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IdeaBall

A Physical Artifact for Moderating and Analyzing Brainstorming Sessions

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Aachen, November 2011
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Abstract

Brainstorming is a prevalent creative method, used for generating innovative ideas. Difficulty to recall the content and progress of a brainstorming meeting, calls for a way to capture and depict relevant information without compromising participant interaction. Brainstorming also relies on the anonymity clause to remove social deterrents and to encourage active participation. Noting idea authorship could function as a reward and increase participant motivation, especially in recurrent groups.

In this thesis, we developed the IdeaBall system for the capture and review of meeting information during brainstorming. The IdeaBall system includes an embedded prototype and a desktop application. The embedded prototype captures meeting information and identifies idea authors during a brainstorming session. The desktop application is then used for the meaningful depiction of the gathered information.

We presented a review of creative techniques and their main characteristics and concluded that brainstorming, is a general method that yields innovative ideas. We then analyzed different meeting capture and review systems and tools and evaluated them with respect to brainstorming attributes. Based on the aforementioned reviews, we derived a solution concept for a tool, the IdeaBall system, to support co-located brainstorming.

We further refined the solution concept and identified research questions, that the IdeaBall system should answer. An iterative design process was applied to the development of the IdeaBall system components. The system components include the embedded ball prototype, called the IdeaBall, and a software application for logging and presenting captured data, the IdeaBallNavigator.

We validated and verified the system, by conducting qualitative user studies. Results from the evaluation helped us to answer the original research questions. We concluded that the IdeaBall system is a suitable tool to further expand, in order to answer questions on idea authorship in co-located brainstorming.

Überblick

Brainstorming ist eine weit verbreitete, kreative Methodik zur Erzeugung innovativer Ideen. Schwierigkeiten sich an den Inhalt und den Verlauf eines Brainstorming-Treffens zu erinnern, erfordern die Sammlung und Präsentation relevanter Information, ohne die Zusammenarbeit der Teilnehmer zu gefährden. Brainstorming sollte auch von Anonymität gekennzeichnet sein, damit Teilnehmer keine sozialen Hindernisse haben und zu aktiver Teilnahme motiviert werden. Das Notieren einer Autorenschaft könnte als eine Art Belohnungssystem funktionieren, insbesondere bei wiederkehrenden Gruppenzusammensetzungen.
In dieser Arbeit, haben wir das Ideaball-System für die Sammlung und Aufarbeitung von Daten eines Brainstorming Treffens entwickelt. Das Ideaball-System beinhaltet einen eingebetteten Prototypen und eine Desktop-Anwendung. Der Prototyp sammelt Brainstorming Informationen und identifiziert die Autoren während des Brainstormings. Die Desktop-Anwendung präsentiert anschließend die gesammelten Daten.
Wir haben einen Review von kreativen Techniken und ihrer Hauptcharakteristika präsentiert und sind zu dem Schluss gekommen, dass Brainstorming, eine allgemeine Methode ist, die zu innovativen Ideen führt. Danach haben wir verschiedene Systeme und Tools, die für die Aufzeichnung und Bewertung von Meetings benutzt werden analysiert. Basiert auf diesen Reviews, sind wir zu einem Lösungsansatz gekommen; ein Tool, das Ideaball-System, um Brainstorming am gleichen Ort zu unterstützen.
Wir haben den Lösungsansatz verfeinert, in dem wir Forschungsfragen identifiziert haben, die das Ideaball-System beantworten sollte. Ein iterativer Design-Prozess wurde für die Entwicklung der Ideaball-System-Komponenten angewendet. Die Komponenten des Systems beinhalten einem eingebetteten Prototypen im Form eines Balles und eine Anwendung, den IdeaBall-Navigator, der für das Protokollieren und für die Präsentation der gesammelten Daten verantwortlich ist.
Wir haben das System validiert und verifiziert durch qualitative Benutzerstudien. Die Ergebnisse haben uns geholfen die Forschungsfrage zu beantworten.

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Many thanks to Lars, who always believed in me. I would also like to thank my family for everything.

Conventions

Source code and implementation symbols are written in typewriter-style text. `myClass`

The whole thesis is written in American English.

Chapter 1

Introduction

An innovation is ”something (as a device) created for the first time through the use of the imagination”.[inn, 2011] Technological advancements and the transformation of innovation into a business field in itself, call for attention to the processes that support them. Brainstorming is a technique predominantly used for generating innovative ideas. Enhancing and supporting brainstorming would, therefore, have an impact on the quality and quantity of innovative ideas generated.

1.1 From Design to Innovation

Creativity harnesses innovation. With an extensive amount of knowledge at our fingertips thanks to search engines and interactive web tools, a lot of research is focusing on how to better utilize them to breed creativity and, consequently, innovation.[Shneiderman, 2007][Mamykina et al., 2002] At the center of creativity lies group interaction. It is through sharing expertise, knowledge and experience that groups are able to produce the most innovative ideas. [Warr and O'Neill, 2005]

The field inherently connected to creativity is design. A design process consists of three stages: problem analysis, idea synthesis (ideation) and idea evaluation, where

in each stage, groups can apply different creative techniques.[Jones, 1992] The field of Computer Supported Collaborative Work (CSCW) focuses on supporting group processes in order to improve group productivity. Supporting the design process, however, has a different, more vague, set of requirements than traditional group processes. Additionally, the goal of productivity in creative processes remains unclear, as it is usually congruent to finding an innovative solution to a problem, which may not always be easy to recognize and assess. Finally, how group participants behave and what triggers their inspiration is often a personal process that is difficult to predict, and consequently support.

Studies have proven that Group Support Systems (GSS) for creativity often outperform traditional group creative sessions, as they remove the practical difficulties of having a large group interacting as well as social deterrents. [Hender et al., 2001] In many cases, however, traditional group sessions are still preferred, mainly for the perceived productivity and quality, that face-to-face interaction entails [Hilliges et al., 2007], in addition to the inspiration that a well-designed physical environment can evoke.[Moultrie et al., 2007, Kelley, 2006] In contrast to traditional sessions, GSS provide a detailed overview not only of the results but also of the proceedings of a session by allowing participants to review and follow up on ideas even after the session has expired.

1.2 Motivation and Anonymity

Alice, the head of the research and development department, at a big company, attends a brainstorming session for ideas on possible innovative products to introduce to the program. It is a traditional brainstorming session for a small group, where all participants, apart from Alice, have similar backgrounds and positions in the company. Bob has an idea, on which the group immediately starts building other ideas. Towards the end, Eve, a very active participant, presents an idea built on what was originally Bob's. Alice, satisfied with the amount of ideas, recaps the session and assigns further research on that last idea to Eve. Leaving the

session, Bob feels that an unfairness on his expense took place by assigning any further research to Eve. From now on, he decides to participate in brainstorming sessions more passively, keeping his ideas to himself to later privately present them to Alice. Jane, another participant, found some ideas very interesting and made a mental note to look them up further. She did not take any notes during the meeting and now cannot recall neither the author nor the exact idea.

The above vignette, about brainstorming at a fictional department, portrays how anonymity in traditional brainstorming, may hinder participation. In addition, it also shows the difficulty of recalling brainstorming content. A discrete way of assuring idea authorship could allow the lifting of anonymity without making participants too conscious of the fact or distracting them from the generation of ideas. Finally, the ability to navigate through meeting content could also help participants to recall specific parts.

Depending on the environment setting, group creativity meetings, such as brainstorming, have either cooperative or competitive characteristics.[Paulus, 1999] Paulus acknowledges the collaborative character in research and development teams. Nevertheless, he proceeds to clarify that a system that does not recognize "individual differences in the quality of contributions", i.e. does not provide adequate rewards, it also does not adequately motivate participants. Rewards should, however, be carefully planned, as they risk increasing the level of competition within the group.[Paulus, 1999]

With the prevalence of social media and web 2.0 applications, GSS and idea management systems have been widely employed, by either making use of crowd sourcing or by providing a platform for the discussion of ideas from all departments within a company. As GSS represent the digital counterpart of traditional ideation group techniques, a lot of the principles encountered in the latter are mitigated to their digital counterpart.[McLeod, 2011]

Anonymity, as suggested by Osborn, the inventor of brainstorming, represents the pillar of a successful brainstorming session.[Osborn, 1957] Research in the employment of idea management systems in small groups, has proven,

however, that rewards and knowledge of the idea originator may contribute to increase the degree of motivation and commitment of the participants.[McLeod, 2011]. This finding calls to reconsider the effects of anonymity during brainstorming, especially in the field of radical innovation, where truly innovative ideas are scarce. Identifying the author of an idea during traditional brainstorming could, therefore, function as a source of motivation just as in the case of idea management systems described by McLeod.[McLeod, 2011]

1.3 Ambient Technology and Tangible Interaction

From smartphone multitouch displays to pressure watches for the elderly, portable, interactive devices have taken the market in the last years by storm. The fields of ambient interaction and tangible technologies now span not only the academic, but also the commercial realm. Small, portable, omnipresent, dedicated devices take the focus away from two dimensional displays and bring it to the real world. Users can interact with these tangible three dimensional objects, to complement their ongoing activities and build a mental model of their interaction, in a way that is disparate to the case of the desktop.

Interaction with an ambient device during brainstorming, without distracting from the task of idea generation, would serve as a medium for enhancing the brainstorming experience by making it more fun and simultaneously noting idea authorship.

1.4 Objective

The goal of this work is to support small group brainstorming meetings for innovation through the employment of a physical artifact for moderating interaction and unobtrusively capturing brainstorming data. Finally a desktop ap-

plication logs user interaction during the session and identifies idea authorship.

1.5 Thesis Overview

The following chapter introduces the theoretical framework for this work. It provides an overview of the characteristics and principles of creativity techniques and analyzes different meeting capture and review systems and assesses them with respect to brainstorming meetings. Chapter 3 presents the research questions of this project and elaborates on the system implementation. Chapter 4 provides details on the techniques used to evaluate the final prototype and analyzes the results from this evaluation. Finally, chapter 5 provides a summary of the entire work and presents possible future directions.

Chapter 2

Theoretical Background and Related Work

The goal of this work, as mentioned in the previous chapter, consists of ensuring idea authorship during brainstorming in small groups. This is achieved through the employment of an embedded physical artifact during the brainstorming session and a desktop application to allow the reconstruction of the meeting. This chapter presents a review of creative techniques and their basic characteristics. It also reviews existing Interaction Capture and Retrieval (ICR) systems and tools for capturing and browsing through meeting information.

2.1 Creative Techniques

Creative Techniques usually refer to methods for approaching new problems and generating innovative ideas. The fields of marketing, business, innovation research, as well as companies within themselves, often rely on the successful employment of creative methods to solve issues or reinforce communication in the workspace. In the field of technological innovation, creative techniques may be applied at any phase to find novel solutions, or to exhaustively assess proposed solutions. A lot of design and creativity researchers have presented structures to describe the

creative process. Apart from small differences and different naming, one can easily identify a common high level break down.[Warr and O'Neill, 2005] A high level break down suggested by Jones[Jones, 1992] consists of 3 stages: *analysis*, *synthesis* and *evaluation*. Analysis consists of defining the problem and extensively describing and researching all its facets to come up with a solution. This solution is then realized during the synthesis stage. Finally, during evaluation the final solution is matched up against the problem. Should the solution fall short of solving the problem, the 3 stages are repeated until it fits.[Warr and O'Neill, 2005, Jones, 1992]

Suitable problems for using creative techniques are usually problems where a satisfying solution is not visible and thus creative thinking is required to uncover it.[Brown and Kusiak, 2007] Following is a presentation of idea generation techniques, which usually take place right after defining the problem, as a first step to developping a solution for it.

2.1.1 Creativity and Design

Group sessions and the fun factor

The success of group sessions often relies on the *fun factor*, a measure of how engaging and enjoyable an activity is.[Kelley, 2006, VanGundy, 2004] In groups, an informal, friendly atmosphere can positively affect participants and evoke their creativity.[Amabile, 1983] The fun factor can increase motivation in the group, encourage participants to defer criticism and, additionally, to abandon their fear of judgement.

The rest of this section presents both analytical and intuitive creativity techniques for idea generation.

2.1.2 Creative Methods

The basic attributes of idea generation techniques are stimuli and associations. An idea generation method can rely

either on external or internal stimuli to trigger the generation of ideas, as well as free, forced or remote (present in electronic methods) associations to control the direction of generated ideas. There exist three categories of creative techniques depending on whether they use intuition or analytical methods, what Proctor identifies as ”letting ideas flow” and ”making ideas flow” respectively [Proctor, 1999], as well as a combination of the two. Studies have proven that techniques that do not have a strict frame and rely instead on intuition, produce more novel ideas than techniques that don’t.

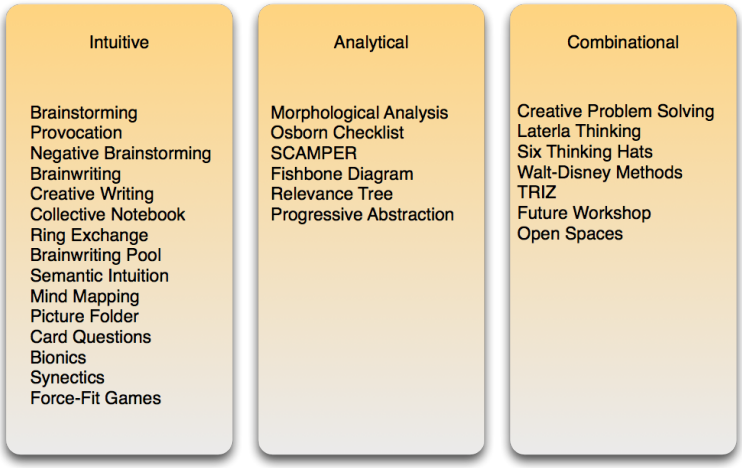

Figure 2.1: The 3 categories of creative methods

2.1.3 Brainstorming Techniques

There exist a plethora of intuitive creative methods, with brainstorming being the most popular.[Higgins, 1994, Geschka, 1996]

The four core brainstorming principles

The core principles of Brainstorming are *deferred judgement* and *quantity breeds quality*, *welcome the unusual*, *combine to improve*.[VanGundy, 2004] The basic assumption is that by generating ideas faster, after a specified amount of time, there is a good possibility that an appropriate solution can be found in the idea pool. The validity of the quantity breeds quality concept, can be verified by comparing it to

how organisms survive in nature.[Parnes, 1999] Mutations happen in nature indiscriminately (quantity), yet the environment allows the fittest to survive (quality). In group creative processes, however, achieving a high rate of idea generation can only be achieved by removing the social inhibitions, that are usually present in social interactions and force participants to filter their ideas, hence the need to defer criticism.

