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The IDE Studio

- Development of an Environment for Distributed Design Work

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Abstract

Chalmers University of Technology has an outspoken objective to be in the front line in the area of distributed engineering. Thus, a room especially equipped for this type of work will be set up, the IDE studio. This thesis is the initiating step towards establishing the type of functionalities to be supported, and proposes how they could be carried out.

The initial work involved set up of testing equipment while determining the desired functionalities for the IDE studio, primarily through making interviews and studying predetermined requirements. This resulted in a number of system attributes and functions forming a framework for the development. Additionally, these also made it possible to systematically identify thirteen scenarios. It was found to be a complex process to identify what hardware, software, and room layout to be used. Consequently the work to identify support for the use cases was carried out in three iterations resulting in requirements for a complete studio, also modelled in a 3D environment. An estimation of the cost for the remaining investment and a timetable were also made to complete the description of the IDE studio. Finally, this part of the thesis ends with a section providing recommendations and suggestions for further work

It was needed to choose among different hardware solutions during the project why an effort has been made to provide descriptions of some existing on the market today. The same goes for software concerning different modelling and sharing environments. Moreover, a related work section has been put together to offer the reader a brief compilation of some of the work done earlier in the field.

The most important contribution to the field of distributed engineering made in this report is the coupling between the scenarios and the technological choices. The development has been done firstly with needed and desired functionalities in mind, putting the user instead of advanced hardware solutions in the centre. The thesis can also function as an introduction to remote collaboration since it discusses many of the common tools and provides basic explanations.

Keywords

Distributed engineering, Collaboration Environment, Broadband Applications, Engineering Design, Industrial Design Engineering.

Preface

This thesis is the last part for fulfilment of the requirements for the degree of Master of Science in Mechanical Engineering at Chalmers University of Technology. I am indebted to the people working at the department of Product and Production Development, especially my examiner professor Johan Malmqvist and my advisor MSc, LicEng Peter Schachinger, for providing an opportunity for me to develop my knowledge in a field that I find very interesting. I do also appreciate inputs given by Krister Sutinen and Per Gustavsson. I would also like to thank the members of the Division of Computer Aided Design at Luleå University of Technology, especially Peter Törlind, for the support throughout the work. The project has also included some industrial representatives giving a lot of their time to explain and answering questions. For this reason they should be mentioned as well: Claes Eve (Cyviz), Lotta Quist (Volvo Trucks), Mathias Johansson (Framkom), and Patrik Svensson (Hampf Design).

Finally I would like to thank my family, girlfriend, and her family for supporting me throughout my education. You have always been there for me, thank you.

Jonas Norrström

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1 Introduction

The first chapter of this thesis includes background, purpose, objectives, approach, scope/limitations, and finally an outline of the thesis.

1.1 Background

Most companies concerned with development of products have a need to exchange information within different locations of the company and with sub-contractors. This is especially true in an era when it is common that firms are geographically distributed at different locations, or collaborates with other enterprises, nationally or internationally. Consequently a need to exchange information through remote means arise. That is why it becomes desirable to investigate if environments where companies can store a core competence in-house, and depend on other firms to provide complementing competence can be created. The development in the field of computer hard- and software has enabled new methods for exchanging product information. These methods are based on the concept of virtual meeting places. Engineering and industrial designers will be provided meeting places where they can meet, share, and exchange engineering information electronically. This can be geometry, design documents, results from simulations, animations, or other information. Finally, Chalmers University of Technology has a vision to work with and develop methods for distributed engineering. One step in this direction is to create the IDE studio where the principles of remote collaboration will be applied. IDE stands for Industrial Design Engineering, a blend between Industrial Design and Engineering Design.

1.2 Purpose

The purpose of this project was to explore the field of distributed engineering, especially for industrial designers, in order to identify scenarios to be supported in the IDE studio. Moreover should a conceptual environment for the studio be motivated, set up, and modelled.

1.3 Objectives

- Set up a desktop testing equipment for distributed engineering
- Install the SMILE [Framkom, 2001] software with the surrounding hardware
- Arrange a connection to Luleå
- Choose and install shared software for connection to Luleå
- Analyze different hardware and software alternatives of interest for the IDE studio
- Describe different techniques for video conferencing
- Describe of the work of designers, ideas and visions around the field of distributed engineering and software
- Investigate how distributed engineering using broadband tools can be introduced in the work of designers. Provide a description how these can be carried out in the IDE studio through a number of scenarios
- On the basis of existing demands and those found during the work, state the requirements for the IDE studio and model it in a 3D environment
- Estimate the cost for setting up the IDE studio

- Provide building order considerations and a plan for further implementation
- Propose areas for further work

1.4 Approach

The work was divided into two phases. The first mainly concerned the set up of the testing equipment, and carrying through different types of tests. The second involved the actual process of developing scenarios, and the design of the IDE studio.

1.4.1 Phase 1

The most important part of the first phase was to set up the test equipment for distributed work, see appendix F. This included acquiring proper hardware (computers, camera, microphones, and speakers), install the video conferencing software SMILE, further described in appendix I, and test a connection to Luleå. Tools for sharing programs or files were also tested, see appendix J. This was followed by a survey of existing soft- and hardware for video conferencing, distributed information, and 2D or 3D. See appendix K and L. In addition, another survey was made in order to understand the work of designers. This was done in order to identify scenarios where distributed solutions could be used. The survey of soft- and hardware was mainly done through written sources, while the one concerning designers was made as interviews. The questionnaire used is provided in appendix G.

1.4.2 Phase 2

The aim was, as mentioned earlier, to construct scenarios where distinct couplings between software, hardware, and concrete situations were made. In short it can be expressed as, when should a certain equipment be used and with what software. Moreover, the initial steps of an object-oriented methodology were used, as described in [Larman, 1998], to identify the different scenarios. As a consequence the development became iterative and followed a process where, firstly, a feasibility study primarily based on interviews with designers was made. A requirements section where system attributes, system functions, and use cases were identified followed, analyse and design sections were written when the requirements were established. The relationship between the constructed scenarios and the system attributes was made in the analysing section. The design section followed the analyse section and consists the set up of the studio, resulting in an actual layout suggestion. This includes placement of equipment, software and hardware constellation, requirements, physical wiring, and 3D models. To conclude the work with the IDE studio cost and building order considerations are also provided.

1.5 Scope and delimitations

Delimitations are sorted under *level of descriptions, software, hardware, and the scenarios.*

An effort has been made to make technical descriptions, and construction of scenarios in such manner that a person with little computer experience will be able to follow the discussion without any immediate problems.

There are a lot of computer programs able to function in a shared distributed environment. These include software for conferencing, sketching, information sharing, and modelling. It is not possible to evaluate each available program why an effort has been made to find the most relevant and present them. In some cases where there were one or a few software especially suited for the studio the investigation was limited to this or these. An example is the PDM system BSCW [Orbiteam, 2001].

The construction of a multi purpose studio for a group of people is a complex task, which can be solved by usage of a wide variety of hardware. An effort has been made to present several hardware alternatives. However it is not, within reasonable time, possible to provide all why a selection has been made.

The technology discussed in this thesis can be used in a wide variety of situations. It is not within the scope of this thesis to describe them all. For this reason has an effort been made to identify a number of basic scenarios that can be combined to a larger number of different situations. Still, it would probably be possible to find situations not covered by the suggested scenarios, thus these are considered to be outside the scope of this thesis. Furthermore the identification of scenarios has been made especially for designers. Naturally other groups with use of distributed solutions can be identified. However, it is not possible, within a reasonable time limit, to cover more than one area. Finally, the scenarios will be constructed with the present situation of designers in mind. For this reason the description of the workflow at design studios is based on interviews. The number of interviewed designers is limited to two. This due to the fact that it was noted after the first two interviews that most of their answers were similar. Consequently, no more interviews around this theme were made.

1.6 Outline of thesis

An outline has been put together where each chapter and appendix are briefly described. This was made in order to help the reader to navigate in the thesis.

Chapter 2. The aim of this chapter is to establish basic scenarios for the usage of the IDE studio. They are identified through using existing requirements, experiences from other studios, and interviews giving system attributes and system functions resulting in a number of use cases, also called scenarios.

Chapter 3 describes the development of the studio environment in three iterations. Firstly the scenarios identified in the second chapter are expanded to real use cases. The investigation continues with an analysis section where the relation between the system attributes and the scenarios are made. Finally, a design section presents the actual design choices. These steps are carried out separately for all iterations.

Chapter 4 presents a calculation of the cost for setting up the studio as suggested in the thesis. Furthermore a section is devoted to describe in which order different parts of the studio should be included in the system.

Chapter 5. To test certain functionalities was equipment for testing set up during the project. This chapter presents that and some of the experiences of the usage.

Chapter 6. Chapter 2 to 5 is a stepwise process to form the conceptual IDE studio. The aim of this chapter is to summarize the result of that work.

Chapter 7 presents the conclusions that have been made during the work.

Chapter 8. Some suggestions for further work are presented.

Appendix A. In this first appendix is a complete table of the figures presented in this thesis listed.

Appendix B. The second appendix is similar as the first with the difference that it presents all tables used in the thesis.

Appendix C. A lot of different acronyms are used in the area of distributed engineering. For this reason has most of the ones used been collected in a table presented in this appendix.

Appendix D. Relevant words has been gathered and explained in a glossary to make it easier for the reader.

Appendix E. The work with the thesis has been carried out using a time plan. This is presented in this appendix.

Appendix F. During the completion of the IDE studio concept has testing equipment been set up and used. The layout of that equipment can be viewed in this section.

Appendix G. An important feature for completing the second chapter was information from interviews from designers. The questionnaire used can been read in this section.

Appendix H. A compilation of experiences from other studios was presented in the second chapter. A more complete description of related work is provided in this appendix. It concerns the VITI program, the interactive room at Stanford, and the interactive studio at Luleå University of Technology.

Appendix I. This appendix is devoted to describe the nature of video conferencing. Both classical approaches, H323, and newer, Smile, are discussed. The emphasis of the description is on the latter since it will be the dominant tool in the IDE studio.

Appendix J describes tools for enabling sharing of environments. The areas up for discussion are thin clients, NetMeeting [Microsoft, 2001], Division MockUp, and DIVE. These types of tools all provide different kinds of functionalities of interest for the IDE studio.

Appendix K. Aside from conferencing and sharing software are tools for modelling and information sharing of interest. This section describes some available on the market with focus on usage in distributed environments.

Appendix L. The design section in chapter 3 is characterized by actual design choices. For this reason a benchmark of existing hardware on the market has been made. The result is presented in this appendix. The investigation covers displaying of images, recording images, capturing of sound, speaker system, sketching and writing tools, storing and accessing information, controlling system, and wireless solutions.

2 Development of scenarios for the IDE studio

As found out during the VITI project (appendix H) it is important to consider not only the technical problems, but also to envisage anticipated use, and try to have natural and unforced scenarios for the infrastructure that is to be set up. Consequently it is important to find areas of use and functionalities in order to for a new, ever so sophisticated technology, to be successful.

The first part of this chapter can be described as a feasibility study where firstly the IDE studio project at Chalmers will be presented followed by experiences from other studios. Then the work of designers is described based on interviews to briefly envisage the general situation of the design process. This gives the framework for the development of the studio environment. Following sections are aimed to identify and develop different scenarios of how the studio could be set up and used to support the design work.

2.1 The IDE studio

The acronym IDE is, as mentioned in the introduction, a blend between Industrial Design and Engineering Design forming Industrial Design Engineering. The visions and purposes of the studio have been described in [Schachinger, 1999]. The objective is to create a scene where researchers, students, and others can act as actors or audience. The objective is also to create an environment that as many as possible will be able to use. For this reason flexibility is of great importance together with good storage possibilities so that projects easily can be paused and continued as needed. The core of the chosen solution this far is a big screen with back-projection, and a powerful computer suited for graphics showed in stereo in real time. Colour laser printers, 3D glasses, computer screens, a 3D mouse, a 3D scanner, and a 3D printer may also be added to the studio as it evolves.

2.2 Experiences from other studios

Three other projects have been studied to gather experiences from other projects made in the field of distributed collaboration. These are the VITI program including a number of nodes in Sweden, the interactive room at Stanford, and the interactive studio in Luleå. Experiences drawn from these projects are summarized below. More complete descriptions can be found in appendix H.

2.2.1 The VITI project

This section presents the activities supported by the infrastructure and qualitative experiences, remarks, and feedback from the use of the VITI infrastructure as described in [Bullock and Gustafson, 2001]. These reflections are based on experiences from both people supporting their day-to-day work with the infrastructure and those developing the same.

The main supported activity during the VITI project was electronic meeting environments where video conferencing was the main tool. Furthermore, video conferencing was used in conjunction with other tools, notably the use of Smile [Framkom, 2001].

One of the original goals with the project was to see the development of the desktop level through the use of regular day-to-day use. This did not become the case mostly due to software problems and the lack of a driving force behind the use. That is, a specific reason to use the desktop system on a regular basis. A comparison was made between studio and desktop environments showing that video update rates were slower, and audio delays larger for the desktop system running the conferencing software Marratech [Marratech, 2001].

The main goal, and also the strength of the VITI project, was to support meeting activities that otherwise would have forced the participants travelling to meet in person. Moreover, the word “support” here implies that an experience as close as possible to that of being in the same physical space as the other person was to be created.

A second strength of the program has been that the created infrastructure supports a wide range of heterogeneous networking technologies in the same meeting environment. Owing to this a possible weakness also was created since a trade-off between quality and flexibility had to be done.

The process of controlling and configuring the infrastructure is, at the moment, a weakness. This due to the fact that there is a strong reliance on technical experts to configure each meeting and to make sure that there are no problems. A solution to this problem is proposed where simple “push-button” interfaces encapsulating many small actions are created. Another problem encountered on several occasions, having nothing to do with the technical configuration, was the intention of the people involved in the meeting. This implies that the communication between participants and organisers are vital to a successful meeting.

Finally a weakness that is something of a problem should be discussed. The problem referred to is the one of creating appropriate audio support. This is especially problematic when sources from different technologies and levels must be mixed together. Moreover has feedback and experiences showed that it is possible to hold a satisfactory meeting when the participants have good audio connection but poor or no video connection, whilst the reverse does not work at all. To sum up, audio has a major bearing on a successful meeting.

2.2.2 The interactive room at Stanford University

Considerable work around the area of distributed engineering is done at Stanford University, USA. The information in this section is gathered from [Stanford, 2001]. There it is described that most of today's computing environments are designed to support the interaction between one person and one computer. The user sits at workstation or laptop, or holds a PDA, focusing on a single device at a time (even if there are several around and they are linked and synchronized). Collaboration is accomplished over the network, using e-mail, shared files, or in some cases explicitly designed "groupware". In non-computerized work settings, on the other hand, people interact in a rich environment that includes information from many sources (paper, whiteboards, computers, physical models, etc), and are able to use these simultaneously and move among them flexibly and quickly. The few existing integrated multi-device computer environments today tend to be highly specialized and based on application-specific software.

The aim for the interactive room, or iRoom, at Stanford is to design and experiment with multi-device, multi-user environments based on a new architecture that makes it easy to create and add new display and input devices, to move work of all kinds from one computing device to another, and to support and facilitate group interactions. In the same way that today's standard operating systems make it feasible to write single-workstation software that makes use of multiple devices and networked resources, higher-level operating system are constructed for the world of ubiquitous computing.

The current work is focused on an augmented dedicated space (a meeting room, rather than an individual's office or home, or a tele-connected set of spaces), and to concentrate on task-oriented work (rather than entertainment, personal communication, or ambient information). In the future, it is likely that, technology of the used kind will become cheap enough to be part of the common living space for many people, and it is anticipated that the built infrastructure will be put to a wider range of uses. The recognition that the environments built are situated in a larger context in which people work individually at workstations, in remote locations with mobile devices, or in person without computer augmentation are also important. The interactive workspace is not a replacement for these other ways of working, but an addition to them, enhancing high-information, high-interaction collaborative activities.

2.2.3 The interactive room in Luleå

The experiences using the interactive room in Luleå is much like the ones made during the VITI project. This is natural since it was a node in the project. However, some points can be presented that has been emphasized in tests and at interviews, [Törlind, 2001].

In using the studio in Luleå they have experienced that it can be used in a broad spectrum of activities ranging from lecturing to research work. Most of these, up 80%, are in fact non-remote contacts. This means that a studio, in order to work well, must be well equipped for regular day-to-day work in different constellations.

Another point especially stressed, concerned the actual set up of a studio. A couple of aspects were recommended for consideration. The first was to avoid building a studio without contacting professional firms. The major reason for this was to avoid a centralization of knowledge to one person, and assuring the functionalities of the studio keeping the builder responsible. There have been examples in Luleå when it was noticed that some requirements were not fulfilled when testing the studio forcing the hired firm to remodel parts of the studio. The importance of using a controlling system was also stressed. They mean that this system clearly makes it easier to use the studio, both for professionals and beginners. When using the studio they also experienced the advantages of a wireless microphone system. This since it provides good quality, induces no echoes in the system, and enables the user to move with preserved audio quality. Finally, a wireless system based on WLAN has been adopted in the studio. This makes it easy to use, for example, laptops in an efficient way.

2.3 Interviews with industrial designers

As mentioned earlier one objective of this thesis is to describe the work of industrial designers. The main reason for this is that this information is a part of the foundation onto which the scenarios will be constructed. The two sections below present the interviews with industrial designers from Volvo Trucks and Hampf Design respectively.

2.3.1 Industrial designer working at Volvo Trucks

This interview [Quist, 2001] revolved around several topics including *the design studio, the project process, types of projects, types of meetings, software in use, and visions around distributed engineering*. These subjects will be presented below.

2.3.1.1 The design studio

The design work takes place in a design studio where a team collaborates to complete different projects. A schematic figure of the studio at Volvo Trucks is provided below to provide an idea of how they can be set up.

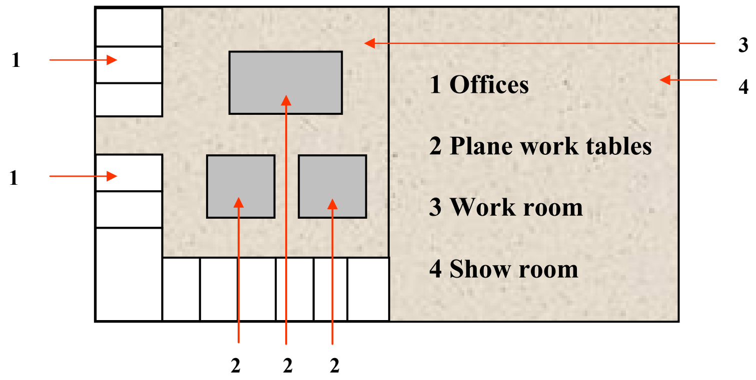


Figure 1 The studio at Volvo Trucks

2.3.1.2 Project process

Simplified the developing process at Volvo Trucks can be divided into six steps. The process goes from a general approach to a more specific. This means that a large team is concerned with the project in the initial phase. As the project evolves less and less people are involved. The first step of the process concerns finding a concept. The tools used are primarily sketches drawn by hand and sometime in Alias [Alias|Wavefront, 2001]. When a design is found that is to be further developed modellers make physical models, often in natural size. The biggest use of VR tools is probably in this work. Not to replace physical models but to function as complement. Consequently, it would not be necessary to create as many physical models. The third step concerns putting the model on a plane worktable and measure with laser equipment. When this is done, surface modeller's make numerical bases using CATIA [Dassault Systemes, 2000]. During the fifth step functions are tested. For example it could be of interest to se how panels fit together. Furthermore, rapid prototyping is often used in this process. The final step concerns the milling of hard foam models.

2.3.1.3 Types of projects

There are basically two types of projects at the design studio, re-design/facelift projects and new design projects. These are different in nature and are consequently not dealt with in the same way.

Re-design or facelift projects are characterised by the use of computer tools in early stages. A major problem in this process is the converting between different computer formats. It can be between programs or old and new versions of the same program. These types of processes are characterized by a shorter sketching phase, resulting in a quicker generation of surface models.

The second type, new design projects, concerns the development of a totally new product why the sketching phase becomes much more important and therefore longer. Moreover, the engineering design department is more involved in these projects.

2.3.1.4 Types of meetings

In order to identify different types of possibilities to support meeting activities, five meeting types were identified. Each will be presented below under the paragraphs *brainstorming sessions, supplier meetings, design engineer meetings, internal design meetings, and design shows.*

Brainstorming sessions are meetings where the meeting organizer has put together a group of innovative persons to, for example, generate ideas to solve a problem or create or evolve a product. The most common tool in this process is sketching. These sessions are usually in-house, even though Volvo does have development departments in both Brazil and America. Owing to this it would be interesting to enable, under the right circumstances, designers at Volvo in Göteborg to have sessions with the other two departments.

The second types of meetings are those with *suppliers*. These are meetings where people from both inside and outside the company participate. The tools used are primarily computer models, whiteboards, and sketching boards.

The *design engineering meetings* are in-house and can concern generation of ideas, new products, and problem solutions. They are usually made when something is not right. Furthermore these meetings are informal, and the most common tool is sketching.

The fourth type is the *internal design meeting*. They are held in the show room and are internal for the department. In general regular sketching is used and no computer tools are used.

Last to be discussed are the *design shows*. They are official and present new projects or products. For these types of meetings virtual reality tools are common. At the moment the software Opus Realizer [Opticore, 2001] is used at Volvo Trucks.

2.3.1.5 Software in use

It is of interest to know the types of software used in a design department. This is the case since if the software tools of designers are identified it can be investigated whether they can be used in a distributed manner. At Volvo Trucks following tools are mainly used, Microsoft Office [Microsoft, 2001], CATIA, Alias, Opus Realizer, and Photoshop [Adobe, 2001]. The importance of Photoshop was especially emphasized since it provides an efficient way of showing large models exported to images. For this reason models in for example Alias are exported to Photoshop and viewed there.

2.3.1.6 Visions around distributed engineering

Video conferencing equipment is available at Volvo Trucks and has been tested by the design department. The results has not been satisfying, consequently the tool is not used to any large extent. The major drawbacks were bad picture quality and delay between picture and sound, providing an inhuman impression not desirable to work in. This is especially true if the meeting participants never have meet in person before the distributed meeting. It is important to note that meetings often are of a delicate nature making it really important that nobody is misinterpreted due to technical limitations.

The suggestions to overcome these problems and make designers wanting to use this type of tools were several. The most important thing is probably enhanced picture quality and very little delay between picture and sound. Furthermore, the meetings would probably give a better result if the participants were in natural size. Experiments with tables that continue into the projected image should be done to provide an impression of sitting at the same table. It is also important to avoid building an environment where short sharp sounds easily are created, for example from a chair being pushed back resulting in a squeaking sound. The environment used this far at Volvo was also experienced as static. It was hard to identify the person addressed with a question since the camera view was the same all the time. The room did not feel flexible at all and had to be booked beforehand. Consequently, a solution based on more mobility and flexibility, where each participant can sketch on a whiteboard to explain an idea, would be more interesting for the industrial design department at Volvo. Furthermore, it is possible that asynchronous work is more important to support than synchronous at the moment. But it is possible that a need for the latter will arise with a proper environment. It is not very common that industrial designers work together in the creating phase. Possibly, a synchronous solution would be of interest when different solutions are tested and discussed, or on a conceptual level where a couple of people generates and tests ideas.

2.3.2 Industrial designer working at Hampf Design

The second interview [Svensson, 2001] was carried out with a designer working at a design firm with five employees. The company is involved in projects developing a wide variety of products including office, transportation, medical, industry, building technology, graphic design, public design, and packaging design products. The discussion in the text below will be made in the following four areas; *work process, software in use, the need for a distributed environment, and visions around distributed engineering.*

2.3.2.1 Work process

The work process at Hampf can be divided into three separate steps, which are *analysis, concept generation, and designing.*

The *analysis phase* is a research step. In short an effort is made to identify the identity of the client and its trademark. Moreover similar products are investigated and evaluated.

The initial step together with requirement specifications and similar information makes it possible for the design firm to generate outlines for a number of possible solutions, *concepts*. For a project of normal size one or two designers are involved. The work is generally carried out as brainstorming sessions to generate ideas. These are discussed between industrial designers and the customers until one or two concepts remain to be further developed. The most common tools in this process are sketching, paper and pen or a Wacom tablet [Wacom, 2001], or simple 3D computer models. This is an important phase since it establishes the project and involves important meetings with the customers.

The final phase concerns the actual design work. Initially foam models are made to capture the actual physical size of the product. Like most processes in the design work this is an iterative work where both computer and physical models are generated. Furthermore rapid prototyping (SLA) is used to study different details and their form. When a final design is decided upon a model maker creates a physical prototype. Important outcomes of the final process are also basis material for construction, images for exhibitions, and marketing etc. Finally, the most commonly used formats in this process are IGES and STEP.

2.3.2.2 Software in use

There are a lot of different software tools to choose from when design work is to be performed. The surface modelling tools used to communicate 3D structures are Alias and Rhinoceros [Rhinoceros, 2001]. Furthermore, a solid modelling tool is used, Pro/Engineer, mostly for engineering design. AutoCAD [Autodesk, 2001] is used for 2D illustrations. The software Adobe Illustrator [Adobe, 2001], Freehand [Macromedia, 2001], Photoshop, and Page Maker [Adobe, 2001] are used as graphical tools. Finally, Opus Realizer was installed recently for the creation of high quality images.

2.3.2.3 Need for distributed environment

When discussing distributed environments, it is clearly stated that there is a need for this type of collaboration. This is true due to the fact that many customers are situated in other cities or countries. The biggest potential probably lies in complementing different types of meetings. Consequently, the technology should be used to minimize actual physical meetings, not replace them. A big potential lies in the possibility to arrange good brainstorming sessions with customers. Both video and different types of whiteboard functions should be possible to share together with a 3D or virtual reality environment, where all participants can control the geometry. Finally pure meeting sessions could be held to check for example time plans.

2.3.2.4 Thoughts and visions around distributed engineering

There are, according to the interviewed designer, some requirements in order to make distributed environments a desirable tool in the day-to-day work for a designer. Firstly it is desirable to be able to see each other. Preferably it should also be possible to see the image sent and to present and navigate in 2D and 3D. It would also be desirable to perform brainstorming sessions where tools like Wacom boards or whiteboards can be used in a common workspace. A vision is to be able to meet in a virtual room where different sessions could be held with virtual projectors and whiteboards.

2.4 Requirements

This is the second step, and concludes previous sections, in the development of the studio environment according to the object-oriented method used in this thesis. A description of needs and desires for a studio environment for industrial designers will be investigated in this section. This will be based on the requirements, experiences, and interviews presented above. Finally, they will be expressed as *system attributes*, *system functions*, and *use cases* as described in [Larman, 1998].

2.4.1 System attributes

These express the characteristics or dimensions of the work of industrial designers. Importantly system attributes describes general properties of the scenarios, not functions. The following system attributes were identified:

Table 1 System attributes

Attribute	Details and boundary constraints
Flexibility	The room should be easy to configure to different types of work why the equipment for distributed engineering must be possible to rearrange after the current needs.
Short delays	An experienced problem with video conferencing has been long delays between audio and sound. It was clearly stated during the interviews that it is not acceptable to have these long delays. For this reason will a system be created that minimizes the delays.
Picture quality	Another experienced problem with video conferencing has been poor picture quality. The aim will be to create a system providing an environment with good image quality.
Audio quality	Audio quality has been found to be, at least, equally important to image quality. For this reason some effort will be put into creating an environment that generates good audio quality.
Ease of use	The thought is that the system should be easy to set up and use according to the needs of the user making it accessible for more people.
Presence	If industrial designers should find distributed collaboration as a functioning tool it is important to create a sense of presence between the participants of the conference.
Mobility	This is rather important since many firms do not have the possibility to have a separate room only for video conferencing where everything is set up in a static manner. Therefore could a solution based on mobility be of interest.
Adaptability	The system must be able to deal with various file formats such as STEP and IGES.

2.4.2 System functions

The system functions describe what the system is supposed to be able to accomplish. The functions in the table below are all of interest to apply in a system for distributed engineering. However, it might not be possible to implement them all due to parameters like cost or the technical maturity of a certain technology. For this reason they should be considered as a collection of functions generated in a brainstorming session. They will be chosen among in the complete scenarios to create a studio fulfilling the requirements as good as possible.

Table 2 System functions

Ref #	Functions
1	Enable usage of a whiteboard
2	Provide a possibility to use lap tops with WLAN connections
3	Provide good possibilities for sketching sessions
4	It should be possible to locate the speaker and generate an overview of the room through cameras
5	It should be possible to share 3D software and other useful tools through different programs
6	Provide virtual environments for meetings
7	Usage of 3D on big screen
8	Provide the users with shared force and touch feedback utilities
9	Enable usage of thin clients to enable sharing of desktop environments
10	Provide possibilities to use a PDM system
11	Provide possibility to use rapid prototyping equipment, possibly together with force feedback tools
12	It should be possible to stream media from a streaming server
13	It should be possible to use remote control of the camera
14	Usage of stereo video to show physical objects in a computerized environment
15	Possibility to choose image source after needs. (Desktop, projector etc)
16	Provide a IP address register to facilitate for the users

17	Good support for brainstorming and presentations should be available to users
18	Possibilities to review a picture before it is showed to the audience
19	It should be possible to carry out video conferences with the participants in actual physical size
20	Choose onto which screen an image should be projected

2.4.3 Use cases

These are created to improve the understanding of the requirements. They are narrative descriptions of the domain processes. For the development of the IDE studio, the domain processes will be constituted of the scenarios. The terms use case and scenario will be considered to have the same meaning as a consequence. A number of use cases have been identified below. They will later be ranked and considered according to iterative developing cycles.

