

Mobile Device Usage in Interactive, Co-located Presentations

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Declaration

I hereby declare and confirm that this thesis is entirely the result of my own original work. Where other sources of information have been used, they have been indicated as such and properly acknowledged. I further declare that this or similar work has not been submitted for credit elsewhere.

Hagenberg, September 26, 2016

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¹<https://github.com/irisSchaffer/>

Abstract

Mobile devices such as smartphones, tablets and laptops have become our every day companions and can act as an endless source of information, knowledge and inspiration. However, despite studies having demonstrated the benefits of targeted smartphone use in classrooms and meetings, they are still perceived as impolite and disturbing during presentations. These, on the other hand, are often still one-man endeavours, from slide preparation, giving the talk to lastly follow-up work such as hand-outs. In an effort to destigmatise mobile devices usage and make presentations more memorable, engaging, and collaborative, a prototype of an extensible JavaScript presentation ecosystem with a multitude of interactive mechanisms was implemented. These functionalities are the result of the analysis of several types of presentations and their weaknesses and, amongst others, include the possibility for the audience to browse and follow slides on any mobile device to account for individual learning-pace, as well as spontaneous reactions via emoji and votes on polls (both prepared and created on-the-fly) to more reliably estimate ones crowd's mood and background knowledge. Moreover, to truly involve audience members in shaping the presentation, the functionality to alter the 2-dimensional slide-sets in real time was realised. This way, listeners can share related multi-media content as well as questions and comments as new main or sub-slides.

Although more thorough, long-term studies will be necessary to validate our approach, consequent informal evaluation of the system in internal presentations and meetings has been promising and decidedly positive. Despite showing room for improvement, all features were understood by the users, with the content sharing functionality sparking most interest and excitement among listeners. The observation of the usage of the tool has moreover given way to further research projects and ideas.

Kurzfassung

Mobile Geräte wie Smartphones, Tablets und Laptops sind unsere täglichen Wegbegleiter und dienen als endlose Quellen an Information, Wissen und Inspiration. Obwohl Studien die positiven Effekte von zielgerichtetem Einsatz von Smartphones in Klassenzimmern und Meetings bewiesen haben, gilt die Verwendung dieser in Präsentationen noch immer als störend und unhöflich. Präsentationen, andererseits, sind von der Vorbereitung der Folien, dem Vortragen bis hin zur Nachbereitung von Hand-Outs meist immer noch die alleinige Aufgabe der Präsentatoren. In einem Versuch das Stigma um mobile Geräte zu wenden und Präsentationen ansprechender, einprägsamer und kollaborativer zu gestalten, wurde der Prototyp einer erweiterbaren JavaScript Präsentationsumgebung mit mehreren interaktiven Mechanismen implementiert. Die entwickelten Funktionen bauen auf der Analyse unterschiedlicher Präsentationsformen und ihrer Schwächen auf und umfassen unter anderem die Anzeige und Synchronisierung der Folien auf persönlichen Geräten um auf individuelles Lernverhalten einzugehen, sowie momentane Reaktionen auf Präsentationsinhalte mit Emoji und das Abstimmen auf vorbereitete und während der Präsentation angelegte Umfragen, um das Abschätzen des Vorwissens und der Stimmung des Publikums zu erleichtern. Des Weiteren werden Zuhörer_innen aktiv in die Gestaltung der Präsentation miteinbezogen indem es ihnen ermöglicht wird Fragen, Kommentare und andere multimediale Inhalte als neue Haupt- und Subfolien mit der Präsentation zu teilen.

Obwohl tiefergehende Langzeitstudien notwendig sind um unsere Ansätze zu legitimieren, sind ersten informellen Evaluierungen des Systems in internen Meetings und Präsentationen vielversprechend und durchwegs positiv. Auch wenn die Auswertungen Verbesserungsmöglichkeiten verdeutlicht haben, so wurden doch alle Mechanismen von den Benutzer_innen verstanden, und besonders das Teilen multimedialer Inhalte weckte das Interesse des Publikums und konnte dieses begeistern. Die Beobachtung der Verwendung der geschaffenen Werkzeuge konnte außerdem neue Ideen inspirieren und hat mögliche weitere Forschungsprojekte aufgezeigt.

Chapter 1

Introduction

1.1 Motivation

Mobile phones, tablets and laptops have become our every day companions. We take them with us wherever we go, may it be the classroom or meetings, lately they have even made an appearance in courtrooms [16]. Especially during presentations mobile device usage is still perceived as impolite and can be a source of distraction [2, 3, 23], although studies indicate that lecture-relevant phone use in classrooms can actually be beneficial for information-recall [22].