Brainstorming as suggested by Osborn, relies on internal stimuli and free associations to encourage an abundant flow of ideas. Participants generate ideas with free associations. Following, they can choose to use these new ideas as stimuli to trigger new ideas.[Hender et al., 2001]

"Process Loss" effects in group brainstorming

Productivity, based on the quantity criterion, depends greatly on whether the session is individual or a group session. One would easily expect, because of interaction and diversity in the participants' backgrounds and experiences, that group brainstorming would yield more results. It has been proven, however, that group brainstorming is actually less productive than individual brainstorming. Paulus and Dzindolet, attribute this difference to the effect of "process loss" that is present in group brainstorming sessions.[Paulus et al., 1993] Group brainstorming sessions are more susceptible to factors that hinder productivity, such as social apprehension, limited speaking time and motivation loss, factors that are absent in individual sessions.[Warr and O'Neill, 2005]

A solution to overcoming "process loss" and increasing productivity in group sessions is to have an individual session precede it. Such combination of the two configurations can actually produce the best results both in quantity and quality, than either configuration would produce by itself. Indeed, this was also Osborn's claim that group brainstorming should take place after individual brainstorming is completed. This way by preparing individually, group sessions can overcome any "process loss" issues.[Hender et al., 2001, der Lugt and Visser, 2005]

The unfocused nature of group brainstorming, however, constitutes it difficult to carry out correctly. Qualified moderators can assume a coordinating role to ensure the ses-

sion yields meaningful results. The role of the moderator consists of providing participants with a clear and succinct definition of the problem, ensuring that only one person gets to speak at a time, without breaking the flow of the session and rapidly writing the ideas on the board for common reference.[Parnes, 1999]

Although criticism is deferred and previous ideas can be used as stimuli, sometimes a session runs out of momentum. Again, a coordinator can increase motivation in the group by providing participants with positive reenforcement, and repeating previously mentioned ideas. Additionally, one can increase motivation during a group session by setting "aggressive goals".[Kelley, 2006, Brown and Kusiak, 2007, Wilson, 2006] Aggressive goals create a sense of momentum and camaraderie as the group is striving to achieve a common, challenging goal.

Finally, at the end of a brainstorming session, an evaluation should follow on the collected ideas, to select the best one. Some popular evaluation techniques are: the six thinking hats, the delphi technique, and the fishbone diagram. For more information on evaluation techniques see [Brown and Kusiak, 2007], [Higgins, 1994].

Traditional Brainstorming Technique

The traditional brainstorming technique consists of a group of 6-13 participants and a, preferably trained, moderator. The session begins with the moderator presenting a clear definition of the problem in question. For the next 30-40 minutes participants speak up their ideas. The moderator chooses who will speak next and makes sure to rapidly write down ideas on a whiteboard, that is visible to the whole group. During the course of the session the moderator ensures that participants indeed defer judgement and generate ideas at a high rate.

2.1.4 Brainwriting Techniques

A Brainstorming variant that has become a creative technique in its own right, is *Brainwriting*, a technique developed at the Batelle Institute in Germany in the 1970s.[Geschka, 1996]

Brainwriting adopts a more analytical and disciplined approach, in an effort to overcome the shortcomings of brainstorming. The time limit in combination with the quantity requirement hinder brainstorming productivity. Some participants find it difficult to pay attention to what other participants are saying while coming up with their own ideas. Additionally, in the absence of a skilled moderator, the session may not yield any meaningful results. Finally, under time pressure, ideas on the whiteboard are sometimes difficult to read and interpret after the session.[Geschka, 1996]

Brainwriting attempts to overcome the aforementioned issues by adopting a structure that is less centralized around the moderator, and allows participants to write down their own ideas. To keep motivation high, brainwriting techniques rely on explicitly presenting participants with previous ideas to use as stimuli.

Two popular brainwriting techniques developed at the Batelle Institute in 1983, are the Ring Exchange Technique and the Card Exchange Technique.[Geschka, 1996]

Ring Exchange Technique (a.k.a. 6-3-5 Technique)

In the Ring Exchange technique each participant gets a sheet of paper and within 5 minutes has to write 3 ideas, one in each column. After time is up, the sheet is passed on to the person to the right. Upon receiving a sheet the participant writes 3 ideas in each column using the previous ideas in that column as stimulus. Finally, the process of writing down ideas and passing the sheet on, continues until participants receive their original sheet. [Higgins, 1994]

This technique does not overwhelm participants with in-

formation. Instead, participants take time to think and have the convenience of writing down and expressing their ideas themselves. Discussion is limited, but it can also take place at a later stage when analyzing the proposed solutions.

This technique is also referred to as the "6-3-5 Technique", as the original proposal consisted of 6 participants, 3 ideas in 5 minutes, until a sheet circles through and reaches its owner.

Card Exchange Technique

The Card Exchange technique makes use of pin cards. Unlike the Ring Exchange Technique, cards do not correspond to a participant but to an idea. Therefore, participants use a new card for every new idea.

Participants write down ideas for 5 minutes and pass them to the person to their right. That person may choose to read the ideas on the cards received for inspiration, but is not obliged to. At the end of the session, that is once all cards loop through all the participants, they are gathered and pinned on a board. Participants can then use their spatial memory to get a better overview, arrange and cluster ideas by moving the corresponding cards.[Geschka, 1996]

This technique gives participants more freedom than the Ring Exchange Technique, since using other ideas as stimulus is not a requirement. Additionally, having a card correspond to an idea allows for better visualization by sorting and arranging cards accordingly. Sorting and clustering cards requires using spatial memory, which is especially well developed in humans and can help to better recollect the experience later on. Additionally, writing ideas in parallel can increase the quantity of ideas and ensure that ideas are well expressed, since the originator is the one who writes it.[Geschka, 1996]

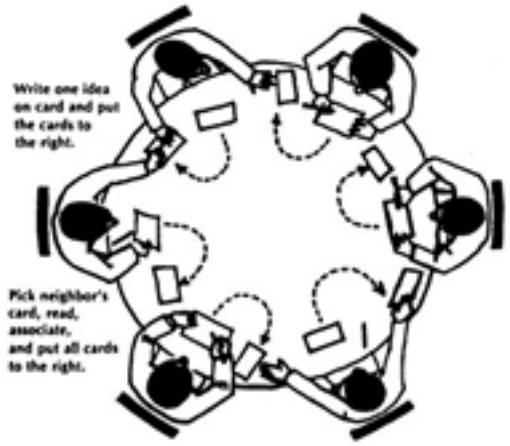

Figure 2.2: The Card Exchange Technique.[Geschka, 1996]

2.1.5 Visual Confrontation Techniques

Visual Confrontation techniques, use analogies,like Synectics, for idea generation. Unlike Synectics, however, they use visual stimuli for idea generation.[Geschka, 1996] Pictures, by avoiding verbal associations, are raw input, allowing users to form their own associations, without consciously thinking of the process.

A picture is worth a thousand words. The possible combinations, associations, and stimuli, therefore, are likely to differ between members, since they each draw on their experience and knowledge domain. Visual memory is primarily a function of the right brain, where intuition also resides. By closely observing visual input, therefore, other right brain functions are invoked such as imagination, intuition, recognizing patterns, integration of multiple inputs, similarity spotting, to name a few. [Michalko, 2006]

Visual material can be either random or problem related. Random material is used for *estrangement*, to get users to relax and disengage from the specific problem. Problem related material, achieves the opposite, by bringing the problem back to focus for users to create forced associations.

Two Visual Confrontation techniques, also developed at the Batelle Institute in Germany, are: Visual Group Confrontation and Picture Folder Brainwriting.[Geschka, 1996]

Visual Group Confrontation Technique

Visual Group confrontation involves creating random and related stimuli and associations, like in traditional Brainstorming. The procedure involves two stages. In the first stage, the group looks at random, unrelated pictures, preferably displayed on a big screen, accompanied by relaxing background music. Afterwards, pictures related to the problem at hand succeed the unrelated pictures. The related pictures, aim to "trigger confrontation"[Geschka, 1996], and challenge the participants to form associations with the previously presented pictures. After the presentation of the related pictures, a group discussion can follow. The group discussion, may have a lively, unpredicted character, as the contribution of each member depends on their own associations, based on the visual content.

The unstructured nature of this discussion, however, can make the documentation of ideas difficult. Additionally, when tracking an idea back, the original visual stimulus may be difficult to identify, even for the idea originator.

Picture Folder Technique

The Picture Folder technique is a Visual Confrontation technique that uses Brainwriting to overcome the difficulty of idea documentation.[Geschka, 1996]. It combines the, previously described, Exchange Card and the Visual Group Confrontation techniques.

The picture folder, consists of 3 pictures for estrangement, followed by 7 problem-related pictures, in a fashion similar to Visual Group Confrontation. Afterwards, group members follow an exchange card approach, writing down ideas on pin cards and passing them around as stimulus. Finally, the cards are placed on a pin board for evaluation.

2.1.6 Reversal Techniques

Reversal techniques are linear techniques that push participants to think outside the box. They "destabilize conventional thinking patterns and free information".[Michalko, 2006] Social conventions and assumptions based on history and everyday interaction, condition the way we think and make us blind to a spectrum of completely new possibilities. Reversal techniques rely on reversing or exaggerating aspects of the problem statement or common assumptions it makes and finding solutions for these reversals and exaggerations and then fitting them back to the original.

The success of reversal techniques, however, depends on the extent to which participants have been able to identify the problem aspects and assumptions in the first place, without proposing ways to do it easily.[Hender et al., 2001]

Two popular reversal techniques are: *Assumptions Reversal* and *Negative Brainstorming*

Assumptions Reversal Technique

The Assumptions Reversal technique, as its name suggests, relies on reversing problem-related assumptions, to remove imaginary boundaries that inhibit the breadth of the participants' thoughts. The absence of such invisible limitations, encourage the generation of truly original ideas.

The group starts by tackling the problem definition to identify assumptions that it makes. Such assumptions may be fundamental, so deeply engrained in our culture that we do not normally notice them. The group participants then proceed to challenge and reverse each assumption. Finally, they review and discuss interesting reversals and how they may go about accomplishing them, in order to finally choose one.[Michalko, 2006]

Negative Brainstorming Technique

A creative technique that sprang off of Brainstorming is Negative Brainstorming. The philosophy behind negative brainstorming is that it is often easier to detect shortcomings than solutions. These shortcomings can sometimes make a good solution visible.[Wilson, 2007] In this case, two wrongs do make a right. By negating the problem statement and again negating possible remedies to this negation, one can come up with solutions to the original problem. It builds on our "mental rigidity", i.e. the constraints that keep us from thinking outside of the box, in order to finally overcome it. At once, the obstacles that hindered productivity become candidate solutions for the reversed problem, and their respective reversals become candidate solutions for the original one.

Negative Brainstorming starts out by negating the problem definition. It then proceeds to identify groups of negative comments that explain why the problem exists. Finally, using the aforementioned groups it attempts to find remedies to them and consequently, to the original problem. Negative Brainstorming is more focused and linear than the Assumptions Reversal technique, and thus, may not produce original solutions as easily. Finally, an evaluation technique can help filter out the best solution.

2.1.7 Question Techniques

Question techniques rely on a logical breakdown of the problem and the systematic answering of action questions. They can be used individually although, the they are more suitable for groups. They are built on the idea that "everything new is just an addition or modification to something that already existed".[Michalko, 2006] The assumption is that by systematically answering such guided questions, the user focuses on transformations that alone or in combination can bring about a solution. Consequently, question techniques are primarily analytical, as they follow a conscious, systematic method to generate ideas. They can be used as standalone techniques, depending on the type of

problem, or in combination to intuitive techniques, to increase motivation.

Osborn Checklist Technique

In his seminal work introducing brainstorming, Osborn also presented a checklist for guiding the idea-generation process. The checklist consists of various action verbs that, individually or in combination, the user may apply to the problem in order to tackle the problem from a different perspective and stimulate idea generation. The Osborn checklist consists questions on how to go about applying different transformations to the problem.

- Other uses?
- Adapt?
- Modify?
- Magnify?
- Minify?
- Substitute?
- Rearrange?
- Reverse?
- Combine?

This method, as most question methods, is very systematic and aims rather at encouraging users to tackle the problem in a different way, than the intuitive, subtly guided idea generation of intuitive techniques, such as brainstorming.

SCAMPER Technique

The SCAMPER technique, introduced by Michalko in his book "Thinkertoys", is a modified adaptation of the Osborn

Checklist. By applying the following 5 transformations to aspects of the problem, the user can generate alternative ideas and, hopefully, novel solutions. [Michalko, 2006]

SCAMPER is a mnemonic for the 5 transformations:

Substitute something

Combine something with something else

Adapt something to it

Modify or ***M***agnify it

Put it to some other use

Eliminate something

Reverse or Rearrange it

Users isolate aspects of the problem and tackle one by one using SCAMPER. By applying the SCAMPER transformations for each step of the problem, the more ideas surface.

2.1.8 Classification of Creative Techniques

The creative techniques described provide an overview the group interaction and creativity field. Table 2.1 depicts a classification of the creative techniques presented based on group interaction and innovation characteristics.

Traditional brainstorming, brainwriting, and visual confrontation techniques provide a high innovation degree. Reversal and questions on the other hand, produce ideas of a rather low innovation degree. They disintegrate problems and systematically analyze them to generate ideas. Thus their approach is more analytical than intuitive.

The ring exchange, card exchange, and picture folder techniques, as presented above, have a high innovation degree. Their structured nature and focus on individual writing,

	Innovation Degree	Group Interaction	Idea Generation
Traditional Brainstorming	High	High	Sequential
Brainwriting			
Ring Exchange	High	Medium	Parallel
Card Exchange	High	Medium	Parallel
Visual Confrontation			
Visual Group Confrontation	High	High	Sequential
Picture Folder	High	Medium	Parallel
Reversals			
Assumption Reversals	Low	High	Sequential
Negative Brainstorming	Low	High	Sequential
Questions			
Osborn Checklist	Low	High	Sequential
SCAMPER	Low	High	Sequential

Table 2.1: Classification of Creative Techniques

however, hinders group interaction. One could easily support co-located brainwriting techniques by using idea management applications. Such a system, however, would neither be applicable, nor expandable to other creative techniques.(see 2.1.2—"Creative Methods")

Finally, traditional brainstorming and the visual group confrontation technique, have a high innovation and group interaction degree. Visual group confrontation can easily be regarded as an extension to traditional brainstorming, as visual material is presented before or during the session, then followed by traditional brainstorming. The issue of idea authorship emerges during brainstorming, where participants actively express their ideas. The objective of this work (1.4—"Objective" is to develop a system to support group interaction and ensure idea authorship during ideation. Based on the aforementioned objective and the description of creative techniques, traditional brainstorming is the most suitable technique to support.

2.2 Meeting Capture and Review

In his 1992 seminal book "Design Methods" [Jones, 1992], Jones identifies three points of view for the design process: creativity, rationality, and control.

From the creativity viewpoint, the design process is analogous to a black box. It relies on the designer's intuition and creativity. One cannot present a logical explanation for the outcome. Creativity is the only explanation for what takes place inside the box. From the rationality viewpoint, the design process is analogous to a glass box. One can logically follow the process as the solution is developed. Finally, from the control viewpoint, the design process is analogous to that of "a self-organizing system capable of finding shortcuts across unknown territory". This is a completely controlled and focused process with definite, yet perhaps not novel solutions.[Jones, 1992]

Osborn and Gordon, two of the most important figures in the field of creativity methods, recognized the importance of creativity for the generation of novel ideas early on, and developed design techniques from the creative viewpoint.

