

The Access Grid in a Multi-Campus Live Lecture Environment: Collaborative Graduate Courses at Purdue University, Iowa State University and Indiana University

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Abstract: The Access Grid (AG) [1] enables group-to-group collaborations through the integration of resources such as multiple camera views, large-format displays, shared audio, and interfaces to visualization environments. It is a powerful tool that allows for face to face communication among all the sites participating in a venue (virtual room where meetings take place.) Purdue University, Iowa State University, and Indiana University have been collaborating for the last few years on jointly delivering specialized graduate courses in virtual reality and interactive technologies over the AG. This paper presents our experiences on integrating the AG into the graduate curriculum at those universities.

Introduction and Background

The Access Grid (AccessGrid 2006) allows participants from many geographically distant sites to communicate and collaborate with each other easily and inexpensively. Unlike traditional videoconferencing, Access Grid (AG) runs over Internet2, using open source software developed by Argonne National Labs. Each AG site is called a “node” and contains hardware and software resources to enable the collaborative experience. A group of nodes interact through a shared “venue”, which is a virtual room in which the meeting takes place. The venue holds information about users, data, shared applications, and media streams. A typical set up is an actual room with some furniture and a screen to project images. The room is instrumented with video cameras and audio systems to capture different views from the group in the room as well as the conversations that are taking place. This set up allows that each user node in a venue can see the other participants, as well as the data and the shared applications in that specific venue (Childers 2000). The software to participate in an AG venue is quite flexible, allowing each site to operate using a variety of hardware setups, ranging from individual laptop-based nodes to large classrooms with multiple projected displays.

Iowa State University (ISU), Purdue University, and Indiana University (IU) introduced AG nodes into their institutions in 2002-2003 with the primary motivation of exploring course sharing and collaborative teaching across the three campuses. These three universities provide similar courses in the area of Virtual Environments, Computer Graphics, and Interactive Technologies. However, each one of them does not have enough faculty available to deliver these courses on a regular basis. The AG offers a potential solution to the shortage of experienced instructors by bringing in colleagues from other universities. The live experience provided by the AG creates an environment very close to that of having the instructor physically located in the classroom. In situations where instructors are available at two or more institutions, the AG enriches the experience through the sharing of the complementary perspectives and experiences of the collaborating instructors and the participating students.

ISU, Purdue, and IU have a long history of providing distance education courses for most of their programs. For example, ISU has been providing the Introduction to Virtual Environments (IE 584) and the Emerging Interactive Technologies (IE 574) graduate courses via distance learning since 2001. However, conventional distance learning infrastructure prevents direct communication with the remote students. The main reason is that distance learning lectures are designed for passive viewing by the remote students. There is little or no possibility for those students to directly participate in the classroom while the lecture is taking place. Although the authors of this paper have used tools such as chat rooms to allow for live communication for the remote students during the lectures, it is far from providing a classroom-like experience for them. The authors have also experimented with conventional videoconferencing as a way to provide a more interactive participation in the lectures. However, this particular

approach has presented limitations, as it is difficult (and expensive) for students to access videoconferencing facilities, and it also has increased the cost of delivering those courses due to access fees, software licensing and other issues.

However, we remained committed to investigating technologies that would enable us to provide distributed learning environments to remote students and also across universities. The next step in this investigation has led us towards the AG. The AG offers a cost-free environment for the students, easy to install and use in the computing resources available to them, and provides a classroom-like experience. The instructor can interact with all the students equally independently of being local or remote. Furthermore, students can also interact with each other and have the possibility of working together in class projects in ways not possible otherwise.

The AG significantly enhances the distance learning experience. First, experienced instructors may not always be available locally at a specific campus. This is especially true for specialized university courses such as Introduction to Virtual Environments. AG technology gives students access to courses and instructors that might not be available to them otherwise by bringing that expert from another campus into the AG classroom. In addition, even at universities with qualified instructors, enrollment at each site for courses such as this is often small, creating classes with only 5-10 students. By combining several smaller groups of students at different campus through the AG, the students can be involved in and interact with a larger group of students, and the instructors can pool their teaching resources to provide higher quality instructional materials, rather than each working individually to produce the same materials at each site. This set up also allows for active discussions during the lectures, which are key part of graduate courses and difficult to handle via conventional distance learning methods. By having the students actively involved in the virtual classroom, assignments such as reading papers and preparing a class discussion are now possible without leaving out any registered student. Similarly, remote students can provide live presentations equally participatory as those of the students in the classroom. Furthermore, through the different AG tools, students can also provide hands-on demonstrations of their class projects through tools such as AGJuggler (AGJuggler 2006), a virtual reality AG extension to the popular virtual reality application development framework VR Juggler (Bierbaum 2001, VRJuggler 2006).

