Science
- Three CS/EE Online elective courses, which may be chosen from either Electrical Engineering or Computer Science

Enrollments in the programs are given in Table 3.

Table 3 *CS/EE Online* Enrollment History

Institution	Discipline	Fall 2000	Spring 2001	Summer 2001	Fall 2001	Spring 2002
UT-Arlington	CSE	4	58	58	44	75
	EE	NO	2	NO	5	9
UT-Dallas	CS	10	33	NO	70	92
	EE	37	61	NO	5	47

NO – Not Offered

Program and Course Development

The full *CS/EE Online* program is scheduled for development and deployment over a three-year period beginning in fall 1999, with eight of the 24 courses being developed each year. Each of the four involved academic departments developed two courses per year. This approach spread the development load evenly over the UT-Arlington and UT-Dallas faculties and support staffs. To date, the approach has worked well and while some schedule slippage has occurred, it has been minimal. All courses will be available online by spring 2003.

The typical development cycle for a course begins in the fall or spring semester and runs for 12 months. The faculty member in charge of development is given a one-course reduction in teaching load that semester in order to provide time to develop materials necessary for online delivery. The following semester, the faculty member refines the material while teaching the course under development. A third semester is used for final implementation and testing of course materials. One month of salary is provided to the faculty member during the summer of the development year by the program.

Faculty members are assigned a graduate assistant for a period of 12 months to assist in the development of course materials. At UT-Arlington, the Center for Distance Education (CDE) provides additional support for instructional design and development of graphics and media.

The UT TeleCampus insists on maintaining the highest possible standards for its programs. These standards are articulated in its *Principles of Good Practice* document that all faculty members teaching UT TeleCampus courses must agree to follow. Additionally, all *CS/EE Online* instructors are required to take a one-day training course covering UT TeleCampus standards, technology, and services. At UT-Arlington, the CDE also evaluates all courses before releasing them to the UT TeleCampus.

An Academic Affairs Committee (AAC) and an Executive Committee (ExC) are providing development-time and long-term oversight of *CS/EE Online*. AAC membership includes graduate advisors and representative faculty members from the two institutions. The ExC is composed of the academic deans and department chairs. TeleCampus officials serve as ex-officio members of both committees. The AAC is primarily concerned with operational issues while the ExC deals with policy matters. Both committees meet semi-annually.

Course evaluations are conducted online by the TeleCampus staff for each course at the end of the semester. Evaluation questions are written by the staff with input from and approval by the AAC and ExC.

Course Offerings

CS/EE Online courses are offered at least once per year so that students may finish their programs of study in a timely manner. Core courses and popular electives are usually offered more often. Offerings are scheduled three years out for the fall and spring semesters. Summer offerings, in general, cannot be scheduled more than one or two semesters in advance due to the uncertainty of faculty availability. Table 4 shows course offerings through summer 2005.