Brainstorming(see 2.1.3—"Traditional Brainstorming Technique") with its loose structure and favor of quantity over quality, cultivates creativity and is, therefore, favored for the generation of innovative ideas. Its loose structure, however, also makes it difficult to reconstruct a brainstorming meeting. In terms of capturing, brainstorming meetings are like regular meetings, with unanticipated interaction, turn taking and content.[Yu et al., 2000] The reconstruction of brainstorming meetings can be achieved through the employment of ICR systems. ICR systems capture interaction during meetings with the minimum amount of intrusion.The successful use of an ICR system in brainstorming is equivalent to its seamless, unobtrusive integration in the brainstorming meeting.

Following is a review of ICR systems, focusing on two aspects: *brainstorming capturing*, that is the user experience during a brainstorming meeting, and *brainstorming reviewing*, the reconstruction of the meeting after it has come to

an end.

2.2.1 Pen and Paper

Pen and paper are the traditional medium for capturing meeting information.

Meeting capture requires two readily-available components. In the case of brainstorming, a recorder may write down ideas on a board.

Reviewing meeting information, however, stumps on different issues. The content is difficult to digitize, search and annotate. Information is encoded and linked based on the recorder's judgment rather some objective rule. In addition, accurate timeline information for simple time-based navigation are also unavailable.

Pen and paper have the advantages that they are ubiquitous and ready to use for meeting capturing. The lack of customized information and semantic indexing, however, does not give absent participants the opportunity to obtain an overview of the meeting. Furthermore, for participants to better recall a meeting, audio and video information is often useful. In the case of pen and paper, however, such information is unavailable.

The aforementioned disadvantages for meeting capturing and reviewing, also apply to brainstorming meetings, constituting pen and paper an unattractive option. Finally, author identification of a generated idea that is in plain view and persistent throughout the session makes the social deterrent clause, that Osborn warned of, more prominent.

2.2.2 Audio and Video

Another traditional method for capturing meetings, includes simple audio and video recording and processing with simple processing tools. A microphone and camera,

without particular setup or calibration, may capture audio and video information during a meeting.

Capturing audio and video this way, ensures an unobtrusive system that gathers information throughout the meeting. Reviewing the gathered information, however, without the use of additional software to process it, is an arduous task. Users are required to go through a primitive timeline to filter and annotate audio and video, which for long recordings may be cumbersome. A possible enhancement would be the interception of video information with presentation slides, where applicable.

Although, unobtrusive, this method requires a lot of user processing. Even then, however, no significant semantic content is produced, since the original data was not information rich. Like in the case of pen and paper, navigation through non-searchable content is difficult, and no meeting summary is available.

2.2.3 Smart Meeting Systems

Meetings involve group interaction. Meeting content, therefore, involves more than the meeting minutes - in the case of brainstorming, ideas generated - noted on a piece of paper. Smart Meeting Systems capture audio, video and context data from sensors during a meeting and infer interaction information from the gathered data. Based on this interaction they aim to provide extensive information on the rich content of a meeting, construct a timeline and extract semantic information from it, with minimal user post processing.[Yu and Nakamura, 2010]

Smart Meeting Systems tend to require a lot of technological equipment, (see figure 2.3), such as dedicated hardware, a dedicated room and a predefined room arrangement. It is based on this room arrangement that camera and microphone arrays are positioned and calibrated Additionally, they may include other sensors to detect user presence and interaction with artifacts.

Algorithmic analysis of video data produces information

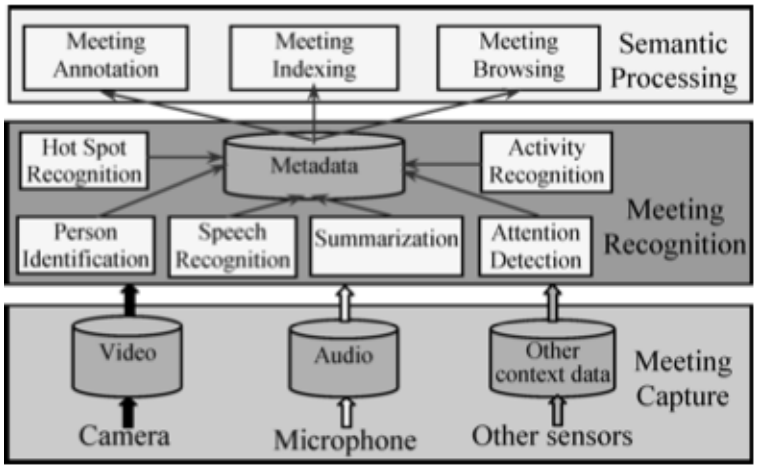

Figure 2.3: Smart Meeting System Architecture [Yu and Nakamura, 2010]

on hand, body and head movement, from which important interaction information, such as gaze and attention direction can be inferred.[Xiong and Quek, 2005] The combination of video, audio and context data allow smart meeting systems to identify the speaker, transcribe audio, perform handwriting recognition, categorize notes, infer spoken content importance and interaction with semantically indexed artifacts during a meeting.[Yu and Nakamura, 2010] Semantic level indexing provides an extra layer of information that allows absent participants to quickly extract important meeting information and conclusions.[Yu and Nakamura, 2010]

As previously mentioned, smart meeting systems, usually perform extensive meeting data gathering and information processing. They are unobtrusive, allowing participants to focus on the subject at hand, rather the operation of the system. In the case of brainstorming with its unstructured nature, smart meeting systems could potentially extract important information for a detailed reconstruction of the meeting. Indeed, researchers have found a correlation between gestures and voice pitch of female participants during brainstorming with the quality and quantity of ideas generated.[Garrahan et al., 2010]

Smart meeting systems capture and extensively perform low-level as well as high-level data analysis to produce a meeting timeline along with semantically significant information. Their complicated setup, cost, hardware overhead and indiscriminate gathering of data render them an often unattractive solution.[Yu and Nakamura, 2010]

This thesis project aims to produce a single digital tool to discretely visualize user participation in brainstorming, while keeping further participant interaction information private. Therefore, a smart meeting system is unsuitable for the needs of this project, despite being ideal for the capturing and reviewing of unstructured meetings, such as brainstorming.

2.2.4 Digital Devices and Tools

As portable electronic devices employ more components and functionality in ever decreasing packages, a lot of portable, no setup, meeting capturing possibilities become evident. Smartphones, digital pens and notepads can serve as artifacts that enhance meeting capturing and reviewing with minimal technological overhead.

- Digital Whiteboard

  Whiteboards, like overhead projectors, are typically employed during meetings to ensure that participants share a common view. As previously mentioned, during brainstorming, the recorder usually records ideas on a whiteboard (see 2.1.3—"Traditional Brainstorming Technique"). Projects involving digital whiteboards to enhance meetings, often include the use of tablet PCs to enable all users to modify the whiteboard content and thus, communicate their ideas by sketching.[Forster and Wartig, 2009, Bastéa-Forte and Yen, 2007, Haller et al., 2010]

  A research project, at Stanford university, first examined the benefits of using a digital whiteboard and tablet PCs for making changes on a shared canvas. [Bastéa-Forte and Yen, 2007] Participants are

more active than in traditional brainstorming meetings. Through a table PC is participant is able to enter and modify the recorded content. Whiteboard modifications and additions appear in different colors, according to their originator. Through such a simple color coding scheme participant contribution is always visible, allowing participants to monitor their input.The formality of written in comparison to verbal content, and the persistent identification of ideas throughout the session act as a social deterrent, with participants spending time to formalize their input.[Bastéa-Forte and Yen, 2007].

Digital whiteboards are particularly useful for facilitating meetings and empowering users to actively participate in a meeting. Most digital whiteboard applications, however, including the aforementioned project, do not handle meeting capturing and reviewing. Meeting capturing is a byproduct of interacting with the digital whiteboard system - the recorded content made visible and available for copying. Meeting review, however, is complicated as there do not exist integrated software for building a timeline, identifying users and semantically annotating whiteboard content.

For the purpose of brainstorming, the employment of a digital whiteboard would be useful for the obvious interaction benefit, where users can use sketches to elaborate on ideas. Additional information capturing, such as audio, would enhance whiteboard data and render timeline navigation possible. Additionally, discrete capturing of an idea originator, rather than persistent color coding of ideas during brainstorming, may remove some the fear of judgement. In conclusion, a digital whiteboard, may enhance the brainstorming experience, yet for the goals of this thesis for capturing and displaying an interaction timeline and author identification, a digital whiteboard is not a viable stand-alone solution.

- Meeting Essence II [SJ Yu, 2010]

  Meeting Essence II is a project developed at the Carnegie Mellon university, for individual audio capturing using just a smartphone and working internet

Figure 2.4: Meeting Essence iPod Touch Interface[SJ Yu, 2010]

connection.

Meeting capturing with Meeting Essence II involves the simple task of participants launching the Meeting Essence II application on their smartphone. Each participant is equipped with a smartphone(prototype version requires an ipod/iphone), connected to the internet and running the Meeting Essence II application.

As the meeting progresses, participants may choose to record what a participant is saying by tapping on the participant's name on the smartphone display. A simple user interface includes color-coded blocks, each labeled with the participant name it represents(see figure 2.4). In addition, each participant block includes a timeline axis with information on the time segments that participant recorded.

Meeting reviewing with Meeting Essence II, takes place in real-time. Participants' status is made visible as they log in and out of the system. More importantly, recording events are logged and made visible to everyone on their smartphone display also in real-

time. This allows participants to have an overall view of what others deem important during the meeting. After the meeting is over, participants may merge the different recording events, thus creating an indexed meeting timeline.

Meeting Essence II is an affordable tool for audio recording and simple indexing of meeting information.The minimal processing overhead allows the real-time update of meeting information, an open issue in smart meeting systems.[Yu and Nakamura, 2010] It's main disadvantage, however, lies in the effort to use it. It uses everyday, readily available devices yet their use during the meeting is obtrusive. Evaluation showed that recording drawed attention away from the meeting. Simple audio recording and real-time feedback are powerful tools. They may not provide the extensive information of smart meeting systems, yet their quick setup and use, render them an attractive option for ad-hoc recording.

- Livescribe Pulse Digital pens have been in the market for a long time. The goal of providing users with the capability to digitally create content without typing, is most evident with the creation of the stylus. The Livescribe Pulse, first introduced in 2008, is a revolutionary digital pen, which also integrated audio recording and a small display to play short media, all packed in a pen. (see figure 2.5)

  For meeting capturing users could use the Livescribe Pulse to verbally annotate content as they write it on the special Livescribe paper. Accompanying software tools facilitate easy reviewing of written and spoken content. Audio and writing are synchronized. The Livescribe paper allows users to select from specific commands where by selecting a written content they can listen to the accompanying audio part. In addition, Livescribe also offers language translation capabilities.[Schreiner, 2008] Meeting reviewing includes interacting with the Livescribe Pulse pen and paper. Users can additionally use timeline navigation to navigate through the notes and spoken content. Merging information from different pens, however, is not possible with the available software. Nevertheless, Live-

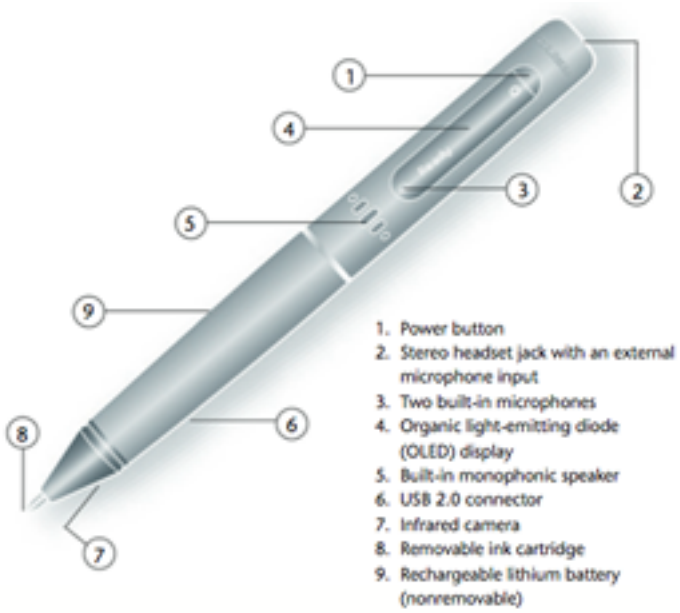

Figure 2.5: The Livescribe Pulse [Schreiner, 2008]

scribe provides developer tools that enable the easy development of such applications.

The Livescribe Pulse is a great tool for information capturing during brainstorming meetings. Its small portable size and pen form factor do not distract from the goal of brainstorming. Good audio quality in combination with annotated content also facilitate the navigation through captured information. Unlike smartphones, however, Livescribe Pulse pens are not ubiquitous. Equipping each participant with one will incur a significant additional cost. Finally, as noted in 2.2.4—"Digital Devices and Tools" brainstorming idea quantity suffers, when participants communicate their ideas by sketching instead of verbally.

2.2.5 Evaluation of Capture and Review Systems with Respect to Brainstorming

A meeting is a broad term encompassing many types of group gatherings. Thus, meeting capture and review

Brainstorming Meeting Capture				
	Ubiquity	Cost	Sensitive Data Capturing	Distracting
Pen & Paper	High	Low	Low	High
Audio & Video	High	Medium	Medium	Low
Smart Meeting Systems	Low	High	High	Low
Digital Devices & Tools				
Digital Whiteboard	Medium	High	Medium	Medium
Meeting Essence II	Medium	Medium	Low	Medium
Livescribe Pulse	Low	High	Low	Medium

Table 2.2: Review of ICR systems meeting capturing characteristics with respect to brainstorming

Brainstorming Meeting Review					
	Search	Index	Navigate (Timeline)	Navigate (Index)	Identify Author
Pen & Paper	Low	Low	Low	Low	Medium
Audio & Video	Low	Low	High	Low	High
Smart Meeting Systems	High	High	High	High	High
Digital Devices & Tools					
Digital Whiteboard	Low	Low	Low	Low	Medium
Meeting Essence II	High	High	High	High	High
Livescribe Pulse	High	High	High	High	Medium

Table 2.3: Review of ICR systems meeting reviewing characteristics with respect to brainstorming

systems developed within this realm cannot represent a panacea for capturing and reviewing of all types of meetings. Brainstorming is a special kind of meeting, whose success depends on the commitment and level of participation of its members during the meeting. Preparation and following up on the content are rendered insignificant without the emergence of meaningful results during the actual brainstorming meeting.

Table 2.2 presents a review of the systems presented in this section according to capturing attributes that are relevant to brainstorming meetings. An attribute of great importance is *Level of Distraction*. The success of a brainstorming meeting relies on the intuition and spontaneity of its participants, which can easily be interrupted if users have to take notes or become conscious of their actions. Likewise,

Table 2.3 presents a review of the aforementioned systems with respect to reviewing characteristics.

Audio & Video and Smart Meeting Systems distract participants the least. However, cost and the gathering of excessive private information make Smart Meeting Systems an unattractive option. Audio & Video are the best option for capturing information. Yet, this option lacks semantic indexing for reviewing gathered information, thus rendering it an unviable option for the objective of this thesis work. A system with similar meeting functionality to Audio & Video in combination with semantically enhanced reviewing capabilities would allow the unobtrusive gathering of brainstorming data and its meaningful depiction by identifying idea authorship and allowing browsing based on generated ideas and participants.

2.3 Solution Concept

This chapter presented a theoretical background of creativity techniques. Based on the premise that brainstorming meetings rely heavily on group interaction and represent a subset of meetings in general, it went on to analyze different meeting capturing and reviewing systems and review them in the context of brainstorming.

