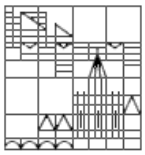

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Remote Sketching on Paper

Bachelor thesis

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To my parents.

Abstract

This bachelor thesis elaborates an analysis about collaborative sketching in today's practice. Consequently, the concept of interactive paper is presented.

Afterwards, the idea of the *Remote Sketching on Paper* approach, in combination with the interactive paper technology, is presented and a scenario based development process is described and used to design and implement the user interface and the interactions of a low-fidelity prototype.

In addition, an evaluation of the system is conducted with real users through an usability test and interviews.

Diese Bachelorarbeit erstellt eine Analyse des aktuellen und kollaborativen Skizzierens. Folglich wird das Interaktives-Papier-Konzept vorgestellt.

Danach wird die Idee, des *Remote Sketching on Paper* in Kombination mit der Technologie des interaktiven Papiers präsentiert, und einen szenario-basierter Entwicklungsprozess für das Design und die Implementation der Benutzeroberfläche und der Interaktionen eines low-fidelity Prototyps angewendet.

Zusätzlich, wird eine Evaluation des Systems mit Hilfe eines Usability-Tests und Befragungen mit reellen Benuztern durchgeführt.

Preface

I would like to thank all those who either directly or indirectly contributed to the outcome of this bachelor thesis. First of all, I would like to thank as well as Prof. Dr. Reiterer, as the Global Information Systems Group (GlobIS) at the ETH Zurich, that gave me the opportunity to work on this interesting project. Then I would like to thank Hans-Christian Jetter, Nadir Weibel and Elke Reuss (at the beginning and at the end of the project) for their constant assistance in my work. They provided me with the right guidelines, ideas and some useful literature. Finally, I would like to thank my family and my friends who always sustained, encouraged me and showed interest in my work.

Konstanz, July 2008

Hermann Hofstetter

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Chapter 1

Introduction

Millenniums have passed since human beings started sketching for the first time. The first examples of sketching, as we think of it today, come from Siena (Italy), from Mariano di Jacobi [LM04]. These were delivered to the emperor in 1433. Landscapes, cultures and languages have changed and evolved, but the sketching activity has remained almost the same: humans are still sketching using their hands and artifacts on different kinds of surfaces just as thousands of years ago.

This kind of act is mostly applied to express ideas, thoughts, emotions, theories and complex mechanisms and usually serves to record content and information quickly for later use. The artifacts have always been of different forms and types like wood sticks (i.e. when sketching on the sand) or pencils and pens (i.e. when sketching on paper), but the result has always been the same: a simple drawing for content communication. Because of this purpose, sketching usually involves more people who are ready to collect, elaborate and then discuss the information. Sketching can also be performed in many different environments and situations, depending on the kind of artifact that is available and how the content is required to be transmitted.

When sketching in collaboration has to be performed, some limitations arise in the physical world: synchronous collaborative sketching is only possible if all participants are all at the same place; a copy of the original must usually be sent to the missing participant through a physical medium. It usually takes too long to get quick feedback; this could be very important in a work environment. With the advent of the digital world and the fast Internet connections, more and more tools and approaches to solve these limitations have been tried and researched [Hof08]. This bachelor thesis will present and analyze a new approach which combines the advantages of the actual technologies with the interactive paper approach [Sig06] augmenting the users interaction in a remote environment resulting in a better effectiveness. This thesis is structured as follows:

Chapter 2 describes, defines and analyses the activities of sketching and collaboration and illustrates their role to better understand the meaning of collaborative sketching.

Chapter 3 describes the project goals and main ideas and gives a short introduction

to the architecture and the technologies used for the project.

Chapter 4 depicts the scenario-based design adopted for the *Remote Sketching on Paper* project requirement analysis: a user centered design process. This describes hypothetical stakeholders/personas, problem scenarios and claim analysis. Additionally, the requirement analysis is detailed. Furthermore, two scenarios are chosen to introduce and elaborate the design phase, which presents an abstract modelling of the users and of the tasks specified in the requirements analysis. Based on these models, first rough and then more concrete drafts of the user interface, system components and interactions are then presented.

Chapter 5 describes the implementation process, explaining its architecture and the technologies used.

In Chapter 6 an evaluation of the developed application (prototype) and approach is given.

Furthermore, Chapter 7 makes conclusions about the presented project and provides information about work that could still be done on this project.

Chapter 2

Sketching and Collaboration

In this chapter – taken from the term paper *Collaborative Sketching: a state-of-the-art analysis* and written by myself [Hof08] – a closer look to sketching and collaboration is given to explain how the process of collaborative sketching is built and carried out.

2.1 Sketching

2.1.1 Definition

Sketching is often used when explaining new ideas. The combination of drawing and talking in sketching is a natural means of expression. When interpreted by another participant on the basis of their background and with misunderstandings clarified interactively, sketching provides a rapid way of communicating many complex ideas [FU02] in many different fields as for example design, architecture or software engineering (i.e. system architecture modelling).

2.1.2 Role

Idea generation techniques, like brainstorming, are commonly applied for generating ideas. In the existing body of idea generation techniques, the primary mode of expressing ideas is in written language. Usually, during idea generation meetings, brief descriptions of ideas are listed on a flipchart or on paper, in form of sketches, especially when design ideas have to be generated. Researchers have often connected this activity of sketching to creativity in design [vdL02]. Sketching is a very descriptive way of communication. Very often it is by far easier to explain or model something by sketching than it is to describe the same situation in a verbal manner. Ideas can be explored more freely and quickly, especially when sketched with a pen on paper: using complicated computer software or hardware the flow of thinking may also be interrupted, and as reported by B. Lawson [Law94], sketching plays a fundamental role for designers:

> *"They find it hard to think without a pencil in their hand."*

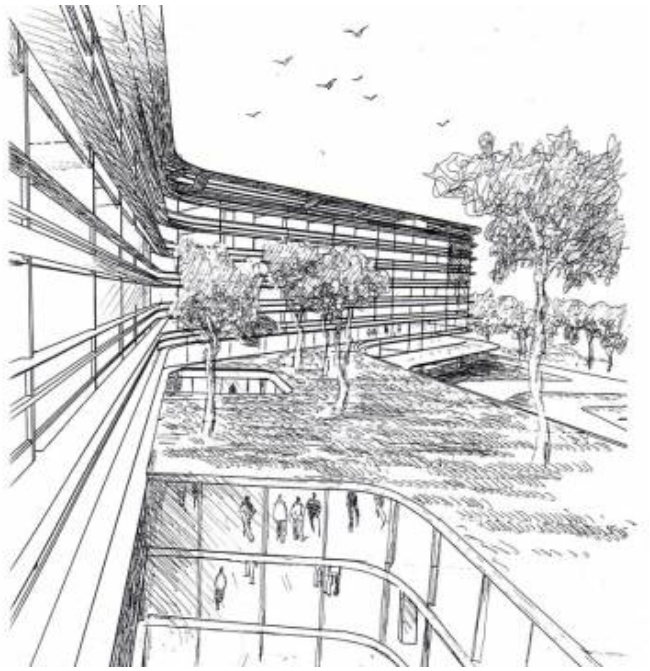


Figure 2.1: Hospital sketch
(`http://zlgdesign.blogspirit.com/`)

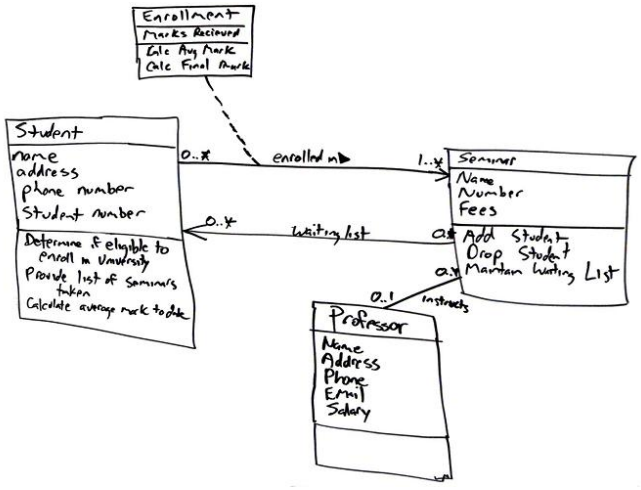


Figure 2.2: Sketch of an Unified Modelling Language model in software engineering
(`http://www.agilemodeling.com`)

Studies also show a relationship between sketch and cognitive process. One of their role is to extend the limitation of our memory. People also use sketching to compensate short term memory. D. A. Norman [Nor93] argued that human cognitive resources are highly overestimated; without external aids humans have only a limited memory and reasoning capacity. In addition, Artman and Ramberg et al [ARSCP05] confirm that sketching plays a major role in supporting collaborative work.

2.1.3 Elements

According to A. Blaser's [Bla98] technical report, all sketch elements can be divided in three categories: objects, relations and annotations. Every sketch can be split up into sets according to these basic elements. Annotations are not essential parts of a sketch, but objects and relations are mandatory; consequently it is possible to formalize a sketch. Objects are the primary elements in the sketch and knowledge about them reveals what the sketch is concerned about. They are logical instances or entities in a sketch and can be composed of multiple intersecting or non-intersecting strokes. They are in general highly abstract representations of their real life counterpart and often are described with simple lines or boxes. An object can also be defined by an annotation only.

A relation is a link between two or more objects. An annotation is a written or spoken verbal note specifying, describing, or defining an object, a group of objects, a relation between two objects, or properties of objects or relations. They are frequently used to describe characteristics of an object that can not be expressed graphically.

2.1.4 Attributes

Compared to A. Blaser's formalization of sketches, Bill Buxton [Bux07] captures the relevant attributes of sketches in a less abstract way:

- **Quick**: A sketch is quick to make
- **Timely**: A sketch can be provided when needed
- **Inexpensive**: A sketch is cheap
- **Disposable**: The investment with a sketch is in the concept, not the execution
- **Plentiful**: Sketches tend not to exist in isolation. Their meaning of relevance is generally in the context of a collection
- **Clear vocabulary**: The style in which a sketch is rendered follows certain conventions that distinguish it from other types of renderings
- **Distinct gesture**: There is a fluidity to sketches that gives them a sense of openness and freedom. They are not so precise as engineering drawings

- **Minimal detail**: Include only what is required to render the intended purpose or concept. It is usually helpful if the drawing does not show or suggest answers to questions which are not being asked at the time [Law05]
- **Appropriate degree of refinement**: It seems helpful if the drawing suggests only a level of precision which corresponds to the level of certainty in the designer's mind at the time [Law04]
- **Suggest and explore rather than confirm**: Their value lies not in the sketch itself but in its ability to provide a catalyst to the desired and appropriate behaviours, conversations, and interactions
- **Ambiguity**: Their value is in being ambiguous, to be interpreted in different ways, even by the person who drew them

2.1.5 Paper sketches

As we have seen, sketches allow to quickly preserve thoughts and design details before they are forgotten. The disadvantage of making these sketches on paper is that they are hard to modify as the design evolves. Most of the time sketches must be redrawn on a new paper sheet. These hurdles can be in part be solved, by sketching on erasable whiteboards or on translucent paper. Nevertheless, these are still not the best tools, because translucent layers require forethoughts on the part of the designer in terms of commonality and layout of components, scaling and deletion of objects that are not achievable on whiteboards [LM95].

Paper sketches don't support *design memory* [HK93]. Sketches may be annotated, but it is not easy to search them to find out why a particular decision was made. Sometimes annotations are even more valuable to clients than the sketches themselves [BB94]. Consequently, paper sketches are difficult to search and reuse.

2.2 Design in collaboration

As seen in Section 2.1, sketching is frequently performed to communicate ideas to other people. This happens, most of the time, during collaborative work. Sketching and collaboration are consequently closely related to each other. In this section design in collaboration will be described and analyzed in detail.

2.2.1 Definitions

Collaboration

A collaborative process takes place when something is accomplished by a group instead of a single person. Thomas Kvan [Kva00] tells that there are three facets of a task which determine the success of group effectiveness:

- how closely group members work together

- how group performance is rewarded
- members' belief that the group can be effective

Design

Thomas Kvan [Kva00] defined design as follows:

> If you ask a design team what they were doing, the participants typically will not think of a time when they are not designing. They will describe a complex series of decisions, threads which were picked up and dropped, tasks and events which occurred. Typically, they will describe intense and extended periods of time when they worked intensively together to solve the design problem. Challenged to identify discrete tasks, they may tell about tasks that took hours, days, or weeks. Consequently, design collaboration is composed of:
>
> - Mutual collaboration, in which the participants are busy working with the other
> - Exclusive collaboration, in which the participants work on separate parts of the problem, negotiating occasionally by asking advice from the other
> - Dictator collaboration, where the participants decide who is in charge and who leads the process

2.2.2 Differentiation

We are able to differentiate between four basic spatiotemporal structures [Pen92] in collaborative design, because it usually takes place in space and time:

- Collocated synchronous: all collaborators work face-to-face in the same setting, like a brainstorm session which often requires physical proximity for intensive communication
- Collocated asynchronous: collaborators are in the same room, but are left alone to concentrate and the teamwork is completed through indirect communication
- Remote asynchronous: collaborators are not in the same location (i.e. office) and they work through indirect communication (mail, delivery services, etc.)
- Remote synchronous: collaborators are geographically separated but they are able to use direct communication while designing alone (i.e. phone)

2.2.3 Interactions

The New Shorter Oxford Dictionary defines interaction as

> a reciprocal action; action or influence of persons or things on each other.

Involving more participants, (design in) collaboration, is composed of interactions between these actors and objects. For example activities like sketching, writing, talking, gesturing, coordination, etc.

Michael Baker [Bak99] divides these interactions in three different groups: communicative, argumentative and constructive interactions. He gives the following definitions:

Communicative interaction involves communication like sequences of mutually dependent communicative actions. Such actions can of course be verbal, in the case they are performed by a speaker with the intention of producing specific cognitive effect in a listener, or nonverbal in the case the communication takes place with gestures or similar actions.

Argumentative interactions are a specific type of communicative interaction which involves also non-verbal (i.e. text, sketch, ...) and verbal (i.e. speech) actions to form reasons and to draw conclusions and apply them to the discussed case.

Constructive interactions describe the way in which the conceptual points of view of people who are trying to understand a complex physical device go through successive iterations, between understanding and non-understanding. An interaction is constructive if it literally leads to the co-construction or building of something-meaning, understanding, solutions to problems, and sometimes knowledge. An interaction can also be constructive to the extent that it generally contributes in some way to cooperative goal-oriented activity.

2.3 Importance of paper

Everybody is sourrounded by paper. Digital documents are printed out for proofreading (emails, presentations, etc.), shelves contain journals, magazines and books, desk and monitors are augmented with Post-it notes, as we will see in Chapter 4, Subsection 4.1.2, architects sketch mostly on paper and it is seen as a physical object which can be handed to others very easily. Even in very high tech environments, i.e. offices with computers, scanners, digital cameras, video cameras – tools that allow digitalization – paper is still the most present artifact, an example is given in Figure 2.3.

Trends show that the new technologies have so far failed to have the predicted effect of the 30 years old Business Week article [Bus75] on paper consumption. It is continuously increasing and has more than doubled since 1975 [Sig06]. Two significant trends can be marked:

Figure 2.3: Example of an academic's office
[Sig06]

1. Everybody has gained, through interconnectivity, access to more information than before. In a survey of 150 American companies it was reported that network access to Internet and Intranet caused a noticeable increase in the amount of printing [SH03]. Apparently, users need to print the downloaded information to read it and to make sense of it. A study revealed that e-mail introduction caused, on average, a 40% increase in paper consumption. Using e-mail means also that people get more messages than they ever received before when they used paper and mail. The more information people receive and have access to, the more they need to print it out [SH03].

2. In the last decade, new technologies have provided the means by which it is possible to produce low-cost, high-quality, personalized paper documents. It is then normal that people are taking advantage of this and are consuming more paper than ever.

Anyhow, it should be noted that despite encouraging the consumption of paper, new technologies enable us to work much more efficiently with digital documents than before:

- Word-processing applications have virtually replaced the typewriter for the creation, modification, and reuse of work-related and personal documents, memos, and mail

- E-mail has replaced the paper inter office memo and the digital transmission is now the main way for sending and distributing documents, messages, and memos within and between organizations

- Computers are smaller, more lightweight, and wireless with longer-lasting batteries. Working with digital documents and accessing networks while on the move is

easier than ever

- Many paper directories, reference manuals, dictionaries, encyclopedias, technical documentations, forms, catalogues, newsletters, magazines, and journals are being made available in electronic form on CD-ROMs or online
- There are more online, networked databases and search tools for publishing finding, and retrieving information
- Cheaper, better scanning and imaging devices, and software for conversion of paper documents into digital form, have made digital archiving of legacy paper documents easier

2.3.1 Affordances of paper

According to Sellen and Harper [SH03] while technologies have been largely adopted over the last 20 years, the affordances[1] of paper have ensured its retention as a key information medium.

The physical properties of paper – portable, light, cheap, flexible, robust etc. – afford many different human actions, as grasping, folding, carrying, manipulating, folding and with marking tools sketching and writing. However, three different classes of problems can be presented by paper: symbolic problems, cost problems and interactional problems. Symbolic problems because paper is seen as symbol of the past and as progress failure. Paper limits are reflected on costs, considering the money that takes to store, deliver and manage, compared to the digital technologies. Interactional limitations consists in the limits imposed by the nature of paper as physical medium for interaction: it is difficult to amend and revise, to access remotely, to change state (show feedback) and so on.

The physical properties of paper make many actions not possible and many activities not achievable, for example:

- Must be used locally and cannot (without supporting technology) be remotely accessed
- Paper occupies physical space and thus requires space for its use and storage: vast amounts of paper require vast amounts of storage space
- Paper requires physical delivery
- A simple paper document can be used by only one person at a time
- Paper documents are not easily revised, reformatted, and incorporated into other documents
- Paper documents cannot be easy replicated (without scanners, photocopiers)...
- ... and cannot display moving images or play sounds

[1] The properties of objects determine the possibilities for action

Reading

The book *The myth of the paperless office* [SH03] describes four key reasons why paper supports reading so well:

1. Paper helps to navigate through documents with flexibility; the document size indicates how much information is stored and readers always know where they are in the document by flipping pages
2. Paper facilitates the cross-referencing of more than one document at a time, placing for example the documents next to each other
3. Paper allows mark-ups, that help re-reading and structuring thoughts, very easily
4. Paper allows the interweaving of reading and writing, for example placing a document next to a notebook it is possible to take notes while reading

When it comes to settling down and reading something, documents are often printed out before being read. People don't like to read from computer screens and usually complain about the feeling of tired eyes when reading large quantities of text. Reading is also performed in combination with a pen in the hand quite often.

Knowledge work

With the help of some studies, Sellen and Harper [SH03] discovered that paper supports at least five key aspects of knowledge work:

1. Paper endorses authoring work; even though digital supports are used during document composition, paper is still a key part of the process
2. Review of documents is usually done and commented on paper
3. Activities thinking and planning is done on paper
4. During conferences reports hard copies are gone through and annotations are done during the discussions
5. Whenever an important document needs sharing, it is printed out and hand-delivered to co-workers

Support for collaborative work

The physical properties of paper allow for support of important aspects of collaborative work; these interactional properties are not easy to provide with digital media and collaborative tools. Many offices and work environments have been designed around paper, so any attempt to replace it comprehends the change of these work practices itselves, as demonstrated in three case studies described in *The myth of the paperless office* [SH03]. Paper is so persistent because it serves well for many tasks. It is a very reliable medium

for the display of real-time information and at the same time a mechanism, which coordinates teams and stores knowledge until it is ready to be shared; it is an artifact in support for face-to-face interaction, retrieval, reminding, organizing, and documenting of an individual's knowledge. Paper can be co-opted, shaped, and adopted to meet the needs of the work.

2.4 Paper and collaborative sketching

As presented in published research [Ali01], in current architectural practice – traceable also in other fields like design, education, etc. –, where extensive collaborative sketching is performed, preliminary designs are mostly created on paper and/or in scale models before being represented digitally through specific CAD (Computer Aided Design) applications. Only few computer tools are available today to assist architects and designer in these early and conceptual design stages, where freedom, speed, ambiguity and vagueness are needed to quickly create objects in their minds and, as described at the beginning of this chapter, to create *plentiful*, *suggesting and exploring* – rather than confirming drafts. Consequently, designer and architects produce many sketches and models to satisfy the brief and pen and paper are then really important at this stage. Their collaboration takes place in a face-to-face environment where they express their ideas, thoughts and make their annotations on paper.

2.5 Conclusion

As shown so far, the dream of the paperless office has still not taken place in reality. Anyway, if paper cannot be replaced by digital media, it is already possible to try integrating it more closely into digital information environments. Doing it this way, the best of the physical and the digital world can be gained. In my term paper *Collaborative sketching: a state-of-the-art analysis* [Hof08] current technology approaches have been presented and described in detail, but further on in this bachelor thesis a new solution is introduced. The highly optimised properties of paper media, which have evolved over the last two thousand years [Sig06], are augmented and enhanced with new digital features by tightly integrating paper and digital technologies. Chapter 3 will describe an application running on this kind of technology to support remote collaborative sketching.

Chapter 3

Goals and technologies

In this chapter the bachleor project goals and the interactive paper approach will be presented and explained. One of the main advantages of this bachelor project is that it allows working with standard paper, a physical interface that is able to interact with digital information and consequently used as a very portable input device. As mentioned in Section 2.3, paper is an everyday use artifact that supports collaborative working as well. Having particular physical properties (portable, light, cheap, flexible, robust etc.) it affords many different human actions as grasping, folding, carrying, manipulating and, with marking tools, sketching and writing.

3.1 Goals

Before technology became so evolved, especially in the communication and graphical fields, sketchers (i.e. architects and designers) who collaborated with other colleagues, had to be at the same location at the same time (*collocated synchronous*). Communication was spontaneous and ideas were represented, whether verbal or non-verbal, by talking and using traditional drawing tools. If they were geographically displaced, the interaction was then space-affected as well as the probability of being time-affected (*remote synchronous* and *remote asynchronous*). In this case, communication was usually mediated through telephone and graphical representations were sent by fax or as posted documents. Telephone-based communication is usually very fast, but could also lead to serious communication breakdowns, considering that 2D and 3D visual representations would have to be translated into verbal representations. It is very hard in a telephone conversation to point to a part of a drawing in context unless both parties hold separate copies, and even then, it is very difficult to establish long-distance frames of reference. The continuous development of computer and telecommunication technologies has seen architects increasingly using these media for communication as well as for work. Hence, architecture as a profession is becoming dependent on computers not only in ways of documenting designs but also in the form of representing and communicating design ideas between various parties, from colleagues to clients to the general public [GM02].

In the early nineties, Mark Weiser[1] coined the term *Ubiquitous Computing*. Instead of trying to digitalize the physical world and using computers mainly as storage components, small computers could be embedded in everyday objects to make them more powerful in terms of connectivity and information exchange with surrounding objects and the environment [Sig06]. These physical artifacts can be used as input and output devices. The resulting tangible user interfaces are then a new form of interaction with computers in a more natural way by electronically coupling physical and digital objects. Users don't have to work with a digital representation of a physical concept, but can work directly with the physical object that has either some embedded computing power or is connected to a server performing the requested operations.

The classical way to integrate paper and digital information is the *document identification*. It provides the user with more information, that is encapsulated within the digital world to that specific document. To augment different parts of a document the user's position within the document is tracked. The *position tracking* technologies differ in terms of mobility and resolution offered. Those with low resolution are usually used to address parts of the document and those with a high resolution to capture writing. It is also important to mention that during the last decade many efforts have been done on the software development side to deliver user interfaces that give the feeling of working on paper. Position tracking, software with special user interfaces and functions and scanning of documents are the most used techniques in every day practice when digital versions of sketches and designs are needed.

Taking into consideration the previous discussion it becomes evident that the technology for collaborative sketching should resemble the traditional sketching environment as much as possible.

Another issue of current technologies is portability and the lack of synchronous communication software during sketching [Hof08]. Either the input device/method differs from paper and pen (i.e. no sketch feedback of the drawing on the graphic tablet, mouse and keyboard as input, etc.) or it can only be worked on sketches asynchronously. Tools that simulate paper closely are expensive and still not so handy in their utilization: they are usually too heavy and too big. They can also break easily and the sketcher cannot act as natural and as fast as he would do on standard paper.

In addition, as mentioned before, the preferred collaborative way is usually face-to-face. In the digital world, when collaborating remotely, a similar situation as face-to-face can only be achieved with synchronous tools (with audio and video communication). People are taught drawing and sketching, alongside with speech, from a very early age. From this point of view, pen input is as natural as speech and should certainly be considered as an important modality for computer interaction. As we have seen, pen and paper are also traditional companions in many creative activities and should be used as input devices.

To keep the sketching act as natural as possible, the system should also be fast, reliable and easy to use and learn: like grabbing a piece of paper and start drawing on it, without carrying cables, heavy hardware or using complex software. Intuitiveness is

[1] At the Computer Science Lab at Xerox PARC, `http://www.ubiq.com/ubicomp/`

important to focus on sketching and not on how to use an application. Since the traditional environment is considered as best suited for this task, the tool should resemble it as closely as possible. However, as shown in the term paper [Hof08], no technology is able to incorporate standard pen and paper and at the same time allow live digitalization in parallel with remote audio and video communication and multi-user sketching over the Internet.

The following sections will present and focus on a technology that overcomes the listed limitations: it is based on standard paper, standard pen and can work together with Skype, which makes possible synchronous video, audio communication and floor control (it allows to make improvements of sketches in a private space, before the results are published to other participants engaged in the real-time collaborative process) [BMBE01].

3.2 Interactive paper

The integration of paper and digital media involves two main steps. First, a method to link paper to digital actions is required. In a second step, the information acquired by a specific hardware solution is used to access the appropriate digital information or service. This implies the availability of a software framework (*iServer*[2]) for the link and information management. In addition, the GlobIS group[3] developed a powerful and flexible cross-media information management architecture, which facilitates adaptation to evolving technologies and makes paper a first-class medium in the context of an interactive information system, allowing linking not only from paper to digital resources, but also from digital resources to paper and even from paper to paper [Sig06], the so called *iPaper* framework, that works in combination with the *iServer*. Therefore, this same technology would permit digitalization of paper sketches as well.

3.3 Anoto technology

The Swedish company Anoto[4] developed a digital pen and paper technology for high-resolution paper-based position tracking. The idea is to detect the pen (x,y) position on a paper document. As reported by Beat Signer in his PhD thesis, the pen works as follows [Sig06]:

> The position information is directly encoded on each piece of paper, in this case using a special pattern of tiny visual dots as shown in Figure 3.1 (courtesy of Anoto Group AB). One can assume that there is a virtual grid over a page and the dots are printed with a small displacement relative to the intersections of the horizontal and vertical lines of the grid fitted to the dot matrix. Each dot then encodes a two bit sequence which is defined by

[2] `http://www.globis.ethz.ch/research/iserver/`
[3] `http://www.globis.ethz.ch`
[4] Anoto AB, `http://www.anoto.com`

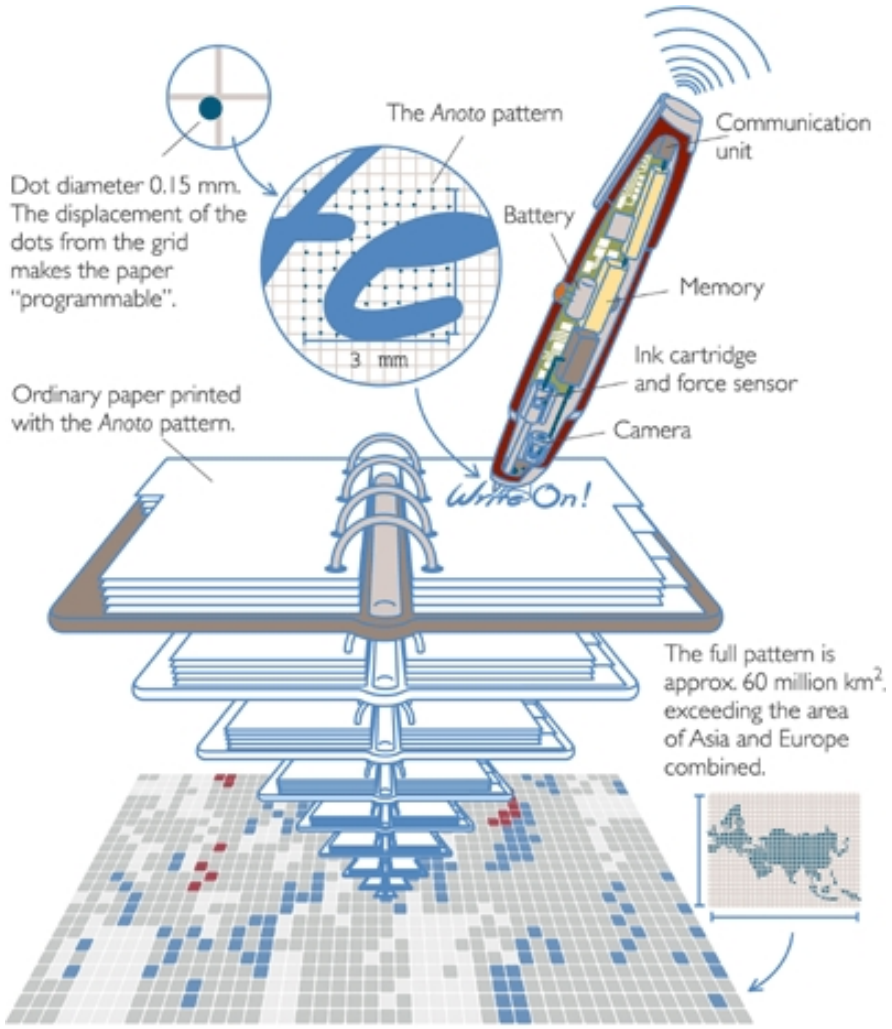


Figure 3.1: How the Anoto pen works

> its horizontal and vertical displacement from the corresponding intersection point. Several dots together form a unique sequence of zeros and ones which defines a position in a large virtual document space. The dot pattern results in a slightly grey page background with minimal interference with the document's content.

This pattern is almost invisible and absolutely does not interfere with the reading and writing on the paper. Standard paper is being printed with this pattern through a printer driver plug-in on standard printers.

> A special digital pen for the Anoto dot pattern has to be equipped with a camera in addition to the writing stylus to track the pen's movement relative to the paper surface. A record of the pen's movement can then be used to recreate what a user has written within the digital world.

The pen costs approximately 300$, has rechargeable batteries, is light and uses standard ink. It comes with an USB cable, has built-in Bluetooth to transmit the coordinates and a docking station for charging, connecting or downloading data from the pen to the personal computer.

3.4 iPaper

As mentioned before, the GlobIS group developed a framework which enables flexible integration – through plug-in support – of different input devices and applications with the Anoto's interactive paper technology. The *iPaper* plug-in has been implemented to connect the two technologies together and works as follows:

> It is based on a client-server architecture. On the client side, a special input device, for example the digital pen, is used to detect (x,y) coordinates within an interactive paper document and send these to a computing device such as a regular PC or a PDA. In addition, the input device has to identify the document it is used on and the page number within this document. The document's identifier (ID) and page number together with the positional information are transmitted from the client to the server component responsible for further data processing via an HTTP request. The server side consists of a cross-media information management component *iServer* (allows the definition of links between arbitrary digital or physical resources), with the interactive paper resource plug-in (*iPaper*). It is important to note that all operations on the server side are completely independent of a particular paper, printing or input device technology. The only information required by the server is the document identifier, a page number and an (x,y) position [SN07].

> The *iPaper* plug-in supports simple links between printed and digital materials as well as highly-interactive applications where users can easily

Figure 3.2: Interactive slide handouts of the PaperPoint application

> move back and forth between the printed and digital worlds. The introduction of geometrical shapes as a specific form of selector for interactive paper enables to define active areas on a page. Each time a user points to a position within an active region, its associated links will be activated (request to the *iPaper* plug-in which has to resolve the selected shape) [Grob].

The *iPaper* plug-in is used, for example, to support pen-based writing capture in the *PaperPoint* application (Figure 3.2). This is a tool that enables *PowerPoint* presentations to be controlled through the *iPaper* plug-in from printed slide handouts. The slides can also easily be annotated during presentations by simply drawing on the printed version of the slide [SN07]. The paper *input device* is shown in Figure 3.2. A similar approach could be used for the sketching application.

3.5 Remote Sketching On Paper

The *Remote Sketching on Paper* project's proposal delineates the tasks and goals of the bachelor project in detail and it can be found in Appendix A.1. The *Remote Sketching on Paper* approach shows how actions of sketching and handwriting on paper can be transmitted in parallel to voice or video communication in mobile, desk and meeting environment. In Chapter 2 attributes of sketches like quick, inexpensive, minimal detail, etc. [Bux07] were described. Therefore, the *Remote Sketching on Paper* approach implements them through the use of standard paper and a normal pen. The development of a prototype connecting the well-known Skype application with the *iPaper* infrastructure would support the remote synchronous collaboration and at the same time work

Figure 3.3: The Remote Sketching on Paper functionality

as a bridge between Skype and the sketching interface, providing users with the needed sketching environment (Figure 3.3). Once the connection between the interactive paper, the pen and Skype is established, it is then possible to sketch on paper in the four spatio-temporal structures presented in Subsection 2.2.2.

As mentioned before, every interactive paper page has its own document identification (ID) and to create a new page in the application, it would be sufficient to point the pen over a new interactive paper sheet. To open an existing sketch, the action would be the same. To change colors and style of the sketch it would be enough to use a pen (also with unique IDs) with a different color or a thicker/thinner style. These kind of actions would maintain the nature, simplicity and spontaneity of sketching, even if the user is digitalizing his work and collaborating together with other people over the Internet.

Chapter 2 illustrated the disadvantage of making sketches on paper being hard to modify as the design evolves. Most of the time, sketches must be redrawn on a new paper sheet. These hurdles can be solved in the *Remote Sketching on Paper* by sketching on translucent paper with the pre-printed pattern. In addition, having a straight digitalization, scaling and deletion is then possible (in the digital world).

The synchronous digitalization of the paper sketches can also support *design memory* (i.e. undo and redo functions in the digital world), handwritten text on the paper can be digitalized and recognized too, consequently searching of annotations would then be easy as recording the entire sketch process together with the audio/video communication. The result would then be an easy search and reuse of paper sketches.

As described in in Chapter 2 there are three types of collaborations: mutual, exclusive and dictator. Implementing floor control functions like in the groupware system Lyceum [Hof08], in the *Remote Sketching on Paper* approach, all three collaboration types could be easily implemented, allowing a real collaborative process (similar to face-to-face collaboration) even if in a remote environment. Audio and video communication would also support all three types of interactions (communicative, argumentative and constructive) during collaboration as defined in Chapter 2. The mobility/portability of paper and the pen would also prevail against the current input devices.

The *iPaper* framework also supports handwriting and gesture recognition, which could be easily be integrated in the *Remote Sketching on Paper* approach for user

sketching and annotation support. Additionally, gesture recognition allows the system to understand drawings and to adjust (interpolate) them for precise form design.

3.6 Motivation

A short summary about the advantages of the *Remote Sketching on Paper* application versus current software and hardware technologies for remote sketching is presented in Table 3.1.