Table 4 *CS/EE Online* Course Offering Schedule

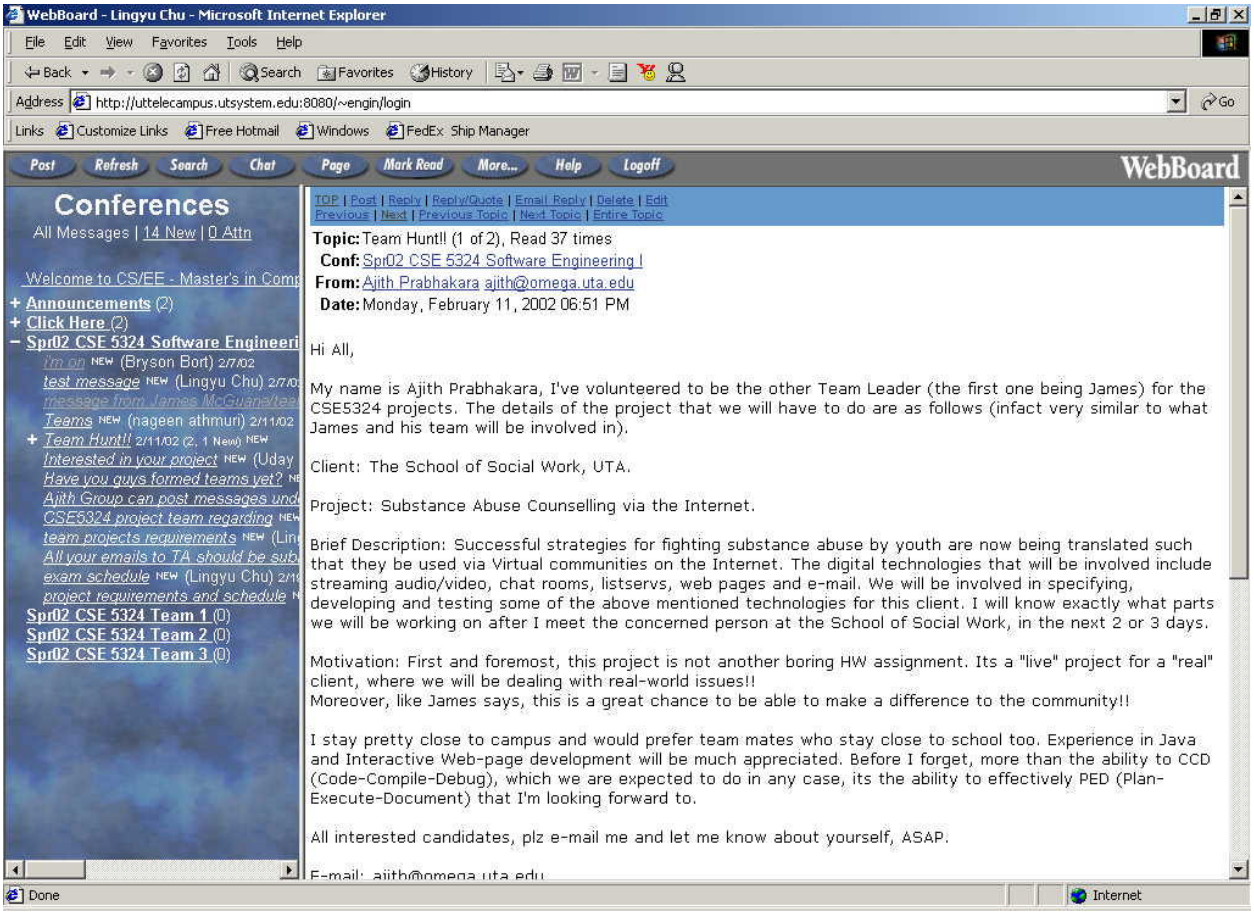
Campus	Course	Su02	Fa02	Sp03	Su03	Fa03	Sp04	Su04	Fa04	Sp05	Su05
UTD EE	6340		X	X	*	X	X	*	X	X	*
	6344		X		X	X		X	X		X
	6345	X			X			X			X
	6352		X	X	*	X	X	*	X	X	*
	6310		X		*	X		*	X		*
	6390			X	*		X	*		X	*
UTD CS	6352		X	X	*	X	X	*	X	X	*
	6359		X		*	X		*	X		*
	6378			X	*		X	*		X	*
	6385	X	X	X	*	X	X	*	X	X	*
	6386		X	X	*	X	X	*	X	X	*
	6390		X	X	*	X	X	*	X	X	*
UTA EE	5301	X		X	*		X	*		X	*
	5302	X	X	X	*	X	X	*	X	X	*
	5361	X	X	X	*	X	X	*	X	X	*
	6364			X	*		X	*		X	*
	5367			X	*		X	*		X	*
	5350		X	X	*	X	X	*	X	X	*
UTA CSE	5311	X	X	X	*	X	X	*	X	X	*
	5324	X	X	X	*	X	X	*	X	X	*
	5330	X	X	X	*	X	X	*	X	X	*
	5348		X		*	X		*	X		*
	5350	X	X		*	X		*	X		*
	6345			X	*		X	*		X	*

X = course will be offered. * = course may be offered.