Chapter 3

System Implementation

This work aimed to produce a physical prototype for moderating and logging events during the ideation phase. The prototype focused on simplicity and efficiency for a target audience of a small group of 3-10 participants applying a creative technique to generate innovative ideas. The main aim of the physical artifact, from now on called the Ideaball, was to control turn taking in a small group during brainstorming, as well as to ensure a playful, happy atmosphere. The desktop side focused on an efficient way for entering, editing participant and idea information, as well as providing a way to playback ideas and listen to the entire brainstorming session. The development process for the physical prototype and accompanying software followed an incremental and iterative process.[Cockburn, 2008]

3.1 Research Questions

This work aims to investigate whether a single tool can answer the following research questions

- Can an embedded physical artifact unobtrusively support synchronous and co-located work?
- How does an embedded physical tool influence the perceived quality of the brainstorming experience?

- Idea ownership: When idea ownership is hinted, how does that affect participant motivation?

Based on the review of meeting capture and review systems (see 2.2.5—"Evaluation of Capture and Review Systems with Respect to Brainstorming") in the previous chapter and in conjunction with the research questions, the following solution design emerged: In order guarantee idea authorship, in a seamless manner that does not distract from the actual brainstorming task, a ball can be introduced to the group brainstorming setup for meeting capturing. Firstly, it adds a fun factor to brainstorming [Higgins, 1994]. Secondly, its main affordance of throwing can be used to control turn taking and thus distract from its main use of ensuring idea authorship through audio recording. Finally, smooth color transitions provide unobtrusive visual feedback pertaining to the session. Meeting review will take place using an accompanying desktop application for timeline based navigation, browsing through raw as well as semantically indexed captured data.

3.2 System Design

The system consists of the IdeaBall, an embedded artifact, and the IdeaBallNavigator, an application that analyzes and displays information gathered from the IdeaBall.(see figure 3.1)

Storyboards were created to obtain an overview of how interaction with the system during brainstorming could evolve.(see A.1.1—"Storyboards") Additionally use cases diagrams provided further information on the interaction between participants-IdeaBall-IdeaBallNavigator.(see A.2.1—"IdeaBallNavigator Paper Prototypes")

For the rest of the implementation iterative and incremental design cycles were applied separately to the IdeaBall and IdeaBallNavigator. That is, IdeaBall and IdeaBallNavigator were developed separately. Finally, the two were combined and user tests on the complete system took place.

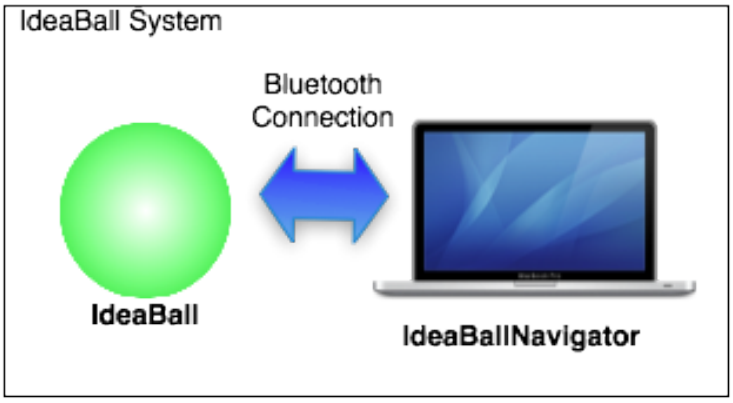

Figure 3.1: The system consists of an embedded prototype, the IdeaBall, and a software application, the IdeaBallNavigator

3.3 IdeaBall Design

As previously mentioned, from an interaction point of view, the IdeaBall will control turn taking during a brainstorming session. Passing an object around for the purpose of controlling who talks during brainstorming is already a popular technique.[Higgins, 1994].

IdeaBall functionality includes audio recording and identifying the participant holding the ball at any given point in time during the brainstorming session. Recorded audio and participant timestamp information are directly transmitted to a computer running the IdeaBallNavigator application. The IdeaBall changes its surface color to provide feedback on its current state, such as on, off, registering, etc.

3.3.1 IdeaBall Main Components

IdeaBall Printed Circuit Board (PCB) components were selected based on their features, availability, and their aggregate cost.

The main electronic components consist of a bluetooth

module with an audio codec, a microphone, an accelerometer, a Radio-Frequency Identification (RFID) reader, and a microcontroller. A red-gree-blue (rgb) Light Emitting Diode (LED) and a piezo buzzer provide feedback on the IdeaBall's state. Figure 3.2, shows a high level depiction of the communication between the board's main components.

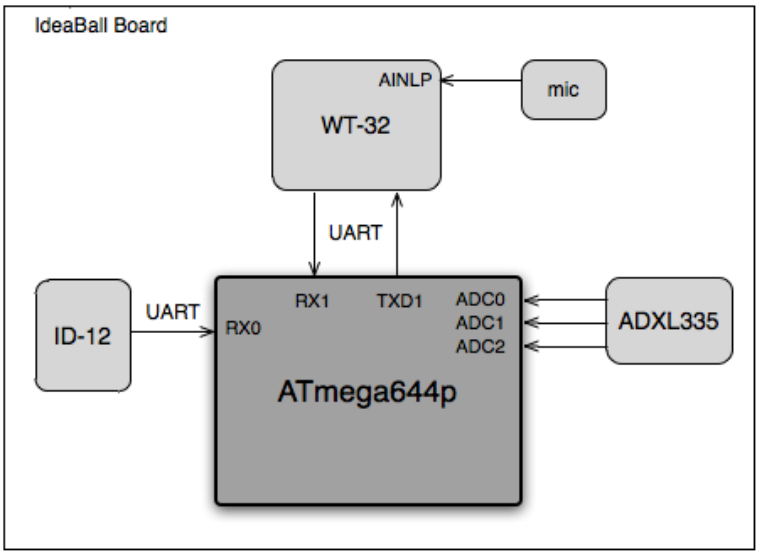

Figure 3.2: IdeaBall main component communication (see A.3—"IdeaBall PCB" for detailed schematic and layout information)

An 3-axis accelerometer provides a means for users to control the IdeaBall. It delivers acceleration information from three axis to the microcontroller. The microcontroller then processes this analog data to detect whether the participant shaked the ball. Shake information is not passed to the IdeaBallNavigator application, but is rather used by the microcontroller to switch between its states.

The Bluetooth module, is a class 2 WT32 audio bluetooth module from Bluegiga. It uses the iWRAP 4 firmware and was configured using serial AT commands. A Micro-Electro-Mechanical-System (MEMS) microphone is connected to an operational amplifier, which is then connected to the bluetooth module's left audio channel.

An ATmega644p micrcocontroller from Atmel is serially connected to the bluetooth module, as well as the RFID reader. It also collects analog information from a 3-axis accelerometer. The ATmega644p detects shake events by collecting accelerometer data using a 16bit timer interrupt. In order to obtain fine timer granularity, the ATmega644p is connected to 5V supply voltage and can thus run at a maximum frequency of 20MHz. Shake events are used to change processor states. Depending on the micrcocontroller's state, serial interrupt events collect tag information from the RFID reader. The microcontroller sends this information to the bluetooth module using serial, only when the new tag is different from the last one detected. This way the IdeaBallNavigator knows that incoming bluetooth events correspond to a different author.

A 3-axis accelerometer, the ADXL335 from Analog Devices, provides analog axes information to the ATmega644p. It has a sensing range of +/- 3g. The g-force for shake is +/- 1.5g.

The RFID reader used in this project is the ID-12 from ID Innovations. It is a 125kHz RFID reader, with an integrated antenna and typical 8cm read range. It serially transmits ASCII (American Standard for Code Information Interchange) encoded RFID tag information to the ATmega644p.

The IdeaBall is accompanied by ”user tags”. ”User tags” are narrow fabric strips with a small round RFID tag glued in the middle of the strip. ”User tags” are worn around the hand, with the RFID tag placed on the palm, in order for the RFID reader to read tag information upon user interaction with the IdeaBall.(see figure 3.3)

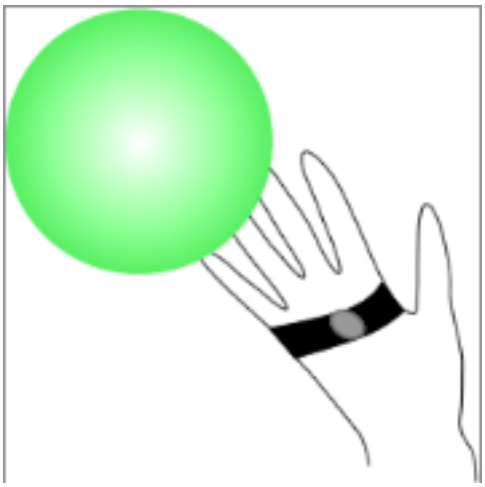

Figure 3.3: "User tags" identify the user interacting with the IdeaBall

3.3.2 IdeaBall Board Design Iterations

The IdeaBall PCB went through two main design iterations to resolve size and functionality issues

IdeaBall Design - First Iteration

In the first iteration, the IdeaBall consisted of a plastic, hollow, 16cm diameter ball obtained at an arts&crafts store. The 9x10cm PCB board was place placed inside the ball (Figure 3.4).

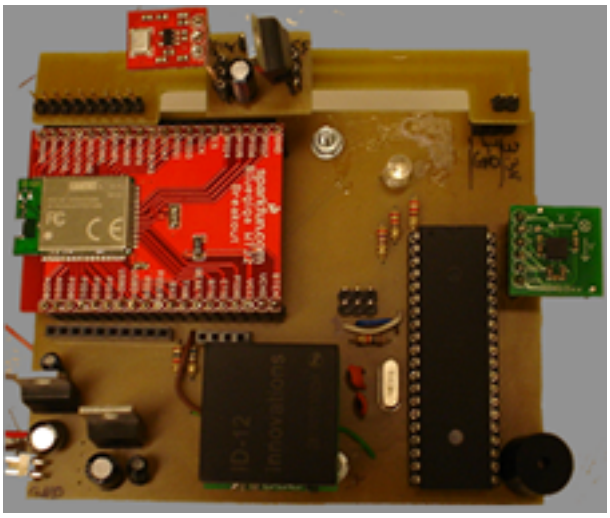

Figure 3.4: First IdeaBall board prototype iteration

Interaction with the ball was not optimal, because of the ball's size. With the PCB fitted on the middle of the ball, the distance between the RFID reader antenna and the surface of the ball was well over 6cm. This distance is within the reading range of the ID-12 for card sized RFID tags. For small RFID tags, however, the reading range of the RFID reader was well below the aforementioned 6cm distance, and there was, therefore, no inductance between the tag and RFID antennas.

Finally, the PCB was powered by 5 NiMH batteries. The batteries were stored in the bottom of one of the ball's hemispheres. The uneven ball weight, made throwing the ball awkward, in addition to it being too heavy to hold.

During the first IdeaBall prototype iteration, the ball's size caused a lot of issues, the main ones being inability to read RFID tags, and uneven weight distribution.

IdeaBall Design - Second Iteration

The second iteration of the IdeaBall used a 9cm diameter ball. Instead of one through-hole rgb LED, this design

made use of 3 surface mounted rgb LEDs. The components were arranged to fit a 12cm diameter PCB as shown in figure 3.5 (for the PCB eagle layout see A.3—"IdeaBall PCB"). The distance between the RFID reader antenna and user tag antenna was within the RFID reader's range. Finally, the smaller ball volume ensured a weight distribution that was more even than in the first design iteration.

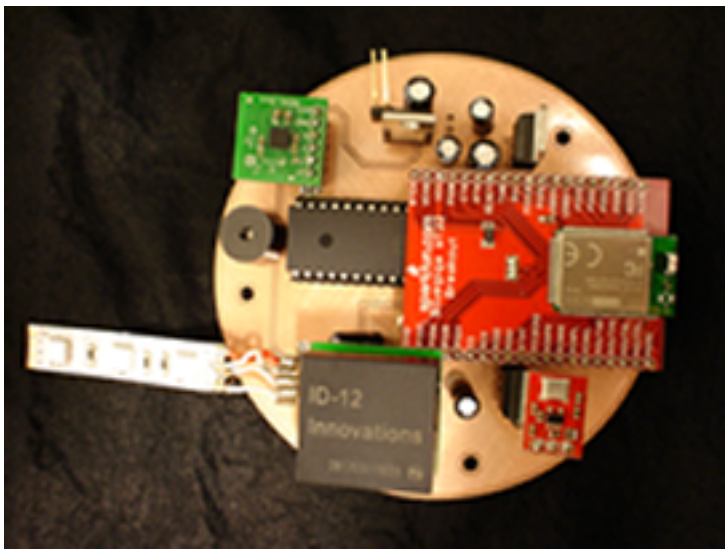

Figure 3.5: Second IdeaBall board prototype iteration

3.3.3 IdeaBall Communication

The IdeaBall can be in one of five states: `START`, `NAVIGATORCONNECT`, `WAITRECORD`, `RECORD` and `END`. State transitions are triggered either by shake events or incoming bluetooth messages. The IdeaBall changes the color of its rgb LEDs to denote the state in which it is.

On startup (`START` state), the IdeaBall waits until it receives a `NavigatorConnected` message. Upon receiving the message, the IdeaBall changes its color (`NAVIGATORCONNECT state`). The user can now shake the Ball to signal that recording should start (`WAITRECORD` state). The IdeaBall sends a `recordRequest` over bluetooth, and receives a `connectionReply` message and

moves on to the RECORD state. In this state, it processes serial receive interrupts from the port connected to the RFID reader. It parses the input to extract the tag id information and stores it locally. Upon receiving a new tag, it compares it to the old one, should they be different it, it sends this tag id over bluetooth. When the user shakes the ball while in the RECORD state, the IdeaBall sends a DisconnectRequest and moves on to the STOP state, without waiting for a reply. In this final state, the IdeaBall glows white.

3.3.4 IdeaBall Design Challenges

Design challenges during the development of the IdeaBall prototype include technical decisions on which technology and components to use, as well as trade-offs between form factor and functionality.

An important design challenge included the decision to use Bluetooth for direct transmission of audio data instead of storing it on an external component for later transmission. The reasons behind this decision include the availability and reasonable price of Bluetooth modules with an integrated audio codec, mainly due to the prevalence of cell phone headsets. In addition, participants do not have to worry about storing space when meetings take too long. Finally, should for any reason the IdeaBall stop responding or break, meeting information is not lost, rather already transmitted and saved on the computer running the IdeaBallNavigator application.

Bluetooth served as the information transmission medium

Another design decision involves the use of an RFID reader instead of post processing incoming audio data to identify the speaker. The WT32 bluetooth module allows the simultaneous use of the headset profile as well as the serial port profile. Therefore, audio as well as serial data can be transmitted without reconfiguring the bluetooth module. The microcontroller, therefore, can send serial RFID tag data to the bluetooth module. Finally, the audio data quality is not high enough for speaker recognition, because of noise the microphone picks up inside the ball.