Presentations, on the other hand, have remained largely unchanged since the launch of PowerPoint in the late 1980s [42]. In fact, some of the features overhead projectors innately offered, namely the annotation of transparencies during the presentation and sorting and choosing slides before presenting them, have effectively been lost with the introduction of presentation software. While the amount of presentations given has continuously risen, the modus of presenting has stayed untouched: In most cases, there is one presenter and a group of co-located listeners. The speaker prepares slides prior to a presentation and has the responsibility of educating, fascinating, inspiring and keeping the audience awake, while catering the presented contents to the respective listeners. Although interactive elements in presentations have proven to be twice as effective at engaging listeners and beneficial to information-recall [81], presentations have largely remained a static endeavor for the speaker alone.

Mobile phones, tablets and laptops, however, hold the potential of challenging this status quo. Their growing computing power as well as ubiquitousness make them suitable candidates for interacting with presentation software, thus transforming presentations into a more collaborative effort. Instead of banning modern technologies, incorporating mobile devices has proven to foster collaboration and connection between attendees in meetings [3] and has the potential of promoting participation and helping introverts

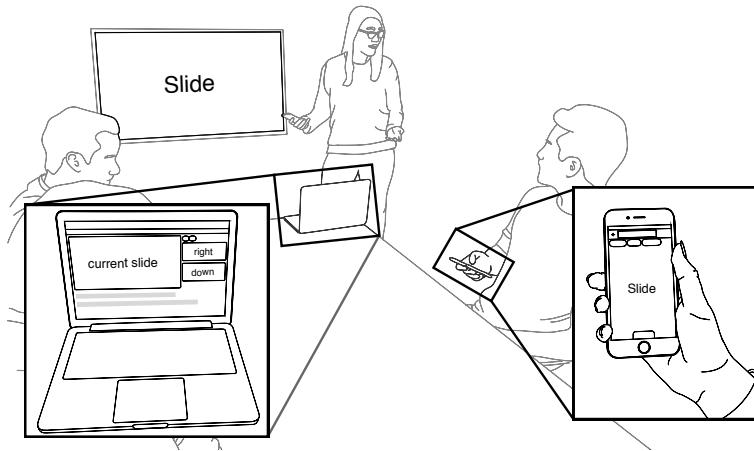


Figure 1.1: Unveil presentation in action: the projector displays the current slide, listeners can follow and interact with presentations on their personal devices and listeners can control the presentation using theirs.

overcome the hurdle of speaking out loud [4]. At the core of this thesis therefore stands the question: How can mobile devices be integrated into presentation workflows to engage and involve the audience, while transforming the stigma around mobile phones into something positive?

1.2 Goals

The main objective of the project consequently is the exploration of different ways of incorporating personal devices in presentations efficiently and productively. This involves both the conception of such mechanisms, as well as their implementation in an online presentation tool. Due to the high number of different settings and contexts in which talks can be given, and since we feel meetings and other business-related presentations with small numbers of attendees offer the perfect playground and most possibilities for interactive mechanisms, this thesis focuses on presentations in business-settings.

The proposed presentation software includes device-independent altering of pre-defined 2-dimensional slide-sets by listeners and presenters in real time. It allows audience members to view slides on their personal devices, either navigating freely or synchronised with the presenter (see figure 1.1). Additionally, the developed libraries offer support for real-time voting, as well as voting creation on-the-fly. Instantaneous audience reactions via emoji and different paths through the presentation were also realised.

As far as the implementation is concerned, it was our declared goal to create a modular ecosystem other developers can tap into, reuse, overwrite

and extend. Since the web was chosen as a platform for its rapid prototyping and iteration cycle possibilities, it was paramount to make the application feel as fast and responsive as possible, to give it the look and feel of a native application [8]. Therefore the user interface and interaction design were at the core of the project with the overall objective of creating an interface that works across all devices, without feeling unnatural.

Finally, an evaluation of the developed mechanisms was desirable. Since thorough long-term studies with control groups are beyond the scope of a master thesis, we constrained ourselves to the informal observation of the system in a series of internal meetings and presentations.

1.3 Structure

This thesis is organised into eight main chapters. First of all, we want to establish the context around the present work by introducing the reader to existing research and projects in the field of interactive presentations in chapter 2. Since an overwhelming number of studies have been conducted in educational settings, the chapter is further divided into classroom 2.1 and office 2.2 related approaches as well as general presentations 2.3.

In chapter 3 different types of presentations are analysed for their shortcomings and suitable solutions are developed. These are formulated into distinct interactive mechanisms for which clear requirements are established. Based on these requirements, chapter 4 goes into details on the interface and interaction design of the application as a whole and each of its interactive mechanisms. The general flow and setup of the proposed software are also discussed.

Chapter 5 lays out the entire implementation of the libraries involved in the presentation tool. It first defines the scope of the project 5.1 to then cover the server setup 5.2, before offering more insight into the underlying front end technologies used 5.3. Finally the general project structure 5.4, as well as all developed libraries are discussed in detail.

Since we pride ourselves in having developed an entirely open-sourced presentation ecosystem which we want others to explore, reuse and extend, chapter 6 shortly addresses the usage of the resulting libraries from a developer's perspective.