The development of use cases is partly based on the identification of different actors in the system. The two most obvious actors in the IDE studio environment are present and remote industrial designers. The ones in the studio at Chalmers are referred to as present. They will be considered to be four, numbered one to four in the further description of the studio. This since it is quite a common size for a project group. This amount can however be increased if needed. The first is the main user and is responsible for the control system, consequently the session, and the other three are members of the session. The people at the same remote end, one or more, are treated as one actor why one actor representing each remote host will be used. Another important person is the system administrator. Even if the desire is to create a system requiring no administrator, this is very hard to accomplish practically since a system for distributed engineering easily becomes complex. But, as stated in the system attributes section, the aim is to create a system characterized by ease of use. An actor does not have to be a person, it can also be a system. For this reason, the different computers used in the system can also be included as actors so their specific functions can be described. The identified actors can be viewed in the table below.

Table 3 Actors in the present system

Actors	Number
Present designers	1 to 4
Remote designers	1 or more
System administrator	1
Intergraph computer	1
SGI O2 computer	1
Supporting computers	1 to 3

The actors will perform different actions in the system. These can be described in use case diagrams, see below, together with the actors. The system barrier is considered to be the complete equipment for distributed engineering. Consequently, the system barrier will cover both software and hardware components. The dashed lines in the figure below describe that a specific actor can be included in a use case, however this is optional but often necessary.

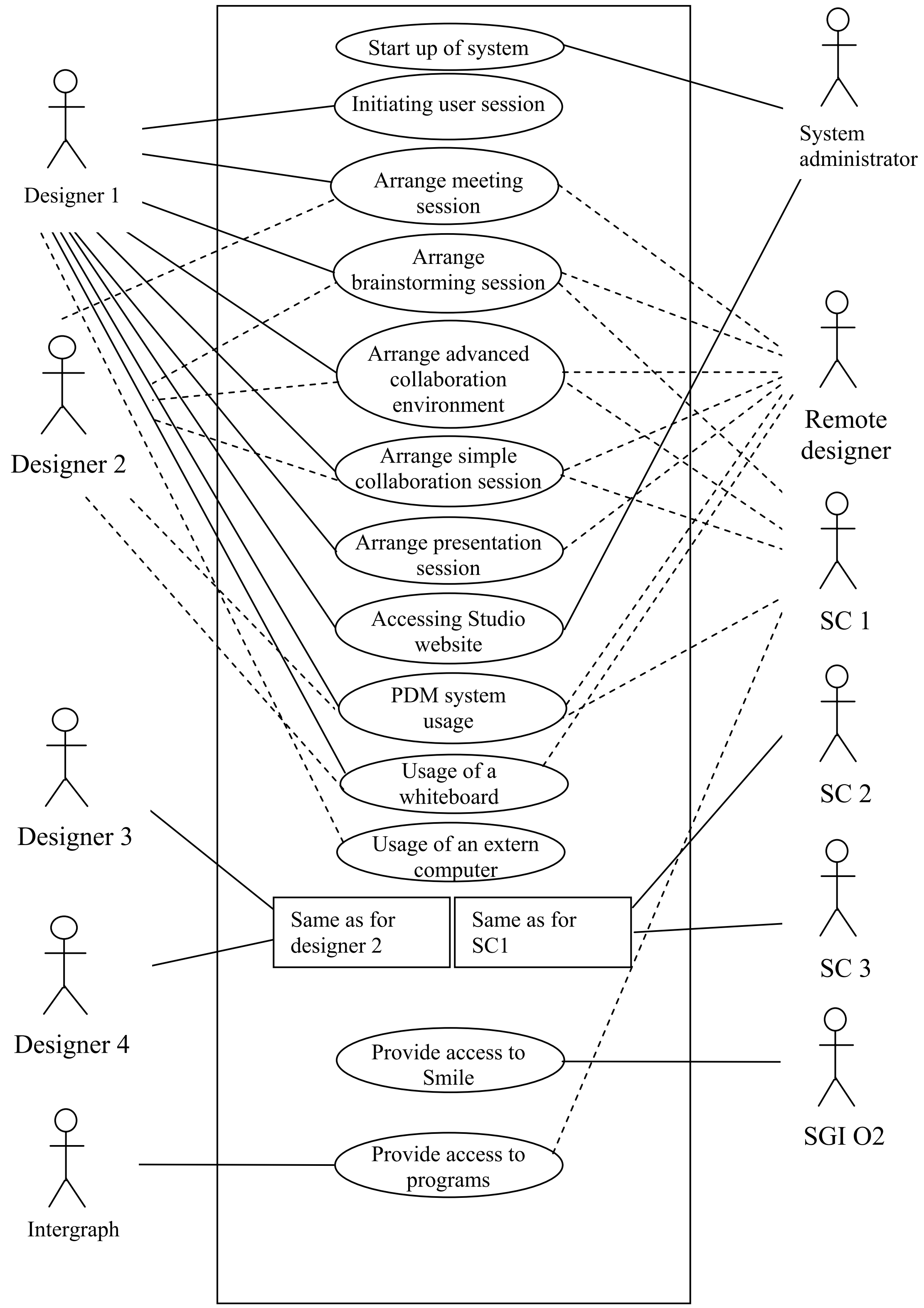


Figure 2 Scenarios for the usage of the IDE studio at Chalmers

The reader should note that the use cases provide access to Smile and provide access to programs with the SGI O2 and the Intergraph as actors, are included in most of the other use cases. This means that these two computers in reality will be actors in nearly all of the other scenarios, much like the supporting computers. However these are presented as separate actors without connection to other use cases. This is a simplification made in the figure to make it easier to overlook. In the further development below this will be accounted for.

The use cases that have been identified above are all different scenarios of how the studio at Chalmers could be used. The next step is to further develop the different scenarios and start an investigation of how they should be supported in greater detail. It is likely that this process will be too complex to be carried out straightforward. For this reason the use cases has been ranked according to the table below.

Table 4 Ranking of use cases

Priority	Scenario	Reason	Iteration
1	Initiating user session	Foundation for the function of the system	1
2	Provide access to Smile	Very important for the system	1
3	Provide access to programs	Very important for the system	1
4	Arrange a meeting session	Basic function	1
5	Arrange simple collaboration session	Basic function	1
6	Arrange advanced collaboration environment	Improves collaboration abilities	1
7	Arrange brainstorming session	Improves collaboration abilities	2
8	Usage of PDM system	Improves collaboration abilities	2
9.	Usage of a whiteboard	Improves collaboration abilities	2
10.	Usage of an extern computer	Improves collaboration abilities	2
11.	Arrange presentation session	Improves collaboration abilities	3
12.	Accessing studio website	Facilitates for the user	3
13.	Start up of system	Minimal effect on system	3

Next a high-level description of each identified use case will be made. These are made as a start point for understanding the degree of complexity and functionality in the system. Furthermore high level does imply a brief description. Thus they should be vague on specific design decisions.

Table 5 High level description of the found scenarios

1. Initiating user session	
Actor	Designer 1
Description	A designer arrives at the studio and wants to use the equipment for distributed engineering. A login takes place at the place intended for Designer 1. The use case is ready when a web-site has been accessed providing a presentation of the studio and its functions.

2. Provide access to Smile	
Actor	SGI O2
Description	The operative system Irix is installed on a SGI O2 computer. Smile is installed on this machine. The use case is finished when Smile has been accessed, with or without the studio website.

3. Provide access to other programs	
Actor	Intergraph, Supporting computers 1-3
Description	The operative system Windows NT is installed on the Intergraph computer and probably also on the supporting computers. These four computers, mainly the Intergraph, will store all programs except Smile. The use case is ready when the desired software has been accessed on the desired computer.

4. Arrange a meeting session	
Actor	Designer 1(initiator), possibly one or more of designers 2-4, one or more remote designers, Intergraph (optional), SGI O2
Description	The designer can choose among Net Meeting and Smile depending on bandwidth availability and quality requirements. However, Smile will be used most of the time. The use case is finished when the page describing how to set up a simple meeting is displayed, and after the users has launched corresponding programs.

5. Arrange simple collaboration session	
Actor	Designer 1(initiator), possibly one or more of designers 2-4, one or more remote designers, Intergraph, SGI O2 (optional), Supporting computers 1-3 (optional)
Description	The user wants to share a non-3D environment with a remote user. It can for example be a whiteboard, video-editing program, or an MS Office document. The most common tools for this process will be NetMeeting or a thin client, why the user can choose between these two possibilities. These sessions are most often completed with transmission of video, preferably through Smile. The use case is ready when a web page describing the nature of simple collaboration sessions is displayed, and when the users have launched and begun sharing the programs that are to be used.

6. Arrange advanced collaboration environment	
Actor	Designer 1(initiator), possibly one or more of designers 2-4, one or more remote designers, Intergraph, SGI O2 (optional), Supporting computers 1-3 (optional)
Description	The user, and possibly colleagues, wants to share a 3D environment with one or more remote users. It will be possible to use either DIVISION MockUp or DIVE [Sics, 2001]. Typically, Smile and whiteboard capabilities will be a part of this type of sessions. The use case is ready when the wizard is showing a web page describing the nature of advanced collaboration sessions and when the users have launched the programs that are to be used.

7. Arrange brainstorming session	
Actor	Designer 1(initiator), possibly one or more of designers 2-4, one or more remote designers, Intergraph, SGI O2 (optional), Supporting computers 1-3 if designer 2-4 takes part in the session
Description	The users want to hold a brainstorming, or another type of meeting, based on sketching, why advanced sketching tools together with video, whiteboard and simple or advanced collaboration programs are used. The use case is ready when the wizard is showing a web page describing the nature of brainstorming sessions and when the users have launched the programs that are to be used.

8. Usage of a PDM system	
Actor	Designer 1(initiator), possibly one or more of designers 2-4, one or more remote designers, Intergraph, Supporting computers 1-3 if designers 2-4 takes part in the session
Description	A web-based PDM system, appendix K, should be used to support asynchronous project work. For example information from distributed project groups can be logged in and out of the system. The web-server will be placed at a present or remote computer, others will function as clients to this. The use case is ready when the wizard is showing a web page describing the nature of the usage of the PDM system and when the users have finished the desired tasks.

9. Usage of a whiteboard	
Actor	Designer 1, designers 2-4 (optional), Intergraph, SGI O2 (optional), remote user (optional)
Description	Whenever work should be carried out in the studio, with or without remote users, a whiteboard is useful tool. The whiteboard in the studio should be possible to use as an interactive screen onto which a user can navigate by pressing on the screen. Furthermore, it should be possible to write with pens directly on the board. Moreover, it should be possible to share the whiteboard with one or more remote users.

10. Usage of an extern computer	
Actor	Designers 1-4 (optional)
Description	If a user that wants to use the capabilities of the studio would like to connect an extern computer, most often a laptop, this should be possible through the usage of WLAN connection and VGA cables

11. Arrange presentation session	
Actor	Designer 1(initiator), one or more remote designers, Intergraph, SGI O2 (optional)
Description	When a project should be presented either as finished or at a completed project step, the IDE studio can be used. The user can chose to show CD ROMs, DVDs, videotapes, and models in various design programs like Maya or DIVISION MockUp. The studio should provide a good environment for these types of showings. Using the video and sharing tools makes it possible to include remote users in the presentations. If a designer is working in a 3D modelling program where the models are very large can these be exported to image formats and presented with an advanced presentation tool like Photoshop or Opus Realizer. The use case is ready when the wizard is showing a web page describing the nature of the presentation sessions, and when the users have launched the desired programs so they are ready to begin the presentation.

12. Accessing studio website	
Actor	Designer 1, Designers 1-3 at will, supporting computers if designers 1-3 are active in the use case, Intergraph, system administrator
Description	The system administrator is responsible for the website. This means that this use case can be started when the website is to be updated or rearranged. The use case can also be started by designers 1-4 when they access the website during a session to, for example, use the wizard or search for IP addresses. It should be possible to search for, add, or remove an IP address. The website can be launched from a regular browser why outside users can use the page. This makes it possible to have an electronic booking system of the studio. The use case is ready when the web site has been updated or rearranged by the administrator or when designer 1-4 or an outside user is done.

13. Start up of system	
Actor	System administrator
Description	The start up of all collaboration equipment.

3 Iterative development of the studio environment

The framework for the development of the IDE studio has been established in chapter 2 above. The identified use cases will be further developed in three different iterations. Each will comprise real use cases, analysis, and design considerations.

The high-level description of the use cases in chapter 2 can be further developed to become more real [Larman, 1998]. This means that the different processes will be described in terms of their real design committed to input and output technologies. The purpose of the analysis sections is to investigate the relationship between the system attributes and the real use cases. This is important since the system attributes are the guidelines to which the system should be designed. Each of the eight attributes identified under section 2.4.1 be considered. The design sections are the final steps in the development cycle of the scenarios. Consequently, after considering the last iteration, a complete studio will be presented. For this reason will actual design decisions be made under these sections based on information from earlier steps and appendixes. Finally, each sub-section will be divided into software and hardware parts.

3.1 Iteration 1

According to the ranking of the use cases this section treat; *initiating user session*, *provide access to Smile*, *provide access to programs*, *arrange a meeting session*, *arrange simple collaboration session*, and *arrange advanced collaboration environment.*

3.1.1 Real use cases iteration 1

The use cases providing access to Smile and other programs are intuitive and will not be further described in this sections since they solely concerns proper installing of programs.

Table 6 1. Initiating user session

	Actor action		System response
1.	A designer wants to use the equipment in the studio. A login with user name and password takes place on the screen by the control system.		
		2.	If the user has a valid username and password, a login takes place on the Intergraph computer. The image is showed on a monitor in front of the user requiring the usage of one VGA socket (15 pin) on the computer. The signal is passing through the controlling system.
3.	If the user does not know how to use the studio a log on to a specific studio home page can take place through web browser.		
		4.	A web browser is launched on the Intergraph computer and showed on the monitor in front of the user.
5.	The user can choose to read about the system and its capabilities or specific functions grouped in different sections like: • Video conferencing		

	• Shared environments • Sketching sessions • Sketching tools • Whiteboard tools • Presentations • Multimedia • Controlling system • PDM system The user can choose to acquire information about a section by pressing a button that starts up a wizard providing stepwise information how to set up the system according to the desired function. The exact design will appear as the project evolves.		
	Alternative course		
3.	The user knows how to use the equipment and does not want to access the studio home page.		

Table 7 4. Arrange a meeting session

	Actor action		System response
1.	One or more industrial designers are sitting in the studio and want to have a meeting with a remote group of designers. The designer sitting at the control system enters the section describing meetings on the IDE studio web site.		
2.	The meeting environment is started following the stepwise procedure		
3.	The default screen for showing video is the large screen in front of the conferencing table why the projector for this is turned on showing a log on screen from the SGI O2 computer.		
		4.	The signal from the VGA socket on the SGI computer passes through the controlling system why it is possible to change the active screen to any of the others in the room if desired.
5.	Designer 1, responsible for the session, types username and password using the same mouse and keyboard as for the Intergraph machine. This is possible through the usage of a keyboard mixer.		
		6.	If the password is correct the start page for the SGI will be shown on the chosen screen.
7.	Starting the program Smile on the SGI O2 computer launches a meeting session. This is done through typing start-Smile in the catalogue video or to double click on the Smile icon.		
		8.	The login screen for Smile is shown.
9.	The user types the required information.		
		10.	The Smile program menu is shown on the chosen screen.
11.	The user can chose to transmit video, audio,		

	connect to a media-streaming server, or make a SIP invitation.		
12.	The control system can be used to control which camera to be used to capture video, a main camera or an overview camera.		
		13.	Using the composite input, the video is sent to the SGI O2 via the controlling system.
14	The received video signals from the remote users are opened on the screen in front of the conferencing table.		
		15	The signal is received by the SGI computer and forwarded to the controlling system where it will be distributed to the desired screen.
16.	During a session, a remote control daemon can be used The cameras are interconnected through the VISCA port in order to support this function.		
		17.	The signal is sent from a serial port on the SGI O2 to the cameras via the controlling system.
18.	The four designers speak to the remote designers.		
.		19.	The speech from each designer is transmitted to a receiver and further to an auto mixer and off to the SGI O2 via the controlling system.
20.	The remote designers speak to the present ones.		
		21.	The incoming sound signals to the SGI O2 passes through the controlling system to the speaker system.
	Alternative course 1		
1.	The designer at the control system knows how to use the system why there is no need to access the web place.		
2.	The conferencing environment is started. 3-21 is the same as above.		
	Alternative course 2		
1.	The alternative to Smile is NetMeeting. This program is installed on the Intergraph computer. The user double clicks on the NetMeeting icon on the desktop monitor to start the program		
		2.	NetMeeting starts and awaits a connection IP address.
3.	The user can now choose where to project the image, preferably on the screen in front of conferencing table. Since there are two VGA signals from the Intergraph computer these can be placed beside each other. This to facilitate the usage of sharing, file transfer, chatting, and whiteboard tools.		
		4.	The audio and camera constellations are the same as for the usage of Smile above. However, the control system must be used to switch the audio and camera signals to the Intergraph computer.

Table 8 5. Arrange a simple collaboration session

	Actor action		System response
1.	The project group might use Smile and want to share software that is not graphically very advanced like office, whiteboard, or acrobat software. The conference remains on the same back-projected screen and the NetMeeting program is opened on the Intergraph machine.		
2.	The designers might use the wizard to be able to set up the studio in the desired manner.		
3.	The controlling system is used to project the first VGA signal from the Intergraph computer on the display at Designer 1. The second is not used in session at the moment.		
		4.	The first signal from the Intergraph is displayed on the desired monitor.
5.	Designer 1 arranges the sharing with the tools in NetMeeting.		
		6.	The image is showed on the desktop screen.
7.	Designer 1 chooses onto which back-projected screen the shared environment should be projected the with the control system.		
		8.	The VGA signal from the Intergraph is sent to the desired projector.
	Alternative courses		
1.	The project group might use Smile and want to share software that is not graphically very advanced like an office, whiteboard or acrobat software.		
2.	The designers might use the wizard to be able to set up the studio in the desired manner.		
3.	In this type of session it is desired that designers 1-4 are able to share their own documents at will, just as the remote users. For this reason a thin client will be used, VNC. The Intergraph, the supporting computers, and the remote computers all can function as clients and servers why all have access, and can thus study each other’s work.		
4.	The desired exchange of programs can be projected onto any desired monitor or back-projected screen using the controlling system.		
		5.	The VGA signals are transported to the desired screen.

Table 9 6. Arrange advanced collaboration environment

	Actor action		System response
1.	A project group is working in the IDE studio. They want to share a 3D environment with one or more design groups. Usually these types of meetings will be completed with video transmission through Smile. The video is showed on the screen in front of the conferencing table. Designer 1 opens the section describing advanced collaboration in the wizard. If the VGA signal from the Intergraph computer is not present on the desired desktop monitor, use the controlling system to arrange this.		
		2.	The system shows the wizard on the desktop screen in front of designer 1.
3.	The user opens DIVISION MockUp and arranges the sharing according to the description in the wizard and uses the controlling system to project the image from the monitor to the movable screen.		
		4.	The VGA signal from the Intergraph computer is sent to the projector by the movable back-projected screen.
5.	If desired, a 3D mouse and stereoscopic glasses can be used to navigate in the model.		
	Alternative course		
3.	The user opens DIVE and the sharing is arranged according to the description in the wizard, and uses the controlling system to project the image from the monitor to the movable screen.		
		4.	The VGA signal from the Intergraph computer is sent to the projector by the movable back-projected screen.

3.1.2 Analysis issues for iteration 1

The work in the first iteration is primarily aimed at supporting synchronous work in the form of arranging a meeting session, and also simple and advanced collaboration sessions. The rest of the scenarios discussed, initiating a user session and providing access to various programs, are not of that nature but are important to the functionality of the system why they are a part of the first iteration.

Flexibility is, according to the interviewed designers, an important attribute to consider in developing an environment for distributed engineering. Consequently a controlling system will be used functioning as the heart of the system. With this, the user can project images on any screen, use different cameras, tune audio, and adjust microphone signals etc. This also enables the possibility to launch video conferences on both the SGI O2 and the Intergraph computers. This in order to be able to use Smile on the former, and NetMeeting on the latter in low bandwidth sessions, and to simplify testing of future software that may be optimised to run in an NT environment. However, the employment of a controlling system can also prevent flexibility in one aspect. This due to the fact that the console for controlling most probably will be set up at a specific place. This problem can be solved with a wireless system where the control system is run on a portable device.

To further improve the possibility for flexible usage of the studio, the microphone system should be wireless including headset, transmitters, receivers, and an auto mixer. A system like this is suggested since it provides good audio quality, supports mobility, and is easy to expand.

The projection areas will be set up to support different types of work. This is especially true for the movable screen, already bought. This implies that it will remain flexible, meaning that it will be possible to arrange it as desired in the room, or somewhere else. All other projection areas will be fixed.

The supporting computers are another consequence of the effort to create a multipurpose studio. These provide an opportunity for designer two to four to work isolated or with Designer 1 or remote users.

The camera system and Smile are also improving the flexibility since they support remote steering. The cameras are interconnected through the VISCA port in order to support the remote control daemon in Smile. Since the cameras are connected to the computers via the controlling system, the choice of which camera to be used can be determined by this.

Short delays are the second attribute to be considered. It concerns the video transmission and refers to the delay between sound and image. The software providing least delays, for the time being, is Smile. Consequently this program will, almost without exception, be used in video transmission since it provides short delays between audio and image together with superior image and audio quality, compared to alternatives on the market. But as mentioned above the system will be set up so that future alternatives easily can be tested.

Image quality. Two cameras, one main camera and one overview camera capture the video, possibly a document camera could be added. The video can be sent through one or more of three inputs, Svideo, composite, and camera. The Sony EVI-D31 was, when testing, connected via the composite connection. However, a shift can be made to the Svideo connection since it provides a slightly higher quality. As described under the paragraph short delays, Smile provides good image quality compared to alternatives.

Audio quality also refers to the meeting sessions and Smile offers good conditions for audio as described above. It is also important that the speaker systems that are connected to the SGI O2 and the Intergraph are of good quality. Furthermore the microphone system is also very important for the quality of the session why a wireless system with headsets is recommended.

Ease of use will mainly be supported by the controlling system since it can be programmed with different levels of abstraction. For example, a skilled user can use a mode where the user governs almost everything whereas a beginner can use a mode where almost everything is tuned automatically. In order to further simplify for the user, an IDE studio homepage should be developed providing some functionalities and information about the studio, capabilities, purpose, and so on. This homepage should also store a type of wizard function providing a stepwise description of the foundational features of the system like video conferencing, shared environments, and controlling system. This will be further discussed in the accessing studio website scenario.

Presence. A common problem with video conferencing is the difficulty to create a sense of presence between sender and recipient. When designing the IDE studio, this feature was especially considered for the screen at the end of the conferencing table since it will be used most often for conferencing. For example, the conferencing table could be placed so a feeling of the table continuing into the back-projected image is created. Moreover, good audio quality, image quality, and short delays will further enhance the feeling of presence.

Mobility. This feature is hard to consider since the equipment in the IDE studio should stay in the room and has no need for a high level of mobility. Generally, small conferencing equipments can be made very mobile, but when a larger system is installed with back-projection, wireless equipment, large screens and so on things get too complex to move around all the time. Some degree of mobility is however desirable to have in the system to support more situations. For this reason one of the screens to be used will be movable, also described above.

Adaptability refers to the formats to be used in the system. This is most often a feature that has to be controlled on the programs that are to be used. Concerning the IDE studio this could be, for example, DIVISION MockUp [PTC, 2001], Photoshop, or Maya [Alias|Wavefront, 2001].

3.1.3 Design issues for iteration 1

As mentioned earlier, design issues can be divided in software and hardware why this section has been divided in these two.

3.1.3.1 Software

A lot of software is needed to support the scenarios of the first iteration. According to the use cases the following functionalities are desired. A web browser installed on all computers in the system, video conferencing programs, appendix I, tools for sharing programs, appendix J, and finally the application programs like Microsoft Office, Pro/Engineer [PTC, 2001], Maya, some of Adobe programs [Adobe, 2001], appendix K.

The installation of a web browser needs no further explanation. Either Internet Explorer or Netscape will be installed on all computers in the system. The most important feature for the first iteration is the video conferencing software. Three different programs have been mentioned in earlier sections, Marratech, Smile, and NetMeeting. There is no doubt that Smile is the most capable software available on the market for the time being, without any immediate competitor. For this reason, this program will be used almost without exception in conferences. It has best functionality on an SGI O2 computer why it will be installed accordingly. Additionally, the media streaming server, remote camera control daemon, and the audio/video reflector/mixer available on the Internet should be installed on the same computer. However, NetMeeting, installed on the Intergraph computer, will be used in point-to-point meetings in low bandwidth sessions. It is important to emphasize that the system will be designed to make it possible to use a conferencing program on the SGI O2, as well as the Intergraph computer if a new software optimised to one of the two is to be tested.

Another important feature of distributed collaboration is the ability to share programs with a remote user. This will be accomplished at two levels in the IDE studio, simple and advanced. For simple sharing either NetMeeting or a thin client will be used. The former will mainly be used to share desktops and programs in the IDE studio, but also has capacity for chat, whiteboard, and file transfer. The user, most often Designer 1, can distribute more than one program at the time to one or more persons, remote or present. For this reason will all computers in the system be equipped with this software. In some applications, for example education sessions, it may be desirable to be able to take control over another desktop aside from the one currently used. A good way to do this is to use a thin client. There are a lot of different alternatives on the market. For this reason has the positive experiences from other studios with the use of the free software VNC [AT & T Laboratories Cambridge, 1999] worked as guidance. This program should be installed on all computers in the system resulting in a situation where present and remote users can share all programs. However, the best results are achieved with programs not handling very complicated geometry. The capacity is sufficient to arrange distributed learning with Maya without any problems. If the present design group want to share an advanced collaboration environment, implying a sophisticated 3D or a VR environment the choice is between DIVISION MockUp and DIVE. The main program will be the former since it provides good handling of large models and has an acceptable collaboration environment [Interview with Törlind, 2001]. The strength with DIVE is that it provides a better collaboration environment, but on the other hand it provides a worse environment for the sharing of large models [Interview with Törlind, 2001]. These programs will be installed on the Intergraph computer and launched through the Start menu. Solely Designer 1 will guide the advanced sharing. This in contrast to the simple sharing where all designers could share their documents at will.

The last part of the software section will concern the programs the designer need to carry out their daily work. It can for example be Microsoft Office, Alias, Pro/Engineer, Maya, some of Adobe programs etc. These programs can vary in time and will not affect the other parts of the system to any great extent.

3.1.3.2 Hardware

According to the previously written the software situation is established for the first iteration. Next to be considered is the hardware situation. This investigation will be extensive since almost all capacities of the studio are needed in the scenarios of current interest. The first parameter to be considered is the actual placement of the equipment in the room followed by discussion of the place of work for the project group. Next are the computers, screens and projectors, video cameras, microphone and speaker system, controlling system, and finally curtains considered.

The placement in the room. The studio equipment will be set up in a room of an approximate size of 8 x11 meters. This is a large room and all of it will not be used for the distributed work scene. Consequently several different alternatives can be considered for the placement. The image below has been put together to evaluate different alternatives. It shows a scale model of the studio with seven considered alternatives. Is was assumed that the equipment requires around 5 x 8 meters when creating the images why a rectangle with this relationship has been placed in different ways in the room.

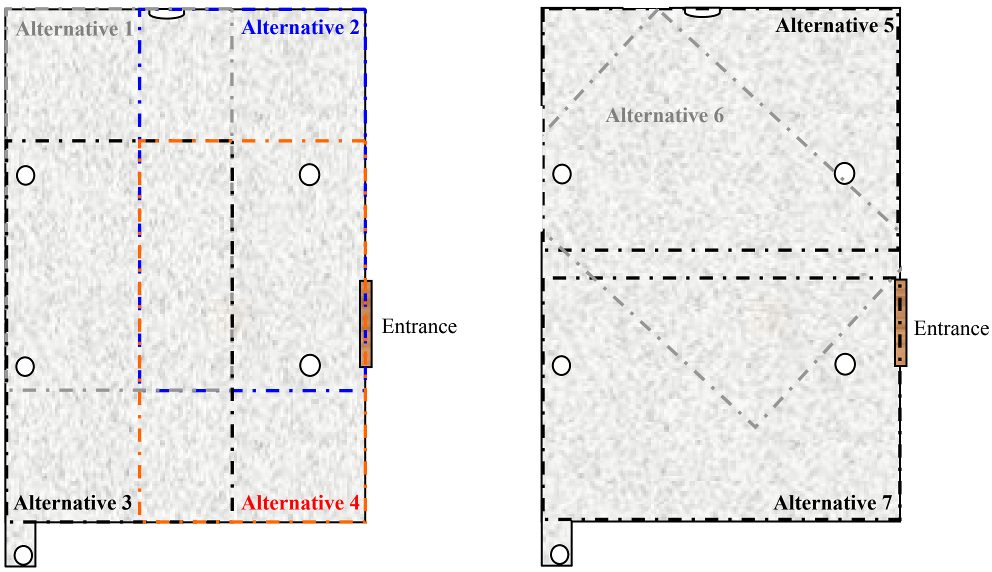


Figure 3 Different placement of the equipment in the studio

A basic criterion for constructing the IDE studio was to preserve the feeling of openness and space provided by the many windows on the wall to the left in the images above. A placement of equipment close to the windows would crowd the space in front of them and create extra problems with ambient light, why curtains almost constantly would have to be used to cover the windows and thus removing much of the positive atmosphere in the room. Consequently alternative one and three will appear as less good choices. Moreover, the first impression when someone enters the room is important. It is, for example, a bad idea to put screens or chairs so they end up crowding the entrance, forcing the person stepping into the room to walk around them. Placement two, four, and six will probably have problems related to this. Alternative two and four also have a problem with columns ending up at strategically bad places, and six will probably require unnecessary much space in the room which results in an ineffective solution. To sum up, previous discussion has eliminated alternative one to four and six, leaving five and seven for further discussion. The two are much alike but the former provides more space for the studio without disturbing the area in front of the entrance. Moreover, the distance from the colons to the wall is slightly longer, which makes it easier to effectively use this space. As a result of this the suggestion will be to set up IDE studio according to alternative five.