RFID tags worn by each user allow the system to identify the user holding the ball

Form vs. Functionality Trade-Off

Understanding the limitations of a prototype was a challenge, especially where trade-offs were concerned. The trade-off between usability and audio quality was the main challenge when it came to the design of the IdeaBall. The PCB, including the microphone is contained inside the ball shell. Because of this hollow structure, the microphone picks up a lot of noise, especially when users play with the ball. A medium sized hole on the surface of the ball close to the microphone, and a padded cone adjusted from the microphone to the hole on the surface of the ball, limited the affordance[1] of throwing the ball, yet ensured an acceptable audio quality. This solution did not resolve the problem in its entirety, but alleviated it to a degree where audio content can easily be understood and voices discerned.

3.4 IdeaBallNavigator Design

The IdeaBallNavigator aims to provide an overview of the meeting with audio playback, time-based and indexed navigation. It runs locally and is meant to be used by a single user.(see 3.4.2—"IdeaBallNavigator Design Challenges").

The IdeaBallNavigator went through a series of iteration cycles. The system use case diagrams provided details on the IdeaBallNavigator operation. Additional UML diagrams assisted in identifying IdeaBallNavigator entity objects and attributes.(see A.2.2—" System Object Identification") The IdeaBall Navigator was developed in Objective-C and uses MAC OS 10.7 frameworks.

3.4.1 IdeaBallNavigator Graphical User Interface Iterations

The main goal of the IdeaBallNavigator user interface is to provide an overview of speaking time during brainstorm-

[1] In his 1988 book *The design of everyday things* Norman defines the term affordance as "[...] the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used" [Norman, 1988]

Figure 3.6: First IdeaBallNavigator prototype

ing as well as navigation, playback, searching and some modifying capabilities of data captured by the IdeaBall.

IdeaBallNavigator - First Iteration

In order to determine the layout and functionality of the IdeaBallNavigator prototypes were developed. (see A.2.1—"IdeaBallNavigator Paper Prototypes"). The first prototype(figure 3.6) determined color coding participants and their ideas for easy identification and mapping. The layout involved two horizontal tiers, the bottom part focused on time-based navigation, whereas the top one focused on indexed navigation. The bottom tier was a color-coded horizontal timeline depicting ball possession throughout the session. A superimposed player on top of the color coded timeline played the audio data gathered.

The top tier was used for browsing, modifying, searching and navigating through participants and ideas. It contained three parts. The leftmost part (1.2) was a vertical coverflow containing a summary of participant information. Likewise, the rightmost part (1.3) was another vertical coverflow containing a summary of ideas. Selecting an entry from either of the participants or ideas coverflow loaded a view in the centre (1.2) showing more detailed in-

formation of the selected participant or idea. Selecting a participant from the participants coverflow filtered the participant's ideas on the right coverflow. Likewise, selecting an idea filtered its author from the participant coverflow.

Coverflow interaction cannot be conveyed in paper prototypes. User feedback of a preliminary software version, reported confusion. The connection between the participant and ideas coverflows was not evident. Users were unsure why a selection from one coverflow would filter entries on the other one. In addition, including more than one coverflow on the same interface made participant and idea browsing overwhelming.

A feature to kept in future iterations was the timeline with the color coded blocks to display ball possession and consequently speaking time. It provided a complete overview of turn taking during the brainstorming meeting and the superimposed player allowed navigation through audio either linearly or based on ideas.

IdeaBallNavigator - Second Iteration

The results from the first iteration suggested to drop coverflows altogether and go back to the drawing board. Paper prototypes were again developed to test how users respond to lists for displaying participants and ideas. Lists are very common and interaction with them is straightforward. Therefore, unlike in the first iteration, paper prototypes were suitable for determining the overall layout of the IdeaBallNavigator. Other additions included in the second paper prototype iteration include a sidebar for easier navigation and the rearranging of the top tier layout(see A.2.1—"IdeaBallNavigator Paper Prototypes")

The main layout of the user interface remained the same. It was still divided into two parts, the bottom portraying a timeline along with audio data and the top portraying participant information and ideas. The top part consisted of three parts. The leftmost part was a sidebar showing which "view" is currently selected: participants, ideas or session. The middle part contained a scrolldown list of

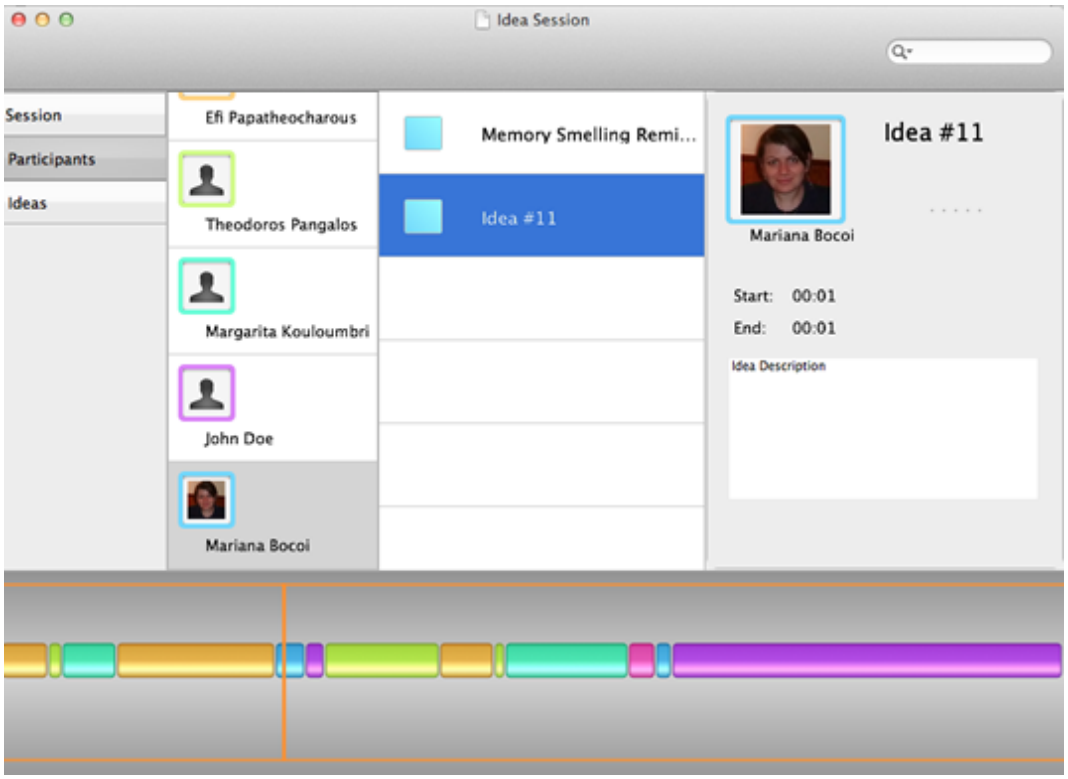

Figure 3.7: Second IdeaBallNavigator prototype

participants or ideas, depending on the sidebar selection. Finally, the rightmost part showed information on the currently selected idea or participant, allowing users to modify the selected option.(see figure 3.7)

This second iteration of the IdeaBallNavigator user interface, after the implementation of minor changes obtained from user feedback during testing, was also the final one.

3.4.2 IdeaBallNavigator Design Challenges

A design challenge encountered during the development of the IdeaBallNavigator included the distinction between private and visible information.

The IdeaBallNavigator application runs locally. It is neither distributed, nor does it keep track of people's profiles

The IdeaBallNavigator application runs locally

or ideas. The main goal of the IdeaBallNavigator is to provide participants with an overview of the session as well as with the ability to search, listen to ,and modify information. It focuses on the visualization of information for private browsing allowing participants at the end of each session to choose which information to disclose. It is a lightweight application, where all the data gathered, including audio, are saved in a single file.

Speaking time is visualized using a color-coded timeline

Speaking time is visualized qualitatively but not quantitatively. Speaking time is not correlated to the spoken content. Especially during brainstorming, redundant content is not unusual. Portraying the sequence in which users talk, in order to better assist them to recall the session, without focusing on spoken duration was the main goal of the timeline. By providing color coded content, attention is drawn to speaker order rather than quantifiable spoken duration. One can only roughly infer speaking time with respect to the meeting duration.

Idea authorship is guarded by rendering some information unmodifiable

Another challenge pertaining to privacy and visibility concerned the distinction between modifiable information and paths to it. After the session end, participants can enter their information to complete their profile. Participant profile information is then stored and also made visible as author information of an idea record. To ensure the tight coupling between participant and idea information, one cannot change author information on an idea record. One must rather modify the participant's record directly, where changed information are also updated on the participant's idea records. This structure creates a shared awareness of constraints [Erickson and Kellogg, 2003] and a greater sense of idea ownership. Finally, participants may not edit the audio file, as audio evidence is what users use to determine whether information is correctly indexed and depicted.

3.4.3 IdeaBall System Overview

IdeaBall and IdeaBallNavigator went through several incremental iterations until the final product.

The IdeaBall, is an embedded prototype used to facilitate

turn taking during brainstorming, as well as capture meeting information. A PCB that is fitted inside a ball, hides the technical aspects. Information is gathered using an RFID reader and a microphone. Visual and audio feedback, provide information on the ball's state and the identification of the user holding the ball, respectively. Design challenges mainly involved the choice of hardware and packaging. Trade-offs were closely analyzed, with the most significant being the compromise between audio quality and affordance.

The IdeaBallNavigator went through several paper prototype and implementation iterations. It presents an overview of the session and has additional browsing, searching and modifying functionality. A major design challenge concerned the architecture of the application, with the final version being a locally run, lightweight application, where all data captured, including the audio file, are saved in one file. Another design challenge involved the layout of the application. Clustering and color coding relevant information to provide a quick overview of the content was the main goal of the application.

System software and hardware were developed and tested separately and together. The next chapter presents an evaluation of the system. The final version was evaluated by conducting a heuristic evaluation on the IdeaBallNavigator interface and user tests on the IdeaBall and IdeaBallNavigator system.

Chapter 4

Evaluation

The final prototype, was validated against the meeting capturing and reviewing attributes presented in Table 2.2 and Table 2.3. Verification included user tests and heuristic analysis of the IdeaBallNavigator graphical user interface.

4.1 Prototype Validation

In 2.2.5—"Evaluation of Capture and Review Systems with Respect to Brainstorming" important attributes of meeting capture and review systems in brainstorming were established. Following is a validation of the IdeaBall and IdeaBallNavigator against the respective attributes.

4.1.1 IdeaBall Validation

The IdeaBall is an embedded prototype, that captures audio and turn taking during brainstorming.

Cost: The prototype cost is low, as it does not make use of specialized or expensive components. On the contrary, the electronic components used in this project are readily available in many consumer electronic stores. Likewise, the plastic ball was obtained from a hobby store.

	Meeting Capture Attributes			
	Ubiquity	Cost	Sensitive Data Capturing	Distracting
IdeaBall	Low	Low	Low	Medium

Table 4.1: IdeaBall validation

Sensitive Data Capturing: The prototype does not capture sensitive information, such as gaze direction or facial expressions during brainstorming. It only records audio during brainstorming as well as turn taking information.

Distracting: Interaction with the IdeaBall, under the disguise of a turn taking facilitator object does not distract from the idea generation goal. Discrete, yet present, visual and auditive feedback upon interaction with the IdeaBall bring its additional role of meeting capture to the participants' attention.

Ubiquity: Although IdeaBall parts are readily available in the market and configuration is included with this work, the IdeaBall, by virtue of being a prototype, does not satisfy the ubiquity requirement.

4.1.2 IdeaBallNavigator Validation

Search: The IdeaBallNavigator includes a search bar for searching *Participant* entries, or *Idea* entries, or *both*.

Index: The IdeaBallNavigator presents ideas belonging to a participant aggregated together. Additionally, color coded participant information on the participant, idea and timeline views provides an overview of participant ideas and speaking time.

Timeline-based Navigation: The timeline on the bottom tier of the user interface provides an immediate overview of turn taking as well as speaking duration during the meeting. Users can select an idea from the timeline to view its record or use the player to listen to it.

Index-based Navigation: Users can navigate through ideas

	Meeting Review Attributes				
	Search	Index	Navigate (Timeline)	Navigate (Index)	Identify Author
IdeaBallNavigator	High	High	High	High	High

Table 4.2: IdeaBallNavigator validation

based on the author's color either from the color-coded timeline-view or based on the corresponding color swatch of each idea. Additionally, users can perform a search to filter out ideas, participants or both. For ideas possible indices are: `Title`, `Start Time`, `End Time`, `Author`, `Rating`, and `Description`. Likewise, for participants possible indices are: `Name`, `Institute`, `Number of Ideas`, `About`. (see A.2.2—" System Object Identification")

Identify Author: The IdeaBallNavigator presents the author's name, photo, and application-assigned color on every idea record. In addition, author information is not editable from the idea record, but rather directly from the participant record.

Based on the above analysis, we can conclude that the IdeaBall and IdeaBallNavigator fulfill the requirements for a brainstorming meeting capture and review prototype as described in this thesis.

4.2 Qualitative User Studies

Qualitative user tests were conducted to establish the usability of the system and its suitability for further long term testing on how idea authorship affects the quality of co-located brainstorming. Establishing a conclusion on the actual effects of idea authorship, is beyond the scope of this work.

4.2.1 User Studies Description

User tests consisted of 2 brainstorming sessions, the first with 3 and the second with 4 participants. Users were given a consent form to sign and a questionnaire to answer before brainstorming. They were then introduced to the IdeaBall system and were instructed to pass the ball around for turn taking. Finally, the brainstorming task description was passed around to the participants.

You work for a company called OldInnovation. You are brainstorming on what attributes the company's newest product should have.The product is a device that keeps company to the elderly when they are alone, both during the day and night. You brainstorm on the following product attributes: functionality, appearance, name.

Average brainstorming duration was 15 minutes, during which an average of 25 ideas were generated

Users were then asked to complete specific tasks (B—"User Questionnaires") using the IdeaBallNavigator and loudly describe what they were doing and expecting from their actions. Finally, they filled out a user questionnaire pertaining to the brainstorming experience using the IdeaBall and brainstorming browsing using the IdeaBallNavigator. The questionnaire also included a final section with questions to establish whether the IdeaBall system prototype can be used to further investigate the effects of identifying idea authorship in co-located brainstorming.

In some cases, retrospective interviews took place to obtain user feedback and recommendations on additional system functionality.

4.2.2 User Studies Results

Users liked using an object for turn taking

Users immediately grasped the notion of using the IdeaBall for turn taking and, therefore, only spoke when they were holding the ball. On the actual interaction with the ball, user studies results showed that users liked the idea of us-

ing a physical object to control turn taking, they were yet not comfortable throwing the ball, due to fear of breaking it, either by dropping it or by ruining the circuit through the hole on the ball's surface. They were, however, very fond of the control they had over who speaks next, such that they only had to focus on one person at a time.

All participants completed user interface tasks succesfully

All participants completed the IdeaBallNavigator user tasks successfully. In completing the tasks, none of the users used the search button to answer the questions. All participants referred to the color coded timeline while solving the IdeaBallNavigator GUI tasks. 50% of the participants immediately referred to the timeline to answer questions such as *Number of Ideas*, *Number of participants* and *Listen to Idea*, by counting colored blocks.

Time- and author-based indexing helped navigation

Participants commented on the timeline and color-coding of participants. When asked to remember an idea they liked and listen to it, they all referred to the timeline for an estimate at which time point the idea was expressed. They then referred to the color-coded blocks to identify its author. Users mentioned that even with a larger group of up to 6 people they felt confident they would be able to find ideas within a reasonable amount of time.