Course Design and Delivery

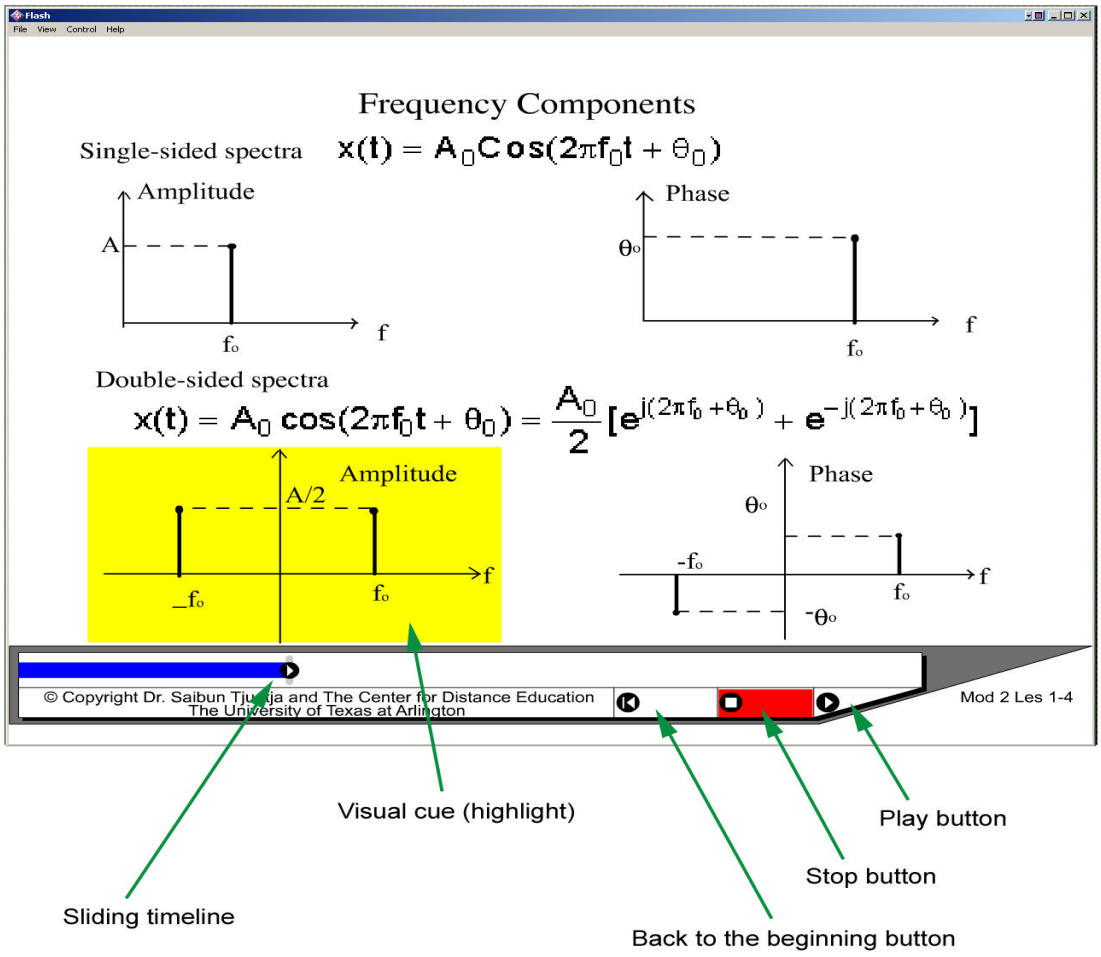
CS/EE Online courses are delivered via the World-Wide-Web in the form of hypertext files. This permits a wide range of options for course design and implementation. All courses are designed to facilitate asynchronous and self-paced learning. On-line Web access (utilizing course WebPages and WebBoard, and email) is used to facilitate group discussions and Q&A with the instructor, and support other logistical needs such as homework assignments. FAQs and threaded discussions are provided through the course WebBoard. Threaded discussions and Q&As are kept from each semester and are made available to students in future semesters through the WebBoard. Use of the WebBoard to organize project teams in CSE 5324 is shown in Fig. 1.

