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Experiences with Distributed Open Source Courses

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Abstract

The field of information technology extends continuously. This implies an increased number of IT professionals as well as rapidly evolving technologies. In universities, the challenge is to manage increasingly large student groups, while at the same time the teachers need to use a lot of time in developing new IT courses and updating the old courses. Unfortunately, many universities face the lack of teaching resources to deal with the situation. To address these problems we have started an Open Source Courseware (OSCu) project. The fundamental goal of the project is to increase cooperation between universities in course development. In this project we produce open source course materials, and use these materials for distributing courses to several universities. The distributed course model offers universities an easy and inexpensive way to broaden their course selection and to distribute knowledge between teaching personnel from different universities. This paper introduces the principles of the course material production and the distributed course organization in the OSCu project. We also discuss the issues noticed when planning and implementing our first course according these principles during spring 2002.

Keywords: university education, distributed course organization, course material reusability

1 Introduction

The continuous extending of the field of information technology results in two basic problems in university education. Firstly, more and more students need to be educated in IT skills. Therefore, there should be more professors to teach and mentor the students. Due to the lack of professors, many courses — especially basic ones — are predominantly given by teaching assistants. Secondly, the scope of the field is extending so rapidly that the teachers need to invest a lot of time for their personal state-of-the-art knowledge. A lot of effort is also needed in order to keep the teaching materials up-to-date with the latest technological advancements.

The two above factors are the basic causes for many practical problems in software engineering education. The courses are difficult to organize due to large class sizes and constantly changing teaching staff. Especially teaching assistants change very often because of changing or finishing their research projects, or leaving the university for a position in the industry. Due to the lack of professors, the leaving assistant may have had a whole course on his/her responsibility. Therefore, the courses must be very independent of the teaching staff. In fact, they must be designed and documented so that the lectures can be given by anyone with enough knowledge and experience of the contents of the course. Another problem is, that all universities do not necessarily have any teaching personnel with enough knowledge to build a new course about the latest issues on some particular emerging expert area.

These problems are difficult to solve with traditional means within any single university. Therefore, we have approached the problem with a scheme that relies on the cooperation between several universities in course development. A project named OSCu (Open Source Courseware) started fall 2001 by three Finnish universities, Tampere University of Technology (TUT), Oulu University (OU) and the University of Tampere (UTA). In short-term, the idea of the project is to offer new courses and to improve cooperation between universities. In the long run, we aim at an eased exchange of high-quality courses between universities, with an option to train teaching staff via distributed courses. Courses given in the scope of OSCu will be documented thoroughly for easy adoption by the teaching staff in other universities. With the centralized course material organization, we have a possibility to build an always up-to-date course material bank that collects experiences and latest material updates from course developers. At the same time, we can offer all the universities an easy access to the course materials.

There are also several other ongoing projects dealing with similar issues, for instance Candle [3], CUBER [6], OR-World [18] and UNIVERSAL [19] projects. Also these projects aim at better cooperation and course exchange between universities. They, however, mainly concentrate on course material banks whereas we have concentrated on developing a working cooperation scheme for implementing university courses. Therefore, while the course material production and archive are important issues also in the OSCu project, these issues are considered mainly from the viewpoint and practical needs of the distributed course implementation model and face-to-face education. Just after the planning of the OSCu project was launched, also MIT announced its intentions of releasing open courseware on all their courses in MIT OpenCourseWare initiative [15]. Their

project concentrates at offering their materials publicly available as opposed to the OSCu project where the aim is at a continuous cooperative development of the courses.

The rest of this paper is structured as follows. Section 2 describes the idea of considering a course as an individual project entity that should be developed for best possible portability. Section 3 introduces a distributed course model for organizing courses simultaneously in several universities with local support and tutoring for all students. Section 4 presents the requirements we have planned for course material production in order to obtain reusable course materials. Section 5 introduces selected technical implementation for delivering course lectures in the distributed model and section 6 provides an insight to a course organized according to the introduced practices during spring 2002. Section 7 lists the next steps of the project and section 8 concludes the paper.

2 Course as a project entity

At the Institute of Software Systems in TUT, basic software engineering courses have already for several years been typically given to several hundreds of students at a time. The constant lack and change of personnel and other resources have forced us to invent efficient ways for implementing and organizing the courses. The strong engineering background of the laboratory personnel has led to a practice where each course can be carried out as a team project, like any conventional engineering project. The analogy is straightforward. A well organized course has exact dates for the beginning and the closing, agreed personnel and teaching material, well-defined tasks for all the personnel, and checkpoints and documentation regarding the progress of the project. This change from the traditional teacher-centered to course-centered thinking gives us the basis for the OSCu project.

2.1 Teacher independent courses

The basic idea is to give each course a status as an entity of its own, not linked to any person. In TUT this has been supported by assigning each software engineering course a user account on the computer network. Course home directory provides a static archive for all course related materials, structured according to their role in the course instruction. Moreover, courses have their own webpages and E-mail addresses for interacting with students. When teaching personnel changes, the new lecturer (or other course personnel) immediately has an access to all the old course material for him/her to freely use and to develop further.

When a course is given, a team is gathered to implement the course as a project. During the implementation of the course, this team meets weekly to discuss urgent issues and course progress and to ensure that all the crucial issues have been addressed. These meetings are recorded in the minutes and by the end of the course the collection of these minutes forms a 'course diary' to document the implementation and progress of the whole course project.

2.2 Cooperative course development

Experiences gained at TUT have evidenced that the above scheme enables smooth transition when people responsible for lectures, exercise sessions, and overall bureaucracy change over the years. Therefore, we have used this idea as a guideline when planning course development practices for the OSCu project. When refining the course material production process to produce as university-independent and well-documented material as possible, the course can be adopted as such even to other universities.