	Software	Rating	Hardware	Rating	Remote Sketching	Rating
Synchronous Communication	Not well supported by sketching software except for Lyceum and WhiteBoardMeeting or similar applications	–	Software dependant; problem is that some software don't support specific input devices	– –	Based as well as on synchronous as asynchronous communication	++
Physical properties	Not applicable	– –	Display and the input surfaces are usually separated and produce an eye-to-hand coordination problem that delivers unexpected results. Consequently, placing and moving sketches in the real world next to each other is only possible after printing	+	Portable, light, cheap, flexible, robust etc. - afford many different human actions, as grasping, folding, carrying, manipulating, folding and with marking tools sketching	++
Interaction with sketches	Zooming, scrolling for work precision, color picking from millions of colors (with direct feedback)	++	Only the Wacom display pen tablet supports zooming and scrolling	+ / –	No zooming or scrolling or wide color palette supported	– –
Sketching instinctiveness	Eye-to-hand coordination problem, snythetic ambient light, sketching artifacts not paper and pen; less aesthetical feelings	– –	Simulation of natural sketching very close to reality, through special pens, tablet surfaces and paper	+	Standard pen and paper as input devices, high fidelity with classic sketching activity	++
Digitalization	Digital ond only after printing also physical	++	Digital ond only after printing also physical	++	Simultaneously digital and physical	++
Costs	From cheap to expensive	+	Rather expensive especially the ones with a display	– –	Rather cheap	+
Design memory	Supported	++	Supported	– –	Supported	++
Portability	Practically not supported (computer, mouse, keyboard, etc.)	– –	More portable than software, but some devices still heavy, big and not soo handy	–	Portable: paper sheet, pen and PDA for client software	++
Learnability	Software dependant	- -	Low, simulating sketching activity	+	Low: standard paper and pen. Creating new sketches is exactly the same as taking new paper sheet, changing color is the same as use different colored pen. Communication learnability might be higher if user has never used a software like Skype	+
Archiving	Supported	++	Supported by the software they are connected to	+	Supported	++
Annotations	Keyboard (digital)	++	Handwritten text	–	Handwritten text with handwriting recognition option (for digitalization); annotations can be searched	++
Recording	Not well supported	–	Not supported	– –	Audio, sketching and video supported	++

Table 3.1: Remote Sketching on Paper vs. other technologies, a winning solution

3.7 Conclusions on sketching remotely in collaboration

So far it has been illustrated, that despite all technology achievements and solutions in the digitalization era, most of the users still rely on traditional tools to sketch (remotely) in collaboration or limited software or hardware solutions are used.

This bachelor thesis has introduced a technology that is able to unify and connect the physical and digital world in a very user friendly, natural, intuitive, fast and cheap way: it combines the advantages of the paper and pen (as traditional sketching tools) and the advantages of the remote collaboration software that have been presented in the term paper [Hof08] all together.

The interactive paper technology enables now, through the *Remote Sketching on Paper* approach, not only enhanced writing and reading [Sig06], but also *enhanced sketching*.

When designers, architects and other users sketch with a common pen on standard paper (traditional and most intuitive and natural way of sketching) following is then allowed:

- Everything can be digitalized automatically without further actions or steps as well as in a mobile (portability) as in a desktop environment
- Remote collaboration is achievable through a Skype integration
- Storage and version archiving can be done simultaneously as well as in the digital world (as digital files and folders) as in the physical world (as paper sheets in folders)
- Through further implementations reuse and merging of sketches (when sketched *offline*) can also be allowed
- Enables synchronous communication involving different input channels like video or audio that simulate collocated synchronous (face-to-face) collaboration very closely
- Supports asynchronous scenarios very well (users don't work constantly in collaboration): it can be used as a desktop sketching tool

Chapter 4

User centered design process

This chapter describes the appliance of a scenario-based development for the *Remote Sketching on Paper* project: starting from a root concept, gathering information through online surveys, field studies, creating stakeholder profiles, analysing tasks and artifacts, describing imaginary users (personas), problem scenarios and last but not least identifying features of a situation that have important effects on the actors.

4.1 Scenario-based usability engineering

For the requirements analysis of the *Remote Sketching on Paper* project a scenario-based development (SBD) has been chosen during an expert group meeting. According to the book Usability Engineering by M.B. Rosson and J.M. Carroll, SBD is defined as follows:

> Descriptions of people using technology are essential in discussing and analyzing how the technology is (or could be) reshaping their activities. A secondary advantage is that scenario descriptions can be created before a system is built and its impact felt.
>
> Scenarios describe the behaviors and experiences of at least one actor and at least one task goal [RC02].

These scenarios include a structure, activities and events, what actors do, what happens to them and how the setting is changed. Consequently, these scenario descriptions can be a handy tool to manage the usability engineering's tradeoffs – shown in Figure 4.1 – without committing to details keeping the design space open for changes, inspiring new ideas and giving additional feedback.

Being very descriptive entities, their understanding and revision is easy. These scenarios allow to create a clear image on the system capabilities and at the same time help creating different alternatives and design suggestions.

> SBD starts with requirements analysis. It is the phase of software development in which the clients' needs of a project or technology are analyzed.

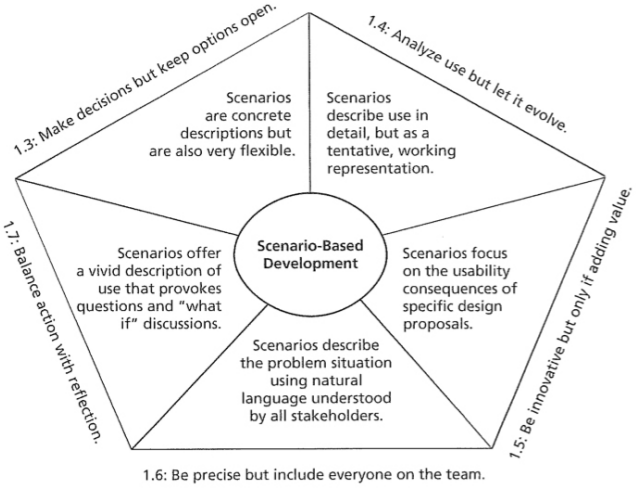


Figure 4.1: Tradeoffs
[RC02]

> It usually starts with a mission statement or orienting goals, then becomes more elaborate through studies and meetings with clients. Nonetheless it is practically impossible to specify all software requirements in advance. Only with already available options can the client understand his real needs. This is one of the causes why requirements analysis has to be seen as an ongoing process. Usability engineers must understand and analyze in detail the client, his work practice, his needs and participate in requirements to see if they can identify problems or opportunities that might be addressed by new technology [RC02].

Requirements analysis can be summarized as in Figure 4.2.

4.1.1 Root concept

First of all, a root concept should be developed with high-level goals that include a statement of project vision and rationale, an initial analysis of the project stakeholders and an acknowledgement of starting assumptions that guide the development process [RC02].

Usually, a vision statement comes from management, clients or marketing divisions, from open-ended discussions about new technologies, or as a solution to specific known problems. In this case the vision came as a bachelor proposal from the GlobIS Group's senior researchers at the ETH Zurich (please refer to Appendix A.1).

Hence the root concept at the beginning of the *Remote Sketching on Paper* project was developed and reported in Table 4.1.

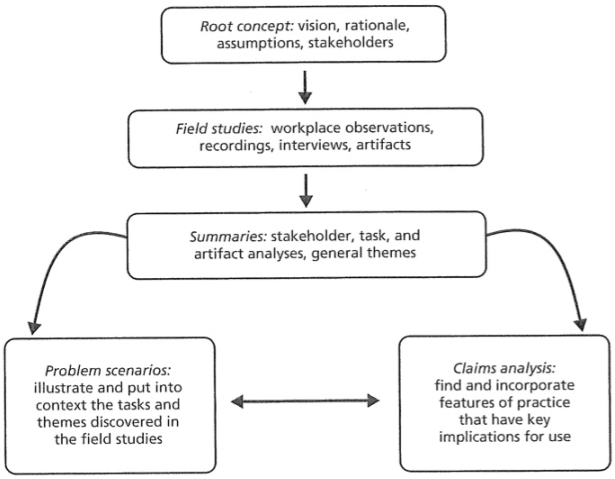


Figure 4.2: Scenario based analysis
[RC02]

Component	**Contribution to the root concept**
High-level vision	Sketching and handwriting on interactive paper over the Internet in parallel to voice or video communication in mobile, desk and meeting environment.
Basic rationale	Paper as a medium has many advantages over digital media in terms of how people can work with it, both individually and in groups. Paper supports forms of collaboration and interaction that are difficult to mimic in current digital world Enhancing of sketching through the use of interactive paper: straight sketch digitalization augmented with audio, video and history function. Synchronous communication involving different input channels like video or audio on one side and paper on the other.
Stakeholder group	
Design student at technical school	Tool that allows speaking and discussing different viewpoints about sketches with remote student colleagues and teachers.
Architecture student	Sketching on paper and sending digital version to professor or work assistant. Less loss of sketches on mobile environment
Professional architect	Sending, receiving, modifying sketches synchronously and asynchronously on mobile environment.
Software engineer	Cheap and handy tool for UML (Unified Modeling Language), diagram design and visual requirements specifications on standard paper. Version-control (Wiki) and archive feature.
Professor in architecture	Enhanced classes with remote collaborative sketching by teaching with audio and video recording.
Professional designer	Enhanced archiving/retrieving of sketches through automated digitalization working as usual with a pen and standard paper.
Starting assumptions	Will be built using the services and infrastructures of the iPaper famework of the GlobIS Group Will communicate with Skype and with Adobe Flex (Actionscript)

Table 4.1: Root concept of the Remote Sketching on Paper project

4.1.2 Field studies

As modeled by Rosson and Carroll, the root concept prepares then the scene for a field study of current practices, which describe the work in three different dimensions:

1. The activities of the workplace: What are the personal or organizational goals that individuals or groups pursue? What actions do they carry out to pursue these goals?
2. The artifacts of the workplace: What information is retrieved or created in the course of carrying out work activities? What tools (computer based or not) are used to create and work with this information?
3. The social context of the workplace: How are individuals and groups organized into larger structures? What roles are defined? How do people depend on each other in achieving their goals?

In the *Remote Sketching on Paper* project these three dimensions where analyzed through an online survey, published research [Ali03] and online video material (i.e. DESIGNsuisse, aired on September 23rd 2007 at 17:00 o' clock on the Swiss SF1 channel).

4.1.2.1 Online surveys

Online surveys, as information gathering tool, have become more and more popular, particularly because of the number of people using Internet, that during the last decade augmented exponentially (faster connections and lower prices for technology).

Definition

The term *Online Survey* encloses surveys, where participants [uS01]...

- ...can fill forms online that are saved on a server
- ...can download and send the forms later as email-attachments
- ...can receive the forms per email and resend them filled

Advantages

Online electronic surveys have the advantage, that they are much more flexible than classical questionnaires on displaying questions, because they can be presented with check boxes, pull down menus, popup menus, help screens, graphics. Online surveys are also cheaper to administer, because no additional paper or materials have to be purchased and postage costs can be avoided. There are also free online survey builders (i.e. `http://www.befrager.de` or `http://freeonlinesurveys.com/`) that can be used and where data/answers can automatically be stored. Since data is collected into a central database, the time for analysis is subsequently reduced and errors can be corrected

quickly without reprinting everything. In addition, statistical calculations are done automatically by the system. Attracting the appropriate target audience often requires advertisement. Through bulletin boards, forums and emails it is also quite easy to advertise them and to reach a wide range of possible participants quickly.

Disadvantages

The survey's response rate could be limited, if many of the targeted users have no Internet access and many people have no strong motivation on filling questionnaires online [ANP07].

Design

It is always important to determine the information that is wanted from the surveys. Every user should interpret the question easily and identically, even if the survey is in two different languages (i.e. the *Remote Sketching on Paper* online survey was in German and English). Consequently, false conclusions can be avoided. A short introduction should inform the subject what the main purpose of the questionnaire is and its completion should also not take too much time. Additionally, the number of questions should be communicated too and at the end a brief thank you should also be included. It is also very important, prior publication, to test the survey with more people to obtain feedback (clear enough, difficulties encountered, etc.). Trust between the survey's subjects and the researchers can be achieved by telling the participants that anonymity is guaranteed, that the survey can be interrupted at any time and that if there is interest, results and evaluations can be provided.

Contact letter

After determining specific target groups from different fields, institutions and countries, a contact letter was written in three different languages (English, Italian and German). Afterwards, universities' departments, professionals' associations, schools and online communities were contacted. The detailed contact list can be found in Appendix A.5, the contact letter in Appendix A.2 and the online survey in Appendix A.14.

4.1.2.2 The survey

The survey was published at the beginning of September 2007. On Monday, 8th October 2007 the data was then collected and analysed. 63 users completed the survey. The minimal proposal paper's requirements were 34 participants. The survey contained 20 questions (15 mandatory ones): 17 multiple choice questions and 3 open questions. The average completion time was approximately 10 minutes. The survey can be found in Appendix A.14 in English. A German version was published online as well. Microsoft Excel was used as analytical tool for a descriptive statistical analysis of the source data. The survey was structured in four distinct topics: personal information, computer

experience, collaborative work and *Remote Sketching on Paper*. A detailed evaluation can be found in Appendix A.4 and helped making following conclusions:

Personal information conclusions

From the information gained, it was possible to conclude that the questions could be understood quite well and that the presented technology could be imagined clearly.

Computer experience conclusions

It is clear that implementing *Remote Sketching on Paper* as a sort of plug-in for an instant messaging/phone application would totally make sense.

Collaborative work conclusions

Face-to-face, email, audio, communication, coordination of the parties/joint work, sketching, brainstorming are the core components of the (remote) collaborative work and Skype is the *must use* application for the *Remote Sketching on Paper* project (see Appendix A.4).

Remote Sketching on Paper approach conclusions

People showed high interest in the new technology/tool, even more after explaining everything in detail. They would also appreciate the mapping of many digital functions on paper. Almost everyone would use it for sketching, except some students. In addition, all professionals like professors, architects, designers, etc. would use it for sketching as well. Background communication software should be Skype. On the other side users showed high interest in its integration with digital imaging applications like Adobe Photoshop and office software like Microsoft Office or OpenOffice.

4.1.2.3 Published research

Researcher Dzmitry Aliakseyeu conducted detailed workplace observations, interviews and architects' working process analyses in his PhD thesis *A Computer Support Tool for the Early Stages of Architectural Design* [Ali03] . He carried out a brainstorm session with professional architects, an enquiry in the form of a questionnaire with practitioners and students from the architectural department, and observations and interviews in the architectural students workshop.

Brainstorm session

According to four involved practitioners by Aliakseyeu, the design process starts from making or reading the brief[1] . The brief is one way of communicating between architect and client; the other way is through presentation. When the architect comes out with

[1]The brief is a list of demands and wishes that the client has

the first conceptual idea of the design, he can present it to the user in order to evaluate it or to clarify some of the aspects of the brief, or to convince the user to change some points. For this presentation the architect can use different representational tools as text and words (to explain concepts), sketches (to show atmospheres and ideas), etc.

Enquiry

The most relevant results of the enquiry are detailed in Aliakseyeu PhD thesis and summarized here as follow:

- A sketching advantage is the mobility of the pen and paper
  - sketching can be performed in different environments such as office, home and outdoors [Ali03]
- Architects also often reuse ideas and materials from previous projects
  - easy material storage and management can be useful
- Transparent paper, text (writing) and images are important tools for designing
  - an image can inspire the architect; sometimes it displays materials or an atmosphere that the architect likes; it displays a certain composition of proportionsitemize
  - text is used as annotation, explanation or as keywords; sometimes it is used in schemes or in a description of the conceptual ideas
- Computer tools for sketching are used only by 30% of the practitioners and none of the students uses them (similar results were shown in the conducted online survey)

4.1.2.4 Online video material

The television show *DESIGNsuisse* aired on September 23rd 2007 at 17:00 o' clock on SF1 channel was also a source for understanding the importance of sketching during the design process of a professional designer, in this case of the Swiss designer Joerg Zintzmeyer:

> *I'm still sketching, yes. I think sketching is something really important. Sketches hold ideas that can quickly be understood by other co-workers. Sketches tell someone the basics quickly.*

Stakeholder	General group characteristics	
Students	Background:	Moderate experience with computing. Familiar with a wide range of applications (especially web, internet messaging/phone, games, office and image editing). Moderate experience with CAD applications and traditional tools. Less/no experience in collaborative work.
	Expectations:	Tool to improve collaborative sketching for exchanging ideas over the internet in mobile and desk environment in parallel to audio and video communication. Organizational/Archiving tool. Improve experience with classic tools as paper and pen.
	Preferences:	Most comfortable with notebooks and fancy applications' interfaces. Machines don't have to be very efficient. Have no problem to work with more applications at the same time.
Professionals	Background:	Very good experience with computing in their field, collaborative work and traditional tools as paper and pen. Good experience with web based, CAD and image editing applications.
	Expectations:	Tool to optimize workflow, collaboration and feedback on sketches allowing the use of traditional and digital supports in mobile environment (with audio communication). Importing sketches should be available and *merging changes* functions and revision control should be implemented too.
	Preferences:	Most comfortable with clean and simple interfaces, which incorporate the essentials functions. Very fast applications are preferred, and all needed functions should be integrated (prefer to work with one application at time). Tool has to work without interruptions when needed. Concerns about access rights and information display. Comfortable with desktop and mobile computers.
Software Engineers	Background:	Excellent experience with computing and collaborative work. Very familiar with programming platforms and with a really wide range of applications. Moderate experience with CAD and image editing applications. Good experience with classic tools as paper and pen (for prototyping).
	Expectations:	Improvement of visual specifications considering clients' needs and requirements in mobile and desk environment.
	Preferences:	Prefer fast and simple interfaces. Prefer to control application with keyboard shortcuts. Comfortable with desktop and mobile computers. Save function is a must.
Professors	Background:	Excellent experience with classic tools. Able to do the entire work without using technology. Very familiar with collaborative work. Experienced users with CAD applications. Less familiar with instant messaging applications.
	Expectations:	Tool to improve collaborative work, use of traditional supports and learning. Get more familiar with instant messaging and remote collaboration applications, which support audio and video communication. Should be easier to use than other tools as phone.
	Preferences:	Notebooks are preferred but also desktop computers are an option.
Designers	Background:	Extremely familiar with traditional tools, less experience with computing. Moderate experience with messaging, CAD and image editing applications.
	Expectations:	Tool to improve digitalizing/archiving/importing/searching of sketches.
	Preferences:	Comfortable with notebook computers. Tool should be attractive with fancy and easy to use interface.

Table 4.2: Stakeholder's profiles

4.1.3 Summaries

4.1.3.1 Stakeholder profiles

In observations each stakeholder group is organized into stakeholders profiles, which summarize the general characteristics of each group. These summaries are organized into background, expectations for the proposed system and preferences regarding information technology [RC02].

Considering the field studies, the stakeholder profiles in Table 4.2 were developed for the *Remote Sketching on Paper* project. These profiles are then used to create Personas [C+04] who will play the role of actors in the problem scenarios (see Subsubsection 4.1.3.4).

4.1.3.2 Tasks analysis

Another set of summaries is developed to document the tasks of each stakeholder group. For tasks that are particularly important in an activity, usually a hierarchical task analysis is being developed, where complex tasks are composed in subtasks [RC02].

In the *Remote Sketching on Paper* project three main complex tasks, that will be addressed in some way, could be recognized: sketching, collaborating, archiving. It makes also sense to analyze in detail how they are accomplished.

Each box in the task analysis diagrams represents a task step. Vertical lines indicate decomposition of a step into two or more subtasks; these are grouped together under the horizontal lines. Numbering indicates how a task is decomposed, and the plans show the logical ordering or dependencies among subtasks [RC02].

Hierarchical task analysis for Sketching

As shown in Figure 4.3 sketching can be decomposed in three different activities: determine design stage, define concepts and basic ideas and select the artifact. If necessary, these can be done in iteration. The design stage can be determined by extrapolating the main elements from the brief, assignment or client requests, and then by discussing them, or if sketches already exist and new changes requests are available, the main elements should be extrapolated. Once the design stage is defined, the artifact for sketching can be selected. The next step is to choose between working in the physical or in the digital world. If the choice falls for physical world, the paper size, paper material, pen type and color are selected, in the case of digital sketching, the input device choice falls between mouse and tablet.

Hierarchical task analysis for Collaboration

According to the field studies, collaborative work can be decomposed in four different actions as shown in Figure 4.4: task determination, participants' choice, meeting organization and summing up of the discussion results. The task is determined and participants in the collaborative work can be chosen as soon as the main discussion

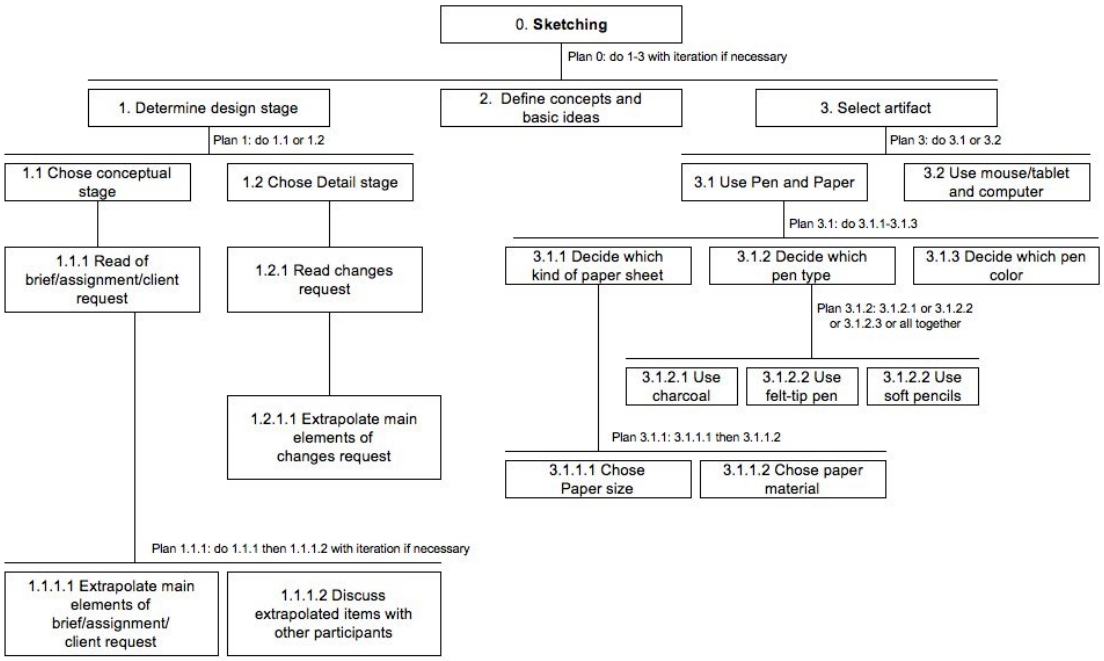


Figure 4.3: Hierarchical task analysis for Sketching

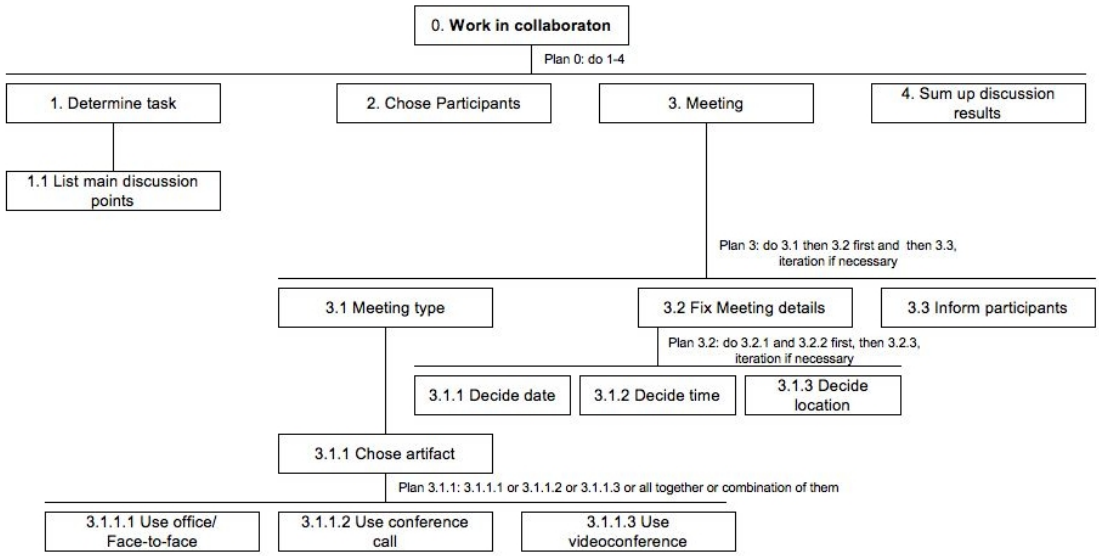


Figure 4.4: Hierarchical task analysis for Collaboration

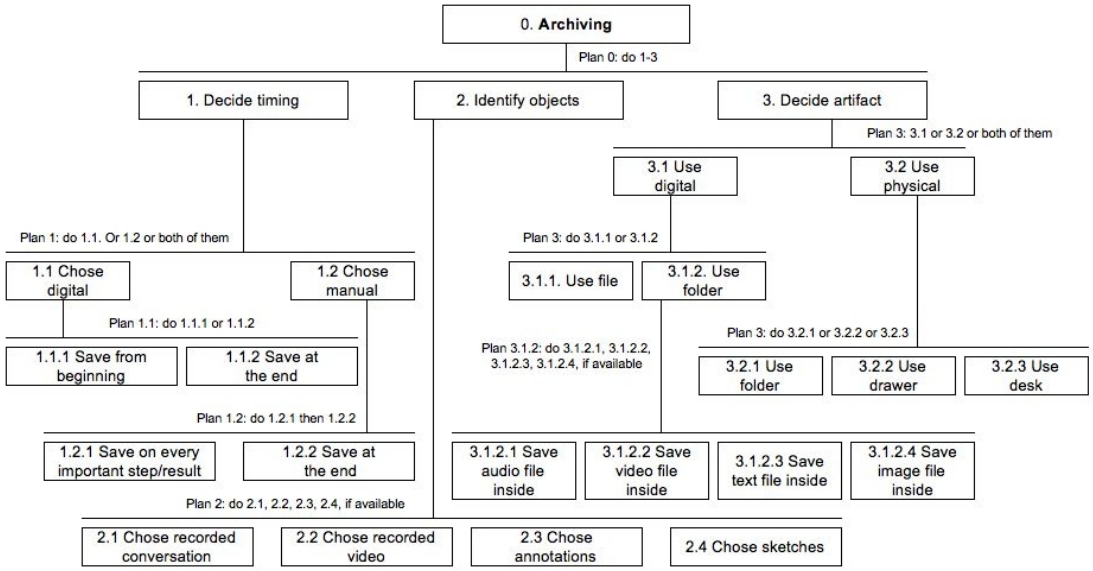


Figure 4.5: Hierarchical task analysis for Archiving

points have been listed. The next step is to organize the meeting, where the collaboration process should occur. There are different types of artifacts that can be chosen from to define the meeting type: office for face-to-face meetings, conference call over phone, Internet or videoconference. Date, time and location should also be fixed to organize and to book participants' time. These decisions are of an iterative kind, because it usually takes a while until everybody is able to attend the same meeting. Once its details have been fixed, everybody is then ready to be informed. A lot of information and results are created in the moment that all participants are coordinated and the discussion/collaboration starts. This data should then be stored or summed up in some ways for further evaluations.

Hierarchical task analysis for Archiving

As Figure 4.5 shows and according to the field studies, users who sketch, often reuse ideas and materials from previous projects. Consequently, archiving of the work is an important task. It can be saved digitally or manually. When the user decides to save the work manually, he can choose between:

- Saving after every important step or result or...
- ...whenever he wants or...
- ...when the work is done

In the case he decides to use the automatic/digital saving function, the system saves automatically everything from the beginning and at the end.

Thereafter, the object or result to archive should be identified. Once they are assessed it should be chosen on what kind of medium they would be archived:

- Digital medium
- Physical medium
- Physical and digital at the same time

If the medium is digital, everything can be saved in a file or in a folder – this usually contains a file for every single object. In case it is a physical medium the choice falls on office artifacts (i.e. drawers, folders, desks, etc.).

4.1.3.3 Artifact analysis

Workplace artifacts can be of different type, for example: briefs, phones, desks, photographs, address books, books, digital cameras, white- and blackboards, scanners, envelopes, files, folders, pens, (colored) pencils, (colored) paper sheets, reports, video (tapes), recordings, rulers, transparent paper, tablets, printers, projectors, lights, scissors, software (email clients, instant messaging software as Skype, CAD, image editing, etc.), knives, (colored) cartons, drawers with different objects to get ideas from (for example the IDEO company[2]), etc.

4.1.3.4 Personas

A persona is a user archetype that can be used to help guide decisions. They easily allow understanding, who the users are and which are their goals and requirements. These users are not real persons, but they represent them through the entire development process [C+04].

The stakeholder profiles created before and the statistical evaluation of the users who participated at the online survey will be used now to describe and develop these Personas. For the *Remote Sketching on Paper* project seven Personas were created. Two of them are presented in this Section and will be then used as a *supporting tool* for the application's implementation of the GUI and its functions. The other four Personas and the Non-Persona (for whom the tool/system should not be designed) can be found in Appendix A.7.

Mika

- Age: 21
- Gender: Female
- Education: High school – studying design at technical school
- Marital status: Not married

[2] `http://www.ideo.com/`

Figure 4.6: Picture of Mika (`http://www.imagevortex.com/`)

- Nationality: French-Japanese
- Wealth: Above average, daughter of a rich Japanese entrepreneur

Mika is a very open minded, creative person who loves arts. After high school she decided to become a famous designer. She likes to combine new and old technologies, because she is half Japanese and half French. The French part is excited by the new tools (such as computer technology) and the Japanese part is more artistic and human: she has a passion for traditional Japanese antiquities.

Mika is a design exchange student at the Hochschule Konstanz Technik, Wirtschaft und Gestaltung, Germany (technical, business and design school). Her family, friends, colleagues and teachers from her home live all in Osaka, Japan.

To stay updated with all new trends in Japan, to feel close to the family, best friends, to exchange ideas and educational information about the exchange semester, she makes intense use of Internet, email and instant messaging applications. She is very committed to her studies and work and she never misses a lesson. During the evening she spends some time chatting over the web with her Japanese friends, hangs out for a drink, to dance or to visit plays at theaters with her new German friends. On Saturday mornings she usually goes to the antiquities market to find new ideas or to buy new *old* furniture for her room in Konstanz.

Mika would like software that allows her to speak and discuss with the Japanese colleagues and teachers all the different viewpoints about her sketches, because she wants to keep this mix of cultures even in her design proposals.

Claudio

- Age: 28
- Gender: Male
- Education: Master degree in Computer Science
- Marital status: Not married, in a relationship

Figure 4.7: Picture of Claudio (`http://www.imagevortex.com/`)

- Nationality: Italian
- Wealth: Low budget

Claudio is not married but has a girlfriend who lives abroad; they met when he was doing his exchange semester in USA.

After graduating in computer science at the ETH Zurich he has been working as a software engineer in a small company in Switzerland. He is in charge of the visual requirements and the software specifications of the projects and has to deliver UML diagrams for all kind of projects. Because of this, he is often in clients' meetings together with his boss.

Claudio is quite a team player, discussing every detail with clients and with working colleagues to try delivering the right product. At his company, workers are accustomed to develop very modular software components to be extremely flexible, to allow quick changes and to have a clean source code. UML models are thus a high priority in this kind of software development process. Visiting clients frequently, being in charge of the visual requirements and developing the software with a modular approach he needs a mobile technology that delivers him tools for presentations, sketching of UML models, version archiving, sending of the jobs that have been done and last but not least letting him make conference calls and sketches with software engineers and GUI (Graphical User Interface) developers (the best would be to be able to remote sketch all together: clients, developers and himself) at his office. Because the company he works for is quite a small one and has low budgets, this technology shouldn't be too expensive.

4.1.4 Problem scenarios

A problem scenario tells a story of current practice. These stories are carefully developed to reveal aspects of the stakeholders and their activities that have implications for design. Other members of the project team should be able to read the problem scenarios and appreciate the work-related issues that the field study has uncovered. It is called *problem scenarios* not because they emphasize problematic aspects of current practices, but rather because they describe activities in the problem domain [RC02]. Two problem

scenarios involving the described Personas will be presented now. Four other ones can be found in Appendix A.10.

Mika asks some feedback about her sketches from her professor in Osaka, Japan

Mika sketches a lamp with modern and Japanese characteristics on her laptop, with her tablet board and the adequate software. As soon as she is finished, she would like to discuss it with her professor and to show it to her classmates in Osaka. She has saved the file as an image.

To save money she turns Skype on to start a conference call. Once everybody is connected she sends the file with the built-in Skype function. As soon as they get it, Mika explains how she did the design and what she has learnt. The professor and the other students ask her many questions and then he gives her feedback.

Mika has a text editing application and a sketching application running on the background to make notes and to quickly make changes on the digital sketch. She changes between the three applications with the *ALT-Tab* keys combination.

After the discussion and the explanation round, knowing that they may be interested in what she has been doing and what she has learnt at the German school, Mika looks on her computer for more saved sketches and sends them as separate files to the audience. A new discussion round starts.

It is getting late now and Mika has to meet with some friends for a pick-nick at the sea. She thanks and says goodbye to everybody who is connected, saves all opened files in the different applications and then she closes the Skype connection, her notebook and gets ready to go out.

Claudio modeling UML diagrams for the new software module

Claudio is on a client's meeting with his boss and project leader today to discuss the visual requirements for a new application. During the meeting there is also a conference call going on to receive live information on the visual requirements with the GUI developers from Claudio's department. The visitors and their clients make paper prototypes/design proposals on paper for the interface during the discussion and an employee writes down the report. At the end of the meeting there are a lot of papers and big whiteboards sheets filled with graphics and annotations. Before leaving, Claudio takes all these artifacts and folds them in a folder.

After a couple of weeks and after the visual requirements have been specified, Claudio and the other software engineers build simple diagrams and UML models with specific software for the modular application they are going to develop. When specific models for a discussion or meeting are needed, they just start the software, open the equivalent file and print it out.

Every night a back up of all projects is executed automatically by the system. To save space, the company usually physically archives only paper sketches. Emails, UML models, diagrams and all digital work is archived on computer machines.

Claudio is used to work long hours and to go back home very late. He spends most of his time – when not in a meeting – at his desk in front of his computer. For this reasons he uses Skype frequently to communicate with his girlfriend in the United States. This allows him to keep in touch more often with her. During visual requirements sketching or UML models designing, Claudio keeps the Skype windows minimized; in case he wants to call her, he switches between the applications with the *ALT-Tab*-keyboard combination.

4.1.5 Claims analysis

Claims analysis identifies features of a situation that have important effects on the actors. Each of these features are written down with its hypothesized positive and negative effects [RC02].

Based on the the problem scenarios, the field studies, task-, stakeholder- and artifact-summaries, claims analysis were elaborated in Tables 4.3 and 4.4.

4.2 Design

Abstract users and task models, resulting from the requirements anaylsis, are presented in this chapter and, based on these models, first design drafts of the user interface and system components are shown. Therefore user role models, an user role map, essential use cases, a use case map, a content model and an operational model are delineated. This chapter is based on the book *Software for use: a practical guide to the models and methods of usage-centered design* by Larry L. Constantine and Lucy A. D. Lockwood [CL99].

4.2.1 User role models

The relationship between the users and systems is represented as roles that are usually constructed by asking these questions [CL99]:

- Who would or could use the system?
- What is the general class or group to which they belong?
- What distinguishes how they would or could use the system?
- What characterizes their relationship to the software?
- What do they typically need from the software?
- How do they behave in relation to the software, and how do they expect the software to behave?