Chapter 7 outlines the results of our informal evaluation and observation of the system in regards to its usability 7.1 and the creation of presentations 7.2, to then reflect on the chosen architecture 7.3 and give an outlook on future work 8.1.

Finally, we briefly talk about the conclusions we draw from this project in chapter 8 and again summarise our findings.

Chapter 2

Related Work

The idea of using electronic devices to foster group interaction in meetings and presentations is not new. Stefik et al. [38] already experimented with the use of personal computers in meeting rooms as early as 1987 and Myers et al. [31] developed a collaboration tool which could be used to annotate PowerPoint slides from PDAs in 1998. Since then, digital whiteboards, telepresence systems, productive multi-user web applications and other computer-aided collaboration tools have become a common sight and we choose to carry smart devices around wherever we go. Surprisingly little research, however, has covered the use of these mobile devices in the context of presentations. Most of these studies were conducted in the educational sector and usually aim at quizzing students, which is why an own sub section is dedicated to classroom related approaches. While most relevant research has concentrated on one aspect, such as real-time polling [19] or remote-controlling [9], no system known to us has combined as many interactive mechanisms in one application as ours and allowed seamless integration between them, which sets the present approach apart.

2.1 Classroom related

As growing class-sizes have caused student participation to sink drastically [4], researchers have tried to deploy mechanisms to make lectures more interactive and engaging. The first approaches in this field of student-response-systems (SRS) utilised so-called clickers (see figure 2.1) – remote-control-like devices, connected to a receiver station via radio frequency technology [83] which can be used for tasks like taking attendance and voting [7]. Using these clicker systems has shown to “yield a strong and positive relationship with student learning” [7]. However, the limitations of clickers – the need for proprietary hardware and the limited interface consisting only of a few buttons – lead researchers to experiment with personal mobile devices as input instead. In 2007, Lindquist et al. [27] presented a system integrated



Figure 2.1: *i>clicker* devices, used in [7]. Image source [74].

with the University of Washington’s Classroom Presenter software, which lets students submit answers to assignments and in-class quizzes via SMS and MMS or using their laptops. Although the mobile phone users struggled with the input of longer messages, they perceived the ubiquity and convenience of using a light-weight personal device as an advantage. Most students, however, were worried about the costs of using SMS or MMS as a requirement in class – a concern modern devices with internet access and cheap data plans dispel. The first of these web-based approaches were explored around the same time. Esponda [13] for example describes a system in which iPods and other wifi-enabled devices can be used to answer questions during class. What is interesting about her approach is not only the technology used, but also that questions do not have to be prepared in advance, but can also be created on-the-fly, using a pen-based tablet, resulting in more lively and spontaneous student-teacher-interaction. The creators behind *i>clicker*¹, the clicker system used in [7], have also recognised the shortcomings of their hardware-approach and now build mobile apps for students’ personal devices. Like [13], their application makes it possible for lecturers to prepare quizzes beforehand or create polls on-the-fly to monitoring the students’ knowledge, understanding and progress. Although also available as iOS and Android app, like most modern approaches, the *i>clicker* software also has a web version, making use of modern browsers’ possibilities and the device-independence of the web as a platform. The tool *ASQ* [40] lets lecturers create HTML5 presentations with *impress.js* [68] which are then distributed to listeners via a link. Students follow the presentations on their mobile devices, and can submit questions connected to the current slide to the speaker. Quizzes (both open questions and multiple-choice) can be embedded in the slides by the teacher. These quizzes can either be graded automatically (for coding assignments and multiple-choice questions), corrected by teaching assistants or by the students in self or peer-assessment. While this project has put a lot of effort into the server-

¹<http://www1.iclicker.com/>

side and administration of slidesets, the present work concentrates more on the client-side and does not provide slide management tools. In contrast to our implementation, however, this approach lacks Another interesting approach is presented by Cheng et al. [10], who propose a system which generates HTML presentations from *Microsoft PowerPoint* slides and lets viewers add their own content (either additional material or questions) as vertical sub-slides. This way a tree-like structure is created in which teachers and students collaborate in interactive presentations. This architecture also inspired the sub-slide based presentation space deployed in this software.

Another popular application, with richer audience-speaker-interaction and an emphasis on listener-listener-interaction is *Backstage* [59]. As digital backchannels like Twitter can foster the sense of community within the audience, but are usually hard to follow for presenters, Bry et al.[4] developed a backchannel specifically for large classrooms. Students can post messages publicly and send private messages to their colleagues. These public posts can be up or down-voted, as well as marked as unrelated. Together with an ageing-algorithm, this community feedback is used to estimate a post's relevance. Important feedback is then presented to the lecturer, to allow him or her to get a better sense for the audiences' opinion and understanding. Additionally, small quizzes and polls serve as performance feedback to the teacher and students. Though one of the most mature systems studied for this thesis, having been developed specifically for classrooms, the use of the software in other scenarios is not ideal. Moreover, most of the features concentrate on listener-listener-interaction, while the present thesis focuses on mechanisms strengthening the speaker-audience-interaction.