The workplace for the design group is of very critical nature. This since the success of the studio is depending on how well project groups experience the usability of the room. It is important to keep in mind that this type of rooms often is used to a high degree in non-distributed sessions. This makes it important to create an environment well suited for regular in-house work. Following features will be considered concerning the workplace. Firstly *the size of the project* group followed by the *conference table*, *keyboards, mouse*, *monitors*, and *computers*.

The *size of the project group* is initially thought to usually be 4. This number is chosen because it is a common size of a project group. Furthermore, a fundamental train of thought with the studio is that it should be an effective workplace with good functionalities for both in-house and distributed work, making each place a quite large investment. For this reason has a small group been chosen in the beginning. The environment will however be easy to expand and, as can be read later on in the thesis, it will be possible for up to 8 persons to work in the studio at the same time with the chosen configuration. As a consequence it will be place for slightly fewer ordinary places, but they will be provided with more and effective tools.

The *conferencing table* will be chosen according to the conditions described above. Three different types of tables been considered, as can be seen in the figure below.

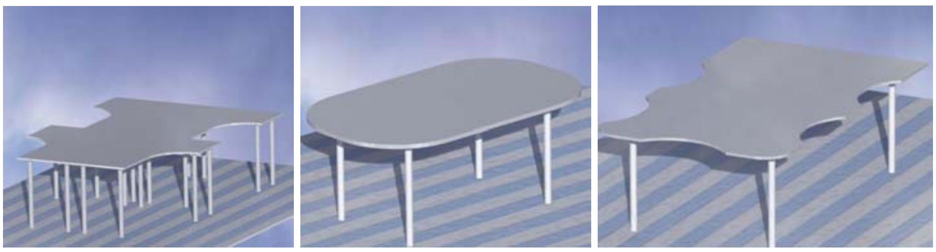


Figure 4 Table alternatives for the IDE studio

In the first picture, the one to the left, a screen should be placed at the broadest end of the table. Due to the form all four designers in a conference session, where everyone has the concentration at the end of the table, will be provided with a space in front of them. This can be used as a work area during sessions, and provides the user with a comfortable position towards the screen. Moreover, it enables the possibility to place a monitor so that it will not be in the way during video conferencing. The reader should also note that each designer has enough space to use sketching tools, keyboard etc since the table a quite long. If there should be activities alongside the table, for example at a screen, the extra space will provide the users with a possibility to position them selves so they will not block the view of each other. The major drawback with this type of table is that they provide poor condition for more than four participants. However two chairs can be placed at the thinnest end of the table if needed, and a couple of stand up tables can be placed beside the table. If it should constantly be larger groups working than four the table can be completed with another section providing opportunity for five or six to work at the same time.

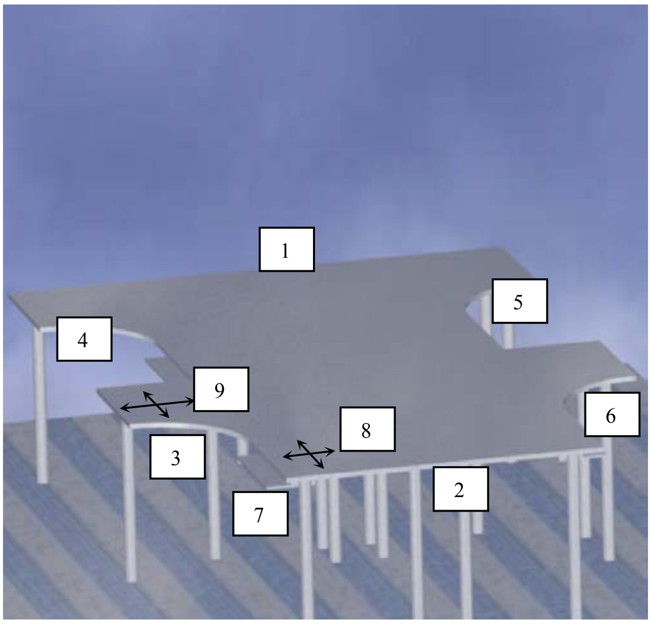
The second type of table, the one in the middle, provides different possibilities than the first since it does not offer any distinct places to work. It will, for this reason, be easy to work in groups larger than four. However, this type of tables may provide a little bit worse working situations, especially at video conferencing. To sum up, the strength is the flexibility and the setback is the loss of functionality.

The last picture, to the right, will provide less good work situation than the first and worse flexibility the second table type, and it is not easily available on the market, compared to the other two. The arguments previously presented provides enough to makes these types of tables a less good alternative in choosing a conference table.

To sum up, the first table considered is the one most in line with the purpose of the studio why a table of this type is suggested for the studio. Following paragraphs will consider other parameters around the workplace and finally will an overview picture be drawn over the total workplace.

The next subject to be considered is the *keyboards and mice*. Since a designer should have access to the Intergraph computer, the SGI O2 computer, or one of the supporting computers depending on whether they are designer one or two to four, each must be provided with a keyboard. The connection at Designer 1 will be equipped with a keyboard-mixer enabling the same keyboard to be used with both the Intergraph and the SGI O2 computer. It is probable that the type of monitors used will be of a type with pressable screens, see appendix L, eliminating the need for a mouse other than for the SGI O2. If regular monitors should be used the keyboard-mixer will be used to arrange the coordination between the Intergraph and the SGI O2 mouse.

The last subject to be considered in the workplace has briefly been touched upon in the sections above. It concerns the *computers* that are to be present in the system. The core is made up of an Intergraph computer and an SGI O2 computer. The former is a powerful computer optimised for advanced graphical tools and will store almost all programs that will be used in the system making this an important part of the system. The latter is to be used with the software Smile, requiring all its capacity, in video conferencing. Aside from these, the set up of the system will require a set of quite low performance supporting computers. This is the case since it should be possible to use each workplace as a separate unit, able to provide browsers, Microsoft Office programs, and other software required. The chosen size of the project group is four why three supporting computers are required. The requirements on these will be further discussed in a later scenario concerning brainstorming sessions. Finally, the five computers described above will be placed in an apparatus closet not visible to the users.



1. The screen end	4. Workplace for designer 2	7. Retractable board for keyboards
2. Place for two extra chairs	5. Workplace for designer 3	8. Space for monitor
3. Workplace designer 1	6. Workplace for designer 4	9. Conferencing area

Figure 5 Conferencing workspace

The screens and projectors have involved extensive work because there are several aspects to consider in order making a good choice, see appendix L. A movable screen, 250 cm times 200 cm, existed at the starting point of this project making it the foundation onto which the rest of the screen configuration was built. The first parameter considered was the number of screens needed in order to create enough capacity in the system without exaggerating, resulting in unnecessary high costs. Considering the scenarios in the first iteration it would probably be possible to manage with one screen for the video conferencing beside the existing one. However, it is motivated to choose two with later scenarios in mind. The existing movable screen is intended for usage with a projector. The question was to consider whether to use front- or back-projection. According to the advantages and disadvantages with projection provided in appendix L back-projection will be used. Concerning the other two screens the first consideration was about what technology to be used. Since the size of the image is of great importance the choice was made between plasma screens and back-projection. Considering cost, performance, and functionality back-projection screens were chosen. The main reasons were that back-projection offer possibility for larger screens to lower cost.

The second consideration was to choose the size of the screens resulting in an aspect ratio. This was done using a projector and measuring image size and projection distances. The tests resulted in a desired screen width of 150 cm and a screen height of 120 cm giving an aspect ratio of 5:4. The environment was built in a 3D environment providing an opportunity to check the design choices. Some images rendered from this model will be presented in the end of this iteration. The two screens under discussion should be placed in front of the conference table and the movable one beside. The environment for video conferencing is set up with an aim to create a good support for collaboration. An example environment can be seen in the figure below. The reader should notice that an effort has been made to make it look like the table is continuing into the back-projected screen creating a feeling of sitting at the same table as the remote users. Note that a large projection screen is used giving the remote participants their actual physical size.

Figure 6 Example environment

The third consideration concerned choosing between fixed and movable screens. The choice became the former since there is already one movable screen in the room. Furthermore the set up of a studio of this size is a complex process with a lot of wiring. In order to be able to do this in a neat manner fixed screens are better. They also have a tendency to provide images of higher quality since they are stable, always having adequate focus and projection distance.

The fourth consideration was about what material to use for the screens. This is depending on the required bending angle, field of view, viewing angle, gain, resolution, uniformity, and dispersion. To evaluate some of the parameters the figure below with the intended placement of the screens has been created. The placement is motivated with that it was the most space saving and functional that could be found.

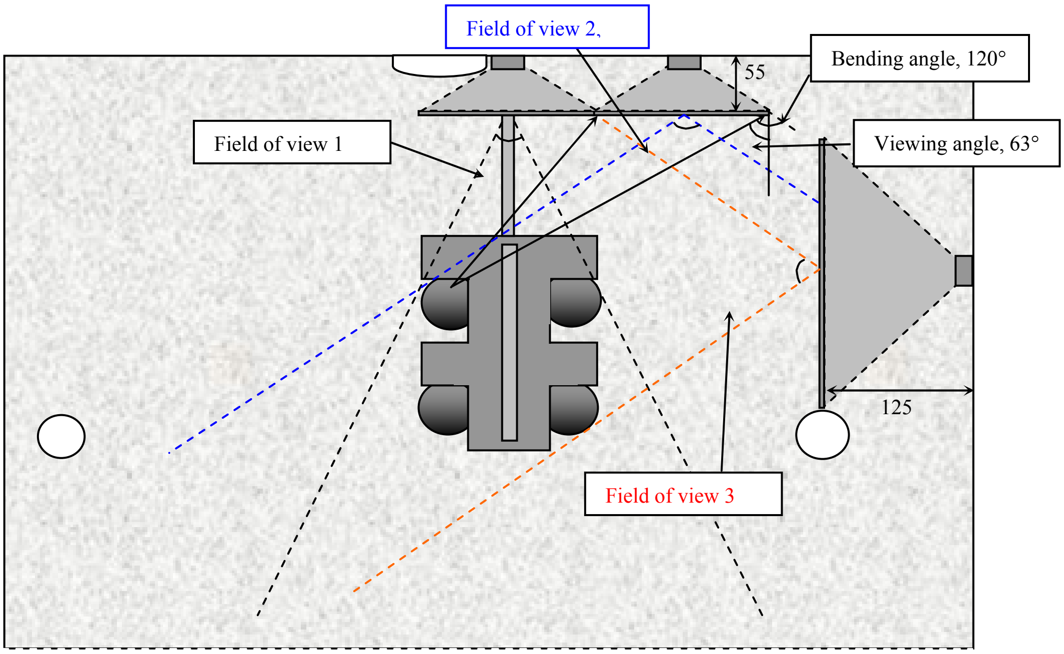


Figure 7 Requirements on screens

The image shows the bend angle, field of view, and the viewing angle required in the room. Moreover designer 2 was picked as reference for the bending angle and the viewing angle since that placement is the most critical for these parameters. It is also considered important to be able to work in normal daylight with good picture quality, therefore the screen material should provide high gain, resolution, uniformity, and dispersion. Finally the intention with the two screens by the table end is that these should be built in a wall with a glass plate in front of them making it possible to draw directly on the screen. For this reason a solution based on a soft screen material was considered to be the best.

Two distances were placed in the figure above to provide the desired projection distances for the projectors. However, a projector with the required aspect ratio, 5:4, requires 225 cm for the movable screen and the 145 for the others to give the desired image size. These measures are far from the one presented in the figure. The solution to this is to use a mirror device at each projector, reducing the projection distance with about one meter.

The natural choice for projectors in a studio of this size would be LCD or DLP. Due to the picture quality, contrasts and colours, provided by the DLP technique, a projector of that type is suggested, further information in appendix L. Resolution is important for how the quality of the images is perceived. For that reason should the chosen projector be capable for at least XGA (1024 x 768 pixels) or SXGA (1280 x 1024 pixels).

Included in the existing equipment of the IDE studio is a pair of stereoscopic glasses with corresponding equipment for stereo visualization. These will primarily be used with the large movable screen. Since this type of advanced graphics already exists to some extent in the room no further investment in another type of technique, see appendix L, is suggested in the first phase of the set up of the studio. This alternative could be considered when the studio has been used for a while. Consequently the eventual use of future stereo be should reflected in the choice of projectors.

To sum up it has been described in the paragraphs above how three screens should be used and placed in the IDE studio. Moreover the requirements on material for the screens have been presented. Finally it was considered to be a good choice to use two DLP projectors with capacity to project with high resolution together with the existing one. Each projector must be provided with a mirror device to acquire adequate projection distance. Finally, the existing support for stereo visualization is considered to be enough at the moment.

Video cameras. It is important to use a camera with good performance in video conferences, see appendix I. Important features for the IDE studio are pan/tilt functions, zooming, adjusting different features of the picture (bright, hue etc), auto-focus, and remote control. As mentioned in earlier sections the Sony EVI-D31, appendix L, was chosen as main camera. This is motivated with its good capabilities, and that the software Smile supports it. The placement of the main camera will be either on top, or at the centre of the screen at the end of the conferencing table. The former since the camera will not disturb the image and the easier mounting, the latter since it provides a better sense of eye contact with the remote user. However, this feature is easily tested out when the studio is set up and the opinions of different users can be accounted for. The field captured by the camera is important for the placement of the table. The angle is 49° and the table will be approximately 150 cm. Consequently the distance can easily be calculated using basic trigonometry. Since the camera firstly will be placed on top of the screen the calculation has been done according to that assumption resulting in following distances.

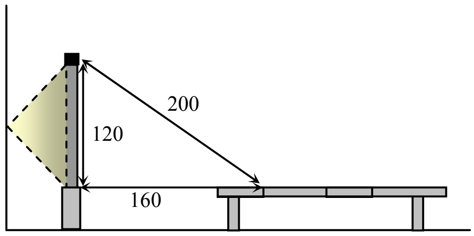


Figure 8 Camera distance

Another similar camera will be placed on a place in the room covering a different view than the main camera. The column by the windows was considered as the most suitable position, see the figure below.

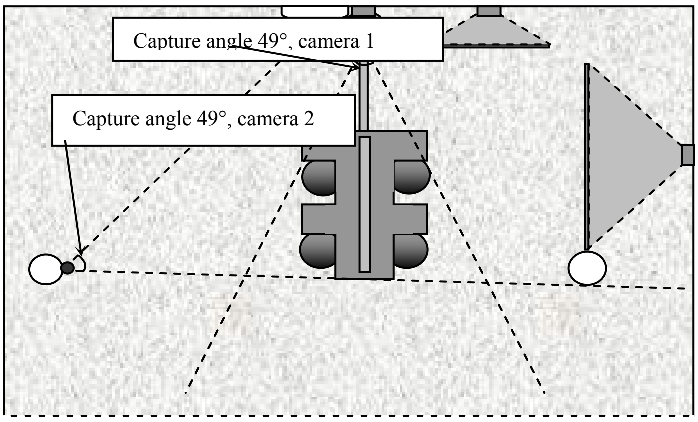


Figure 9 Placement of cameras

The physical connection for the cameras will be set up using the serial and composite port on the SGI O2 computer. The signals will pass through the controlling system making it possible for the users to interchange between the two cameras during a session. Furthermore the serial port on the computer should be connected to the VISCA in on the cameras enabling remote control. An overview figure showing the intended wiring over the whole system has been constructed and will be provided at the end of iteration 3.

The Microphone system and suggested systems are briefly mentioned in appendix I, and L**,** where the importance of the system was emphasized. A selection can be made between wired and wireless solutions. The nature of the IDE studio makes it suitable for a wireless system adding desired flexibility to the system.

The chosen system should be dimensioned for at least four people, and should also be easy to expand if conferencing with larger groups are desired. A system like this will be made up of transmitter, receiver, and an auto mixer, appendix L. The transmitters are connected to a headset and carried by the users. The transmitters send signals to a receiver in an apparatus closet. The purpose of the auto mixer is to mix the signals before they are sent to the controlling system and further to, in most cases, the SGI O2 computer. A detailed schematic scheme of the connections will be presented in iteration 3. A suggestion for a system could be the WMS 81 or 300 by AKG [AKG, 2001].

The speaker system can be chosen based on numerous criteria. However the microphone system is more important than the speaker system why, initially, more careful consideration should be made into this system. For the time being does a system with base reflex box and two small speakers exist in the studio. The sound provided by this system could be of enough quality. The suggestion is to implement a controlling system with ability to switch sound source between the SGI O2 and the Intergraph. As the system grows and the testing becomes more elaborate the system can be expanded if needed, without unnecessary extra costs.

The Controlling system is one of the most important or maybe the most important part of the IDE studio, appendix L. With this flexibility, functionality, and user friendliness capabilities can be integrated into the system. The users can, for example, choose which screens, computers, and speakers to use, making the studio very flexible. Moreover distinct use cases can be programmed into the system making it easier for new users. The system will be handled by Designer 1 and thus installed at that place, unless a wireless system is installed. There are a couple of companies on the market selling controlling systems, for example Demovision, SIE, Lanyfax, Imapact Europe, and Opticore.

Curtains and screen-offs are the final subject to be discussed in iteration 1. The primary reason for the need of previously mentioned is to create adequate light and sound conditions in the studio. They will also function as a way to screen off the room. Consequently a video conferencing session will not necessarily acquire the whole studio, adding to the usability of the same. Below a picture is presented showing the imagined curtains and screen offs in the IDE studio.

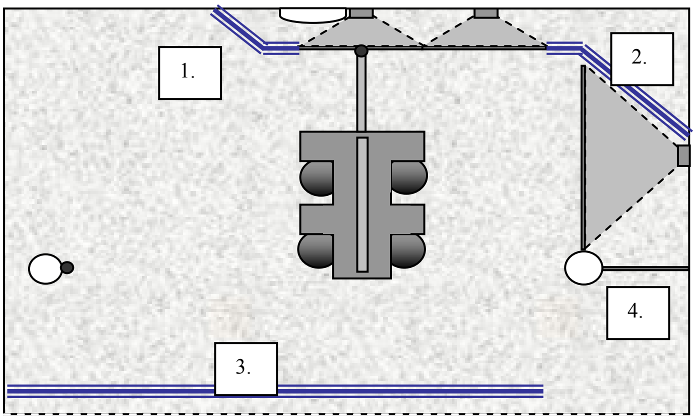


Figure 10 Curtains and screen-offs in the studio

The curtains depict one and two in the figure serves as borders to the area around the fixed screens. Their purpose is to provide god light condition for the projectors and to absorb sounds from the same. In the space behind curtain two will an apparatus closet be placed containing computers, sound receiver etc. Number two is placed as shown so that the conferencing area will look good even though the movable screen has a changed position or is absent. Curtain three will serve as a screen off, and to give the sent images adequate depth. Moreover, it will be possible to pull it all the way across the short side of the room if desired.

Curtains one to three will be made out of cloth and should be in an as absorbing and light sealing material as possible. The last one to be discussed is number four. This is thought to be a notice board or a project group board available for those working in the studio.

Iteration one will be ended with some images created to show the reader what the room will look like at this point in the developing process. As the work proceeds in later use cases the model will be completed. The aim is to show the table and screen configuration.

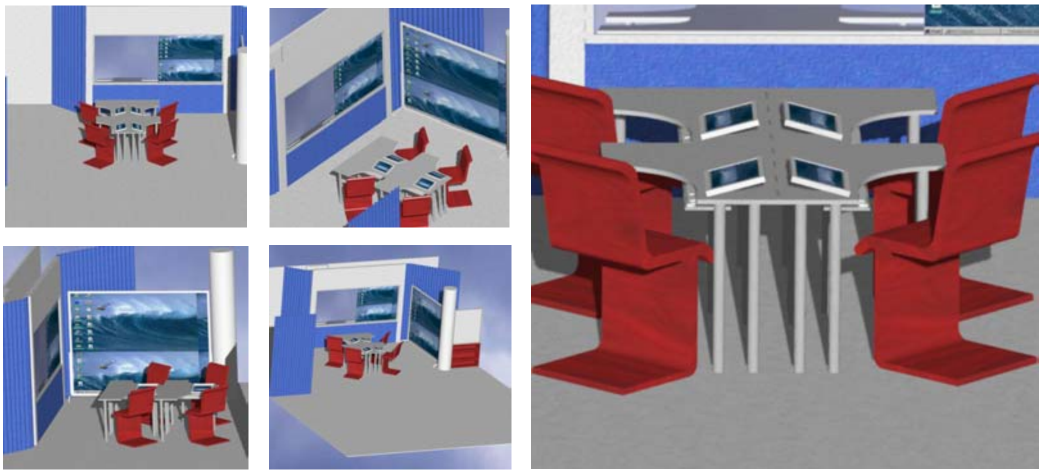


Figure 11 The IDE studio after iteration 1

3.2 Iteration 2

The second iteration will complete the first with support for brainstorming, PDM systems, whiteboard, and extern computers. The description will be made, as for iteration 1, through real use cases, analysis, and design.

3.2.1 Real use cases iteration 2

Four different scenarios are considered. These are *arranging brainstorming sessions*, *usage of PDM system*, *usage of a whiteboard*, and finally *usage of an extern computer*.

Table 10 7. Arrange brainstorming session

	Actor action		System response
1.	The system is started according to previous use cases. A project group of four people wants to carry through a brainstorming session. If desired can the users use the wizard to set up the system. The work is done without video conferencing at the same time. The users sit down at the conferencing table. All users have access to a pressable screen and a keyboard. Designer 1 logs on to the Intergraph computer and the others on the supporting computers.		
		2.	The computers are started up and the start page is shown on the screens in front of the designers.
3.	The aim is to carry through a sketching session why all users open a program according to this, for example Illustrator, using the start menu.		
		4.	Program according to the choice of the users is started.
5.	The designers can now start the discussion and sketch their suggestions directly on their respective screen. Designer 1 sits at the controlling system. With this the images from all users can be projected onto any of the other three screens, making it easy to work together discussing different solutions. Preferably will the screens at the end of the table be used during creating sessions enabling for all participants to easily see the current sketch.		
		6.	The images are switched from the monitors on the desks to the larger projections screens in front of, and beside the conferencing table as commanded from Designer 1. It may also be possible to program different standard configurations into the controlling system making it easier for Designer 1.
7.	Enabling for all users to be able to save their documents in the same place in the system makes it possible to open all suggestions from the same computer. This is especially useful in the evaluation of finished sketches. Preferably the largest screen in the system, placed alongside the table, should be used for this work. Consequently all users turn to this screen. Notice that the screen is placed so that a person can act in front of it if needed.		

	Alternative course		
1.	The system is started according to previous use cases. A project group of four people wants to carry through a brainstorming session. If desired can the users use the wizard to set up the system. The work is assumed to be done with remote designers through video conference. The users sit down at the conferencing table. All users have access to a pressable screen and a keyboard. Designer 1 logs on to the Intergraph and the SGI O2 computers, and the others on the supporting computers.		
		2.	The computers are started up and the start pages are shown on the screens in front of the designers.
3.	The video part of the session is carried out as described in the use case meeting sessions above. The brainstorming is carried out as recently described with the difference that there is one large screen less available due to the video transmission, and that a connection has to be made to the remote design group. In most cases the back-projected screen at the end of the table will be used for the video, and the screen beside for the sharing. The designers each invoke a VNC server.		
		4.	The system starts a VNC server providing the desktop images from the designers to the remote users.
5.	The designer who desires can connect to a VNC server at the remote end giving access to the remote screen.		
		6.	The connection to the remote host is accepted and the remote screen is visible at, in most cases, Designer 1. This process can be repeated until a designer has access to all remote desktop screens.
7.	Since the Intergraph has two VGA signals it is to prefer that Designer 1 connects to the remote users. Designer 1 can then use the control system to project one VGA signal storing all remote users to any screen and keeping the other on the own sketching tool. This will make it possible to for all designers to see the remote sketches while working on their own.		
		8.	The images are projected as desired by Designer 1.

Table 11 8. Usage of PDM system

	Actor action		System response
1.	The system is started according to previous use cases. The four designers working at the IDE studio are included in a project with none, one or more remote designers. If desired they can use the wizard to set up the system. The Intergraph used by Designer 1 has a server function while all others are clients, including the supporting computers used by designer two to four.		
		2.	The PDM server has been started and is hosted by the Intergraph computer. Through browsers can all users be active in the system.
3.	Designer 1 chooses the type of session. Either programmed in the control system or improvised. Consequently the usage of the PDM system can be combined with other use cases like meeting sessions or brainstorming.		
		4.	Images are projected and other tools like cameras and programs adjusted to the choices made.

Table 12 9. Usage of a whiteboard

	Actor action		System response
1.	The system is started according to previous use cases. A desire for usage of a whiteboard occurs. No remote users are present. If desired can the web page be used to set up the system. A designer starts the program hosting the whiteboard tool.		
		2.	Default screen for whiteboard is the screen beside the one directly in front of the end of the table. The projector behind this screen has been turned on. The whiteboard program is started on the Intergraph computer or one of the supporting computers, and shown on the monitor in front of the designer invoking the program.
3.	The designer can choose to work from the table, sketching directly on the monitor or to act by the large screen. If the latter is desired Designer 1 adjusts the system accordingly.		
		4.	The chosen monitor image is shown on the desired screen.
5.	A user can use a special pen provided with the whiteboard system to sketch directly on the screen. It will also be possible to use the large screen as a pressable screen with a possibility to invoke programs and navigate.		
		6.	Programs and commands are launched according to the choice of the users.
7.	The pages written on the board can be saved and distributed to other users.		
		8.	The mailing tool is used.
	Alternative course		
1.	The system is started according to previous use		

	cases. A desire for usage of a whiteboard occurs. Remote users are present. If desired they can use the wizard to set up the system. A designer starts the program hosting the whiteboard tool.		
		2.	Default screen for whiteboard is the screen beside the one directly in front of the end of the table. The projector behind this screen has been turned on. The whiteboard program is started on the Intergraph computer or one of the supporting computers, and shown no the monitor in front of the designer invoking the program.
3.	The designer can choose to work form the table, sketching directly on the monitor or to act by the large screens. If the latter is desired Designer 1 adjusts the system accordingly. Since remote users are present in the session will these also be included in the session using the tool for distributed work included in the software for the whiteboard system.		
4.	4-8 are the same.		

Table 13 10. Usage of an extern computer

	Actor action		System response
1.	The system is started according to previous use cases describing the initiation of a user session. If desired, the wizard can be used to carry out this use case. Designer 1 to 4 uses the system when a desire to connect an extern computer occurs. Most often this will be a laptop owned by one of the designers at the table or a guest wanting to take part in the session. The extern computer or computers are connected to the system with a VGA cable and a WLAN card to gain access to the web.		
		2.	The new computers are connected to the system.
3.	Designer 1 can, if needed, project the image from one of the new computers on a desired back-projected screen.		
		4.	The system is configured according to the choice of Designer 1, showing images where desired.
4.	The extern computers can be used in the system		

3.2.2 Analysis issues for iteration 2

The second iteration completes the first with support for asynchronous work, whiteboard, and connectivity to extern computers. The relationship to the system attributes will next be investigated. However, not all identified areas are of interest, only flexibility, ease of use, and mobility.

Flexibility. The importance of making it possible to configure the IDE studio to different types of work has been emphasized several times. During almost all types of projects the process of generating ideas or solutions to problems is a common aspect of the work. For this reason one aim is to make the studio a useful tool for this line of work, adding to its flexibility. A PDM system will be used to support, especially, asynchronous work making it an even more useful tool for project groups. For example, a design group or a project leader at Chalmers can keep track of where the project is in the development process, and what the different members are occupied with in an easy manner. The set up of a pressable whiteboard, possible to govern from the conference table or directly on the screen, functioning both in distributed and ordinary situations clearly add to the desired function. Finally it is suggested that the studio is set up with a WLAN network providing good opportunity to invite outside users and easily expand the system when needed.

Ease of use. The PDM system will provide an opportunity to keep track of the information and people in projects making the work at the studio simpler. It might also be easier to use the studio if the connection of the laptop of a temporary guest can be done without any complex manoeuvres.

Mobility addresses the possibility to configure the room, bring it with you. For this reason the WLAN is considered to solely add to the flexibility of the studio, not the mobility.

3.2.3 Design issues for iteration 2

As for iteration 1 the discussion around design issues will be divided into two parts, software and hardware.

3.2.3.1 Software

The users can choose the software for the brainstorming sessions according to previous knowledge and the desired quality on the sketches, for example Microsoft Paint [Computerhope, 2001] or Adobe Illustrator. The different sketching programs will be installed on all computers except the SGI O2 making it possible for all users at the conferencing table to participate in the session. A thin client will be used to enable brainstorming with remote designers. This was discussed in iteration 1 why there is no need for further discussion. Furthermore, the document sharing software BSCW should be downloaded and installed on the Intergraph computer making it a server. For motivation of the choice and information about the system, see appendix K. Both present and remote users can access this program through web browsers installed on their own computers. Finally software will be provided with the chosen whiteboard tool. This should be installed on both the Intergraph and the three supporting computers making it possible for all designers to use the system.

3.2.3.2 Hardware

The hardware situation will be described for the brainstorming, whiteboard and the wireless system since the PDM system does not include any hardware.

Brainstorming. To carry out a brainstorming session is a quite straightforward process if done with paper, pen, and a whiteboard. The question was how this process could be developed and supported in a computerized and distributed manner. Since designers are supposed to use the equipment the ability for all participants to sketch is rated high. Descriptions of different alternatives have been done in appendix L. The equipment will be optimised for 4 person groups. Nevertheless, the system will be constructed so that it can be easily expanded to fit larger groups. The backbone for enabling sketching is the completion with supporting computers to the system, each storing a sketching tool as described above. Through the controlling system the ideas from different designers can be projected on any screen in the room so that it can be discussed in the group. If work is to be carried out in a distributed manner, the sketching environments can be shared so that the work in the project group can be followed by a remote, group and vice versa.

The selection of hardware for the support of brainstorming will be a trade-off between cost and sophistication. The requirement adds two types of hardware to the IDE studio, supporting computers and sketching tools.