Consequently, these user role models for the *Remote Sketching on Paper* project were constructed:

Situation feature	Possible Pros	Possible Cons
Use of different applications	Increases familiarity with different software Increases digitalization Increases electronic exchange	Many applications opened at the same time – users can get confused or loose their concentration Users have to get familiar with more software During electronic file exchange, recipient needs to have specific applications to open the received files
Asynchronous collaborative working	User can concentrate more on individual work without being interrupted Deeper evaluations at any time	No real-time feedback from other collaborators Less integration of new ideas, proposal Supervisor cannot watch the collaboration process between different parties Decisions take longer
Paper archiving	Reliability of physical artifacts Everybody know how to handle/archive paper in folders Portability Easier to compare work Always available and usable	Reliability of physical artifacts (fire, water, theft, etc.) Real-time digitalization not possible Easier to loose More difficult to find
Phone discussions	Beside a phone no additional hardware needed Easy to use More chance to get in contact with collaborator Portability Synchronous exchange of thoughts	Waiting time during search for saved work Call costs Not so handy to save conversation Not so handy to organize saved conversations
Traditional applications	No more learning needed Almost every function is implemented for the particular purpose	For full collaboration many of them needs to be used simultaneously
No fully collaborative classes	Teacher can focus more on his students and can explain stuff more easily Students can clarify their role more precisely among the group Less organizational issues by deciding at beginning who does what	Less real-time collaboration Slow results Less direct professor interactions during design; precise evaluation can be conducted only at the end of the assignment Process-report could be not precise, something could be missing. Professor may not be able to correct wrong actions Brainstorming less efficient
Email	Fast exchange of files through well-known tool Recipient can sometimes receive the data even on his mobile phone Asynchronicity (people may prefer to respond asynchronous)	Asynchronisity (feedback cannot be always instantly) Some people don't check their email inbox often or are not able to receive emails on the mobile phone Could be marked as spam
Face-to-face	Direct personal relations Emotions can be perceived quickly Non-verbal cues Gestures can be watched through the environment and the collaboration process	Because of interpersonal behavior rules some aspects could not come out

Table 4.3: Claims analysis

Situation feature	Possible Pros	Possible Cons
Digital UML and diagram modeling	Precision Direct integration in source code (semantic interpretation) Documentation development faster Major changes in the model structure can happen more quickly	Portability Need specific UML application Collaboration on UML model during meeting not possible
Handwritten text as annotation	Very fast, easy and intuitive process Can be placed everywhere Emotions can be visible in the handwritten text	Sometimes it is difficult to read Uncomfortable to send it digitally Cannot be reused or reintegrated properly
Working in digital world	Everything is digitalized in real-time Extremely wide choice of tools for sketching without carrying them around Choice of colors Instant editing History functions Less space for backups Sending data is quicker and a lot easier Very precise sketching and filling (i.e. Fill and Zoom functions) Digital and physical version (after printing) available Automated back ups Sketch can be augmented/linked with sound, video and other file formats (save everything in a system folder)	Less familiarity with traditional tools Less aesthetical feelings than with sketches made on paper (i.e. pencil pressure). Computer-generated looks often the same. With natural sketches on paper artist utilize his free expression/emotions that in computer systems are not implemented [SS97] No guarantee that it will always work No 100% guarantee that backups will be really safe Platform/system dependency
Working in physical world	Natural and intuitive actions can be accomplished Touchable results Actions/tasks can be performed in different environments Real objects can be manipulated and analyzed in real environment Compare two sketches in real world (with real colors, real ambient light, etc.) Physical archive management Transmission (i.e. sending per standard mail) delivers a physical and an identical copy for the recipient	Automated actions not available Search of work and artifacts more difficult Artifacts (like pencils, paper, etc.) need space Artifacts (like pencils, paper, etc.) get used up and need to be replaced by new ones Transportation in physical world takes longer
Digital transparent layer	No space needed Unlimited layering Selection of layers to hide is very easy Lights and other effects can be applied as layers	Computer and software are needed Layers can complicate the sketch
Real lights and drawers with objects	Touching and feeling of the objects in the real ambient /environment Object behavior can be studied/seen	Limited space Limited quantity

Table 4.4: Claims analysis (continued)

DesignStudent

Moderate use especially in desk environment; instant messaging functions (audio and video) for collaborative work and discussions; easy to learn and to use; support for sketching with a pen; save and send function. Standard export formats (i.e. JPG). Basic drawing (line, rectangle, circle, color palette) functions for sketching. Digital interface should be fancy/attractive. Primary goal: sketch new designs. Import of pictures.

ProfessionalDesigner

Frequent use; rapid, easy operation, collaborative sketching (audio, video), send, version-number (archive), search function. Annotations, image import, color palette, drawing tools. Strong pen and paper support for sketching. Export function in different formats (JPG, PDF, PNG, BMB, etc.). Print function. Primary goal: sketch for work and reuse and modification of sketches. Working also without digital support. Skype control.

ArchitectureStudent

Moderate use in desk and mobile environment. Strong support for collaborative working: multiple sketchpads with multiple users working at the same time. Easy to learn and to use. Primary goal, sketching for university assignments. Standard drawing tools. Fancy interface.

ProfessionalArchitect

Frequent use in mobile and desk environment. Recording function for audio, video and sketching. Importing of sketches with implemented *merging changes* function. Strong version management function. Send, export functions in different formats. Must be reliable, fast and efficient. Simple interface incorporating essential sketching functions. Access management. Search function. Primary goal: professional sketches in remote and non-remote collaborative environments. Workflow management functions (manager and user selection). Annotation support. Fast and simple interface.

SoftwareEngineer

Frequent use in mobile and desk environment. Fast and simple interface (control with keyboard shortcuts). Diagrams drawing and text input support. Skype control. Main goal: visual specification and sketching of UML models.

ArchitectureProfessor

Moderate use in desk and mobile environment. Watching function of connected designer. Video, audio support and recording of single elements. Easy to use, especially the instant messaging functions. Skype control. Multiple user support. Main goal: coordination, analysis and recording of multiple users during sketching.

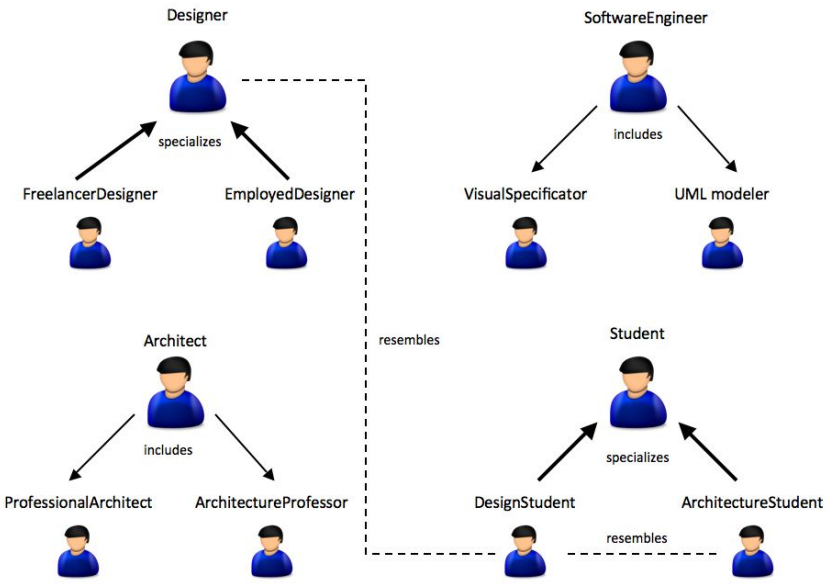


Figure 4.8: User map

4.2.2 User role map

The user role map (Figure 4.8) captures the *big picture*; it shows the roles fitting together in defining who will use the system and how. It is referred to a map because it represents the interrelationships among all the roles that users can play in relationship to a given system. Within a user role map, roles can be interrelated in several different ways: by affinity, by classification, or by composition [CL99].

4.2.2.1 Affinity

Affinity is used to refer to a recognized similarity or resemblance of an unspecified nature. User roles may be similar in style of interaction, in expectations, or in terms of any of a variety of common characteristics [CL99].

4.2.2.2 Classification

In some instances, a user role is a subtype of another, more general role, and represents a more specialized version of that role. Users in this role will have many functions in common; they are likely to have different levels of experience and skills using the system and show different patterns of usage [CL99].

4.2.2.3 Composition

Some roles combine the characteristics or features of two or more other roles and are, in a sense, composed out of these other roles [CL99].

According to the user modelling, the map in figure 4.8 has been created for the *Remote Sketching on Paper*.

4.2.3 Essential use cases

An essential case is a structured narrative, expressed in the language of the application domain and of users, comprising a simplified, generalized, abstract, technology-free and implementation-independent description of one task or interaction that is complete, meaningful, and well-defined from the point of view of users in some role or roles in relation to a system and that embodies the purpose or intentions underlying the interaction. Essential use cases are composed of three components: a statement of the overall user purpose or intention expressed within the use case plus a two-part narrative comprising the user intention model and the system responsibility model [CL99].

The essential use cases for the *Remote Sketching on Paper* project are presented in the following tables:

User intention	**System responsability**
Open Skype	
	Verification of identity
Identify self	
	Show contact list
Chose collaborator	
	Connect users
Use pen	
	Send data via Bluetooth
Sketch on paper	
	Show sketch on screen

Table 4.5: StartSketching essential use case

User intention	**System responsability**
Save video, audio and sketch of current session	
	Allow saving of everything at the same time
Start recording	
	Record
Stop recording	
	Session recording confirmation

Table 4.6: StartRecording essential use case

User intention	System responsability
Use send function	
	Prepare image/sketch
	Give format and method options
Choose method	
	Process selected method by the user
	Show recipients' list
Chose recipient	
Confirm sending	
	Send the sketch
	Send confirmation

Table 4.7: SendSketch essential use case

User intention	System responsability
Switch to Skype	
	Show Skype Logo
Select Skype logo	
	Switch to Skype interface

Table 4.8: UseSkype essential use case

User intention	System responsability
Use insert function	
	Give image files list
	Show browse option
Select file	
Confirm selection	
	Insert selected file on screen

Table 4.9: ImportPicture essential use case

User intention	System responsability
Create new sketch	
Finish sketch	
	Give automatic and manual archive option
Select option	
	Confirm storage

Table 4.10: Archive essential use case

User intention	System responsability
Use export function	
	Offer different format options
Select format	
	Give space for name
Enter name and confirm	
	Confirm export

Table 4.11: Export essential use case

User intention	System responsability
Annotate sketch	
Use pen for annotation	
	Recognize handwritten text by pen on paper
	Show annotation as digital text on screen

Table 4.12: Annotate essential use case

User intention	System responsability
Use find function	
	Show button or field for search
Insert keyword to search	
	Show image browser Adapt browser with keyword
Select picture	

Table 4.13: SearchPicture essential use case

User intention	System responsability
Close application	
	Show close/stop function
Select function	
	Ask for saving
Chose Yes or No	
	Close application

Table 4.14: StopApplication essential use case

User intention	System responsability
User want to sketch alone and block others	
	Show Manager function
User select Manager function	
	Block other users

Table 4.15: ManageWorkflow essential use case

User intention	System responsability
Use print function	
	Show print function
Select print function	
	Connect sketchpad with printer
Take the print-out	

Table 4.16: PrintSketch essential use case

User intention	System responsability
Load Sketch (screen and paper)	
	Insert image/paper (screen/paper)
Sketch over paper	
	Show new drawings on screen

Table 4.17: ModifySketch essential use case

User intention	System responsability
Find Sketch	
	Show search field
Insert keyword	
	Show image browser Adapt browser with keyword
Select picture	

Table 4.18: SearchSketch essential use case

User intention	System responsability
Use PDF function	
	Create PDF of sketch
Send function	
	Connect to email client
	Attach file
Insert recipient name	
Confirm sending	
	Send email

Table 4.19: SendPDF essential use case

User intention	System responsability
Select line tool on screen/paper	
	Activate line drawing function
Sketch on paper	
	Show line on screen

Table 4.20: DrawLine essential use case

User intention	System responsability
Select circle tool on screen/paper	
	Activate circle drawing function
Sketch on paper	
	Show circle on screen

Table 4.21: DrawCircle essential use case

User intention	System responsability
Select open function	
	Show browser
Select file	
	Open file

Table 4.22: OpenFile essential use case

User intention	System responsability
Select open function	
	Show browser
Select recorded file	
Press play	
	Play file

Table 4.23: PlaySketchingSession essential use case

User intention	System responsability
Click Undo button (paper or screen)	
	Remembers last drawing by user
	Deletes last drawing by user

Table 4.24: UndoDrawing essential use case

User intention	System responsability
Browse all files	
	Offer Browse Window
	Show files as images
Move between files	
	Flips the files

Table 4.25: Browse essential use case

User intention	System responsability
Click Redo button (paper or screen)	
	Remembers last drawing by user
	Repeats last drawing by user

Table 4.26: RedoDrawing essential use case

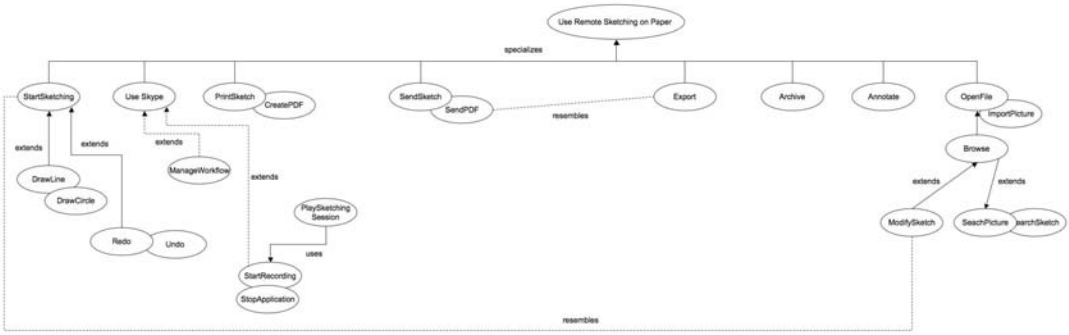


Figure 4.9: Use case map for the Remote Sketching on Paper project

4.2.4 Use case map

The use case map (Figure 4.9) partitions the total functionality of the system into a collection of interrelated essential use cases. By separating out distinct and meaningful interactions and showing how they are related, it is possible to construct a simpler overall model of the supported work and the capability the system should supply. They can be interrelated by classification, extension, and composition or by affinity. These relationships allow separating out common elements of the supported work resulting in a simpler task model [CL99].

4.2.5 Content model

Constantine and Lockwood describe the content model as follows:

> This model deals with the basic presentation of the user interface. Where, how and what tools will the user need to perform a particular task.

4.2.5.1 The content model for the Remote Sketching on Paper project

VirtualSketchpad

Placed in the center of the application – Sketching is the main function and has to possess main focus. As well as on paper as on application interface.

SketchpadSwitch

Related to sketchpad and modifying state of the sketchpad, placed both in proximity.

SearchField

Upper right: Most commonplace. Dropdown with listing of results.

ToolPicking

Considering the most picked up functions during sketching (Line Drawing, Diagrams,...), placement on paper should be on the right side, because only 7-10% people are left handed[3]. To preserve mapping between physical and digital world, placement on the right side of the application interface too.

HandwrittenInput

Virtual Sketchpad on digital interface. Paper interface: handwritten recognition has specific input field.

SkypeFunctions

Placed on left and right side of paper (StartCall, StartVideo, Private, Public, StopCall, StopVideo, etc.). On upper left side of the paper and left lower part of digital interface: used just a few times during sketching session.

RecordingFunctions

Placed near the Skype functions (similar interaction tools).

Save

Left side of sketchpad. No dialogue interface if already opened file. If new file, same dialogue interface as *Save As*.

Save As

Left side of sketchpad. Transparent dialog interface over sketchpad, with *Ok*, *Cancel* and textfield for filename input.

Export

Left side of sketchpad. Transparent dialog interface over sketchpad, with icons of exporting formats, then same interface as *Save As*.

Open

Left side of sketchpad. Digital: Transparent dialog interface over sketchpad, with *All* or *Sketch image*, *Recording* icons, then file browser with corresponding formats and *Ok* and *Cancel* buttons. On paper: new paper sheet and touch of pen on paper (for sketches only).

[3] http://en.wikipedia.org/wiki/Left-handed

Archive

Attached to sketchpad/left – (paper and digital): System automatically saves with automatic file name, date and time without showing dialogue interface.

Print

Attached to sketchpad. Dialogue appears with print options.

Insert

Left side of sketchpad. Transparent dialog interface over sketchpad, with *All* or *Sketch*, *Image*, icons, then file browser with corresponding formats and *Ok* and *Cancel* buttons.

NewSketch

Paper: take new paper sheet and click on it with pen.

Send

On the left side. Transparent dialog window appears over sketchpad asking what kind of format (JPG, PDF, etc.) is prefered, recipient.

WorkflowManagement

Near tool functions, easy to pick up to quickly block sketching of other collaborators.

StartApplication

Icon on paper together with SkypeStart functions (see above).

EndApplication

Upper right side, near end call. Because of similarity. Digital: upper right side.

DialogWindows

Transparent appearance on application interface, transparent overlay over sketchpad (white), to have context of the sketch always visible before making any choice.

ContactList

Placeholder showing Skype contacts.

Browsing

Appears as dialog window. Cover Flow style.

Undo and RedoFunction

Attached to sketchpad, because undo and redo referred to sketching actions taking place on (virtual) sketchpad

Dialogue window appears every time to confirm interactions, i.e. as *Sketch Saved*, *Line tool selected*, *Archiving*, etc., as a form of visual feedback and in combination of audio.

4.2.6 Operational model

> Systems need to be fitted not only to the work that they support but also to the context in which that work takes place. Systems that are deployed and used in different environments or different settings may require different solutions to user interface design problems [CL99].

As seen in the requirements analysis of the *Remote Sketching on Paper* project, the system will be used in different contexts, environments and settings. It is composed of two different interfaces: one is the paper interface, which is used to sketch and the other one is the software interface that is used to communicate and to watch the digitalized sketch. The system can also be used in a closed (like an office) and in a mobile (i.e. on the plane) environment.

As stated in the stakeholder analysis of the requirements analysis, speed of operation and accuracy play a different role under different users. For example students have moderate experience with computers and software and don't need machines or systems to be too efficient. On the other side, professionals, who do their job with such a system, need efficiency, speed of operation, etc. Users that have less experience (like students) and users who have less time (i.e. professionals) need also a system that is easy to learn and use. Students, that have to use such a system to do assignments, should also be stimulated by using it. They may like the system if it has a fancy user interface.

4.2.7 Incumbent profile

> Deep knowledge about the application and the system usually implies familiarity with vocabulary and concepts that can ease learning and use, but such familiarity can also carry expectations about how information and capability will be presented. If such expectations are not met by the design, usability will be reduced for some users. Very young or elderly users may need special accommodation: enlarged visual targets and large, highly readable fonts may be appropriate for these populations as well as for the visual impaired. Age, educational level, and cultural background are obvious factors influencing the designer's choice of appropriate vocabulary and usage within the user interface [CL99].

The *Remote Sketching on Paper* project doesn't have too young or too old people who will interact with the system, so special accommodation like enlarged visual targets and large, highly readable fonts aren't needed. Further considerations shouldn't

be a matter for the designer's choice of the appropriate vocabulary and usage within the user interface. Everybody had already some kind of computer and remote collaboration/communication experience and is familiar with the act of sketching on paper. Computer drawing software has also been already used by most of the users.

4.2.8 Interaction profile

According to Constantine and Lockwood, the interaction profile includes information regarding how users can be expected to interact with the system being designed. Following aspects of the interaction profile can have a substantial influence on user interface design [CL99]:

- Frequency of use
- Regularity or periodicity of use
- Continuity (continuous versus intermittent use)
- Intensity (rate of interaction) and volume (total amount of interaction)
- Concentration (batches or distributed use)
- Complexity of interaction
- Predictability of interaction
- Locus of control

Taking in consideration that the *Remote Sketching on Paper* system will be used frequently, as stated on the online survey and as described in the stakeholder analysis, its user interface should be designed to minimize user errors or to reduce the consequences of errors. Being used by professionals, the system should also be accurate and not so complicated in its usage.

> In case the user doesn't look all the time on the screen, the user interface in such context cannot rely solely or primarily on visual feedback or error or warning messages. In these cases, sound might be much more effective [CL99].

The system is used in synchronization with a papersheet, where users are sketching. Most of the time they'll have their focus on the paper and will look on the screen to see if the connected user makes comments or adds some drawings. Their main task is sketching and it is performed on the paper. The user interface should provide big popup windows with visual feedback (text, graphical), enhanced with audio feedback, that can be perceived by the user even if he is looking at the paper. For example, if he selects a tool on the paper, audio feedback should be played and a popup should appear/blink/blend shortly on the computer screen.

4.2.8.1 Environment profile

> Many aspects of the actual physical working environment within which systems are used may need to be taken into account for effective user interface design. These include the level of ambient noise, the lightning conditions, and environmental factors. This information is captured in the environment profile. Outdoor settings can impose design constraints that are dramatically different from those in a conventional office [CL99].

The *Remote Sketching on Paper* system will be used in a mobile (i.e. at the university cafe, train, etc.) and a desk environment (i.e. office). The user interface will then be dealing with different levels of ambient noise (i.e. cafeteria) and lightning conditions (less clearness when outside of the office, sun could blend the computer screen). Audio feedback is of high importance for the environment profile too and a dark background with very bright text could be helpful in case of a strong light source pointing at the screen. Working in collaboration, users could also be distracted pretty easily (by other remote and non-remote collaborators); the user interface should help returning to tasks or show what it has been done so far. This could be accomplished through highlighting of the used/selected functions.

As preferred by professionals to increase the speed of operation, the user interface interaction should also be allowed with keyboard shortcuts [CL99], therefore they should also be implementd in the *Remote Sketching on Paper* application.

4.3 Design prototypes

In this section, the resulting prototypes will be presented. Their development is defined through users, functions and active components requirements.

4.3.1 Users

The *Remote Sketching on Paper* project doesn't have too young or too old people who will interact with the system, so special accommodation like enlarged visual targets and large, highly readable fonts aren't needed.

Taking in consideration that the *Remote Sketching on Paper* system will be used frequently, as stated on the online survey and as described in the stakeholder analysis, its user interface should be designed to minimize user errors or to reduce the consequences of errors. Being used by professionals, the system should also be accurate and not so complicated in its usage.

Furthermore, Section 4.2.1 clearly presents users' needs and expectations from the application to achieve their goals.

4.3.2 Functions

Every interactive paper page has its own document identification (ID): to create a new page in the application, it would be sufficient to point the pen over a new interactive

paper sheet. To open an existing sketch, the action would be the same. To change colors and style of the sketch it would be enough to use a pen (also with unique IDs) with a different color or a thicker/thinner style. These kind of actions would maintain the nature, simplicity and spontaneity of sketching, even if the user is digitalizing his work and collaborating together with other people over the Internet. The disadvantage of making sketches on paper is that it is hard to modify them as the design evolves. Most of the time, sketches must be redrawn on a new paper sheet. These hurdles can be be solved by sketching on translucent paper with a pre-printed Anoto pattern (more information about this technology has been described in Chapter 3, Section 3.3).

For the *Remote Sketching on Paper* project there are two different interfaces to develop: one is the paper interface, which is used to sketch and the other is the software interface, which is used to communicate and to watch the digitalized sketch. The system can also be used in a closed environment (like an office) and in a mobile one (i.e. on the plane).

A detailed decription of the system's core functions have been presented in Section 4.2, Subsection 4.2.5 of this Chapter.

As stated in Subsection 4.2.8, the user interface should provide big popup windows with visual feedback (text, graphical), enhanced with audio feedback that can be perceived by the user even if he is looking at the paper. For example, if he selects a tool on the paper, audio feedback should be played and a popup should appear/blink/blend shortly on the computer screen.

Furthermore, as described in the Environment Profile (Section 4.2.8.1), audio feedback has high relevance and a dark background with very bright text could be helpful in case of a strong light source pointing at the screen. Working in collaboration, users could also be distracted pretty easily (by other remote and non-remote collaborators); the user interface should help returning to tasks or show what it has been done so far. This could be accomplished through highlighting of the used/selected functions and drawing modes.

The results of the design analysis are two interactive paper prototypes...

1. A3 page with active components (application functions) and a placeholder for an A4 page for sketching covered with the Anoto pattern

2. A4 page as sketch area

... and different sketches for the graphical user interface of the software application that connects the *iPaper* framework with the Skype functions (Appendix A.9).

4.3.3 First paper prototype

The first paper prototype (Figure 4.10) didn't represent the easy-to-learn, efficient-to-use and safe-to-use usability goals (see Figure 4.11). The prototype had too many sketching and application control functions, which could confuse the user, slow down and make unnatural the design process. For example, the color palette could be left away by using different color pens. If the user would have picked up a color from this

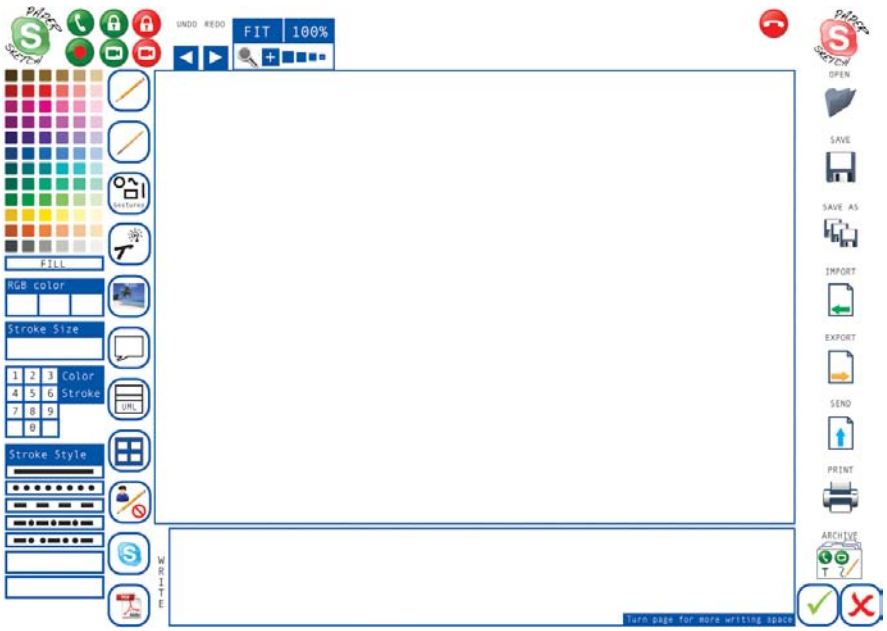


Figure 4.10: The first paper prototype

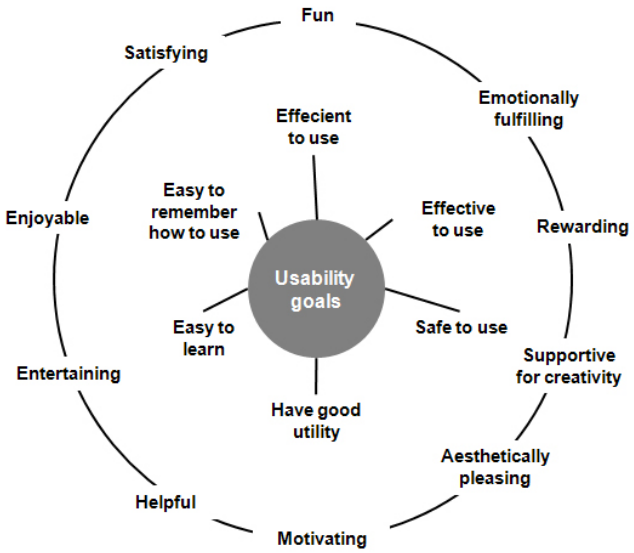


Figure 4.11: Usability Goals [JRS02]

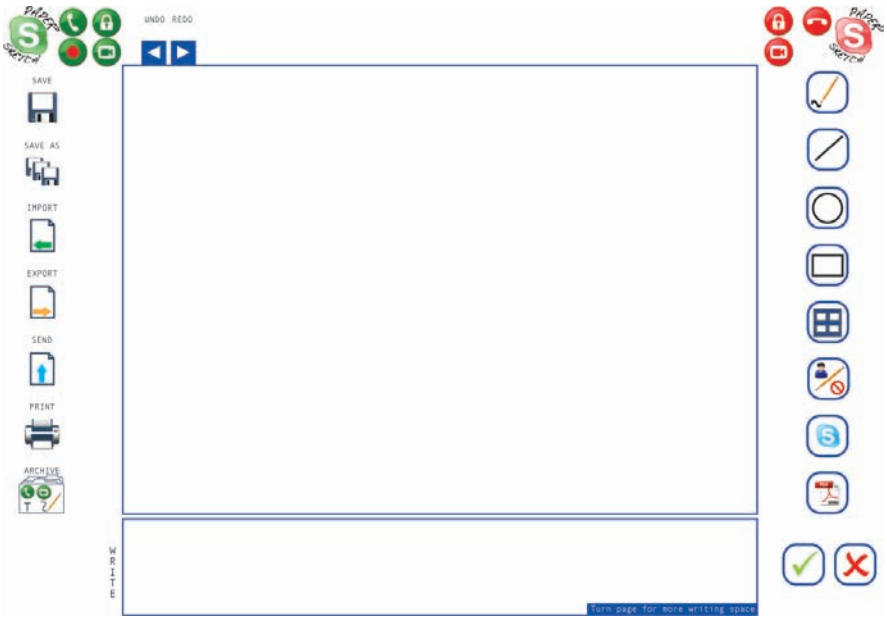


Figure 4.12: The final paper prototype

palette or define it by inserting the RGB numbers[4], he couldn't receive any feedback on the paper. By using colored pens this misunderstanding could be avoided. A similar issue could come up with the stroke style and size (for users much simpler to draw it during the sketch then selecting it from paper). For the same reason, the pencil and the brush icons were eliminated.

4.3.4 The final paper prototype

As we have seen, most of the people are right-handed, so positioning the drawing tools on the right (Figure 4.12) makes much more sense, avoiding – by picking them up with the pen – to cross the paper sketch with the arm or hand. As explained, sketches must be quick and simple and implementing a zoom function on paper would only complicate the entire process – it should also be remembered, that the sketch's state on the paper can't change (resize, undo, etc.), because for the current technology restrictions, paper is not able to give feedback. The comment icon could also be left away: for sketchers it is much more natural to directly annotate on the drawing without selecting an icon first. The option of handwriting recognition is still available by writing in the appropriate box placed beneath the sketching area.

Most used functions like the tools in Figure 4.14 (freehand, line, circle, rectangle drawing, virtual sketchpad switcher, user blocking, bring-up Skype interface and creating a PDF) are still available to skip one mouse interactions and to let instantly appear dialog interfaces on the application. This can then be interacted with, through

[4]http://en.wikipedia.org/wiki/RGB

keyboard and mouse or through the handwriting recognition provided by the box mentioned before, in combination with the *OK* and *Cancel* icon button – a filename can be written down with the keyboard or through the recognized handwritten text on the paper. Similar thoughts were behind the implementation of the most used application control buttons as *Saving*, *Saving as...* , importing, exporting, printing and sending or archiving. These, being not strictly sketch-related, have been placed on the left side of the prototype. On its upper left corner (as standard and as the first place where the sight is directed by users) the start icons for the application and the communication (audio, private communication, video and recording) are placed. The stop icons are respectively placed on the right upper corner of the prototype. These control functions, being Skype-related, are characterized by the Skype styleguide and are separated from the sketching area and the drawing tools on purpose.

4.3.5 Gestalt laws

In the book of Colin Ware [War04] the Gestalt laws (organizing object and information for best perception) are well described:

> The word Gestalt simply means pattern in German. The work of the Gestalt psychologists is still valued today because they provided a clear description of many basic perceptual phenomena. They produced a set of *Gestalt laws* of pattern perception. The Gestalt laws easily translate into a set of design principles for information displays.

4.3.5.1 Proximity

Spatial proximity is a powerful perceptual organizing principle and one of the most useful in design [War04]. Things that are close together are perceptually grouped together. In the paper prototype we have four distinct groups of objects placed in proximity: the control icons, the drawing tools, the communication functions and the handwriting recognition box. This one is in proximity of the Confirm and Cancel button to clarify the grouping of these three objects. The shapes of individual pattern elements can also determine how they are grouped. Similar elements tend to be grouped together. Because of this, the application control icons and the drawing icons have similar functions; consequently they are also of similar design.

4.3.5.2 Symmetry

Symmetry can provide a powerful organizing principle. Symmetrically arranged pairs of objects are perceived much more strongly as forming a visual whole [War04]: in the prototype the focus is set to the sketching area, but the control and the drawing icons are placed symmetrically on the left and on the right reminding of their similar functionality.

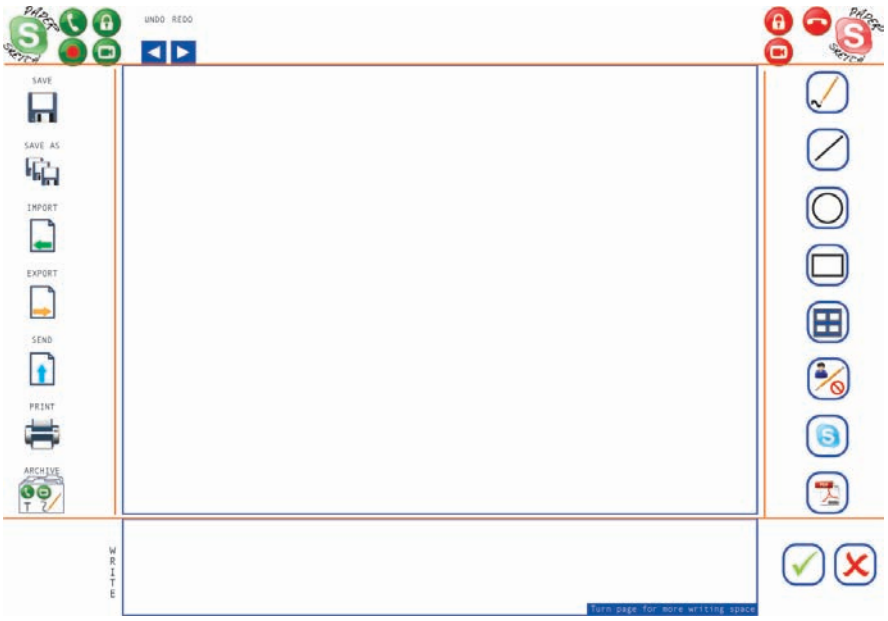


Figure 4.13: Continuity on the paper prototype

Figure 4.14: Drawing tools icons

4.3.5.3 Continuity

The Gestalt principle of continuity states that we are more likely to construct visual entities out of visual elements that are smooth and continuous, rather than ones that contain abrupt changes in direction [War04].

In the paper prototype the continuity principle is mapped in Figure 4.13.

4.3.6 Closure

A closed contour tends to be seen as an object. The Gestalt psychologists argued that there is a perceptual tendency to close contours that have gaps in them.

Wherever a closed contour is seen, there is a very strong perceptual tendency to divide regions of space into *inside* or *outside* the contour [War04]. In the prototype the closure is represented by the sketching and handwriting recognition boxes.

4.3.6.1 Icons

They were designed as self-explanatory as possible (Function Follows Form) to ease the recognition process of the functions (Figures 4.14, 4.15, 4.16). Briefly: Affordance (it is

Figure 4.15: Application control icons

clear what should be done) and Mapping (i.e. Diskette for saving).

(a) Start application

(b) Communication

(c) Stop application

(d) Stop communication

Figure 4.16: Paper prototype icons

4.3.7 Active components and user interface low-fidelity prototype

Active components are the interface between the interactive paper, Skype and the *Remote Sketching on Paper* Adobe Flex[5] application.

> An active component is a piece of program code that can be linked in the same way as any other resource and that gets executed after the corresponding link has been activated [Sig06].

Their functionality and the system behavior during interaction have been modeled and can be found in Appendix A.8. A detailed description is given in Chapter 5.

4.3.7.1 User interface low-fidelity prototype of Adobe Flex application

First drafts on paper of the application's user interface, according to the requirements and design conclusions so far, were sketched and can be consulted in Appendix A.9.

[5] `http://www.adobe.com/products/flex/`

Chapter 5

The Prototype

In this chapter the prototype for the *Remote Sketching on Paper* project is presented. This chapter is divided in two parts: implementation and user interface development. The first one describes the technologies that have been used and the system's architecture. The second one illustrates – with the support of two scenarios – the design decisions for the prototype and for a *yet-to-be-implemented* final application.

5.1 Design and Implementation

5.1.1 Technologies—goals and tasks

The *Remote Sketching on Paper* prototype makes use of many different technologies that have to communicate together harmoniously. As we have seen in Chapter 3, the user should be able to sketch on an *interactive paper sheet* and the system should be capable to show the sketch on the screen and at the same time send it over the Internet to another user, who can annotate, sketch and interact with it as well.

