Development of an Ambient Intelligence System

Magazine eins

Issue 02

Concept

Prototypes

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Editorial

Motivation

Disturbance and loud soundscapes in offices are tiring and exhausting, especially in open plan offices. Most of all, people complain about colleagues making phone calls or talking with other colleagues. A space to retreat is one possible counteraction, but and time to release tension is difficult to find during a usual office day. An area which provides space for short relaxation and privacy, but at the same time the technical equipment to be productive is our approach for relieving stressed people.

Challenge

Phone calls and communication in offices are essential and cannot be eliminated just to improve the concentration of employees. Moving the calls to another place is obvious. But the change of location within the office is time consuming and in competition to productive working conditions. On the other hand, it can lead to new creativity and a better productivity if the space one is retreating to is equipped correctly. The change of location has to be as comfortable as possible. Every barrier between the usual desk and the new space is a serious problem for the existence of the product.

Approach

With the idea of improving communication in offices we explored the options to give people a space where phone calls can be made without disturbances. Thus, neither the colleagues get disturbed by the phone call one is making, nor is the caller disturbed by other people. To create a good working environment for employees, they have to have full access to their personal computer. We made a questionnaire and researched in the field of phone and office behaviors to validate our findings.
A technical prototype illustrates the functionality of the product, while a low scale model and 3D renderings were built to get an impression of materials and the overall design. Finally, a real size prototype is used to get an impression of the dimensions. For the financial feasibility we developed a business plan.

Result

To our surprise, we found out through the questionnaire that a lot of people leave their desk while making phone calls and that most of the materials our target group needs for their work is in a digital format. The real size prototype demonstrates that the end product can be smaller and still provide enough space for the user. The technical prototype gives a good impression of the workflow, while the setup-time between Comport and phone has to be improved, the connection to a remote computer is already very fast.

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Scenario

Eric returns from his lunch break in a good temper. The miso soup that he had for lunch was extraordinarily tasty and the day's work is almost done, although the afternoon has just begun.
On his way from the office door to his desk, he gently nods at his colleagues. Some of them are working on a project that should have been completed days ago, but is not coming to an end.
Back at his desk, he takes a look around and recognizes how stressed these people are and how glad he is not to be in their situation.
There is one important phone call left for this day, which he does not expect to be unpleasant, but to take at least an hour.
In order not to disturb his colleagues with a phone call, he goes to another room to make the call.
The computer in this room automatically establishes a connection to his computer, so that he can access the relevant Excel sheet to have all necessary information present when talking to the customer.
Only half an hour has passed when he leaves the "phone room" and returns to his desk.
Last mission for his day–accomplished.

The Final Idea

The idea of giving people extra space for communication is not new to us. In fact, this was one of the ideas that we had compiled after one week. Still, it took us a focus group and a prototypical implementation of a "ssssssh machine" to get back to where we started.

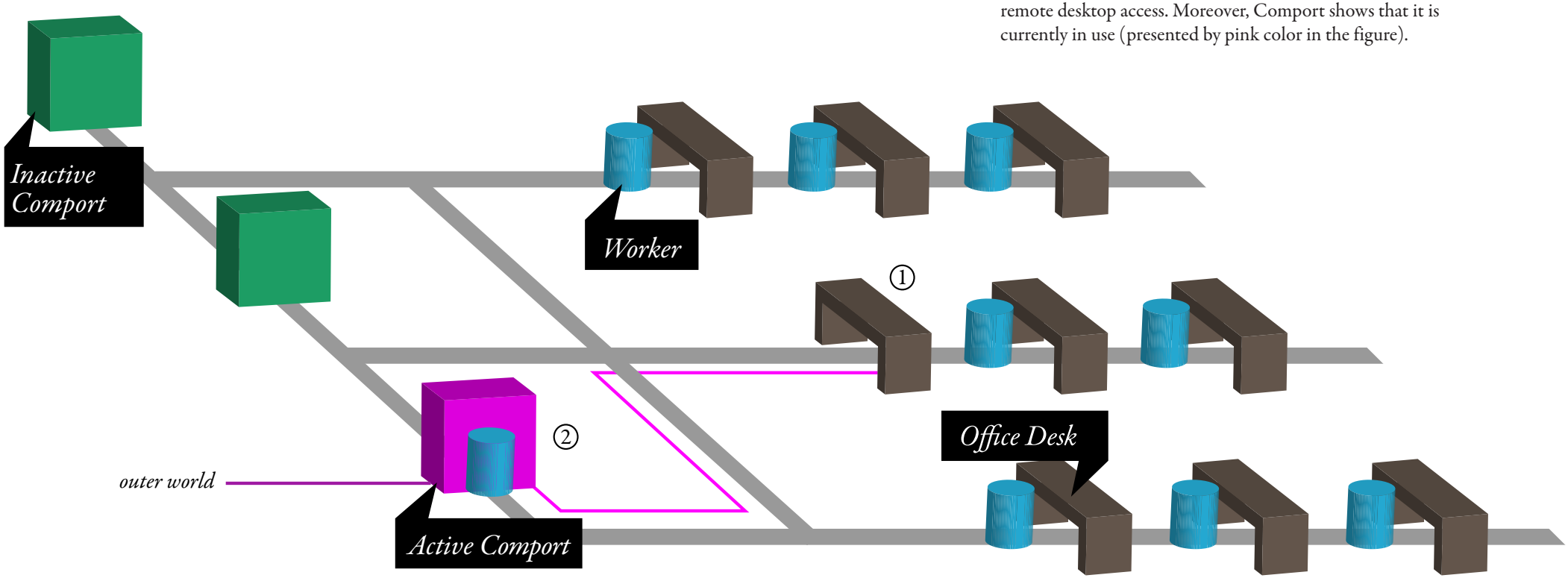
As the focus group as well as the prototype testing would show us later, distractions are context sensitive, which means, among other things, that noise does not necessarily have to be disturbing. In one situation one may consider background music to be distracting and annoying, in other situations it may be relaxing.
How people react to different stimuli depends on the kind of work they are doing and, more abstract, their physical and mental constitution.
Another notable remark of the focus group participants would be that potentially disturbing factors should rather be moved away to another location, instead of being completely eliminated.
With this in mind, we developed the idea of isolating potentially disturbing phone calls, which were considered most disturbing, to a place that offers most of the advantages of your personal desk. We call this approach "Comport".
When we think of a normal office day, we imagine people sitting in front of their desks, being creative, making phone calls, thinking about problems, reading emails and once in a while discussing problems with a coworker.