Fig. 1 – Use of Threaded Discussion in CSE 5324.



UT-Arlington courses in the *CS/EE Online* program are designed with the following additional features to facilitate asynchronous and self-paced. (1) Students can access and work on the course materials anywhere and anytime, on-line or off-line. This requirement necessitates that most of the course materials be available locally at the students workstation/computer. In the current implementation, in addition to the textbook, the post-processed lectures (with animation, synchronized narrations, etc) for the entire semester are distributed to the students in the form of CD-ROM at the beginning of each semester. (2) The post-processed lectures allow students to work on the course materials at their individual pace. The user-control functions in each lecture permit them to stop/pause, go back, resume, repeat, or quit and resume at the last discussion at a latter time. In courses where significant amount of lecture materials (diagrams, figures, etc) are not available in the textbook, electronic lecture notes are provided to the students (either downloadable or included in the lecture CD-ROM). Fig. 2 shows a snapshot of a lecture utilizing visual cues and control buttons that allow students to control the pace of a lecture/lesson. The visual cues and the narratives are synchronized, and the progress in the lesson is indicated by the sliding timeline. The control buttons permit the student to review/replay specific part of the lecture or jump ahead to any arbitrary point in the lecture timeline.

Fig. 2 – Use of Visual Cues and Control Buttons in EE 5361.

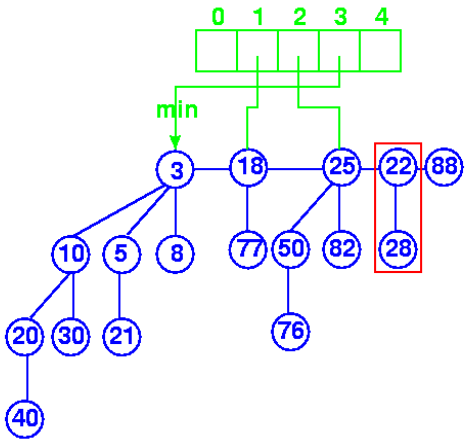


Java applets are incorporated into CSE 5311 course materials to enhance student's visualization of abstract data structures and algorithms. Fig. 3 shows a snapshot of an applet that shows (animates) how individual trees are consolidated in a Fibonacci heap data structure.

We have not conducted any scientific studies to determine the effectiveness of Web-based delivery of the *CS/EE Online* courses as compared to traditional methods. However, anecdotal feedback from students suggests that the Web-delivered courses are at least as effective as their traditional counterparts. The asynchronous, self-paced features are not available in traditional courses and provide distinct advantages for part-time students who are working full time and for students who are remotely located from campus. The use of Java Applets, enhanced visual cues, animations, and audio and video clips provide multimedia enhancements to the usual lecture featuring chalkboards, overheads, and/or PowerPoint presentations. Multimedia presentations can be used in a traditional classroom. However, it is rare that a faculty member has the resources and/or motivation to develop the material for such an application. One side benefit of

having developed the *CS/EE Online* program is the availability of high quality multimedia material that can be used online, for self-study, and or in the classroom.

Fig. 3 – Snapshot of a Java Applet Illustration in CSE 5311.



Administrative Issues

Several interesting administrative issues arose during the early stages of development and deployment of *CS/EE Online.* A number of these issues and their resolutions are described below.

Students must be admitted to either UT-Arlington or UT-Dallas in order to pursue a *CS/EE Online* degree. Admission processes and standards are the same for online and traditional on-campus programs. However, the processes may be completed at distance. The admitting institution is called the *home institution* and is also the degree granting institution for the student once degree requirements are completed. The other institution is known as the *host institution* for the *CS/EE Online* student.