Some of the technologies were already implemented and could be used straight away: the *iServer* framework, the *iPaper* plug-in and *Skype*. Therefore, the task was to develop an application with its own customized user interface (in Adobe Flex), an interactive paper prototype (on standard paper), an *iFlex* interface (in Java) that allows the communication between the *iServer*/*iPaper* framework and the Adobe Flex application, and last but not least a Java interface that is able to handle the communication between all different technologies.

iServer and iPaper

iServer enables cross-media linking based on a set of link management information concepts. Links connect different entities defined in terms of selector or resources. Resources represent an entire information unit [Groc], while to control the granularity of link sources and targets, selectors allow to address parts of a resource. For a particular kind of media, plug-ins for *iServer* might be provided. To handle interactive paper resources and selectors, the *iPaper* plug-in has been implemented. Figure 5.1 shows the

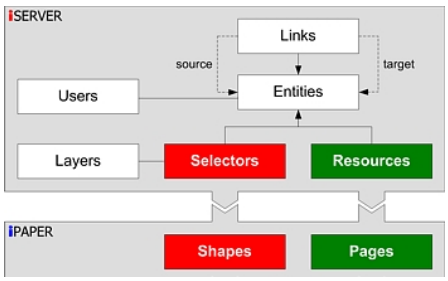


Figure 5.1: The iPaper plug-in [Groa]

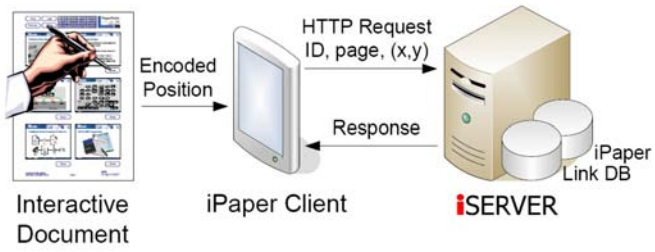


Figure 5.2: Basic iPaper architecture [SN07]

basic *iServer* model and its *iPaper* plug-in. In *iPaper* a resource is represented by a single page and a selector is an active area defined by a shape within that page [Sig06]. Furthermore, *iServer* provides *active components* (stand-alone code fragments) which are integrated as source or as target of a link: when a link is selected (like for example a *paper button*), the active component may be retrieved and the program code contained executed.

Figure 5.2 illustrates the basic *iPaper* architecture. When the pen is pointed to a (x,y) position on an active area, the selected shape is processed by the *iPaper* plug-in and its associated links are then activated. To know the correct shape that should be processed, the *iPaper* uses a document id, a page number, and the (x,y) coordinates where the pen has been pointed on the paper. Depending on the linked resource, digital services might be activated both on the server side or on the *iPaper* client.

Adobe Flex 3.0

At the beginning of the project the idea was to use the Skype plug-in *WhiteBoardMeeting*[1] as the user interface for the *Remote Sketching on Paper* application: the sketches on the interactive paper should have been sent over the *iServer* framework to this Skype plug-in. However, it was decided to develop a standalone GUI in Adobe Flex 3.0: the *iFlash* plug-in for the *iServer* framework was already implemented on a previous project [Fre06] and could be used as starting point for the implementation of the new

[1] `https://extras.skype.com/1137/view`

iFlex plug-in that will be described later on. Flex offers a set of user interface components like buttons, list boxes, trees, data grids, several text controls, various layout containers, modal dialogs, animation effects, application states and other interactions. The main programming languages are MXML[2], an XML-based markup language, and Actionscript[3] (the Adobe Flash scripting language). Flex supports fast user interface and interaction prototyping and it is easy to learn.

Skype

With the online survey that has been outlined in Chapter 4, it was possible to find out that Skype[4] is the most used and preferred tool for remote communication on a computer. One of the main advantages using Skype for this project is that being so widely used to communicate over the Internet, no specific communication setup and configuration have to be implemented. Skype is already taking care of all these tasks.

iFlex

Based on the mentioned *iFlash* [Fre06] plug-in for the *iServer* framework, the *iFlex* implementation handles the communication from *iPaper* up to the Adobe Flex GUI. A socket opened between *iPaper* and Flex allows *active components* – mapped on the A3 paper sheet – to run methods in Flex from the paper interface or to process the (x,y) pen position, the document id and the page number on the Flex user interface.

Skype4Java

To send data from Java to Skype and vice versa the *Skype4Java API*[5] has been used. With this API it is possible to create classes in Java that interact and use functions provided by the Skype application. For example, a Java method, such as `getAllConnectableFriends` is able to fetch all current connected Skype contacts. Other Java classes could start Skype calls with a selected friend and so on.

5.1.2 Architecture

As described so far, the *Remote Sketching on Paper* prototype has been implemented in Java. Further on, the *Skype4Java API* has been integrated to exchange data between Java and Skype and vice versa. The *iFlex* plug-in allows the communication between the *iServer*/*iPaper* framework and the Adobe Flex application. Adobe Flex has been used to develop the GUI and Skype as a support tool for the communication between remotely located users. Figure 5.3 illustrates the main architecture behind the prototype. Communication starts from a pen interaction on paper and after being processed by the *iPaper*/*iServer* framework is transferred to *iFlex* which acts as a bridge between

[2] `http://en.wikipedia.org/wiki/MXML`
[3] `http://en.wikipedia.org/wiki/ActionScript`
[4] `http://www.skype.com`
[5] `https://developer.skype.com/wiki/Java_API`

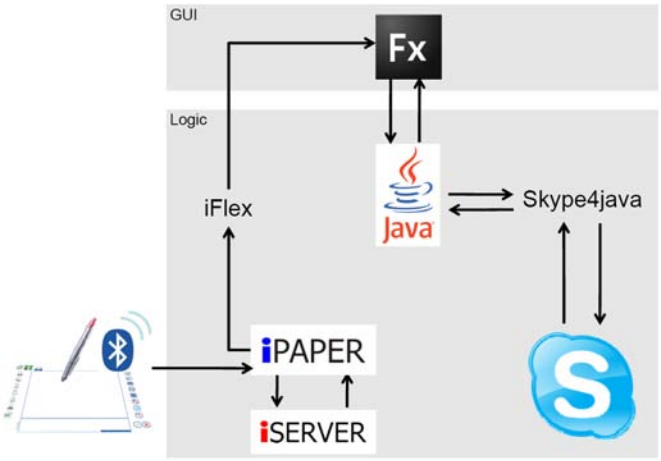


Figure 5.3: The Remote Sketching on Paper architecture

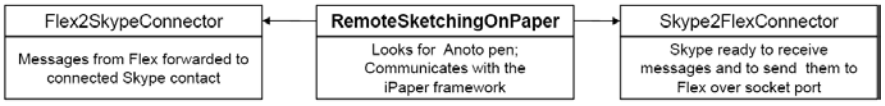


Figure 5.4: Running the main class

iPaper and the Java code. In order to communicate over the network the *Skype4Java* interface connects to Skype and sends the wanted commands to it.

5.1.3 Java implementation

Main application

To run the *Remote Sketching on Paper* Java application, the main class `RemoteSketchingOnPaper` should be started. This class first looks for connected pens. It handles then the setup between the application and Skype. Consequently, messages arriving from Flex can now be forwarded to a connected Skype contact (`Flex2SkypeConnector`) and Skype is ready to receive messages and forward them to Flex over the socket port (`Skype2FlexConnector`) as shown in Figure 5.4.

Flex connection interface

To initialize the communication mentioned before, the `FlexConnector` class is needed (Figure 5.5). This class connects with Flex on the port 17000. If Flex has not been started or the connection cannot be initialized it throws an exception. In the same package the class `Constants` contains all messages that can be sent to Flex.

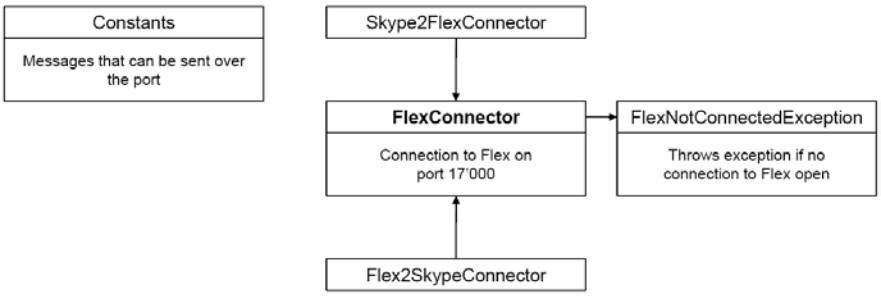


Figure 5.5: The FlexConnector class

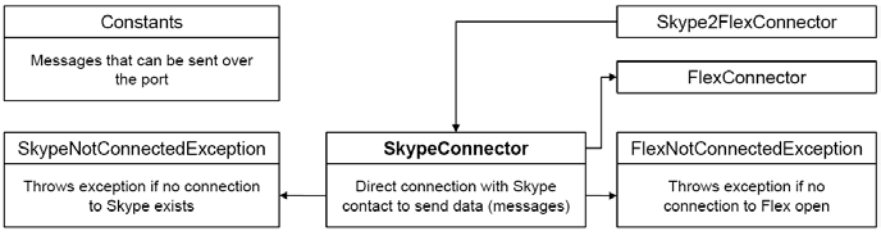


Figure 5.6: The SkypeConnector class

Skype connection interface

The main task of this class is to establish a connection between the application and Skype: it connects with the Skype server (an exception is thrown in case it is not possible or Skype has not been started), fetches connectable friends, connects and disconnects to and from Skype contacts, listen for Skype messages and last but not least sends messages about the connection and the contacts status to Flex.

iFlex

As outlined in Figure 5.7, the *iFlex* plug-in is composed of two classes, handling the active components selected on paper (Appendix A.8, Figure A.14). The `RemoteSketchingCanvasStub` class receives (from the *iPaper* framework) the points sketched on the

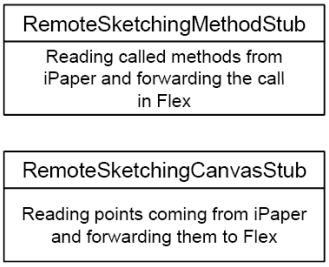


Figure 5.7: The iFlex plug-in classes

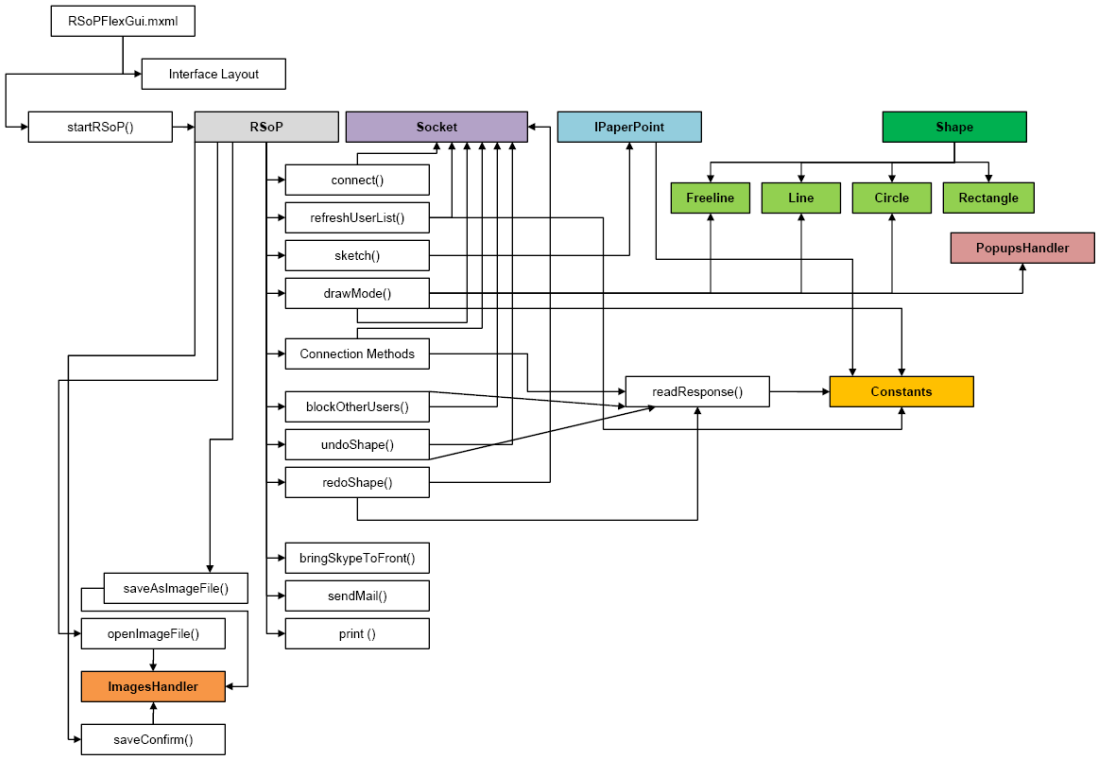


Figure 5.8: The Flex architecture

paper canvas (an active component as well) and forwards them in the needed format and scaling to Flex. However, as soon as *paper buttons* have been selected, the `RemoteSketchingMethodStub` receives data from the *iPaper* framework and notifies Flex which methods should be executed: the message sent is composed of a document id, a page number and the method name that should be run.

5.1.4 Adobe Flex implementation

To run the *Remote Sketching on Paper* Flex application, the MXML file `RSoPFlexGui` is first called. It defines the entire GUI layout, the application states[6] and calls the method *startRSoP()* to run the core functionalities of the software, such as initializing popups, buttons and running the main ActionScript file, which opens the socket port (to send and receive messages) and initializes all drawing functions.

All images and the sound file (for the audio feedback) are stored in a separate folder (`assets`). All core functions such as the drawing of the received shapes on the screen and the communication with the other technologies have been implemented in Actionscript.

[6] *StartState*: the initial interface; *Blocking*: interface changes when user is blocking collaborator from sketching (Figure 5.30a); *Blocked*: when the user is being blocked the interface changes informing him that he can't sketch until he is unblocked from the other user (Figure 5.30b)

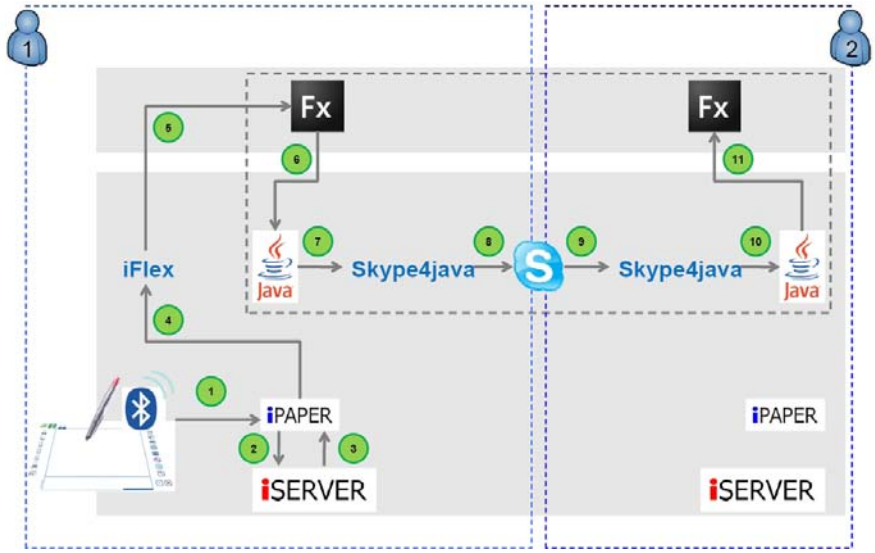


Figure 5.9: The working architecture

The main class of the core functions is the `rsop` class. It implements all receiving and sending functions needed for the remote collaboration (i.e. the opening/closing of the socket ports, the fetching of connectable friends, the connecting and disconnecting to and from Skype contacts, etc.), for drawing and for the user interaction with the GUI (i.e. printing, sending emails, undo, redo, etc.). The `IPaperPoint` class takes care of the points arriving from the *iFlex* plug-in.

The `sketch()` method communicates with the `IPaperPoint` class to add the received points to the document.

Once the methods are called from the paper sheet, they arrive in Flex as messages through the open socket. These messages are read and according to the required functionality a method is executed or points are used to draw shapes on the screen. The same class is in charge of transforming activated Flex functions in messages to send over the socket opened with the Java application of the other connected user.

An additional class (`ImagesHandler`) has been developed and has access to the filesystem to load and save sketches. Furthermore, the `PopupsHandler` class creates popups as soon as some of the buttons (undo, redo, circle, line, etc.) are activated.

5.1.5 The working architecture

In the following subsection we give an example of the system at work when a user wants to use the *Remote Sketching on Paper* application. Figure 5.1.5 shows how the system logic works when one user (User 1) draws a sketch on the interactive A3 paper sheet and wants to show it to one of his Skype contacts (User 2) interactively. The dataflow goes through eleven steps:

1. The x and y coordinates, the page number and the document ID of the sketch

are sent from the pen via bluetooth to the computer system, which is already listenting for them

2. The coordinates are backed up in the *iServer* link database and the link from the selected shape is retrieved
3. The selected active component is executed within *iPaper*
4. The communication with *iFlex* is opened
5. Once the received data is processed, *iFlex* knows whether it has to send points or method calls to Flex. Messages arrive now to Flex and the right functions are consequently activated or the received points are shown in the virtual sketchpad of the application user interface
6. Because the user is connected with one of his Skype contacts (to sketch in collaboration), Flex forwards the received messages to Java
7. With the help of the *Skype4Java API*...
8. ...the messages are then forwarded to Skype
9. Skype then, again with the *Skype4Java API* support, ...
10. ...sends them to the Java application running on User's 2 machine
11. The messages travel now from Java to the Flex socket of User 2, who is now able to see the sketch of User 1 on his screen

It must be pointed out that the application works also in single mode: even if no Skype connection is available, User 1 can still sketch on paper and the drawing is shown on the screen (Flex application). The dotted grey rectangle on Figure 5.1.5 emphasizes the fact that the application can work also without the *iPaper*/*iServer* infrastructure: sketching in collaboration using a mouse and a keyboard.

5.2 Remote Sketching on Paper user interface prototype

As described in Chapter 4, the user interface prototype is based on two personas and problem scenarios (Mika and Claudio). The interaction with the system will be shown through screenshots of the prototype (developed with Adobe Flex 3.0) and mockups of the final application, these were created in Adobe Photoshop.

5.2.1 The prototype interface layout

First of all, a dark-gray application background has been chosen taking into cosideration the environmental profile described in Chapter 4, Subsubsection 4.2.8.1. To enhance the contrast of the interactive windows a black background has been implemented in combination with white text and labels. The sketching and communication tools and

functions have the same look as the one on the paper prototype to make a stronger link between the input and output device and the sketching action. As on the paper prototype, the sketch area is placed right in the middle of the application, therefore the user has his focus on the sketching component, which is the main functionality of the application. The *Undo* and *Redo* functions, that can only be effective in the digital application, are placed right on the top left corner of the virtual sketchpad to represent the association with the drawing canvas, that has the same border color as the icons for the *Undo* and *Redo* icons. Selected objects on the screen are generally shown with an orange border.

Colors play a major role for visualizations, for their ability to code the information. Visual objects can represent complex data entities and colors can code the attributes of these entities. As presented in the book by Colin Ware [War04] there is a list of recommended colors to code information. In this project there are for example orange, as we have seen for selected objects (orange supports concentration), navy blue to link active sketching objects with the paper toolkit, black/dark grey for screen backgrounds and so on. Small objects such as the sketching buttons have highly saturated and contrasted colors to achieve a maximal differentiation. As Ware describes, if colors are used to highlight black text, they should be bright/light.

Functions on paper

The separation of the functions which should have gone on the paper or on the digital application was quite difficult to decide and analyze. The biggest hurdle is clearly the paper, which, for the time being, cannot give feedback to the user and can't change state. Selected objects can be shown only on the software. The user has to watch the screen. Therefore, it has also been decided to map many functions on the *digital world* as well as on paper – as stated in the survey by the participants (see Appendix A.4, table A.3) – consequently users are free to choose how much they want to work on the paper or with the software and a mouse. Perhaps (can only be studied with a more high fidelity prototype and multiple usability tests), if the user gets more and more familiar with the application and especially the paper technology (direct feedback), they may tend to use mostly the pen and the paper instead of the screen and the mouse or tablet input devices. The graphical user interface and its dialogs were developed taking into consideration the *DIN 9241 standards for office activities on the computer screen*, the eight golden rules by Ben Schneiderman and the requirements analysis presented in Chapter 4.

DIN 9241 standards [Dah06]

In part 11 of the DIN 9241 the main goals, that should be followed by interactive systems, are: effectivity (precision how the users accomplish their tasks), efficiency (describes the payload of the user to accomplish the tasks efficiently) and satisfaction (describes how well the user feels when using the system). Consequently, the usability of a system can be defined as follows: Usability is the measure of effectivity, efficiency

Figure 5.10: The paper prototype

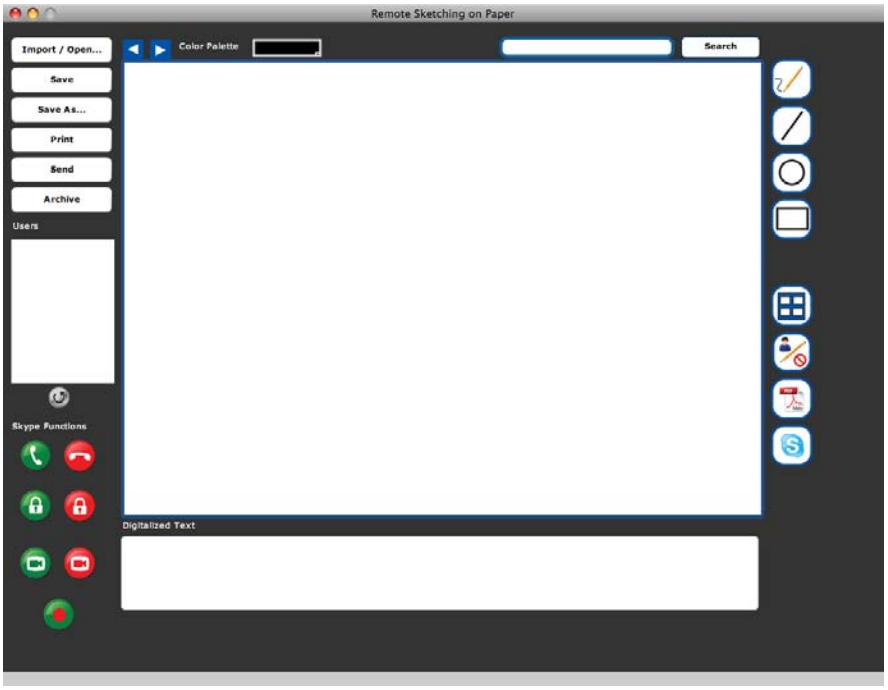


Figure 5.11: The user interface

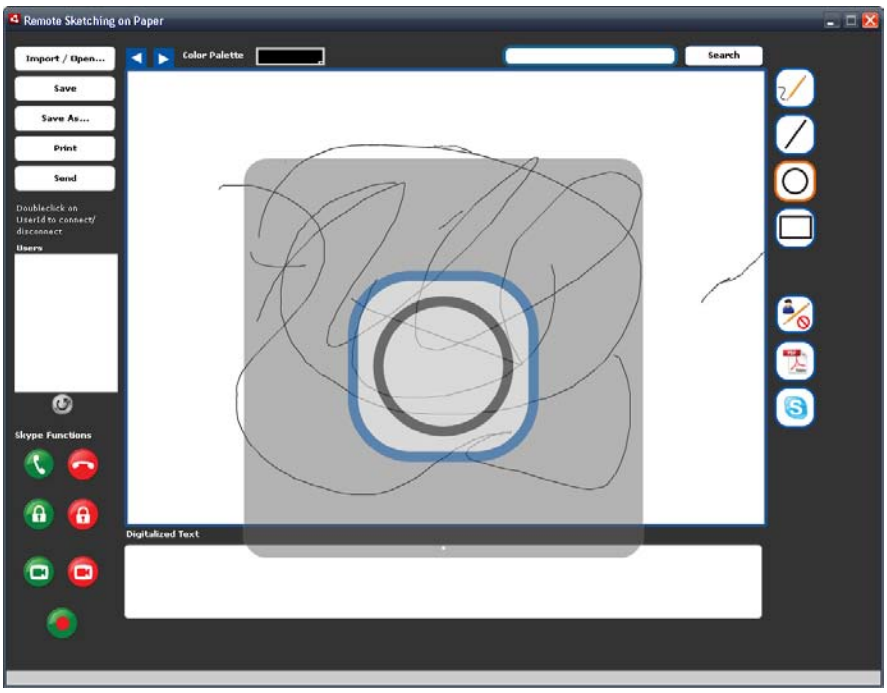


Figure 5.12: Popup for the circle function

and satisfaction on how the users can complete their tasks with an interactive system. Based on part 11 of the DIN 9241, part 10 can be presented, which indicates what kind of properties dialogs should have to be well designed: suitability for the task (the dialog should show only the information needed to complete the task effectively and efficiently), self descriptiveness (the system should give feedback after user interaction), controllability (speed, exit or undo of dialogs under user control, alternative input methods should be freely chosen by the user), conformity with user expectations (information visualization should be consistent), error tolerance (system should prevent user from doing errors and in case of error, automatically prevent them), suitability for individualization (option to individualize menus and GUI objects) and suitability for learning (system should support the learning-by doing principle).

Shneiderman's Eight Golden Rules of Interface Design [Shn97]

To improve the usability of an application it is important to have a well designed interface. Shneiderman's Eight Golden Rules of Interface Design suit quite well for this purpose.

1. **Strive for consistency**: Consistent sequences of actions should be required in similar situations; identical terminology should be used in prompts, menus, and help screens; and consistent commands should be employed throughout. The interaction windows of the *Remote Sketching on Paper* application are consistent

2. **Enable frequent users to use shortcuts**: As the frequency of use increases, so do the user's desires to reduce the number of interactions and to increase the pace of interaction. Therefore and as stated in the requirements analysis (Chapter 4), the final application should have keyboard shortcuts implemented

3. **Offer informative feedback**: For every operator action, there should be some system feedback. For frequent and minor actions, the response can be modest, while for infrequent and major actions, the response should be more substantial. The *Remote Sketching on Paper* system, as shown in the mockups, gives feedback through popups and audio (Figure 5.12).

4. **Design dialog to yield closure**: Sequences of actions should be organized into groups with a beginning, middle, and end. The informative feedback at the completion of a group of actions gives the operators the satisfaction of accomplishment, a sense of relief, the signal to drop contingency plans and options from their minds, and an indication that the way is clear to prepare for the next group of actions. The *Remote Sketching on Paper* system, as shown in the mockups reflects this rule in its entirety when the user wants to save, send, organize sketches and so on.

5. **Offer simple error handling**: As much as possible, the system should be designed that the user cannot make a serious error. If an error is made, the system should be able to detect the error and offer simple, comprehensible mechanisms for handling the error. The *Remote Sketching on Paper* prototype doesn't offer error handling at this stage: errors are being ignored.

6. **Permit easy reversal of actions**: This feature relieves anxiety, since the user knows that errors can be undone; it thus encourages exploration of unfamiliar options. The units of reversibility may be a single action, a data entry, or a complete group of actions. The *Remote Sketching on Paper* offers *Undo* and *Redo* to allow easy reversal of actions

7. **Support internal locus of control**: Experienced operators strongly desire the sense that they are in charge of the system and that the system responds to their actions. Design the system to make users the initiators of actions rather than the responders. The *Remote Sketching on Paper* system gives users the full control on almost everything: only an interpolation function takes control of the sketched points to show them properly on the screen, but for rectangles, lines and circles recognition is the user who decides when such functions should be used

8. **Reduce short-term memory load**: The limitation of human information processing in short-term memory requires that displays be kept simple. To start sketching and understand how the *Remote Sketching on Paper* application works the user doesn't need to read a manual, everything is easy to use, kept simple and self-explaining

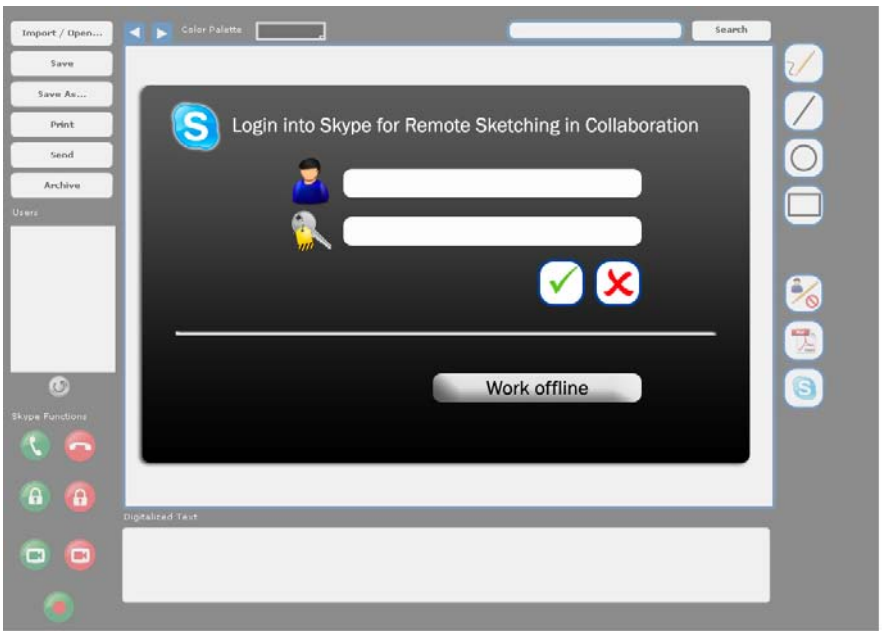


Figure 5.13: The application has been started

5.2.2 Commenting sketches

The main actor of this scenario is Mika. She is at home at her desk and has the notebook running in front of her. She would like to sketch something to show to her Japanese professor and get, later on, feedback from him.

Consequently, she takes the printed paper prototype out and with a pen she starts the *Remote Sketching on Paper* application by clicking on the *start application* logo on the paper interface. An interaction window appears on the screen. She can now choose between working online over Skype (typing the Skype login data, Skype will be started too) or offline as shown in Figure 5.13. She clicks the *Work offline button*. Now she has the application running and she can start drawing on the paper (as described in the previous chapters, everything will be drawn simultaneously on the virtual whiteboard).

The pen has a blue color and a style size of one point. If she wants to change them she just need to take a pen with different properties. She starts sketching now.

Once she is finished, she wants to save the sketch, hence she clicks with the pen on the *Save* logo on the paper. Again, an interaction window appears, it looks exactly like the *Save As...* window, because if the sketch would have already been saved, no dialog would appear and the sketch would be overwritten (Figure 5.14). The dialog shows a classical filesystem directory tree where the location can be chosen from and an input textfield for the filename. The system takes automatic care of the file type (and extension), to facilitate the process. An interaction with this dialog could also be possible through the paper prototype: handwriting the filename in the provided *writing area* on the paper and/or on the backside of the paper sheet (it could also be used

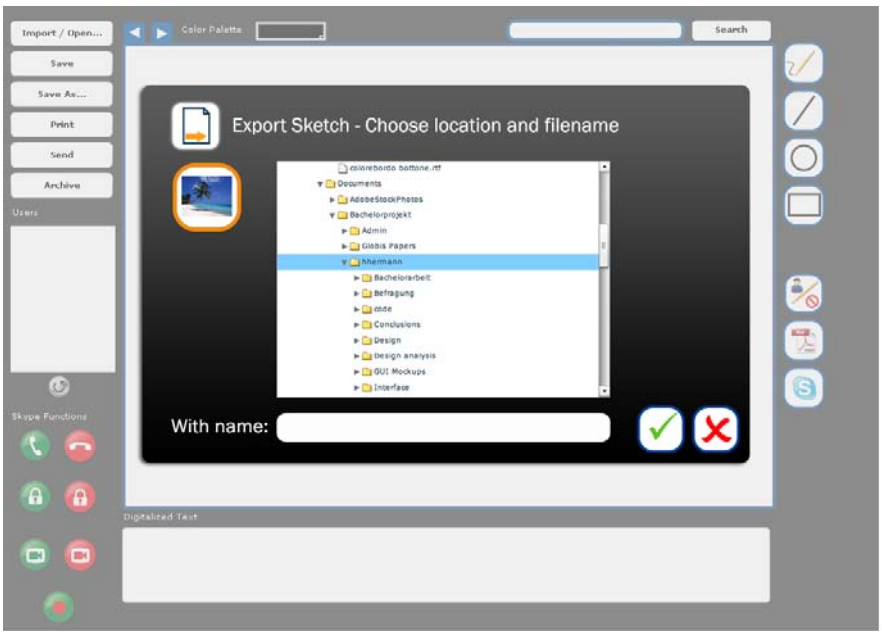


Figure 5.14: Saving the sketch

for annotations), the system would recognize the text and fill it in the filename input textfield. To confirm or cancel the input given, Mika can therefore click with the mouse one of the two buttons next to the textfield or selecting one of them on the paper with the pen. Because she has done the process correctly, she proceeds clicking the *OK* button and the interaction window changes to a status one, showing the process of saving (Figure 5.15): additionally it shows a blinking *Save Icon* on the upper left corner. Once the operation is completed the system confirms that the file has been successfully saved (Figure 5.16). Mika now waits some time – thinking about time difference – to connect to Japan for the commenting session with her professor and her old classmates. After having a snack she restarts the *Remote Sketching on Paper* application.

At the *Login* window she inserts her *Skype* username and password and the main application window with the virtual sketchpad starts. On the left side (in the box *Users*) the available/online Skype users are shown. Her professor is already online, therefore she clicks twice on it (*User 1*) to open a direct connection with him. The text color changes now from black to blue to show that the connection was successful (Figure 5.17), otherwise a popup shows that the connection could not be established. Now she just clicks on the green icon next to his user name to start a call – to stop the call she just have to click on the red icon next to the green one. She has also the option, once the connection between her and the other user is established, to start/stop the same functions hitting the icons on the A3 page with the pen. During conversation the audio can be turned off using the last icon. When the system is calling and the green icon to start a call changes color to gray (not selectable anymore) a popup window, as shown in Figure 5.18, informs that it is making a call with the selected user (to stop the call

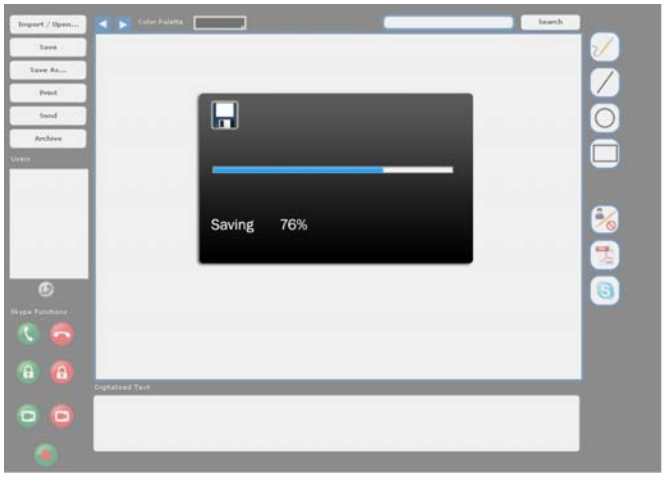


Figure 5.15: System is saving

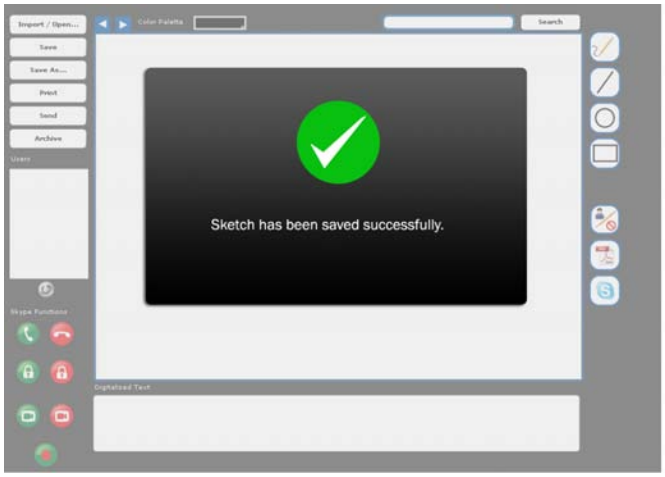


Figure 5.16: Saving successful

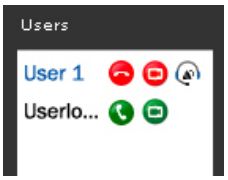


Figure 5.17: Connected to user

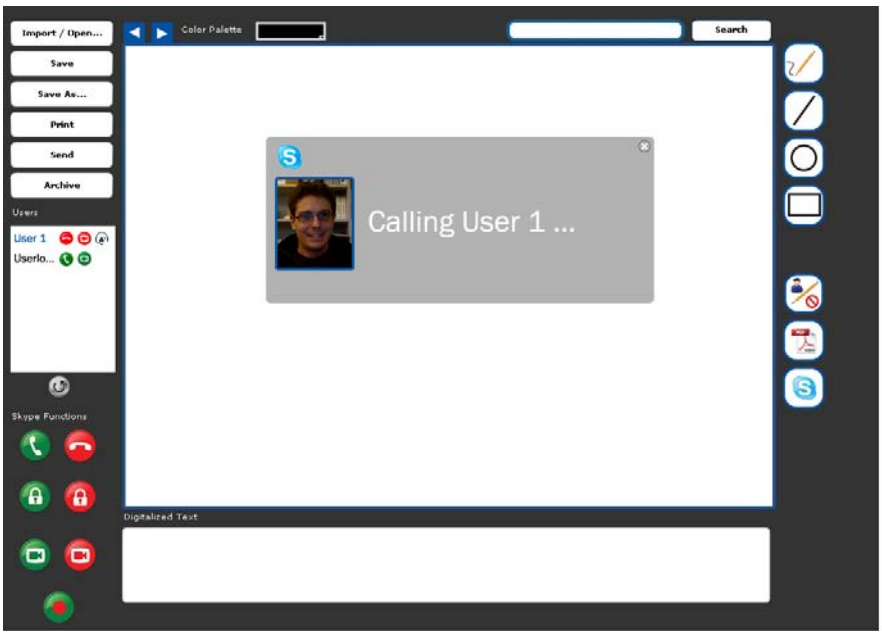


Figure 5.18: Call the user

instantly a close icon has been implemented on the upper right corner of the pop-up). Afterwards, she wants to show the previously saved sketch to the audience. She has three options: get the sketch on the standard paper and then select it with the pen – and the sketch will be automatically be loaded on the virtual sketchboard – or clicking the *Import* icon on the A3 page (the so called toolkit page), which then opens a *Media Browser* window on the screen, or with the mouse click on the *Import/Open...* button to open the *Media Browser* too. To look after saved sketches/images she could also use the *Search function* on the upper right corner of the screen using the mouse and the keyboard.