In fact, each of these tasks could be done at a different, more suitable location than the usual desk. When being creative, one may like to go outside for a walk in the park, during a phone call one may like to isolate oneself to focus on the phone call, when thinking about problems one may like to have only his computer in a dark and empty room and so on.

Our system helps people to switch places.
It can be imagined as a large phone booth where people go in and make their phone calls. The system automatically identifies the entering person and provides access to their personal computers. Phone calls can be held via a handsfree set and, while in the room, people will not be disturbed by others.
The system also recognizes when a person is already making a phone call and is about to enter the room. It will then switch to hands free speaking, as soon as the door is closed.
Not only the Comport behaves smart, but also the desk. It will, for example, shut down the display when a person is about to leave the desk.
The system will make work more productive and less exhausting.

Functional Principle

In Figure 7–1, the basic principle of Comport is shown. In step one, a person in an office receives a phone call on a mobile phone and leaves the desk to make the phone call in Comport.
In step two, the person enters Comport and is given remote desktop access. Moreover, Comport shows that it is currently in use (presented by pink color in the figure).



① User leaves desk to make a phone call
② User enters Comport & has remote desktop access

Figure 7–1: How Comport works

Research

Focus Group Evaluation

As the idea of Comport evolved, it was of essential importance to the team to verify the project's relevance and applicability to real life situations. Given the project's time scope and the availability of potential interview partners, we decided in favor of a focus group. This enabled us to draw qualitatively valid conclusions with a rather small group of participants.

The thesis, we attempted to validate, was that the main disturbances for people in an office are auditive and visual impacts. The participants started off with what came as a surprise to us. Two of them stated that they, indeed, had or had had an office but were hardly ever using it. Instead the group consented that they all had various fields of work that each required different environment parameters. They were not necessarily unhappy with that fact, but mentioned that a big downside was the lack of availability of information, documents and other materials in the respective work environment. The same applies for situations where people are in transit.
Asked for the relevance of working in one office with others versus having a room for oneself, our participants reflected pros and cons in various contexts. Not having people around when working on tasks that require a high level of concentration and a long uninterrupted period of time was considered more productive. This productiveness, however, comes at the cost of a higher stress level. For other tasks, such as conceptual work, input by others was highly appreciated and considered necessary. Offices with many people can facilitate this need for exchange.

The interview participants emphasized the context sensitivity of disturbances. As they pointed out, disturbances can be distracting as well as convenient, depending on factors like work load and personal mood. Independent from the way a disturbance affects people, there were a couple that nearly always lead to annoyance. Top mentioned was talking people, and especially conversations on the phone.

As it turned out, wether or not an external impact is perceived as a disturbance or a good excuse for taking a break highly depends on its context. The important factor in this consideration is, wether the individual is able to freely choose to interact with others or wether one is a victim of a given situation.

Questionnaire Evaluation

In order to get an impression of how people communicate in office environments, especially concerning phone calls, we decided to create a questionnaire.
The questionnaire was created to evaluate the following questions:

- In what situations do people leave their working places?
- Do people leave their working place for phone calls?
- How much time do people spend making phone calls?
- Do people mainly work with digital or analog documents?

The last question is to find out if a remote desktop connection, which is only capable of serving digital data, is sufficient for making phone calls away from the own desk.
We sent the questionnaire to seven companies that mainly use open plan offices with between 5 and 15 people.

All companies offer design and development services, which correlates with frequent communication with customers.

All companies that we sent the questionnaire to are companies that seem to match our target group. That means that the offices were not too large for a Comport to work efficiently and people did not spend the whole day making phone calls. Just imagine a Comport in a call center: the concept would not work, because all Comports would be permanently occupied, making them to "micro offices" instead of a place to stay temporarily.
Accordingly, these service oriented companies that do more than only communicate are our perfect target group.
Thirty participants completed the questionnaire. This gave us a good impression of the behavior of people working in these kinds of offices.
13 participants said that they leave their desk for making phone calls (the exact question was "Zu welchen Anlässen verlassen Sie Ihren Arbeitsplatz?"). This proofs that there is a need to make phone calls away from the normal desktop. We do not know the exact reasons for people to leave the working place. We assume that they do it for reasons of speech privacy and disturbances.
Except one person, our participants said that they mainly work with digital documents. This makes Comport suitable, because it makes digital document access sufficient.
Most of our participants say that when they work with analog documents, they use notebooks and sketchbooks. Notebooks are mostly small and people are used to carry them, so that using notebooks in Comport is not a problem. Sketchbooks are mostly larger than notebooks, but can be used in Comport, if needed, as well.

We asked 30 people from different agencies in the area of Frankfurt.

working mainly digitally — 29/30

number of phone calls — 5–50 a day

leaving desk for phone calls — 13/30

Research

Target Group

Comport does not only address one single target group. Instead, Comport addresses end users as well as people who will retail Comport, like interior designers and people who plan the offices.
These target groups all have a different point of view. For end users, the daily usability is the curcial criteria, whereas for interior designers, Comport e.g. needs to be seamlessly integratable into offices.

To reduce design complexity, Comport focuses on our primary target group: the end users.

Our end users are...

- people who work in open plan offices
- people whose work is not limited to a certain task
- people who do not exclusively make phone calls
- people whose working environment is mainly digital

Our user research, especially the questionnaire, proved that these people can be found in service oriented companies that are specialized on design and software development. Several conclusions can be drawn from these companies, respectively their employees.
The work they mainly do requires a high level of concentration. The level of education is high; they often have a technical background and have a high aesthetic standard.

Research

Figure 13–1: Feeling Comport's target group

Existing Approaches

Open plan offices are currently very popular - at least among employers. "Großüraumbüros haben Vorteile - für Arbeitgeber: niedrige Baukosten, kurze Wege, schneller Inforamtionsfluss, leichte Arbeitsüberwachung." [1] Even potentially more traditional bodies, such as the University of Applied Sciences, Darmstadt, are moving away from separate single offices, towards more open solutions. As our focus group talk affirms, there are, indeed, advantages beyond financial considerations, like, for example shorter distances for communication. All potential advantages, however, come at the cost of privacy and silence. To counteract those insufficiencies, different companies have taken various approaches we evaluated.

Googles's approach aims towards small conference rooms and working areas in which people can be productive without distraction from the outside. As the images show, all of their concepts emphasize comfortability and privacy.
More reduced concepts are presented in a short article from "Kulturspiegel" [1]. The scantiest version comes from the "Prooff" [2] design collection and is nothing more than an open telephone booth without telephone. Thus its name: "PhoneBox". It offers relatively little to the user. Only some minimal visual barrier and hardly any acoustic shielding. It does not look very comfortable and it is unclear what the incentive would be to use it.