The Institute of Software Systems at TUT has some experiences of using these principles to provide complete courses successfully to other universities. In this project the goal is, however, instead of just delivering a course material packet, to start a continuous cooperative course development tradition between several universities. With active usage of a course, its materials get updated continuously and gradually the course combines the knowledge of several experts of the field. In practice, naturally, it is usually only one teacher who originally creates the course, but when he/she releases it freely for others to use and modify, we will get to our goal of cooperatively maintained course material bank.

2.3 Dividing courses into subsections

Traditionally course curriculas differ greatly between different universities. Because universities define their study programs independently, they also have different kinds of basic and advanced courses which often combine issues differently from other universities to form the course curriculas. Therefore, it may be difficult to include a new course from another university to the study program without overlapping already existing courses. In such a situation, teachers may not be interested in all the issues covered by the course available, and would like to use only part of the course to complement one of their courses.

As a solution, we have defined in each course how they could be divided in smaller sections. Each section contains lectures, exercises, course projects and other usual course content, but forms a smaller entity than the whole course (usually roughly 1.5 ECTS credit units). With this practice, we hope to increase the ease for taking these course materials into use. Naturally each subsection contains preknowledge requirements that must be taken into account when adopting the study unit into use.

3 Distributed course model

A complete set of course materials is not, however, always enough to help a teacher to prepare him/herself to give a new course. The teacher may, for instance, not have good enough experience of the issues covered in the course. Moreover, it is

always difficult to just adopt somebody else's material if one has not seen the original author using it, or otherwise know how the material was planned to be presented. Documented instructions about the material usage and videos of the lectures do help, but still, the teacher may not feel him/herself confident enough for giving the lecture to an audience.

With open course materials, however, it is possible to allow universities and the student groups in them to join the course hosted by another university and to see in practice how the course is given. After joining the course a few times as a remote participant, the university has enough competent course staff to teach the course themselves with the provided materials. The university could also decide to stay with the courses as a remote partner with the other university taking care of the leading of the course.

3.1 Distributed tutoring work

In many cases, remote courses are organized by simply allowing students from other institutions to take part in the university courses by travelling to the university premises or studying through the possibilities provided on the internet. This increases the workload of the university that provides the course, since each of the distant students needs tutoring by the university teachers. Especially when communicating by E-mail etc. teacher's workloads are high, since answering questions and providing feedback in writing takes inevitably more time than face-to-face communication.

In contrast to these practices, our approach for sharing courses does not rely on tutoring all the participating students only from one point. All the universities have their hands full with the limited resources to deal with their own students. Therefore, it is not possible to take care of the students from other universities as well. Rather, the additional tasks of the course providing university should be minimized, and each university should take part in the course implementation when concerning their students.

The basis of our distributed course model is presented in the following. Well-documented course materials define the contents of the course. A hosting university takes care of lecturing, planning, and general control of the course. They set the timetable for the course and deliver lectures and materials for all universities. Other participating universities take care of their practical arrangements, giving exercise sessions, tutoring their students and grading their course works and exams locally by themselves. From the viewpoint of the hosting university, the course is different from the usual only in that all the student groups and course assistants are not physically located in the same premises.

3.2 Multi site course management

With the practices presented above, a local course has changed into a multi-site project. This brings us the challenges of synchronizing the course contents in different locations and keeping the whole project from falling apart. At TUT we had already some experience of organizing courses with this model. We have used similar model for importing a course on software security from another university during years 1998 and 1999. The constant staff meetings useful in the single-university settings are an absolute necessity in a multi-university setting. These meetings are the only way for controlling the whole course project and keeping close contacts between all teaching staff, no matter which university they work at. Also the minutes of each meeting are irreplaceable when there are many issues to be covered and possibly some persons are unable to attend the meeting.

This coordination and synchronization work inevitably increases the workload of the course providing university when the number of course sites and course personnel increases. Although the workload of the providing university does not increase linearly with the number of distant students, every university adds a new need for coordination when joining the course. But since the course would have been given in the hosting university anyway, this is much less extra work that would have been required if they would have organized a separate course or tutoring for a similar number of distant students. The university that provides the course also gains valuable feedback and development suggestions for the course from the students and staff of other universities.

3.3 Student's point of view

Including courses from other universities to a degree at home university often demands a lot of bureaucracy between the institutions. Students are required to find out themselves about suitable courses and negotiate with professors whether they can participate the course and if it can be accepted to their degree. Many forms, applications etc. need to be filled by students, professors, student office secretaries etc. Still this is becoming more and more common, because students are better aware of their field and want to study also issues that are not offered at their home university. In addition to the extra bureaucracy, taking courses from other universities brings forward also other issues. Different universities may have different schedules for semesters and exam periods, different means for intercourse communication and practical exercises etc. on the course. A student needs to adapt the whole 'culture' of the university in order to participate a course at it. Also technical support and course tutoring for visiting students may not be organized as well as for the local students, especially when studying over the internet.

The presented OSCu model does not have above mentioned problems, because the students are studying at their home university. When a teacher decides that their university participates to a course as a remote partner, he/she defines and announces the prerequisite courses needed at their university, the degrees it can be included to and which students are allowed to register for the course. For the student the course seems as an additional optional course and is registered to his/her degree as any other course given in that university. The study community and culture are the same as

usually in the university. And if course exercises etc. require new tools to be used, a local tutor supports the students in these technical as well as in any other course-related issues.

As presented, this model is mainly used for distributing a course between student groups at different universities. It has been seen as an important part of the lecture that the students get together to a group (with a lecturer or a local tutor). Also for the students of the remote university the course appears like a normal university course, except that the lecturer is not physically present at all universities. It is also possible for the students to form study groups of their own and join the lecture in their own group. This is convenient, for example, if there are several university students working in a same company, and the company offers them a chance to study during the workdays. It is common for today's university students to work besides studying and by this method they can more easily combine their work and studies and thus reach their degree although working at the same time.