The search function (Figure 5.19) works as follows: typing text in the provided input field – which then becomes highlighted to show that it is active – the results appear straightforward in a drop-down under the searchfield. The search works at the same time as a filter, ordering and grouping the results by filetype and by excluding everything that doesn't contain the characters given as input for the search. Mika can select the file by mouse or keyboard (cofirming the selection with the *Enter* button). The selected file has a blue shading and on the left side of the results, icons represent the filetypes of the grouped results. The *Media Browser* can be used to search a file (sketch, image, recorded audio, video, sketches) with mouse and keyboards. These files are shown as images (Figure 5.20). The filename is augmented through two additional icons which represent the content of the file, in this case some text annotations and a sketch. The needed file is then selected from a fisheye visualization (more important information represented larger than less important one). Revisions of the file can then be chosen from a scroll-down selection on the upper side of the screen. Clicking on the

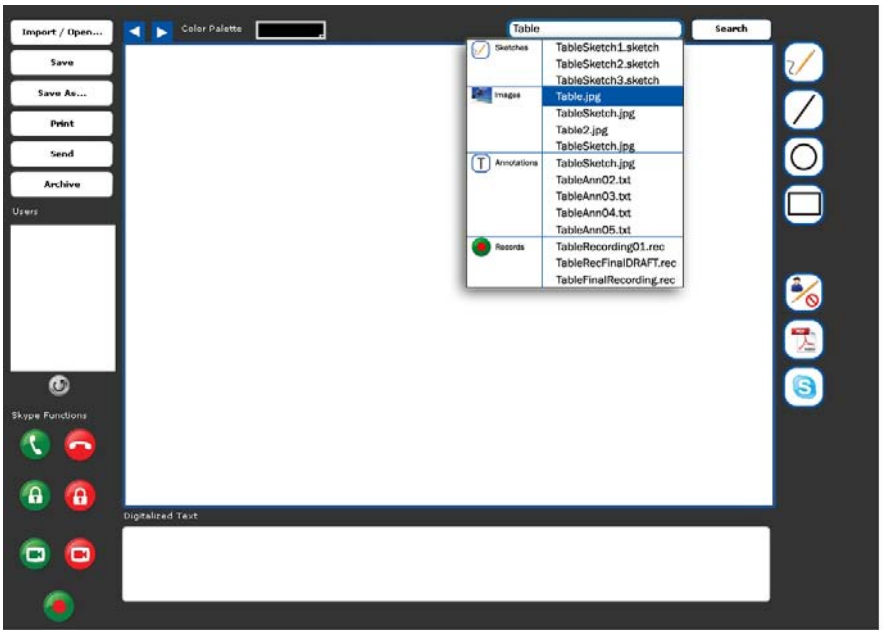


Figure 5.19: The search function

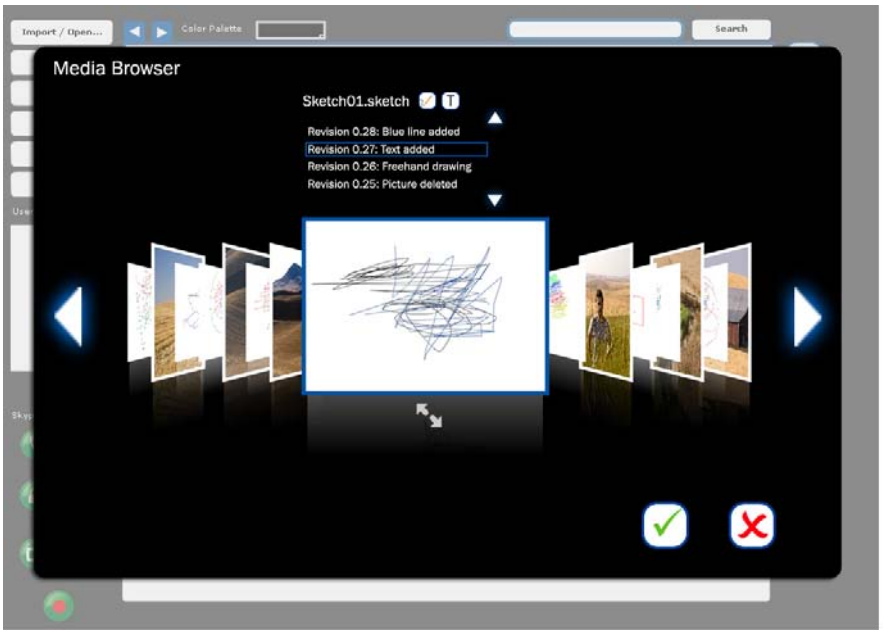


Figure 5.20: The media browser main window

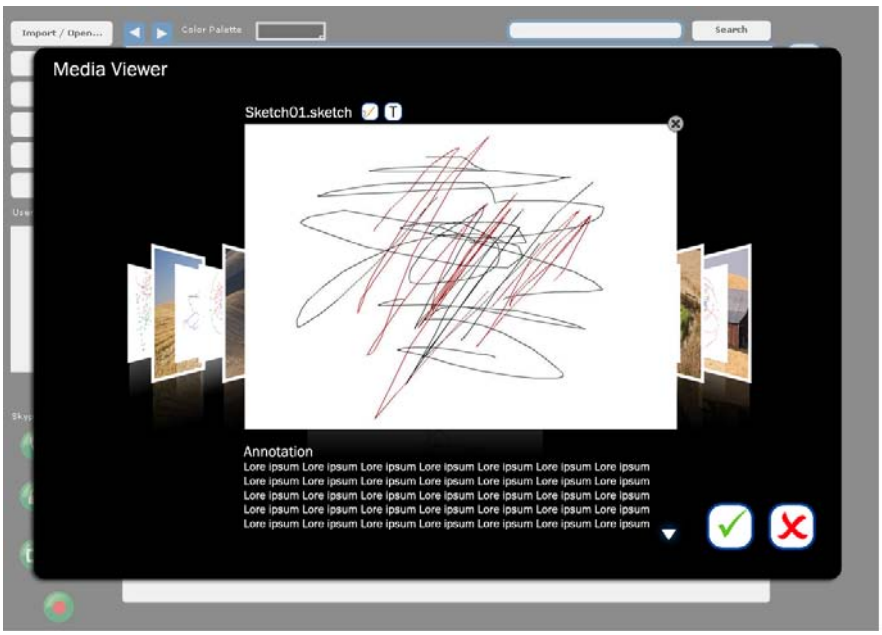


Figure 5.21: The media browser viewer window

lowest icon under the selected image, the GUI shows a zoomed version of the image with the annotations (Figure 5.21). To exit the *Zoom Mode*, she needs only to click on the cross icon on the upper right corner of the image. As in the *Media Browser* window she can confirm or cancel the selection clicking the *OK* or the *CANCEL* icons on the screen or on paper respectively. Once she has loaded the file on the virtual sketchpad the professor can see it too and can comment on it or make changes with the mouse. At the moment the technology doesn't allow recognition of the exact point where a sketch can be continued with the pen, only on the original printed document would it be possible.

Once the commenting session is finished, the professor asks her to send him and her old classmates a nice sketch to discuss it later on. At this point she hits the *send icon* with pen on the paper (she could also use the button on the application interface).

A new interaction window appears (Figure 5.22) where the format of the attachment can be chosen (options are shown automatically depending on how the file was saved).

As soon as the format is selected and automatically highlighted with an orange border, a new window shows the different input fields for recipient(s), *CC*, *BCC* and message (as shown in Figure 5.23). The recipient's email addresses can be manually typed in or they can be picked up from the address book by clicking on the icon next to the email input field. To send the message, Mika can click on the confirmation button on the screen or with the pen on the paper.

As for the *Save/Save As...* functions a status window appears to inform the user the process of sending the email (Figure 5.24). Again the icon on the upper left corner blinks.

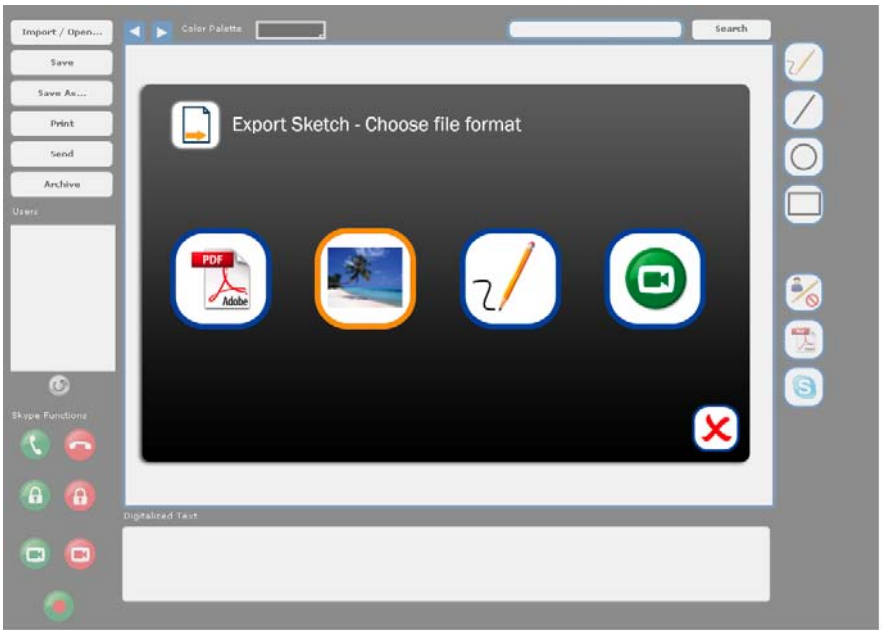


Figure 5.22: Choice of format to send

Figure 5.23: Send the sketch

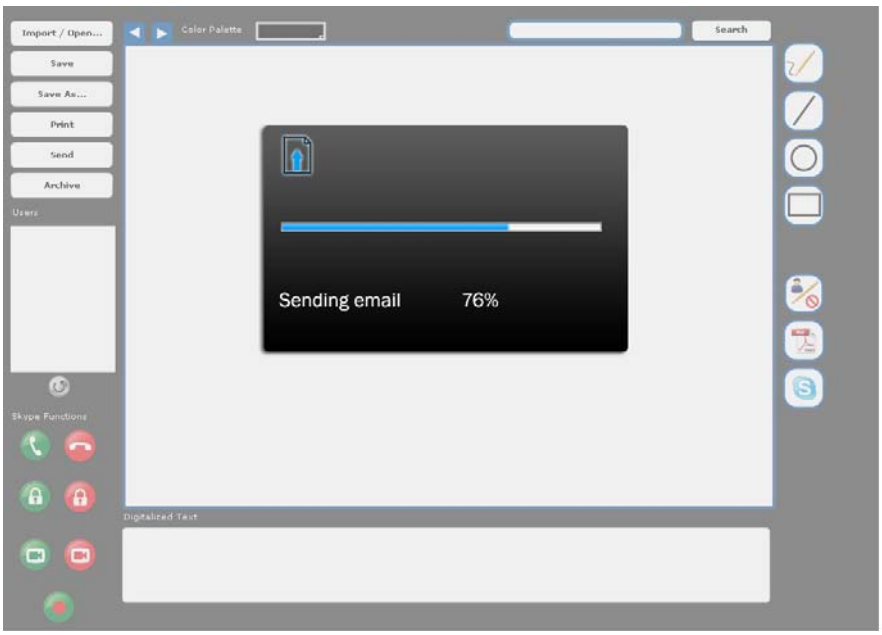


Figure 5.24: Sending the sketch

Once the email has been sent a short popup informs that the email has been sent successfully (Figure 5.25). When everything is done, Mika then clicks the *End Call* button next to the user name or on the paper to end the call and to disconnect from the professor she clicks again on his user name, that changes color to the default one: black (not connected).

5.2.3 Sketching an application architecture (UML)

Claudio, being a software engineer who is in charge of the visual specifications and the delivery of UML diagrams for modelling systems' architecures, wants to show his new ideas for the new module to his colleague that at the moment is abroad at a client's meeting. Once they have started the *Remote Sketching on Paper*, connected to each other and started a call, Claudio starts the video conference with his colleague (Figure 5.26) by clicking the proper icon on the paper with the pen.

Now he starts sketching an UML diagram of the module's architecture using the UML (future implementation) icon on the paper (see Figure 5.27).

When he draws a diagram on the paper, it is then automatically interpolated and adjusted boxes are created from the system (Figure 5.28). By writing in the proper fields of the boxes, the application recognizes the handwritten text and digitalizes it.

His colleague wants to make some changes on the architecture, therefore, to avoid confusion on the screen, he uses the *Switch Sketchpads* icon to split the virtual sketchpad in four parts. On the left, Claudio can watch his sketch and on the right the one from his colleague.

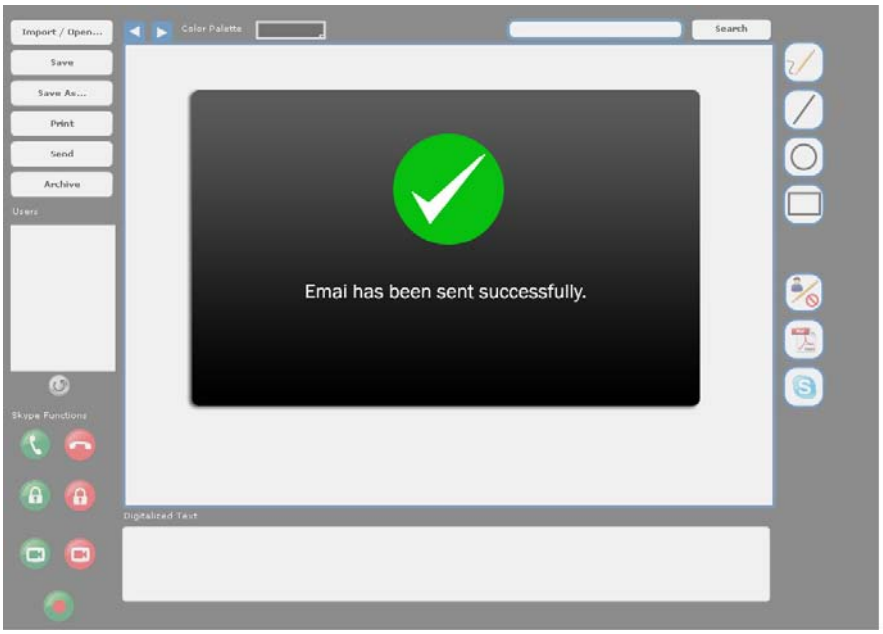


Figure 5.25: Send successful

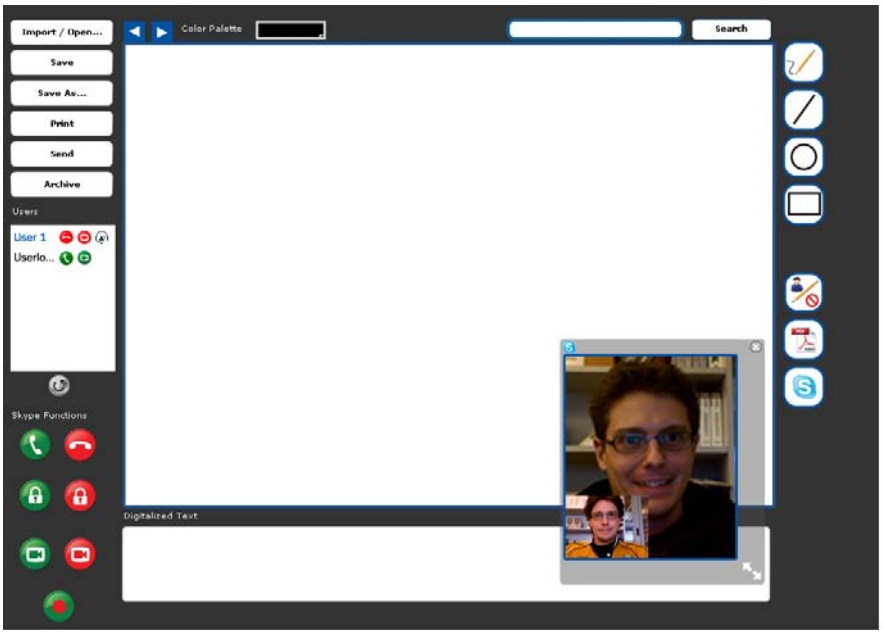


Figure 5.26: Videocall running on application

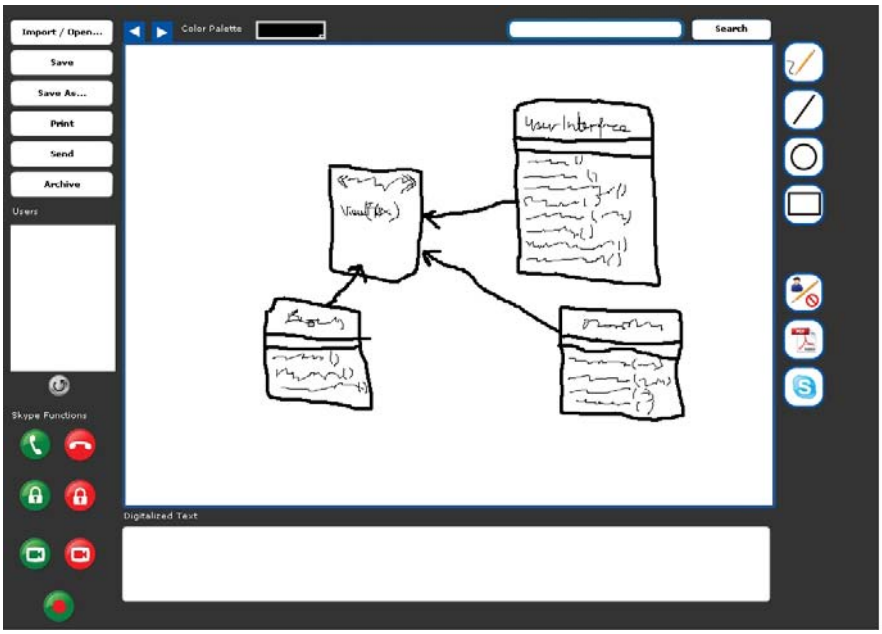


Figure 5.27: UML sketching

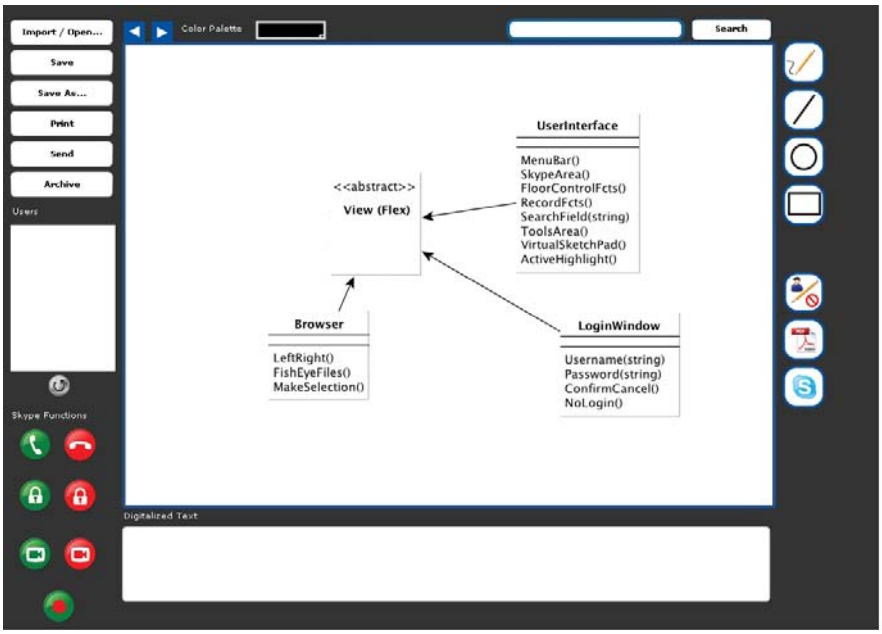


Figure 5.28: UML sketching recognized

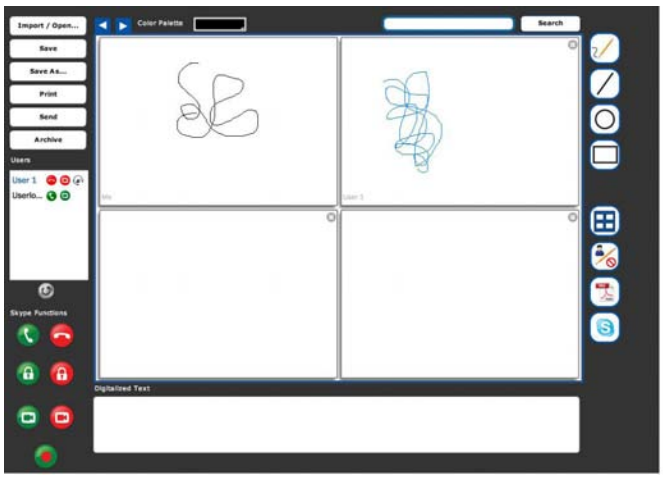
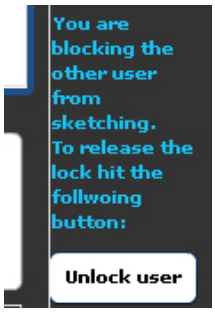


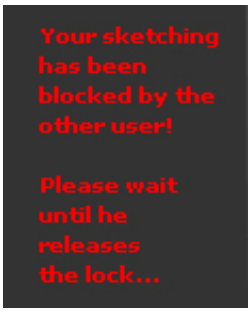
Figure 5.29: Multiple sketchpads view with switch button

By clicking on the *Cross/Close* icon or again on the *Switch Sketchpads* icon (from the interface or from the paper sheet directly), on the upper right corners of the divided sketchpads (Figure 5.29), they can then return to the classical view of one virtual sketchpad, where both sketches will then be overlapped and shown in two different colors. In both scenarios (Subsection 5.2.2 and 5.2.3), the users can also utilize the *Block other user* icon.

When User 1 presses this icon on the paper with the pen or on the screen with the mouse he receives system feedback (on the lower right corner of the screen) informing him, that he is preventing/blocking User 2 from sketching (Figure 5.30a).



(a) Blocking users



(b) User is blocked

Figure 5.30: System's feedback for block function

To unlock the user, either the icon on paper or on the screen or the *Unlock button* under the system feedback text should be pressed. At the same time, user two is informed that user one is blocking him (Figure 5.30b). In case he tries to sketch when he is blocked, an alert window, tells him that he is being blocked and that he can't sketch.

Chapter 6

Evaluation

According to the project proposal, an usability test with the *Remote Sketching on Paper* prototype application involving up to six participants had to be conducted and evaluated. Therefore, in this chapter, the usability test and its results are presented.

6.1 The usability test

The usability test took place at the usability lab of the University of Konstanz during two days. Altogether there were three sessions with two users each, collaborating in two separate rooms. Five users were team members of the Human Computer Interaction Group of the University of Konstanz, including the professor, and one user was a student of another group of the Computer Science Department. They were filmed during the test and an interview took place right after the completion of the tasks. The entire usability test – each session – lasted approximately one hour.

The first session on the first day was meant as a pre-test and on the other day the real test took place. Because the pre-test felt very good and delivered quite good results and feedback, no changes to the tasks had to be made and it was used as input for the evaluation as well.

After a short introduction about the application, the users had to complete five exercises to get used to the system and then seven other tasks to work in collaboration with the other participant. The tasks and the interview took place in German (all participants were German-speaking). Tasks and questions can be consulted in Appendix A.11 and A.12. The A3 paper sheet prototype and the application interface were slightly simplified for the usability test (i.e. only a start and stop call function placed next to each other as shown in Figure 6.1) – according to focus groups and discussions – to avoid major misunderstandings: some functions had not been implemented yet on the application prototype (i.e. the multiple sketchpads function).

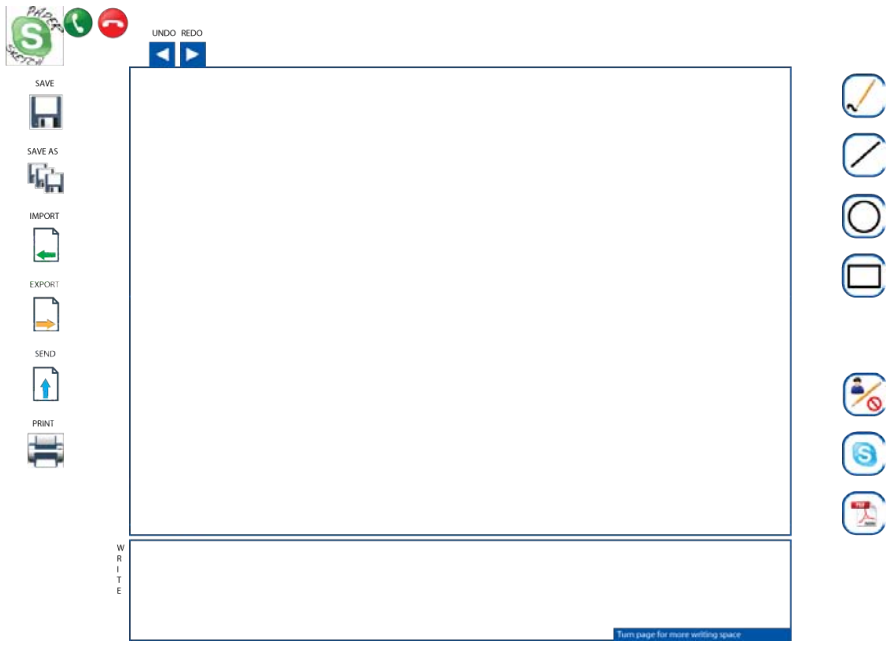


Figure 6.1: The simplified paper prototype for the test

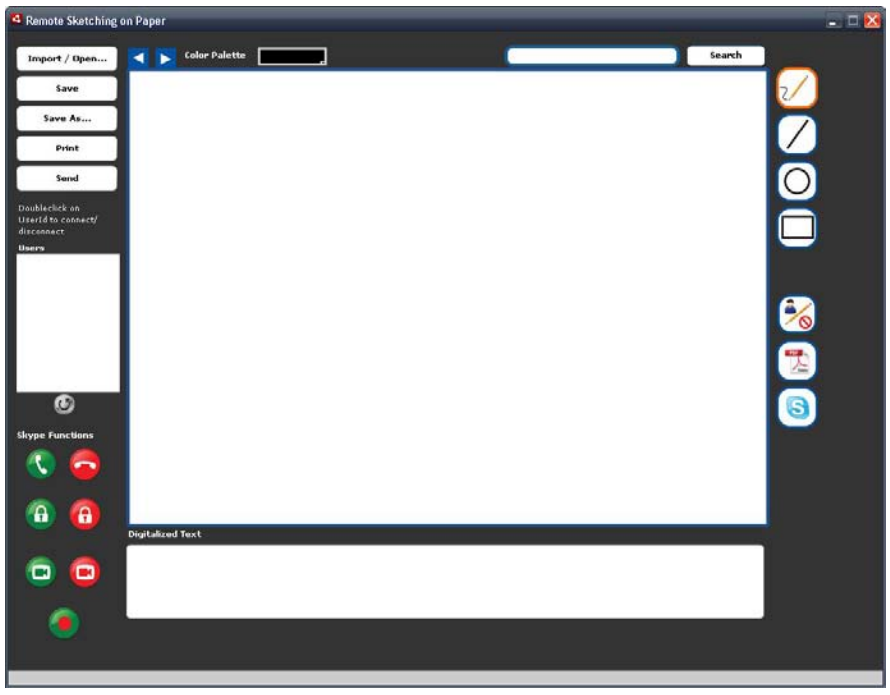


Figure 6.2: The simplified application prototype for the test

6.2 Usability test goals

The usability test's goals were as follows: find out how well the application could be used for sketching and collaboration, if the application is easy to learn, if the nature of sketching is preserved, if the functions and icons on the paper prototype are self-explaining enough and how many functions are expected by the users on paper to interact with the application and last but not least, what should be improved for the final application.

6.3 Results

Detailed evaluations of the users' tests can be found in Appendix A.13.

The first and most important result is that everybody who worked with the *Remote Sketching on Paper* prototype had lots of fun with the freehand drawing tool, and stated that working with the interactive paper is much better than using a mouse or another input device for sketching. Most of them also preferred to use the functions from the paper instead from the computer.

Second, the nature of sketching is preserved when users want to make a new sketch: using a new paper sheet to start a new sketch and to erase the digital canvas seems to be very well accepted and to work well. One thing here should be corrected: the filename of the previous sketch is still shown on the application window title.

During the opening operation users expect (according to the requirements analysis as well) that when a sketch is positioned over the A3 page and they click with the pen over it, the application opens the sketch automatically, without interacting with the computer and the system.

Furthermore, when saving the sketch, they would like to write the filename on the proper A3 writing area – for the prototype handwriting recognition was not implemented yet – instead of writing it on the screen with the keyboard.

Nevertheless, the option to use keyboard and mouse should be left, because some of them still preferred to work sometimes with these tools – two users directly used the mouse and keyboard to save and open sketches and to answer Skype calls. They also expected to confirm or cancel actions on the screen directly from the paper sheet. Consequently, users stated that more functionality should be implemented on the paper.

One of the users was also left-handed and he stated that he had no problems using the A3 page for sketching and that he could reach every function quite well.

As shown in Appendix A.11 the first exercise was to describe the functions on the paper before using the system, here the users had some difficulties to understand the meaning of the *Block Other User* icon and the *Skype* icon; for this one they were thinking that it should be used every time they wanted to use *Skype* instead of utilizing it to bring *Skype* in foreground. Additionally, only one user of six used the *Block others* icon – they coordinated themselves through voice – and nobody used the *Skype* icon, therefore their presence on the final paper prototype could be questionable. Some users also stated that a resizeable, maximizeable window would be appreciated to gain more

sketching place and facilitate their reading on the screen.

During the test it was possible to realize that people have two different ways to draw rectangles. Therefore, two users had problems sketching them: there are users that make rectangles without detaching the pen from the paper – as implemented for the *Remote Sketching on Paper* – and others that do four connected lines – for them it was not possible to understand how the rectangle function works and they just drew lines and diagonals to complete the task – unfortunately, they also used the rectangle function first and thought that the same properties had to be applied for circles as well. Such problems – the *Block Other User* icon, the *Skype* icon and the drawing tools – could be solved by showing an introduction video when starting the application for the first time or by providing a manual.

In addition, a *polygon drawing* function would be appreciated by some users, instead of offering only the *line tool* one.

Some bugs in the prototype appeared when one user used the *Undo* or the *Redo* function when the other collaborator was drawing something. As soon as they also tried to write in capital letters, the points were not recognized properly by the system – the interpolation function doesn't work as it should do – therefore further debugging should take place.

As presented in Chapter 5 drawing mode icons on the screen, when selected, get an orange border. Unfortunately, this kind of feedback was not enough for some users, who started drawing in the wrong mode. A possible solution to this issue would be to implement a blinking state for these buttons when they are selected to reach a stronger highlighting.

Furthermore, as shown in Chapter 5 the virtual sketchpad should be split in different parts to avoid confusion during collaborative sketching: one for each user and maybe one where the sketches of all users are shown. Furthermore, some reference points or guidelines on the paper sheet would be appreciated by the users when drawing – simplification and help for the placement of objects on the screen. Additionally, one user would like the mouse cursor on the screen to somehow follow the pen before he clicks the paper – at the moment, not possible because of technology limitations.

Users also stated that, once a final application is relased, they would use it for sketching, because at the moment no other approach is capable of preserving the nature of sketching as well as the *Remote Sketching on Paper* application does.

Chapter 7

Conclusions and future work

7.1 Conclusions

According to the analysis of the existing technologies and users' behaviours, people are still sketching with standard paper and a pencil. The goal of this project was to provide a prototype based on the interactive paper technology, which still makes use of standard paper and pen, but is capable to digitalize the work and allows remote sketching over the Internet with other people. Moreover it should be pointed out, that this approach leaves the sketching operation as natural as it is with standard tools.

The prototype's usability, that was needed to conduct the usability test and to guarantee the nature of sketching, could be ensured through a detailed needs and requirements analysis, that was based on a user centered design process.

Developing the graphical user interface with Adobe Flex was a good choice, because it allowed to create interactive and attractive (highly customizable) graphical objects pretty quickly and easily. In addition, the GUI integration within Skype and the *iServer* framework occurred smoothly without any particular hurdles. Sending points or calling methods from the paper sheet to the remotely located client happened almost instantaneously. This shows, once again, the versatility of the *iServer* infrastructure.

Once the prototype was running, the usability test showed how users appreciated the fact that this technology allows sketching on a standard paper with just a pen and, at the same time, see the drawing digitalized on the screen. Users got also familiar with the paper prototype and the application. They understood, without reading any manuals, how to use the active components on the paper (selecting them with the pen), where it should be sketched or how a new sketch could be initialized (changing paper sheet).

Nevertheless, a serious challenge of the *Remote Sketching on Paper* approach is offered by the paper itself: currently it can't give any feedback. It is not possible to know the selected drawing mode or, when working in collaboration, where the pen should be pointed at to continue the sketch of the other connected user. To do so, the other sketch should be sent, then loaded and printed out with the consequence of a fast usability reduction. Furthermore, the cognitive burden of the users is also affected:

during the sketch process, they have to sketch, constantly check the screen, coordinate themselves through audio communication and last but not least be creative.

Anyhow, since a couple of years, researchers have been working on a particular paper that uses conductive ink to integrate touch sensors. These can change the state of the printed object[1]. Therefore, it would just be a matter of time until the described hurdles would be overcome and this project could be used as an inspiration to future *Remote Sketching on Paper* projects capable of delivering an infrastructure that fulfills all usability aspects. At the same time these possibilities would offer a perfect environment for sketching on paper in collaboration from remote sources.