A more elaborate version by Bene Büro Möbel is "PARCS Phone Booth" [3]. If one considers Phone Box to be a portrayal of the former open phone booths, PARCS Phone Booth goes even further back in time and mimics the open phone both's predecessor: the closed phone booth. Here, the visual and acoustic shielding is more pronounced and a user is provided with more privacy. As far as one can tell from the pictures, PARCS Phone Booth provides a standing aid, that makes it more comfortable than Phone Box.
Vitra offers a broader concept. "Communal Cell" is a modular furniture system that can be used to create small and mid-size compartments within a larger office. These compartments are not only meant for work, but can also be home to an office kitchen, meeting environment or such. As they are about shoulder-high, they offer visual privacy to a certain extent while the acoustic reduction capability is doubtable.

All concepts share the effort to create privacy within an open office infrastructure. Some incorporate electronic communication. In case of Google, according to the pictures, telephones are an integral element for their approach. None of the above, however, goes further in making data accessible on demand in a working environment. This is where Comport comes into play.

	Company	Space Needed	Visual Shelter	Auditive Shelter	Remote Desktop Access	sitting/standing	Phone Integration
Google Office Zurich	Google	L	yes	yes	no	sitting	yes
PARCS Phone Booth	Bene	S	partly	partly	no	standing	no
Phone Box	Prooff	XS	hardly	hardly	no	standing	no
Communal Cell	Vitra	M	yes	partly	no	sitting	no
Comport	eins	M	yes	yes	yes	standing	yes

Table 14–1: A comparison of existing products

Reservation & Priorization System

A system like Comport should provide a reliable environment for communication. This goal raises the question how to ensure appropriate availability. Options would be to prioritize usage scenarios over others, or to create a reservation system. Prioritization could be based on the kind of communication one intends to utilize. Since Comport's main purpose is to be used for voice calls, a model in which calls trump other sorts of communication would be thinkable. Depending on a company's corporate culture, prioritization could also be achieved according to a person's status, assuming that most important streams of communication would always obtain highest priority.
The need to reserve commodities, services or places seems to be a genuine human, if not German, desire. Undeniably, it can help to plan appointments. In the case of Comport, a reservation system could be easily integrated into a calendar software, so that an employee could choose to reserve a Comport by simply checking an option field along with entering a meeting.
Neither approach would be especially hard to build, but each one entails a lot of challenges. Prioritization would most likely not enhance the atmosphere in an office. Further more, people would be subject to (unpredictable) disturbances by people who are higher up in the hierarchy or by colleagues who have a reservation for the Comport. Either way, precious trains of thought would be destroyed and the concept would foil its self. Further more, there would be the danger of "over reservation" that might result in unused Comports that are blocked by reservations. It would soon become sort of a private office for some and would be unavailable to the majority.
In conclusion, we decided that Comport's value lies in it's spontaneous short term character that would be impaired by reservation or prioritization, and thus abandoned these concepts.

Figure 18–1: Image of the inside

Personalization

When we started to develop the concept of the Comport, one of our main ideas was to make the Comport highly personalizable. Interesting is why we removed nearly every single personalization aspect in the end.
Long lasting throughout the concept was the idea of a personalized background (or mood) image inside, and automatic person related light adjustments. To answer the question from the beginning, neither personalized background images nor automatically adjusted light is truly necessary.

What makes the adjusted light unnecessary, is the fact that we use as much of the ambient light atmosphere as possible anyway. A differing light atmosphere inside is difficult to manage, as it depends on many different parameters: e.g. day time, mood of user and brightness in the office. While these values change over and over again during a day, to find the right lighting situation for the user is hardly possible and if the user has to adjust the light every time he enters anyway, we decided to stick with a standard light dimmer which will not raise the cost for one Comport in unnecessary heights.
The adjustable background image is a neat feature, no question. However, there are some questions arising from it. How can the user change the background? Is there a limited set of predefined images or can the user take one of his private pictures? Either way, the effort is questionable and besides, there is a more obvious solution to it: Just use the background image of the user's personal computer. It is assumable that the user likes this image, and he can change it whenever he likes to, to whatever he likes to. To leave the user undisturbed by the background image, but on the other hand to provide a comfortable atmosphere, the background image will be reduced to color information and digitally placed on the acrylic glass stripes of the Comport. That also slowly billows (Figure 18–1). By that, the background is an addition to the user's background image.

Another important part of the personalization is the control of the volume. And again we wanted to make it as intuitive as possible. The user can change the volume of the hands-free speaking system like he changes the volume of his notebook, with the exact same keyboard keys. Both, the voice of the conversational partner and the sound from the notebook will be emitted from the hands-free speaking system speakers - the volume is modifiable by the volume controls of the notebook.

Design Concept

Inspiration

In the present time, it is more than difficult to find a place where we can be in solitude, a place with absolute silence, no people around and most of all no distractions at all. We are in a rush, unlearning to be alone, we get stressed and the only way out is either a solitary confinement or a getaway to some kind of desert.

That might sound a little exaggerated, yet it is not arbitrary and the Comport is one way to get back some kind of that solitude in situations where we like it: namely during phone calls and work.

A variety of things influenced our design of the Comport. Most of all it should combine the mood we get in certain places. We thought of places like libraries, churches, hunter stands, cottages and even cinemas, where the acoustics create a special atmosphere and sound environment.

We looked at churches designed by Tadao Ando, which are mainly build of concrete walls. Large windows and cross shaped openings in the wall lightens the room and by the combination of the light atmosphere, the simplicity of the plain concrete walls and the lack of decorations, even a picture of the church seems calm and quiet by only looking at it. The simplicity and honesty of the