Students register for courses at their home institution using that campus' standard registration process. Both institutions have online registration systems enabling registration at distance. Registration at a host institution is handled through the use of a special registration form that is available online from the UT TeleCampus.

An early administrative decision was to establish a common cost structure for both institutions and to include a special *CS/EE Online* fee to help defray program costs. Also, it was decided to drop certain fees, such as the Health Center fee, for students only taking courses at distance.

Tuition rates at UT-Arlington and UT-Dallas are the same on a semester credit hour basis. However, the fee structures are quite different. Hence, in order to reach a common per course charge for *CS/EE Online* courses, it was necessary to set a different amount for the *CS/EE Online* fee on each campus. The amount being charged Texas residents for a 3-hour course is $625. Costs are higher for students not meeting Texas residency requirements.

CS/EE Online students must take courses from both the home and host institutions in order to complete degree requirements. This raised an issue on how to handle credits earned from a host institution. One option was to consider them as transfer credits. This was problematic since both institutions limit the number of transfer credits allowed on master's degree programs. Also, transferring credits was inconsistent with the concept of a joint program. The solution adopted is a form of cross listing of courses. The 12 UT-Arlington courses have each been assigned a corresponding number by UT-Dallas and vice versa. For example, if a UT-Dallas student takes a UT-Arlington course, the UT-Dallas number is recorded on the student's transcript. The UT-Arlington faculty member is shown as the instructor of record. Also, UT-Arlington receives the tuition, fee, and State formula funding for the course.

The above solution precipitated a problem relative to faculty appointments. This was solved by the use of adjunct appointments. Hence, each UT-Dallas *CS/EE Online* participating faculty member has an adjunct appointment at UT-Arlington and vice versa.

Several faculty-related issues have also arisen in the areas of intellectual property and teaching loads. *CS/EE Online* participating faculty members are required to sign an intellectual property agreement before course development begins. The agreement that faculty members sign provides for full faculty ownership of the intellectual property rights to all materials contributed by the faculty member. The agreement also provides for UT-System ownership of the courses offered by the TeleCampus.

Faculty members teaching a *CS/EE Online* course are given the same teaching load credit as for teaching a traditional organized, on-campus course. While *CS/EE Online* faculty members do not have to deliver lectures they do have to assign and grade homework, projects, and examinations; interact with students at distance; and assign course grades.

Lessons Learned

The development costs for the CS/EE online program were driven by the quality standards of the UT TeleCampus and the two campuses together with a tight completion schedule. UT TeleCampus funded the CS/EE online program at $35,000 per course with UT-Arlington/UT-Dallas providing the rest of the needed support. The actual development cost per course (faculty off load + faculty summer salary + 12 months GTA support + support for a half-time media-development staff + hardware & software cost) far exceeded $35,000. Also, the faculty time and effort needed to meet deadlines and quality standards exceeded the original expectations.

Online education takes more faculty time per student than classroom education, hence one cannot teach as many students on line as one can in a classroom. This is caused by the need for rapid response to students in email, chat rooms, managing threaded discussion groups, etc.

As has been discussed, the development of online courses is expensive. In engineering courses, there is also a significant on-going maintenance cost to continue to update the class to stay abreast of the developments in the technology and the industry. This raises a significant question about how the content of the courses will be controlled and maintained. The courses will only be cost effective if they can be taught using lower paid instructors than were used to develop them. Can these instructors change the courses? If the developer is not associated with teaching it in the future, how will he/she be compensated for development work to keep the course up to date?

Enrollments in the program have been modest but are beginning to grow. Factors that have affected enrollment include the incomplete state of the program and the added cost. The former factor will be eliminated once all 24 courses have been completed for online delivery and are offered on a regular basis. Enrollments have also been impacted in part by the current economic downturn that has hit the telecommunications industry. This deterrent should be removed as the economy recovers. However, this experience brings into question the long-term viability of focused degree programs.