7.2 Future work

One of the projects goals was to implement a working prototype. Therefore, not all requirements have been implemented yet and as we have seen in the usability evaluation (Chapter 6) some improvements can still be done. Taking in consideration the user centered design process and the mockups of Chapter 5, there are still modifications to do on the GUI and in the application's functions. A document management system (Media Browser, Media Viewer) for archiving, the search function, the login, export, send, etc. windows should be implemented as well. Additionally, according to the usability test, the redesign of the virtual sketchpad would (Figure 5.29, Chapter 5) improve the collaboration environment. Other missing requirements are the handwriting recognition for annotations, an UML drawing function, the automatic load of saved sketches on the screen when the user hits them on the paper with the pen, session recording, videoconference mode, pen recognition for the color and style selection and last but not least – as stated in the requirement analysis – transparent paper support. According to the usability test evaluation, redesigning or deleting some icons (i.e. *Block other user*, *Skype*) would make the paper prototype even more self-explaining. A more extensive debugging should take place as well, especially to optimize the drawing function that, as we have seen after the usability test, doesn't work as perfectly as it could be.

More user studies and usabilty test should definitely be conducted to improve further paper and application prototypes.

[1] `http://technology.newscientist.com/article/dn11989-interactive-paper-sounds-exciting-.html`

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Appendix A

Appendix

A.1 Project's proposal

As we have seen in the previous chapters build, design and planning projects normally involve different actors such as architects, designers, engineers and are often defined over various phases going from sketching the initial ideas through the whole design process until the definition of the final project, often in terms of plans, blueprints or schemes. Communication plays a major role in these phases since it is often important to exchange opinions between parties in order to advance to the next phase.

Despite large investments in CAD, office productivity tools and archive databases, sketches are still made on paper and even digital plans are often printed and annotated with relevant comments during discussion with different parties. As soon as a project involves more partners, the design process may become non linear and very complex to manage especially if partners collaborating on the same tasks are located far away from each other. In this cases sketches, or annotated plans are normally sent by fax or by physical mail to the other partners and discussed off-line once arrived at destination.

Also in design and planning, the earlier predictions of the paperless office no longer seem realistic. Paper as a medium has many advantages over digital media in terms of how people can work with it, both individually and in groups. Paper supports forms of collaboration and interaction that are difficult to mimic in current digital world. The tools and applications available nowadays does not take this into consideration and does not yet allow a synchronous communication involving different input channels like video or audio on one side and paper on the other side.

Instead of replacing paper, we focus on linking it with the digital world, enabling users to freely navigate within information spaces that span over printed and digital resources. The Interactive Paper technology developed within the GlobIS[1] group at the ETH Zurich[2] integrates printed and digital material allowing to effectively bridge the paper-digital divide.

The main focus of this project was to investigate how actions of sketching and

[1] `http://www.globis.ethz.ch`
[2] `http://www.ethz.ch`

handwriting on paper can be transmitted in parallel to voice or video communication in mobile, desk and meeting environment. The project analysed different aspects of remote sketching over paper taking into consideration both technical and social issues.

After analysing the existing approaches for synchronous sketching and voice communication, the development of a basic prototype connecting the well-known Skype application with the iPaper infrastructure will be investigated based on the Skype API[3] .

Before, during and after the development of the prototype, several user studies were planned. The aims of these studies were:

1. to identify the users' needs and requirements respectively
2. to ensure the prototype's usability

The prototype and the user studies were integrated along the way into extended prototype mock-ups and the further development of them will be based on the outcome of the studies. Given the tasks, the project was structured in three distinct phases. Depending on the time constraints the project covered the first two phases and the third phase respectively.

1. **Analysis of users' needs** Before implementing a prototype, the users' needs should be analysed carefully. Existing multimedia collaborative communication tools should be assessed in order to find out common characteristics and missing features. Target users of the planned system have to be selected among people that communicate via such tools and would like to use sketches during their session. With the help of an online questionnaire, target users should be asked about their needs/requirements when working with the system. The main focus of the survey is to find out, how users would like to use the sketching tool, and what features should be provided, respectively. Ideally, 34 or more persons should participate in this part of the study. The questionnaire should be designed such that it can be analysed easily (e.g. using Excel). At the same time the iPaper technology and the Skype APIs will be analysed in order to gain more knowledge about them and a very basic prototype connecting iPaper and Skype will be developed.
2. **User interface study** Based on the results of the requirements analysis, on the features provided by the available tools, and on the experience gained working with a paper-digital mixed application, the interactions between paper and digital artefacts will be analysed to build the basis for the design and implementation of extended prototype mock-ups. The prototype should be developed using the Adobe Flash / Flex platform[4] and the iFlash plug-in enabling links from paper to Flash to be built. It then will be evaluated for example with the help of a usability test to ensure the user interface's usability. 5 to 6 participants will be recruited for the test. The prototype will be implemented such that it provides logging of the users' interaction with the system, in order to analyse them automatically.

[3] `https://developer.skype.com/wiki/JavaAPI`
[4] `http://www.adobe.com`

3. **Collaborative working situation** The findings of the aforementioned test are used to improve the prototype mock-ups. In this phase further improvements in the setting of a remote collaboration as well as more complex aspects such as synchronising sketching with conversation, supporting sketching replay, enabling sketching publishing and reuse, etc. will be taken into consideration and potentially developed by means of an extended prototype mock-up. A further assessment will then take place. This study aims to test the system with regard to its appropriateness when two people work collaboratively using sketches. The study will take place in the frame of an experiment and a given task. Ideally, 9 to 12 teams (each with two people) should participate this part of the study. Participants should be familiar with multimedia communication tools, i.e. they should be a member of the target user group (see point 1). Also here, the logger will be used to analyse the users' interaction in detail. At the end of the project the student should submit a project report containing a complete description of the consulted resources and the related work as well as details about the implementation environment and related technologies. The proposed approaches and the developed infrastructure and mock-ups should be extensively documented and explained. The user studies should be described and all results reported accurately. The prototype usability should be analysed in the report and extensively described. Future improvements and further investigations should be provided.

A.2 Contact letter

Some minimal but not content-related changes were applied to the letters depending on the recipient.

English

Dear...,

We are working on a bachelor-project in collaboration between the Human Computer Interaction Group at the University of Konstanz and the Institute for Information Systems at the Swiss Federal Institute of Technology in Zurich (ETH).

The main focus of the project is to investigate how actions of sketching and handwriting on paper can be transmitted in parallel to voice or video communication in mobile, desk and meeting environment. The project will analyse different aspects of remote sketching over paper taking into consideration both technical and social issues. Before implementing the prototype we want to analyse users' needs carefully and therefore ask you, your colleagues and your students about your needs and requirements when working with this kind of system. We would like to find out how users would use the sketching tool, and what features should be provided, respectively. Therefore we are conducting an online survey. The survey takes 20 minutes and your collaboration is very crucial for the success of our project!

All data collected will remain confidential and no individual responses will be reported. The raw data will be used for statistical analysis. If you have any questions

regarding this survey, as well as if you are interested in the results of this study, please do not hesitate to contact us:

Nadir Weibel: weibel@inf.ethz.ch

Hermann Hofstetter: hermann.hofstetter@gmail.com

If possible we kindly ask you to advertise this online survey

(`http://www.befrager.de/befragung.aspx?projekt=3625`)

on your internal mailing list.

Thank you so much for your time and participation.

Best regards,

Nadir Weibel, Hermann Hofstetter

A.3 Survey's introduction

English—German version was published too

Welcome to our online survey and thank you for participating. The survey takes about 20 minutes of your time. Your collaboration is very crucial for the success of our project!

What is our goal?

The main focus of the project is to investigate how actions of sketching, free design and handwriting on standard paper can be electronically transmitted over the internet in parallel to voice or video communication – Imagine you would be able to freely design on a paper sheet and your drawings would be automatically transmitted over the internet to your design partner(s) (remote partner) in a digital form so that he could be able to instantly watch the sketch on the monitor – The project will analyse different aspects of remote sketching over paper taking into consideration both technical and social issues.

Before implementing the prototype we want to analyse users' needs carefully and therefore ask you about your needs and requirements when working with this kind of system. We would like to find out how users would like to use the sketching tool, and what features should be provided, respectively.

There are 20 questions in this survey. Some of them are facultative.

Questions marked with * must be answered. Thank you!

Privacy policy (only in German).

A.4 Evaluation of the survey

Personal information

The total number of participants at the time of the evaluation was 63 (n=63). Most of the participants were between 20 and 35 years old (Figure A.1). 40% of the population's gender was female and 60% male. The population education was quite high: almost every participant had an high school or higher degree (Figure A.2). Just only one person had a middle school degree, therefore it was quite easy for them to understand and answer the questions.

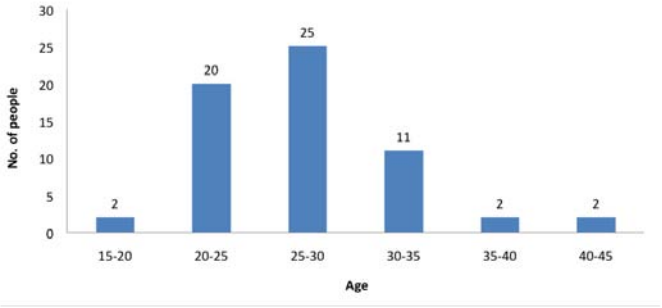

Figure A.1: Participants' age

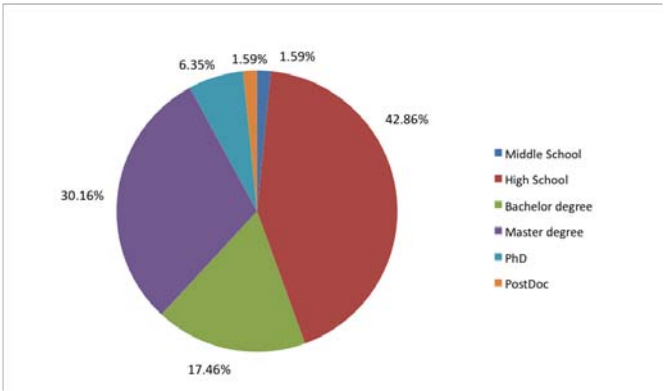

Figure A.2: Education

Current position

As said before, private companies, professionals' associations, institutions and universities' departments were contacted and asked to complete the questionnaire, nevertheless mainly students and researchers participated in this online survey, perhaps more interesting information could have been gained if more professionals would have completed it (Figure A.3).

Question: How long do you work with the computer per day?

This question showed that most people works more than 4 hours per day with the computer (Figure A.4), therefore, the users are quite comfortable with the technology's utilization.

Computer experience

Question: Do you use some kind of computer software to make phone calls, chat or communicate with other people over the internet (Skype or similar applications or instant messaging systems like Windows Live Messenger)?

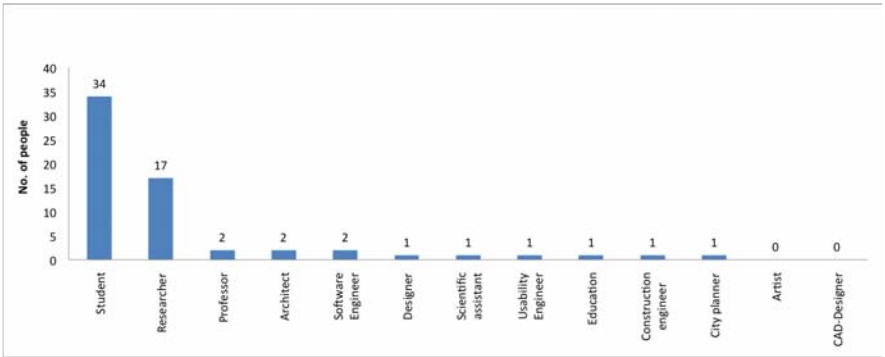

Figure A.3: Current position

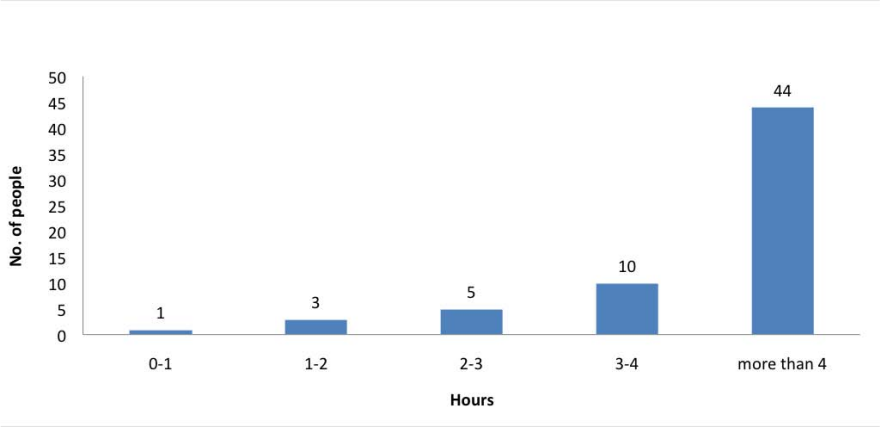

Figure A.4: Working with the computer per day

87% of the participants answered that they use some kind of software to make phone calls, chat or communicate over the internet with other people . The rest (13%) motivate their distance from this kind of tools as follow:

- An architect and a researcher said, that they prefer old tools like phones
- An usability engineer and a researcher said, that they don't have enough time to use these tools
- A usability engineer explained, that he has not enough people/partners to communicate with
- A researcher thinks that these tools are not necessary, because he never needed them

Question: In which situation do you use the application mentioned before?
As shown in Figure A.5, 36% of the people use this type of software only to communicate/chat/phone with friends and family), but 49% use it as well as for the private as for

the working environment (to communicate/chat/phone with work colleagues). Almost

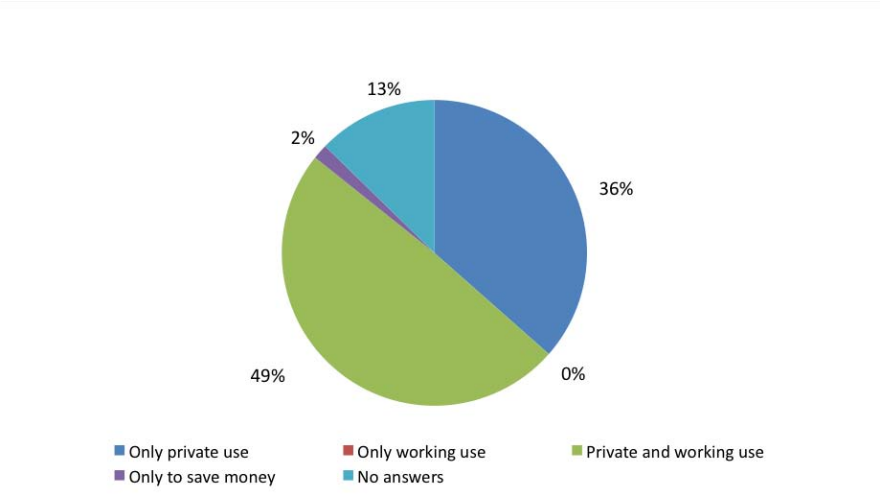

Figure A.5: In which situation used

the entire population is very familiar with software to communicate/phone/chat over the internet.

Question: Which function do you use at most?

The text function in these applications is used at most (Figure A.6). Audio function is in the second place and mostly used by students (4 of 33) and researchers (1 of 16), but 2 students (of 33) use the email function at most. There are 2 software engineers, one uses text as the most utilized function, the other one email. One professor uses email and the other one text.

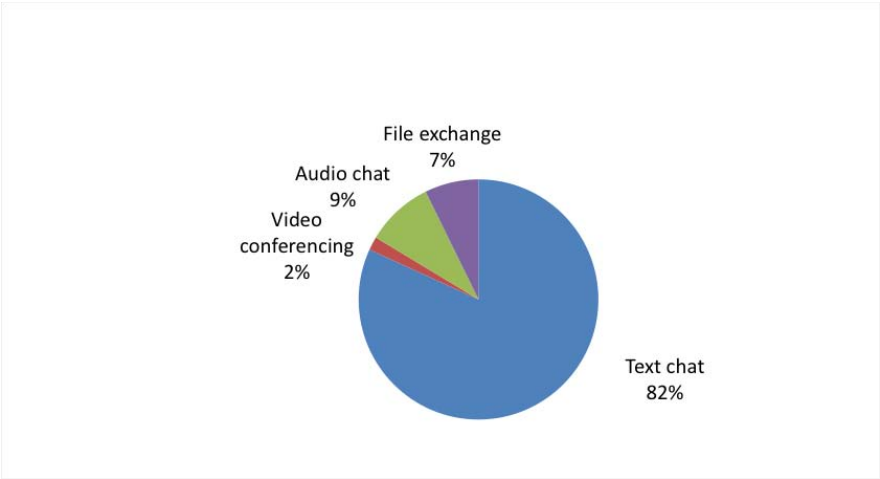

Figure A.6: Which function is most used

Collaborative work

This section of the evaluation was created to have better understanding about the software's user requirements and proceedings during a remote collaboration environment.

Question: When you work together with someone else on a project (collaborate), which technique or tool do you use?

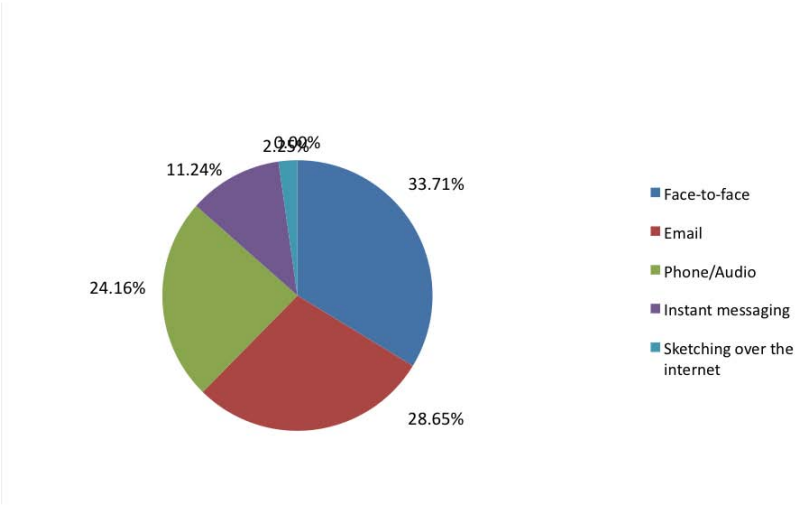

Figure A.7: Which technique or tool is used

Face-to-face is clearly the preferred technique (Figure A.7), followed by email and audio communication. Instant messanging plays a minor role and video tools are totally ignored for project collaboration.

Question: Please rank the following 7 activities (Communication (between the project members), Relationship building (between the project members), Coordination of the parties and the joint work, Individual work within the collaborative environment, Brainstorming/Sketching of ideas, Evaluation of the results, Discussion and acknowledgment of the joint work) based on their importance when you work together with someone else on a project (collaborate). As we can see from Table A.1, communication plays the major role. It is clear, that the supporting application should be some kind of software for communication (i.e. Skype – audio communication is its core function) and at the

Rank	Activity	No. of rank
1	Communication	29
2	Coordination of the parties and the joint work	18
3	Brainstorming/sketching of ideas	13
4	Individual work within the collaborative environment	13
5	Discussion and acknowledgement of the joint work	9
6	Evaluation of the results	26
7	Relationship Building	18

Table A.1: Ranking of activities by users during collaboration

same time coordination, workflow and participants management functions should be provided.

Question: How do you proceed (step-by-step) when you are collaborating on a project with someone else?

Examples on how users proceed (step-by-step), when they collaborate on a project with someone else are given in Appendix A.6 and they confirm the ranking of Table A.1.

Question: In order to work in collaboration on your project, do you currently use any software tool? 71% uses software to work on collaboration (Table A.2). 29% doesn't use one.

Question: Yes, I use the following one(s).

Software	**No. of people that use the software**	**User type**
Skype	36	Student, Researcher, Professor, Software Engineer, Designer, Architect
ICQ	16	Teacher
Windows Live Messenger	10	Student, Researcher, Software Engineer, Architect
Mailclient	8	Student, Researcher, Designer
Google Talk	2	Student, scientific assistant
Webspaces (BSWC, etc.)	2	Researcher
AIM	2	Student, scientific assistant
Yahoo Messenger	1	Student
StudiVZ	1	Student
CAD-Software	1	Architect
Linux Talk	1	Researcher
Powerpoint	1	Researcher
Wiki	1	Researcher
iChat AV	0	-

Table A.2: Software used for collaboration; Webspaces, StudiVZ, CAD software, Linux Talk, Powerpoint, Wiki proposed by users

Question: A virtual sketchpad/whitepad is an online system (application) that supports collaboration. It is possible to exchange thoughts and drawings together with colleagues, friends or family. Have you ever used one? Question: Yes, I use the following one(s).

89% of the participants never used a virtual sketchpad/whiteboard before and only one architect of two already used one. He used/uses Skype Sketchpad. All other users are students (as before Skype Sketchpad and two of them Windows Live Messenger Whiteboard).

Question: Imagine you would be able to freely design on a paper sheet and your drawings would be automatically transmitted to your online design partner(s) in a digital form. Would you use this kind of Remote Sketching on Paper? The arguments listed by questioned users for giving negative answers were the following ones:

- Physical meeting is missing
- Emotions, mimic, gesture not implemented
- Not fast enough or not enough functional

Remote Sketching on Paper

Question: Imagine that you are working together with someone else on a project and you use a software like Skype, Messenger etc. At the same time you can use a technology like Remote Sketching on Paper. It would be then possible that some functions for controlling the software and the remote sketching are provided on paper (interactive paper with operational elements). Please tell us where you would like to have/ to be able to use following functions: on paper (interactive paper), in the digital world (software graphical interface) or on/in both of them (paper and digital).

	Paper	Digital	Paper and digital	Result
Application control with buttons	3	35	25	Paper and digital
Application control with gestures	9	28	26	Paper and digital
Color palette	15	15	33	Paper and digital
File chooser	4	43	16	Digital
Switching between users' sketchpads	6	22	35	Paper and digital
Drawing tools selection	15	11	37	Paper and digital
Zoom, pan and scroll function	10	20	33	Paper and digital
Enhanced zoom	10	21	32	Paper and digital
Authoring of chatroom messages	3	43	17	Digital
Free movement/placement of sketchpad, chat and video windows	7	34	22	Paper and digital

Table A.3: Users' preferences on functions' placement: on paper, digital or both

Question: Would you like Remote Sketching on Paper to provide handwriting recognition too? Most of the people would like Remote Sketching on Paper to have handwriting recognition too, but there were also good explanations why it should not be implemented.

84% answered with a *Yes* and 16% with a *No*. Users' explanations for *No* answers:

- Handwriting express emotions and not mathematical formulas
- Not needed
- Too complicate for the software
- Doesn't work well
- Typing is faster with the keyboard
- Digital File with handwritten text is not needed, because they are used just for comments

Users' proposed functions

- History function recording all last working steps (proposed by more users: a student and a researcher) that can be undone – on paper and digital
- A student proposed a line drawing option to draw/modify lines with a slider (stepwise) – on paper and digital
- Predefined diagrams and drawings (like in Microsoft Powerpoint) should be provided (Researcher) – on paper and digital

- An architect would like to have transparent paper support to use it as a layer – on paper and digital
- Erasing tool (student) – on paper and digital
- 3D Switcher (student) – on paper and digital

Question: Let's say that our Remote Sketching on Paper approach is available. How important would it be as a function/subfunction of the following applications? Question:

Rank	Applications	No. of choices
1	Digital Imaging (e.g. Adobe Photoshop, Illustrator, GIMP, ...)	46
2	Office Applications (e.g. Word, Powerpoint, Openoffice, ...)	44
3	Applications for calling over the internet (e.g. Skype)	42
4	CAD applications (e.g. AutoCAD, ArchiCAD, ...)	36
5	Digital Publishing (e.g. Adobe InDesign, QuarkXPress, ...)	31
6	Instant messaging applications (Messenger, Google Talk, ...)	29
7	Proposed by participants: Google Sketchup	2

Table A.4: Ranking of activities by users during collaboration

Would you then start to use Remote Sketching on Paper to work in collaboration, if it would be available?

94% of the users stated that they would start using it.

Compared to the other question: *Imagine you would be able to freely design on a paper sheet and your drawings would be automatically transmitted to your online design partner(s) in a digital form. Would you use this kind of Remote Sketching on Paper?*

Now only 6% would not use *Remote Sketching on Paper* (before they were 10%) and 94% would start using it right now if available (before only 90%). Extra comments such as

> I have been waiting for a long time for a tool like this one

were given as additional input by different users.

Question: If you answered Yes: For what kind of projects or tasks would you use it?

A.5 Contact list

- Hochschule Konstanz
- Deutsche Bauzeitung
- Hochschule für Gestaltung und Kunst Luzern
- Hochschule der Künste Bern
- Zürcher Hochschule der Künste
- Associazione Studi d'Ingegneria e di Architettura Ticinesi

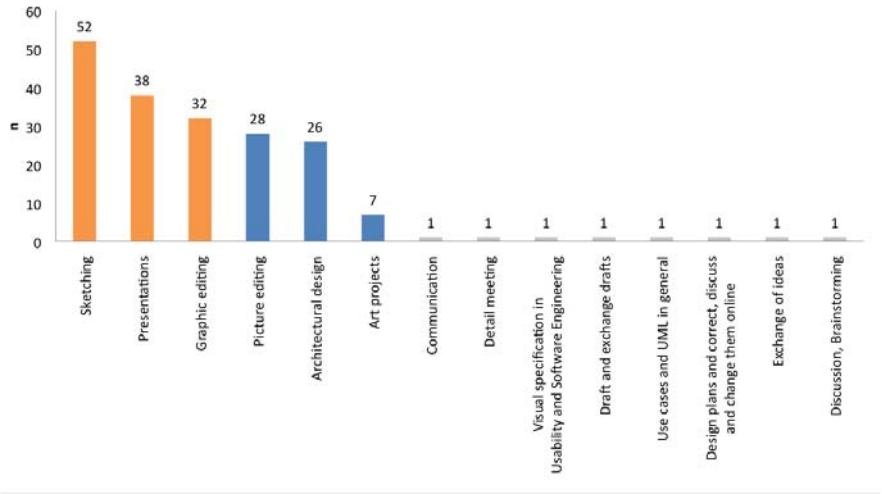

Figure A.8: Gray diagrams proposed by participants

- Schweizerischer Ingenieur- und Architektenverein
- ETH Department Architektur
- Architekturforum
- Interaction Design Association
- Nielsen Norman Group
- Skype forum
- ArchitectureWeek DesignCommunity Forum Index
- Hochschule Wirtschaft und Technik Chur
- Graphic Design Forum
- Universität Konstanz
- Software Engineers and Designer in different countries
- And many other Universities' departments around the world

A.6 Participant's feedback on working in collaboration

Student 1

1. What we want to do?

2. Discuss
3. Sketches and ideas
4. Distribution of first tasks
5. Individual or group tasks' completion depending from the kind of task
6. Meetings to discuss everything
7. Tell others what has been done
8. Continue to work together
9. Distribution of further tasks
10. On task completion, thoughts on presentation and on how everything will be applied
11. Presentation after divide the content between co-workers

Student 2

1. First group's brainstorming (Search for ideas, give first approximative path)
2. Research and find first draft in individual working sessions
3. Group's choice about the most appropriate ideas
4. Draft development (in individual working sessions, but with constant contact for open questions' explanations)

Student 3

1. Group discussion about the project
2. Individual drafting, construct,..
3. Discussion about individual work
4. Agreeemnt on choice of particular solution
5. Group's accomplishment of the project through task partitioning between collaborators

Student 4

1. Meeting
2. Discussion
3. Tasks distribution
4. Meeting and further discussions

Student 5

1. Define tasks
2. Unconventional approaches
3. Strong references and examples embedding as inspiration tools
4. Common target
5. Individual work
6. Check milestones
7. Follow the process

Student 6

1. Sketch individually
2. Put ideas together
3. Discuss
4. First sketches
5. Model testing
6. First drawings, then constant collaboration wit co-workers

Student 7

1. Analyse
2. Discuss and distribute tasks
3. First step together
4. Evaluation
5. Individual work with frequent meetings
6. Summarize results
7. Completion

Student 8

1. Brainstorming and first concept developing
2. First 10 meetings happen with all project's partners
3. Discussions and concept development
4. Distribution of project's parts for individual work; design of first drawings
5. Exchange and revision of individual work; periodic meetings
6. 10 meetings before project's completion, project's perfection

Student 9

1. Create ideas (each one alone)
2. Compare ideas
3. Find best solution together

Student 10

1. Analyse task and start making first individual thoughts about it
2. Group's brainstorming
3. Concept
4. Concretization
5. Targets
6. Make overview about the tasks
7. Distribute tasks
8. Trade-off and control of the results

Student 11

1. First fix own position in the project
2. Get information about other project's collaborators' position
3. Build working relationships between collaborators
4. Work on assigned, individual tasks without forgetting main goal and other collaborators
5. Celebrate success together with the team members and check strengths and weaknesses of the project or of the teamwork

Student 12

1. Fix appointment with project partners, exchange of emails and phone numbers
2. Meeting, task's and procedure's discussion, collaborative brainstorming or tasks distribution between collaborators, fix date for next meeting
3. Further working or collation of own result
4. Organize meetings till final result
5. Final discussion

Student 13

1. Meet people on the project
2. Collect contacts
3. Find abilities/features in meetings (strengths)

Student 14

1. Individual brainstorming
2. Group's brainstorming
3. Tasks's distribution
4. Individual work in one group
5. Meeting for overview and state of the work

Student 15

1. Formulate common goal
2. Brainstorming / Ideas' generation
3. Partition of the tasks
4. Fix sub-ordinate targets festlegen
5. Cross-comparison and communication between team members
6. Final discussion
7. Present results

Scientific assistant 1

1. Organize periodic meetings for information exchange
2. E-mail or phone ocmmunication

Scientific assistant 2

1. Meeting, process task
2. Brainstorming on possible solutions
3. Partition tasks between project's members' competence areas
4. Individual work
5. Meeting and discussion
6. Revised revision
7. Completion
8. The most important aspect is a fast, uncomplicated network between the project's members. Unappropriate communication makes project fail

Researcher 1

1. Groups' meetings (in emergency phone conferences) to present or discuss the actual state to explain the problem situation and for tasks' distribution
2. Individual work on own subtask under sporadic communication with the main project partner (i.e. coordinator) for direct feedback or to vote for a process
3. Transmission of own subresult to direct project's partner or coordinator
4. Publication of all project's members' subtasks
5. Reciprocal comments and corrections of subtasks by other members
6. Further cycle starting with step 1 till final result's accomplishment (cycle needs at least two days, typically five days)

Researcher 2

1. Start-meeting between all project's participants to discuss content and goals
2. Bilateral discussions, which regard mostly only two members of the project's team
3. Problem analysis, check resources for the project
4. Decide timeplan
5. Start the project

Researcher 3

1. Present the project
2. Document (autnomous)
3. Brainstorming
4. Decide tasks
5. Individual work with regular meetings and discussions (everyone should know the (state of the project)
6. Find solution in the team
7. Discussion

Researcher 4

1. Collect information
2. Coordinate collaborators
3. Meetings
4. Individual work
5. Evaluate/determine results

Researcher 5

1. First drafting of the project
2. Define work packets
3. Individual work and constant information exchange
4. Discussion of intermediate results
5. Evaluation

From education

1. Communication

Usability engineer

1. Check requirements
2. Fix appointments
3. Budget estimation
4. Work's coordination
5. Execute work and control it

Software engineer

1. I listen and write down the main points
2. I make questions and write down the main clarifications.

Construction engineer 1

1. Organize ideas
2. Develop concept
3. Distribute tasks
4. Process the tasks and coordinate with other team members
5. Create final documentation
6. Further project's phases supervision

Construction engineer 2

1. Exchange contacts
2. Use cases
3. Solution's drafting
4. Concept
5. Individual work with quality's control
6. Check if requirements observed
7. Evalutation of results
8. Celebrate with Prosecco

Professor

1. Clients' briefing
2. Present project in the team
3. Goals
4. Brainstorming/Ideas
5. Design/communication
6. Presentation to the client
7. Elaborate
8. Final presentation

Designer

1. Group's meeting
2. Procedures' discussion
3. Tasks' distribution
4. Individual work
5. Further meeting
6. Analysis

A.7 Additional Personas

Maximilian

- Age: 35
- Gender: Male
- Education: Master degree in Architecture
- Marital status: Married with 2 children
- Nationality: American
- Wealth: High income

Figure A.9: Picture of Maximilian (`http://www.imagevortex.com/`)

Maximilian is a very successful American architect and has two main offices in the USA: one is located in New York and the other one is in Los Angeles. For each office he has 15 architects. For bigger projects Maximilian has also freelancers that work for his company to support the marketing campaigns, especially during pitch phases.

Maximilian has always welcomed new technology to optimize the workflow process in his offices and therefore money could be saved and work could be much quicker and efficient. He is always looking for workflow optimization: he keeps himself updated on the latest products and technologies (software and hardware), he is a so called *early adopter*.

He also invests money to train his employees on new products. He is just a perfectionist. Having two main offices it is always very difficult to make the quickest decision at the right time, especially when frequently being in airports and at clients' meetings. Therefore he makes wide use of his mobile phone, his notebook, instant messaging software and his webcam, especially to keep in touch with his wife and his two children that live in New York.

He uses the public wireless in airports, parks, hotels and clients offices very often. Maximilian likes to travel light and he is looking for a tool/gadget/software that could optimize his work with his employees. He would like something light that could help him sketching, discuss and send or receive the work to his offices instantly over the internet.

Susan

- Age: 22
- Gender: Female
- Education: Bachelor of Arts – studying architecture
- Marital status: Not married
- Nationality: Swiss
- Wealth: Very low budget

Figure A.10: Picture of Susan (`http://www.imagevortex.com/`)

Susan is almost done with her studies: she is doing her bachelor project in architecture. She studies at the University of Lugano, Ticino, Switzerland, but she lives near Milan, Italy.

She has a quite small budget. She works as a part time employee in an architecture office in Milan as well. Therefore she is always on the move and has not a lot of time for friends now. Susan needs to change train to get to Lugano and every time she has to wait quite a long time before she can take the next connection. Fortunately there is a Starbucks where she can have breakfast comfortably and can do some of her work in combination with a free internet wireless connection; she thinks email is a very helpful technology.

She has a lot of ideas for her projects and does plenty of sketches, the problem is being always on the move: she always sketches on paper and sometimes when she arrives at the university to discuss them, she doesn't find them, because she has lost them on the train or has left them in the Starbucks or she has thrown them away by mistake. It has already happened that Susan couldn't discuss anything during a meeting with her professor, because of the mentioned problems. She would like a technology that could allow her to sketch on paper, at the same time send everything to her professor or to her boss' assistant, save it in some way *on the fly* on her laptop and give her a support for archive management.

Prof. Hofmann

- Age: 45
- Gender: Male
- Education: Professor in Architecture
- Marital status: Married, without children
- Nationality: German
- Wealth: High budget

Figure A.11: Picture of Prof. Hofmann (`http://www.imagevortex.com/`)

Prof. Dr. Hofmann is a teaching architecture professor at the University of Konstanz, Germany. He is specialized in landscape architecture and he is famous in this branch. The other famous architect Botti, who teaches at the University of Lugano, Ticino, Switzerland is his friend. They studied together and since then they have always kept in touch and work sometimes together on different projects.

Recently, Prof. Dr. Hofmann had the idea, being an innovative person, to teach a class through videoconference in Switzerland and one in Germany together with Prof. Botti. Both classes are divided in groups and each one is composed of German and Swiss students. These groups have to present their project at the end of the semester. With the video support, both professors want to supervise the students' work and would like to help them completing their task giving their input as experienced architects and professionals. The input and the work consist in sketches about the assigned projects. If this new type of teaching method has positive results they want to continue during the coming years too. Prof. Dr. Hofmann is looking for a technology that enables the remote digital exchange (over the internet) of sketches, audio and video between all collaborating parties.

Christelle

- Age: 35
- Gender: Female
- Education: Bachelor degree in interior design
- Marital status: Married, with 3 children
- Nationality: French
- Wealth: Low budget

Christelle lives in Paris. She studied interior design and has a bachelor degree. She works from home to stay as often as possible with her children. She has a client portfolio and

Figure A.12: Picture of Christelle (`http://www.imagevortex.com/`)

receives weekly, monthly tasks and comments/inputs. Christelle sketches mostly on paper (she doesn't like computers too much). Thereafter she usually scans them and sends everything via email to the customers and waits for a feedback, which arrives per phone or per email: customers don't have the time to rescan the commented or modified sketches, they prefer to call her.