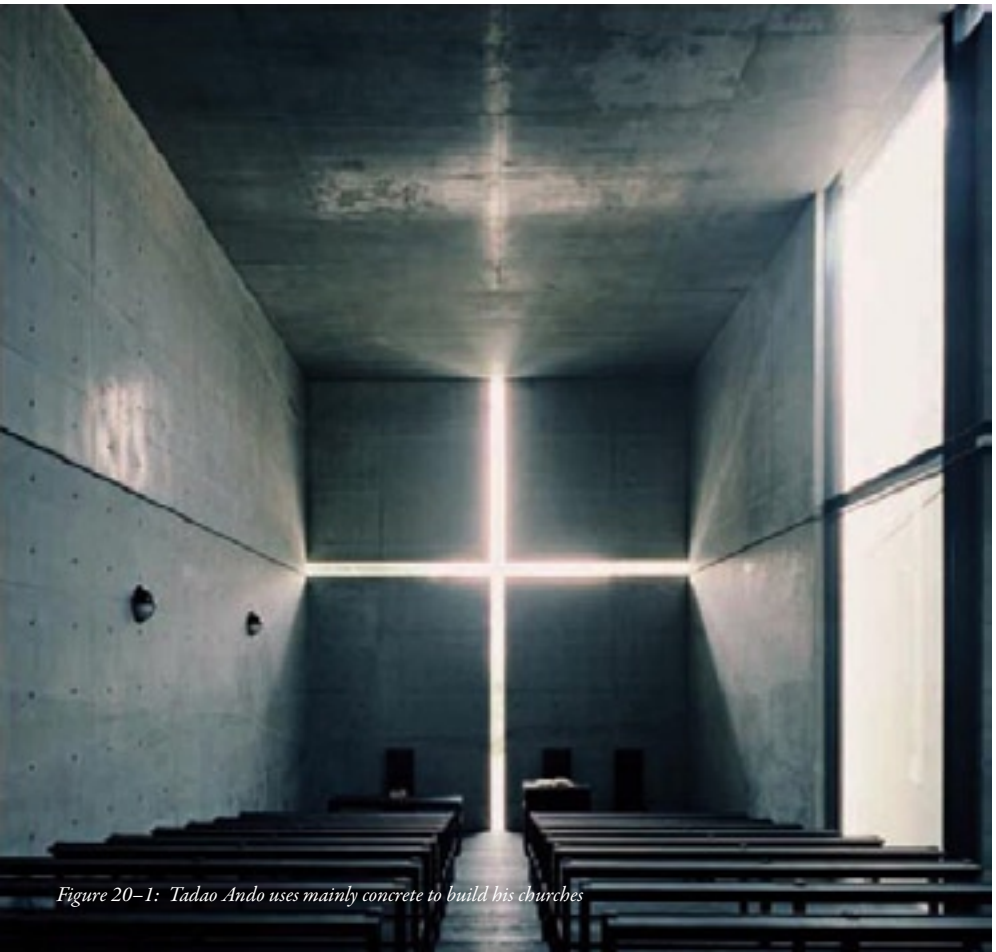


Figure 20–1: Tadao Ando uses mainly concrete to build his churches

Figure 21–1: Hunter stands, no fancy equipment nor any entertainment

Figure 22–1: Detail felt view
Figure 22–2: Feeling Felt Cinema, a cinema made of felt.

Figure 23–1:
Hermès is a french dress company.

materials is one thing we like to transfer to the design of the Comport.

Hunter stands are in some way interesting as well. The hunter concentrates on this one particular task, to observe the deer and eventually shoot it. No distractions, complete silence.

Design wise they provide a clear view and some sort of protection from the environment. We like to support our customer in the same way, to focus on their task - making phone calls. No fancy equipment, nor anything entertaining to distract the user.

Good equipped cinemas emphasize the acoustics of their rooms, the more sound absorbing the walls the better, because reflections of sound waves can destroy the acoustics. And the curios thing which happens in a cinema is that you forget about the people around, there is only you, the screen and the movie. In the Feeling Felt project, the architects have gone one step beyond standard absorbers on the wall. The cinema is completely encased by felt, to create a special sound atmosphere.
The felt does not only provide an acoustically warm sound, also visually the room gives the impression of comfy and warmth.
At last we thought of cottages in the wilderness and found something else. The Hermès Shop design. Hermès build something which reminds us of a combination between cottages and large tents or even caves. By the open structure of the entity the room gets divided into multiple areas, without isolating the different spaces. Also has this structure a positive effect on the appearance, it seems lightweight and not bulky. As the Comport will take some space in the office we try to adopt that effect, to give the impression of a lightweight construction.

From the inspirations above result some parameters for the design of the Comport.
It should be designed simple and made of raw and honest materials to enhance the concentration of the person inside. It should project the feeling of protection from the outside, as well as it should protect the outside from the inside by acoustical means. The materials and the form should also transfer comfort and warmth, without making the Comport a bulky piece of furniture. Its overall appearance should be lightweight.

The Comport consists of an inner and an outer part. The inner part is where the user keeps himself. It is made of felt layers to absorb sound, like in the felt cinema. Gaps between some of the felt layers, lighten the inside— a natural light atmosphere should be created. The outer part of the Comport is made of several wooden frames enclosing the inner part. Each wood frame has a gap as well, to support the lightweight look of the Comport.

Building The First Prototypes

3D renderings made with the Software Cinema 4D gave us a good first impression of how the Comport could look like. The overall look is very realistic and a good fundament for decision making. Yet, it does not provide the effect of a real size model. It is also difficult to explain the functions of the Comport purely by digital images. Thus, the motivation behind building a 1:10 model and a real size model was to first of all have a basis for presentations and secondly to revise whether the designed size of the Comport is working after all.

The 1:10 Model

The model was build with the help of an external assistant due to a lack of time, while the conceptual work for the construction was done by ourselves, the building of the model was mainly accomplished by our assistant.
The wooden frames of the Comport are made out of 25 walnut bars (Figure 25–1). For the inside we used an acrylic film and several felt stripes. The base plate is a dark pressboard and for stability reasons we used four threaded bars to which the construction is attached.
Overall, the construction worked out as planned, only little inaccuracies and the light flexibility of the walnut bars made it difficult to work very accurately. In some areas the construction looks a little bit skewed, but the overall impression is very good, especially when lighted right. (Figure 27–3)

Figure 25–1: One of the first renderings

Figure 25–2: A 3D rendering in an office

26–1: Laths from which the portal frame is made

Figure 27–1: The final 1:1 construction

27–2: Cut walnut bars

Figure 27–3: The 1:10 model

The Real Size Prototype

For further development, the real size prototype was of high importance, because we needed an evaluation on the size of the Comport. The prototype portal frame is made out of 12 laths (Figure 26–1), 24 brackets and countless screws. We also wanted to reproduce the inside of the Comport, thus we cut out the form of the inside out of two pressed splint boards. One was attached on top of the frame construction and one at the bottom. A protective sheet is used as a connection from the bottom to the top, by that the shape of the Comport interior is created. Felt stripes underneath the Comport provides necessary mobility to move it around in the room.
An essential experience we gained by the real size prototype is that we can reduce the size of it by around 25%. At the moment there is sufficient space for two to three people.
Apart from that the construction gave an amazingly real impression of how the final Comport could feel like. (Figure 27–1)