Participants reported they understood and did not mind that ideas, as they are labeled in the IdeaBallNavigator, do not actually refer to original ideas, since participants may repeat themselves. They would have liked, however, the interface to accurately depict when a participant had more than one idea while holding the ball rather than just label the entire speaking time block as one idea.

With regard to the question of idea authorship, participants liked the coupling between ideas and authors because it made navigation easier. Only one third of the participants felt that identifying ideas and authors would motivate them more. From this one third, everyone found the IdeaBall System suitable for capturing such information.

Finally, users recommended useful features to include in future versions of the IdeaBall system prototype

- make the IdeaBall out of a rubbery material
- include a countdown timer to show how much time is left during the session and visual feedback from the ball
- allow users to navigate through the IdeaBallNavigator interface by rotating the IdeaBall
- allow users to group and create idea associations
- synchronize content with the Digital Whiteboard

4.3 Discussion

The IdeaBall system was validated against attributes for meeting capture and review systems for brainstorming, and verified by conducting qualitative user studies. User studies provided feedback on user interface improvements and better packaging for the IdeaBall. Interacting with the IdeaBall was not distracting to users, although they were aware of its role of information capturing in addition to controlling turn taking. User studies also reported that the IdeaBallNavigator provides a good overview of turn taking and both timeline based and index based navigation was intuitive. Finally, users who felt strongly about idea authorship reported they felt the IdeaBall system accurately depicted the connection between participants and ideas without making them conscious of data capturing or putting emphasis on talking duration.

Based on the user studies results we can conclude that the IdeaBall can make brainstorming meetings more fun, and may be also incorporated in brainstorming meetings in an unobtrusive manner. Based on the user results, while bearing in consideration that the IdeaBall system is a vertical prototype focused on capture and review, with regard to idea authorship, we can conclude that the IdeaBall system is a suitable tool to further expand and answer questions on idea authorship in co-located brainstorming.

Chapter 5

Summary and Future Work

This work produced a prototype for capturing and reviewing co-located brainstorming meetings, with an emphasis on idea authorship. The IdeaBall is a prototype for recording brainstorming information. Likewise, the IdeaBallNavigator is a desktop application for reviewing brainstorming information.

5.1 Summary

Creativity is important for the generation of innovative ideas. This work presented a review of common creative techniques. This review provided an insight into the origins and principles of each technique and a better general understanding of their use for idea generation. The reviewed creative techniques were then classified on the *innovation degree* of generated ideas, *group interaction* and whether ideas were generated in *sequence* or *in parallel*. Bearing in mind that we want to create a new tool to support group creative techniques for innovation in combination with the aforementioned classification, brainstorming was chosen as the creative technique, for which to develop a meeting capture and review tool.

There exist a lot of meeting capture and review systems for general meetings. Brainstorming is a special type of meeting. It lacks a structure, requires active group participation and no distractions. Different meeting capture and review systems were then presented and assessed based on attributes relevant to brainstorming meetings. A lot of tools require that users take some sort of notes or sketch, which affects the quantity and quality of ideas produced. Based on these attributes and how different meeting capture and review systems were classified, a solution concept was developed. Central to the solution concept was the hypothesis that identifying idea authorship could motivate participants. The solution concept involved the development of a vertical prototype for brainstorming meeting capturing and retrieval.

Research questions were then identified. They focused on how an embedded artifact may affect the quality of the brainstorming experience, and whether the same artifact may be used to examine the level of participant motivation in brainstorming when users know their ideas are being recorded.

IdeaBall and IdeaBallNavigator design and implementation went through several iterations

Storyboards and use cases were created to analyze interaction and determine system characteristics. The system consists of the IdeaBall, used for meeting capturing, and the IdeaBallNavigator, used for meeting review. Both parts of the system went through several iterations. The IdeaBall is an embedded physical artifact, namely a ball, used for turn taking during brainstorming. It records audio and timestamped RFID tag events. RFID events occur when a user wearing a *user tag* interacts with the ball. The IdeaBall can thus serve the double role of a speaking token and that of an embedded artifact for information capture. IdeaBall design iterations mainly affected its packaging and board layout. The IdeaBallNavigator is a local desktop application that organizes and presents captured information, allowing users to search, index and navigate through the captured material by either using the timeline or author-indexed lists. Paper prototypes determined the layout of the IdeaBallNavigator user interface. In the first iteration paper-prototypes proved inadequate to simulate coverflow interaction. Design challenges and trade-offs were considered throughout the development of both system parts.

The resulting system was then compared to the attributes previously identified as important attributes for brainstorming meeting capture and review tools. Finally, user tests were conducted in order evaluate the system, and answer the research questions from 3.1—"Research Questions". User tests evaluated the overall brainstorming experience with the IdeaBall, the usability of the IdeaBall-Navigator and provided feedback and recommendations for further improvements. Users reported that they liked passing an object around to control turn taking and were not particularly conscious of the IdeaBall's data capturing functionality. The liked that the object was a ball and found the change-of-hands events helped them keep an estimate of the number of ideas generated. Participants also praised the color-coding of participants and the blocked timeline. They mentioned that the indexing of events based on time and color, helped them with recalling content and finding ideas faster.

5.2 Future Work

The qualitative user studies, especially the follow-up interviews, yielded interesting suggestions to incorporate or further investigate in future versions of the system.

5.2.1 Long term user studies

Increasing the motivation of participants during co-located brainstorming, can also increase their commitment and consequently, the quality of the ideas generated. To test this hypothesis a tool for gathering and presenting such information is needed, as well user studies with statistically significant results. In 4.2.2—"User Studies Results" we established that the IdeaBall system is suitable for further investigation on whether idea authorship affects motivation in co-located brainstorming. Long-term user studies with a greater sample of groups, which meet regularly and consist of the same participants, such that possible competition within the group is accounted for, should be con-

ducted. Results from these user studies would help determine whether there indeed exists a correlation between idea authorship and motivation in co-located brainstorming.

5.2.2 System Improvements

As mentioned in the previous chapter, the result of this work is a vertical prototype concentrating on using an embedded artifact to unobtrusively capture information during brainstorming and allow users to navigate through meeting content based on the idea's originator. The tool was evaluated positively by users, and they made recommendations of improvements that would make interaction with the artifact and software more pleasant.

Audio Quality

The IdeaBall is an embedded prototype that receives incoming events and forwards them using a bluetooth connection to a connected computer. Users found the audio quality good enough to identify the speaker and the spoken content. Noise picked up by the microphone, however, did distract them. Better audio quality either in hardware or software for reducing noise levels would make listening to ideas require less concentration.

Different Shell Material

Form and material affect the affordance of the IdeaBall. User recommendations included using rubber to cover the ball to encourage throwing. Further user recommendations included changing the shell's form by putting rubber hand traces on it, so that users are constrained to hold it in a certain way.

Discretize Ideas

Users commented they would like the system to detect when an individual says two consecutive ideas without passing the IdeaBall on. Currently the IdeaBallNavigator would list them as one. Discretizing Ideas either by interaction with the IdeaBall (such as rotation) or with audio processing on the software side, would indeed give a more accurate impression of the number of ideas generated and progress of events.

5.2.3 System Additions

The IdeaBallNavigator went through rigorous design and implementation iterations. Users from the user studies were overall satisfied with the software and the navigation experience. They commented on existence of indexing without the need for user processing, and identified features that they would like to see implemented in future versions.

In brainstorming sessions, the use of a whiteboard, visible by all participants, ensures that participants can use material from the board as stimulus and have a common point of reference. Users reported that they would like to have a view of the whiteboard included in the software. Incorporating whiteboard content as a video in addition to the recorded audio would help them to better recall meeting content, especially in meetings with a long duration.

Structuring meeting content can help participants to cluster and connect relevant ideas in a meaningful way. This structure helps participants to evaluate the meeting and concentrate on ideas they deem relevant and important. Participants tried to create connections between ideas by writing the name of the relevant idea in the other idea's description field. They then commented that they would like to be able to drag ideas to create connections between them. Creating a graph of connected ideas would help them to structure the meeting content.

In addition to connecting ideas, users reported that they would like to attach relevant material to ideas, such as research papers and images. Ability to add attachments would increase the information content of ideas and allow users to use one application for reviewing brainstorming meetings and browsing through relevant content.

Finally, the prototype could be extended to support the Visual Group Confrontation technique.(2.1.5—"Visual Group Confrontation Technique ") By detecting long pauses, or after a participant shakes the IdeaBall, pictures may be projected on a large common screen.

5.2.4 Additional Applications

The IdeaBall system has been conceived and designed based on an analysis of creative techniques, with the goal of better supporting the generation of innovative ideas. It may, however, be used in different fields as well. It may be used to document therapy group conversations, especially with children, where the fun factor may help them to cooperate better. With a few firmware modifications, the IdeaBall may be used as an ambient device. Finally, more obvious applications include the support of other, more structured types of meetings.