Students can also be offered a possibility to follow the lectures anywhere by themselves, if the lectures are delivered freely over the internet. But then the idea of a lecture situation is lost. When gathering a group of students together to follow the lecture, the students are more concentrated than when sitting alone by a computer watching the small live video picture several hours in a week. The OSCu project aims mainly at easing the development of traditionally given courses, consisting mostly of contact education and having a fixed timetable. However, there are no restrictions why these basic ideas could not be transferred also to courses that are partly or completely given and tutored over the internet.

3.4 Vision of the scheme

With the presented distributed course model we could have, for example, following development. Professor A in the university X decides to produce a new course on the latest developments in ubiquitous computing. Universities Y and Z both have a considerable number of students who would like to study these issues, but their university does not offer any courses about them. University Z does not even have any staff to develop such a course from a scratch. Thus Y and Z ask to join the course and hire teaching assistants C and D, respectively, to take care of the local organizing and tutoring tasks. A big group of students from university Y works in company N and the company provides them a possibility to follow the course lectures in the company premises. Figure 1 presents the situation in a graphical format.

Next year university Y decides to change the course language from Finnish to English. They produce a new version of the course and begin to offer it to their students. University Z has both English speaking and Finnish speaking students, so they join both the Finnish version of the course from the university X and the English version from the university Y. They can now offer two optional courses for their students with the work resources of two teaching assistants and without a need for a lecturing professor.

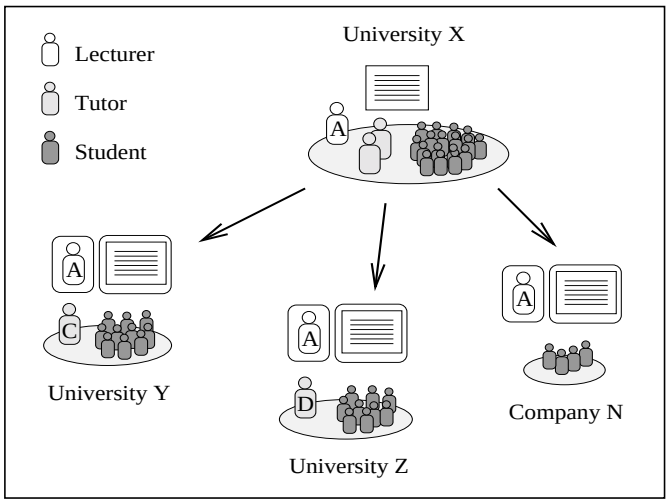

Fig 1: Distributed course organisation.

When a couple of years later professor X retires, the teaching assistant D from the university Z has been assisting the course so many years he/she is able to take the responsibility of the whole course and the university Z begins to host the course also for the university X. The new situation is illustrated in Figure 2.

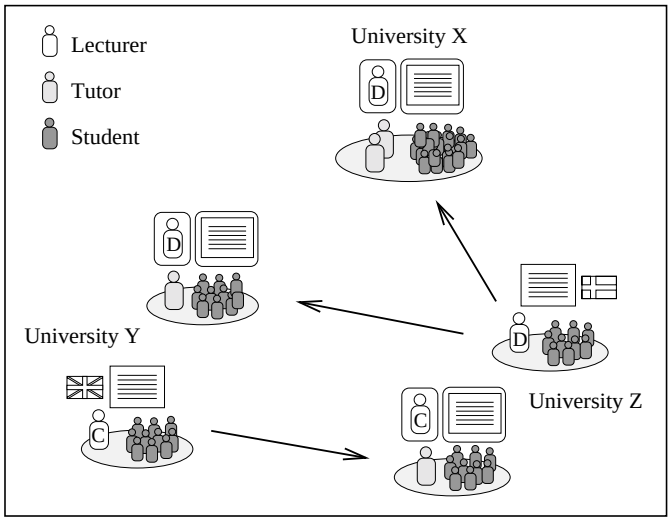

Fig 2: Revisited distributed course organisation.

4 Guidelines for course material production

OSCu courses are designed to be offered also to other universities and by other teachers than the original providers. Therefore, all the material needs to be structured and provided with information of the content and teaching methods planned for the course or the content part in question. Since courses will be created by several teachers, we need a set of specific guidelines in order to build a common course material bank, where the courses can be easily accessed, used and modified

by anyone. The main issues in archiving the materials are introduced in the following.

4.1 Copyrights and material delivery

Firstly, in order to achieve free usability for all teaching material developed in this project, we have made an agreement about the principles of material copyrights. All the course material will be provided under GNU Free Documentation Licence [8]. This assures that the materials will be given freely for anybody to use and modify as long as he/she agrees to the licence, i.e. after his/her modifications gives the materials forward under the same licence. OSCu coordinator maintains the central material archive and the consistence of the course material delivery packages.

Although the materials are offered freely for use, we do want to keep track about the places where these materials are used and gather feedback and the latest updates to the materials as well. We also need to control that students cannot automatically load themselves e.g. exam questions and answers from the course they are participating. This requires authentication and restriction methods to be implemented to the material management and delivery system. At the moment, when the number of courses and participants is small, we manage this with E-mail-based interaction and UNIX file hierarchies. Later, however, when dealing with increasing number of material requests, we plan to implement a WWW-based inquiry system for searching and delivering materials. Until then the materials can be requested by E-mail from the project coordinator (1st author of the paper). During the first couple of years, the course materials are developed for teaching in Finnish language, but later we will develop also course packages in English.