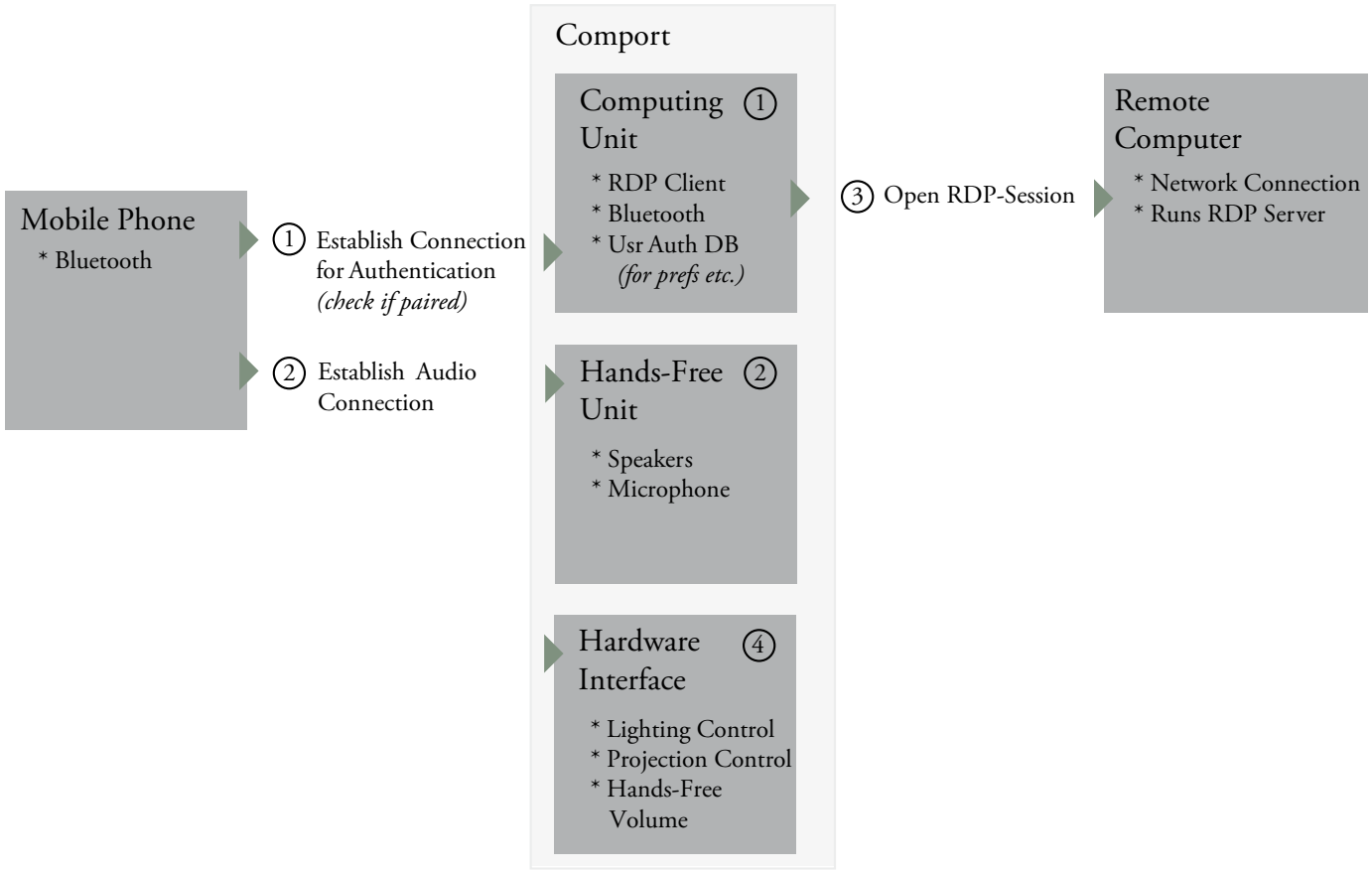


Figure 28–1: Technical components

Technical Overview

1. A person with a phone and activated Bluetooth enters the Comport. Comport continuously "listens" for Bluetooth devices that are in range an can, as a consequence, identify the person. If the person's device is already registered in the Comport database, the person is authenticated.
2. If there is an active phone call on the person's phone, it is passed to Comport's hand-free set.
3. A remote desktop session to the person's remote Computer is established, using the authentication data stored in the Comport database.
4. Optional: User specific preferences are applied. Personal preferences are currently not part of the concept, but are designated.
5. When the person leaves Comport, the Bluetooth connection is interrupted. Correspondingly, the remote desktop connection is closed and all applied preference settings are reset.

The following chapters discuss the elements introduced here in depth.

Desktop Remote Control

The wish to control computers remotely is old and became relevant once network systems enabled several computers to interact. Remote controlling computers allowed people to perform maintenance tasks and to run programs on other machines, without having direct access to the computer hardware. Moreover, people were able to work on affordable computer terminals while running programs on "super computers". This was significant when the performance of home computers was insufficient for complex tasks.
The most prominent examples for those remote control programs are the Berkeley r* utilities [1], telnet [2] and ssh.
Telnet has almost disappeared, because it does not support encryption. SSH and modern versions of the r* utilities widely support encryption technologies. Why not use these for Comport?
There is one important drawback: graphical user interfaces are poorly, or not at all, supported.
The more modern alternatives are programs that are capable of showing and controlling graphical desktops remotely.

A common solution is called Virtual Network Computing (VNC), consisting of VNC clients (which access a remote machine) and VNC servers (which provide remote access to the local machine). VNC is a de-facto standard and implemented by lots of open-source softwares. VNC uses the Remote Frame Buffer Protocol (RFB)[3], which allows computers to communicate independently from client and server implementation as well as the used operating system and graphical user interface.
It is shipped, for example, with Mac OS 10.6 and Ubuntu 10.10.
Microsoft's approach for remote desktop connections uses the Remote Desktop Protocol (RDP)[4]. Several clients and servers across multiple platforms exist [5]. Microsoft's remote desktop system supports encryption technologies and is actively developed. Former security issues concerning Denial-of-Service attacks were solved in an update 2005.[6]
Teamviewer [7] is a program that runs on Microsoft Windows, Mac and Linux and provides access to any other computer. Commercial use requires a license fee.

Team Viewer connections are encrypted, using RSA Public/Private Key authentication [8]. The strength of Team Viewer are remote sessions via Internet, because it works without configuration of ports, proxy servers and firewalls.

There are several pre-conditions for the technology to be used in Comport.

