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A Virtual Classroom Via Dataconferencing: A Multi-Institutional Experience

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Abstract - This paper presents the experience of five faculty from four universities who are co-developing and team teaching courses using the world-wide web (WWW). In particular, two novel power engineering courses, *Flexible Control of Transmission Systems* and *Flexible Control of Distribution Systems*, introduce the student to the application of power electronic-based controllers, known specifically as flexible ac transmission systems (FACTS) controllers, to enhance the performance of the transmission and distribution systems in an electric power system. In order to leverage faculty expertise in the various topics included in each course, a unique partnership was formed among five faculty from the following universities: University of Arkansas, Kansas State University, University of Missouri-Rolla and Purdue University. In order to achieve the most effective presentation, in the presence of geographical, cost, time and technology constraints, the co-developers decided to pursue various distance learning strategies to link the four universities together in a live interactive virtual classroom utilizing dataconferencing software and the WWW. In this paper we address the trials and tribulations of our experience. In particular, we discuss the use of video tape technology by mail, the use of live audio and video via an integrated service digital network (ISDN) approach, and lastly, dataconferencing software in conjunction with telephone conferencing. Each of these alternative methodologies are examined in detail and are compared and contrasted from a cost and pedagogical point of view based on our experiences.

INTRODUCTION

The electric power industry in the USA is in a state of flux due to the Federal Energy Regulatory Commission's (FERC) Orders 888 and 889 issued in 1996. These orders will completely change the way the business of generation, transmission, and distribution of electricity is conducted. The vertically integrated companies will be split into different companies dealing with generation, transmission,

and distribution. The generating companies will be allowed to compete for selling electricity to the customers, and the customers will have a choice of selection of their energy supplier. Restructuring in this manner will change the operating constraints for transmission and distribution systems.

Several new technological advances hold considerable promise for maintaining a high level of reliability and power quality under the restructured environment. Power Electronics-based Flexible AC Transmission System (FACTS) devices are very attractive because of their ability to change transmission characteristics in response to changing system requirements. Similarly, advances in distribution automation technology and in power electronics-based custom power technology will allow improvements in efficiency, reliability, and quality of distribution systems. Thus, the new generation of engineers graduating with a degree specializing in electric power systems must have knowledge of these advanced technologies and their applications.

Five professors at Kansas State University, University of Arkansas, University of Missouri - Rolla, and Purdue University have been active in research dealing with different aspects of the new technologies. Their specific areas have very little overlap, but they complement each other very well. Also, all of them were well acquainted with each other through networking at regional and national conferences. Geographical proximity also played a large role in reinforcing the team. This group jointly applied for and received a Combined Research and Curriculum Development (CRCD) award from NSF in 1995 for their project entitled Flexible Power System Control.

The primary focus of this collaboration is to develop two senior/graduate level courses; one in distribution system control and the other in transmission system control. These courses are to be taught simultaneously via communication links between the four campuses. The goal is to develop a "virtual classroom" relying heavily on the World Wide Web

(WWW) for dissemination of course material and information. Every semester a new technology or technique for delivery of course material to students has been introduced. This paper will present a summary of advantages and disadvantages of various technologies that were implemented. Also, some of the difficulties that the investigators had to overcome will be highlighted.

COURSES

Flexible Control of Distribution Systems

Distribution systems are a significant part of power systems in terms of overall investment. It is generally believed that in the USA the total investment in distribution systems is equal to that of generation. In terms of percentages the breakdown is roughly 40% in generation, 20% in transmission, and 40% in distribution. Distribution systems are also important because they are closest to the customers. Thus, any problem in distribution systems affects the customers directly. Although distribution systems are a large and important part of the power system, research interest related to them, both at universities and at utilities, has been historically low. Very few universities offer a course in distribution systems and very few textbooks are available on distribution systems.

Recently, however, interest in distribution systems both in industry and in universities has increased. Some of the factors contributing to this change are deregulation and unbundling of electric utility business, increased emphasis on quality and reliability by the customers, advances in computer and communication technology, and advances in power electronics technology. The interest in distribution systems should continue to grow because further progress in all four areas mentioned above is expected in the future.

Flexible Control of Distribution Systems was offered for the first time in Fall 1996. The main theme of this course is application of advanced communication and control devices for improvement of efficiency, reliability, and quality of electricity distribution. The first part of the course included distribution automation functions and their economic analysis, techniques of outage location, cold load pick up and its impact on transformer loading, step-by-step system restoration, optimal system design for restoration, system reconfiguration, and voltage and var management. The second part of the course emphasized custom power including static compensator, dynamic voltage restorer, solid state breaker, instantaneous power theory, revised instantaneous power theory, and unified power flow.