4.2 Contents and structure of the materials

For understanding how the course materials were planned to be used, each teaching entity should be provided with instructions for the teaching staff. For instance, we have stated for all exercises that the material for an exercise session must consist of at least following items: exercise questions, model solutions and an instruction file containing the goals and main points of the exercise session and a description of preferred working and tutoring methods. With distributed teaching model these instructions support several teaching assistants and assure students the same level and contents on exercise sessions in all universities. For assuring enough information to the instruction files, we have stated the fields and minimum requirements about their contents.

In addition to stating the required files for each item we have also given instructions about the directory structures for courses. The goal is to have similar file and directory structures in each course so that the materials are easy to maintain and access. Figure 3 gives an example of the planned file structure for course and course exercises.

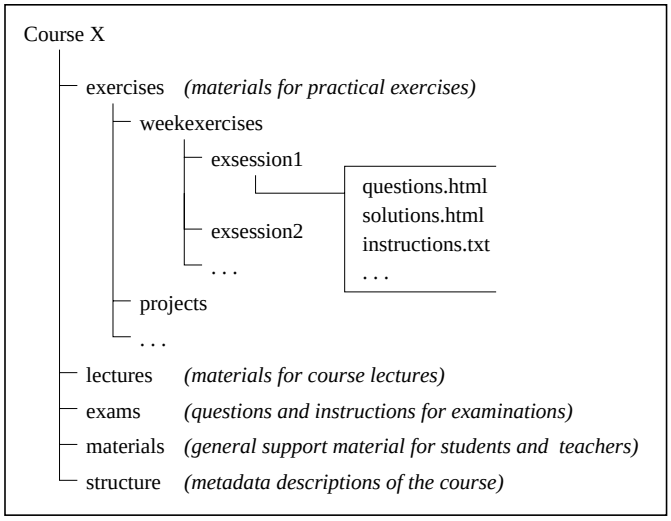

Fig 3: File structure for course materials.

For best possible portability, the materials are instructed to be saved in standard formats, for example as ASCII text or Hypertext Markup Language (HTML) files. No proprietary word processor formats, for example Microsoft Word documents, are allowed, since these formats are not stable and restrict the environment the teachers should work in. We have not, however, found a good solution for a lecture presentation format. The transparencies could be saved and presented as a Portable Document Format (PDF) file, but then they could not be modified by the next user. LaTeX [14] system is a good option for teachers that work in UNIX environment. However, it does restrict the user environment, since there are not LaTeX versions for all platforms. Finally we came to the conclusion, that the lecture transparencies are saved as PowerPoint presentations [16], as long as there are no generally used standardized formats for presentations available.

4.3 Metadata descriptions

At the moment there are many ongoing development projects, for instance Ariadne [1], IMS [10] and Dublin Core [7] for developing standards and practices for reusable teaching materials. There are also both national and EU initiatives to support the localization and usage of the standards and recommendations, for instance SCHEMAS project [19] and the Finnish TIEKE organization [21]. Since we aim at a large bank of course materials, that are easily available for everyone, we have actively followed the progress of these projects. We see it essential to be able to attach to these courses information about the contents, version, keywords etc. Because most of the existing description practices seem to converge towards IEEE Learning Object Metadata (LOM) Standard draft [9], we have decided to use it as a basis for our metadata descriptions. LOM is meant for describing all teaching material units, starting from very little entities. This, however, sets a heavy workload for the teachers, who at the same time should write and develop the material itself.

At this point we have come to a consensus of adopting a practice where only major units such as courses and their 1.5 ECTS cu subsections are provided with formal metadata. Smaller units, e.g. exercises, have only textual instruction files for describing their purpose and usage as previously introduced. This provides sufficient support for reuse for us at the moment, but we follow the situation and change the practices if seen necessary. With the present implementation, it is possible to later add metadata descriptions also for smaller entities, relying on the present instruction files. However, adding more metadata descriptions requires definitely us to be able to provide the teachers a good editor for attaching the metadata descriptions to the material files.

An important issue in constructing a data archive is to design the material descriptions for best possible searchability. The LOM specification sets basic classification rules for the material: user role, material level, discipline and a field for keywords. It does not, however, define the vocabulary for the keywords. This is understandable, since there are no international glossaries that would be actively updated and contained at least reasonably good variety of terms for all possible disciplines. For computer science there are a few thesauruses, from which the ACM Computing Classification System [2] is probably the most widely known and used. For example, the CUBER project [6] uses the terms from ACM in their metadata descriptions. With a general vocabulary, however, there is always the problem that it does not contain the latest terms nor the most commonly used ones. Therefore, we use both terms from the ACM term list and free terms of author's own choice in the material description. This increases the probability of search matches considerably when there are also search terms from everyday life of the field in question. Naturally the search engine should also have synonym mechanisms.

4.4 Documenting experiences and feedback

Traditionally, when a teacher develops a course and teaches it, he/she gains experiences by which he/she can develop the course further. As mentioned before, at TUT this is supported by collecting documentation of the weekly meetings of the course personnel. This provides the teacher next year a possibility to read this course diary and see how the course was implemented and whether any problems were faced. With this kind of collected data it is much easier to develop the course implementation further. Since in our project the teacher of a certain course is assumed to vary often, it is all the more important to provide practical information about the previous course arrangements and about the possible problems and considerations teachers should take into account.

With distributed courses the hosting university is required to collect a general course diary and all participating universities are required to write a report at the end of the course. In this report, all universities are required to document their local arrangements together with conclusions about the course implementation and student feedback from their side. These reports and the general course diary are then saved as a part of the course material for future course teachers.

5 Lecture implementation in the distributed course model

For the students, lectures are the most important part of getting introduced by an expert to the new ideas and issues of the course. Due to the lack of literature on latest advancements on the field, the lectures often provide information that cannot be obtained anywhere else. Students do always have a possibility to download or copy lecture transparencies, but documents never offer the same information as when presented by a person with experience of the issue. Naturally course learning objectives are also supported by practical exercises and course projects. However, students still need to first get the knowledge and the new ideas in order to be able to apply them in the exercises.