Working for more companies at a time doesn't help Christelle to quickly find the sketches when she receives a phone call and sometimes her children are the cause of such a distressing organizational issue: sketches on the table, if not filed quickly, are being used as toys or as paper where children draw on.

Christelle would like to sketch on normal paper as she usually does but at the same time it would be extremely helpful if everything could be automatically archived and saved on her computer. In this case losing the papers with the sketches wouldn't be such a big problem, because she could always be able to print them out from the computer and of course send them directly, without scanning, to her clients.

Non-Persona – Karl

For whom the tool/system should not be designed.

- Age: 20
- Gender: Male
- Education: High school – studying Business and administration
- Marital status: Not married
- Nationality: South African
- Wealth: Low budget

Karl is from South Africa and has received a scholarship in business and administration at the Zurich University in Switzerland. He is a very busy student: after classes he works part time in a bank and twice a week, at evenings, he organizes meetings and talks with representatives of major companies at the finance club of the faculty. He

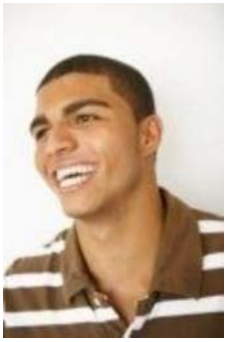

Figure A.13: Picture of Karl (`http://www.imagevortex.com/`)

speaks 4 languages (Afrikaans, English, German and Italian). He knows a lot of people and loves to participate in social events. He does almost everything with his computer: organizing the events, exchanging emails, calling over the internet with Skype (to keep in touch with his family in South Africa), making conference calls with the companies, creating presentations for his talks, doing his work and reading the classes' books on the computer.

Karl is a very talented speaker and presenter. During the presentations he likes to improvise, to involve the crowd and to walk around the room. He is using a remote control for the presentation, to be as mobile as possible and to skip from slide to slide, but he would like to have something more flexible and that would let him improvise more (for example skipping slides without letting notice it to the spectators) and that at the same time he could draw on the projected slides. He would like to work together on the slides with the other members of the club over the internet and he is looking for a cheap way (he is still a student) to remotely show his presentation live in different places (like other universities' finance clubs).

A.8 Modelling of the active components and the system behavior

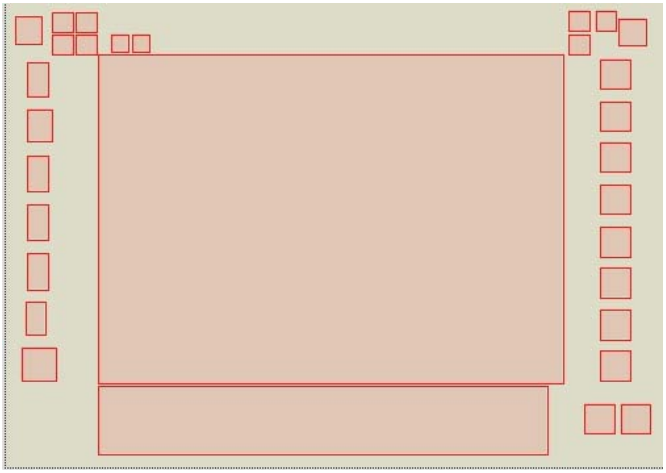

Figure A.14: Active components on the A3 paper sheet

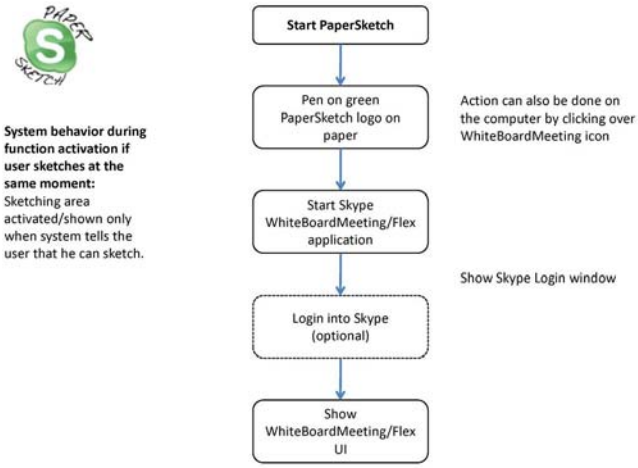

Figure A.15: Active component StartPapersketch

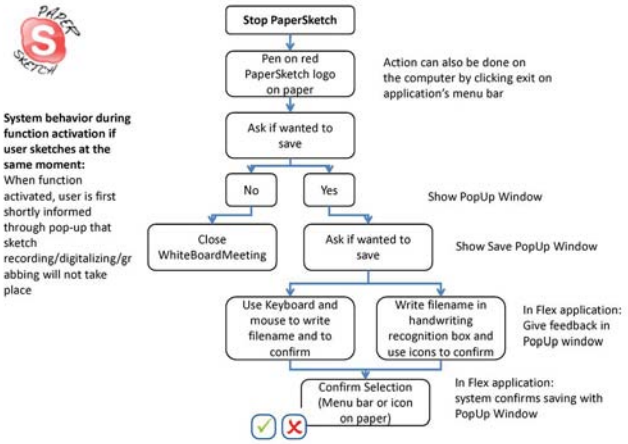

Figure A.16: Active component StopPapersketch

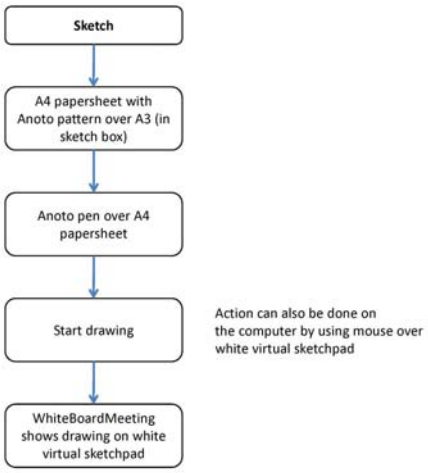

Figure A.17: Active component Sketch

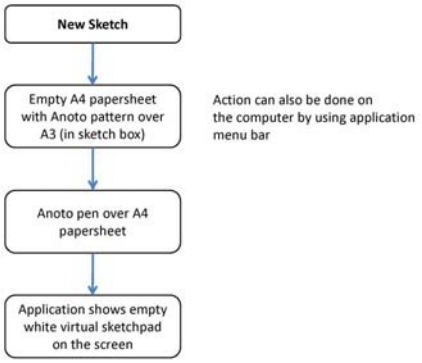

Figure A.18: Active component New Sketch

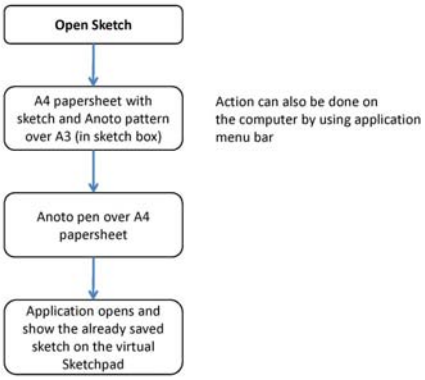

Figure A.19: Active component Open Sketch

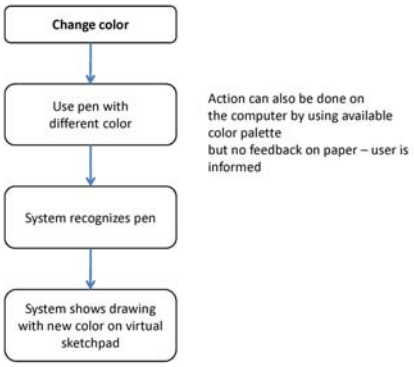

Figure A.20: Active component Change Color

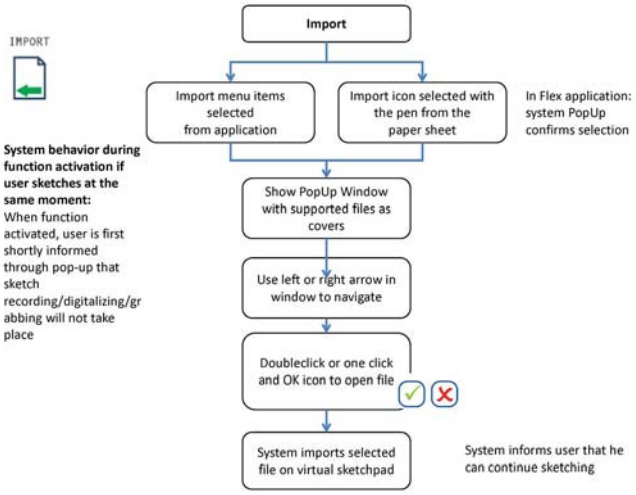

Figure A.21: Active component Import

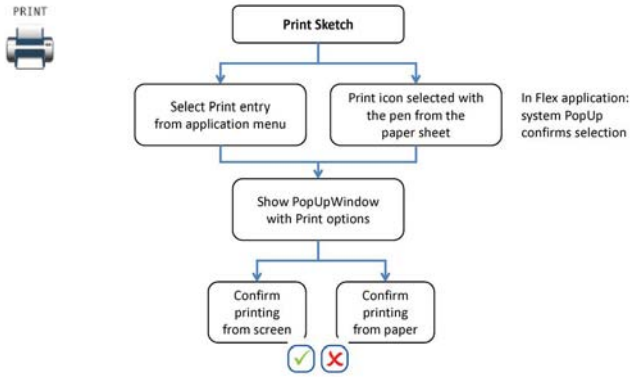

Figure A.22: Active component Print

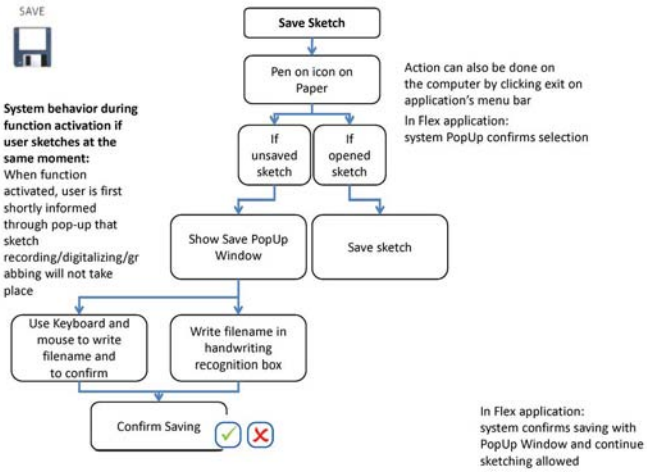

Figure A.23: Active component Save Sketch

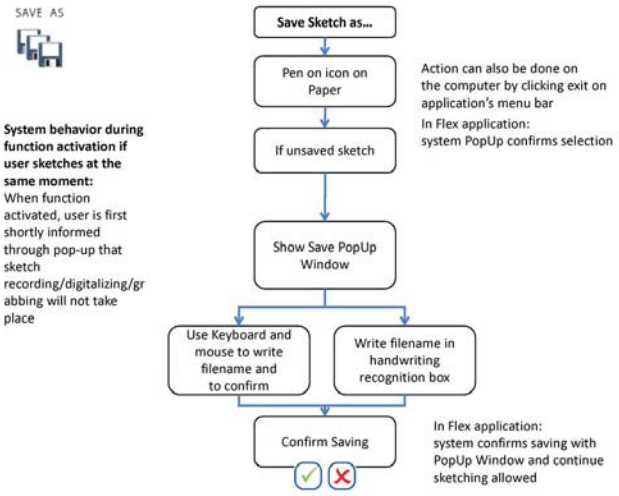

Figure A.24: Active component Save Sketch as...

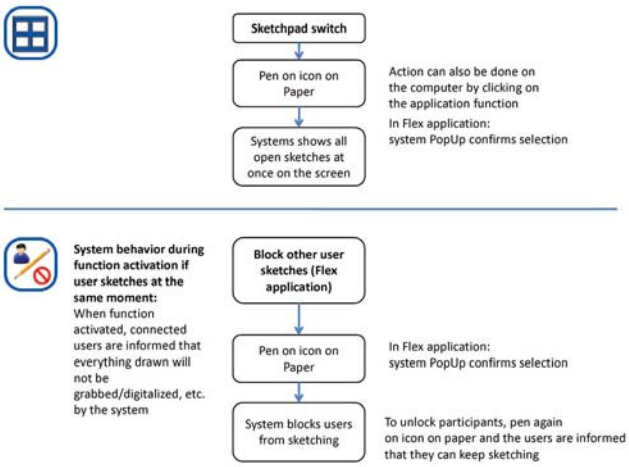

Figure A.25: Active component Sketchpad switch and Block other user skecthes (in Flex application)