Like Backstage, most of these approaches sound promising but are tightly bound to an educational context. The project discussed in this thesis, however aims for a broader field of application and concentrates on business-settings.

2.2 Office environments

In contrast to classroom-related presentations, meeting-related ones usually have an significantly lower amount of participants, as well as a smaller gap between the speaker and the audience. Another difference lies in the polling, surveying and quizzing functionality most of the presented projects offer: while these usually have only one correct answer in educational settings, to grade students [4, 27, 40], the goal in meeting environments is to make decisions and collect ideas, without judgment and often anonymously. The systems we want to quickly introduce all have a focus on mobile devices and their usage in meetings and office-related presentations and curiously were all developed by Microsoft Research: In [3], as well as examining the perception of smartphone use in meetings, the mobile application *Meetster* is

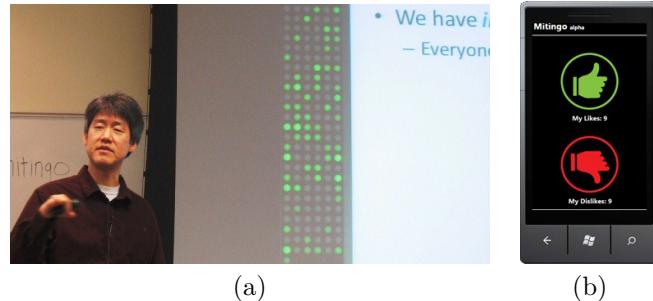


Figure 2.2: *Crowd Feedback* [39] used during a presentation (a): The bar next to the slides shows one dot per participant in the meeting, the dots can be controlled with the app (b). The feedback dots fade out over time. Image source [39].

presented. The study finds that although people primarily use their phones for meeting or work-related tasks, they tend to think their colleagues use theirs for private purposes. Unlike the present thesis, in which mobile devices should be used in the context of presentations, *Meetster* was developed to help getting to know other meeting attendees in a playful way. This changed the perception of using one's smartphone during the meeting and was described as "fostering social interactions". While the findings of the study conducted as part of this publication legitimise our approach, this thesis presents a more practical approach, more relevant to the presentation itself, instead of just connecting meeting attendees through a game.

A system concentrating more on presentations directly is *Crowd Feedback* [39], a piece of software which allows listeners to give a speaker continuous, real-time feedback, using their personal devices. A responsive web application with a like and dislike button controls the feedback-system. The participants' reactions are shown with a red (dislike) or green (like) dot for each attendee in a sidebar next to the presentation slides (see figure 2.2). An evaluation of the system showed that the participants felt more engaged with the presentation and connected to other listeners. Many users stated only having the possibility to like or dislike did not reflect enough options and that a button related to the speech pace might have helped. It was also noted that the sidebar was perceived as disturbing and made it harder to pay close attention to the presentation. This study and its conclusions have inspired the implementation of an instant feedback mechanism for listeners in the present work, however, instead of only having the binary like and dislike, the reactions are based on emojis, allowing for more insightful and faceted feedback.

The third study concerns itself with the navigation through slides: *Office Social* [9], a PowerPoint plugin with companion smartphone app, allows presenters and listeners to navigate through PowerPoint slides using their



Figure 2.3: *Office Social* [9]’s smartphone app interface. A preview of the slide is shown on top, followed by big buttons for navigating between slides. In the left picture, the application is in *review* mode, where a local copy of the slides can be navigated through. By pressing a button in the interface the *interaction* mode is activated, allowing listeners to navigate through the master slides (right). Image source [9].

mobile phones (see figure 2.3). Members of the audience can either browse the slides privately, or take over the control of the presented slides, allowing them to effectively steer the presentation or discussion. As in the present approach, Chattopadhyay et al.’s software allows members of the audience to review the slides privately, making it possible for latecomers to catch up and to generally estimate the length and direction of the talk [9]. However, as their interface focuses on the navigation between slides, the preview of the slides is fairly small. Our approach tries to focus on the content of the slide and instead of offering big buttons to navigate around, makes use of intuitive swipe gestures, which can potentially be used eye-free more easily [32]. Another disadvantage is the overhead of having to download a smartphone application before the start of a presentation, as well as the limitation of the application only being available for Windows Phones.

2.3 General presentations

Since lectures and meetings both are very specific forms of presentations, a few paragraphs should also be dedicated to general approaches in this third section. One publication, which concentrates on polls and their real-time evaluation and rendering is [19]: Inoue et al. present a system which distributes *Microsoft PowerPoint* presentations using modern web-technologies while making it possible to alter and update the slides in presentation mode. This way questionnaires can be answered and their results displayed in real-time. Additionally, members of the audience can add annotations (both handwritten and digital) to slides. Although this approach seems very promising, pictures, videos and other types of media are ignored entirely. Moreover the interface seems too complicated for small devices and is there-

fore only usable on laptops and maybe tablets.