The supporting computers are needed to enable all four designers to work at the same time. It has been, to all small extent, tested to connect more than one tablet to the same computer. However, the functionality cannot be guaranteed since conflicts between different devices can occur. This together with the fact that the tablets can be used more flexibly motivates another solution. If project groups of four persons are to be supported three extra computers are needed since the Intergraph computer can store one sketching tool. These do not have to be expensive top of the line products. The requirement is that they can host the sketching tool with supporting software, network connection, and software for distributed work, for example VNC. Consequently a 300MHz PII or PIII processor and 128 MB of RAM will be sufficient, why the supporting computers should not be especially costly compared to the rest of the equipment.

Concerning the sketching tools, the most desired solution is based on four LCD tablets. This since they are easy to use for sketching, even for a less skilled user, and provide a regular screen onto which a user can navigate and access programs by pressing directly on it. An example of an exiting system of this type is the Wacom PL series, se appendix L. These are connected to an USB or serial port and to the DVI or DFP connector on the graphics card. The connections from the four tablets will be directly to each computer, not passing through the controlling system. This since a need for changing computers between the different tablets cannot be foreseen at the moment. However, when Wacom was contacted they announced that the PL Series are to be replaced in the near future with a better and cheaper system, Cintiq. Consequently should an investment for the IDE studio await this product and evaluate its capabilities since they are not available in time to be included in this thesis. Solutions based on LCD tablets are likely to be expensive to set up and, if desired, expand. Still, a fact is that they will make a major contribution to the system enhancing the functionality, ease of use, and the effective use of space. For the functionality and effectiveness of the studio it is quite important to provide sketching tools to all users. It should, for this reason not be considered a good alternative to provide one designer with a LCD display, hoping that would be enough. Instead it would probably be wiser to find a cheaper alternative that can be provided to all. For this reason another solution, based on sophisticated non-LCD tables, can be considered. An example of tables like this are the Intuos from Wacom, see appendix L. Note that it is important that the tablets are advanced and of adequate size since designers are going to use them, they should not feel restricted by the technology. The aim is to create the reverse situation. An Intuos board requires a supporting screen. It can be a back projected image, a regular, or flat monitor, see appendix L. A solution based on back-projection will require as many projectors and screens as tablets. This would make the system complicated to expand and very expensive. For these reasons it is probably better to adopt a solution where all participants can use a desktop monitor. Preferably a flat screen lying almost on the table should be used so that it will not block the field of vision of the image captured by the camera, or the users. An example with desk, tablet, and flat screen can be seen in the figure below.

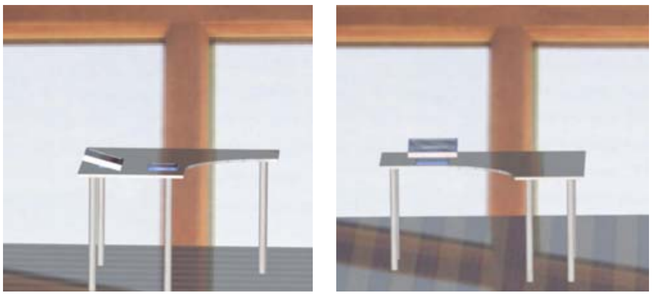


Figure 12 Rendering of monitor, tablet, and desk configuration

Another less expensive example is based a solution with regular monitors. The benefit with this type of solution is strictly economic since these types of screens acquire much of the space on the desk, and blocks the field of view for the users. This configuration can also give a very crowded impression through the lens of the camera, which is not desirable. Nevertheless, a solution like this could be considered if the monitors could be lowered into the desks so that only the screen would be visible to the users.

Finally, the room should store a WLAN system providing simple access to the system with laptops making it simple for different persons to use the room with their specific programs and models.

Whiteboard. The whiteboard is an important tool in almost all situations where something should be explained or investigated. The usage of a whiteboard is considered to be an own scenario in this thesis, but can function as support for almost all other use cases. For the IDE studio it is of great importance that the whiteboard can be shared with remote users. Furthermore, functionality with a pressable screen would be desirable since it provides great opportunities for good teaching and displaying sessions. In the chapter for sketching and writing tools, appendix L, a few options are described. Considering the studio as described in iteration 1, the Matisse system can be ruled out together with the Hawk eye system. This since no plasma screens are to be placed in the room, and that both the eBeam and the Mimio systems are preferred before the Hawk eye. In evaluating the different alternatives left, SMARTBoard, eBeam, and Mimio an effort was made to find the one best suited to be placed in the IDE studio. Since a whiteboard is to be added to the room, an attempt will be made to combine this with a screen. Evaluating the existing configuration from the first iteration gives that the movable screen, and the screens at the end of the table should not be altered since their functions are clearly defined. It is also hard to motivate the extra cost to add a fourth screen in a good way, why it remains to investigate the one beside the screen at the end of the table. If an image is to be projected on the whiteboard it will be required that either front or back-projection are used. Since acting in front of the projected image will occur back-projection is the natural choice. This will rule out the Mimio system since eBeam have superior capacity for back-projection. The remaining choice is between the SMARTBoard and the eBeam system. The former is without a doubt the one offering the most sophisticated functionality. But, the latter can be integrated into the desired system in a good way and is less expensive. For cost considerations it is more important to invest in, for example, better sketching tools. One of the advantages with eBeam lies in that the screen beside the one at the end of the table easily and effectively can be combined with a whiteboard. As for the physical connection to the rest of the system eBeam requires an USB or a serial connection. The connection will only be carried out to the Intergraph computer in the first phase, this due to the fact that the written whiteboards easily can be distributed to the others in the session. In conclusion one big screen hosting two projectors will be set up at the end of the table. The projection material will be soft, but importantly a mirror will be placed in front of the cloth making it possible to draw with a whiteboard marker directly on the glass. The two projectors are suggested to work in a soft-edge configuration, but if cost is an issue, will probably a hardedge alternative work almost as well. If there in a session should occur a requirement for a larger screen can the movable screen be used.

Wireless system. As mentioned earlier a WLAN system will be used to accomplish mobility through a wireless network. As a consequence, the IDE studio will be set up so that an extern computer, most often a laptop, can be connected to the system. VGA cables for extern computers will be installed at each place at the conference table. To provide effective temporary places four stand-up tables will be added to the system, each storing a VGA cable. All places with extra VGA cables will have possibility to conceal these when not used. It will be a channel in the conference table and holes at the table.

As for iteration 1, iteration 2 will be ended with some images created to show the reader what the room will look like at this point.

Figure 13 The four stand-up tables with main and overview camera

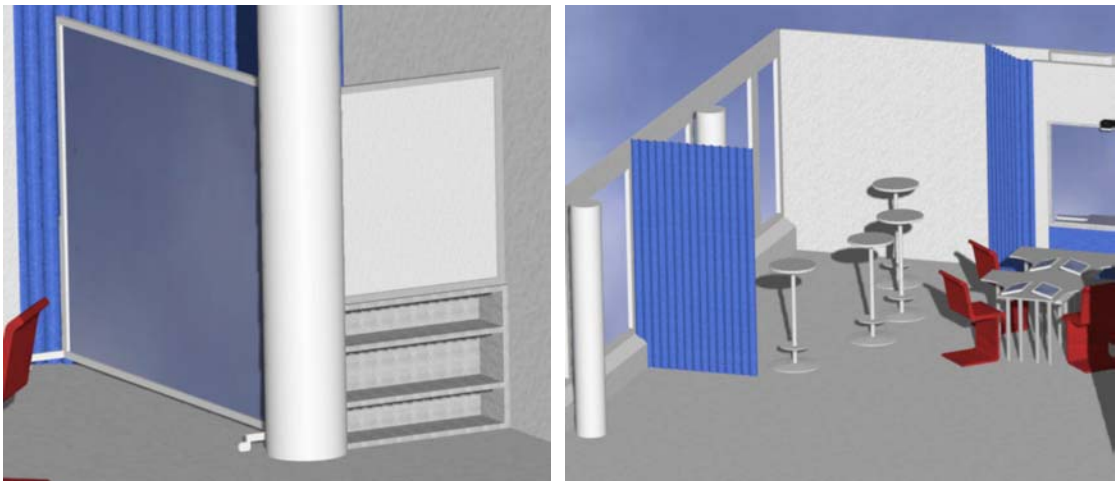


Figure 14 Movable screen, noticeboard and an overview

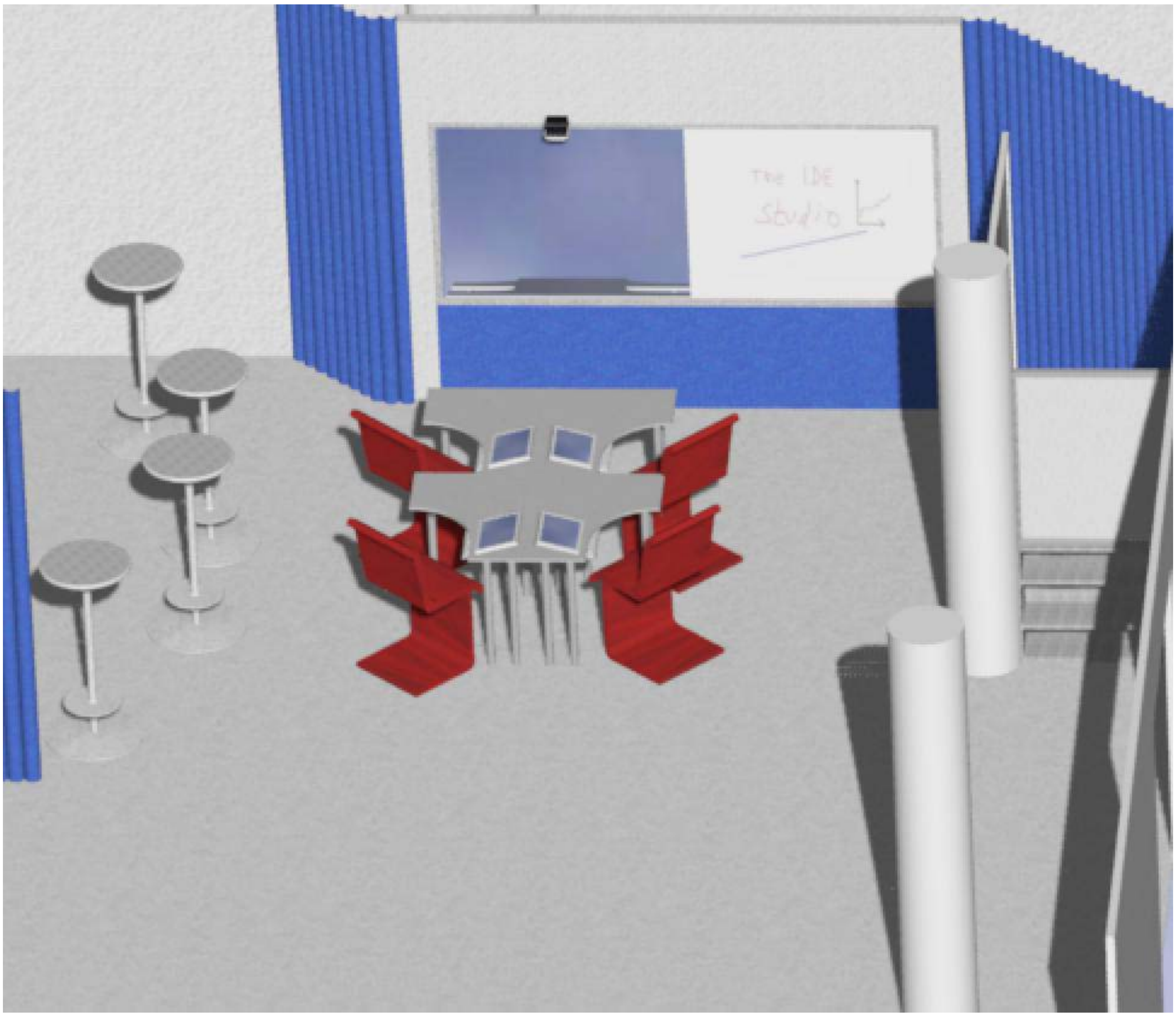


Figure 15 The whiteboard screen, conference table, and main camera

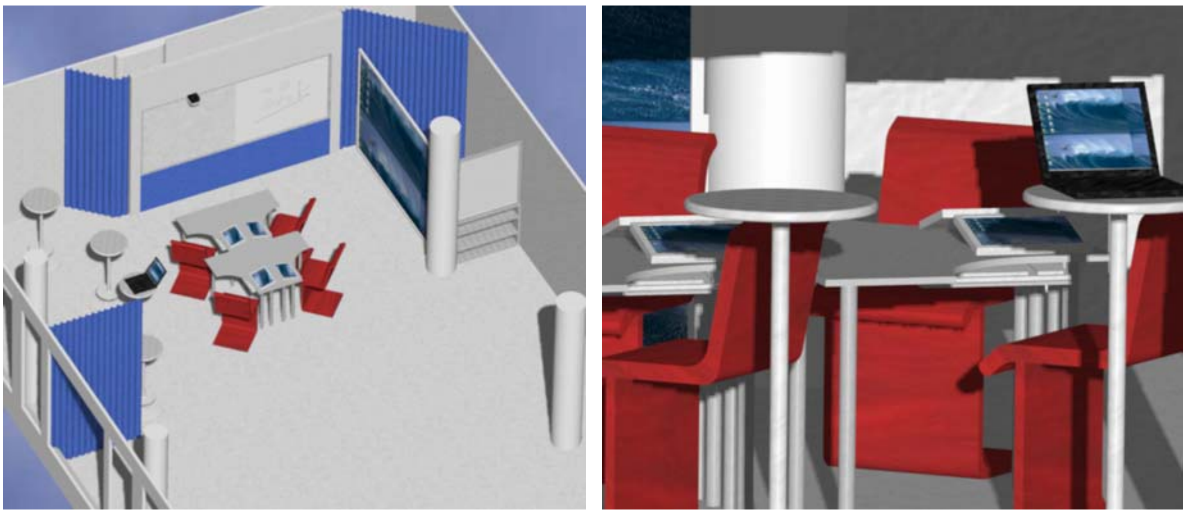


Figure 16 Person working at the stand-up table

3.3 Iteration 3

The third iteration is the last one to be carried out. The areas in focus are intended to enhance the presentation abilities of the studio, and to further simplify the usage of the same. Moreover, the last scenario to be constructed according to [Larman, 1998] should be the description of the start up of the system, why the development has been done accordingly.

3.3.1 Real use cases iteration 3

The third, and last, iteration will conclude the work with the real use cases and presents the scenarios for *arrange presentation session*, *accessing studio website*, and *start up of system*.

Table 14 11. Arrange presentation session

	Actor action		System response
1.	A group of designers are working at the studio. A material, model or project shall be presented to a group of people from a computer program. The source file can exist on the hard disk, CD-ROM or DVD. Furthermore this takes place without remote contact. An inexperienced user can choose to use the web page to set up the system. In most cases Designer 1 will be responsible for the presentation why the program hosting the desired project is started on the Intergraph computer.		
		2.	The desired program is launched, and the image is shown on the LCD screen at Designer 1.
3.	The project can be presented directly in the program used to develop the model or exported to, for example, Photoshop requiring less space. Projects are normally presented on the large screen alongside the table why the projector to this screen is started up. However can the screens at the end of the table be used if the group attending the presentation is small Designer 1 will use the control system to adjust the screen configuration as best suited for the situation.		
		4.	The projection environment is adjusted according to the commands of Designer 1.
5.	Using the tools of the studio, the presentation can begin. The presenter is free to act either at the conferencing table, or in front of the screen. The audience can use the space around the stand up tables to find good places to watch and listen.		
	Alternative courses		
1.	A group of designers are working at the studio. A VHS video shall be presented to a group of people from a videotape recorder. Furthermore this takes place without remote contact. An inexperienced user can choose to use the web page to set up the system. In most cases Designer 1 will be responsible		

	for the presentation why the control system are used to adjust the system so that the video signal can be seen on the movable screen. However, the fixed screens can be used for small groups.		
		2.	The signal from the video is converted to a VGA signal and sent to a projector.
1.	A group of designers are working at the studio. A material, model or project shall be presented to a group of people. Furthermore this takes place with the possibility of remote contact. An inexperienced user can choose to use the wizard to set up the system. To distribute presentations the media streaming function in Smile can be used why designers arranges the system according to a meeting session. If a material should be presented to a remote user they connect to the streaming server at the studio and the other way around for the reverse situation. If the latter is the case Designer 1 connects to the remote server via Smile. Moreover the projection environment is adjusted so that the audience can watch. Most often the screen alongside the table will be used.		
		2.	The signal from Smile is sent to the desired projector.

Table 15 12. Accessing studio website

	Actor action		System response
1.	The system administrator wants to change the information on the studio website to update it according to some changes made in the studio. The editor for editing websites are opened at the administrator makes the changes.		
	Alternative course		
1.	The design group are working at the studio and want information about: • The studio • Getting an IP address • Booking • Initiation of user session • Access to programs • Arrange meeting session • Collaboration • Brainstormin • The PDM system • Usage of a whiteboard • Usage of an extern computer • Arrange a presentation session Description of each of these areas will be		

	provided on the Studio website. Each field should have an own button making it easy for the user to navigate. The information behind the button should be opened in a new browser window.		
		2.	Browsers and screens are opened and configured according to the choices of the users.

Table 16 13. Start up of system

	Actor action		System response
1.	The system administrator is responsible for the equipment in the studio why also responsible for the start up of the same. The most fundamental is to turn on all five computers in the system. The three supporting computers, the SGI O2, and the Intergraph.		
		2.	Each computer makes its initiation process and sends the login screen to the controlling system.
3.	The control system is turned on.		
		4.	The default configuration is that the signal from the Intergraph is shown on the LCD tablet at Designer 1. The other three LCD tablets will show the logon screens from the supporting computers. Thus will the signal from the SGI O2 not be visible without turning on a projector or changing the signals to the tablets. Default projector for the signal from the discussed computer will be the one at the fixed screen directly at the end of the table. This since this screen will be the most common for conferencing. Default screen for the second VGA signal from the Intergraph computer will be the fixed screen beside the conferencing screen. This screen will be used as back-projected whiteboard why it should be easy to act in front of it. The default configuration for conferencing will be for usage of Smile. This means that the microphone and cameras are coupled to the SGI O2 computer.
5.	If the eBeam system has not been used before, an initiation process has to be carried out for this system. This is made directly on the fixed screen beside the conferencing screen.		

3.3.2 Analysis issues for iteration 3

Iteration three concludes the analysis phase. The scenarios for presentation sessions, accessing the studio web site, and finally the start up of the system will be analysed after the same criteria as other use cases in earlier iterations.

Flexibility. If the IDE studio could be used, besides as a good work area for designers, a place where presentations could be held, in-house or remote, VHS, or computerized, the usability of the studio would be further expanded.

Ease of use. The scenario describing the accessment of the studio website are primarily intended to increase the number of people able to handle the studio, making it more accessible for an everyday industrial designer. To some extent this is also related to the flexibility since the studio can be used more flexibly if users with widespread experiences can use it. Finally, the scenarios under discussion do not, to any big extent, affect the other system attributes identified in section 2.4.1.

3.3.3 Design issues for iteration 3

The design description for iteration three ends the development of the IDE studio. The scenarios for presentation session and accessing the studio website will be analysed. Furthermore this section, like the previous two, is ended with a series of images. However, a wiring scheme showing actual physical connections, and an overview figure will also be provided.

3.3.3.1 Software

To fulfil the scenarios under discussion some software may be needed. For example a player for CD and DVD discs, and programs used to present projects, like Photoshop or Opus Realizer. There is no extra software needed to incorporate a wizard function into the IDE studio. Still, this is considered the best place to discuss this functionality. As mentioned earlier the major purpose of the studio website is to make it easy to use the system. This ranges from actual work, finding of IP addresses, and to book the studio. It is suggested that the site consists of the following topics:

*The studio***.** In order to help a user to understand the system a description of the studio should be made. This includes the purpose, intention, and the different parts of the studio.

*Getting an IP address***.** If the studio comes to function as desired, there will be many potential users. However, it takes knowledge of the recipient's IP address to carry out a video conferencing session. This is not always information that the user keeps track of. For this reason should an applet be included into the web page. This should only be accessible to authorised users and they should be able to add, search for, edit, and delete IP addresses.

Booking. An important aspect of the studio is to create a feeling for the users that it is easy and funny to use it. This feeling can be further enhanced if it is not required of the users to go to the room to see if it is in use or booked.

The basic functions. Finally the website must contain information of the different scenarios for the usage of the studio namely; Initiation of user session, Access to programs, Arrange meeting session, Collaboration, Brainstorming, The PDM system, Usage of a whiteboard, Usage of an extern computer, and finally to Arrange a presentation session.

3.3.3.2 Hardware

The only new hardware needed in the third iteration concerns the support for presentation sessions since accessing the studio website requires no new hardware in the system. In the most simplified, for the development of the studio, case is no further investment required to carry through a presentation session. The basic equipment already exists, computers, big screens, and projectors. Nevertheless, the usability of the studio can be further increased if a couple of other tools are included into the system. Moreover this equipment should be placed in a second apparatus closet under the fixed screens making it easy and natural to access them. The considered tools are a DVD-ROM drive, a CD-RW drive, and a videotape recorder. This constellation is suggested since it provides a broad alternative for the users. If work with huge models is to be carried out in the studio DVD's can be used. It will however, for most work, be enough to read and store on CD's why this function should exist in the studio. Additionally both the CD and DVD drive will be connected to the parallel port directly on the Intergraph. Finally, it is quite normal to use VHS videocassettes in education or at displaying sessions why this function also have a place in the system. For the latter a conversion from the video signal to a VGA signal must be made, sometimes this is possible in the controlling system.

As mentioned above will a couple of figures follow below. The first is the scheme of the actual physical wiring in the studio followed by an overview of the room and some rendered images.

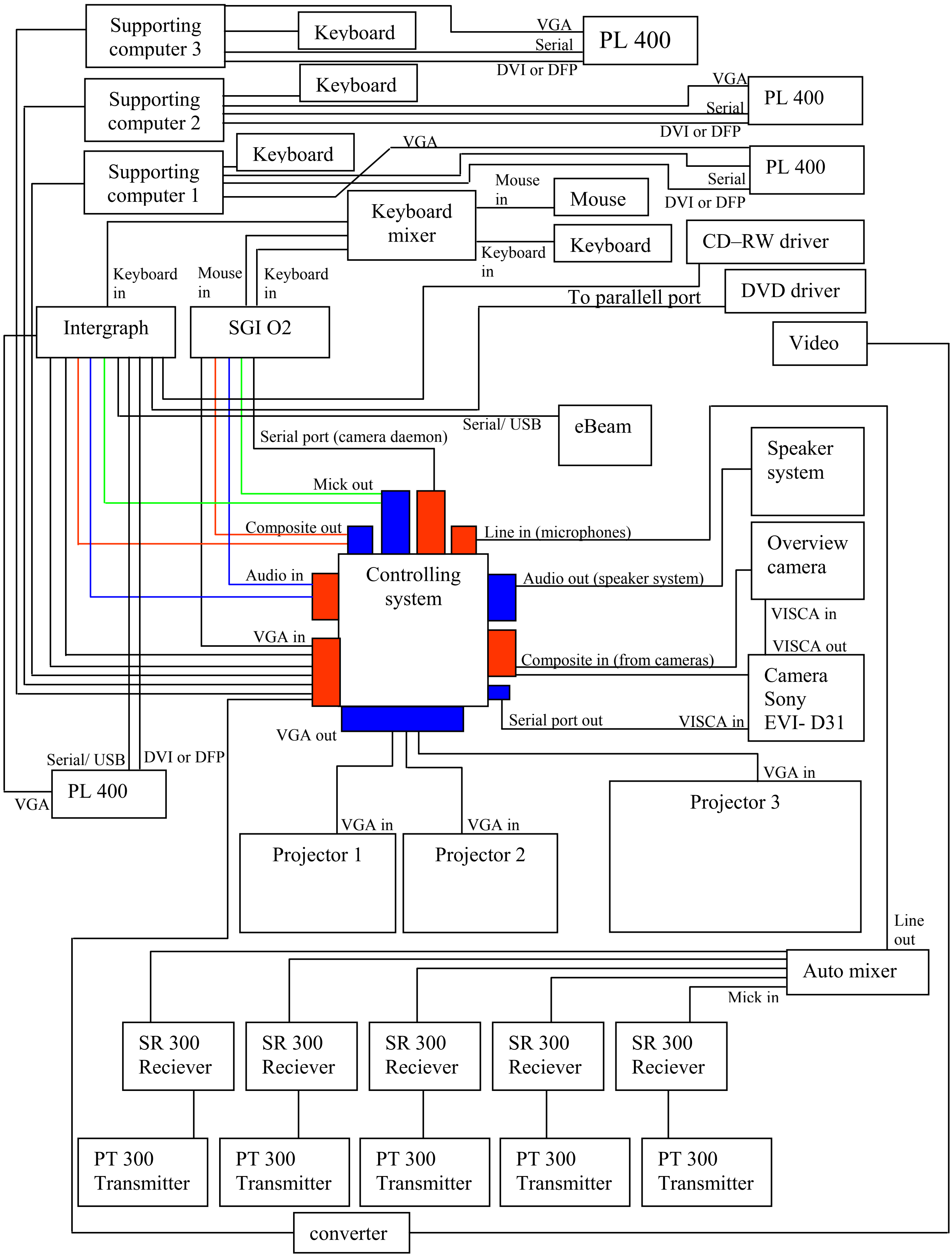
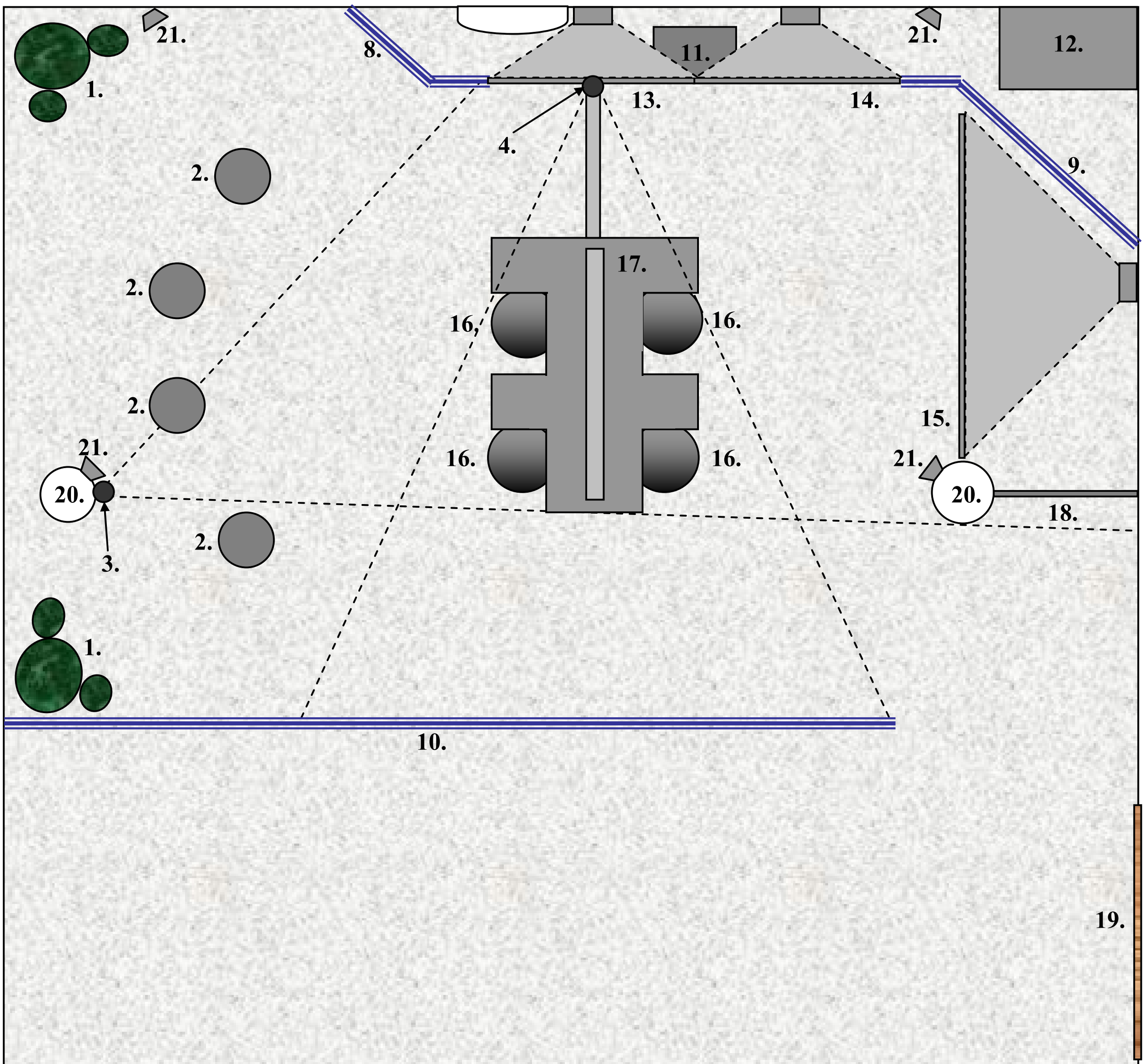


Figure 17 The Physical wiring of the IDE studio



1.	Green plants	8.	Curtain 1	15.	Back-projected screen 3
2.	Stand-up tables	9.	Curtain 2	16.	Chair
3.	Overview camera	10.	Curtain 3	17.	Conferencing/work table
4.	Main camera	11.	Apparatus closet 1	18.	Notice-board
5.	Projector 1	12.	Apparatus closet 2	19.	Door
6.	Projector 2	13.	Back-projected screen 1	20.	Existing pillars
7.	Projector 3	14.	Back-projected screen 2	21.	Speakers