Also with distributed courses, lectures are an important part of the course. In all universities the students gather together for lecture sessions, and have a possibility to present questions and to discuss course related issues with the lecturer, tutor or with each other. Our task was to design a technical implementation that would support normal-like lecture situation in all universities, no matter where the lecturer was physically located. One of our main restrictions was, however, that no one of the participating universities would need to make big investments for setting up the course, since this would most likely discourage universities from joining the course.

5.1 Selecting technologies for the lecture delivery

There were some basic requirements for the technical implementation of the lectures. Firstly, we needed to implement two-directional interaction between all the universities. The goal was to simulate a traditional lecture so that all students have the possibility to present questions to the lecturer, no matter which university they follow the lecture at. Thus there should be almost real-time video and audio delivery between all universities. For example, sending a video stream from the hosting university would not have fulfilled the requirement, because of the delay caused by packing and unpacking the stream for presentation. Videoconferencing devices and software make it possible to deliver pictures of all participants to each other, so we decided to use them.

The next step was to decide the details for the videoconferencing connection. One of the ideas of this project was to develop a model where new participants do not need big financial investments on the technical arrangements. Therefore, we needed a solution for best possible multipoint videoconferencing connections with moderate costs. An ISDN-connection (H.320 standard [11]) would provide a

reliable connection with a constant bandwidth, but requires a special video conference room with ISDN connection and equipment. This option had to be discarded both because of the high costs of such systems and the requirement for a special room. Most of the software engineering courses are very popular and can have several hundreds of students. They would not fit into any videoconferencing rooms, thus we have to be able to organize the lecture in normal class rooms. This left us with two IP-based videoconferencing possibilities, Mbone tools [20] and H.323 standard [12].

The biggest Finnish university cities have the benefit of being connected to each other with 1.5 Gbit FUNET connection [5]. The connections also to other universities are good and all universities have a local network available at least in some of their class rooms. Thus the present project participants and most probably also future members have the possibility for an IP-based connection that would not cost any extra fees. There are also several IP-based videoconferencing software products available very economically or even completely free of charge. IP-based video conference equipment can be set up with low costs to any room with a network connection. The drawback of the IP-based equipment is that they are sensitive to any problems in network connections and to the load on the network. With Mbone tools it is possible to form multipoint connections easily. Unfortunately the tools themselves are difficult to use and the multipoint sessions very complicated to set up. So we decided to use H.323-based tools for the video conference and use a multipoint control unit (MCU) for forming multipoint connections. This would not add the costs, since a few universities already have a MCU and also CSC, Scientific Computing Ltd. [4], offers MCU services for Finnish universities free of charge.

5.2 Implementing the lecture situation with videoconferencing devices

In a normal lecture situation a lecturer is situated in front of the audience and students can see the lecturer and the other students in the same room. In a distributed lecture situation all students naturally need to see the lecturer, but it is rather irrelevant for them to see the students from other universities. The situation is meant mainly for lecture presentations, not for discussion between different student groups. The student collaboration can be organized during exercises or via internet discussion groups, if considered as a good form of education for the course. With large student groups a course wide discussion would be impossible to manage anyway. Thus the questions during lectures are to be presented either to the lecturer or to a local tutor or to the local students. A local tutor or professor is always available in the lecture situation to discuss course-related issues with the students during lecture breaks or exercise sessions. Hence, during lectures we send video only one way, from the hosting university to the other student groups and use the two-way connections only for delivering audio between universities.

The practical lecture arrangements are simple, and can be implemented in any room with network connections. The lectures are given in the hosting university in an auditorium, equipped with a video camera and two computers. Other universities need two computers and data projectors to participate to the lectures. A video conference connection is established to deliver the picture of the lecturer to all universities and to provide a real-time audio connection between all sites. The video picture contains only the lecturer, and lecture transparencies are delivered in a separate connection with the second computer. By this arrangement we do not need an camera expert to mix the picture of the lecture and the transparencies or to plan how to alternate the sending of them in a real-time situation.

This two-connection arrangement also adds some technical reliability to the lecture situation. If one of the connections fails, the other one might still work and the students are not totally lost during the time it takes to reform the connection. Unfortunately, this is not a rare situation in videoconferencing, especially when implemented with small-scale conference equipment that are not as reliable as heavy videoconferencing systems. The presentation delivery is organized by application sharing over internet via the T.120 standard [13]. This form of connection is pretty stable and usually works more reliably than audio/video connections. With application sharing the remote universities can share the same view of slides and other material that is projected from the laptop to the audience at the class room of the hosting university.

Figure 4 presents the communication connections necessary for the lecture situation. University X delivers the picture and the voice of the lecturer to the universities Y and Z. All universities have a two-way audio connection to each other. MCU takes care of the sharing of the audio and video transmissions to all sites. Application sharing can be carried out without a multipoint connection unit.

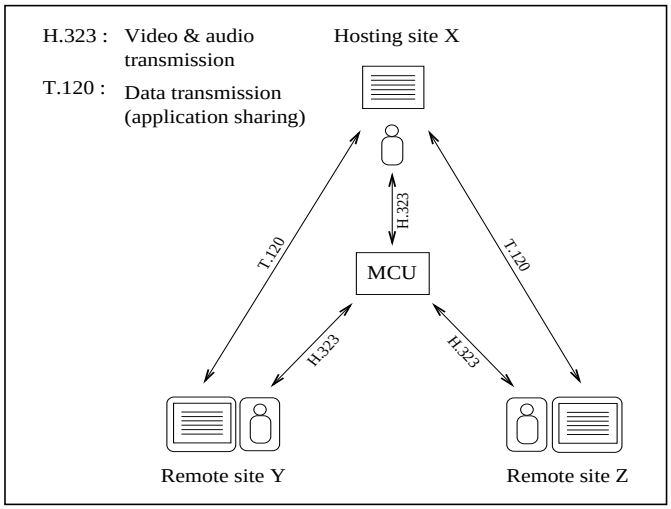

Fig 4: Communication connections between different sites in a lecture situation.