It has also been interesting to note that most enrollments in the program to date have been students already pursuing degrees on campus. They have chosen to enroll in *CS/EE Online* courses for convenience, to take specialty courses not available on their home campus, and/or to circumvent on-campus enrollment limits.

In conclusion, development and deployment of CS/EE Online has been a challenging and rewarding experience for all involved. We believe that the program quality and accessibility will attract more students as the economy improves and as the program becomes more visible. An important side benefit of the program has been the bridges that have been built between the UT-Arlington College of Engineering and the UT-Dallas Erik Jonsson School of Engineering and Computer Science.

Acknowledgements

The authors wish to acknowledge the contributions of Dr. J. Ronald Bailey, Dean of Engineering at Florida Institute of Technology, for helping formulate the *CS/EE Online* concept while at UT-Arlington. We would also like to thank Dr. Darcy Hardy, Marta Hubbard, and other members of the UT TeleCampus staff for their help and guidance. UT-Arlington wishes to thank Dr. Pete Smith and Eli Collins-Brown of the Center for Distance Education for their help with administrative matters and course design. Finally, we express our appreciation to all of the *CS/EE Online* participating faculty members for their hard work and dedication to making the program possible.

References

1. "Best of the Online," *US News and World Report*, October 15, 2001, pp. 62-67.
2. The University of Texas TeleCampus website, http://www.telecampus.utsystem.edu/.

Biographies

BILL D. CARROLL, PH.D., P.E.
Dr. Carroll is Dean of the College of Engineering and Professor of CSE at UT-Arlington. Previously, he served as chair of the CSE Department. Carroll is an IEEE Fellow and recipient of an IEEE Third Millennium Medal. He is a past recipient of the ASEE/Dow Young Faculty Award. He is a Past Director of IEEE and a former member of the EAC of ABET. He received B.S., M.S., and Ph.D. degrees in EE from the U T-Austin.

WILLIAM P. OSBORNE, PH.D., P.E.
Dr. Osborne joined UT-Dallas in September 1995, as Dean of the Erik Jonsson School of Engineering and Computer Science and Ericsson Chair. He came to UT-Dallas from New Mexico State University, where he was Professor of Electrical and Computer Engineering, holder of the Carden Chair and Director of the Center for Space Telemetering and Telecommunications Systems. Osborne serves on several corporate and university advisory boards.

BEHROOZ A. SHIRAZI, PH.D.
Dr. Shirazi is a Professor and Chair of Computer Science and Engineering Department at UT-Arlington. Before joining UT-Arlington he was on the faculty of Computer Science and Engineering at Southern Methodist University. He has received numerous teaching and research awards and has served as an IEEE Distinguished Visitor (1993-96) as well as an ACM Lecturer (1993-97).

C. D. CANTRELL, PH.D.
Dr. Cantrell is Professor of Electrical Engineering and Physics at UT-Dallas. He is also Director of the Photonic Technology and Engineering Center (PhoTEC). Before joining UT-Dallas, Dr. Cantrell was a staff member at Los Alamos National Laboratory. He is an IEEE Fellow and recipient of an IEEE Third Millennium Medal. He is author of the textbook *Modern Mathematical Methods for Physicists and Engineers.*

SAIBUN TJUATJA, PH.D.
Dr. Tjuatja is Associate Professor and Associate Chair of the Electrical Engineering Department at UT-Arlington. He teaches undergraduate and graduate courses in wireless and data communications, satellite communications, electromagnetics, and random signals and noise including many delivered at distance. Dr. Tjuatja has received several awards for outstanding teaching. He received his engineering degrees from UT-Arlington and Purdue.

Appendix A -- Course Descriptions

CS 6352 - Performance of Computer Systems & Networks (UT-Dallas): Queuing theoretic performance modeling problems occur in several layers of data networks organization. The objectives of this course are (1) to learn queuing theoretic models and analysis techniques of computer and telecommunication network's performance and (2) to apply the principles to formulate and solve some practical performance problems in data networks.