Figure 18 The parts of the room

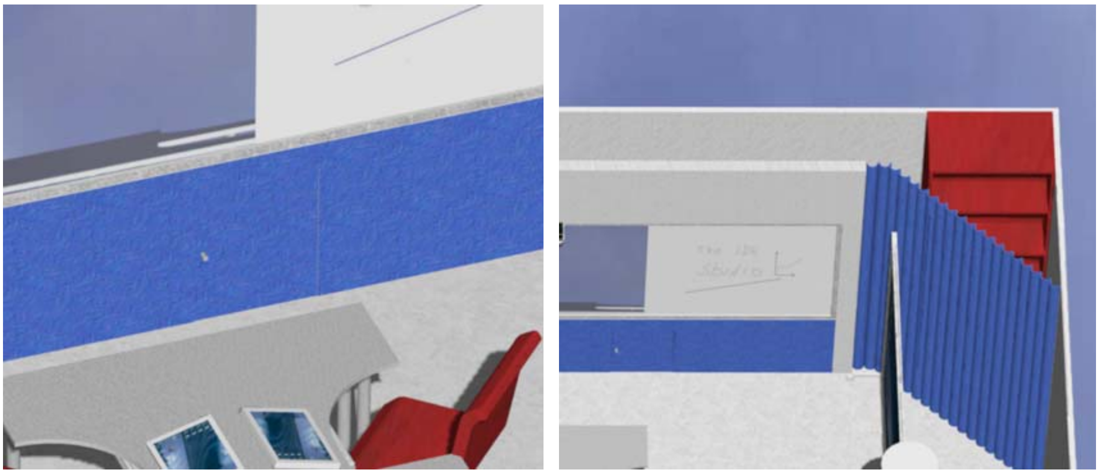


Figure 19 Apparatus closets

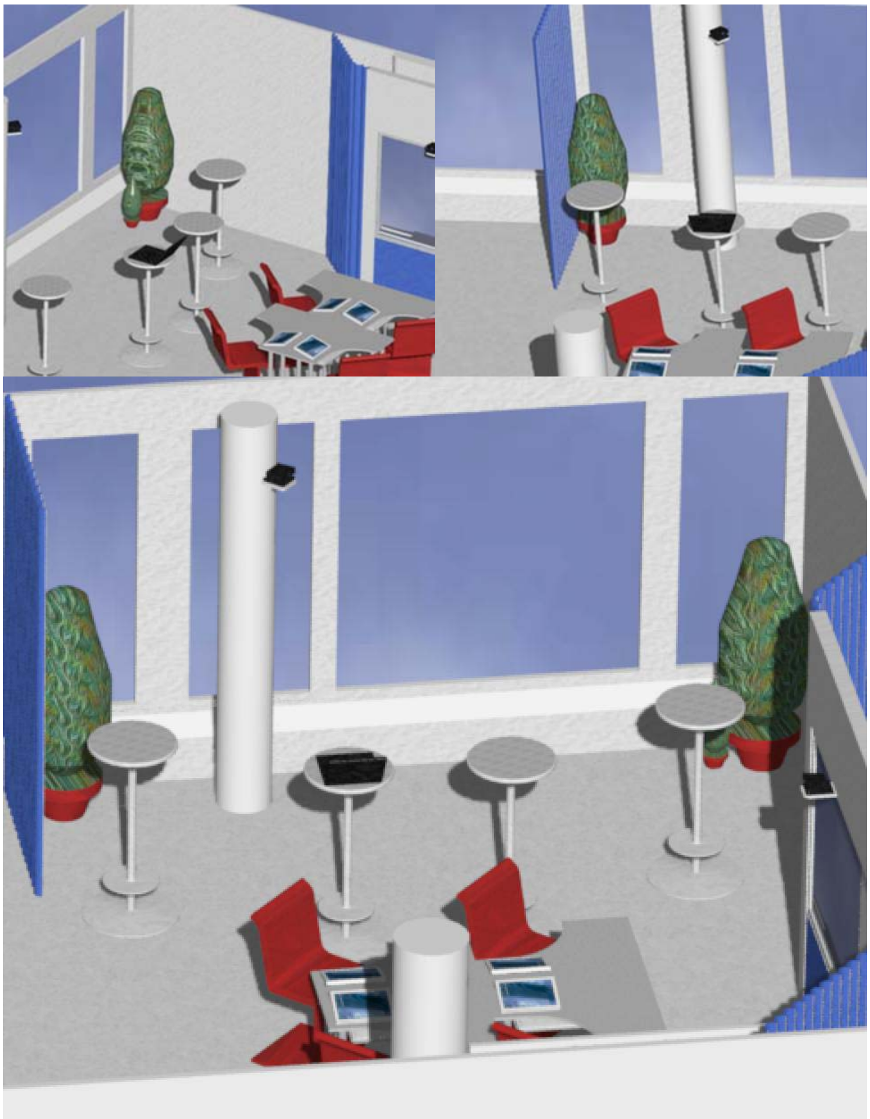


Figure 20 Green plants

4 The chosen configuration

This section summarizes the development of the IDE studio presented in chapter 2 and 3. It includes three different sections; *scenarios, hard- and software, and layout*.

4.1 Scenarios

The overall objective for this thesis has been to create an environment for distributed work aimed for industrial designers. Furthermore this work has included an investigation of how they work, and would desire to work both in distributed and non-distributed environments. The former since the desired environment should support the day-to-day work in design projects as well as supporting new distributed ways. In conclusion a number of design criteria called system attributes were generated together with a number of desired functionalities named system functions. The generated attributes and functions were used to identify a number of scenarios, also named use cases, of basic uses of the studio. They finally became thirteen and are the following:

1. Initiating user session
2. Provide access to Smile
3. Provide access to programs
4. Arrange a meeting session
5. Arrange simple collaboration session
6. Arrange advanced collaboration session
7. Arrange brainstorming session
8. Usage of a PDM system
9. Usage of a whiteboard
10. Usage of an extern computer
11. Arrange presentation session
12. Accessing studio website
13. Start up of system

It should however be emphasized that the scenarios are not considered to be isolated from each other. Consequently larger scenarios can be constructed out of the ones presented above. Since they are thirteen and can be combined in many ways it is impossible and unnecessary to describe all combinations since information already exists. To exemplify this, one scenario will be built up concerning some of the ones presented above. Note that all aspects of the equipment used cannot be described or used in one session, why it should be considered as a brief example.

Imagine that a project group from Chalmers is working together with an American team from University of Michigan. Assume that this group has access to similar collaboration equipment as the one presented in this thesis. The two teams have agreed on a meeting to discuss a solution to a problem concerning their project before the end of the last session. Some time before the meeting will, for example, the project leader access the IDE studio web site to check when the studio is vacant to sign up for a session. Since the group at Chalmers has some issues they want to discuss before the distributed meeting they decide to meet before this.

The group has gathered in the studio on the actual meeting day. When they enter the room they first check the notice board to see if there are any specific messages to the group. There is a note explaining that an extra person will take part in the meeting session. This will make the number of participants five. Consequently one of the stand-up tables will be used in the video conferencing session. Before sitting down at the table the curtain dividing the room is pulled to it place. It is a quite dark winter morning why there is no need for the venetian blinds in the windows.

The project leader, sitting at the place for Designer 1, is used to the studio environment why the studio web page is not needed for using the studio. The first part of the meeting requires a whiteboard why this program is started. Designer 1 steps to the board intended as whiteboard and carries through a session explaining the purpose of the project. At the end of the session a browser is launched through pressing directly on the board. Some websites showing similar products are shown on the whiteboard. The notes is exported to the PDF format and added in the project place in the BSCW system when this initial session in through.

Next the guest is arriving bringing a laptop. A WLAN card is put into the computer and it is connected with one of the VGA cables at the stand up tables. As the meeting with Michigan get closer everybody is provided with a headset and transmitter from the closet below the conferencing screen at the table end. Designer 1 presses a button on the control panel, preparing for a meeting session. When it is time everybody sits at the table, the connection is initiated using Smile. Michigan is already connected why the meeting immediately begins. The remote group wants to show some models they have done why Designer 1 starts DIVISION MockUp and the sharing is arranged. The image is presented on the large movable screen. The remote model is left on the big screen after the presentation has ended, and a brainstorming for solving the presented problem is desired.

All remote and present designers are provided with a LCD tablet connected to a computer. The present designers starts the sketching programs and connects to the remote project leader via a thin client. The remote designers do the same thing to the present project leader. Now everybody can start to sketch as the discussion goes along. Remote or local solutions can be analysed using the screen beside the conference screen if desired. When the session is finished the different propositions are stored and a time for a new meeting is decided upon. The generated sketches are added to the web server together with the ones created by the remote users after closing Smile. Since the session is finished all users log out and the room is restored to its initial state.

4.2 Hard- and software

The continuing work after identifying the scenarios was to make considerations of how they could be carried out in the IDE studio at Chalmers. Consequently this work comprised software and hardware decisions as well as consideration of how a functioning environment for in-house and distributed work should be carried out. This turned out to be a complicated process why the work was done in three iterations. Furthermore each one added new parameters to the system. The final solution was a multipurpose environment with estimated set up cost of 700 000 SEK suited for a group of four designers with temporary places for another four, and included the equipment presented in the table below.

Table 17 Specification of the IDE studio

Hardware		Software	No.	Used/required Capabilities	
Computers	Intergraph	Microsoft Office Browser Sketch program Whiteboard program Software media players VNC Desired design programs DIVISION Mock up DIVE BSCW	1	Keyboard in Serial/USB DVI/DFP VGA Composite in Mick in Speaker out Parallel port	1 2 1 3 1 1 1 2
	SGI O2	Smile Ev. VNC	1	Keyboard in Mouse in Serial VGA Composite in Mick in Speaker out	1 1 1 1 1 1 1
	Supporting Computers	Microsoft Office Browser Sketch program Whiteboard program Software media players VNC BSCW Ev. desired design programs	3	Keyboard in Serial DVI/DFP VGA	1 1 1 1
LCD tablet	PL400[1]		4	Serial DVI/DFP	1 1
Keyboard			4	Keyboard in	4
Mouse (SGI O2)			1	Mouse in	1
Keyboard mixer			1	Mouse (1 to 1) Keyboard (1 to 2)	1
CD-RW driver			1	Parallel port	1
DVD driver			1	Parallel port	1
Video			1	To converter	1
Video converter			1	VGA	1
eBeam			1	Serial/USB	1
Controlling system			1	VGA in VGA out Serial in Serial out Composite in Composite out Line in Mick out Speaker in Speaker out	7 3 1 1 2 2 1 2 2 1
Projector	SONY Vpl-Px20 DLP projectors		1 2	VGA VGA	1 2
Microphone system	Headsets PT 300		5 5	To receiver To SR 300	5 5

[1] New improved product is released by WACOM in near future, Cintiq.

	SR 300 Auto mixer		5 1	To auto mixer To line in	5 1

4.3 Layout

Throughout the work several different layouts of how the IDE studio could be set up has been considered. The chosen configuration, considered the most effective and found to provide the most effective usage of the room, is presented below.

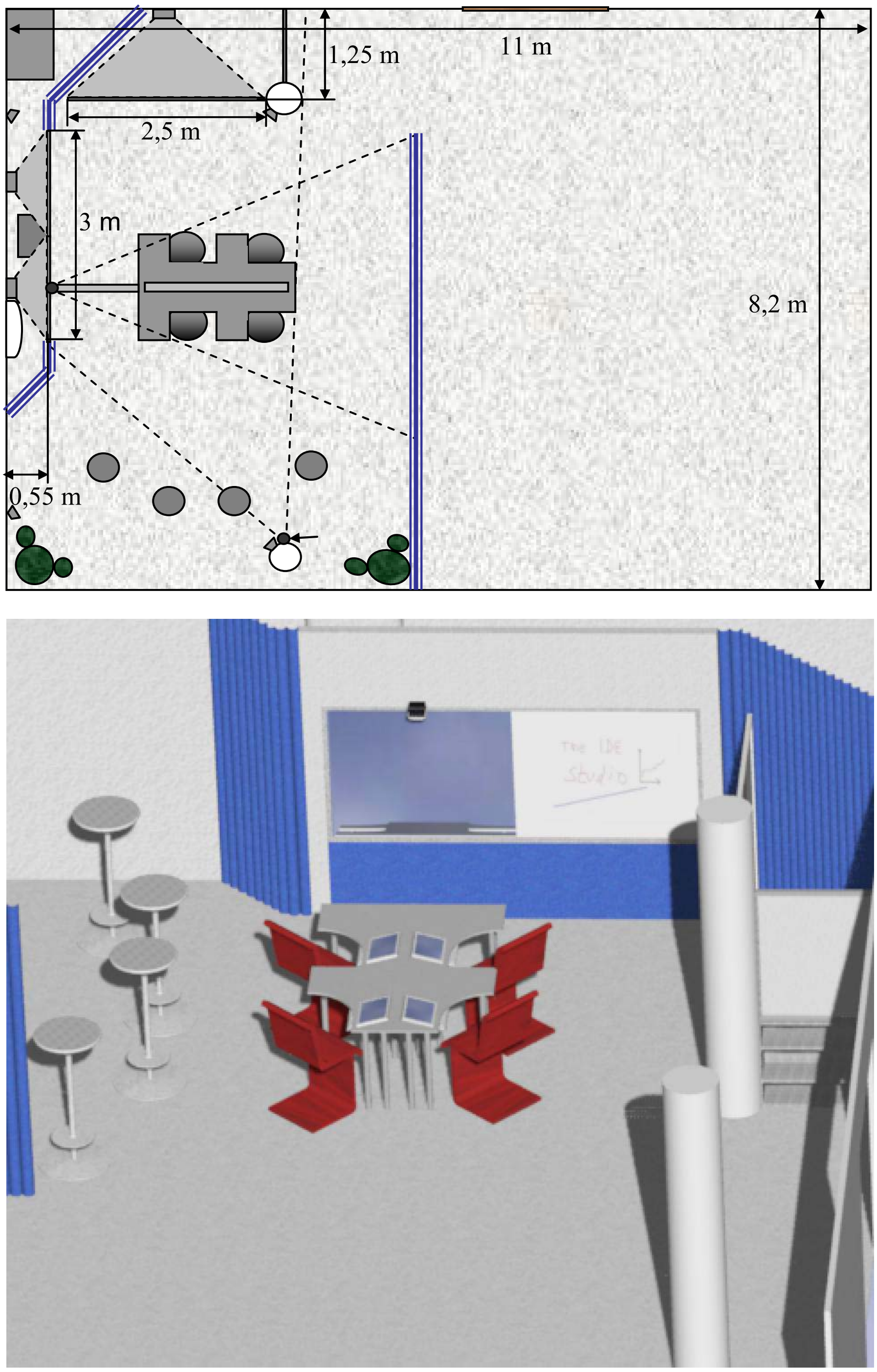


Figure 21 Layout of the IDE studio

5 Cost and building order considerations

This far a complete studio for both in-house and remote collaboration has been designed. But two important considerations still has to be accounted for in order to fully describe the concept. These are the cost for setting up the studio and the building order.

5.1 Estimated cost for building the IDE studio

A cost estimation for setting up the suggested studio has been made and is presented in the table below. The reader should note that the presented costs are estimations given by retailers and homepages. The exact values will depend on specific design choices. This is especially true for the control and microphone systems. The used estimated prices for these are an average between the highest and lowest cost. The total cost for the studio as presented in this thesis becomes around 700 000 SEK calculating this way. It is however hard to put an absolute cost for a studio since it is always possible to make improvements.

Table 18 Estimated cost for the studio

Hardware		No.	Price
Computers	SGI O2	1	30 000
	Supporting Computers	3	21 000
LCD tablet	PL400/Cintiq	4	80 000
Keyboard mixer		1	800
CD-RW driver		1	2 000
DVD driver		1	1 200
Video		1	2 500
Whiteboard	eBeam	1	9 000
Controlling system	Creston 50 000-300 000 SEK	1	150 000
Projector	DLP projectors (XGA)	2	70 000
Microphone system	WMS 81or 300 by AKG, with headsets. 5500-11000 SEK /set	5	27500
	Auto mixer	1	17600
Curtains		3	6 000
Fixed projection screens		2	50 000
Table		4	16 000
Chairs		4	6 000
Apparatus closets		2	1 500
Video camera		1	20 000
Notice board		1	2 000
Stand up tables		4	6 000
Other, unspecified	Wiring, mixers, converters, sound, light…..		200 000
			719 100,00 kr

Software	Price		
Microsoft Office	Exists on Chalmers		0
Browser	Free to download		0
Sketch program	Exists on Chalmers		0

Whiteboard program	Included with hardware or free to download		0
Software media players	Included with hardware or free to download		0
VNC	Free to download		0
Desired design programs	Exists on Chalmers		0
DIVISION Mock up	Exists on Chalmers		0
BSCW	Free to download		0
DIVE	Free to download		0
Smile	Free to download		0
			- kr

Studio cost **719 100,00 kr**

5.2 Building order of IDE studio

The building time for a studio environment strongly depends on the priority and devotion to the project. This is why it is hard to state the exact time acquired to set up a studio. More important is that the construction should be stepwise to offer time for testing of different configurations before large investments. The table below has been put together to offer a framework for the ordering and the set up of different equipment in the IDE studio.

Table 19 Framework for building the IDE studio

Step	Activity
1.	One important consideration in the beginning is to establish how the wiring should be done. The complete studio environment will require lots of cables and they must be concealed in some way to offer a neat solution. This can be done either with a video conferencing floor or wiring pipes. The colour codes and overall style of the room should also be discussed to avoid creating a heterogeneous environment.
2.	A good way to start the implementation is to place the existing equipment as suggested in this thesis. Existing furniture should be used for the workplace.
3.	If the placement works fine it is time to expand the system with the fixed screen. Preferably this includes projectors, mirrors, framework, and screens. The testing continues when this equipment is in place. During this work consideration of for example exact projection distances, placement of work area, and different camera positions must be done. If needed a mirror should be ordered for the large movable screen. In testing it should also be established whether to use a soft or hard edge approach for the fixed screen.
3.	When the wiring strategy and the projection environment is established it is time to further expand the system with an apparatus closet and the controlling system.
4.	The work with the studio homepage should be started.
5.	Supporting computers and sketching tools are suggested to be next up for consideration. Three computers and one sketching tablet should be installed in the beginning. More tablets should be bought after testing the functionalities, establishing benefits and weaknesses.
6.	When the control system, supporting computers, and sketching tools are functioning it is time to expand the system with the microphone system and the whiteboard system.
7.	When the equipment described above is functioning as desired, and has been continuously tested in project work. It is time to consider the workplace. What table or tables should be used and should it or they be movable. A sort of table with a channel in the mitten would be ideally so that connections to extern equipment like computers or an overhead machine can be concealed. Consideration of drapers, screen-offs and light environment should also be done based on testing experiences. Since it is possible to control both light and drapers with the controlling system, this should be considered as well.
8.	Next, consider the stand up tables. Find a type well equipped for the purposes of the IDE studio. Preferably with a possibility to conceal the VGA connection to the rest of the system.

	The question whether to use a WLAN system should be discussed at this point.
9.	The system should store at least one more camera than the existing to provide an overview of the room from a different angle. Maybe a document camera could also be tested.
10.	Equipment like video tape recorders, DVD and CD-RW drivers should be considered for the system. The chosen one or ones should be placed in a second apparatus closet easy accessible for the users.
11.	Complete the studio with green plants and see to that electronic booking functionality on the homepage is functioning.
12.	Refine the studio. Consider for example if the existing sound system is enough, cameras, sketching tablets and so on. The keyword is *TESTING*.

6 Equipment used for testing

This section will firstly discuss the constellation of equipment used during carrying out most of the testing. Furthermore some experiences using Smile and different types of collaboration tools will be presented.

6.1 Hardware constellation

To test different configurations of how a unit for distributed collaboration could be set up, and to test different software, a basic set of equipment was used, see appendix F. The conferencing system Smile was installed on the SGI O2 with Irix as operating system. Mouse, keyboard, headset, and a Sony EVI-D31camera were also connected to the same computer. A projector and a big screen were used when a conference was run. Another computer, the Intergraph, was used to store application programs like VNC, NetMeeting, and Pro/Engineer. The operating system was Windows NT and the computer used a parted desktop environment. The first VGA signal was used to a monitor and the other to a projector.

6.2 Using Smile

The aim of the first phase of the project was to establish a connection to Luleå to test video and audio quality together with some basic functions.

When Smile is started the destination address 224.2.2.2 is suggested. This is a multicasting mode, meaning that the current session is sent to all machines on a network. This could be desirable in some applications but will be impossible at the School of Mechanical and Vehicular engineering at Chalmers for the time being, this since a multicast broadcast will drown the network.

The quality of the video signals was good during the session according to the recipient. However, I feel that some work should be done to make the light environment appropriate. The user should also make sure that the video standard is set to PAL, not NTSC. Moreover the current camera input format is composite. The system in Luleå is using Svideo providing a slightly better image. Additionally the annotation function was tested. When a user wants to use annotations the recipient must enable this in their video window.

Two main functions used with Smile were also tested. The first is a remote control, rcamd that enables the sender to control the remote camera [Framkom, 2001]. This function can be arranged with software, possible to download from the Internet, and usage of the serial port on the camera together with a serial Macintosh cable and a zero modem cable. The second is a media-streaming server, Sserv, also possible to download from the Internet [Framkom, 2001].

A major problem during sessions was the audio. It showed that a microphone amplifier probably must be used to create good audio. In Luleå AKG microphones is used together with EK 31 microphone amplifiers and some wireless alternatives in AKG PT 300. The value is normally placed between 10 and 45 when the microphone gain is tuned in Smile.

Several different projection environments were tested ranging from monitors to front- and back-projection of different sizes. A problem concerning the existing projector in the studio did occur. The image became green in a way that could not be removed with a good result when the SGI O2 was connected to this projector. Luckily this effect was not visible at all testing another projector.

Front-projection on a white wall was used in order to test the effects of different screen sizes resulting in a in a desired size, chosen for the further development of the studio.

6.3 NetMeeting

The software NetMeeting has also been tested in point-to-point connections. It can be used to share video, chat, whiteboards, and programs. The video quality was not as good as for Smile, but the chat and whiteboard functions were functioning well. A completion of the NetMeeting program had to be made on the Intergraph machine before the sharing of files tool could be used. Tests with some office documents were made, functioning without any problems.

6.4 VNC

VNC has been installed on two computers running Windows NT and Windows ME respectively. An effort was made to find a solution where the software could be installed and work on the SGI O2 as well. According to the developers this should be possible. The computer central for the School of Mechanical and Vehicular engineering, MDC, was contacted, but they could not resolve the problem. Consequently the testing was made between the two Windows environments. The software works quite well for simple operations like Office programs and acceptable for more complex programs like Maya.

6.5 DIVISION MockUp

The advanced collaboration in the IDE studio will be carried out using either of the software, DIVISION MockUp, or DIVE. The former is recommended from other testers [interview with Törlind, 2001] and is already installed on the Intergraph computer. For these reasons the focus became to make this program to work. The program is currently functioning, and conversion of different file formats became possible after some problems with licenses and installation. Moreover it should be possible to make exports directly from Pro/Engineer to DIVISION MockUp, but currently this function is not working.

7 Conclusions

A conceptual environment for IDE studio has been created. It does not look much like the existing environments at, for example, Chalmers or Luleå University of Technology. The effort to create a dynamic learning environment optimised for project work, with lecturing capacities instead of the reverse is the major motivation. The room is consequently optimised with tools for carrying out both remote and in-house work, like advanced sketching tools, interactive whiteboard, and a projection environment. The iRoom at Stanford is an example of a studio aiming at the same functionality as the IDE studio.

One of the most important features when creating a studio is to create a long time concept, a configuration that holds a vision. This since it is important that integration and improvement of the day-to-day work must be done. If this fails, yet another not used room with expensive equipment is created. The focus should be on creating functionalities, not the technology.

An environment for distributed work requires at least one remote node to function. This is a very obvious, but important fact. If the chosen set up at Chalmers does not work well with remote nodes, for example at Michigan, the studio is likely to function poorly. The best situation is probably to create a common concept and develop it iteratively through mutual understanding and continuous testing.

Finally, the most important contribution to the field of distributed engineering made in this report is the coupling between the scenarios and the technological choices. The development has been done firstly with needed and desired functionalities in mind, putting the user instead of advanced hardware solutions in the centre. The thesis can also function as an introduction to remote collaboration since it discusses many of the common tools and provides basic explanations.

8 Future work

In constructing the IDE studio on a conceptual base, considerations of a number of basic tools have been made. In studying the table containing the system functions it should be noted that all of the desired features have not been implemented into the system. The reason can be the technological maturity, or the difficulty to apply a certain desired function for the time being. Examples from section 2.4.2 are the ability for users to use force and touch feedback tools, usage of rapid prototyping systems, and stereo video. All these areas are of interest to develop in later further development of the studio.

Another interesting feature with great potential is the development of different user interfaces. A vision would be to construct a web place containing all functions of the studio. This means providing an interface for controlling all aspects of the studio from software to default configurations to control projectors and light conditions. This web place would be possible to access from a handheld or portable computer. A realization of the former requires considerable work to make different platforms to communicate and work together. A possible approach could be to, when the initial set up of the studio is ready, slowly starting to expand the proposed web place with different types of applets, enhancing the ease of use. Finally, an investigation could be made if it is possible to implement web based controlling systems that later can be integrated in the studio web site.

This thesis spans over a wide area leaving little time for a deeper investigation of how couplings to different research areas could be made. It would for example be interesting to investigate how distributed environments relate to product models, data security, human-computer interaction, and larger PDM systems.

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Appendix A List of figures

Appendix B List of tables

Appendix C Acronyms

ATM	Asynchronous Transfer Mode
BSCW	Basic Support For Cooperative Work
CAE	Computer Aided Engineering
CD-ROM	Compact Disc Read Only Memory
CODEC	Compressor/ Decompressor
CORBA	Common Object Request Broker Architecture
CRT	Cathode Ray Tube
CSCW	Computer-Supported Cooperative Work
DIVE	Distributed Interactive Virtual Environment
DLP	Digital Light Processor
DMD	Digital Micromirror Device
DVD-ROM	Digital Versatile Disc Read-Only Memory
Fps	Frames per second
Hdr	High dynamic range
HDTV:	High Definition Television.
IDE	Industrial Design Engineering
IGES	Initial Graphics Exchange Specification
IP	Internet Protocol
LAN	Local Area Network
LCD	Liquid Crystal Display
MCAE	Mechanical Computer Aided Engineering
NTSC	National Television Standards Committee
PDA	Public Display of Affection
PDP	Plasma Display Panel
PDU	Protocol Data Unit
RTCP	Real Time Control Protocol
RTP	Real Time Protocol
SITI	Swedish Information Technology Institute
STEP	Standard for Exchange of Product Model Data
SUNET	Swedish University Network
UDP	User Datagram Protocol
USB	Universal Serial Bus
Vat	LBNL Audio conferencing tool
VGA	Video Graphics Array
Vic	Video Conferencing Tool
VITI	Virtual Information Technology Institute
VNC	Virtual Network Computing
VRML	Virtual Reality Modelling Language
WLAN	Wireless Local Area Network

Appendix D Glossary

Ambient Light:	All light in a viewing room produced by sources other than the screen.
ANSI Lumens:	Brightness is measured in ANSI lumens (American National Standard Institute measurement of "candle" power). This is the accepted measurement of brightness for projectors. The lumen rating is the average measurement achieved by recording brightness at a number of different points within the light source. It is considered the fairest and most accurate indication of a unit's overall brightness.
Aspect Ratio:	An aspect ratio describes the relationship between a screen's width and its height. For instance, conventional television sets use screens with a 4:3 aspect ratio (also referred to as 1.33:1). The first number in the ratio, before the colon (:), refers to the screen's width, the second to its height. In other words, on a 4:3 set, there are four units of width for every three units of height.
ATM:	A transfer mode in which the information is organized into cells. It is asynchronous in the sense that the recurrence of cells containing information from an individual user is not necessarily periodic.
Bend Angle:	The angle between the line of sight and the direction of a ray of light from the projector through a point on the screen.
Blend Shapes:	Animation mixer where, for example, face movements and lip synchronization can be done rapidly through mixing standard expressions.
Bones:	Tool for deformation of geometry, for example the bending of a modelled arm without joints.
Boolean Operations:	Modelling method where “extra” geometry between two objects is added or cut away. A new object can be created through the removement of everything but the “extra” geometry.
Box Modelling:	Method to build geometry where a rough model (mesh) is built. More polygons are thereafter added through a mesh-function to smoothen the rough model.
Brightness:	A viewer's subjective response to luminance.
Bumpmaps:	Method to make a flat 3D surface to look uneven through the aid of an image.
Cartoon Modeller:	Filter in the rendering engine the makes the object look like cartoons.
Caustics:	Rendering method where optical effects such as light shifting and reflexions are calculated more realistic than through ordinary raytracing.
Character rig:	A modelled creature prepared (rigged) for animation with bones, constraints etc.
Clothe:	Fabrics and clothing simulation.
Composite Video:	Composite video signals are connected between products with a single 75 ohm coax cable, usually with RCA connectors on each end. Composite video inputs or outputs are present on almost all contemporary video equipment.
Constraints:	Tool that facilitates and automates animation through predefined boundary values. For example can the eyes of a character be made to always look at a certain object.
Contrast Ratio:	The numeric relationship between the brightest and the darkest portions of a display expressed in Foot Lamberts as a ratio of Max:Min.
Corba:	OMG's open vendor-independent architecture and infrastructure that computer applications use to work together over networks. Using the standard protocol IIOP, a CORBA-based program from any vendor, on almost any computer, operating system, programming language, and network, can interoperate with a CORBA-based program from the same or another vendor, on almost any other computer, operating system, programming language, and network.
CRT:	Cathode Ray Tube. Also known as 3 guns. Used with two piece projection, direct view monitors and television.
Datagrams:	A datagram is a self-contained independent entity of data carrying sufficient information to be routed from the source to the destination computer without

	reliance on earlier exchanges between this source and destination computer and the transporting network.
Diffusion:	A coating applied to a transparent substrate in sufficient density to exhibit a projected image.
Dispersion:	The degree to which a screen scatters the light it transmits from a projector.
Dynamics:	A way to automate animation through the aid of physical simulations. The movements of objects are based on their mass and friction characteristics together with, for example, gravity and collisions with other objects. Rigid body (animation of solely hard objects) is the most common dynamics method.
Extrude:	To punch an object out of a profile.
Field of View:	An area in front of a screen in which all members of the audience seeking acceptable viewing conditions should be positioned. Measured in degrees from screen centre, a field of view is conical in shape and enlarges as the distance straight back from the screen is increased.
Foot-Candle:	The fundamental unit of illumination representing the light intensity over a 1 square foot surface which is 1 foot away from a standard candle.
Foot Lambert (ftL):	Unit of luminance equivalent to 1 lumen per square foot.
Fresnel Lens:	A device comprised of a large number of closely spaced concentric circles cut into one surface of a sheet of acrylic which can reduce the incident bend angles of light rays emanating from a projection source placed behind it.
Gain:	A measurement usually made perpendicular to screen centre of the luminance transmitted by a screen, divided by the luminance radiating from the projector.
Half Angle:	The number of degrees a viewer needs to move away from the perpendicular before the observed gain is reduced by 50%.
Hardware Overlay Planes:	Function in advanced 3D cards that enable more rapid special functions. For example Artisan in Maya.
Hdr:	A new standard for the handling of light values far beyond the max values of a screen.
IGES:	A neutral format for the exchange of geometry information between 2D or 3D models.
Keyframing:	Method to create animation through stating different values (position, rotation etc) to different points in time. The values at a certain time are called a keyframe. The computer interpolates between keyframes resulting in an animation.
Lath:	Turning geometry out of a profile.
LCD:	Liquid Crystal Display. This is a digitised display consisting of a pixelized image that is projected.
Lenticulation:	A cylindrical lens, which causes light rays passing through it to be dispersed perpendicular to its axis. A large series of parallel lenticulations is often cut vertically into a screen surface to improve its horizontal dispersion.
Light Valve:	A video projection system generally using a high power xenon arc lamp to project a bright (up to 7000 lumens) video image by using an electron beam to scan and construct the image.
Lumen:	Quantity of visible light energy falling on 1 square foot of the surface of a hollow sphere of 1 foot radius which has at its centre a light source of 1 standard candle.
Lux:	Quantity of visible light equal to 1 lumen per square meter.
Luminance:	Measured brightness of the screen. Luminance is expressed in foot lamberts (inch-pound units) or millilamberts (SI unit). Brightness is the perceived light, while luminance is the measured quantity.
Mental Ray:	Highly advanced rendering engine for extremely high demands. Exists as a module to Softimage and to 3D studio Max 3.
Metaballs:	Object that, in a gravitational manner, creates surfaces depending on if there are other metaball objects in the neighbourhood. If two metaball objects are put close to each other they will float together.
Marratech:	Multicast desktop conferencing system.
Mimio:	Tool for incorporating a whiteboard into a videoconference session or for distributed usage.