5.3 Following lectures without attending them

IP-based videoconferencing equipment in lower price classes does not provide other features than basic videoconferencing. More advanced systems also offer connections for a video recorder or a possibility to provide video stream of the lecture. Also some MCU's can provide these features. The audio- and video broadcast can be transformed to video stream and sent to internet real-time for anyone to follow. When combined to a WWW-based application sharing, this provides a mechanism for the students that are unable to be physically present in the lecture session to follow the lecture by their own computer. We do not, however, encourage students to use this as a primary form of following the course lectures. Real-time stream delivery will be combined to some of the courses during fall 2002 to gather experiences and feedback from students and teachers.

Streaming or taping the lectures to a traditional video provides also a possibility to later edit these lectures into a self-studiable form with synchronized transparencies and lecturer presentation. These kinds of lectures can be offered to students that were unable to follow the lecture real-time or otherwise want to revise the contents of the lectures. The best way to provide these lectures for students would be a media server, where the students could select easily the parts they are interested in by winding the lecture forwards and backwards. During spring 2002 we have taped two of the course lectures in order to test the equipment and the editing process. In fall 2002 we plan to save all the streamed lectures and synchronize them with the transparencies for both the students and the teachers to study later.

6 Implementation of a trial course

During spring 2002, we have organized the first prototype course according to the presented guidelines. In this instance, the subject was *Programming of mobile devices*, with 4.5 credit units as its size. The course was hosted by Tampere University of Technology, and participated by the universities of Oulu and Tampere. In addition, a group of TUT students working at Soon Communications, a local telecommunications company, participated in the course by following the lectures on the company premises. This corresponds to the general situation presented in figure 1, with TUT as the hosting university X and OU, UTA and Soon Communications as remote course sites.

The number of participating students ranged between 20 and 80 at the different sites, with the total number of students being around 150. The total number of teachers and assistants involved in organizing the course was 10, with the majority of personnel working for TUT. In addition, Soon Communications had their own coordinator, who took care of their technical arrangements on a voluntary basis.

6.1 Course material

This was the first time the course was organized. Therefore, the material needed for the course was created and collected more or less single-handedly by the lecturing professor during the fall 2001. The lecture material was handed out to the students at the beginning of the course, which was considered as a necessity for the course to succeed due to the distribution scheme. After that, all material has been collected, completed with exercise and exam materials, and formatted as instructed in Section 4.

The lecturer has developed the course further during the spring. In practice, simultaneous planning of the next and implementation of the current version of the course has required two course folders, similar to the basic course folder model presented in figure 3. One of the folders has been used for recording what has been done this year, and another that includes the improvements for next year. The recording folder includes diaries updated each week concerning the current situation at the course, and the feedback coming from the participants. In contrast, new material includes improved lecture handouts and some new ideas on how to organize exercises next year.

6.2 Course personnel organisation

The course lecturer took care of the course material production, lectures and controlling the course progress. He also took care of the coordination of the course and led the weekly meetings of the course personnel. The main task of the local teaching forces was to ensure that practical matters would be taken care of and that the students in all universities would have mentoring during programming exercises. This has worked well, and no special problems have been encountered.

Local arrangements were also needed for the examination arrangements, because all the participating universities are independent and a professor in one university cannot accept credit units for another. Therefore, the course needed a professor that would take the responsibility of accepting the course examinations on behalf of his/her university. As a side effect, some personnel involved in the scheme at the different universities were of a bigger status than standard exercise assistants would have been. In practice, the professors took care of the official tasks and nominated assistants to handle e.g. exercise sessions and other practical arrangements. This works well as long as it is clear who has the responsibility and authority over practical course issues. If the tasks are distributed to too many persons, it complicates communication between the universities and the integrity of the course in the remote university may suffer.

As anticipated, the communication between the different organizers has been found very important. Due to geographical distances, weekly meetings between all the teaching staff would have been be impossible to organize in one physical location. Therefore, these meetings were aided

by communications media. Several medias were tried out during the course, including normal telephone, video conferences over the Internet, and conference phone calls. These meetings were mostly focused on the exercises, because they constituted the biggest technology transfer from one university to others. In addition, three face-to-face meetings were agreed, scheduled before, during, and after the course. Moreover, an option was made for an emergency face-to-face meeting if absolutely needed. Fortunately, no emergency meetings were required.

6.3 Technical implementation

The distribution scheme was implemented according to the principles introduced in section 5.2. In our case, the lectures were given in an auditorium, which was already equipped with a video camera, a data projector, and an audio system. For the lecture arrangement we just brought with us to the room two laptop computers and a ViGO video conference device [23]. Oulu University had class rooms with solidly installed videoconferencing equipment, thus they could use them and did not need to obtain any new equipment for the scheme. University of Tampere joined the video conference first with Netmeeting [17], but later acquired also ViGO for faster connection and better reliability in the video and voice connections.

One of the computers and connections at each site was used for the video conference. The multipoint connection was formed by using the MCU by CSC [4]. The other computer was used for sharing the presentation application from the lecturer's desktop. This application sharing was implemented with Netmeeting software [17]. At the hosting university, a separate person operated the sending of the lecture and controlled the video camera. This person also monitored the whole conference and all connections with the monitoring tool offered by the CSC. With many conference sites, it would have been impossible for the lecturer himself to take care of all the connections and monitoring while giving a lecture, thus a separate operator person was a necessity. The lecturer, however, took care of the application sharing, since those were the same applications that he showed to the students present in the hosting university. Also the remote universities had separate operators to take care of the technical arrangements of the lectures. Usually these were the same people who were also otherwise engaged in the course arrangement, thus they got a clear picture of the course entity when they also followed the same lectures as the students.