Holding joint lectures gives students the benefit of learning from two or more instructors with different backgrounds and experiences, providing more information and viewpoints than a single instructor could present. This can be particularly useful for graduate level courses, where students should be starting to appreciate that there are still many unanswered questions. They can begin to understand that conflicting theories and opinions can exist and should be examined and critically compared rather than simply accepted as fact. This learning experience can be further augmented when using Access Grid technology because AG technology is cheaply and easily accessible at a large number of locations. This means that expert guest lecturers can also join the lecture sessions remotely, eliminating the time and expense that would normally be incurred, and allowing students to hear from leaders in the field that might not otherwise be accessible to them.

Technical Requirements

The Access Grid Toolkit™ (AGTk) is an open source project, so server and client software is freely available for download and use on a variety of platforms, including Windows and Linux. The software is quite flexible and can run on a variety of hardware setups. A minimal hardware setup could be as simple as a laptop equipped with a webcam and a headset – such setups are often referred to as “PIGs” (Personal Interface to the Grid). Students at remote locations can use PIG setups to attend and participate in class sessions when they cannot be physically present at one of the class locations. These setups have actually been used by both students and instructors of the Introduction to Virtual Environments courses when attending conferences. At the other end of the spectrum are large permanent installations of special purpose hardware dedicated to AG use. These installations are often similar to traditional classrooms or other distance learning classrooms. The AGTk software scales well to support these types of installations as well. A high-speed internet connection is necessary, but is usually present at most colleges and universities already, and increasing numbers of students have broadband network connections from home as well. Currently, AG requires that multicast functionality be enabled on the network. This ability is present at major institutions, but not always enabled on personal internet connections such as cable and DSL providers. Connections from client locations without multicast can be supported if a bridging server is present. All of the client locations

must connect to an AG venue server. Argonne National Labs, the creator of AGTk, hosts venue servers that can be freely accessed. New venue locations can be requested, for example there is a Purdue Room in the Institutional Venues server. An alternative is for sites to run their own venue server, using AGTk. Running a local venue server can provide advantages such as supporting unicast bridging and avoiding high network traffic at busy ANL venues.

The Access Grid node at Purdue University is located in the Envision Center for Data Perceptualization. The room itself is shown in Figure 1. The room can comfortably accommodate approximately 20 people. The front projected screen at the front of the room measures 220" x 58", which allows for 3 projectors. Two additional projectors in a stacked formation can also be used to present passive stereographics for virtual reality demonstrations. Three cameras in the room capture views to be made available to the remote sites on the Access Grid. For audio needs, the room has a wireless microphone for the instructor, plus additional small table microphones for the students. Echo canceling hardware is used to prevent feedback noise. A separate control room is also used, and is separated from the Access Grid room by a large glass wall. This allows a node operator in the control room to see and hear what is happening in the class, and to control various presentation systems such as a VHS tape deck, computers, and DVD players, without intruding on the classroom environment.



Figure 1: Purdue students in the Fall 2004 Introduction to Virtual Environments class participate in a lecture delivered from Iowa State University. Photo was taken from inside the control room.

The Access Grid node at Iowa State University is located in Howe Hall, one of the newest engineering buildings. Figure 2 shows the room configuration. As with the room in Purdue, it can accommodate approximately 20 people. The screen is also run by three projectors with similar projection surface dimensions as those of Purdue. The room has 5 movable cameras to capture different viewing angles of the room and an array of microphones distributed in the ceiling for audio capture in the entire room. In addition to AG hardware, the room is connected to an array of DVD and VHS players, to the main distance learning switchboard, and to the high-end virtual reality computer room for interactive visualization capabilities.

The Access Grid room at Indiana University is located in the Information Technologies building and it is very similar to the other two universities rooms. This setup is shown in Figure 3.



Figure 2: Iowa State University in the Fall 2004 Introduction to Virtual Environments class participate in a lecture delivered from Purdue University



Figure 3. The Indiana University Access Grid node

Introducing AG-based Courses on Campus

In addition to the technical requirements discussed above, there are a number of non-technical issues that must be addressed when designing a synchronous, interactive course across universities.