Multicast:	The ability to broadcast messages to one node or a selected group of nodes.
NetMeeting:	Video conferencing program provided with the Microsoft Office Package.
Nurbs:	Non uniform rational b-splines. Surfaces which curvature depends of resolution depending curves instead of polygons (planar triangles).
Onion Skinning:	A way to facilitate the animation work through showing some of the previous and following picture frames together with the current.
Open GL:	A programming interface (api) for 3D-graphics originally developed by Silicon Graphics. Primarily intended for cad and other 3D programs.
PDU:	A unit of data specified in a layer protocol and consisting of protocol control information and layer user data.
Point-to-Point Connection:	A connection with only two endpoints.
Point-to-Multipoint Connection:	A collection of ATM links, with associated endpoint nodes, with the following properties: 1. One ATM link, called the Root Link, serves as the root in a simple tree topology. When the Root node sends information, all of the remaining nodes on the connection, called Leaf nodes, receive copies of the information. 2. Each of the Leaf Nodes on the connection can send information directly to the Root Node. The Root Node cannot distinguish which Leaf is sending information without additional (higher layer) information. 3. The Leaf Nodes cannot communicate directly to each other with this connection type.
Primitives:	Base objects like spheres, cubes, rings, cones, and cylinders. A common way to model is to make new forms out of primitives.
Projection Axis:	The direction of an imaginary line extending from the centre of the projection lens through the screen's centre.
Quad:	Device for combining several inputs to one. Most often video signals.
Radiosity:	Rendering method for secondary lighting.
Raytracing:	Rendering method for the creation of realistic reflexions and lightshiftings through the tracing of the rays.
Rendering:	A process where an image is created of the modelled objects.
Resolution:	The limit of a display's ability to present distinguishable fine detail. Resolution is often expressed as the number of parallel lines that can be differentiated in a millimetre of screen surface.
Shader/material:	Object surfaces. For example wood or metal.
Skin:	The surface of a 3D-object with created bones.
Soft Body Dynamics:	The possibility to calculate the deformation of soft objects at collisions etc.
Splinebased Patch Modelling:	A way to model where a network of curves is built to represent the curvature of the model. The model is thereafter covered with patches with polygons on the surface. A strength with this method is that the number of polygons can be decreased locally when needed, for example at ears.
Splines:	Adjustable curves.
Svideo:	The Composite video and Svideo signal formats have dominated home theatre interconnect applications. Svideo is often incorrectly referred to as S-VHS since it first came into home use with the introduction of that videotape format. Professionals prefer the name Y/C video rather than Svideo since it is more clearly descriptive of the signal format.
Throw Distance:	The length of the projection beam necessary for a particular projector to produce an image of a specified size.
Unicast:	The transmit operation of a single PDU by a source interface where the PDU reaches a single destination.
UDP:	This is a communication protocol that offers a limited amount of service when messages are exchanged between computers in a network that uses the Internet Protocol. UDP is an alternative to the Transmission Control Protocol (TCP) and it, together with IP, is sometimes referred to as UDP/IP.
Uniformity:	The absence of discontinuity between the brightness measurement at a screen's centre and the brightness measured at its corners and edges.
USB:	Universal Serial Bus (USB) is a peripheral bus specification. USB ports and jacks enable computer peripherals to be plugged into the back of computer. Previously, peripheral devices were added by installing cards into slots inside the computer, and reconfiguring the system. USB ports enable

	computer peripherals to be automatically configured as soon as they are physically attached, without the need to reboot or run set-up. USB supports multiple devices, up to 127, to run simultaneously on a computer, with peripheral devices, such as monitors and keyboards, acting as additional plug-in sites, or hubs.
VGA:	Common computer resolution standard.
Viewing Angle:	The angle from a line perpendicular with the screen, measured horizontally or vertically from the line of sight.
Virtual Meeting Place:	Place where members of a development team can meet, share and interact with engineering information.
Volumetrics:	A way to reproduce volumes, primarily for light and atmosphere effects. Apart from the normal way with the objects as surfaces volumes is used.
VRML:	Tool for creating 3D graphics for the Internet.
STEP:	Standard for the exchange of CAD models between computer systems.

Appendix E Timeplan

	Week																													
Activity	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Establish the project (objectives, limitations, etc)	■	■	■	■	■	■																								
Collect and learn facts about Smile and video conferencing				■	■	■	■																							
Attend a final thesis presentation				■																										
Choose and identify basic hardware constellation					■	■	■																							
Install the Smile software with the surrounding hardware						■	■																							
Arrange a connection to Luleå									■	■	■	■																		
Chose shared software(s) for connection to Luleå									■	■	■	■	■																	
Install and test shared software for connection to Luleå										■	■	■	■																	
Benchmark of existing h.w. for video along with s.w. for 2D and 3D									■	■	■	■	■	■	■	■	■	■	■	■										
Description of the work of industrial designers											■	■	■	■																
Development of scenarios											■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Evolve the videoconferencing room and equipment (h.w and s. w)													■	■	■	■	■	■	■	■	■	■	■	■	■					
Report writing		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Presentation																													■	■
Visits																														
Viktoriainstitutet, kalle@sics.se			■																											
Mattias Johanson						■																								
Designers enligt Peter									■	■																				
Eventuellt någon på Volvo									■	■																				
Peter Törlind															■															

Appendix F Hardware Constellation for Testing

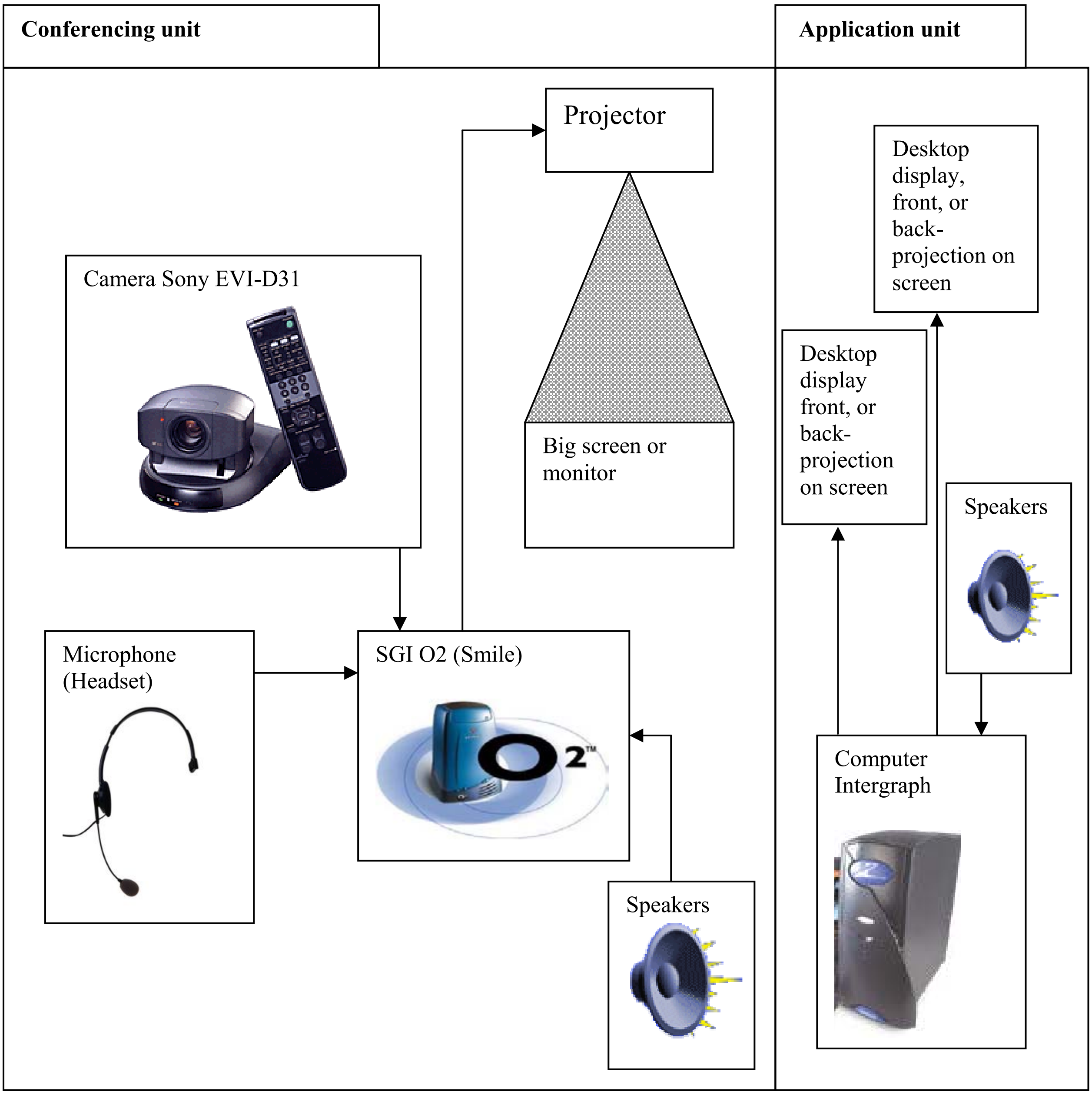

Figure 22 Testing equipment for the IDE studio

Appendix G Questionnaire for designers

1. What kind of tools does a designer use in his/hers work? (Computers and software, drawing, FFF, clay, others (etc))
2. How do you use them?
3. How often do you use them?
4. How does a designer work with other designers?
5. How would it be desirable to be able to work with other designers?
6. What type of information, work is accomplished with non-designers?
7. In what extent is computers used today, why not more or less?
8. What could be the biggest problem to overcome to make designers want to work in a distributed environment?
9. Can you foresee how distributed solutions and could have a negative impact on the work of designers?
10. How are computers used at the present?
11. Is distributed work and computerization more suited for certain types of projects?
12. What kind of projects would you like to be able to create in this environment?
13. Is there a need for abilities to be able to work in a distributed environment?
14. What would you like to be able to do in a distributed environment?
15. Is solely synchronous work important or is there also a need for asynchronous possibilities?
16. Is there a need for mobile solutions, where a notebook can be connected to the system through wireless LAN's?
17. What is his/hers vision of the work of designers in the future?
18. Does he/she have any experience in using VR tools?
19. What type of VR equipment would be desirable, acceptable to use (gloves, helmet, glasses)?
20. What is the most important capability of the VR equipment, resolution, usability, ease of use?
21. How would it be to be able to share an application where force and/or touch feedback can be used with another designer?
22. If it was possible to create a shared drawing tool. How would it be desirable to work with it?
23. What environment would be desirable to work within, desktop, studio or mobile level?
24. What type of resolution and size would be desirable to work with? Stereo projection? Plasma screens?
25. How large investment would be acceptable to make to enable distributed work?

Appendix H Related work

In order to learn from mistakes and successes made by other projects in the area of distributed engineering, a selected number of projects have been studied. A description of these is provided below to provide some background of the field. If a reader should be interested in reading a complete report, they are listed with full information in the references.

1 The VITI program

The focus of the VITI program was to provide electronic meeting environments that are easy to use and afford. Furthermore should the environments be easy to use. The project was divided into three parts, *the VITI infrastructure*, *its use*, *and the future of electronic meeting places* as presented in [Bullock and Gustafson, 2001].

1.1 Establishing the VITI infrastructure

There are many different approaches to create electronic meeting support, most having similar weaknesses. Most important are difficulties in providing high quality, ease of use, adequate functionality, and flexible environments for more than two people. One example is the systems based on telephone principles (H.320 and H.323). The problems previously described motivate the development of a different infrastructure. This was divided into three levels, each representing a certain technical configuration, different possibilities for interaction, and flexibility. These are the desktop, the auditorium/studio, and the mobile levels. The work was concentrated on the studio level, while at the same time encouraging the natural development of the desktop level.

1.1.1 Desktop level

At this level a conferencing application was to be integrated into the standard desktop environment. The aim was to make the conferencing application no more difficult to initiate communication with than a telephone. Furthermore, VITI should make use of the SUNET network. That network does not provide a guarantee of bandwidth since the capacity is shared. There is usually spare capacity, but it was not considered appropriate to run bandwidth intensive applications over it. Owing to this, tools that offered good collaboration using limited resources were considered such as NetMeeting, Marratech, VCON [VCON, 2001], Vic [Network Research Group, 1995] and Vat [Network Research Group, 1995].

As mentioned above, a number of desktop systems were investigated based on different perspectives. At first unicast networking with dedicated point-to-point connections was tested (e.g. NetMeeting). This approach worked poorly with multiple users (more than two). Consequently a multicast system was adopted to overcome the scalability problem. Marratech was chosen due to its good functionality and the offered support from the company selling the software. A problem occurred as a result of multicasting since this is not supported everywhere. The solution became a proxy-server running in Luleå bridging between unicast and multicasting sessions. This device introduced delay and impede performance to the system. It is clearly stated in the report that it is important to consider not only the technical problems, but also to envisage anticipated use, and try to have natural and unforced scenarios for the infrastructure.

1.1.2 The studio level

The aim at the studio level was to provide high quality meeting places at the four VITI nodes, the SICS studio, the Viktoria Studio, the Chalmers studio, and the Luleå studio. In short, Streamrunner video conferencing codecs were used to provide high quality video conferencing over the studio infrastructure, and it was decided to support the software based video conferencing application Smile. It was chosen since it offers high quality video conferencing between workstations and represents a step towards bringing the studio quality level to the desktop.

The studio network infrastructure was established in a star shaped manner between the four studios with SICS in the centre. Furthermore, a Telia TCS ATM network with Cisco ATM switches was used. However, each studio had to be equipped to enable communication through the ATM link. A problem with audio feedback occurred, and therefore feedback destroyers were tested. It was discovered that it was no use to utilize this equipment unless every possible audio connection passes through a similar device. Comparable results were created with careful setting of audio input and output levels inside the studio.

The cameras used were Sony controllable cameras (EVI-D31). Owing to this, a user could control the received video via remote control. But, due to the different completeness of the studios, a situation where each studio could control the cameras in all other studios could not be created. A solution using VNC to allow different computers to be shared between studios was proposed.

When experimenting with different presentations, a need for combining several video inputs to one signal occurred. This was solved through purchasing a quad video device that takes four separate inputs and gives a single output signal. The big advantage with a quad image is that sites with limited display possibilities can participate in four-way meetings. Consequently it became possible to hold meetings away from the four main studios. The major problem with this new approach was that it decreased the quality of the images. The quad was also used to connect different infrastructures and levels to a single signal. For example ATM, SUNET and Marratech at desktop level could be combined with image quality as only loss. Thus, as a result a lot of flexibility had been gained.

Concerning audio it became complicated since it is not acceptable to send back the audio signal to its source. The problem is reduced to setting the correct audio levels in each studio when not using a quad. If a video quad is used, an audio “quad” had to be used as well. Smile will offer a studio level connection on the desktop in the future, making the task of integrating the studio level with the desktop level much easier since studio mixing is done within the software. It must be stressed that the lower quality provided by the quad became unacceptable. A revert back to full screen imaging was made at selected sites.

1.1.3 The mobile level

As mentioned earlier most work in the project was made on the desktop and studio levels. This became the case since these had to be stable and functioning before the mobile level could be investigated. Consequently, the incorporation of mobile solutions to the desktop and studio level was done in the most simple and effective manner, through a regular telephone connection. A standard conference telephone was located in one of the meeting locations. This sends the audio output from the phone, picked up by microphones, to the other locations. Similarly the caller hears the others through conference phone picking up their voices.

Moreover Marratech has been run on desktop PC´s with wireless networking in test scenarios. A complication in this process concerned the audio. There was a big risk of getting distortion since different audio levels are required for different technologies. Finally some, not easily overcomed by technical means, problems occured concerning audio delay between different participants using the desktop and studio environments.

1.2 Description of the four studios

A description of how the infrastructure has been set up has been given above. Below will a description of the four earlier mentioned studios follow.

1.2.1 The SICS studio

The SICS grotto has been set up as a multipurpose conference room usually organised to support small meetings, but can be rearranged to a small auditorium for up to fifteen persons. The studio is equipped with the following equipment; three large back-projection screens, an ATM switch, and video and data switching matrices. Access to meeting environments is made through an SGI O2, standard PC, or StreamRunner video conferencing hardware. An AMX control centre with touch panel is used to control what appears on the screen within the grotto (16×16). Three of the sixteen outputs are in the grotto. Consequently a second studio-like environment can be created and used in addition to the grotto. Hence multiple simultaneous, yet different, meetings can be supported at SICS. A quad video device, described earlier, exists and is connected to a video distribution amplifier, which gives five identical copies of the image. Additionally analogue audio mixing condenser microphones connected to a mixing desk were used. Finally a camera (Sony EVI-D31) was mounted at the centre of the screen to enable eye contact.

1.2.2 The Viktoria studio

Initially, a main meeting room with three large back-projected screens was used as a studio at the Viktoria Institute. Later on in the project a smaller room was constructed supporting small meetings. It was equipped with large screen television sets as main displays. Thus, as a result the studio got relatively inexpensive displays with no need to mix separate audio signals within the studio, as audio and video are implicitly tied together. A scan converter was used to display standard PC signals on the TV sets. A user can choose from five different images to send, either from one of the four cameras or a quad image of them. A mixing box can be used to choose the view to be sent. Finally heavy curtains were placed around all sides of the studio to dampen audio reflexions, and lightning was installed allowing a user to vary the light conditions with a dimmer.

1.2.3 The Chalmers studio

Chalmers is equipped with an advanced system for video conferencing and distance learning with a variety of different video conferencing solutions available. The room is built like an auditorium and it is the least configurable, but most advanced of the VITI studios. The studio has two rear projection screens and a whiteboard using a Mimio. The user can choose between different cameras and audio configurations from the control point. This unit is situated almost at the middle of the left side in the figure below, and can also be used to preview sources before they are displayed on the main screen. The Chalmers node is very well equipped when it comes to H.323 equipment and can act as a bridge between networks.

Figure 23 The Chalmers studio

1.2.4 The Luleå studio

This studio is set up more like a lecture theatre than the other studios, but the whiteboard has been replaced with a large screen display onto which multiple images can be projected. The AVA-ATV pair is connected to a local video matrix. A number of Silicone Graphics workstations and personal computers are also connected to the video switch. Luleå is the site within the VITI network having the most experience of using Smile.

1.3 Future work

The VITI project has successfully established and used an infrastructure for distributed engineering during 2000. However, there still remain a number of problems and challenges that need to be overcomed to make the infrastructure even more accessible. These issues address the infrastructure as well as the use of the same. A brief description of each identified problem will be provided below.

1.3.1 Ease of use

This problem has been identified as one of the most crucial generic problem since it involves a large number of issues at different levels. It is important since it is not possible to force people to use virtual environments, they must have a desire to use it, or gain benefits from its use. Ease of use has been examined from two standpoints, the work that must be done just to enable the possibility of a meeting, and the experience of the meeting. As discussed earlier an expert is required at each location involved in a meeting. One person is also required to have the overall responsibility of the meeting, tuning microphones and cameras etc. There is no good alternative to having a local expert at the moment. In fact it is suggested that without such a person the possibility of having a successful meeting will decrease. To sum up, it is suggested that the responsibilities of the expert is automated and simplified as much as possible making the role rather than the individual the important factor. This is a very practical solution. An alternative approach would be to enable configuration using more advanced sensing equipment such as voice recognition and voice driven interfaces.

1.3.2 Mobility

As mentioned earlier mobility is one area that VITI was unable to address in necessary detail. Owing to this, future work should investigate what kind of experience can be offered to a mobile participant in a distributed meeting scenario. Marratech already supports basic mobile access to distributed meetings through a telephone interface. However, there is poor awareness between participants and poor integration between visually capable participants and the telephone participants. This gives rise to a number of challenges such as what is the best representation of a mobile user, do we use different representations at different levels, what are the bandwidth limitations, and how to make best use of recourses. Finally it should also be considered how mobile users should be incorporated into the fixed environment and vice versa, and how a mobile user should be equipped.

1.3.3 Better integration between different levels and systems

This issue has been touched upon in the section ease of use above. The approach adopted up to date is based on a technique where each level is reduced to a common composite video signal accompanying the audio signal. This approach does provide rather static solutions. If changes are necessary physical rewiring probably is needed which cannot be considered as a good solution. Owing to this there is a need to produce software codecs that can take different inputs, combine, and mix them as necessary. The software Smile is a step in this direction, providing high quality software video conferencing that is equally at home on the desktop or in a studio.

2 The interactive room at Stanford

A project named Interactive Workspaces at Stanford University, USA, is aimed to explore new possibilities for people to work together in technology-rich spaces. Described at [Stanford, 2001]. These spaces will be built up with computing and interaction devices at many different scales. The interactive room, iRoom, is a prototype interactive workspace containing three rear-projected screens with SMARTBoards, a front-projected screen, and a back-projected table. It contains eight computers, which run the screens and room infrastructure. Below a figure are presented showing the conference table, SMARTBoards, and the Mural. Next sections will provide a more detailed description of the room.

Figure 24 The Interactive Room at Stanford

2.1 Description of the room

The iRoom store some devises or functions extra important for the functionality. These are *the iRoom controller*, *the superMouse and keyboard*, *the SMARTBoards*, *the multibrowsing and global clipboard*, *printing/scanning/playing video*, *the mural*, *and the table*. These will be further described below in order to help the reader to understand how an interactive workspace can function

2.1.1 iRoom controller

The iRoom controller web page is used to turn the lights, SMARTBoards, and table on or off, and to project a laptop on any screen. The page is always running on the pen-based Clio mini-notebook in the iRoom, and can also be opened on a laptop to control the room.

2.1.2 Supermouse and Keyboard

These are wireless mouse and keyboard for the SMARTBoards and the table. They enable the user to point and type on any of the SMARTBoards or on the table. Hold down the button at the bottom of the mouse, and move the mouse pointer onto the intended screen. It can also be used on a flat surface like a normal mouse. The keyboard always sends the typed to the screen where the supermouse is pointing.

2.1.3 SMARTBoards

These are used in order to run whiteboard and standard applications on large touch sensitive screens. To make input**,** use a finger as a mouse pointer and bring up an onscreen keyboard with the button on the console below the screen, or use the wireless supermouse and keyboard. The SMARTBoards also run a number of applications, for example Windows 2000 and the standard applications. To use them like a whiteboard, start the Smart Notebook shortcut from the desktop. Use the pens and the eraser under the SMARTBoard to draw and erase on the screen. Select handwriting, and double-click the *A* that appears in its corner, to convert it to text. Use the menu to switch to the standard toolbar for the usual drawing functions (circles, etc.).

2.1.4 Multibrowsing and Global Clipboard

This allows the user to send WebPages and text clippings to other screens. Consequently multibrowsing lets you send URLs from one screen to another. In reality it functions as; in the web browser "in", right-click on a link and select where to send it, a SMARTBoard or the Table. The web page then opens on the chosen screen. You can also use this page to send URLs to a screen entering a multibrowser command.

2.1.5 Printing/Scanning/Playing video

Printing and playing video are not yet fully configured, but scanning can be made.

2.1.6 iMural

This is a digital whiteboard designed for brainstorming. This makes it possible to use it in meetings through using applets to open existing or create new iMural files. The major tool used will be a pen used for drawing on the mural. Furthermore a number of different types of objects can be used in the mural. Mentioned on the web page are text objects, VNC objects, JPEG images, and snapshots.

2.1.7 Table

This is a conference table with a built in computer. Once the table is turned on using the iRoom controller you can use the table display as you would a normal PC. Direct the SuperMouse to the tabletop and the keyboard will follow.

2.2 Software in use

A lot of different software is used in the iRoom. For this reason will a compilation be made in a table below.

Table 20 Software used in the iRoom

Control Panel software	Tspaces
Event heap to Windows keyboard/mouse driver	Windows 98
Java	Windows Eventheap software
Linux Eventheap software	Windows Mural and Millefeuille
Linux Red Hat 6.0	Windows NT
Ninja	

2.3 Using the room

When entering the iRoom the first step is to press the start button located on the wall to power up the SMARTBoards. Secondly you access the iRoom controller, which will enable the user to operate the lights, SMARTBoards, iRoom table, and project your laptop on a SMARTBoard. The controller will be displayed on a Clio mini notebook.

In order to make input to any of the SMARTBoards or the iRoom table the supermouse and keyboard should be used. If the user would like to use the table, this is turned on with the iRoom controller. As mentioned above the iMural can be used for brainstorming sessions, and text objects, VNC objects, JPEG images, and Snapshots can be mural components. Below a figure gives some examples of renderings of the iRoom.

Figure 25 Example renderings

2.4 Physical layout

The dimensions of the room are 12 m × 6,5 m. Furthermore it has been segmented into three parts: CAD Lab, interactive part, and projector area, see the figures below.

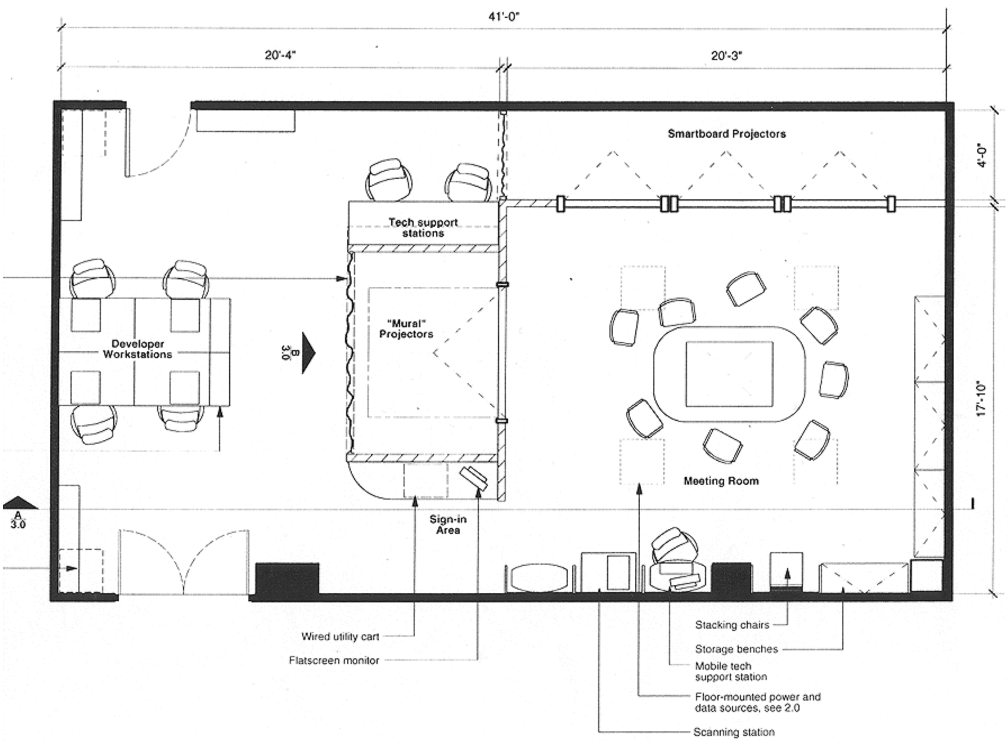

Figure 26 Physical layout of the iRoom

3 Interactive studio at Luleå University of Technology

This section describes the environment for distributed engineering set up in Luleå University of Technology. The information is based on findings in [Törlind, 1998]. The developed system represents knowledge from a number of different disciplines like, virtual reality, distributed collaborative environments, and computer aided design, CAD. The system is a result of collaboration between LTU, SICS, SITI, and Ericsson consisting of three main parts; distributed VR environment, conferencing environment, and a shared document server.