There were plenty of technical difficulties with the lecture arrangements, especially with the video conference connections. They were only two times in the whole spring semester when the conference connections were set up without problems for any of the participants. On almost half of the lectures at least one of the participants lost either voice or video connection once or more often. This could usually be quickly solved by disconnecting them totally from the conference and then calling in again. Unfortunately, this always interrupted the lecture for a few minutes for the university in question. Each university had to boot their devices a couple of times during the spring. Also microphones and their settings gave us some trouble by producing noise that we had difficulties to find the source of.

Some of the problems were caused by the videoconferencing equipment, some by the microphones and loudspeakers, and some were simply due to the load of the network. By selecting ViGO devices we obtained a portable equipment to provide video conferences at a moderate price. The total cost of running the course equipment-wise was approximately 5000 EUR, consisting of two ViGO devices and some speaker phones needed for course staff meetings handled over telephone. The laptops and data projectors were already available, so we did not need to invest on them. This solution, however, has proved somewhat unreliable, and we should potentially consider more reliable videoconferencing equipment — even if it is more expensive.

6.4 Special requirements for the lecturer

The distributed lecture delivery was a challenge also for the lecturer, since keeping the audience interested when displayed on a big screen in front of a class can be much harder than when physically present. The students from the remote universities hardly ever presented any questions even if they were asked to do so. A few times the participants were activated by presenting them e.g. a voting task about issues just covered on the lecture. The local tutors collected the results and delivered them to the hosting university. The lecturer also often used small example applications that brought some variation to the normal presentation. These example applications could be shared from his computer desktop with the same application sharing software as the PowerPoint application and thus did not need any special arrangements.

The video conference arrangements restrict the physical appearance and presentation possibilities of the lecturer. Due to the camera any rapid movements are unacceptable, because they would worsen the picture in the receiving end. Wide movements of the lecturer would also make it difficult for the camera operator to keep the lecturer in the picture. Moving in general was also hardened by the fact that camera was pointed at the lecturer, not to the projected transparencies. Thus all pointing to the presentation material needed to be done on a computer screen. This could be eased by a computer that has a touchscreen, so that the lecturer could use a pen pointer instead of a mouse. Additional challenges were to keep things focused and organized around precomposed slides, because the use of a blackboard was not possible due to the restrictions of image quality over the video connection.

For the lecturer, this means that presentations must be planned in detail, as ad-hoc discussions are hard to communicate over the video conference connection. The lecturer should always keep in mind that there is more

audience than present in the same physical room. Moreover, even simple things like questions coming from the audience require discipline, as the question must always be repeated in order to ensure that all the participants have correctly received it. The lecturer responsible for this course managed to pay attention to these issues better and better during the course. It was very difficult for a first-timer, though, as evidenced by the visiting lecturers. Although they were instructed about the special considerations and requirements for e.g. repeating all questions of the audience, they often forgot these issues and had to be reminded even during the lectures.

Some practical settings were also noticed, which become important when following the lecture by video. Firstly, the camera should be placed in the center behind or among the audience, so that the lecturer looks at the direction of it and the remote students watching the video do not feel as if the lecturer was talking to someone else all the time. Our lectures were given in an auditorium with solid camera installation at the back wall and this forced the students to watch the lecturer from a bit too high an angle. Secondly, most of the teachers have a tendency to turn to the projected presentation on the wall when explaining issues on the slide. Although a teacher is instructed not to do so but to give the lecture straightly to the audience, he/she still does it every now and then without noticing it him/herself. Therefore, it is recommendable that in the remote universities the presentation is projected on the same side of the lecturer projection as it is situated in the original class room. Also a wireless microphone, if used, should be rather kept on the side of the presentation projection if it is not possible to attach it in the middle of the body. With a touchscreen computer these issues can be helped, because then the lecturer points the slides using the computer in front of him and thus faces the audience all the time.

6.5 Differences between universities

As expected, there were some special considerations that had to be taken into account when arranging a course similarly in three independent universities. Although in Finland the general teaching semesters are approximately the same, the lecture and examination periods somewhat varied between these participating three universities. The solution was to try to organize lectures only at weeks that belonged to the lecture period in all participating universities. For this reason there were less lecture hours for use than in a normal 4.5 cu course given at TUT. However, since this was known in advance, the issue could be taken into account when designing the course and gave us no special problems.

The final exam was organized in the last lecture session. Thus, while organized locally, it was synchronized so that we could use the same exam questions in all the universities. Overall, this was a major deviation from the practices of all participant universities, as exams are usually organized after the lecture period is over. Moreover, we had problems in the sense that the normal time reserved for exams was different at different universities. In the end, we had an exam that lasted 3 hours, which is the time that the lecture session normally took. In addition, an agreement was made that the universities are allowed to have exams locally whenever found convenient after the first exam. For this purpose, a question pool was created, based on which additional local exams can be easily arranged.

Another minor problem that emerged in a very early phase of the course was that the different universities had used different information systems for group communication between students and personnel: OU uses a proprietary information system, UTA has a practice of using a WWW-based system, and TUT relies on NNTP-based UNIX News system. We solved the problem by creating a news group that had a bridge to World Wide Web via public domain gateway software. This enabled an approach where both News and WWW could be used for accessing the information. Unfortunately, it was found out during the course that the selected software was not too reliable, and some special measures had to be taken in the form of practices used in sending articles.

We also had some discussions related to the acceptance of exercises, and mentoring given to students at different universities. In the end, this was left to individual universities to decide. However, the overall guidelines defined by the hosting university were to be followed. We later noticed some differences in the level of accepted course programming projects between the universities, but with better guidelines and more communication between course staff we believe that also these differences can be leveled.