- The connections need to offer a high frame rate and image quality. This is important due to the fact that the systems will be used frequently. Although, being used in a local area network, bandwidth use is not too critical, but will be tested beforehand.
- Comport will run in a local network and is therefore not exposed to assaults from the Internet. Nevertheless, data security needs to be sustained. Even in cases of misconfigured or poorly secured networks, remote desktop connections must not be spied out.
- The technology used needs to run on all operating systems that are currently relevant for office computers, so that Comport can be offered to as many customers as possible

Due to its performance advantages and good encryption capabilities, RDP will be used for Comport.
There are several implementations of RDP servers and clients.
Microsoft offers free RDP clients for Mac as well as Windows operation systems.
UNIX based operating system can use the rdesktop remote desktop protocol client.

Figure 31–1: Network cables

Comport incorporates the possibility to access ones personal computer while being inside the Comport and to speak hands-free. Those services establish two requirements for a wireless technology. It needs to be able to couple with a phone for authentication and transmit an audio signal reliably and securely. Further criteria are the range, market penetration and speed. Why are these factors criterias?

The one technology that sticks out in regard of Comport's requirements is Bluetooth, because it combines high quality audio transmission and hardware level encryption.

The capability to handle audio signals is part of the bluetooth protocol stack and is implemented on hardware level. That means that this synchronous connection, Bluetooth uses for audio applications, is fast and resource efficient because the logic does not need to be implemented on software level. Furthermore, Bluetooth supports native AES 128bit encryption. This ensures a secure and tap-proof connection, which is especially important in a business environment.
The encryption capabilities of Bluetooth are also vital for Comport's second use case: Authentication of a user. Bluetooth uses a process called "Pairing" in which a connection between two devices is established for the first time. In order to pair two devices, one has to enter a PIN to avoid accidental or malicious pairing attempts. Since version 2.1, the standard implements Secure Simple Pairing that "has two security goals: protection against passive eavesdropping and protection against man-in-the-middle (MITM) attacks (active eavesdropping). It is a goal of Secure Simple Pairing to exceed the maximum security level provided by the use of a 16 [digit] alphanumeric PIN with the pairing algorithm used in Bluetooth Core Specification version 2.0 + EDR and earlier versions." [1] This mechanism is strong enough to even use a Bluetooth enabled device to function as a door key.[2]

Currently, a shortcoming of Bluetooth is the time it takes to establish a connection between to devices. This time could, in the future, potentially be enhanced through the combination of Bluetooth with a rather new technology called "Near Field Communication".

"The significant advantage of NFC over Bluetooth is the shorter set-up time. Instead of performing manual configurations to identify Bluetooth devices, the connection between two NFC devices is established at once (under a tenth of a second). To avoid the complicated configuration process, NFC can be used for the set-up of wireless technologies, such as Bluetooth."[3]

The above features of the Bluetooth standard make it especially suitable for Comport.

Figure 33–1: Harald "Bluetooth" Gormsson, King of Denmark & Norway, namesake of the Blueooth technology.

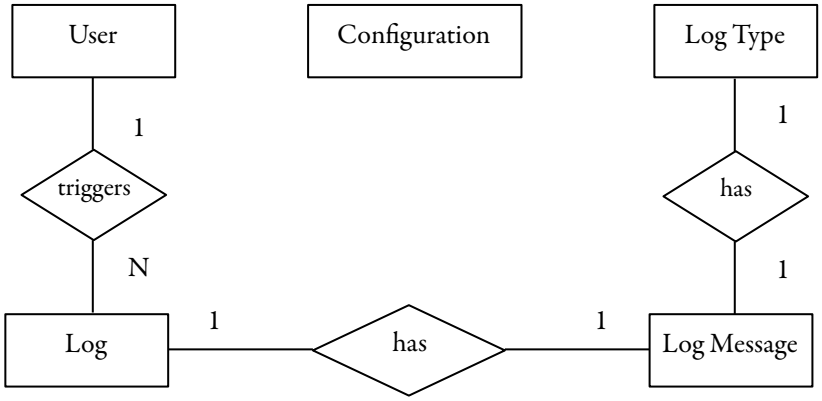


Figure 34–1: ER Model

ER Model And Table Schema

The data that needs to be stored for running Comport is not too complex. The data can be split into three main categories: logging, user specific data and configuration settings. Logging is always invoked by people using the Comport and records usage and errors that occur while Comport is being used.
For each user, information that is required for the Bluetooth authentication process and remote desktop connection is stored. Additionally, further preference data can be stored, although this is currently not part of the concept. The configuration holds Comport specific configuration data.