3.1 Distributed engineering

Computer supported cooperative work (CSCW) can be categorized using a time/location matrix. The figure below was created and presented after CAD also had been included in the matrix. Furthermore does co-located imply face-to-face meetings and remote the opposite. Synchronous work implies work at the same time and synchronous at different times.

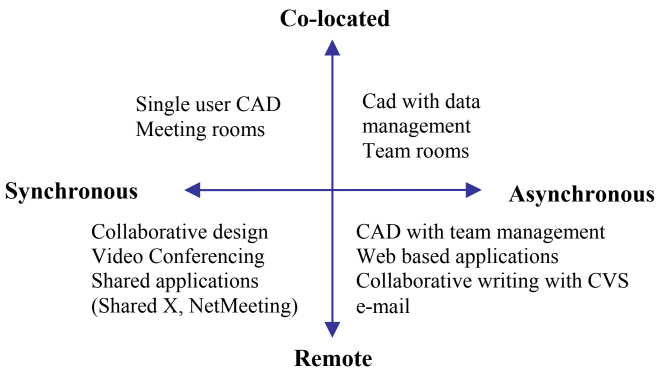

Figure 27 Use of CAD and other design tools across time and space

The matrix is a way to describe how different tools are related. The implemented environment created during the project, supports sharing and exchanging of product data, synchronous as well as asynchronous work, and high quality audio-/video conferencing. Important for the functionality of the system was the implementation of shared environments and video conferencing why these are further described below.

The distributed VR environment is based on the Distributed Interactive Virtual Environment (DIVE), further described in appendix J, by SICS. This is an internet-based multi user VR system where participants navigate in a 3D space and see, meet, and interact with other users and applications. Additionally, the software does support the development of virtual environments, user interfaces, and applications based on shared 3D synthetic environments.

The video conferencing is carried out with the audio-/video conferencing tool Smile since it is designed to take full advantage of the bandwidth. The application has the ability to send live video to all users and stream animations (video sequences) to all members of a conference. The sender can also control the playback interactively.

The tools previously described concentrate on supporting synchronous work. There is often also a need for asynchronous information sharing. For this reason was the virtual workspace system BSCW used. Consequently documents could be accessed through a web-based server through a standard WWW browser. The system could also be used for threaded discussions, scheduling meetings, and invoking synchronous collaboration tools like Smile and DIVE.

3.2 Integration of the main components

The importance of the awareness of presence, and activities of other users are stressed in the work. This was achieved through using a conferencing system together with a shared virtual environment where users are represented and interacts via avatars. The identity of each avatar was illustrated with a facial texture and a logotype on the shirt of the avatar. To illustrate who was talking, a speaking avatar was used. Furthermore, the functionality in BSCW called monitor could be used to keep the users informed about who was currently logged on and active.

Interaction with the distributed environment was done with different types of settings ranging from regular desktop workstations, to VR theatres/CAVES, and head mounted displays. For the daily work a normal engineering workstation with high quality video card and a headset is sufficient enough while group meeting demands more powerful equipment.

3.3 Computer Aided Engineering to VR interface

The communication between the CAE system and the VR system was solved with application program interfaces. The VR system was considered to be the core component for collaboration while the CAE system functions as a tool for designing engineering objects.

Two different types of interfaces were tested. The first one based on a technique where static models were transferred between the systems using VRML. The major drawback in this approach was that the user did not communicate directly with the CAE-database. Consequently, the user could not tell if the VR environment was up to date. For this reason an interface based on CORBA was used providing access to the CAE-models to the user. In reality IDEAS was used as a CAE tool and DIVE as VR tool. The technique using Corba could be used to communicate between various programs, illustrated in the figure below.

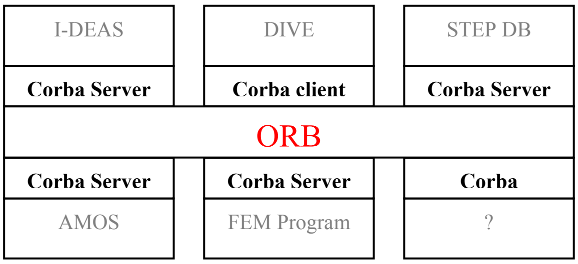

Figure 28 Corba used for communication between different applications

The application was built as a DIVE plug in allowing a shared component to communicate with the software. The formats of the exchanged models will be IDEAS proprietary format if both users are using that specific program, otherwise a STEP model will be transferred. The communication architecture has three layers, user environment, application level, and network transport according to the following figure.

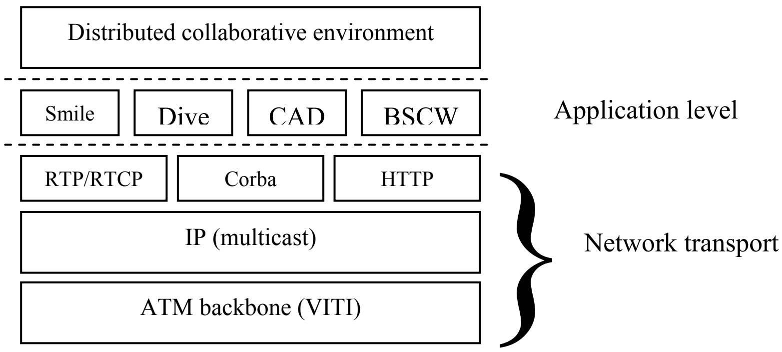

Figure 29 System architecture

Appendix I Conferencing applications

Video conferencing (VC) is in its most basic form a way to enable transmission of images and audio between two or more physically separate locations. The information in this section was provided by two interviews, [Gustafsson, 2001], [Johansson, 2001], and at [Sunsite, 2001] The technique for video conferencing has evolved from being expensive with high demand on the network connection, to less expensive and more flexible systems. It is now possible to use common network types like TCP/IP (Internet) for VC. An example of a software using this approach is Smile based on IP multicast or unicast, the RTP/RTCP protocols and the IETF standards RFC1889/RFC1890/RFC2435/RFC2543 [Johansson]. There is also another, more classical, standard called H.323 for the support of audio/video conferencing over IP. The basic set of equipment needed differ somewhat between the two concepts above, which can be seen in the table below and read about in the text.

Table 21 Basic equipment for video conferencing [Sunsite, 2001]

Equipment	Tool
Video conferencing terminal end-station (client)	Smile/H.323
Peripheral set including camera, microphone, and speakers	Smile/H.323
Workstation (Windows, Mac, and Unix)	Smile/H.323
Network connection	Smile/H.323
IP address for workstation	Smile/H.323
Multipoint Conferencing Unit (MCU), optional if only two users	H.323

There are several important issues to consider when videoconference equipment is to be put together. A few examples are presented in the following table.

Table 22 Areas of consideration for video conferencing

Areas of consideration for setting up a video conferencing unit	Concerns system
Environments of the participants (desktop, conference room, auditorium, or will a few small conference rooms be combined into a larger "virtual" conference room.)	All
Gateways. Is there a need to talk with non-heterogeneous endpoints, such as from H.323 (TCP/IP) to H.320 (ISDN) and vice versa.	H.323
Will there be a need for an MCU.	H.323
Degree of interactivity. How will the meeting be held? Will there be a single main speaker, or will a productive meeting require that the participants are able to speak freely and spontaneously?	All
Role of voice, video, and data. Is voice transmission sufficient? If video is required, must participants be able to see detail, or is video used only to maintain presence? Will graphical materials be exchanged and must participants be able to collaborate using the same application?	All

A video conferencing terminal often comes with a number of software tools including electronic mail, whiteboards, ftp and chats. Moreover, an interface for sharing a third party application often is provided. For a classical system this type of communication is between the terminal and end stations standardised by T.120 standard, but not in Smile based on a different technology.

1 Basic components

As discussed above every video conferencing terminal requires a few basic components like a camera, video display, microphones, and speakers. In addition to these obvious components a couple of others is needed. These include codec (compression/decompression), user interface, computer system to run on, and a network connection. Each of the components mentioned above will have an impact on the performance of the system and will for that reason be discussed briefly.

1.1 The main camera

This devise is highly responsible of how the video will appear at the receiving end. Cameras can differ much in capabilities between each other. They can vary in picture quality, ability to pan, tilt, and zoom, wide angel versus narrow angel lens, manual versus auto focus, manual iris versus auto iris, auto-tracking, remote control, and/or RS-control. To sum up a camera can have a lot of different abilities why it is important to identify what the system is desired to do before choosing it.

1.2 The video display

The video can be displayed with a wide variety of equipment ranging from desktops, TV-sets, plasma screens, and projection, see appendix L. Depending on the needs each of the previous sources has their strengths. Consequently, what is needed and best depends on the specific situation to be supported.

1.3 Audio components

Audio is important in video conferencing, often considered more important, than video. Knowing this, the device that capture local audio (microphones) and those that reproduce remote audio (speakers) are critical conference components. When full duplex transmission is used a couple of characteristics are especially important like echo cancellation, noise suppression, and audio mixing. All of these factors are influenced by the combination of speakers, microphones, and codecs. Furthermore, the key to create audio that supports conference requirements is to examine the quality and the location of the microphones and speakers. If cost is an issue, usage of a quality headset can offer better results than a comparably priced microphone and speaker, and does not induce echo to the system. Additionally headsets can be set up in wireless configurations giving flexible solutions with good quality.

1.4 The codec

This tool is the heart of any video conferencing terminal. The word codec is a short form of compressor/decompressor and is specifically applied to the wide variety of algorithms used to compress or decompress audio and/or video information. Without some form of codec, the transmission of video requires extremely high amounts of network bandwidth. It is the codec that takes the sights and sounds captured by the local cameras and microphones, compresses them such that the they can be transmitted across a network fast enough to enable near real time communication. Codecs can be both hardware and software components. The strength with the former is that they generally perform faster compression/decompression and are non-depending on the underlying system. On the other hand, software codecs are generally easier to install and less expensive, but produce lower quality conferencing with very low frame rates. Finally, in a H.323 desktop application the codec typically resides on an interface board inside the computer or in a software application.

1.5 The user interface

All systems made for use have a user interface. This is responsible for the communication between the system and the user. For example it determines how the user get in and out of conferences, and what can be done in conjunction with a videoconference. These types of systems are important to any type of video conferencing system adding flexibility and ease of use. In this work these types of systems are referred to as control systems.

1.6 The supporting system and network connection

Though the supporting system and network connections are not technically a part of the basic components of a video conferencing terminal, they have a large effect on the terminal performance. For example, available bandwidth will have great impact on how well the video conferencing session can be carried out.

1.7 The H.323 standard

The system to be used in this thesis, Smile, is not based on the H.323 standard. However, this is common in video conferencing equipments. For this reason a short description of elements specific to this will be presented below as an orientation. The H.323 standard defines three additional and related components that extend and improve access to the video conferencing functionality. These include *gatekeepers, gateways and multipoint conferencing units (MCUs)*

A H.323 gatekeeper is assigned control over a set of video conferencing equipment (terminals, gateways, and MCUs) and functions somewhat like a video conferencing "traffic cop". The purpose is to make H.323 conferencing more reliable and secure. A gatekeeper can be a stand-alone software application, and also a scaled down "built in" functionality included within H.323 terminals, gateways, and MCUs. It is widely agreed that gatekeepers are a key concept for enabling scaleable Internet-based video conferencing.

Gateways provide transcoding services such as address translation, network protocol translation, and audio/video coding translation between dissimilar media. The most common type transcodes between H.323 (IP based LAN) and H.320 (ISDN). Additionally, there are also transcoders for H.321 (ATM).

The MCU enables several locations to be brought together into the same conference creating a virtual meeting-room. Thus the purpose for a MCU is to connect three or more video conferencing systems in the same conference. Furthermore, consideration has to be made whether to use hardware or software MCUs. A hardware solution tends to be more expensive, more reliable, and faster. Software solutions provide portable, more flexible, and less expensive solutions, but they suffer from performance issues. An overview of the H.323 video conferencing system is provided in the figure below.

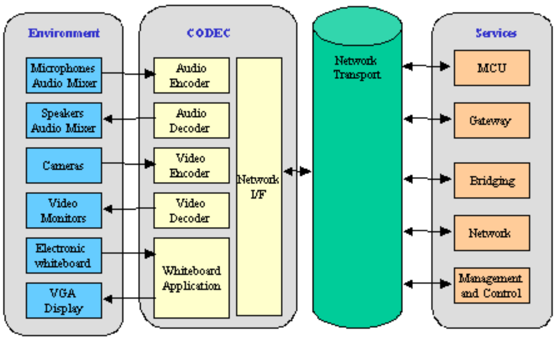

Figure 30 A description of a H.323 system

2 SMILE

This is a software, described in [Johansson], video conferencing tool designed to perform well in respect to quality of the transmitted media when the network bandwidth increases. This will make it a good alternative to conventional desktop video conferencing systems using for example ISDN or the Internet. It can be downloaded from the Internet and requires a completion with a camera, speakers, and a microphone to be able to function as intended.

2.1 Operative systems and hardware platforms

Smile supports a wide variety of operative systems and hardware platforms. However, the different versions can differ somewhat in functionality.

Table 23 Operative systems and hardware platforms for Smile

Opertive system and hardware platforms
SGI O2/IRIX 6.3, 6.5/(SGI O2 video)
SGI Octane/IRIX 6.5/OCTANE compression
HP/HPUX 9.x, 10.x/Parallax XVideo
Sun/Solaris 2.6/Parallax XVideo
Windows NT/Matrox Meteor II/MJPEG
Compaq iPAQ/Linux (receive only for video)

2.2 Network protocols

The communication architecture of Smile and related software is based on the IP protocol. Moreover the IP multicast is used for multipoint operation. Two other protocols are used to package audio and video into datagrams for transmission over the IP protocols. These are RTC and RTCP. The datagrams will be multicasted to a class D IP address if multicasting. If a network should lack multicast support an RTP reflector can be utilized.

2.3 Quality requirements

The design of the software has been aimed at creating high quality interaction. Efforts have been made to remove or limit bad lip synchronization (audio and video synchronization). It has been found that it takes, at least, a frame rate of 15 fps at the resolution 384 x 288 to achieve good duration and interaction of the meetings. Another dealt with problem is the delay between image and sound. Studies have shown that an audio delay of more than 400 ms severely comprises the interaction and that a maximum delay of 80 ms is tolerable.

2.4 Media encoding formats
The video used in Smile is motion JPEG, coding each frame in a video stream independently. This format was chosen over the MPEG and H.261 since it provides higher image quality, lower compression delays, more easy exchange of video images and animations, and finally there are affordable high performing hardware codecs available on the market. Additionally, an experimental Wavelet codec compressing the video has been developed. This will enable the receivers of a video stream to progressively reconstruct the original images with successively better quality.

The audio is coded with uncompressed linear PCM coding with 16 bits/sample at 16 kHz for high quality. This technique is chosen since it is considered to enhance the feeling of a shared collaboration room. For low quality audio a GSM codec is used.

2.5 Animation, media clips, and remote control
Smile can be used as a client to initiate playback of mediaclips from a multimedia server. Furthermore, the media clips, both audio files and movies, can be streamed to all participants of a session. A server called Sserv performs the media streaming. It also contains an interface for remote camera control. This means that a user in a session can control the camera at the sending end. This function is implemented using a background daemon named rcamd supporting the cameras Sony EVI-D31 and Sony VID-P150 (document camera).

2.6 Session initiation using the session initiation protocol (SIP)
This tool is based on the SIP standard, which is considered to be an important part of future IP telephony systems and other synchronous services like video conferencing. In Smile SIP will be used to initiate and maintain sessions over the IP network. Using SIP, actions taken in response to an incoming SIP call can be specified. It has been demonstrated in a prototype how an incoming call generates an SMS sent to the callee´s cellular phone.

2.7 Internet 3D video
A function for sending and receiving stereoscopic visual communication over packet networks exists in Smile. To accomplish this function, two parallel axes cameras are needed to capture two images that are encoded and packetized in RTP packets. The image below describes the technique.

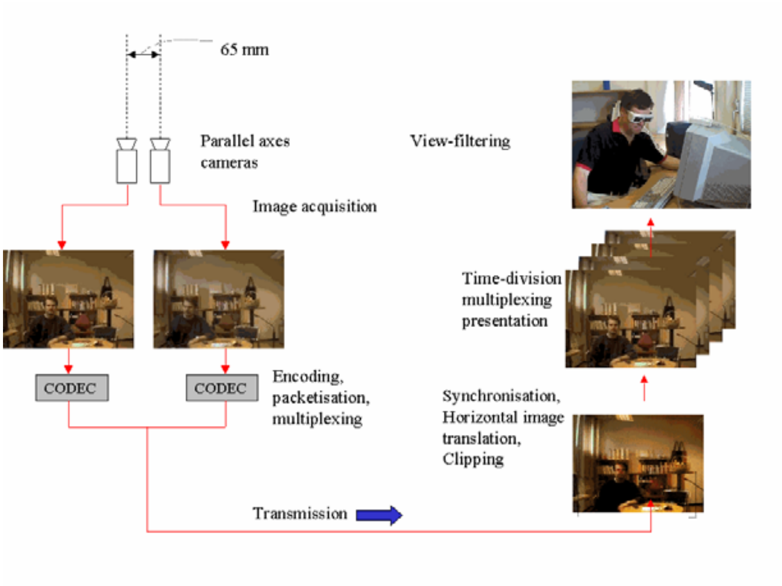

Figure 31 The technique for 3Dvideo [Framkom, 2001]

2.8 Annotation mechanism

Annotations are a way for a sender of video to point out certain things with arrows or circles. The receiver must enable this function in their window in order for the annotations to be visible. An example of what this look like can be seen below.

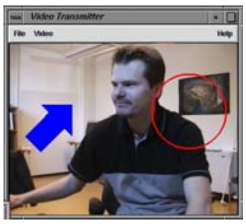

Figure 32 Annotations [Framkom, 2001]

2.9 Scaling

If a video conferencing system should support sessions based on video streams in non-uniform rates without slowing the faster links via video gateways (reflectors) scaling are a good alternative. In other words a single videoconference session will support different levels of quality. For example, if two participants in a session are connected via broadband a third party can join the session even if connected to a low bandwidth ISDN network.

Coding the media in a layered format and a striping of the media layers across a set of multicast groups carries out the scaling. Each member of a conference can join as many groups as their connection allows.

An application for handheld mobile devises has been created within the scaling project. Thus, as result it is possible to run Smile on a Compaq iPAC running Linux. The system was developed using a wireless network called 802.11b (WLAN). But Framkom intends to incorporate support for 3G wireless mobile protocols like GPRS.

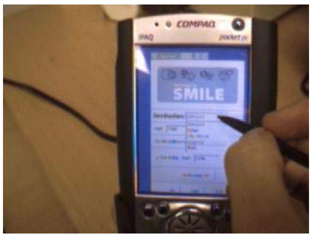

Figure 33 Mobile Smile [Framkom, 2001]

Appendix J Programs for enabling application sharing

There are a lot of different approaches for enabling application sharing. They range from screen dumping programs to the creation of virtual environments. This section has as an objective to present some programs that could be of interest for usage in the IDE studio.

1 Thin Clients

A thin client system, as described in [Aasted, 2001], is based on a client and server environment where the client has a minimal hardware set, meaning a minimal selection of hard drive, floppy drive, CD-ROM drive, or DVD drive. As a consequence most computational load will be placed on the server computer, which also hosts application programs and files. This enables the use of low power, high performance CPUs with good graphics on the thin clients. Moreover this has enabled to integrate them within the display device, or externally mounted behind or beneath a flat panel or a CRT.

A thin client computing architecture is built up, as explained above, by a server computer that are more advanced than the client computers. This has historically been done before without success. The problem then was to create stable and reliable servers. Furthermore did the built up servers require a lot of maintenance causing high costs. Nowadays servers have become reliable and are thus providing a good computing architecture alternative. Modern thin client user environments are providing a user experience similar to that of using a normal program such as Windows 2000. The speed and the workload of the server computer determine the actual user experience. Normally 30 to 60 thin clients to one host are a normal ratio. Finally, one of the largest benefits with thin clients is the centralized administration. This enables update of software once on a server instead of repeatedly on individual machines.

There are several types of thin clients available on the market such as Virtual Network Connection (VNC), NetOp, Windows Terminal Server (WTS) [Microsoft, 2001], Winframe [Citrix, 2001], Ntrigue [Insignia, 2001], Tarantella [Tarantella, 2001], and RapidX [GraphOn, 2001]. Under following sections will two different thin clients be presented, Virtual Network Connection and NetOp.

1.1 Virtual Network Communication (VNC)

VNC, [AT & T Laboratories Cambridge, 1999], is a display system that allows access to a desktop environment from anywhere on the Internet. The system allows collaboration between different machine architectures, making it platform independent. This means that a VNC viewer on a PC computer could be used to display UNIX environments. It is important to emphasise that it is not only applications and data that are shared but the entire desktop environment.

The VNC system has a characteristic where no state is stored at the viewer. As a consequence it is possible to leave the desktop you are sitting at, connect from another and finish your work there. This means that the remote connection will not end if the client computer crashes. Moreover, the system is small and simple to use. It is even possible to run directly from a floppy drive without installation. Another important feature is that it is sharable and can therefore be displayed and used by several viewers at once. Finally but not unimportant the software is free for download on the Internet.

1.2 NetOp remote control

NetOp, [AntonicA, 2001], is another type of thin client that enables remote control of a computer. The strength of the program is the speed of the remote communication. This is carried out through sending data compressed or as commands resulting in fast updates of the screen. Tools for effective file transfer, security, and the support of all standard protocols are implemented. However, this program is not free. Examples of the prices at 2001-06-28 are given below.

Table 24 Example prices of NetOp

Product	Rec. price
1 guest + 1 host	1 870 SEK
1 guest + 10 host	8 100 SEK
50 hosts	21 790 SEK

2 NetMeeting

NetMeeting, [Microsoft, 2001], is a videoconference program created by Microsoft. This program will mainly be used to share simple applications in the IDE studio, but has capacity for desktop and program sharing, chat, whiteboard, and file transfer. It only supports point-to-point connections with audio and video, and do not have the same quality and technical capacities as Smile.

Figure 34 The NetMeeting environment

The benefit with NetMeeting is that it can be used if the bandwidth is limited since it is less bandwidth consuming than Smile. Finally Meeting Point, an expanded version of NetMeeting, can be used if the user wants to share audio and video with more than one recipient. The program supports up to 12 users at the same time.

3 DIVISION MockUp

This is a program able to carry out application sharing. It must be emphasized that this is not the only thing the program can do since it is also intended for creation of graphical visualizations and digital mock-ups. The user also has a possibility to extend the core functions of the program with a number of design options. Owing to this extended support can be provided for simulation authoring, human factor studies, and styling reviews.

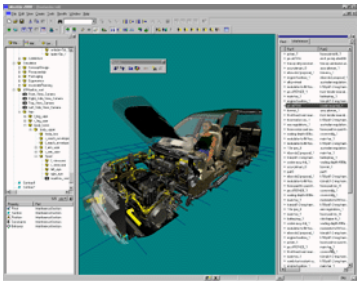

Figure 35 The user interface of DIVISION MockUp

The intention of the following sections is to provide a brief overview of the program including *supported formats, and capabilities,* the information was provided by [PTC, 2001].

3.1 Supported formats

When software is to be considered it is always important to know the formats possible to use within the system. According to PTC's web site DIVISION MockUp can handle following formats.

Table 25 Supported formats by DIVISION MockUp

3D CAD Formats		
Pro/Engineer	Microstation	STL
CADDS 5	Alias	3D DXF
SDRC MasterSeries	IGES	3D Studio
CATIA	MultiGen	GAF/GBF
Unigraphics	Inventor	
Solidworks	VRML	

3.2 Capabilities

The software is especially designed to allow quick loading and real time navigation in very large models. It is possible to carry out an interactive fly-through in a complex assembly. Since this program is presented under the chapter for application sharing programs, the abilities for this type of functionalities will be presented first followed by other features.

The software consists a number of communication tools including possibilities of viewing metadata captured in CAD models, such as part supplier, owner, and material. Moreover, exports to MPEG movies can be done, and finally 3D simulations can be published on the Internet with DIVISION EchoCast, which is a distributed player of MockUp simulations. Consequently the simulations can be interactively viewed using a Netscape browser.

It is also possible to carry out real time multi-user collaboration. This is possible due to a distributed architecture supporting the TCP protocol. In short multiple networked clients can reference to a distributed database and interact in real time. A messaging system communicates only changes within the virtual mock-up, resulting in small bandwidth requirements. It is possible to use following tools:

Table 26 Real time, multi user collaboration abilities

Real time, multi-user collaboration abilities
Identify and resolve issues by conducting real time, interactive, multi-site, and collaborative reviews of the entire assembly
Immediately reveal all sections, changes, and simulations to all participants
Distribute users across multiple machines in both local and wide area networks
Enable the interaction of different hardware configurations across a distributed database
Depict each user as a hand or a full manikin representation that can include accurate texture-mapped representations for a truly realistic and personal presentation
Simulate multi-user maintenance studies, pick a virtual object, and hand it to another user

The visualisation and interactive tools enables the possibility of customizing the loading and visualisation of parts and assemblies. It is also possible to save views, part visibility definitions, and fly-through paths with linked graphical thumbnails for quick preview and selection. The user can replay simulations defined with the motion planning option. Realism can be enhanced using interactively modified lightning, definition and modifying of visual materials, colours, textures, reflection maps, and audio tracks.

Concerning form fit and function several different features are included. It is possible to view sections in the context of a 3D scene or a 2D window. Multiple sections can be created and analysed in real time, and part locations changed to study, present, and interact with alternatives. The program is also able of carrying out interference and clearance checks where hard, soft, and "just touch" conditions can be investigated, and result in interactive reports. Furthermore, a real-time collision detection engine can be used while moving parts and running animations. It is also possible to create joints on parts to constrain movement with defined degrees of freedom and use lightweight manikins for rapid studies of human-centred issues, including reachability, visibility, and operability.

4 Distributed Interactive Virtual Environment, DIVE

The second alternative for sharing advanced 3D models for the IDE studio is DIVE, [Sics, 2001]. This can be considered to be a protocol for manipulating virtual worlds. The biggest difference between this and the one presented above is the collaboration tools. DIVE is an Internet-based multi-user VR system where participants navigate in 3D space and see, meet and interact with other users and applications. To summarize DIVE applications and activities include virtual battlefields, spatial models of interaction, virtual agents, real-world robot control, and multi-modal interaction. It is free for non-commercial purposes and supports a number of platforms including SGI Irix 5.3 and above, HP HPUX 9.0X and 10.X, SUN Solaris 2.4 and above, and SunOS 4, Linux 2.X, Windows NT. The investigation will not be more extensive since this program is not considered to be the one primarily used in the studio.

Appendix K Programs to use in a shared environment

Software besides the ones used for actual sharing is often needed in the day-to-day work for a designer, and thus in the IDE studio. For this reason description of some modelling and PDM systems will follow below.

1 Modelling software

This section aims to briefly present some of the modelling tools suggested by the interviewed designers. The emphasis is to find out if they in some way support distributed work.

1.1 Pro/Engineer

This software is a parametric solid modelling tool developed by PTC, [PTC, 2001]. The product is available in different forms depending on the intended usage. These are design, production, shipbuilding, routed systems, and collaboration. Pro/Collaborate is the most interesting product with the IDE studio in mind. This is a free on-line service hosted by PTC for users of Pro/Engineer. It provides collaborative workspaces where engineers can share their designs with globally dispersed engineers, contractors, suppliers, and other trading partners who need access to a company's product development process.

1.2 Sketching tools

The foundational functionality of the IDE studio is based on sketching on tablets. Consequently tools for this work are needed. However, none of Adobe Illustrator [Adobe, 2001], CorelDraw [Corel, 2001], or Macromedia FreeHand 10 [Macromedia, 2001] was found to support distributed work. For this reason a tool, for example a thin client, must be used to distribute sketches between present and distributed users, independently of chosen sketching software. This means the decision of software for sketching can be made solely on parameters like availability, price, and user friendliness.

1.3 Opus Realizer

This software was created, [Opticore, 2001], to be used by designers and modellers. The program works in real time, allowing the user to immediately see the results of a change. An optimization has been made to create good image quality, making the software a competitive tool for evaluating and communicate a design concept. Various formats can be imported to the program such as Alias, Pro/E, IGES, Rhinoceros, and export is supported to a web format and to high-resolution snapshots. The developers summarize their product in photo-realistic real-time rendering, web export, flexible concept variants, powerful and flexible material handling, model animation, and user friendly interface, where web export are of special interest in this section. This tool makes it possible for a designer to export the design in a web format without decreased quality and is the only support for remote usage.

1.4 Alias| wavefront

This is a company specialized on 2D and 3D graphics, [Alias|Wavefront, 2001]. This objective is carried through with the software Maya and Studio Tools. Neither of these was found to store any special tools for distributed work.

1.5 Rhinoceros

The last software to be investigated is Rhinoceros, [Rhinoceros, 2001]. The program is multipurpose and covers rendering, animation, drafting, engineering, analysis, and manufacturing. This includes CAD/CAM and rapid prototyping. The software is able to translate a number of file formats. These include the important formats STEP and IGES. Finally no specific support for remote usage was found.

2 Systems for information sharing (PDM)

The name PDM stands for Product Data management and these systems are used to coordinate information. They are described in [Konstruktionsgruppen Maskin och Fordonskonstruktion, 2000]. Most are designed to support the product definition during the complete lifecycle of a product. For the line of work in the IDE studio, an extremely qualified tool is not required initially, but a cheap one with good distribution abilities together with ability to access the system via a browser. There are a lot of products to choose among. In the research have candidates like BSCW, eMatrix [MatrixOne, 2001], Windchill [PTC, 2001], Metaphase [Metaphase, 1999] and Agile [Agile, 2001] been identified. However, although BSCW is more of a document sharing software than a PDM system it seemed to be the tool best suited for the studio initially. This since it is easily accessible, can be downloaded from the Internet for free, has been tested before in distributed engineering, and has an adequate level of sophistication for the intended work in the studio this far. A short description of BSCW will be provided below.