Two more products, though not subject to scientific research and more commercial than the approaches presented so far, are *Mentimeter* [52] and *sli.do* [67]. Both tools are web applications with real-time polling support, usable in any presentation. Both systems work very similarly: listeners go to the respective website and enter a presentation code to then be connected to the live voting. A handy feature Mentimeter offers is to query the device's location to determine the right presentation. Sli.do on the other hand also supports questions from the audience, which can be up-voted by the listeners, making it easy for speakers and participants in podium-discussions to answer the most relevant questions. Moreover, additionally to multiple-choice polls, sli.do also supports open questions and ratings. While the creators of Mentimeter provide a PowerPoint plugin, sli.do is not directly linked to any presentations. However, the popular canvas-based presentation-tool prezi [60], offers seamless integration with the application. It is worth noting that prezi itself already offers mobile features out of the box: Presentations can be controlled remotely from the speaker's phone or tablet as well as be viewed and followed by members of the audience in real time, using a mobile application.

More web-based presentation tools include *Google Slides* [50] and *PowerPoint Online*². While PowerPoint Online seems to only offer a simplified version of the desktop application online, Google Slides also provides mobile features such as editing and authoring slides on phones or tablets and controlling them remotely.

To conclude this chapter, a few words should also be said about the JavaScript presentation library *reveal.js* [46] and its accompanying visual editor *slides* [66]. Reveal.js offers features such as remote controlling slides for the speaker and following presentations on personal devices for members of the audience. However, the installation to achieve the latter so-called *multiplexing* functionality, is fairly complex and involves setting up a socket-io server, running the master-presentation statically and locally and uploading a client version of the presentation to a publicly accessible server. Reveal.js offers a reliable online presentation library and could have served as a starting-point for the project presented in this thesis. However, due to their closed environment, tightly coupled code and lacking support for extensibility, we decided to instead implement an own presentation library (see chapter 5, section 5.3.4).

²<http://office.live.com/start/PowerPoint.aspx>

Chapter 3

Requirements and Design Goals

In a first step of identifying possible mechanisms which could make presentations more engaging and interactive, we analysed different types of presentations to find their weaknesses and possible counter measures. In this chapter we will shortly introduce the reader to the considered factors. The most prominent issues are then stated and solutions, which serve as requirements for the interactive mechanisms, are proposed. Finally, these functions are defined and their design goals are discussed.

3.1 Factors

While many factors could be taken into consideration, we constrained ourselves to the following three:

- **Audience Size:** Differences between small and big crowds.
- **Presentation Environment:** Presentation setting and purpose.
- **Speaker and Audience:** Traits, personalities and inter-attendee relationship.

The goal was to find and formalise the main issues with each of the presentation types and from there define requirements for the interactive mechanisms introduced in the second part of this chapter. An overview of our findings can be found in table 3.1.

3.1.1 Audience Size

One aspect which plays an important role in the type of presentation and thereby the interactive mechanisms applicable is the size of the audience. Different challenges present themselves depending on the amount of listeners: While there might be a debate between speaker and audience in small

Table 3.1: Overview of analysed factors and main requirements.

<i>Factor</i>	<i>Main Requirements</i>
Audience size	<ul style="list-style-type: none"> • Big audiences: connecting audience and presenter; estimation of mood and knowledge for speaker. • Small groups: introducing anonymous channels.
Presentation Environment	<ul style="list-style-type: none"> • Fostering collaboration between attendees (in Meetings). • Informational presentations: re-visiting and individually browsing slides (at own pace). • Emotional presentations: involving audience more actively for more personal experience.
Speaker and Audience	<ul style="list-style-type: none"> • Audience: making introverts heard. • Speaker: enabling/disabling mechanisms to avoid stress. • Flat-hierarchies: allowing multiple presenters.

group sizes, it is hard for audience members to directly communicate with a speaker during conferences or in large lecture halls. Shy or introvert attendees might remain unheard [4] and only a usually randomly chosen subset of people get the opportunity to ask audience questions after talks in conferences. At the same time estimating the audience's knowledge and interest as well as the general mood gets increasingly difficult both for the presenter and attendee as the number of participants rises. Additionally to the interaction between speaker and audience, another important factor is listener-listener interaction [29]. Group-dynamics largely depend on the audience size and smaller groups usually perform better than big ones [35]. The general conclusion therefore is that big audiences struggle to connect and interact with the speaker and each other and interactive tools must aim to strengthen the bidirectional bond between presenter and listeners. In smaller groups, on the other hand, the focus should be put on supporting the already existing dialogue and exchange between all participants of the presentation. As peer-pressure might rise in smaller groups and the better listeners know each other, ways of anonymously contributing to the outcome or flow of a presentation become more important.