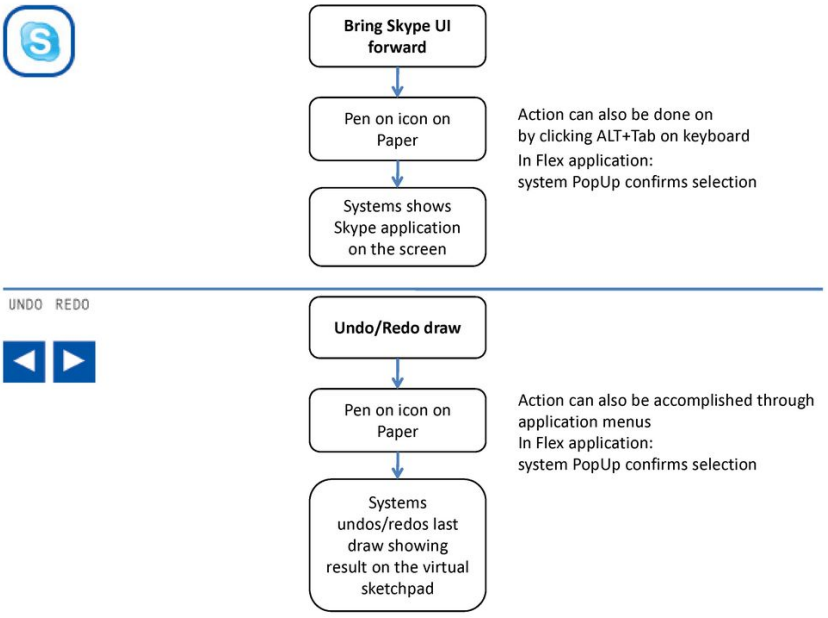

Figure A.26: Active component Bring Skype UI forward and Undo/Redo draw

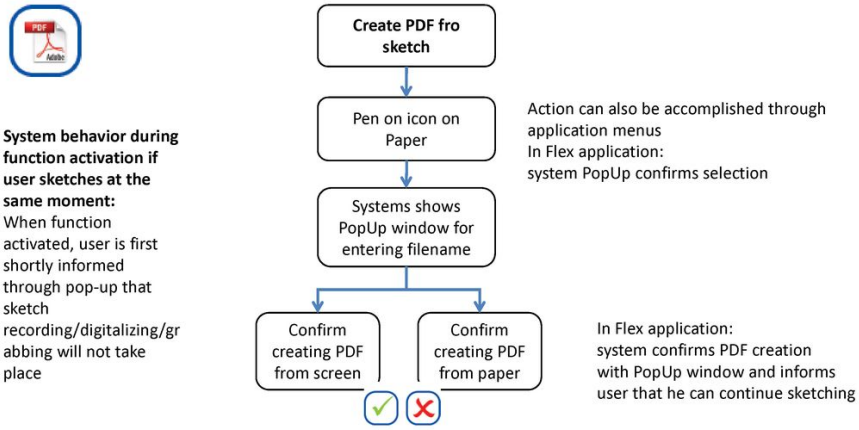

Figure A.27: Active component Create PDF from Sketch

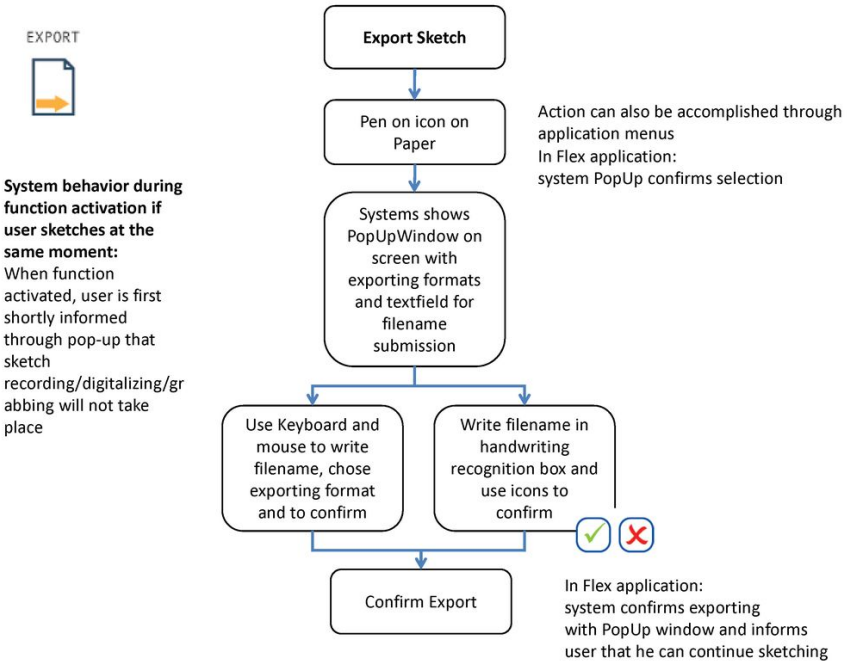

Figure A.28: Active component Export Sketch

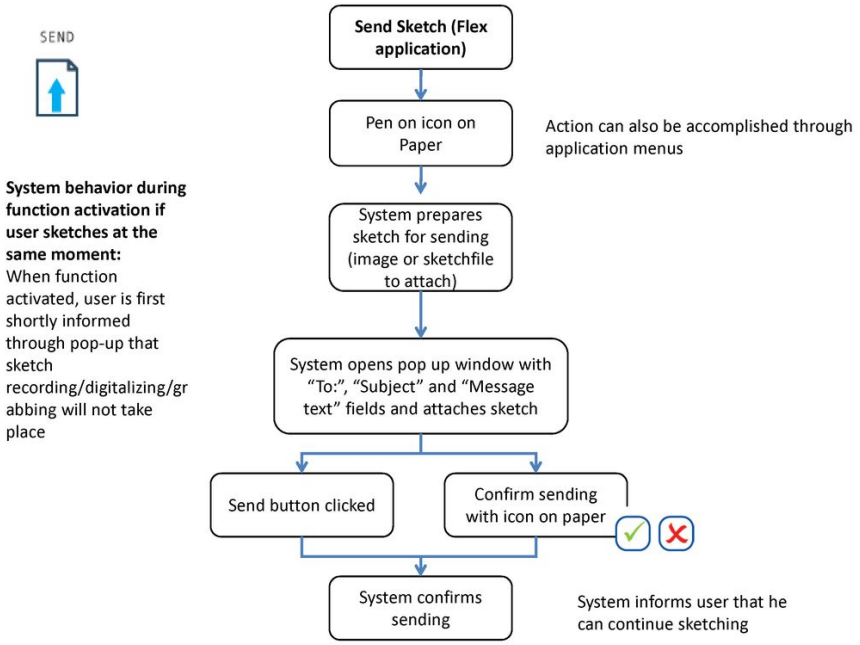

Figure A.29: Active component Send Sketch from Flex Application

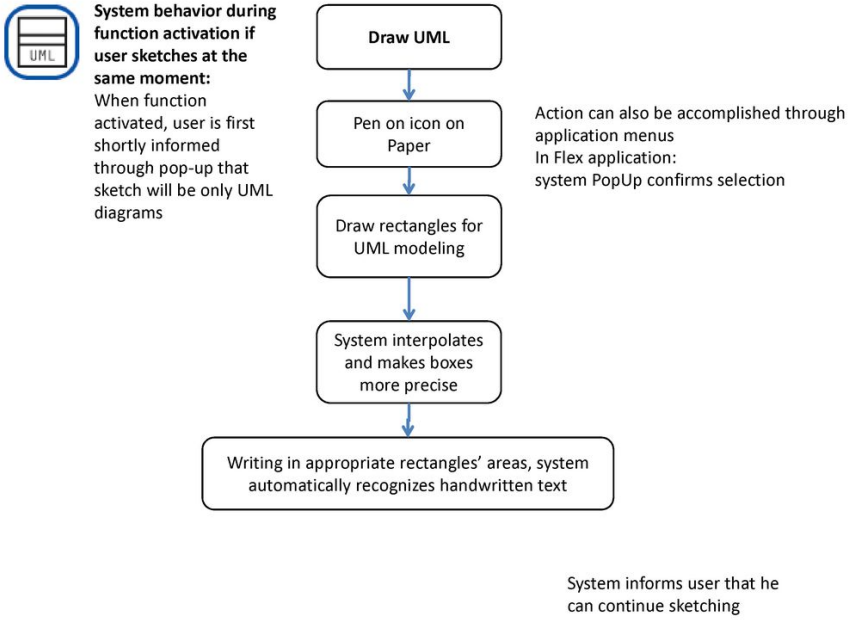

Figure A.30: Active component Draw UML

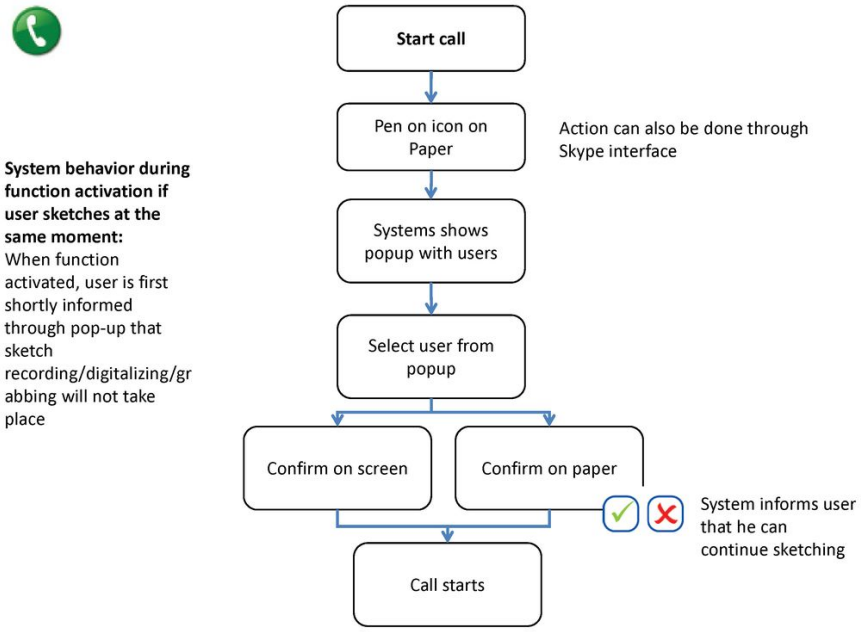

Figure A.31: Active component Start Call

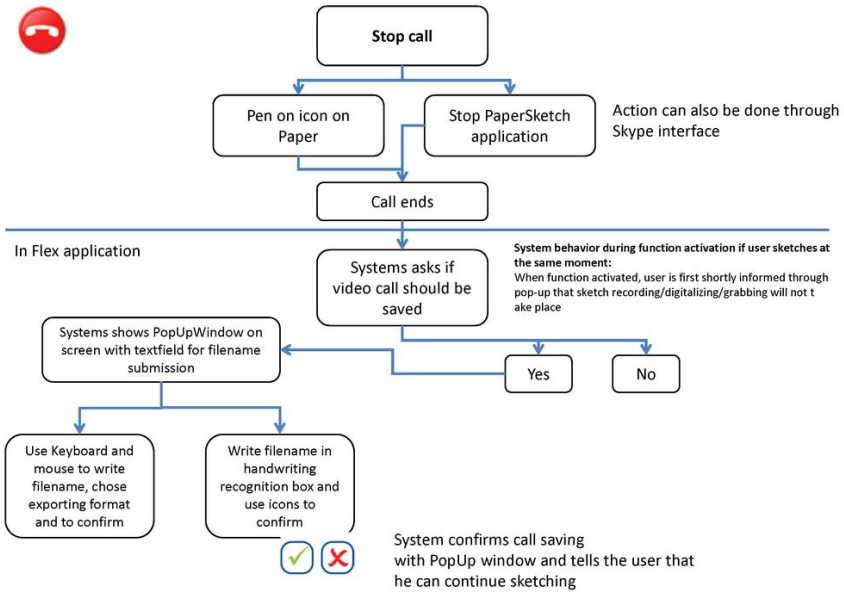

Figure A.32: Active component Stop Call

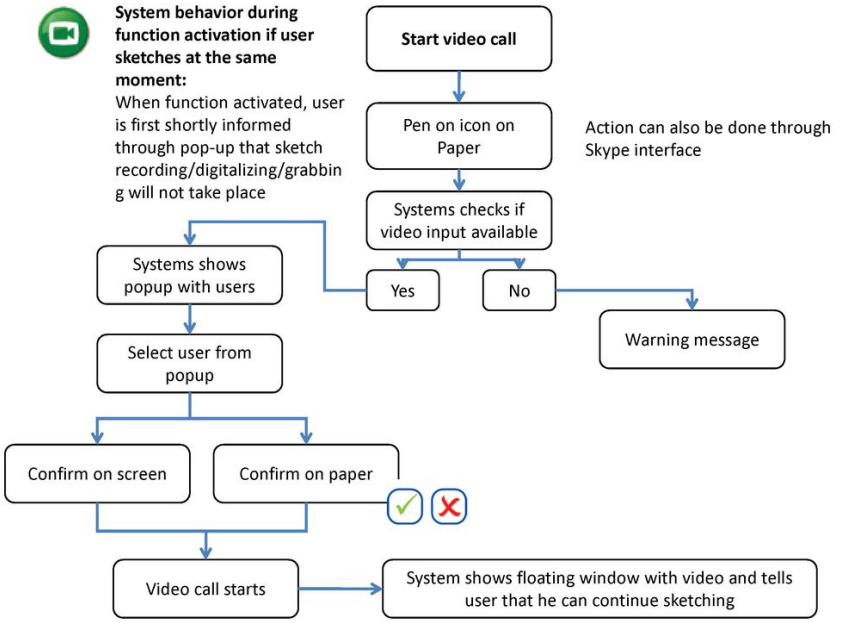

Figure A.33: Active component Start Video Call

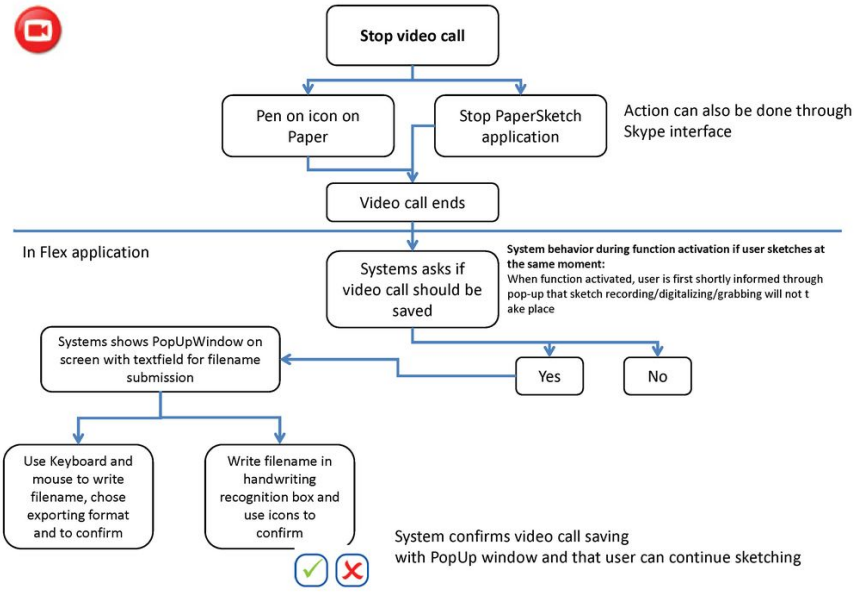

Figure A.34: Active component Stop Video Call

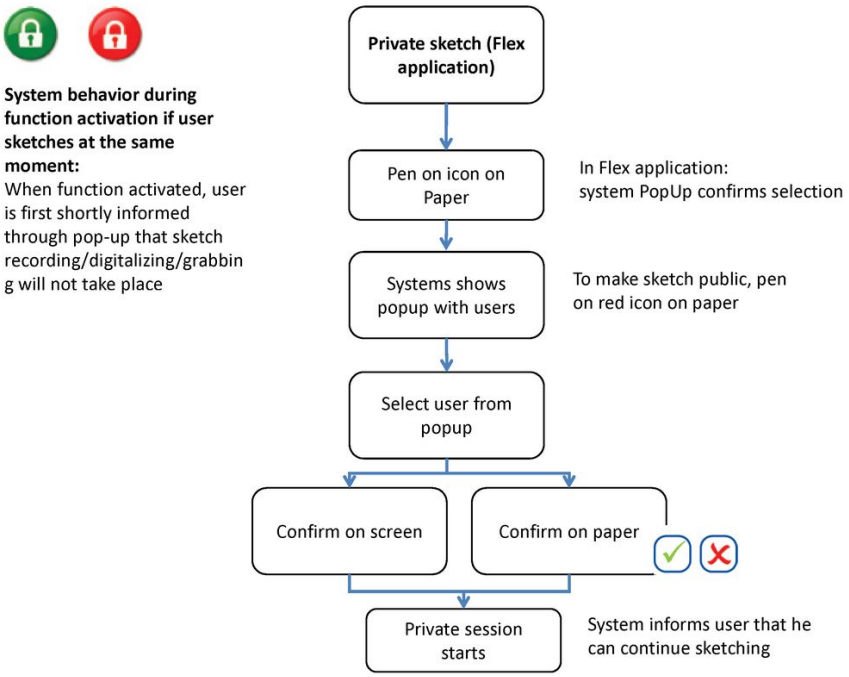

Figure A.35: Active component Private Sketch in Flex application

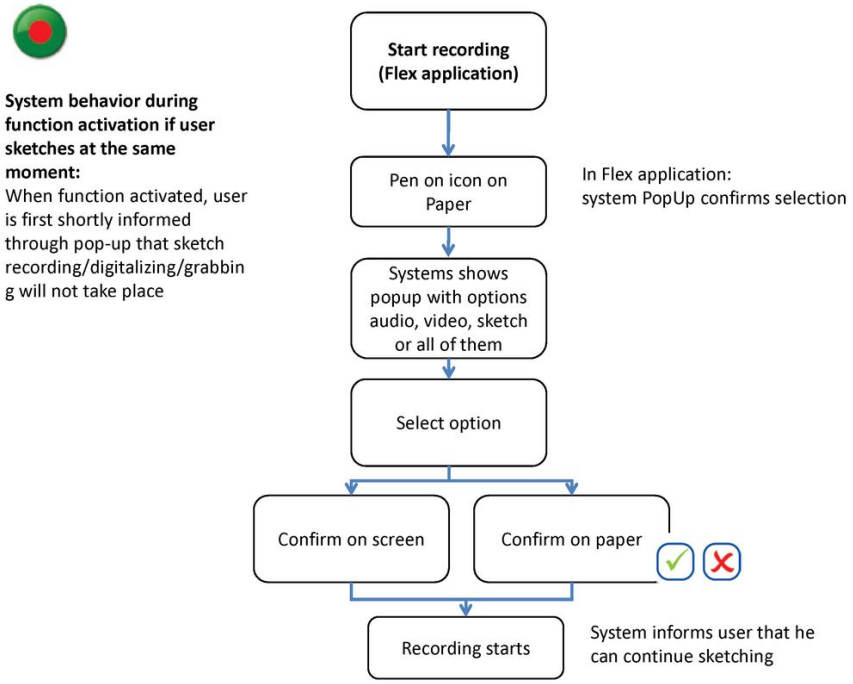

Figure A.36: Active component Start Recording in Flex Application

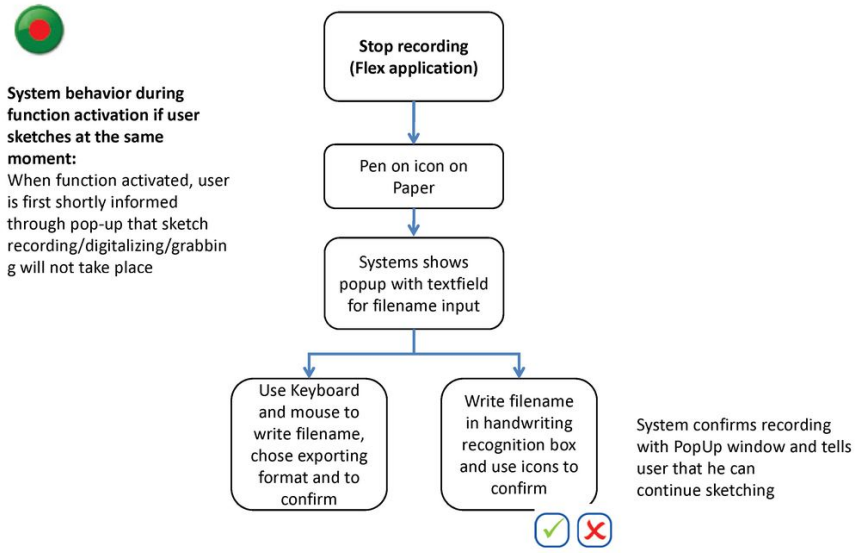

Figure A.37: Active component Stop Recording in Flex Application

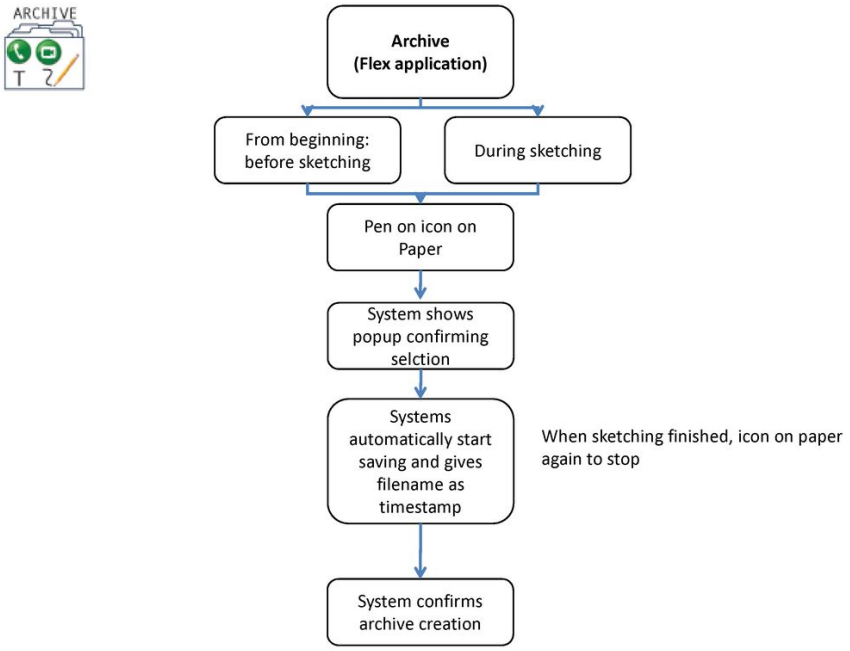

Figure A.38: Active component Archive in Flex Application

A.9 First sketches of the GUI

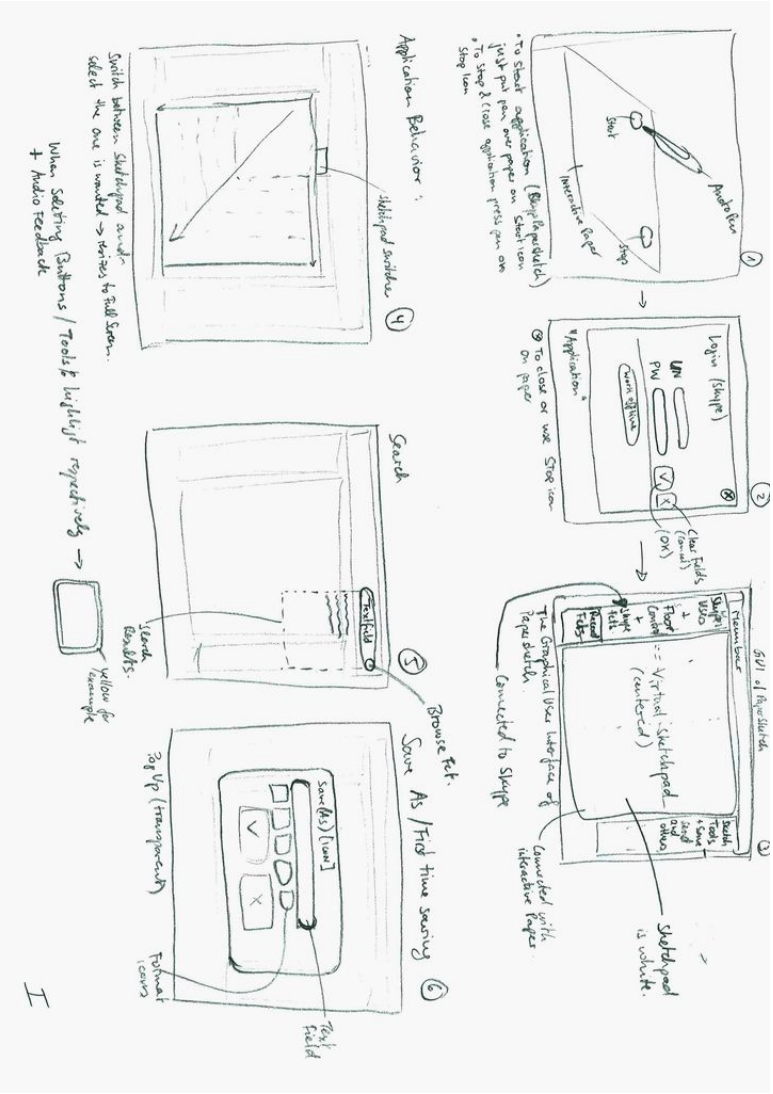

Figure A.39: User Interface low-fidelity prototype, part 1

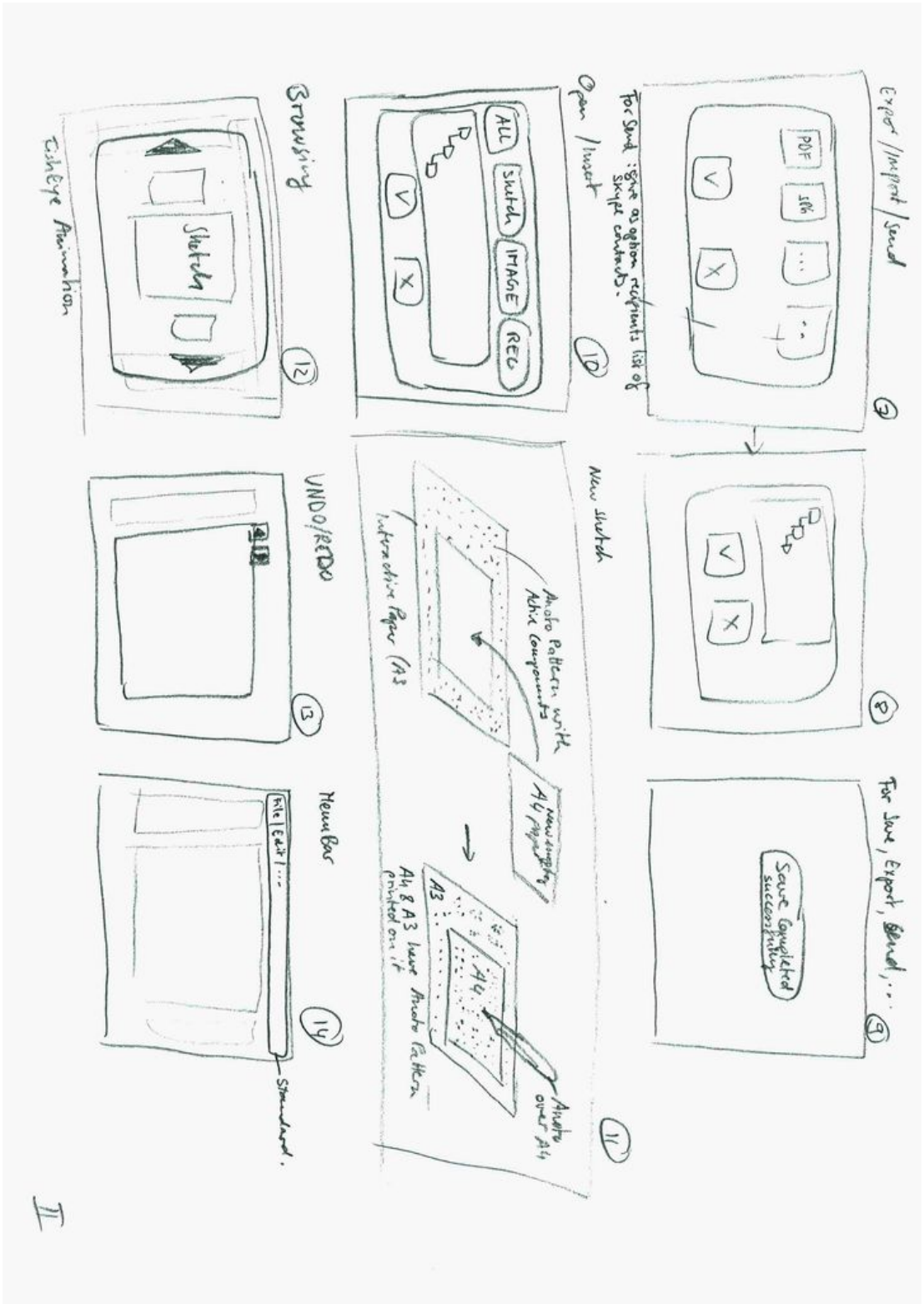

Figure A.40: User Interface low-fidelity prototype, part 2

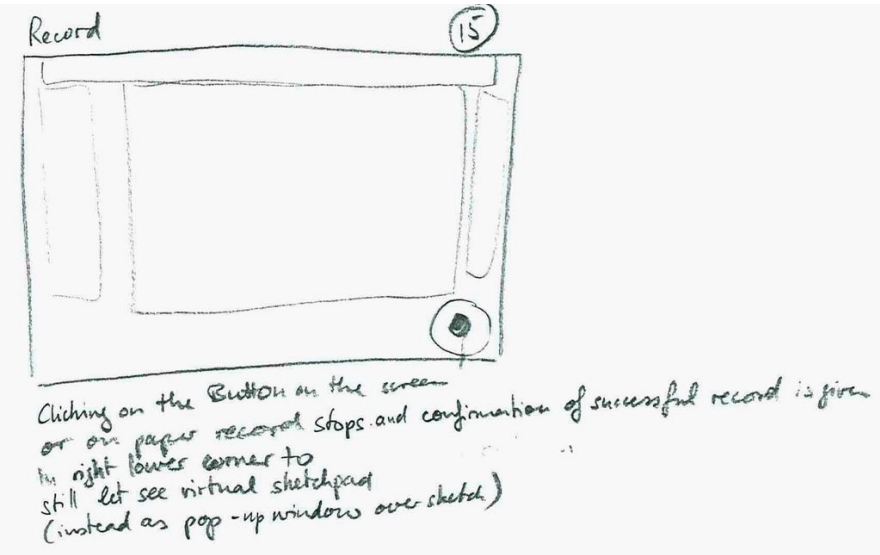

Figure A.41: User Interface low-fidelity prototype, part 3

A.10 Additional problem scenarios

Susan sketches in a mobile environment for the office where she works. Professor Dr. Hofmann gives classes in collaboration with Susan's professor

It is Monday morning, about 6 o' clock. Susan just arrived at the Milan main station to get the train for Lugano. She goes to Starbucks, has breakfast and uses the free Internet connection to check her email. Her supervisor at work is asking her to sketch a design proposal for a new kitchen table. It is getting late; she has to catch the train to Lugano. Once jumped in, she takes out a piece of paper and starts sketching. After a while she feels a little bit tired and decides to take a nap.

The train arrives at the Lugano main station, but Susan is still asleep. She suddenly wakes up and gets off quickly before the train leaves again. At the University, she needs another coffee. Quite soon she has two tough classes in landscape architecture with Prof. Dr. Botti. At the University café she drinks her coffee, decides to make the same sketch on her notebook and to send it as image to her supervisor. The problem is, that being in such a hurry to get off the train, she realizes that she has forgotten to take the piece of paper with her. She resketches it with her mousepad on the computer. Unfortunately it doesn't look exactly the same, as the one sketched before, but she sends it anyway because it is time to go to the lecture.

Prof. Hofmann from the University of Konstanz teaching in collaboration with Prof. Botti from the University of Lugano

After welcoming everybody and teaching some new techniques Susan's professor (Prof. Botti) takes out his notebook and starts the videoconference over Skype with Prof. Dr. Hofmann in Konstanz.

In both classes are eight students. Two groups are formed, each one of them is composed by two students from Ticino and two from Konstanz and they have to complete the new assignment for next week: landscaping of a hill and designing a new house on that hill – The key tasks are written down on the classrooms' blackboards – Two students are in charge of the landscaping and the other two of the building. Susan and a classmate, being students of Prof. Botti, are the *landscapers* and two students in Konstanz, the house designers. They will have separate collaborative sessions with Skype during the week and they'll exchange their ideas through email attachments. One of them is in charge to merge the different sketches, the other one to write down a report for the two professors on the collaborative work. In the last lecture, both professors will then explain their evaluations. Prof. Hofmann is in charge of recording and annotating the lectures given.

Maximilian informs his employees after a client meeting and communicates with his son

Maximilian is in New York now; he is at an important client meeting. He is quite excited and doesn't want to loose the pitch. He promises to deliver some design proposal as

soon as possible.

Right after the meeting and before going to the airport to catch his flight to Los Angeles (LA) (with a stopover in Dallas), he makes a phone call to his substitutes in LA to have them organizing a conference call between himself and all head designers at his company as soon as he arrives at the JFK airport. In the meanwhile, the client is sending them the brief.

Maximilian is in the cab now. He reaches for a piece of paper to write down the main points of the topics he wants to discuss with his employees. He arrives at the airport and has about two hours left for the organized conference call with his offices in LA and NY (New York). He decides to stay in the VIP (Very Important Person) lounge, because it is much more private than in a restaurant or at the boarding gates. He reaches for his mobile phone and starts calling his office in NY – the LA one is participating too – Maximilian takes out the paper from his pocket and tell them the key points of the project and tells them that he would like to see some design proposals as soon as he gets at the NY office. He tells them that he will sketch something during the flight. His sketch will be digitalized in the NY office with a scanner and sent to Los Angeles. After everything is settled he hangs up.

Maximilian has still some time to contact his son who is in a summer camp in France, but has no mobile phone. His son spends a lot of time on the web. Because of this, Maximilian reaches for his notebook, connects it with the wireless network of the VIP lounge and starts Skype. His son is online. They start speaking. Now it is time for Maximilian to get on the plane. He says goodbye to his son, closes his notebook and starts boarding.

Christelle is sketching furniture designs at home for her client.

It is Tuesday afternoon, Christelle just had lunch with her children and now they are playing in the living room together. Her husband is at work. Last Friday she sent her client per mail the design proposal for the new sofas line and now she is waiting for his feedback. Suddenly the phone is ringing: it is him, who tells her he wants to discuss some small details about three specific models she had designed. He explains her which models he is talking about. Christelle has many things on her desk and she realizes that one of her children had just played with the folder where she keeps her paper sketches organized. The client has to wait a while till she finds them. She can now write down the details that are given through. Once everything is explained, they both hang up and Christelle can keep playing with her children.

Later in the afternoon, when her children will be at the kindergarten, she will re-sketch the three sofas. As soon as she is finished with the new sketches, she wants to send them to the client as email-attachments; she usually uses a scanner or a digital camera to create the digital images. The scanner is already connected with her desk computer and the digital camera is somewhere in the house, so she decides to scan the sketches and not to take pictures. Before accomplishing this task she has to turn the computer on, start the image editing software (to scan the image) and the email client (to send the email with the pictures). After a couple of minutes, the email is being

processed, sent and it is on its way to the client.

A.11 Usability test tasks

User 1

Einleitung

Als erstes nochmals Danke, dass Du bei diesem Test mitmachst!

Die Applikation, die wir heute mit Dir testen, ermöglicht das Skizzieren auf Papier. Die von Dir erstellte Skizze wird direkt auf dem Computerbildschirm angezeigt. Einige Funktionen wie *Skype-Anruf Anrufen/Beenden*, genaue Rechtecke/Linien/Kreise zeichnen, usw. kannst Du direkt vom Papier (A3-Blatt, rechts) mit dem Kugelschreiber aufrufen und Du kannst mit einem der Skype-Kontakte über Internet zusammen skizzieren und kommunizieren.

Die Applikation ist bereits gestartet und der Kugelschreiber mit dem Computer verbunden.

Deine Hauptaufgabe ist eine neue Benutzeroberfläche für eine Mail-Applikation zusammen mit einem Skype-Partner, zu designen/skizzieren.

Ablauf

Bitte lese die Fragen mit lauter Stimme und wende dann, bei ihrer Lösung, die sogenannte Thinking Aloud-Technik an: bei der Interaktion mit dem zu testenden Produkt sollst Du deine Gedanken, Gefühle und Meinungen verbal äussern.

Legen wir los mit den Aufgaben...

Ein bisschen Übung...(5-10min)

1. Betrachte und beschreibe das A3 Blatt, das Du vor Dir hast: was glaubst Du, dass die einzelnen Symbole bedeuten und bewirken?

2. Skizziere ein Haus und ein Auto (schematisch), damit Du mit der Applikation mehr vertraut bist. Wie vorher erwähnt stehen Dir neben der Freizeichnung weitere Werkzeuge zur Verfügung um Zeichnungsobjekte genau zu erstellen

3. Die letzte Zeichenaktion passt Dir nicht und Du mŽchtest sie jetzt rückgängig machen. Benutze die Undo Funktion um die Darstellung am Bildschirm zu entfernen

4. Mmmh... jetzt hast Dir anders überlegt, benutze somit die Redo Funktion

5. Bevor Du mit deinem Arbeitskollege zusammenarbeitest, solltest Du noch die Skizze speichern (Hinweis: file extension *.jpg* musst Du unbedingt im Text-Eingabefeld eingeben).

Weiter geht es auf der nächsten Seite...

An die Arbeit... (ca. 30-40 min)

1. Bitte nehme jetzt ein neues Blatt. Berühre das neue Blatt mit dem Kugelschreiber.

2. Jetzt kannst Du warten bis Dein Arbeitskollege (Skype-Kontakt) sich mit Dir verbindet. Sobald Ihr verbunden seid wird es von der Applikation angezeigt (ein [c] neben dem UserID wird angehängt).

3. Als nächstes sollte Dich dein Skype-Kontakt anrufen. Akzeptiere den Anruf, um mit ihm zu sprechen

4. Wie vorher erwähnt, solltet Ihr eine Benutzeroberfläche für eine Mail-Applikation skizzieren.

5. Du kannst, falls nötig, deinem Arbeitskollegen blockieren während dem Du skizzierst, um Verwirrungen zu vermeiden. Dafür gibt es eine Funktion *Block other user* die Du jederzeit benutzen kannst. Du bist zuständig für die Benutzeroberfläche des Kalenders in der Mail-Applikation. Er hingegen, für die Benutzeroberfläche für die Email-Verwaltung. Jetzt könnt Ihr anfangen zu arbeiten.

6. Sobald Ihr Euch über Eure Skizzen einig seid, könnt Ihr den Skype-Anruf beenden und die Verbindung trennen

7. Last but not least, solltest Du die Skizze, die Du auf dem Bildschirm hast, speichern

8. Danach solltest Du in der ersten Skizze (die mit dem Haus und dem Auto) zusätzlich einen Hund zeichnen und als neues File abspeichern.

Danke für's Mitmachen!

User 2

Einleitung

Als erstes nochmals Danke, dass Du bei diesem Test mitmachst!

Die Applikation, die wir heute mit Dir testen, ermöglicht das Skizzieren auf Papier. Die von Dir erstellte Skizze wird direkt auf dem Computerbildschirm angezeigt. Einige Funktionen wie *Skype-Anruf Anrufen/Beenden*, genaue Rechtecke/Linien/Kreise zeichnen, usw. kannst Du direkt vom Papier (A3-Blatt, rechts) mit dem Kugelschreiber aufrufen und Du kannst mit einem der Skype-Kontakte über Internet zusammen skizzieren und kommunizieren.

Die Applikation ist bereits gestartet und der Kugelschreiber mit dem Computer verbunden.

Deine Hauptaufgabe ist eine neue Benutzeroberfläche f§r eine Mail-Applikation zusammen mit einem Skype-Partner, zu designen/skizzieren.

Ablauf

Bitte lese die Fragen mit lauter Stimme und wende dann, bei ihrer Lösung, die sogenannte Thinking Aloud-Technik an: Bei der Interaktion mit dem zu testenden Produkt sollst Du deine Gedanken, Gefühle und Meinungen verbal äussern.

Legen wir los mit den Aufgaben...
Ein bisschen Übung...(5-10min)

1. Betrachte und beschreibe das A3 Blatt, das Du vor Dir hast: was glaubst Du, dass die einzelnen Symbole bedeuten und bewirken?

2. Skizziere ein Haus und ein Auto (schematisch), damit Du mit der Applikation mehr vertraut bist. Wie vorher erwähnt stehen Dir neben der Freizeichnung weitere Werkzeuge zur Verfügung um Zeichnungsobjekte genau zu erstellen

3. Die letzte Zeichenaktion passt Dir nicht und Du möchtest sie jetzt rückgängig machen. Benutze die Undo Funktion um die Darstellung am Bildschirm zu entfernen

4. Mmmh... jetzt hast Dir anders überlegt, benutze somit die Redo Funktion

5. Bevor Du mit deinem Arbeitskollege zusammenarbeitest, solltest Du noch die Skizze speichern (Hinweis: file extension *.jpg* musst Du unbedingt im Text-Eingabefeld eingeben).

Weiter geht es auf der nächsten Seite...
An die Arbeit... (ca. 30-40 min)

1. Bitte nehme jetzt ein neues Blatt. Berühre das neue Blatt mit dem Kugelschreiber.

2. Jetzt kannst Du Dich mit Deinem Arbeitskollegen verbinden: auf der Applikations-Benutzeroberfläche am Bildschirm, werden Deine verfügbaren Kontakte angezeigt und es wird Dir erklärt wie Du Dich mit einem von ihnen verbinden kannst. Sobald Ihr verbunden seid, wird es von der Applikation angezeigt (ein [c] neben dem UserID wird angehängt).

3. Als nächstes sollte Dich dein Skype-Kontakt anrufen. Akzeptiere den Anruf, um mit ihm zu sprechen

4. Wie vorher erwähnt, solltet Ihr eine Benutzeroberfläche für eine Mail-Applikation skizzieren.

5. Du kannst, falls nötig, deinem Arbeitskollegen blockieren während dem Du skizzierst, um Verwirrungen zu vermeiden. Dafür gibt es eine Funktion *Block other user* die Du jederzeit benutzen kannst. Du bist zuständig für die Benutzeroberfläche des Kalenders in der Mail-Applikation. Er hingegen, für die Benutzeroberfläche für die Email-Verwaltung. Jetzt könnt Ihr anfangen zu arbeiten.

6. Sobald Ihr Euch über Eure Skizzen einig seid, könnt Ihr den Skype-Anruf beenden und die Verbindung trennen

7. Last but not least, solltest Du die Skizze, die Du auf dem Bildschirm hast, speichern

8. Danach solltest Du in der ersten Skizze (die mit dem Haus und dem Auto) zusätzlich einen Hund zeichnen und als neues File abspeichern.

Danke für's Mitmachen!

A.12 Usability test interview

1. Wo sind die meisten Probleme aufgetaucht?

2. Hast du Verbesserungsvorschläge?

3. Was war besonders gut?

4. Würdest Du diese Software zukünftig benutzen?

5. Für welche Aufgabe denkst Du, dass diese Software am besten geeignet ist?

A.13 Evaluations of the usability test for each user

Pretest–Monday, 23.06.2008

User 1

The user recognizes the drawing tools icons very easily. He doesn't understand the *Block Other User* icon, because it is not enough self-explaining and its function is not recognized. The Undo/Redo icons are not too clear, he thinks that they are meant to turn pages. The area to put the A4 page is self-explaining enough for him. Writing area is understood, but he states that turning the page for more writing space, will irritate him. During sketching the user is always looking on the computer screen to check if the drawing is shown properly. He states that with the freehand function he has the most fun. Once told him to use the undo/redo function, he has no problems to find, understand and use it. When he saves the sketch, the user would like to write the filename on the A3 writing area, instead of writing it on the screen with the keyboard. As soon the file is saved, he sees that the filename is added on the window title and knows that it has been saved. He is disappointed, that it is not possible to confirm or cancel actions on the screen directly from the paper sheet. He is comfortable when he has to make a new sketch and uses a new paper sheet to do it. At the same time he is disappointed that the filename of the old sketch is still shown on the application title. He would like to have it erased. The Skype icon is not understood as function to bring Skype in foreground, he thinks it must be used every time he wants to use Skype. The

user encounters some issues when he wants to write something on the sketch: not every point is showed properly. During collaboration he coordinates himself with the other user through voice. Only after a while he sees how the drawing modus state is shown. When sketching in collaboration, he asks if it is possible to move the drawn objects on the screen. During the opening operation he expects that when a sketch is positioned on the A3 page and he clicks with the pen over it, the application opens the sketch automatically.

Interview

Problems

He tells that the application is not really for cooperative sketching and that the WYSIWYG principle is violated. There is few feedback on what happens on the other side. Too much has to be coordinated with voice. The coordination work is giant: the user has to concentrate on the paper sheet, the screen, conversation and last but not least he has also to be creative. The cognitive burden is quite high for the user.

Input to make it better

More functionality should be implemented on the paper, including handwritten recognition. The keyboard interaction should be much more less. The ideal case would be: use the computer screen to see only the changes of the other collaborator.

Quite good

Paper functions, control of the computer, drawing and sketching.

Quite bad

Collaborative working is not convincing. At the moment, it could be used more for single mode sketching. For a multi-user scenario, multiple sketchpads on the coputer should be used for every collaborator and then maybe another one where they can sketch together.

Would use it?

If the mentioned problems would be solved, he would use it straight away.

Application scenario

Brainstorming sessions, creative sessions, focus groups in the same room at the same time for 4-6 people.

User 2

The user doesn't understand the Block other user and the Skype icon. Furthermore, he doesn't know how to draw a rectangle and a circle: for example, to draw a rectangle he owuld draw 4 separate lines for each edge instead of drawing the rectangle entirely without making a pen-up. The line function works well for him and he tells, that he likes to draw with this application. As the previous user, he would like to use the text area on the A3 page to input the filename in the textfield in the Save Window. He also understands and uses the marking on the A3 page to place the A4 page correctly. When he receives the Skype call form the other user, he would like to answer it with the pen on the paper. During the collaboration session he has some difficulty to place drawing objects over designed sketch of the other user, but the proportions of the paper give him some help. He still doesn't check how to draw the rectangles. To reopen the previous

sketch he uses takes the old papersheet properly as it would be in the real world. He states for the second time that it has a lot of fun drawing.

Interview

Problems

Application is still buggy. There should be some points of reference on the paper and on the screen during collaboration, to place drawing objects over the other person's sketch. The *Block other user* functions is not needed, because he could coordinate himself with his collaborator through voice. Drawing rectangles and circles not natural (he didn't understand how to draw).

Input to make it better

Having misunderstood how to draw rectangles and circles he thinks that these functions should be implemented better. The mouse on the screen should somehow follow the pen before the pen hits the paper. He would like a color palette on the paper and the symbols on the paper should be exactly as on the screen.

Quite good

Drawing and sketching is natural, much better than with the mouse and the same time it is fun. The learnabilty is fast.

Would use it? Application scenario

He would use it as drawing tool, freehand drawing tool. Tells that for remote collaboration would use it only as a game like the *Yahoo Montagsmaler*.

Test session 1 – Wednesday, 25.06.2008, 10:15-11:15

User 1

The user is left-handed. He understands the icons on paper quite well but the block other user he is not able to tell what it is meant for. He says that he will try it later on. As soon as he starts drawing he laughs and he has fun. To check if the sketch is recognized he always looks on the computer screen. He has no problems to start a new sketch. When he has to save the sketch, as the other users, he would like to write the filename in the text area on the paper. When he starts the call he laughs again and shows happiness on his face. During collaboration he coordinates himself and the other user on which side of the sketch area they should draw. He uses the rectangle function properly and is satisfied of the result. The writing is not precise but he doesn't look upset and rewrites over the written text to let it appear on the screen. He coordinates the work with the collaborator over voice. He uses the block function properly. He wants to integrate the collaborator's sketch in his one. He is successful assuming where to select on paper the not existing object. The proportions of the paper and the screen help him. Audio feedback attracts his attention when changing papersheet. Now he watches the computer screen for feedback less then at the beginning of the test and during sketching he says: *Funny... I like it!*

Interview

Problems

He complains about the line drawing function, which should be able to provide

a polygon function. The system had some problems to recognize written test. Import/export not self-explaining enough, what actually happens.

Quite good

Even if he is left-handed he has no problems, feels right. He likes the freehand drawing a lot.

Would use it? Application scenario He would use the application for remote collaboration, but tells that it would be also do a good job as standalone application (for comics designer, etc.). He states that he had a lot of fun working with it.

User 2

He doesn't understand the meaning of the Skype, Pdf and Block other user icons. He looks very comfortable during the drawing functions selection. To save the sketch he uses the keyboard straight away. When he receives the Skype call he would like to answer it form the paper. He laughs and feels happy when he draws in collaboration for the first time. To stop the conversation he wants to use the paper. To open the previous sketch he uses the computer and then takes the paper. During the test he laughs a lot and seems to have a lot of fun.

Interview

Problems

He says some drawings are not always recognized properly. He would like to work on a bigger/resizeable window and the currently selected drawing mode should appear more clearly on the screen.

Input to make it better

Points of reference on the paper would be very useful when sketching in collaboration. At the moment is very difficult to know where the collaborator has sketched. He says that the sketch opening should happen without screen interaction, but by clicking with the paper on the sketch. *Wanna lose sketch* on the confirmation window is too informal for him, something like *Do you want...* would be better. He mentions again that a resizeable window should be implemented.

Quite good

He likes the rectangle and freehand drawing function a lot. He has also positive comments on the Skype communication integration. Drawing with the pen is much better than with a mouse or a graphic tablet.

Would use it? Application scenario

He would use the software more in single-mode than in collaboration.

Test session 2 – Wednesday, 25.06.2008, 11:15-12:15

User 1

He thinks that the send icon is to send sketches over Skype and not as email attachment. He can't tell what the Block other user and Skype icon do. He uses the undo function a lot to correct sketching errors even if objects don't disappear from the paper. He checks his work frequently on the screen. He really likes to draw: during the waiting time gap

he asks if he can continue drawing. He wants to use the line function as a polygon tool. He likes the option of creating new sketches by just changing paper sheet. During the collaboration he automatically draws some reference points on the paper to know where they are drawing.

Interview

Problems

The application is still buggy. Synchronisation with collaborator is difficult (he had to draw reference points). Input to make it better Some reference points or guidelines/pattern should be provided on paper.

Quite good It is fun to draw.

Would use it? Application scenario The application is for designers more suitable, especially for people who constantly work with a pen.

User 2

Block other users, *Pdf*, *Skype*, *Import* icons are not self-explaining for him. He doesn't check how to draw a rectangle. He constantly watches the screen to check the drawings. During the saving task he would like to input the filename by writing on the proper text area on the A3 page. To accept the incoming Skype call he uses the computer straight away. During the conversation, before starting to sketch, he decides with his collaborator where on which side they should draw. They decide to split the screen.

Interview

Problems

The application is still buggy. During collaboration, reference points are needed. Icons are not self-explaining enough.

Quite good

It is nice to sketch on paper instead of using some othe rinput device.

Would use it? Application scenario He would use it only in a single-mode scenario as a sort of whiteboard.

A.14 The survey

Sprache auswählen:
English

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

globis

Welcome to our online survey and thank you for participating. The survey takes about 20 minutes of your time. Your collaboration is very crucial for the success of our project!

What is our goal?

The main focus of the project is to investigate how actions of sketching, free design and handwriting on standard paper can be electronically transmitted over the internet in parallel to voice or video communication - Imagine you would be able to freely design on a paper sheet and your drawings would be automatically transmitted over the internet to your design partner(s) (remote partner) in a digital form so that he could be able to instantly watch the sketch on the monitor - The project will analyse different aspects of remote sketching over paper taking into consideration both technical and social issues.

Before implementing the prototype we want to analyse users' needs carefully and therefore ask you about your needs and requirements when working with this kind of system. We would like to find out how users would like to use the sketching tool, and what features should be provided, respectively.

There are 20 questions in this survey. Some of them are facultative.

Questions marked with * must be answered. Thank you!

Privacy Policy (in German).

Please click "Next", to start the survey!

QUESTION 1 *

How old are you?

QUESTION 2 *

Your gender?

- ○ Male
- ○ Female

QUESTION 3 *

Your education?

QUESTION 4 *

... and your current position is?

- ○ Student
- ○ Researcher
- ○ Professor
- ○ Designer
- ○ Artist
- ○ Architect
- ○ Software engineer
- ○ Usability engineer
- ○ CAD-Designer
- ○ Other:

QUESTION 5 *

How long do you work with the computer per day?

- ○ 0 – 1 hour
- ○ 1 – 2 hours
- ○ 2 – 3 hours
- ○ 3 – 4 hours
- ○ more than 4 hours

QUESTION 6 *

Do you use some kind of computer software to make phone calls, chat o communicate with other people over the internet (Skype or similar applications or instant messanging systems like Windows Live Messenger)?

- ○ Yes
- ○ No

If you answered "No": Why?

If you answered "No" in the previous question, please skip the next two questions.

QUESTION 7

In which situation do you use the application mentioned before?

- ☐ To communicate/chat/phone with friends and family
- ☐ To communicate/chat/phone with work colleagues
- ☐ Other:

QUESTION 8

Which function do you use at most?

- ○ Text chat
- ○ Video conferencing
- ○ Audio chat
- ○ File exchange

QUESTION 9 *

When you work together with someone else on a project (collaborate), which technique or tool do you use?

- ☐ Face-to-face
- ☐ Instant messaging
- ☐ Phone/Audio
- ☐ Email
- ☐ Video
- ☐ Sketching over the internet

QUESTION 10 *

Please rank the following 7 activities based on their importance when you wor together with someone else on a project (collaborate).

e.g.:
1. Coordination of the parties and the joint work
2. Individual work within the collaborative environment
...
7. Communication (between the project members)

--- Communication (between the project members)
--- Relationship building (between the project members)
--- Coordination of the parties and the joint work
--- Individual work within the collaborative environment
--- Brainstorming/Sketching of ideas
--- Evaluation of the results
--- Discussion and acknowledgment of the joint work

The next question is optional.

QUESTION 11

How do you proceed (step-by-step) when you are collaborating on a project v someone else?
We would be very grateful, if you may list that in a concise way. Thank you.

QUESTION 12 *

In order to work in collaboration on your project, do you currently use any software tool?

○ No
○ Yes...

... I use the following one(s):

- ☐ Skype
- ☐ Windows Live Messenger
- ☐ Yahoo Messenger
- ☐ Google Talk
- ☐ AIM
- ☐ ICQ
- ☐ iChat AV
- ☐ Other:

QUESTION 13 *

A virtual sketchpad/whitepad is an online system (application) that suppc collaboration. It is possible to exchange thoughts and drawings together wi colleagues, friends or family. Have you ever used one?

- ○ No
- ○ Yes...

... the following one(s):

- ☐ Skype Sketchpad
- ☐ Windows Live Messenger Whiteboard
- ☐ Online Sketchpads / Whiteboards (e.g. www.virtual-whiteboard.co.uk)
- ☐ Sketcher
- ☐ Other:

QUESTION 14 *

Imagine you would be able to freely design on a paper sheet and your drawings would be automatically transmitted to your online design partner(s) in a digital form. Would you use this kind of "Remote Sketching on Paper"?

- ○ Yes
- ○ No

If you answered "No": why?

QUESTION 15*

Imagine that you are working together with someone else on a project and you use a software like Skype, Messenger etc. At the same time you can use a technology like "Remote Sketching on Paper". It would be then possible that some functions for controlling the software and the remote sketching are provided on paper (interactive paper with operational elements). Please tell us where you would like to have/ to be able to use following functions: on pape (interactive paper), in the digital world (software graphical interface) or on/in both of them (paper and digital).

	Paper	Digital	Paper and Digital
Application control with buttons (Video on/off, Audio on/off, Recording on/off, Send, Archive, "Private"-Sketching" on/off, etc.)	○	○	○
Application control with gestures (Accept, Reject, Undo, etc.)	○	○	○
Color palette	○	○	○
File chooser	○	○	○
Switching between users' sketchpads on the screen	○	○	○
Drawing tools selection (i.e.: Freehand, lines, Text, circle, squares,...)	○	○	○
Zoom, pan and scroll function	○	○	○
Enhanced zoom (rotation, tilt, skew)	○	○	○
Authoring of chatroom messages	○	○	○
Free movement/placement of sketchpad, chat and video windows	○	○	○

QUESTION 16*

Would you like "Remote Sketching on Paper" to provide handwriting recognition too?

- ○ Yes
- ○ No

If you answered "No": Why?

QUESTION 17

This question is optional.

Do you think about other functions that were not listed?
If so, please fill first the name of the function in the box and then specify again where do you want it to be applied (paper, digital, paper and digital)

Function 1

Function 2

Function 3

Proposed functions' classification

	Paper	Digital	Paper and Digital
Function 1	○	○	○
Function 2	○	○	○
Function 3	○	○	○

Do you have further comments or suggestions about possible other functions?

QUESTION 18 *

Let's say that our "Remote Sketching on Paper" approach is available. How important would it be as a function/subfunction of the following applications?

	not important at all	less important	neutral	important	very important	I don't know
Application for calling over the Internet (e.g. Skype)	○	○	○	○	○	○
Instant messaging applications (e.g Microsoft Live Messenger, GoogleTalk, ...)	○	○	○	○	○	○
Office applications (e.g. Microsoft Word and Powerpoint, OpenOffice, ...)	○	○	○	○	○	○
Digital imaging applications (e.g. Adobe Photoshop and Illustrator, GIMP, ...)	○	○	○	○	○	○
Digital publishing applications (e.g. Adobe InDesign, QuarkXpress, ...)	○	○	○	○	○	○
CAD applications (e.g. AutoCAD , ArchiCAD, ...)	○	○	○	○	○	○
Programming frameworks (e.g. Eclipse IDE, VisualStudio, ...)	○	○	○	○	○	○

QUESTION 19

Are there other tools where you think it would be important to include our "Remote Sketching on Paper" feature? Which ones?

QUESTION 20*

Would you then start to use "Remote Sketching on Paper" to work in collaboration, if it would be available?

- ○ No
- ○ Yes

If you answered "Yes": For what kind of projects or tasks would you use it?

- ☐ Graphic editing
- ☐ Picture editing
- ☐ Sketching
- ☐ Architectural design
- ☐ Art projects
- ☐ Presentations
- ☐ Other:

If you answered "No" in the previous question: Why?

Thank you for participating in this survey!

To return to the online survey please click on "*Back*".
To definitely close the survey, click on "*Finalize, save answers*". Your answers will be then saved in the database. If you don't want that your answers will be saved in the database, click on "Dispose answers". Doing this way you'll end the survey and your data will not be saved.

zurück

Appendix B

Glossary

BMP BitMaP

CAD Computer Aided Design

GUI Graphical User Interface

HTML Hypertext Markup Language

JPG Joint Expert Picture Group

LA Los Angeles

MXML Magic eXtensible Markup Language

NY New York

PDF Portable Document Format

PNG Portable Network Graphics

RFID Radio Frequency Identification

RGB Red Green Blue color model

SBD Scenario Based Development

UML Unified Modeling Language

USB Universal Serial Bus

VIP Very Important Person

XML eXtensible Markup Language