Scheduling

The first issue is one that may appear innocuous but can quickly become a source of trouble: scheduling. Even when teaching a traditional single session course at a university, finding a room with the right space requirements, instructional technologies, and available time slot can be difficult. With multiple sites and universities, the problems become even more complex. For example, each university usually has a set schedule of what times classes begin: on the hour, 10 minutes past the hour, on the half hour, etc. It is unlikely that all the involved institutions will share the same time schedule, and some may be quite resistant to professors' attempts to start a class at a non-standard time. As a result, it may be necessary to resort to blocking out 2 consecutive sessions of class time, then discussing informally with the students that the actual lecture period will start and end at certain times during the 2 hour session. In cases of only small differences, the extra 5 or 10 minutes at the beginning or end of class can actually be helpful as it gives each site some time to discuss any issues relevant to only that site (for example, questions such as "How do I login to the computers in the lab?" can be addressed).

An additional complication occurs if all the sites are not located in the same time zone, which can eliminate several hours of each day from the list of potential candidate meeting times. In the case of the Purdue-Iowa State offering of the course, Purdue University is located in a section of Indiana that did not observe Daylight Savings Time when the course was offered. This meant that while the Iowa State class met at the same time throughout the semester, the Purdue class met at the same "clock time" as the Iowa State students, but met one hour later the other half of the semester in order to meet at the same "real time" as the Iowa State group.

Course Time Length

Related to the issue of meeting time is the issue of total course time. Each university may have its own requirements regarding the number of lecture and lab hours for a course, course prerequisites, or the exact content that must be covered during the semester. These requirements may not be the same at each participating institution. For example, the Iowa State University Introduction to Virtual Reality course does not include a lab session, but the Purdue course does. In addition, students in the Iowa State University course often come from engineering or computer science backgrounds, while Purdue students often come from the Computer Graphics Technology department, where there is less emphasis on programming and technical issues, but more instruction in modeling and animation. For these reasons, we feel that the AG may work better for delivering graduate level courses where instructors have more individual freedom in structuring course activities, content, and time length. We have also found it helpful to have the shared lectures concentrate on general information, conceptual ideas, and group discussions and to reserve technical information regarding local hardware and software implementations for local (non-shared) laboratory sections.

Instructor Interactions

The above factors imply that the instructors at each site must be flexible and willing to adjust content and requirements so that each site is able to provide a course that meets the local objectives. Frequent, open communication between instructors is a must. This can take a variety of forms such as emails, phone calls, or videoconferencing (having only the instructors meet in the Access Grid venue for 5 or 10 minutes just prior to each lecture can be extremely productive). Disagreements are bound to occur, and instructors should be willing to listen to alternative opinions and compromise when necessary to produce a course that is of value for students at all sites. As discussed above, such disagreements can often have a positive impact on the course, as students have the opportunity to see and hear about different viewpoints and gain some insight into the process of working as a team.

Lessons Learned

The AG facilitates cross-campus class sharing, however, it presents interesting challenges both from the instructors' and the students' perspectives. It provides a novel environment, mediated by technology, in which even the smallest

detail can make a difference. This section discusses our lessons learned in the teaching of the Introduction to Virtual Reality course across ISU, Purdue, and IU.

Instructor Perspective

The AG provides an excellent way to bring additional expertise into the course by teaming up with faculty colleagues at other universities. This teaming has a significant number of advantages. On the day-to-day routine, it makes it much easier to balance the busy faculty life of research and teaching. Typically, when a faculty member needs to travel to attend a conference there is conflict about what will happen to the missed lectures. For general courses, other faculty in the department may be able to cover a lecture; however for specialized courses it is difficult to find another faculty member with the knowledge to deliver a lecture. Through collaborative teaching with faculty from other universities, lectures are always covered, through one faculty taking the teaching responsibility while the other is traveling, or both faculty can join the lecture via AG from wherever they may be. Since delivering courses over the AG, the authors of this paper have been able to provide all the lectures at the scheduled times with at least one of the instructors delivering the lecture from his or her classroom.

Collaborative teaching has enriched the class content. For example, one of the authors of this paper is a pioneer in the area of Virtual Reality. Her work on developing the CAVE system (Cruz-Neira 1992) and VR Juggler is typically covered in most virtual reality courses. Students from all campuses have the opportunity of interacting with her and have discussions about her work and the motivation behind her work. These kinds of discussions are very appealing to students because they get first hand information from the researchers that are developing the field covered in class.

Another interesting aspect of working with the AG is that students got adjusted to the system fairly quickly and soon the fact that we were all located in different places made no difference in the interaction. Some students developed friendships through the class meetings even though they had never seen each other in person. Interestingly enough, some of them ran into each other at the end of the semester at a conference and they behaved as if they were “campus buddies” since long ago.