CS 6359 - Object-Oriented Analysis And Design (UT-Dallas): Analysis and practice of modern tools and concepts that can help produce software that is tolerant of change. Consideration of the primary tools of encapsulation and inheritance. Construction of "software-ICs" which show the parallel with hardware construction. Prerequisites: CS 6354 and either CS 5335 or CS 5336.

CS 6378 - Advanced Operating Systems (UT-Dallas): The main focus of this course is on distributed and parallel operating systems. It emphasizes both theory and practice. On the theory side, students will be taught fundamental theory in distributed computing. Prerequisites: CS 5348 or equivalent; knowledge of C and UNIX.

CS 6385 - Telecommunication Networks: (UT-Dallas): The design and analysis of telecommunication networks. Topics include network design issues, network design tools, analysis of loss and delay, modeling networks, review of fundamental graph algorithms, techniques for centralized network design, optimization of routing, ring architectures, mesh architectures, network reliability, survivable networks, wireless networks. Prerequisite: A first course in Probability Theory.

CS 6386 - Telecommunication Software Design (UT-Dallas): Programming with sockets and remote procedure calls, real time programming concepts and strategies. Operating system design for real time systems. Encryption, file compression, and implementation of firewalls. An in-depth study of TCP/IP implementation. Introduction to discrete event simulation of networks. Prerequisites: CS 5390.

CS 6390 - Advanced Computer Networks (UT-Dallas): Overview of the ISDN network and the SS7 protocol. High-speed networks including B-ISDN, Frame Relay and ATM. Congestion control algorithms, quality of service guarantees for throughput and delay. Prerequisite: CS 5390.

CSE 5311 - Design and Analysis of Algorithms (UT-Arlington): This class will cover a number of ideas and techniques useful for designing and analyzing data structures and algorithms. In particular, it will introduce techniques for analyzing upper bounds for algorithms and lower bounds for problems. Problem areas include sorting, graphs, dynamic programming, combinatorial algorithms, computational geometry, encryption, parallel models, and NP-Completeness.

CSE 5324 - Software Engineering I: Analysis, Design and Testing (UT-Arlington): Topics discussed include definitions, basic concepts, motivation, principles, goals of software engineering, as well as technical aspects of software projects, various methods to write

requirements and specifications in addition to methods to decompose and design systems. Implementation and approaches to verification and validation are also considered with issues of software reuse and reliability. Additional Course and Faculty Information

CSE 5330 - Database Systems I (UT-Arlington): This is a first course in database systems at the graduate level. The prerequisites are knowledge of programming and data structures (CSE 5320).

CSE 5348 - Multimedia Systems (UT-Arlington): This course involves the study of representation (coding) and compression of text, audio and video (including popular Standards). Both lossless and lossy compression mechanisms will be covered. The other topics that will be covered include communication issues and technologies pertinent to Multimedia. In particular streaming of media, enhancements to the Internet to support multimedia, and adaptation of technologies like ATM will be investigated. The course will involve extensive programming in Java. Projects will be incremental with the final deliverable being a multimedia browser that facilitates collaboration.

CSE 5350 - Computer Architecture II (UT-Arlington): A study of advanced uniprocessor and basic multiprocessor systems. Topics may include memory management systems, pipelined processors, array and vector processors, and introduction to architecture of multiprocessor systems. Prerequisite: CSE 3322, or consent of instructor.

CSE 6345 - Mobile Computing Systems (UT-Arlington): Mobility management, Mobile IP, hand-off, routing, multicasting, and reliable communication in wireless networks. Data management, push-pull based data acquisition, issues in wireless mobile systems, resource allocation, QoS issues and multimedia transmission over wireless, WAP and Bluetooth technologies, third generation systems. Prerequisite: CSE 5346.

EE 5301 - Advanced Engineering Analysis (UT-Arlington): Analytic and numerical methods for solving engineering problems including topics in linear algebra, Fourier analysis and partial differential equations, complex analysis and integration, numerical methods in linear algebra, and numerical methods for solving differential equations.