3.1.2 Presentation Environment

The environment of a presentation is described by all factors surrounding the presentation. One of them is the setting a talk is given in, in other words, if it is embedded in a meeting, a talk at a conference or a lecture at school or university. Other aspects worth considering are whether the audience is co-located or distributed and which technologies are available. As this work concerns itself only with mobile devices in the context of co-located presentations, difficulties added through remote presentations as well as missing technical equipment will be disregarded in this section. Instead, a closer look will be taken at the setting: In a lecture, it is desirable to measure the students' participation and engagement, as well as their understanding of a topic. In meetings, on the other hand, interactive mechanisms are more likely to aim for the promotion of collaboration between all participants. Conferences might search to foster the interactivity between attendees, to support networking. Instead of taking all possible scenarios into consideration, this work concentrates on business-related settings and explores mechanisms which foster collaboration.

Another part is the purpose of a presentation: McClain [28] identifies four major types: informational, motivational, persuasive and sales. According to him, informational presentations search to educate the listeners, while motivational speeches try to inspire the audience to take action. Persuasive talks usually present new ideas or directions and have the goal of making the listeners re-think old approaches and consider or even embrace new ones. Sales presentations, lastly, often use elements of the other three categories with the aim of "obtaining a decision at the presentation's end" [28]. While motivational, persuasive and to some extend sales presentations often operate on an emotional level in the present moment, informational talks often include a way for listeners to re-visit the taught material through transcripts, lecture notes or handouts. Moreover, motivational, persuasive and sales presentations focus on the goal of getting the audience to take action and therefore put more emphasis on the listeners than content-centric informational speeches. This creates two very distinctive needs for interactive mechanisms: on one side the ability for the audience to actively shape the path of the presentation, on the other hand the possibility to re-visit presentation slides (potentially including notes and additional material), after the end of a talk.

3.1.3 Speaker and Audience

The last factor taken into consideration in this chapter are the speaker and listeners themselves. Depending on the individual interest, but also character traits such as introversion, listeners will be more or less likely to engage in a presentation actively [4]. The inter-attendee relationship as well as the

relationship between attendees and speaker also plays a role in which mechanisms are appreciated and which are not [29]: while it is common for listeners to jump into the role of the presenter in meetings with flat-hierarchies, the same behaviour is a rare sight in lectures or might even be deemed inappropriate or impolite in more formal settings. When taking the speaker into consideration, the set of tools needed are more sophisticated than the ones necessary to only follow a presentation: Foremost, speakers need a way of navigating through slide decks. It is desirable to have an overview of the entire presentation and while listeners only concentrate on the current slide, many speakers rely on notes or use timers, which also need to be placed in the interface. Moreover, the presenter's personal traits, experience and bluntly talent, play a central role in the successful deployment of interactive mechanisms: the flexibility, confidence and technological expertise of a presenter all determine how distracting or even stressful certain features are perceived as and whether a speaker is able to react to these spontaneously [41]. It is therefore crucial to give speakers the ability to turn said mechanisms on and off. An important challenge which also arises with this question is how to design these mechanisms in a way that is neither perceived as intrusive nor interrupting (this will be discussed in more detail in chapter 4). To summarise, when developing interaction tools, it is vital to take a participant's personality and their relationship to other ones into consideration. In the context of presentations, shy listeners should be given tools to make them heard; presenters need full control of the mechanisms provided.

3.2 Resulting Mechanisms

With these aspects and challenges in mind, a multitude of different mechanisms can be derived. Although many more are thinkable, this section concentrates on the ones implemented in course of the thesis project. However, we will try to point out other possible features and provide resources to projects focusing on these. One point to keep in mind is that not all of the presented mechanisms work equally well in every environment but instead have scenarios they are best suited for and others in which they are practically rendered redundant. The ideal settings and key advantages of each of these mechanisms are summarised in table 3.2.

3.2.1 Remote Control

One mechanism of special importance for speakers is the ability to control slides and navigate through them. As many presentations involve more than just one speaker and can profit from sharing control over slides with others [9], any amount of presenters should be able to be connected at any given point. Controlling should be possible from any personal device, may it be a

Table 3.2: Overview of resulting mechanisms, with their key advantages and optimal usage scenarios.

Mechanism	Improvements	Ideal Scenario
Remote Control	More flexibility for presenter(s)	Any, especially multi-speaker presentations
Following Slides	Accounts for individual pace; can replace hand-outs	Any, especially informational presentations for later revision
Paths	Interactivity and flexibility	Any, especially informational
Audience Questions	Anonymity; possibility to be heard in big crowds	Big audiences; small groups for anonymity
Polls	Bond between speaker and audience by querying listeners' interest, mood and knowledge	Usage with paths; big audiences; small groups for anonymity
Reactions	Speaker-audience and listener-listener interaction	Big audiences
Content Sharing	Possibility to shape presentation for audience	Small groups

laptop, tablet or mobile phone, giving the speakers maximal freedom. Suitable interaction metaphors therefore have to be found for different devices.