It was also interesting to note the interactions between groups of students with complementary backgrounds. In any given semester, some students were computer science and engineering majors with strong programming and systems perspectives, while others were computer graphics technology majors with extensive content development and media expertise, and still others were informatics majors with an interest in human-computer interaction methods. The students developed a true understanding and respect for the expertise represented between the sites and learned to benefit from each other’s complementary perspectives and experiences. The instructors selected course assignments, including research paper reviews and project presentations, to facilitate student discussions and to foster inter-site interactions.

Perhaps the most noticeable potential limitation of the AG for teaching is due to the transmission delay among the different sites. It takes some time for the instructors to realize that what they are saying is being listened to a few seconds later. So, when they ask a question of the students, or open the class for discussions, the instructors need to accommodate for this delay and not interpret a few seconds of silence as if none of the students has anything to say.

On the technical side, we have learned that although the AG technology is very stable, it still has unexpected behaviors that cause the system not to be ready at the beginning of each lecture. The instructors had to add an extra 15 minutes before each lecture to come to the AG rooms to test all the connections and information transfer to make sure everything was working properly. Typically, the system support group at each site did a detailed testing each lecture day followed by the instructors running over all the materials used in the lecture. It also took some adjustments to integrate different kinds of media, such as DVD playback, primarily from the technical integration of the hardware into the AG framework. Fortunately, all campuses had good system support groups that were able to work through all the details in the early stages of the collaborative teaching activities.

Another aspect of using the AG is that instructors may be a little limited in the use of whiteboards to clarify any concept covered in class. Our video cameras can capture the whiteboard, but sometimes it is hard to read at other

sites due to lighting conditions, ink color, and other details. We have found that it works best if we use electronic whiteboards integrated directly into the AG technology.

One more issue has to do with instructor preparation time and preparation style. Because all the information needs to be shared live during each lecture, the instructors need to have a well-defined protocol on how the materials are developed and distributed before, during and after the AG sessions. Any new materials using different media need to be tested ahead of time. Definitely, it requires a much higher degree of preparation and coordination than traditional lectures. In general, we have noticed that using the AG places a small increase on the faculty load upfront of each lecture, while it reduces the off-line interaction with remote students. We find this change on the time schedule for courses very beneficial, as it leads to less instructor-student miscommunications.

Student Perspective

We have not yet performed any formal evaluation on how effective AG collaborative teaching is. However, in the past three years, we have collected a significant amount of comments and suggestions from students that have taken the courses. In general, student feedback has been very positive, in particular for those students that have also used more traditional distance learning tools. The fact that they can be active participants in the classroom is the most important factor for the students. The ability to ask questions during the lecture, bring their own opinions during class discussions, and “meet” their classmates offers them a classroom-like experience even when they are participating from a remote location via their laptop. Many students have commented that they feel they get much more from this style than from web-based distance education courses.

The possibility of developing classmate relationships with the rest of the students is also very valuable. Students in the AG classes tend to exchange information via email and help each other on projects and homework as if they all sat down next to each other in the classroom. This dynamic interaction among students is almost non-existent in many conventional distance education courses and we think it has a strong impact on the potential benefits of AG-based course delivery.

One aspect that the students see as a potential shortcoming is that some instructors, in particular those delivering the lectures without local students, tend to deliver the lecture without providing many opportunities for remote students to interact. As mentioned above, instructors need to plan for the inherent delay in the transmission to allow all students, both local and remote, enough time to respond to a question or provide an opinion.

Future Work

Our early experiences of using the AG as a platform for shared courses across campus have been very positive. We expect to continue and increase the number of courses offered in this manner, as well as integrating other universities into these courses.

At this moment, the management of the AG lectures requires an operator supervising the class, making sure the transmission is going well and that no sites are being dropped. This operator also can manage the cameras to send different views depending on the activities that are taking place. Furthermore, some of the integration of teaching tools is not very straightforward, so at this moment, it is necessary to keep this operator during the lectures. As we expand the use of the AG, we need to investigate ways to make its use more transparent for the instructor and less dependent on the operator.

Part of the future work relates more to “politics” than to academic issues. For example, if multiple universities are sharing an AG-base course, which university gets to register the remote students? This is a very sensitive issue, as enrollment numbers are one measure of success in most programs. Coordinating with administration the management of these courses will result in a paradigm change in how registration and enrollment is being accounted for. At the time of writing this paper, we have started discussions with administration to find a good solution to this potential issue.

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