Flexible Control of Transmission Systems

As the industry changes to meet the requirements of competition, engineers will need the technical expertise to make decisions regarding power transmission and economics. Several new flexible control strategies hold considerable promise for maintaining a high degree of power control and reliability under a deregulated environment.

At the transmission level of the power system, a new method of achieving control is through the use of power electronics-based Flexible AC Transmission System (FACTS) devices, named for their ability to change transmission characteristics in response to changing system requirements. Since this is a new technology, there are no textbooks or course materials with which to educate students. However, there is a wide-range of material available in the technical literature. It is the intent of this course to provide students with device topology and control strategies within a power systems framework. This course begins with an overview of transmission system control, moves into some detailed device modeling, then discusses models suitable for system studies, and finally covers the use of these devices to improve several typical system problems. The impacts of FACTS devices on power system operation is analyzed in the last portion of the class. In analyzing the operation of the various FACTS devices, several system based models had to be derived, consistent with the device level operation.

UTILIZING THE INTERNET

In order to facilitate the students, all of the material for the courses are available at web sites. On the main homepage, the students have access to the following materials:

- Students' names, e-mail addresses, and URLs
- Instructors' names, e-mail addresses, and URLs
- Course syllabus
- Bulletin board
- Course notes
- Homework assignments
- Announcements
- Hyper-textbook

In addition to the bulletin board, the students are also enrolled in a listserve email list. Email list-serves proved quite helpful for making announcements, helping with homework and projects, and taking care of scheduling. The WWW was also utilized to disseminate software and data needed for the class projects. The course notes were made available on the web in PDF format for easy printing and in html format for easy viewing directly on the WWW.

LECTURE DELIVERY

Video Tapes

Since this project involves professors and students at four universities, the biggest challenge was delivery of lectures from one site to the others. The investigators wanted the campuses connected to each other via a communication medium such that text, sound, graphics and video could be exchanged between each other in real-time. All this had to be done while keeping the total cost within a reasonable limit. By Fall 1996, when a course was offered for the first time, no viable medium to connect the campuses was available. Therefore, we decided to use video tapes for delivery of lectures. The tapes were sent via express mail to other sites the same day they were prepared. Hence, the students at other sites were behind only by a lecture. This format worked satisfactorily for transferring the lectures, but did not provide opportunities for students at one site to interact with professors at other sites except by email. Thus the lectures were very passive and sometimes uninteresting due to limited participation from students. Moreover, the students at remote sites felt left out of the class.

Videoconferencing

Use of PICTURETEL® (a PC-based videoconferencing setup) with Integrated Services Digital Network (ISDN) telephone lines were considered as an option in summer of 1996. ISDN service was available at K-State, but not at the other universities. By the end of 1996, UA had the ISDN service and UMR had devised a way to interface with ISDN through a dedicated fiber optic cable from Rolla to University of Missouri - Columbia, where ISDN service was available [1]. Thus it was decided to use this setup for the second course which was offered in Spring 1997. The three campuses were connected through an ISDN bridge in Topeka (Scott Sudhoff was at UMR in Spring 1997). Lectures were delivered at one site and were received by other sites in real-time.

One of the primary benefits of using a computer-based technology is that it is very easy to broadcast computer demonstrations. Also, the majority of class notes were prepared using software, such as PowerPoint®. These notes were prepared ahead of time and were posted on the web site for students to download. The instructors found this to be essential because the ISDN connection does not offer fine enough resolution for students to take notes directly from lectures. The resolution of video also made teaching of classes more difficult. It should be noted that a three way connection has distinctly lower resolution than a two way connection. Three way connection also made the setup very fragile. A two way connection can be accomplished directly

between the two sites; however, a three way connection has to be made through a bridge. Hence, on many occasions connection was lost in the middle of the lecture. Overall poor resolution, unreliable connections and high cost contributed to many frustrations and a search for other alternatives.

Dataconferencing Through the World Wide Web

Dataconferencing is a term used to describe sharing of computer data amongst many computers. Such a conference does not include video or voice. However, with a very high bandwidth, which will be available in the future, it will be possible to share video and voice. The arrangement that is in use since Fall 1997 for teaching the classes between the participating campuses is shown in Fig. 1. A dataconferencing software has been installed on a UNIX computer in Electrical and Computer Engineering Department at Kansas State University, which can be accessed through the World Wide Web. A user can start a conference, join a conference, or manage other functions of the conference through a web site. The browser should be Java enabled for proper operation.