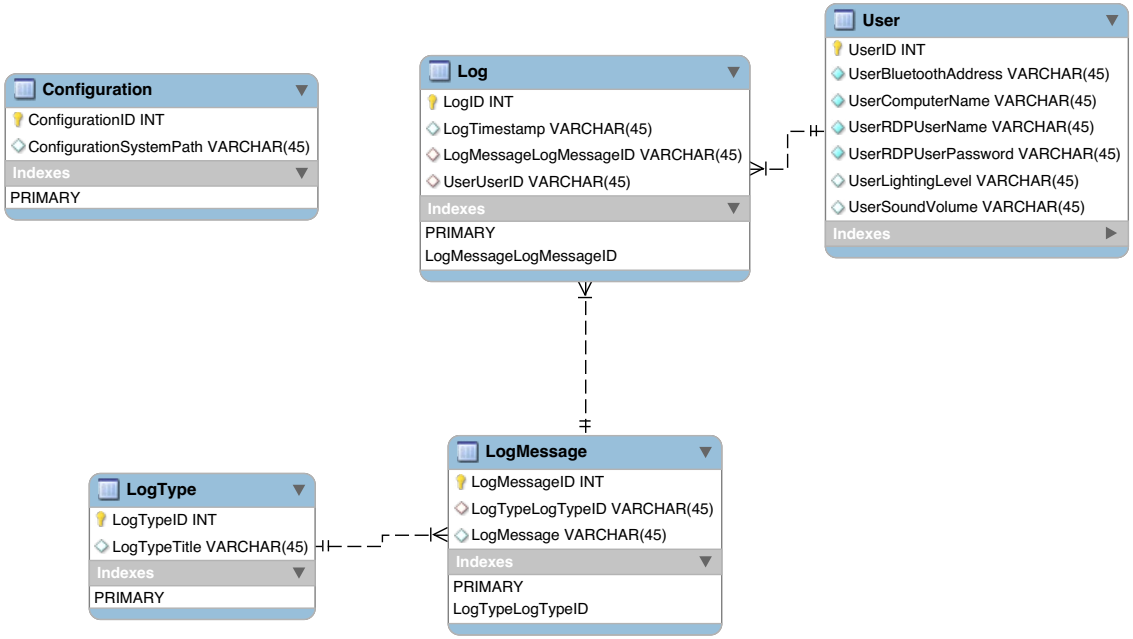


Figure 34–2: Table Schema

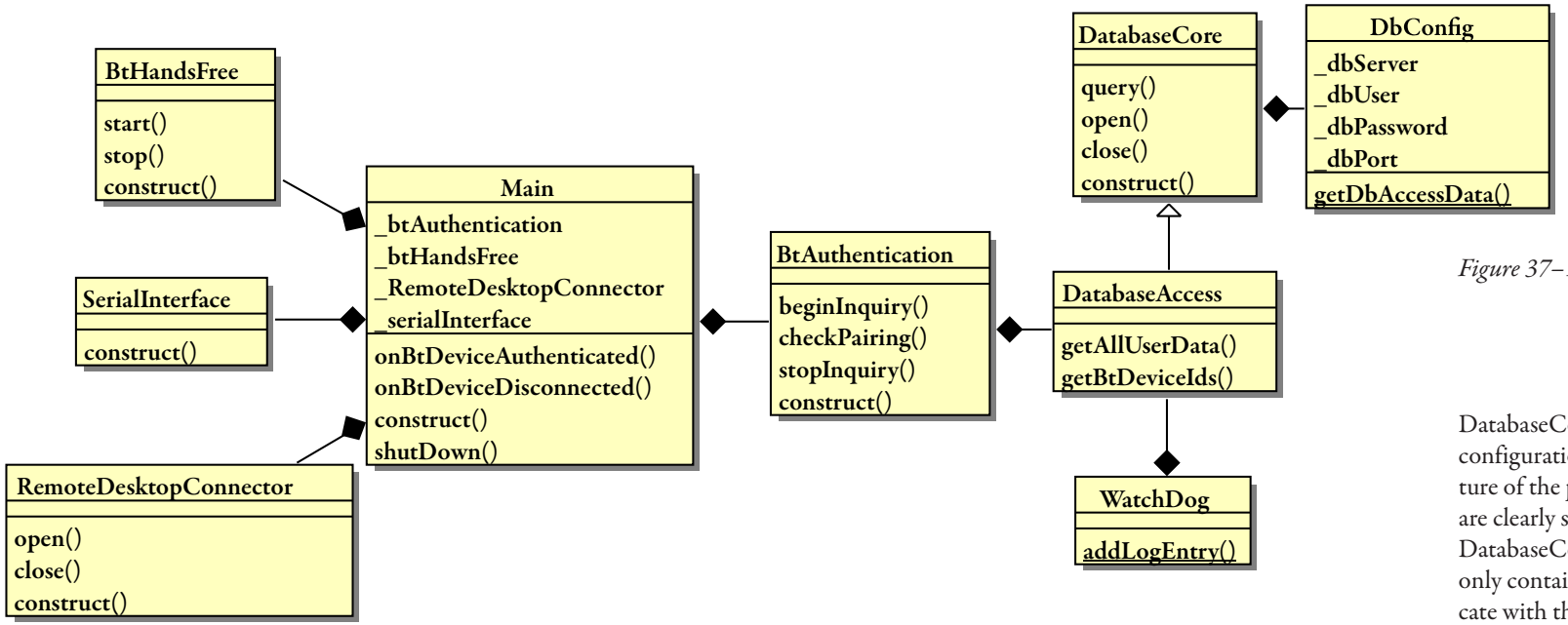


Figure 37–1: Class diagram

Class Diagram

The software backend of Comport will be implemented as object oriented software.
Although the Comport system is currently neither large nor complex, this approach is promising for reasons of maintainability and future enhancements.
Figure 37–1 gives an idea of the software's structure.
Main is the class that is instantiated first (the accompanying object is called "main" throughout the text). It initializes the variables _btAuthentication, _btHandsFree, _remoteDesktopConnector and _serialInterface with the corresponding classes.
For the application flow, the BtAuthentication class is most important.
It recognizes if a user enters or leaves Comport and notifies main. Once a user is authenticated, BtAuthentication returns an object containing all data of the authenticated user, which is passed to _btHandsFree, _remoteDesktopConnector and _serialInterface by main.
Data access is encapsulated in the classes DbConfig, DatabaseCore and DatabaseAccess.
DatabaseConfig stores database access data and is used by DatabaseCore.

DatabaseConfig loads an external configuration file, so that logical structure of the program and configuration are clearly seperated.
DatabaseCore is an abstract class that only contains methods to communicate with the database, but does not define the communications's content.
DatabaseAccess inherits DatabaseCore and provides the methods that are responsible for reading and writing the database. It is implemented following a Singleton pattern, which ensures that there is only one object that connects to the database.

WatchDog takes care of logging notifications, warnings and errors.
AddLogEntry is a static function that can be called from any object to write messages to the database.

Resolving Hosts

To establish a remote desktop connection to a computer, the VNC server's IP address (or DNS/Bonjour name) needs to be known to Comport, i.e. some kind of address data needs to be stored in the Comport database.
The most obvious way is to store static IP addresses. One drawback of this approach is that IP addresses are often dynamically assigned, which means statically stored addresses are insufficient.
Dynamic DNS and Bonjour solve this problem by using static names for computers with dynamic IP addresses. This approach introduces a new problem: The static names are static, but they can be manually changed by the user. That means that, once a user changed his computer's name, Comport can no longer find the user's machine.
The solve these problems, all computers that run a VNC server for use with Comport periodically broadcast a unique Comport client ID along with the machines IP address.
The Comport itself listens for these packages and, once a new package is received, writes it to an internal cache table. This way, the Comport always has a cache with up-to-date IP addresses.

Choice of Database System

Comport needs the means to store user data, preferences and a couple of other settings. Therefore we decided to have a database backend that handles this data. Since Comport is, most likely, going to be installed in pre-existing office environments that potentially already have an information infrastructure and server environment, it should be possible to integrate it easily into this environment. Thus, we decided to use a MySQL database system. Among its advantages is the fact that it is distributed for free, in many businesses a de-facto standard and, even if not already existent, can easily be installed on a regular server.
MySQL is a multiuser database system, which allows several Comports to access the same shared data.
Even though, with the current concept, Comport is not in need of a high performance database solution, it would be possible to add features that require such a data backend. Last but not least, MySQL has grown and become very reliable over course of the last years and can be conveniently maintained.