EE 5302 - Random Signals and Noise (UT-Arlington): This course will cover probability random variables and stochastic processes in physical systems. Topics include probability space, discrete and continuous random variables, density and conditional density functions, functions of random variables, mean-square estimation, random signals, system response, and optimum system design.

EE 5350 - Digital Signal Processing (UT-Arlington): Time and frequency domain analyses of linear time invariant systems. Stability analyses of causal and non-causal systems using the Z-transform. FIR digital filter design. Design of frequency selective IIR digital filters using frequency transformations and the bilinear transform.

EE 5361 - Fundamentals of Telecommunication Systems (UT-Arlington): Examines analog and digital communication techniques including amplitude modulation, frequency

modulation, and pulse code modulation. Time-domain and frequency domain multiplexing. Analog and digital noise analysis, Design of telecommunication systems.

EE 6364 - Advanced Data Networks (UT-Arlington): Network performance analysis, link and upper layers. Internet and ATM protocols, Internet routing and traffic management, ATM switch design and ATM Traffic management. Prerequisite: EE 5302 and 5360.

EE 5367 - Wireless Systems and Propagation Modeling (UT-Arlington): Fundamental principles and techniques of electromagnetic wave propagation as it applies to current wireless and cellular systems, development of models of propagation and their application in wireless system design, characteristics of microwave devices used in wireless systems, system and traffic design techniques used in wireless systems. Prerequisites: EE5302 and 5361 or consent of instructor.

EE 6310 - Optical Communication Systems (UT-Dallas): Operating principles of optical communications systems and fiber optic communication technology. Characteristics of optical fibers, laser diodes, and laser modulation, laser and fiber amplifiers, detection, demodulation, dispersion compensation, and network topologies. System topology, star network, bus networks, layered architectures, all optical networks.

EE 6340 - Introduction to Telecommunications Networks (UT-Dallas): This course presents some of the basic concepts and applications of data networks. The course will 1) define and compare circuit, message and packet switching techniques; 2) present the hierarchy of the ISO-OSI Layers, with emphasis on three layers: The Physical Layer (channel characteristics, coding, error detection); The Data Link Control Layer (retransmission strategies, framing, multi-access protocols, e.g., Aloha, Slotted Aloha, CSMA, CSMA/CD); The Network Layer (routing, broadcasting, multicasting, flow control schemes).

EE 6344 - Coding Theory (UT-Dallas): Groups, fields, construction and properties of Galois fields, error detection and correction, Hamming distance, linear block codes, syndrome decoding of linear block codes, cyclic codes, BCH codes, error trapping decoding and majority logic decoding of cyclic codes, non-binary codes, Reed-Solomon codes, burst error correcting codes, convolutional codes, Viterbi decoding of convolutional codes. Prerequisite: EE 6352.

EE 6345 - Engineering of Broadband Packet Network (UT-Dallas): Detailed coverage, from the point of view of engineering design, of the physical, data-link, network and transport layers of IP (Internet Protocol) networks. This course is a Masters-level introduction to packet networks. Prior knowledge of digital communication systems is strongly recommended. Prerequisite: EE 6340 or consent of the instructor.

EE 6352 - Digital Communication Systems (UT-Dallas): Upon completion of the course, the students are expected to be familiar with the current modulation and demodulation techniques, and signaling formats. Using the knowledge that they build during the course, they would be capable of choosing proper signaling formats for various transmission systems among all the currently existing formats, and even design new digital modems by themselves. They

would build the background to analyze and compare existing transmission schemes in terms of performance, bandwidth, and complexity.

EE 6390 - Introduction To Wireless Communications (UT-Dallas): This course deals with the fundamentals of digital mobile communication systems. Principle, practice, and system overview of wireless communication systems are discussed. Topics include frequency planning, cell planning, propagation issues, modulation, demodulation, coding, encoding, and multiple-access techniques (TDMA, FDMA, CDMA, SDMA, etc.). Performance of various wireless communication systems in the presence of channel effects is also discussed.