A software (FarSite®) installed locally on each personal computer enables connection of the computer to the server. The person who is responsible for teaching on a given day starts the conference. He or she then opens a workbook containing the lecture for that day. A workbook has to be created ahead of time using print capture. It can be created from files created by many applications. For example, a PowerPoint® presentation can be converted to a Farsite® workbook. The conversion results in some loss of quality. Once the workbook is opened in the shared mode, it is seen on the computer screen by all the people who join the conference. Whenever the slides are advanced by the person who is delivering the lecture, the screens at other sites also get refreshed. The software has a pointer, a highlighter, a text tool to enter text, and a freehand tool for writing on the slides. People at other sites can also advance the slides and use all the other features. At some of the sites a projector is used to project the image on a large screen for viewing convenience of students. Teleconference with regular telephones is used for voice communication. A speaker phone in the class allows everyone to listen to remote lectures and to ask questions. A great advantage of this technology is that the students can also prepare workbooks for the work they do for an assigned project and share it with all the students - local as well as remote. Such an activity encourages class participation and discussions by students, which was not possible with video tapes.

Dataconferencing was exclusively used for lectures for the course on distribution systems that was offered in Fall 1997. One half of the lectures were originated from Kansas

State University and the other half were originated from University of Arkansas. The arrangement worked well to our satisfaction most of the time. A few times we faced difficulties mainly due to the internet. On some occasions the network was very congested which resulted in very slow transfer of data between the sites. On certain other occasions the internet connections were not available due to bad weather. Also, we faced problems on a few days for which a reason could not be found. With sufficient experience we realized that to keep things smooth 1) the workbook should not be very large, 2) the workbook should be opened sufficiently ahead of the lecture time, and 3) the workbook should be controlled by the person who has opened it.

Dataconferencing was used again in Spring 98 for the transmission systems course. However, it was used in conjunction with video tapes. Video tapes were used for lectures related to standard course material. These tapes were watched by the students twice a week. This was followed by dataconferencing once in a week to discuss the material which was presented in the two previous tapes and to discuss project work. The tapes were prepared ahead of time to allow each university site to remain synchronized as teaching duties transferred from one instructor to another. The video tapes were also made available as a reference for students to review as they worked on course projects.

STUDENT REACTIONS

The students' reactions to this type of course have been mixed. Some students have really enjoyed the opportunity to learn the material through this course that would not have been available otherwise. There have been some frustrations involved with getting the classnotes in time for class. It can take a long time to print the whole set of notes if they contain significant portions of simulations and/or graphs.

There has not been as much communication between students on different campuses as had been expected. The students seldom use the bulletin board and the listserve capabilities. The students typically email directly to the off-site instructor and/or talk with the on-site instructor. They do not rely on each other as much as they could. Attempts to get students to work together on projects resulted in limited success. Similar to any team project, some students complained that their teammates were not producing any relevant work and that the long-distance communication made it difficult to overcome this problem.

Students' reaction to different technologies were also mixed. The students don't like video tapes very much, but are willing to accept it for a lack of better technology. Their reaction to videoconferencing was very negative; this was primarily due to poor quality of video. They felt that dataconferencing was better because it provides much better picture quality. However, the biggest drawback of

dataconferencing is that the remote students don't see the professor giving the lecture. They only hear his or her voice. They felt that it is important to be able to see professor's emotions during lecture. However, with time they felt more comfortable even though they were not able to see the professor. They still preferred dataconferencing to plain video tapes.

CONCLUSIONS

Table I summarizes the pros and cons associated with each of the delivery methods investigated. In each stage certain advantages were gained as we continued to develop the "virtual classroom." Student participation and interactions in class are important for providing a "virtual classroom" experience. Following are some of the techniques we utilized to encourage active student participation both in and out of the classroom.

- Early in the semester have students and faculty introduce themselves and "play" with the technology.
- Encourage local students offline to prepare and ask questions in class.
- Have group exercises in-class at each site and have sites report to each other.
- Require students to present reports on project work to the class using the technology.
- Have students anonymously "peer review" each other's work and make positive suggestions.
- Present figures and data live and have students explain what is happening, answer questions, or "vote" on correct answers.
- Leaving blanks in the course notes that require students write down some essential details during the lecture.
- When email questions are sent directly to the instructor, the question and answer are forwarded to the listserve.

Early in the semester, it tends to take students awhile to become familiar with the resources available to them. As a result students did not get the notes printed in time to have access to them in class. Not having the notes available tended to make students more passive in class.

Students tend to go to the local instructor with questions even when someone else is teaching the material. In these instances, it is very helpful for all instructors to have copies of project solutions, and other reference material. Local instructors also need to encourage students to contact off-campus instructors as they would local instructors.