Software/Hardware Interface

Although Comport's current concept does not include user preferences that influence the inside of it, the technical concept takes care of possible future requirements.
A programmable micro controller that serially communicates with the actual Comport software is a flexible approach to incorporate further development.
The idea of having a programmable micro controller derives from the so called "Arduino" boards, which we used in several projects before.
These boards are made for prototyping and mainly consist of a USB interface, a voltage regulator and a programmable Atmel Atmega micro controller. The micro controllers can be programmed in an Arduino specific language, which is a simplified variant of C++. When an Arduino program is build, it is first preprocessed to C++ and then compiled and uploaded to the micro controller.
It is so flexible that it can almost perform any kind of task, which is perfect for us, because we do not know any future product specification.
Taking the Atmel Atmega 328 chip as an example, there are 18 input/output pins that can be used to control external devices. This is sufficient even for larger projects.

Operating System

For the prototypical implementation, Comport runs on a Ubuntu 10 operating system.
Ubuntu 10 comes with some great tools for Bluetooth application development, the bluez-utils.
These tools allow us to search Bluetooth devices programmatically. We even used these tools for the prototypical implementation.
Further advantages of Ubuntu for us are good documentation, good performance (even when running inside a virtual machine) and no licensing fees.
The probably most important aspect is that we are experienced in working with this operating system.
Especially the performance and the licensing aspect makes Ubuntu not only attractive for the prototype, but also for the deployed system.

Challenges

During our work, we faced several challenges that would have to be solved in order to make this product work under production conditions.

As mentioned before in “Choice of wireless technology”, many versions of the Bluetooth standard require quite a long time to find new devices in range and make a connection. There a two possible solutions for this issue. One would be the use of the “Bluetooth Low Energy” standard. “Bluetooth low energy technology can support connection setup and data transfer as low as 3ms, allowing an application to form a connection and then transfer authenticated data in few milliseconds for a short communication burst before quickly tearing down the connection.” Another option would be the coupling of Bluetooth with Near Field Communication (NFC). NFC supports an extremely short range around 10cm but can enable Bluetooth to drastically reduce set-up time.
For simplicity reasons we are currently not using link keys to verify the identity of a device but solely rely on MAC addresses instead of IDs.
In order for the Comport to only recognize phones within a range of about one meter, we will need to find a way to narrow down the area that is covered by the Bluetooth antenna inside the Comport. One option is building a highly directed antenna with a very low gain, so that only strong signals from nearby devices are recognized. Additionally we could install shielding for the antenna in order to eliminate disturbance by signals from a further distance.

Last but not least, the technical concept requires a connection between Comport and the remote computer via the Remote Desktop Protocol. To date, however, there is only one known implementation attempt for an RDP server called xrdp [2]. Unfortunately the source code is not running and the whole project seems to have been abandoned a couple of years ago. Hence, we decided to implement a VNC connection for the prototype and accept the worse performance to be able to show the general feasibility.

Programming Language

For the prototypical implementation, we looked at several languages. Among them Objective-C, Bash script and Ruby.
Objective-C provides an extensive framework for Mac OS X that provides a lot of functionality and ways to access data from the Bluetooth hardware. The Objective-C development environment also provides a suite of debugging tools. On the downside, this manyfold of options would have required a period of time to get familiar with the system that was not available to us under this projects time scope.

Instead, we decided to use Bluez tools, a suite of tools for operations on Linux’s canonical Bluetooth stack called “Bluez”. By themselves these tools can do various operations like scanning for devices in range or making connections with afore mentioned devices.
To chain these single units together, we first looked at ways to shell script what we needed. Considering the possibility to work with a database down the road, however, and the advantages of a higher-level approach the Ruby language provides, we decided to abandon Bash and use Ruby.
Ruby is available on all major distributions of UNIX based operating systems, as well as on Windows.
With its gem system, Ruby provides a powerful packet manager that makes it possible to integrate existing modules easily.

Bibliography

Existing Approaches, Page 14

[1] Becker, Tobias (2010). "Die schönste Nebensache", Kulturspiegel Issue 12/2010

[2] cp. www.prooff.com/products/003-phonebox (01/03/11)

[3] cp. bene.com/bueromoebel/parcs-phone-booth-by-pearsonlloyd (01/03/11)

[4] cp. www.vitra.com/en-un/collage/exhibitions/vitra-at-orgatec-2010/ (01/03/11)

Remote Desktop Control, Page 30

[1] Hunt, Craig (1995). "TCP/IP Netzwerk Administration", p. 182, Bonn: O'Reilly.

[2] Hunt, Craig (1995). "TCP/IP Netzwerk Administration", p. 24, Bonn: O'Reilly.

[3] Richardson, Tristan (2010). "The RFB Protocol", RealVNC Ltd. http://www.realvnc.com/docs/rfbproto.pdf (12/13/10).

[4] Author unknown (2007). "Understanding the Remote Desktop Protocol (RDP)", Microsoft. http://support.microsoft.com/?scid=kb%3Ben-us%3B186607&x=13&y=11 (12/13/10).

[5] cp. xrdp, rdesktop.

[6] Author unknown (2005). "Microsoft Security Bulletin MS05-041", http://www.microsoft.com/germany/technet/sicherheit/bulletins/ms05-041.mspx (12/15/10).

[7] Author unknown (2010). "TeamViewer Download", http://www.teamviewer.com/de/download/index.aspx (12/13/10).

[8] Author unknown (2010). "Sicherheit und Datenschutz", http://www.teamviewer.com/de/products/security.aspx (12/13/10).

Wireless Technologies, Page 32

[1] Bluetooth Special Interest Group (20006) "BLUETOOTH SPECIFICATION Version 2.1 + EDR [vol 0]" p. 57, http://www.bluetooth.com/Specification%20Documents/DI_SPEC_V12r00.pdf (01/25/11)

[2] cp. www.sorex-austria.com (01/25/11)

[3] cp. www.sorex-austria.com/nfc.210.html (01/25/11)

Further reading: CRE169 http://chaosradio.ccc.de/cre169.html (10/26/10)

Software/Hardware Interface, Page 39

[1] Author unknown (2010). "ATmega48A/48PA/88A/88PA/168A/168PA/328/328P Summary", Atmel Corporation. http://www.atmel.com/dyn/resources/prod_documents/8271S.pdf (02/06/2011)

Challenges, Page 40

[1] www.bluetooth.com/English/products/pages/bluetooth_low_energy_technology__technical_info.aspx (02/07/2011)

[2] cp. xrdp.sourceforge.net/ (02/07/2011)

Credits

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Notes

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