Appendix A

System Analysis & Implementation

A.1 System Analysis

A.1.1 Storyboards

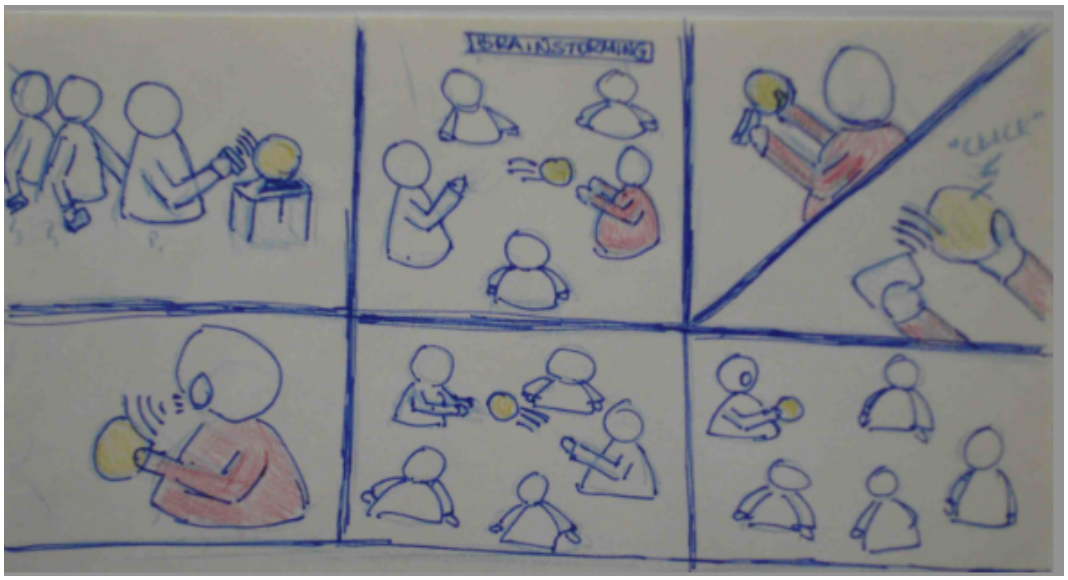

Figure A.1: Storyboard - IdeaBall

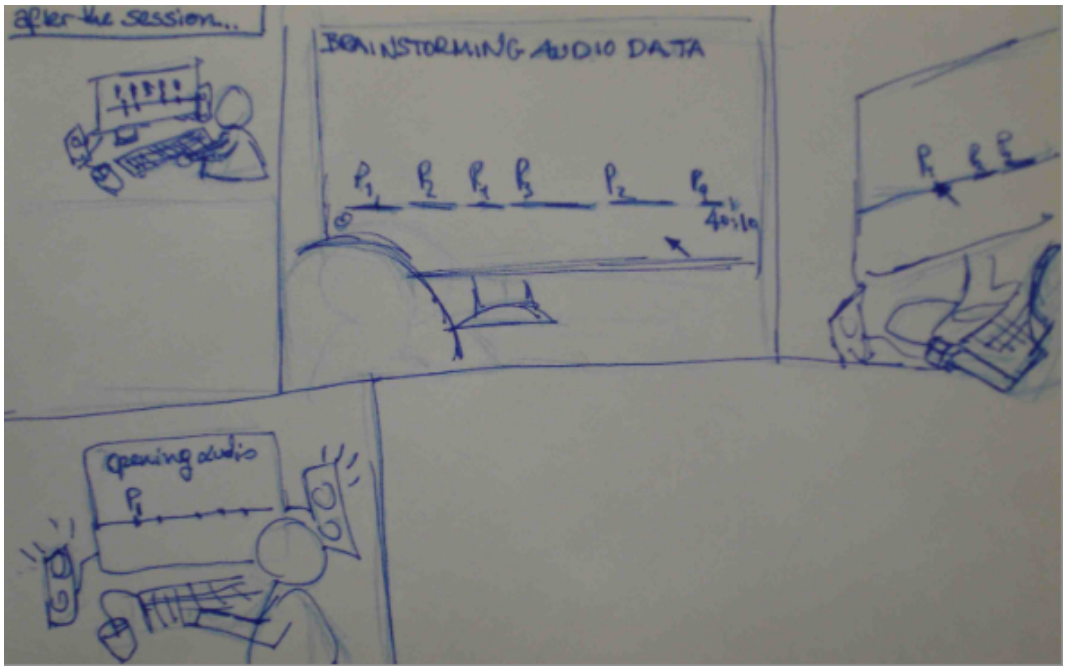

Figure A.2: Storyboard - IdeaBallNavigator

A.2 System-User Interaction from the User's point of view

A.2.1 IdeaBallNavigator Paper Prototypes

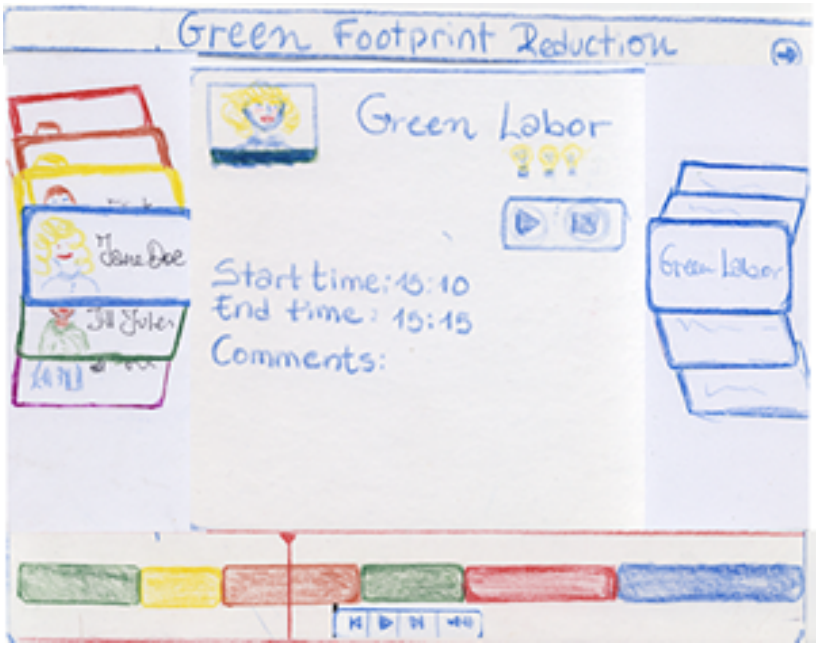

Figure A.3: IdeaBallNavigator First Paper Prototypes Iteration Part1

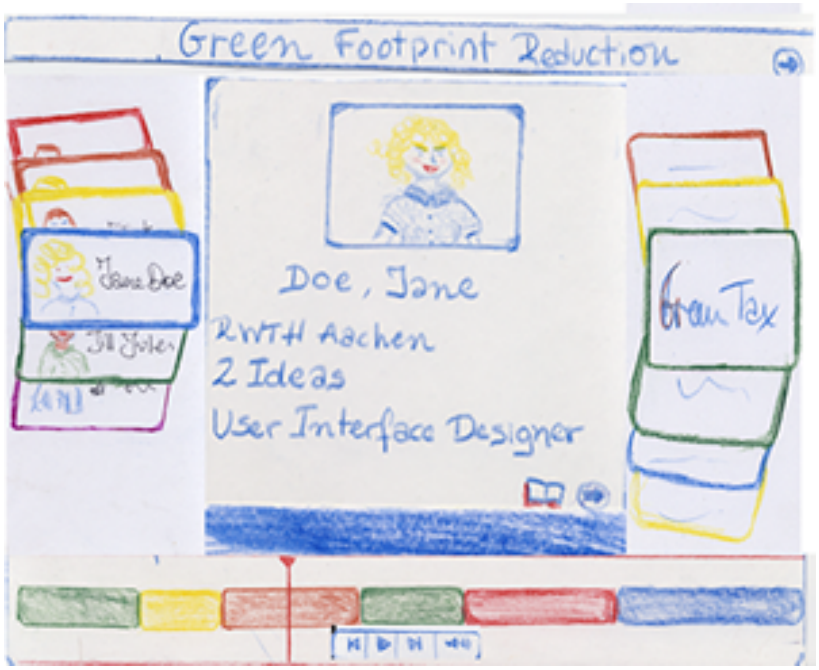

Figure A.4: IdeaBallNavigator First Paper Prototypes Iteration Part2

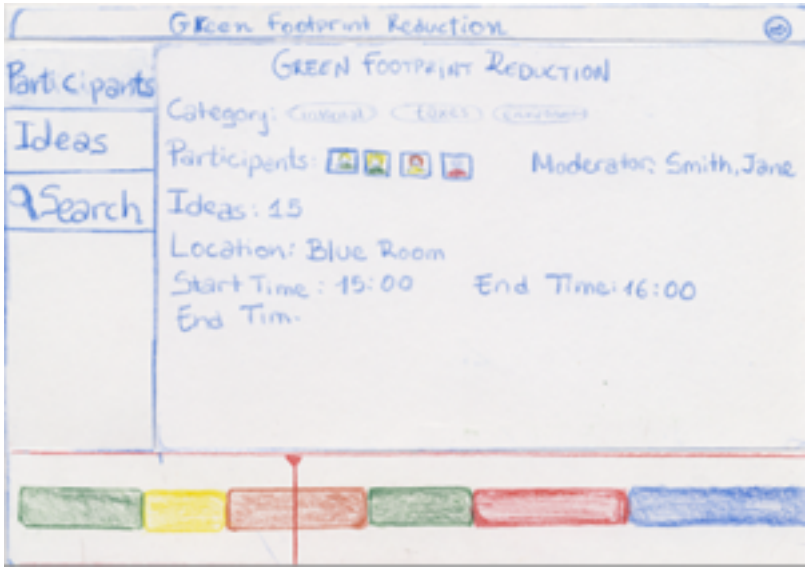

Figure A.5: IdeaBallNavigator Second Paper Prototypes Iteration Part1

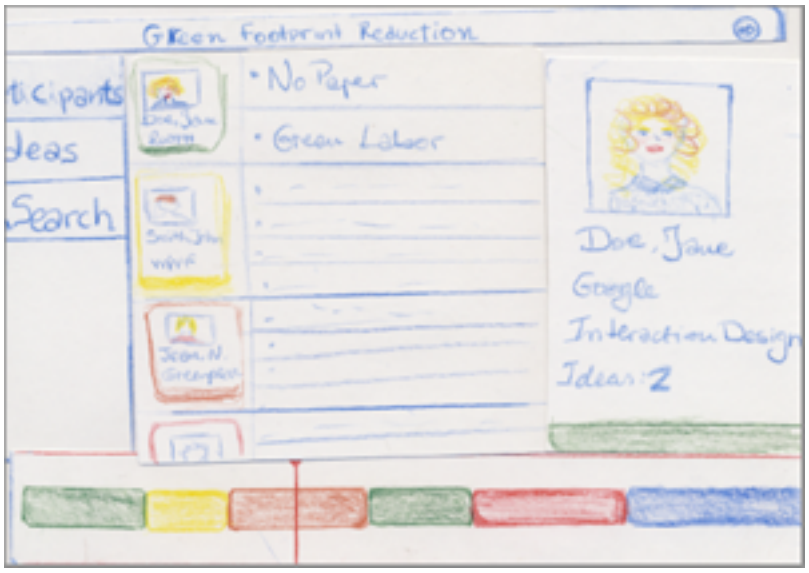

Figure A.6: IdeaBallNavigator Second Paper Prototypes Iteration Part2

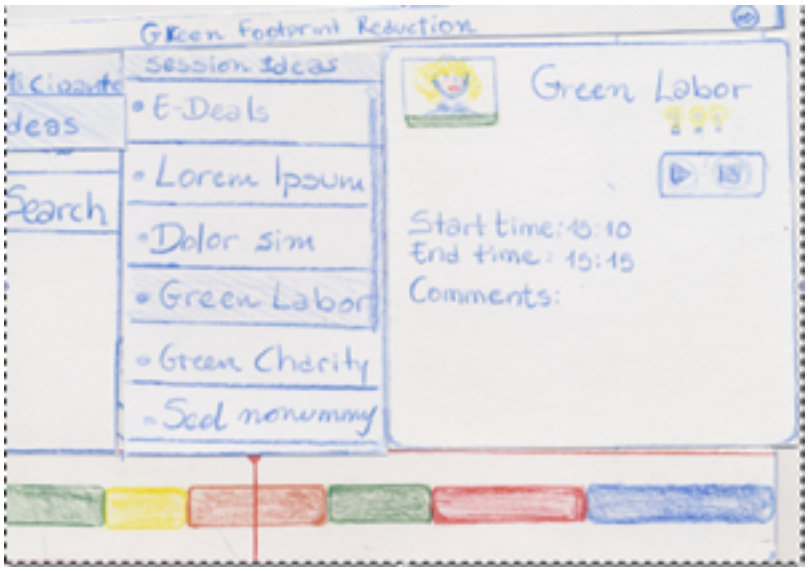

Figure A.7: IdeaBallNavigator Second Paper Prototypes Iteration Part3

A.2.2 UML Diagrams

Use Cases

Use case name	`OpenBrainstormingSession`
Participating Actors	Initiated by `TerminalUser`
Flow of Events	1. The `TerminalUser` clicks on the File-¿Open from the `IdeaNavigator` menu 2. `IdeaNavigator` responds by presenting a file browser window 3. The `TerminalUser` browses and selects the brainstorming session to open by clicking on it 4. `IdeaNavigator` loads the application and shows on the main display screen the timeline with the idea nodes.
Entry Condition	• The `TerminalUser` has launched the `IdeaNavigator` application.
Exit Condition	• The `TerminalUser` closes the application OR • `IdeaNavigator` has loaded the brainstorming session the `TerminalUser` selected OR • The `TerminalUser` has clicked on the "Cancel" button in the file browser window.
Quality Requirements	• `IdeaNavigator` response time to mouseclick and mouseover events is less than 10 seconds.

Table A.1: Use Cases: OpenBrainstormingSession

Use case name	`RecordBrainstormingSession`
Participating Actors	Initiated by `TerminalUser` Participating `Brainstormers` Communicates with the `IdeaBall`
Flow of Events	1. The `Brainstormer` powers up the `IdeaBall` 2. The `IdeaBall` glows red 3. `IdeaNavigator` establishes a connection to the `IdeaBall`. 4. The `IdeaBall` glows blue 5. The `Brainstormer` shakes the ball to start recording 6. The `IdeaBall` sends a record request to the `IdeaNavigator` 7. The `IdeaNavigator` sends a record response 8. The `IdeaBall` glows green 9. `IdeaNavigator` displays a recording message. 10. `IdeaNavigator` displays the elapsed time from the beginning of the recording. 11. The `Brainstormers` start the Brainstorming session by interacting with the `IdeaBall`.
Entry Condition	• The `TerminalUser` has launched the `IdeaNavigator` application. • `IdeaNavigator` has loaded a brainstorming session, that was just created or opened by the `TerminalUser`.
Exit Condition	• The `TerminalUser` closes the application, OR • The `TerminalUser` shakes the `IdeaBall` • The `StopRecordingBrainstormingSession` use case follows.
Quality Requirements	• `IdeaNavigator` response time to mouseclick and mouseover events is less than 10 seconds. • The connection between the `IdeaNavigator` and the `IdeaBall` is reliable.

Table A.2: UseCases: RecordBrainstormingSession

Use case name	`StopRecordingBrainstormingSession`
Participating Actors	Initiated by `TerminalUser` Communicates with the `IdeaBall`
Flow of Events	1. The `Brainstormer` shakes the green glowing `IdeaBall` to stop recording the current brainstorming session. 2. The `IdeaBall` sends a tear down request to the `IdeaNavigator` 3. `IdeaNavigator` tears down the connection to the `IdeaBall`. 4. `IdeaNavigator` populates the timeline with the ideas presented in the brainstorming session it just stopped recording.
Entry Condition	• The `RecordBrainstormingSession` use case has preceeded. • `IdeaNavigator` has loaded a brainstorming session, that was just created or opened by the `TerminalUser`.
Exit Condition	• The `TerminalUser` closes the application.
Quality Requirements	• `IdeaNavigator` response time to mouseclick and mouseover events is less than 10 seconds. • The teardown of the connection between the `IdeaNavigator` and the `IdeaBall` presents no exceptions and takes place within 30 seconds. • Populating the idea timeline happens within 30 seconds after clicking on the “Stop Recording” button.

Table A.3: Use Cases: StopRecordingBrainstormingSession

Use case name	`ListenToIdea`
Participating Actors	Initiated by `TerminalUser`
Flow of Events	1. The `TerminalUser` double clicks over an `Idea Node` on the timeline with the mouse. 2. `IdeaNavigator` responds by moving a slider over the Timeline on the specific idea. 3. `IdeaNavigator` opens a record for the selected idea. Record information includes the idea number,specific time and date and duration of the idea. It also includes the name of the person talking. 4. The `TerminalUser` reads the information and clicks on the play button on the timeline player `IdeaNavigator` plays until it reaches the end of the brainstorming session audio or the `TerminalUser` hits "Stop"
Entry Condition	• The `TerminalUser` has opened a brainstorming session file. • `IdeaNavigator` has loaded a brainstorming session, that was just created or opened by the `TerminalUser`.
Exit Condition	• The `TerminalUser` hits "Stop"
Quality Requirements	• `IdeaNavigator` response time to mouseclick and mouseover events is less than 10 seconds.

Table A.4: Use Cases: ListenToIdea

Use Cases Diagram Overview

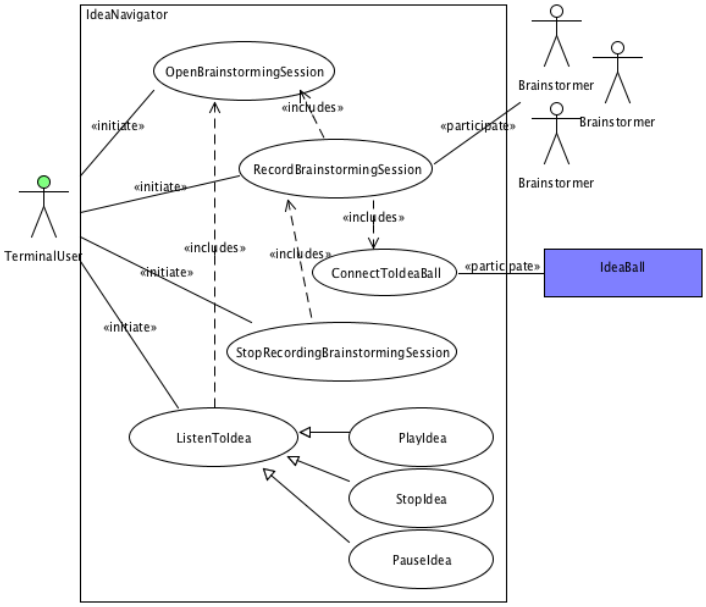

Figure A.8: Use Cases Overview

System Object Identification

The aforementioned use cases facilitate the identification of objects. By applying to the use cases, natural language analysis heuristics by Abbot as described by Brugge and Dudoit in the context of object orientation[Bruegge and Dutoit, 2004], we proceed with the identification of the entity, boundary and control objects in the system.

Entity Object	Attributes & Associations	Definition
TerminalUser	name*(implied)*	The actor interacting with the IdeaBallNavigator
Participant	• Name • Institute • Number of Ideas • About	The actor that participated in the `BrainstomringSession` using the IdeaBall
IdeaNode	• name • Index Numer • Author • Start Timestamp • End Timestamp • Title • Description • Rating	an `IdeaNode` represents is an idea that was expressed during the brainstorming session. It is associated with the `Timeline` and its number identifies its occurrence index on the `Timeline`.
Timeline	• number of idea nodes • brainstorming session • length	A `Timeline` represents a collection of ideas for a particular brainstorming session sorted according to their timestamp
BrainstormingSession	• Name • Description • Start time • End time • Status (recording or stopped) • Date • list of ideas • Brainstorming Group	A BrainstormingSession is created by the `TerminalUser` and uniquely identifies the `Timeline` and its associated `IdeaNodes`.