2.1 BSCW

The abbreviation stands for Basic Support For Cooperative Work, [Orbiteam, 2001], and is a shared workspace system. It can be described as an extended W3 server, providing basic facilities for, primarily asynchronous, collaborative information sharing, activity awareness, and integration of external applications across Macintosh, PC and Unix platforms. The only requirement is that the user has access to a standard Web browser. The purpose of the system is mainly to integrate the simple functionality found in ftp, namely storage and retrieval of documents, with more sophisticated features such as group, and member administration, check-in/-out facilities and access to meta-information regarding documents and members. The system also provides a simple event-based awareness service to inform users, at-a-glance, of the current status and past changes to information held in the workspace.

The system is made up of a server containing a number of workspaces. These are accessible from different platforms using a browser. Each workspace contains a number of shared information objects, and workspace members can perform the actions described above on these objects. The objects currently supported are documents, links (to normal W3 pages and other workspaces), folders, groups and members. Finally each BSCW server maintains an index of all the workspaces it manages. Users access the index using a standard username and password scheme, and the server responds with a list of the workspaces the user can enter. Alternatively, workspace members can access the workspace directly if they know the URL. New users are added to the server by completing (or having an existing member complete) a simple registration form, which asks for a username and the new user's e-mail address. This information is then used to check if the server already knows the user, if not, an initial password is generated and mailed to the given address. This simple registration scheme requires users to give a valid e-mail address in order to log on to the system. Once logged on, users can change their password to something more suitable.

Appendix L Hardware alternatives

There are many ways to set up equipment for distributed work. A number of ways have been described in the related work section, appendix H and through the scenarios. This section presents hardware constellations or components that have been considered during the completion of the thesis. A compilation of the hardware tools discussed has been made in a table in order to provide an overview. The reader should be aware of that there is no connection between alternative number and the quality of different solutions.

Table 27 Hardware alternatives

Hardware function	Alt 1	Alt2	Alt3	Alt 4	Alt 5	Alt 6
Display an image	Projection	Monitors				
Recording image	Sony EVI-D31	Document cameras				
Capture sound	Wired system	Wireless system; WMS 81 and WMS 300.				
Sound	Speaker system					
Sketching and writing tools	Mimio	Ebeam	Matisse	WACOM	SMART Boards	Hawk Eye
Storing/Access information	CDROM	DVD	Video recorder			
Control system	Crestron CNX					

1 Displaying images

There are a number of different ways of generating images. The approaches differ and have different pros and cons. A presentation of different ways of producing images will be made below to provide the reader with a brief overview.

1.1 Projection

Projection is a technology where a projector is connected to a computer and displays the image on a screen. The information provided in this section is based on [Minhembio, 2000], [ISTV, 2001], [Projected Image, 2000], and [Da-Lite, 2001]. There are three types of projectors CRT, LCD, and DLP. The technology first mentioned creates an image with three separate picture tubes (red, green and blue), while LCD and DLP are fixed pixel projectors. Owing to this they have picture elements that make up the structure of the picture. Naturally the size of these elements will increase with the size of the image. LCD projectors use a technique where the picture is built up by three small panels, one for each primary colour (RGB). Each panel has a grid of pixels composed of liquid crystals. A panel can consist of millions of pixels where each one can be individually activated by electricity creating the picture. In comparison DLP, the most recently developed projector type, uses a DMD-chip covered with 500 000 small mirrors in aluminium. Each mirror makes out a picture element, that is three pixels in a LCD display, and can be electrically controlled. The most common resolutions for LCD and DLP projectors are 800 x 600 and 1024 x 768.

Negative aspects with CRT projectors are that they are rather big and ungainly, it takes a specialist to install them, and that they are expensive. Benefits are that most are water-chilled which makes them less noisy, and the good picture quality. Drawbacks with LCD displays are the noise from the fan and that it can be a difficult to create good blackness in the picture. The most positive aspect with them is that anybody can install them. Advantages with DLP are that the picture has good contrasts and colours. Disadvantages are the noise from the fan and the colour disc.

A projector can be placed in front of or behind the screen creating a front-projection or back-projection system respectively. Both systems have pros and cons. A table was put together listing some of these features.

Table 28 Pros and cons of front-projection and back-projection

	Advantages	**Disadvantages**
Front-projection	• Requires no additional space behind the screen • In general, front-projection screens have superior performance in terms of color and viewing angle • Front-projection screens are less expensive and easier to install than back-projection	• Front-projection is more sensitive to ambient light • The screen is reflective and reflects the light from the projector, and light from other sources such as stage lighting and windows • The lighting in the workspace must be carefully controlled to keep it from washing out the screen • The projector must be installed somewhere within the workspace. In many applications it is impossible to place the projector in a location where it in not visible to the audience • A person can easily shadow the screen • It is hard to act in front of the screen in a good way
Back-projection	• Rear projection removes the projector from the workspace. It is behind the screen and out of sight • Insensitive to ambient lighting. Rear projection systems provide a bright image, even in a very well lit environment • It is easy to act in front of the screen without shadowing the projection	• Rear projection is more expensive. The screens are more costly, installation is more intricate and a large space is required behind the screen. However can one or more mirrors be used to minimize the space behind the screen • Rear projection screen surfaces offer narrower angles of view • As the viewer moves off of the centerline of the screen the image brightness drops dramatically • Choosing the right projector. Selecting the proper projector for your installation can be very complicated

It is also important to consider brightness, resolution, and aspect ratio when a projector is to be chosen. Brightness is a measure in ANSI lumens stating how bright the light from the projector are, for example 2500. Resolution is a way to describe how many pixels high and wide an image is. The most common formats are VGA (640 x 480), SVGA (800 x 600 pixels), XGA (1024 x 768 pixels), and SXGA (1280 x 1024 pixels). The aspect ratio describes the relationship between a screen's width and its height If, for example, an image is 1,5 m wide and 1,2 m high the aspect ratio will be 5:4.

In some applications it is desirable to place two or more projectors beside each other on a large screen. Two different techniques can be used to accomplish this, soft edge and hard edge. In short hard edge means that the images is placed between each other, and overlaps in soft edge. To accomplish a soft edge solution projectors with that ability or hardware devices can be used. The figure below shows how a soft edge solution provides a smother, more expensive, solution than the hard edge.

Figure 36 Hard edge and soft edge techniques

A projector projects its image on some type of screen which can be made up of a soft or a hard material, or combination between the two. Depending on parameters like lighting condition, ambient light conditions, required viewing angle, projection method, and cleaning requirements etc. can various screen types be chosen among. They range from projection on a wall, cloth, or frosted glass to very advanced screens with different coatings and layers.

1.1.1 Stereo projection

These types of system were described in an interview, [Eve, 2001]. Stereo projection can be created in two ways, active and passive. Active solutions rely on CRT projectors while LCD or DLP projectors build up passive solutions. Recently a new technique evolved where standard LCD/DLP displays are used to create high quality stereo 3D visualizations. This is made through the use of a stereo 3D converter, two stacked projectors, a regular PC with a graphic card enabling stereo, and standard software, see figure below. Moreover two different graphic cards has been successfully tested, the Wildcat 4110 and the Fire GL2.

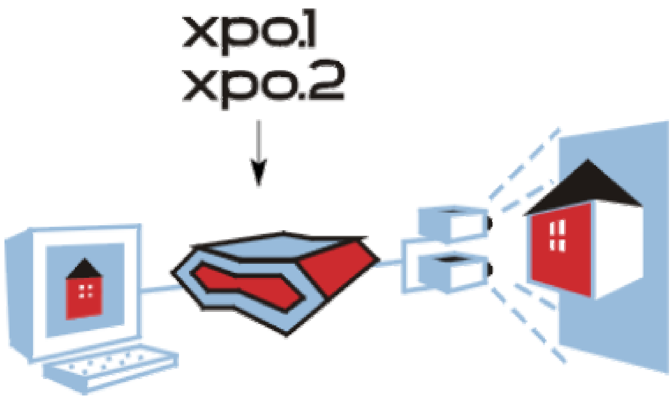

Figure 37 Creating a 3D visualization using a 3D converter box

In short, the basic solution is that an analogous VGA signal from the computer is digitalized by the xpo1 or the xpo2, [Cyviz, 2001]. Owing to this the original signal can be divided in two, left and right. The signals are reconverted to VGA and sent to the projectors. Furthermore, a polarised filter is put in front of each projector. Finally the user is provided with glasses having corresponding polarization with the plates placed in front of the projectors. This technique can be used with both front and rear projection. Front-projection does however require a special silver screen, whilst in rear projection a regular screen or frosted glass can be used. The major problem with frosted glass is that the picture disappears when the user is not standing orthogonal towards the screen. At the moment two different boxes has been developed, the xpo1 and the xpo2. The only difference between the two is the resolution. The former has 640 x 480 to 1024 x 768 and the latter 640 x 480 to 1280 x 1024. In order to be able to work the boxes must be provided with a standard frame sequential stereo monitor signal. This type of stereo signals is supported by the majority of the market leaders in software within CAD/CAM and VR. Nevertheless, there is a solution if software should not support the required signal. A viewer can be downloaded from the Internet, for example from www.tgs.com, free or for a small charge. The user can communicate with the box through a hypher terminal. The communication takes place in a special language for which a manual is provided with the box.

The big strength with this technology is that a high performing 3D system can be created with less investment than earlier. A complete system can be built up for around 200 KSEK, excluding the computer, which is far less than a solution based on standard CRT projectors.

1.2 Monitors

There are mainly two types of monitors being widely used, [Projected Image, 2000]. The traditional ones used for years, CRT (Cathode Ray Tube) and LCD (Liquid Crystal Display). The last mentioned type is becoming more popular all the time, mainly because they have great space saving advantages. CRT and LCD monitors are based on completely different technologies, and thus have quite different display characteristics. However there are also some alternatives to CRT and LCD displays. An overview is presented in the picture below [Projected Image, 2000]. The description is mainly made to show the difference between CRT, LCD and the plasma displays techniques.

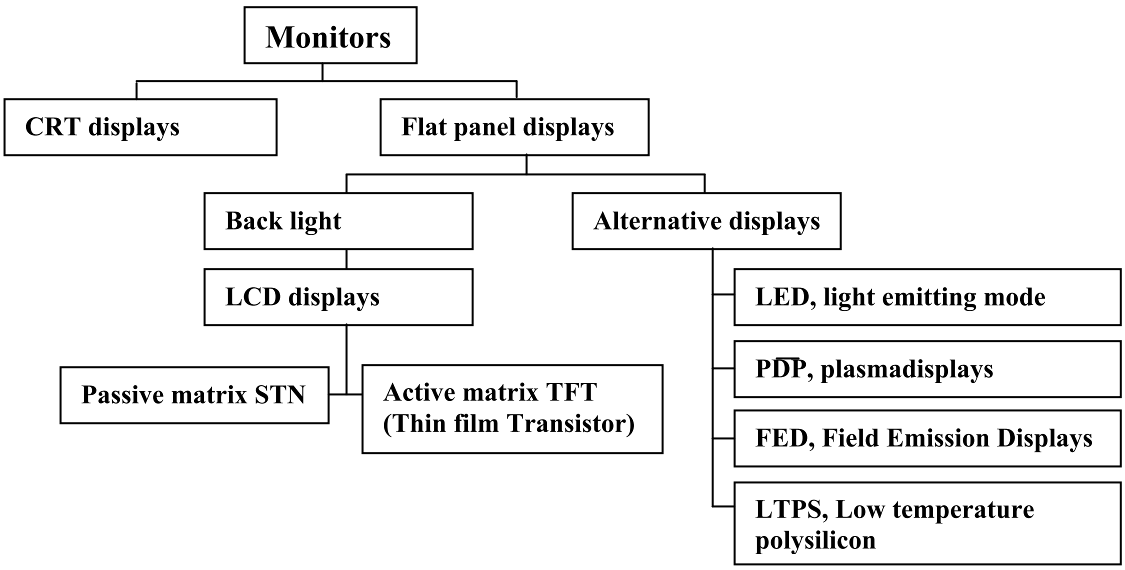

Figure 38 Monitor overview

One of the biggest advantages with LCD monitors is that they are compact and lightweight. They are built up of a very thin screen as opposed to the bulky tube of a CRT monitor. This means that not only do they take up less of the desktop space; they can also be used in many places where a larger monitor cannot fit. The screen size is another consideration. Thanks to advances in LCD technology, colour flat panel LCD monitors are now available with screen sizes comparable to those of traditional CRT monitors.

Most CRT monitors are capable of displaying unlimited colours. Some LCD monitors are only capable of hundreds or thousands of colours, but many of the newer are capable of unlimited colours. An important issue with LCD monitors is resolution. CRT monitors are usually capable of running multiple resolutions. LCD monitors, however, will usually work well in only one resolution. Other resolutions can be sometimes be displayed, but either the image may not be full-screen or the image quality may be poor.

Typically, brightness is not a concern with CRT monitors. LCD monitors are backlit and have different levels of brightness. The brightness rating for an LCD monitor is commonly referred to as nits and usually ranges from 70 to 250, the higher the nits, the brighter the display. Another issue with LCD monitors is the viewing angle. A CRT screen can be looked at from a very wide angle, while a LCD monitor having a much smaller viewing angle needs to be viewed more directly from the front. From the side, the image on an LCD screen can seem to disappear, or invert colours.

Besides being compact and space saving, LCD displays offer several other benefits. For one they consume much less energy than CRT monitors. This makes the LCD great for laptop and portable computers. Secondly, CRT monitors are known to emit harmful radiation, whereas LCD monitors do not. They also offer very good focus characteristics due to the active control of pixels by transistors. Another advantage compared with CRTs is the absence of geometry and convergence errors due to the technical nature of LCDs. Additionally LCDs do not flicker. This is due to the fact that they don't use an electron beam that has to scan left-to-right on each line of the screen. The lights are effectively turned off for a short time on CRTs when the electron beam flies back from the bottom right to the top left corner of the display (blanking). In contrast, the pixels of a LCD are never switched off; they simply change their intensity continuously.

1.2.1 Plasma screens

This section describes the nature of plasma displays as described in [Plasma-USA, 2000]. Flat panel plasma display is a new technology, and is probably the best way to achieve large displays with excellent image quality at the moment. The technique is based on plasma panels. These are composed by arrays of cells in the form of three sub pixels, corresponding to the colours red, green, and blue. Gas in the plasma state is used to react with phosphors in each sub pixel to produce coloured light (red, green, or blue). These phosphors are the same types used in cathode ray tube (CRT) devices such as televisions and standard computer monitors, see figure below.

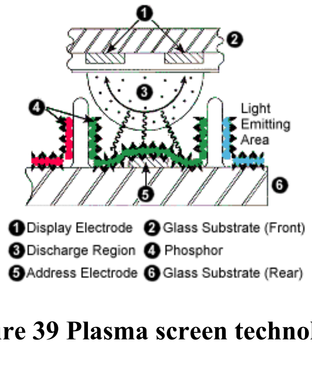

Figure 39 Plasma screen technology

Each sub pixel is individually controlled by advanced electronics to produce over 16 millions different colours. This means creation of perfect images that are easily viewable in a display that is less than six inches thick. Another advantage with plasma screens beside the sharp images is the over 160 degrees viewing angle, which is much more than what a projection screen can produce. Moreover, they perform exceptionally well in bright environments, has no picture flicker, experiences no distortion from electromagnetic interference, and can be used in either landscape or portrait landscape orientation.

Figure 40 Examples of plasma screens

Plasma panels are available in a variety of configurations. Along with varying resolutions, panels come in two aspect ratios: 4:3 and 16:9. The former is the same as conventional televisions and computer monitors. There is an exception in SXGA (1280 x 1024) resolutions, where the actual aspect ratio is 5:4, due to legacy issues of that pixel count.

2 Recording images

The video camera is the device used to record images. The nature and importance of it was mentioned in appendix I. Only one type of camera is considered for the IDE studio as described in this thesis. It is the Sony EVI-D31, which is a camera with broad capabilities. Moreover the video conferencing program Smile supports it. A summation is made below, [Sony, 2001].

High Speed, Wide Range Pan/Tilt
X12 Optical Zoom, High Speed Auto-Focus Lens
S-Video (Y/C) & Standard Composite Output
6 Position Preset
Auto Tracking/Motion Detector
RS-232 Serial Control (VISCA)
Control Via Your Computer Through The Internet
IR Hand Held Remote Control
9600 Baud Data Pass-Through Mode
Time/Date Generator
12 to 14 Volt DC Operation/Power supply Included

Figure 41 Capabilities of the Sony EVI-D31

If a user wants to be able to record information from existing materials or show certain objects can a document camera be a useful tool. They can be constructed in a lot of different ways, one presented below.

Figure 42Example document camera

3 Capture sound

One of the most important features of equipment for distributed engineering is the microphone system. A selection between wired and wireless systems can be made. The obvious benefit with the latter is the enhanced mobility with preserved quality, moreover is the problem with distortion eliminated. Two different systems by AKG have been considered in the development of the IDE studio, the WMS 81 and 300. The information about the systems is taken from [AKG, 2001].

3.1 The WMS 81 and 300 by AKG

These are wireless microphone systems that can be used for several channels simultaneously working in the UHF range. They are made out of microphone, sender, receiver, and base unit. The special features of the WMS 81 system have been summarised in the table below.

Table 29 Feature highlights of the WMS 81 system

Feature highlights
15 selectable frequencies
Tone Code Squelch
Interchangeable microphone elements for maximum flexibility
Pilot tone system for battery data status transmission
Digital "Four Level Diversity" circuitry and SAW filters for interference-free reception
Multichannel capability for simultaneous use of up to 24 channels (depending on local frequency allocation)
Modular system architecture and interchangeable microphone elements
Complete with 19" rack mount kit
Inputs for external boosters or directional antennas

The WMS 300 is a more advanced system than the WMS 81, aimed for professional users. Finally, if more than one user is desirable in a system each must have a microphone, a sender, a receiver, and a base unit. An automixer is used to coordinate the signals.

4 Speaker system

It requires a speaker system in order to be able to listen to the received audio. The complexity of the installed system can vary from small speakers directly connected to the computer to advanced 3D sound systems. Factors like size of room, cost, and usage applications determines the kind system of system to be installed.

5 Sketching and writing tools

It is often desirable to be able to use a whiteboard or a sketching tablet to communicate a message. This is however true for distributed work as well, especially in the IDE studio. Therefore this section discusses different alternatives to accomplish these functionalities ranging from cheap solutions like the eBeam to expensive electronic whiteboards.

5.1 Mimio

The Mimio system, [Mimio, 2001], uses a different approach to data collaboration than traditional electronic whiteboards. It is based on acoustic and infrared (IR) sensors in a data capture bar to track marker position and colour, respectively. The devise is, preferably, positioned along the upper left corner of a whiteboard. The bar is connected with a computer through either a serial or USB interface cable. Furthermore, colour coded marker sleeves, and an electronic eraser is used to add and remove data from the whiteboard.

Figure 43 Electronic eraser, data capture bar, and colour coded marker sleeves

In short, the electronic marker sleeves transmit an ultrasonic signal, which is triangulated by the capture bar. By this method the pens position on the whiteboard is registered. The users must use an electronic eraser to erase. Should a standard eraser or a finger be used, that change will not be registered. Thus, as a result of this technique almost any flat surface can be used as a whiteboard.

Figure 44 Usage of the mimio

The Mimio has a " stroke over time record". This function allows the user to rewind, fast forward and playback everything that has been written on the whiteboard. Consequently this will enable saving a whiteboard, clear it from the screen, start over, and yet be able to recall any previous board or sequence. Future audiences can choose between following the same order as the information was written or pre-selected points in time that were tagged by the presenter.

Data that has been captured can, as described above be stored in the Mimio´s native file format or exported as images or HTML files. Furthermore data can be cutted and pasted between different Windows programs. The Mimio does piggyback on the Microsoft NetMeeting software if a desire for distributed work should appear. Consequently it has a NetMeeting plug-in allowing notes captured on a Mimio capture bar to be directly inserted into the NetMeeting software. Thus, remote participants need only to have NetMeeting to see notes written at other locations.

5.2 eBeam

This system, [E-beam, 2001], is just like the Mimio based on a technology that converts a standard whiteboard to a digital tool. Moreover it is possible to retrofit whiteboards from 1.5 to 8 feet wide and up to 4 feet high. The system can be run both on PC and Macintosh environments. Consequently eBeam cannot be used on a UNIX system. Three main components build up the eBeam system, four marker sleeves, two whiteboard receivers, and one eraser.

Figure 45 Main components of the eBeam system

In order to be able to use the system, batteries and pens must be put into the marker sleeves enabling transmission of a signal to record their position. Next the two receivers must be placed at the top left and right corners on the intended whiteboard. The left receiver is plugged into the right receiver, and the right into a PC using a serial or USB cable. Finally the eBeam software is installed on the PC. An example system can be seen in the figure below.

Figure 46 The eBeam system

The eBeam technology can be combined with a projector attached to a desktop PC or a laptop. Using the eBeam mouse results in a conversion of a whiteboard to into a touch screen. This means that when a LCD display is used with the eBeam mouse application, a sleeve housing the eBeam mouse will be able to control the mouse-cursor from the board. Furthermore, the eBeam mouse stylus makes it possible to point, click, drag and drop, and control most PC operations directly from the whiteboard to which the eBeam pods are connected.

Figure 47 Projected image for usage of the eBeam mouse

The system can also be used to broadcast information written on a whiteboard over the Internet or a corporate Intranet in real time. There is a plug in allowing synchronisation of user strokes with sound. This function is called the eBeam Presenter and records drawings and sounds simultaneously so that images and sound can be sent in sync when the meeting is reviewed later. Moreover eBeam can be used together with NetMeeting. It is possible to save eBeam files (vector based format, WBD) in number of other formats including PDF, HTML (*.HTM), 256 colour Bitmap EPS (*.EPS), JPEG (*.JPG), Monochrome Bitmap GIF, and TIFF (*.TIF).

5.3 Matisse

The Matisse, [Smarttech, 2001], is a thin device to be snapped on in front of plasma screen displays (PDP). A regular Matisse is about 1,5 cm thick and weights around 25 kg and does not compromise the viewing angle. A number of new features are added to the plasma screen. Spreadsheets, word-processing documents, presentation software, image sources, and CD-ROMs and Web sites can be accessed right from Matisse with the touch of a finger. Users can write over applications in electronic ink using the stylus or their finger, then save those notes to a computer file that can be printed, e-mailed or posted to a network. Finally, conversion from hand-written notes into text can be made.

Figure 48 Matisse

5.4 Wacom tablets

Wacom, [Wacom, 2001], is a company creating tablet systems at several different technology levels. They have grouped their products into three classes with the names Intuos, Graphire, and PL series. The former two systems are similar while the latter differ since it also functions as a LCD monitor.

The Intuos and Graphire systems are pressure sensitive tablets used as sketching tools. The former aimed for professional graphic designers, illustrators, web designers, video artists, and photographers while the latter aimed for everyday people interested in digital photography and creating art on their computer. The main differences between for the concepts can be described in terms of resolution, size, and other features.

Figure 49 The Intuos and Graphire systems

Resolution is measured in terms of pressure applied on the pen tip and how accurate the pen is placed on the board. Since the Intuos are a more advanced system it is equipped with a greater level of resolution. Concerning size is the Intuos available in various sizes while the Graphire in only one. A complete summary of resolution, size, and other features is shown the table below.

Table 30 Differences between Intuos and Graphire

Features	Intuos	Graphire
Pressure resolution	1024	512
Coordinate resolution	2540	1015
Size (Inches)	4x5, 6x8, 9x12, 12x12, 12x18	4x5
Pen tilt	yes	No
Menu strip	Yes	No
Tool ID	Yes	No
Quick Point	9X12, 12X12, 12X18	No
Airbrush	Yes	No
4D mouse	Yes	No
Lens cursor	Yes	No

The Intuos is available either as serial or USB tablet that connects to the serial or USB port, respectively. The Graphire is also available both as serial, connects to serial and PS/2 port, and USB version, connects to USB port.

The PL series makes it possible for the user to sketch, draw, annotate, construct, outline, enhance, navigate, and erase displayed content directly on the screen. They are available in three different models with different sizes and technology levels. They require connection to the USB or serial port and to the DVI or DFP port on the graphics card. The software is compatible with all Macintosh/Windows-based applications that support a mouse, and by all pressure-sensitive graphics applications. The PL tablets are, for natural reasons, much more expensive than the Intuos and Graphire systems.

Figure 50 The PL series

To create meaningful brainstorming sessions in the IDE studio may a desire to use more than one board to the same computer occur. This has not been tested to any high extent so the functionality cannot be guaranteed, why this type of configuration should be avoided. Finally, a replacement of the PL series is on its way to the market. Wacom states that it will be called Cintiq and should be cheaper and stores better functionalities than the existing product.

5.5 SMARTBoard

The SMARTBoard, [Smarttech, 2001], is an interactive whiteboard onto which a computer image can be projected. The system is available both as rear and front-projection alternatives, where the former is most sophisticated and costs over 100 000 SEK whereas the latter is priced between 17 and 36 000 SEK. The boards must be completed with projectors and mirrors. It is possible to simply press on the surface of the board to access and control any application. An interesting accessory is a pen making it possible to take notes and highlight important information with electronic ink. This function makes it possible to make notes, which can be saved, printed, or e-mailed. Finally 47 to 72 inches are common sizes on SMARTBoards. The figure below shows some examples

Figure 51 SMARTBoard system

5.6 Hawk eye

The Hawk eye, [Smarttech, 2001], is an optical whiteboard capture system built up of a camera boom with three digital cameras above the whiteboard, control unit with LCD display, embedded processor, Web server, and memory to store images. When the system is installed a button is used to save an enhanced photo of the current whiteboard. The system does connect to networks making it possible to use a web browser to retrieve and distribute notes. Another alternative is to use a printer to create hard copies.

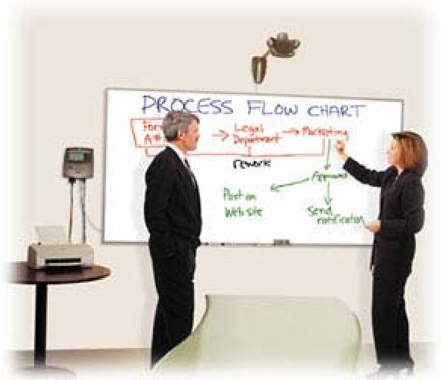

Figure 52 The Hawk eye system

6 Storing and accessing information

A devise that uses a laser to access and write data from a storage medium is called an optical disc drive. The drives are defined by the nature of the storage media they use. A driver for CD-ROMs is called a CD-ROM drive, and a drive that reads DVD-ROM's is called a DVD-ROM drive. The most common disc drives are CD-ROM, CD-RW, and DVD-ROM drives. It is also foremost among these the selection for the IDE studio probably will be made. Other optical disc drives include CD-R (CD-recordable) and DVD-RAM (DVD-rewriteable) drives.

All modern computers today are quipped with a CD-ROM. A CD can store about 650 MB or 74,5 minutes of audio compared to the capacity of the floppy disc, which is 1,44 MB. Moreover it is not possible to read data from any type of DVD, nor record data on any kind of recordable disc.

CD-RW drives has the ability to both write and rewrite information innumerable times on a CD as apposed to CD-R which is not capable of writing more than on time one the same CD. As for the former discussed drivers cannot CD-RW write or rewrite on DVDs.

Currently DVD-ROM drives are at the top of the optical disc hierarchy. The DVD discs have the same size as CDs but can store a minimum of 4,7 GB and a maximum of 17GB.
Finally, concerning the IDE studio, a consideration must be made whether it should be possible to use a video tape recorder in the room.

7 Controlling system

If a conferencing system should be flexible and easy to use, the usage of a controlling system can be valuable tool. This can be used to set up different abstractions in the system depending on what functionalities the user would like to have. The picture below is a simplified model of the parts of the system. Only some basic features are showed. There is possible to order systems that are able to control for example light, video, drapes, telephones, and slide projectors as well.

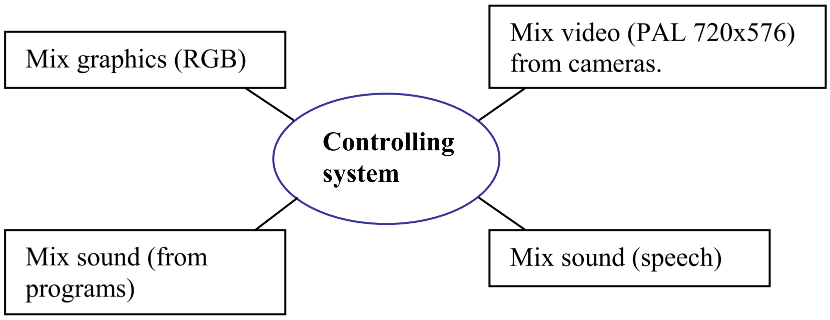

Figure 53 Imputs to a controlling system

7.1 Crestron CNX

An example controlling system is the Crestron CNX built by Crestron and sold by Demovision [Demovision, 2001]. This system can be expanded to cover all aspects of a studio. The control panel can be either wired or wireless.

8 Wireless solutions

It is likely that a wireless system should be suggested in the IDE studio. For this reason a brief description of wireless local area networks, WLAN, will be made under this section, [SSS Online, 2001].

Conceptually WLAN is an extension to, or an alternative to a wired LAN (local area network) using electromagnetic waves to transmit and receive data over the air. The benefits with this type of solutions are obvious. Systems become more mobile and flexible, with a lager capacity to install new users on a temporary basis. Furthermore, these can be configured in a variety of topologies, offering scalability to the system, making easy to be a few or thousands of hosts spread over a wide area.

In a typical WLAN configuration a transmitter/receiver device called access point is connected to the wired network from a fixed location. A single access point can support a small group of users in a range of one hundred to several hundred feet. The antenna attached to the access point is normally placed high, but can be mounted almost anywhere that is practical as long as the desired radio coverage is obtained. End users access the WLAN through wireless LAN adapters, implemented as PC cards in notebook computers; ISA or PCI cards in desktop computers, and as fully integrated devices within hand held computers.