3.2.2 Following Slides

For members of the audience, one important feature is to be able to individually and independently navigate through and follow slides. This makes it possible to re-visiting slides after a presentation, accommodate individual learning paces [10] and even give late-comers a chance to catch up with the presentation [9]. Displaying and navigating through slides should again be possible on any personal device and focus on the slide content in a way that maintains the readability of all text. The mechanism can be designed in many different ways and could even allow listeners to remote control the presentation [9], our implementation however only provides individual slide navigation on the personal device. Additionally, the progress of the presentation should always be synchronised with the individual devices, allowing listeners to truly follow along. This basic mechanism can be extended to offer features such as turning the synchronisation on and off (effectively allowing to navigate freely and jump back to the presenter's state) or to only allow listeners to see the last slide the presenter has already shown.

3.2.3 Paths

Also connected to navigation and following slides is the possibility to offer different paths through the presentation. Especially in informational talks these can account for different backgrounds and levels of knowledge in the audience, they however, also make it possible to get listeners more involved in shaping the presentation. Paths should both be accessible to each audience member individually (for further reference or to catch up on a topic), as well as on the projector (e.g. by polling, as discussed in the next subsection). The possibility to flexibly navigate through a presentation has proven to be one of the biggest advantages of canvas-based presentations [26] and has a wide field of application. The scenarios this thesis concentrates on are the following: On one hand, the paths can cover different levels of details (e.g. *overview*, *regular* and *detailed*), as well as providing a way of skipping certain slides without having to navigate through all of them (e.g. skipping the introduction). Another option would be to let the audience decide between entirely different topics, depending on their personal interest. While canvas-based presentation tools like Prezi innately offer this flexibility, slide-based tools often only make this behaviour possible by manually skipping over slides, which can interrupt the flow of the presentation [11]. PowerPoint extensions enabling advanced forms of navigation, as well as the presenter looking through slides before projecting them are discussed in [11], [33] and [37], the latter, however, will not be part of our implementation.

3.2.4 Audience Questions

A feature well-suited for informative talks, is the possibility for members of the audience to ask questions. Another scenarios are big crowds, in which it is hard to be heard as an individual. A tool specifically designed for such settings is sli.do, which was already introduced in chapter 2 section 2.3. More generally, such mechanism should enable members of the audience to submit questions for the presenter to answer. These questions should either be displayed directly, or collected for the presenter to go through at the end of the presentation, depending on their preference and flexibility. This mechanism also highly depends on the presentation environment: In a classroom, questions should be answered immediately, while conferences usually only allow them at the end of talks. Questions could moreover only be visible to the presenter, or every participant. Concentrating on business-related settings, we propose a question feature which allows audience members to submit questions at any point of the presentation. These should be accessible for every attendee, to spark others' interest and participation. From the presenter's point of view, questions should be displayable instantly, at the end of the talk or any time inbetween, leaving the decision when to react to questions to each individual speaker.

3.2.5 Polls

Another possibility to ask questions is polling. Although polls might also be generated by listeners, we propose a mechanism which lets the speaker create them. To give presenters more flexibility and because questions often only arise during talks [13], these surveys should be creatable in the preparation for a speech as well as on-the-fly, during presentations. This mechanism can help getting to know ones listeners (relationship between listeners and speaker), as well as estimate a crowd's mood (big audiences) and is especially useful in combination with paths. If supporting anonymous voting, relying on electronical aids instead of raising hands can also be beneficial in smaller groups [13]. While a big number of different polling mechanisms are conceivable (open questions, ratings, multiple choice, as well as different ways of visualising the results), single choice voting and visualisation in a bar-chart serve as a starting point for our approach. Another detail lies in when the results are presented: they can either be rendered as soon as a user chooses his or her answer or only after everybody has given their votes. To summarise, the identified requirements for such mechanism are creation beforehand and during the presentation, real-time polling and data-visualisation as well as anonymity of the voting process.

3.2.6 Reactions

As described before, especially bigger crowds suffer from a lack of interaction possibilities between speaker and audience but also between members of the audience. While the latter is discussed in [4], the present work focuses on the interaction between speaker and listeners. Besides the difficulty of asking questions, which was already covered, the main problem for the presenter is to estimate the crowd's mood, which is why we suggest a mechanism that lets attendees send real-time feedback to the speaker. This functionality is based on [39]; as highlighted by Teevan et al., however, their simplistic approach of just offering *likes* and *dislikes* is not faceted enough to represent the full range of emotions listeners can feel during a presentation. It is therefore important to provide more detailed feedback. These reactions can either be displayed only to the speaker, or to the entire audience. The latter might distract listeners [39], however, also holds the potential to encourage others to also react to the current slide and strengthen listener-listener bonding. While this mechanism is expected to work well in bigger crowds, it will likely introduce an unnecessary technical burden to smaller groups, in which it is easier to estimate the attendees' mood.