Table A.5: Entity Objects and Attributes

A.3 IdeaBall PCB

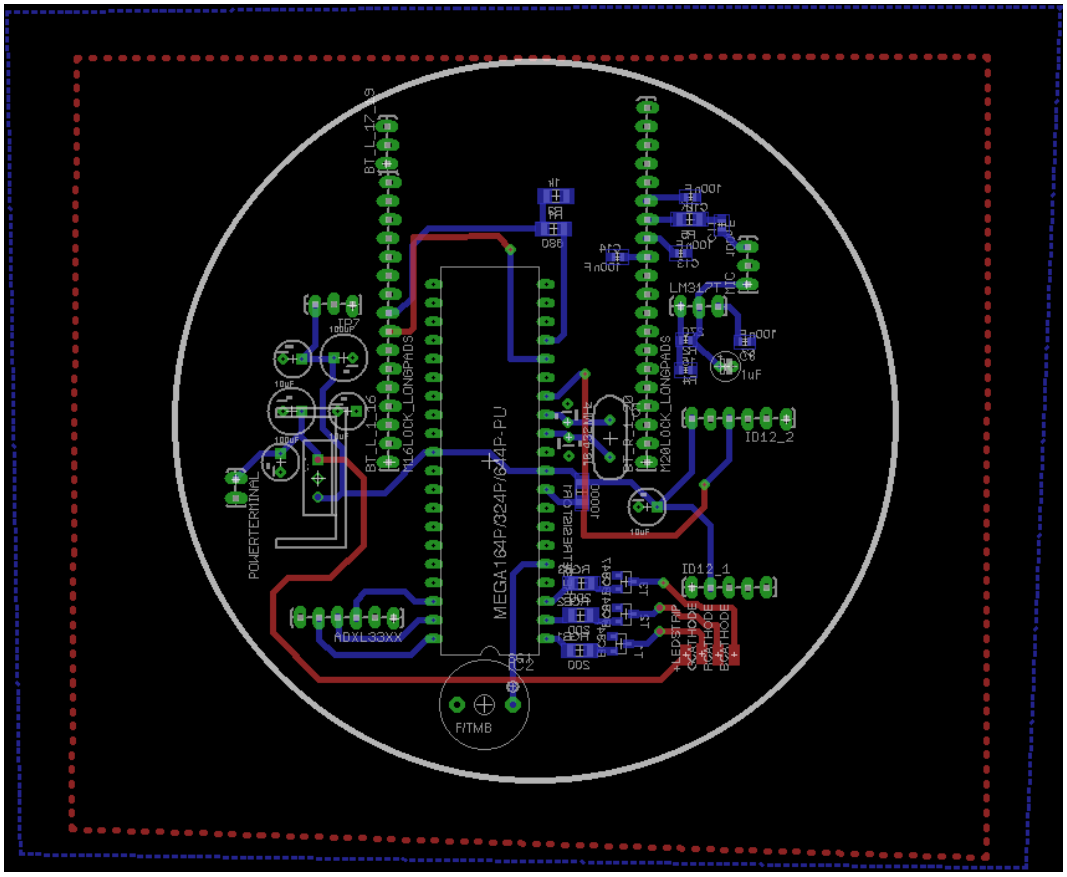

Figure A.9: IdeaBall Eagle Board Layout

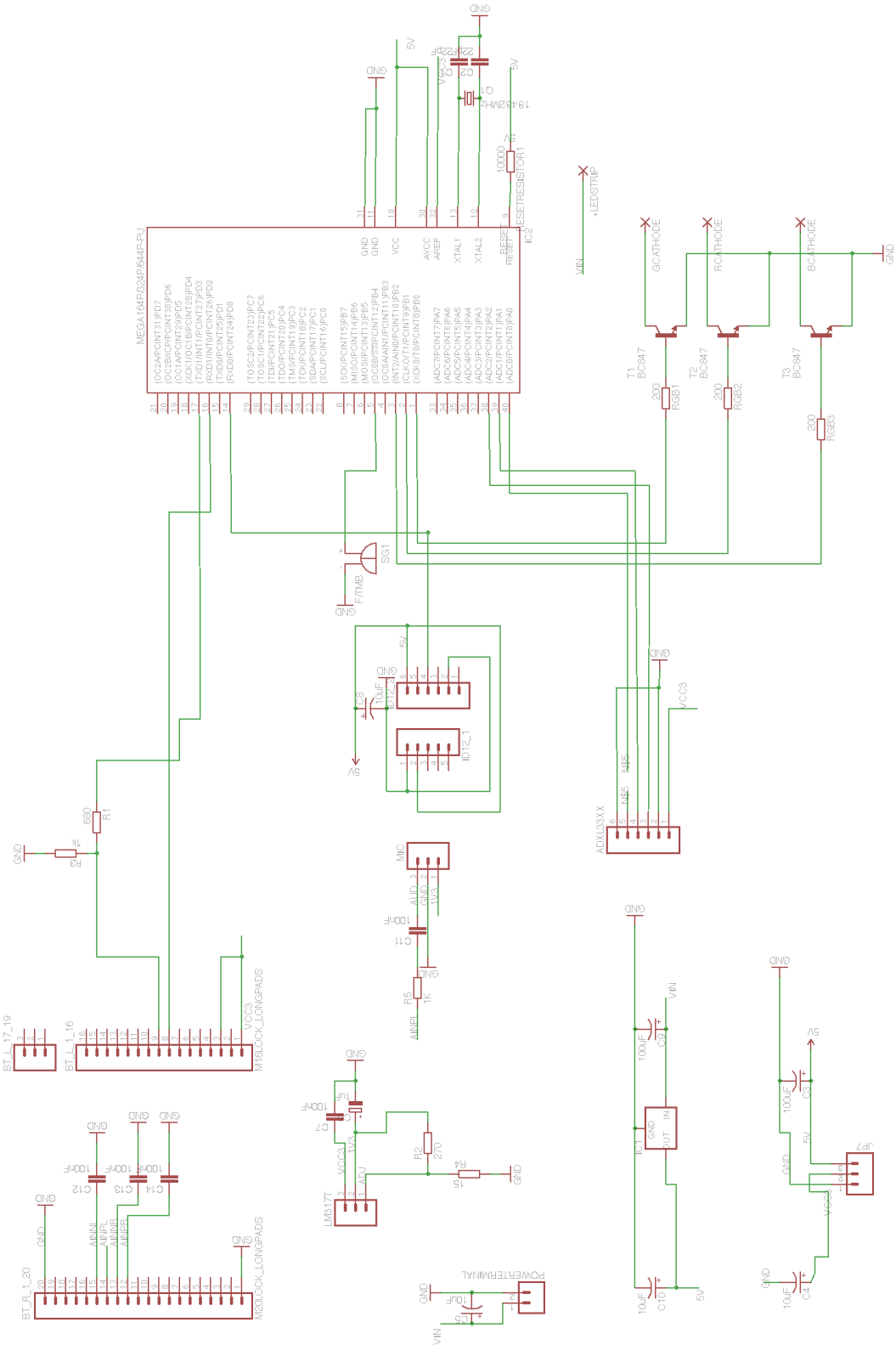

Figure A.10: IdeaBall Eagle Schematic

Appendix B

User Questionnaires

IdeaBall Pre- User Test Questionnaire

1. Have you previously participated in a brainstorming meeting?
   Yes No
   If you answered yes, do you usually take notes?
   Yes No
   If you answered Yes, why do you take notes?
2. Do you participate in brainstorming with the same group of people or are they usually new?
3. Have you ever kept idease to yourself during brainstorming because you were afraid of others stealing them?
   - never
   - seldomly
   - don't know
   - often
   - always

Figure B.1: Pre- User Test Questionnaire

IdeaBall Brainstorming Task Description

You work for a company called OldInnovation.

You are brainstorming on what attributes the company's newest product should have.The product is a device that keeps company to the elderly when they are alone both during the day and night.

You brainstorm on the following product attributes
- functionality
- appearance
- name

Figure B.2: User Test Brainstorming Task Description

IdeaBallNavigator User Tasks

Please try to answer the following questions by consulting the IdeaBallNavigator

1. How many participants took part?
2. How many ideas were there?
3. Fill out your name, picture, description and institute in your participant profile
4. How many ideas did you have?
5. Give a rating for your first idea
6. Listen to your last idea
7. Was there an idea that you liked the most?
   If you answered yes, listen to it

Figure B.3: User Test: IdeaBallNavigator tasks

IdeaBall Post- User Test Questionnaire

Brainstorming Capturing

1. Did you at any point feel uncomfortable during the meeting?
Yes No

If you answered Yes, please elaborate

2. Was it clear when you could start talking upon catching the ball?
Yes No

3. Do you like using an object to control turn taking?
Yes No

4. Did you feel comfortable throwing the ball?
Yes No

If you answered No, please elaborate

5. Did knowing the brainstorming session was being reorded affect your participation level?
Yes No

If you answered Yes, please elaborate

6. For what duration of the session were you concentrated on what was being said?
- Never
- Scarcely
- Sometime
- Most of the time
- All the the time

7. Did you generate any ideas that you are particularly proud of?
Yes No

8. Comments/suggestions for improving the brainstorming experience using the IdeaBall.

Brainstorming Review

9. Can you remember of an idea said (by you or someone else during brainstorming?)
Yes No

10. If you answered Yes, how confident do you feel you can find it using the IdeaBall-Navigator?
- very unsure
- unsure
- don't know
- confident
- very confident

11. What do you think of the IdeaBallNavigator identifying who said what during brainstorming?
- Completely Agree
- Agree
- Neutral
- Disagree
- Completely Disagree

12. How do you feel sharing your ideas knowing you are identified as their author by the system?
- Very Comfortable
- Comfortable
- Neutral
- Uncomfortable
- Very Uncomfortable

13.What additional functionality would you like to see implemented in the IdeaBallNavigator?

Figure B.4: Post- User Test Questionnaire

Appendix C

Digital Content

The attached DVD contains the source code for the IdeaBall and the IdeaBallNavigator. It also includes the Eagle files for the IdeaBall.

Bibliography

Merriam-webster dictionary. Nov 2011. URL UR-http://www.britannica.com/EBchecked/topic/675239/innovation.

Teresa M. Amabile. *The social psychology of creativity*. Springer Verlag, Jan 1983.

Marcello Bastéa-Forte and Corina Yen. Encouraging contribution to shared sketches in brainstorming meetings. In *CHI '07 extended abstracts on Human factors in computing systems*, CHI EA '07, pages 2267–2272, New York, NY, USA, 2007. ACM. ISBN 978-1-59593-642-4.

D Brown and J Kusiak. Creative thinking techniques. *IRM Training - White Paper*, pages 1–12, May 2007.

Bernd Bruegge and Allen H. Dutoit. *Object-oriented software engineering: using UML, patterns, and Java*. Pearson Education, Inc., 2004.

Alistair Cockburn. Using both incremental and iterative development. *CROSSTALK The Journal of Defense Software Engineering*, pages 27–30, May 2008.

R Van der Lugt and FS Visser. Widening involvement in creative group processes. *Proceedings of the 9th European Conference on Creativity and Innovation*, 2005.

Thomas Erickson and Wendy A. Kellogg. Social translucence: using minimalist visualisations of social activity to support collective interaction. In Kristina Höök, David Benyon, Alan J. Munro, Dan Diaper, and Colston Sanger, editors, *Designing information spaces*, chapter Social translucence: using minimalist visualisations of social activity to support collective interaction, pages 17–

41. Springer-Verlag, London, UK, 2003. ISBN 1-85233-661-7.

Florian Forster and Harald Wartig. Creativity techniques for collocated teams using a web-based virtual whiteboard. In *Proceedings of the 2009 Fourth International Conference on Internet and Web Applications and Services*, pages 7–11, Washington, DC, USA, 2009. IEEE Computer Society. ISBN 978-0-7695-3613-2.

Deirdre Garrahan, Orit Shaer, Andreya Piplica, and Kevin Gold. Leveraging gesture and voice data to improve group brainstorming. In *Proceedings of the 28th of the international conference extended abstracts on Human factors in computing systems*, CHI EA '10, pages 3901–3906, New York, NY, USA, 2010. ACM. ISBN 978-1-60558-930-5.

H Geschka. Creativity techniques in germany. *Creativity and Innovation Management*, 5:87–92, 1996.

Michael Haller, Jakob Leitner, Thomas Seifried, James R. Wallace, Stacey D. Scott, Christoph Richter, Peter Brandl, Adam Gokcezade, and Seth Hunter. The nice discussion room: Integrating paper and digital media to support colocated group meetings. In *Proceedings of the 28th international conference on Human factors in computing systems*, CHI '10, pages 609–618, New York, NY, USA, 2010. ACM. ISBN 978-1-60558-929-9.

J Hender, D Dean, T Rodgers, and J Nunamaker. Improving group creativity: Brainstorming versus non-brainstorming techniques in a gss environment. *PROCEEDINGS OF THE ANNUAL HAWAII INTERNATIONAL CONFERENCE ON SYSTEM SCIENCES*, pages 37–37, 2001.

James M. Higgins. *101 creative problem solving techniques: the handbook of new ideas for business*. New Management Publishing Company, Jan 1994.

Otmar Hilliges, Lucia Terrenghi, Sebastian Boring, David Kim, Hendrik Richter, and Andreas Butz. Designing for collaborative creative problem solving. *C andC '07: Proceedings of the 6th ACM SIGCHI conference on Creativity and cognition*, Jun 2007.

John Chris Jones. *Design Methods*. Wiley, Jan 1992.

Tom Kelley. *The Art of Innovation*. Doubleday, Feb 2006.

Lena Mamykina, Linda Candy, and Ernest Edmonds. Collaborative creativity. *COMMUNICATIONS OF THE ACM*, 45(10), Oct 2002.

P McLeod. Effects of anonymity and social comparison of rewards on computer-mediated group brainstorming. *Small Group Research*, Jan 2011.

M Michalko. *Thinkertoys: A handbook of creative-thinking techniques*. Ten Speed Press, Jan 2006.

J Moultrie, M Nilsson, M Dissel, UE Haner, S Janssen, R Van der Lugt, and T Street. Innovation spaces: Towards a framework for understanding the role of the physical environment in innovation. *Creativity and Innovation Management*, 16(1):53–65, 2007.

D.A. Norman. *The psychology of everyday things*. Basic Books, 1988. ISBN 9780465067091.

Alex F. Osborn. *Applied imagination: Principles and procedures of creative problem-solving*. C. Scribner's Sons; Rev. ed edition, 1957.

Sidney J Parnes. Programs and courses in creativity. *Encyclopedia of Creativity*, 1:465–477, Jan 1999.

Paul B. Paulus. Group creativity. *Encyclopedia of Creativity*, 1:779–784, 1999.

Paul B. Paulus, Mary T. Dzindolet, George Poletes, and L. Mabel Camacho. Perception of performance in group brainstorming: The illusion of group productivity. *Personality and Social Psychology Bulletin*, 19(1):78–89, 1993.

T Proctor. Computer programs. *Encyclopedia of Creativity*, 1: 301–307, Jan 1999. analysis of tools.

K. Schreiner. Uniting the paper and digital worlds. *Computer Graphics and Applications, IEEE*, 28(6):6 –10, nov.-dec. 2008. ISSN 0272-1716. doi: 10.1109/MCG.2008.124.

Ben Shneiderman. Creativity support tools accelerating discovery and innovation. *COMMUNICATIONS OF THE ACM*, 50(12):20–32, Jan 2007.

Ted Selker SJ Yu. Who said what when?: capturing the important moments of a meeting. *Proceedings of the 28th of the international . . .*, Jan 2010.

Arthur B. VanGundy. *101 activities for teaching creativity and problem solving*. Pfeiffer, Jan 2004.

Andy Warr and Eamonn O'Neill. Understanding design as a social creative process. *C&C '05: Proceedings of the 5th conference on Creativity & cognition*, Apr 2005.

Chauncey Wilson. Brainstorming pitfalls and best practices. *interactions*, 13(5), Sep 2006.

Chauncey Wilson. Inverse, reverse, and unfocused methods: variations on our standard tools of the trade. *interactions*, 14(6), Nov 2007.

Yingen Xiong and Francis Quek. Meeting room configuration and multiple camera calibration in meeting analysis. *Proceedings of the 7th international conference . . .*, Jan 2005.

H Yu, T Tomokiyo, Z Wang, and Alex Waibel. New developments in automatic meeting transcription. *Proceedings of the ICSLP*, Jan 2000.

Zhiwen Yu and Yuichi Nakamura. Smart meeting systems: A survey of state-of-the-art and open issues. *ACM Computing Surveys (CSUR)*, Jan 2010.

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