On this first course we wanted to compare student performances and thus course lecturer graded the examinations for all students. The scale of the grades distributed very evenly to all universities, thus the difference between remote and local lecturing had not affected to the students' performance in the exam. Actually, the best examination paper was completed by a student from a remote university. Figure 5 shows the distribution of the examination scores.

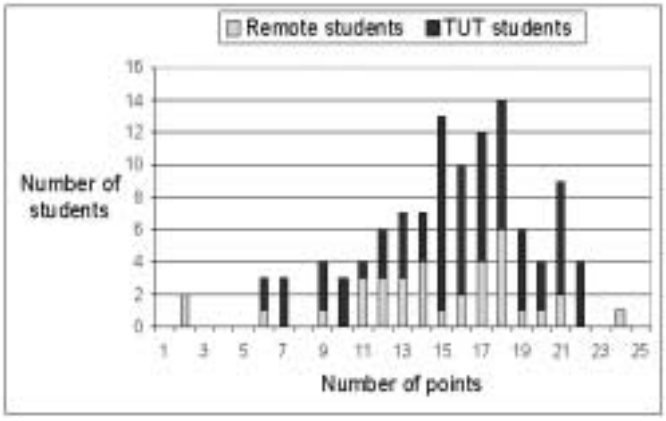

Fig 5: Distribution of examination scores.

6.6 Course feedback

We collected written feedback from course students during the last lecture, and naturally also received oral feedback during the whole spring in exercise sessions and lectures. The main points of the received feedback concentrated on the contents of the course, not on the technical implementation or organization, which was positive. Although we did have several technical difficulties during the lectures, they had not affected to the students discouragingly. The TUT students had practically no comments about the technical equipment, delays and strange noises they had been listening to in their lecture sessions. The students from the remote universities had some more comments, but relatively few persons had major claims regarding technical problems.

Admittingly, the feedback was gathered only from those students who stayed with the course until the end of it. There were also students who dropped out during the course, but the general impression was that this was mostly due to the very laboured first programming project required from the students. There were approximately 170 students in the beginning of the course, 130 students submitted the first course programming project and 106 students attended the final examination. This is a normal drop-out percent at TUT on the advanced courses that are not especially required to a degree. On the other hand there were now participating students that usually would not have a possibility to take the course because of their busy work schedules. For example, it was now possible for a TUT student presently working at a company in Oulu (500 kilometers away from Tampere), to take a TUT course in Oulu University. He attended the course with the students of OU, but the course examination and credits were directly accepted at TUT as a part of his degree.

The feedback from the course personnel was gathered in writing from all the universities in the form of the course reports that are to be saved with the course material of the year. All course personnel will also get together to a feedback discussion in May to analyze the course and the implementation practices more closely. The results of this discussion will also be taken into consideration when refining the process and methods for the courses in fall 2002.

In conclusion, the overall feeling about the course was positive. In fact, due to the requests coming from the participating universities, the course will be implemented next spring with a similar organization and process. We take this as a credit to the scheme that was used in the experiment as well as a tribute to all the participating personnel.

7 Future plans

OSCu project continues with the support of Finnish Ministry of Education until the end of year 2004. By the year 2004 we wish to have proven the benefits of both the open course material production and distributed course model as a form of university cooperation. Having acknowledged benefits for all participants this project will continue as a part of normal university course development and implementation practices. After defining and documenting the best working methods the project can continue with only minimum amount of coordination work for organizing and updating course material and distributed courses.

During fall 2002 we will provide three courses on this project, each university hosting one course. This offers us a good possibility to observe the ideas of the project in action with several different courses and hosting universities at the same time. We will see whether the guidelines developed during this spring will apply generally and how they should be improved further. On 2003 we take new participants for the project and test how the procedures and instructions developed on the first year can be applied to new participants. We will also take at least one more industry partner to see whether the study model can easily be broadened also to others company workers than university students.

The research work for course metadata conventions and course material archives goes on in various places. Also we gather our own experiences from and requirements for the project during this first year. Important feedback from this year's work will be received next year, when the once archived courses will for the first time be unpacked and installed in to use and for further development. We have also considered arranging at least on one course a change in the hosting course personnel in order to see whether the teaching instructions related to the materials are extensive enough. The practices and proposed final guidelines for material production will be developed during 2003.

By the end of year 2003 we will have well-documented and tested practices and instructions for both the material production and usage as well and for implementing courses in cooperation of several universities. In year 2004 we plan to take several new universities into the project and start to implement these ideas on a larger scale.

8 Conclusion

In this paper we have described the basic principles of the Open Source Courseware project. The main goal of the project is to improve cooperation between universities in course material production and course implementation. In this project we gather a group of interested course developers to use and develop the course materials for each course. In good cooperation the benefits are obvious: when each participating university originally produces a course, they receive several other courses in return. Moreover, other experts get to evaluate, update and improve the course contents.

The presented scheme allows easy transfer of knowledge and well developed courses between universities. This reduces the need to develop new course materials when a university wants to broaden the course selection offered to its students. We also presented a model for multi-site courses. In this model a course can be distributed to several universities

without too much extra burden for the hosting university. This model provides the students a possibility to study courses that are organized and given by another university, but without extra bureaucracy and with good local support and tutoring.

In this project we do not aim at providing time and space independent education, but at supporting the basic education activities with course development and implementation in universities. However, the principles of developing well-planned and documented course materials provide also a possibility and good basis to create course packages to be studied as distance education over the internet.

By the experiences during spring 2002 as well as from earlier experiments at TUT we conclude that the basic ideas seem to work well. Both the students and course personnel have given encouraging feedback. The benefits of this knowledge sharing will only increase when more partners participate in the cooperation. We still need, however, more active coordination and organization work for developing and finding the best working methods and practices for this project in the future.

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