We also found that having multiple instructors making assignments and alternating presentations often requires flexibility and special coordination of project due dates. University breaks scheduled at different times also add complexity to scheduling and faculty-student interactions.

Developing these courses and course material has been a great learning experience for the faculty involved in this project. Both the technical content of the courses and the medium by which the courses are taught are on the cutting-edge. Once the "virtual classroom" approach is fully developed, it will have many applications in such collaborative efforts and in distance education.

The instructors have become very familiar with World Wide Web and internet while developing web sites for these courses. They, however, so far have not exploited Java scripts to make the web material interactive. This would be an extremely useful tool not only for the web site itself, but also to incorporate it into the hyper-textbook as an additional learning tool.

Since this project utilized the WWW in many ways, the involved faculty had to learn various facets of the web for classes. The experience gained by the instructors and students will make it easier for them to apply these applications to other courses. This will make the learning process more active both for faculty and students.

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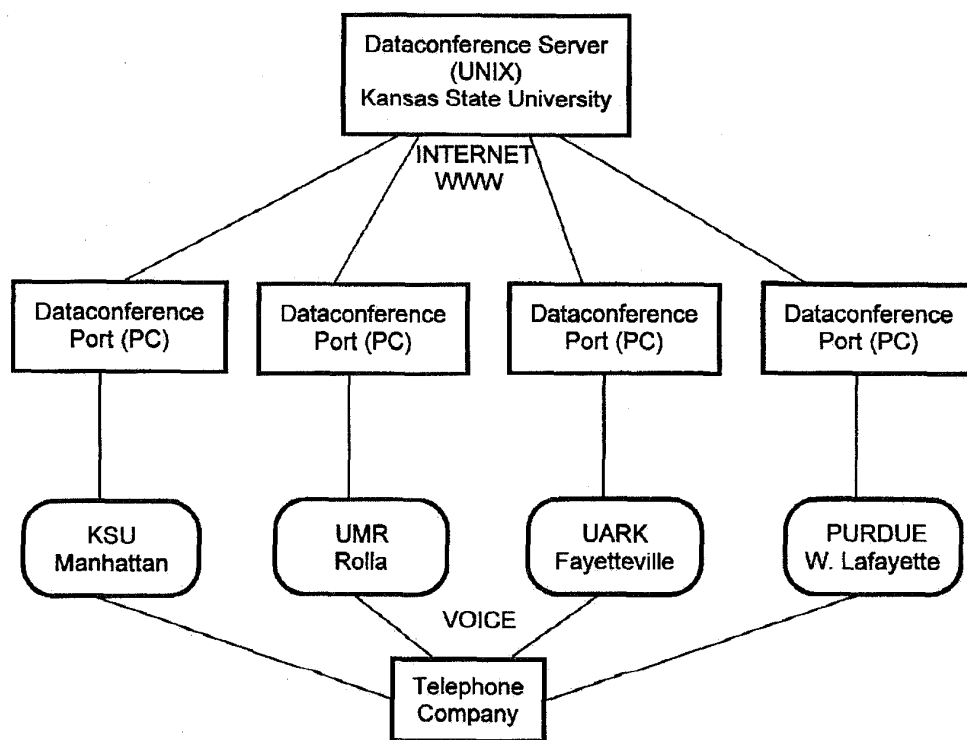


Fig. 1 Communication arrangement for the virtual classroom

TABLE I
*Summary of Advantages and Disadvantages of Different Techniques
Used for Virtual Classroom*

Delivery Format	Advantages	Disadvantages
Video Tapes	<ul style="list-style-type: none"> • Low cost • Technology available • Library of tapes available 	<ul style="list-style-type: none"> • No in-class interactions between campuses. • Changing of instructors can cause schedule synchronization problems
Videoconferencing	<ul style="list-style-type: none"> • Live face-to-face interactions • Easy synchronization of schedules • Allowed live simulations 	<ul style="list-style-type: none"> • Requires new technology or rent of facilities • ISDN line and bridge charges significant • Poor graphics, equations, and text readability • Too many technology reliability problems
Dataconferencing Only	<ul style="list-style-type: none"> • Better visuals • Easy synchronization of schedules • Interaction possible on computer & phone 	<ul style="list-style-type: none"> • Software purchase required • Telephone charges every period • Students don't see instructor • Vulnerable to internet congestion or failure • Requires at least one computer in classroom • No live simulation capability
Dataconferencing & Video Tapes	<ul style="list-style-type: none"> • Library of tapes for reference • Weekly in-class interactions • Some savings in phone charges • Students "see" instructors part time • Less vulnerable to network congestion 	<ul style="list-style-type: none"> • Tapes made ahead of time to maintain synchronism • Simulations only on tape