3.2.7 Content Sharing

In contrast to live reactions and questions, content sharing is especially suited for smaller audiences. As discussed before, tools for smaller groups

should strengthen the already possible dialogue between all participants. These scenarios make it possible for listeners to actively get involved in the presentation and not only shape the path through, but also the content of such. While adding subslides to a slide deck after a presentation [10] and text-based annotations [19, 31] during talks have already been discussed in previous work, to our knowledge, no other study has concerned itself with the possibility of adding listener-generated slides and multi-media content in live presentations. While being an exciting opportunity to explore a widely untouched research subject, this mechanism empowers listeners and transforms presentations entirely by combining classic slides with brainstorming-like interactions and related multi-media content. While the potential of this mechanism will be further discussed in chapter 8, the requirements for this functionality should shortly be defined: It should be possible for any listener to add their own content to any slide. This content includes text, websites (per link), videos and uploaded images (e.g. taken with their personal devices). Presenters should have a way of deciding whether to accept the contribution and if it should be added as a subslide or main slide. Moreover, this mechanism requires a lot of flexibility from the speaker, which is why it is important to allow them to turn off or silence the functionality, providing sensible fallbacks. While content sharing can transform a presentation into an interactive and collaborative effort in smaller groups, the functionality will likely lead to chaos in big groups without further interface changes.

Now that the implemented mechanisms are clarified and their requirements defined, the next chapter deals with the design and user experience of the application.

Chapter 4

Application Design

After defining the mechanisms which will be implemented, in a next step, the design of the application will be discussed. First, the general setup and usage of the application will be covered. For this, we introduce a presenter called Amy, as well as a listener called Greg. These personas will also be used to describe the interaction with the presentation in the following chapters. Then, the general interface of the application for listeners, speakers and on the projector will be examined on the basis on several wireframes. Screenshots of the applications can be found in chapter 6. Finally, we will talk about the interaction principles applied in the project and offer an insight into the user experience design of each of the previously defined interactive mechanisms.

Although all features identified in chapter 3 can be turned on or off, in the following it is assumed that all of them are enabled. The authoring and creation of slides will not be covered in this chapter, but is instead part of chapter 6.

4.1 Application Flow

To depict the typical setup of an unveil presentation, we assume a speaker called Amy, who has already prepared her presentation, and a listener called Greg who wants to follow the slides from his smartphone. The slides are generally hosted on a server. This can either be a publicly accessible one or, if all participants are in the same network, locally from Amy's computer. We assume Amy is serving the slides from her laptop, which is also connected to a projector, moreover she is using her smartphone to navigate through the slide-set (see figure ??). At the beginning of the presentation, Greg and all other listeners navigate their mobile devices' browsers to the set up address (usually a combination of IP address and port). To make this step easier, Amy has added a QR code pointing to the address on the first slide and sent out an e-mail with the link to all participants before the start of the

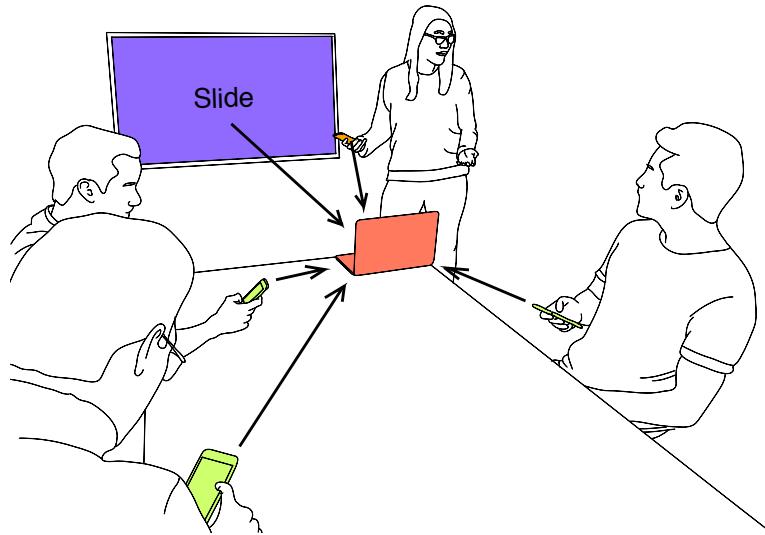


Figure 4.1: Unveil presentation setup. All devices are connected to one central server, in this case the presenter's laptop (red). The projector (violet) displays the current slide, listeners use their smartphones (green) to follow and interact with the presentation and the presenter's smartphone (orange) serves as a remote control.

presentation.

The software supports three different modes out of the box: listener, speaker and projector mode. Depending on the mode, a certain set of features is activated, allowing Amy to have a different interface and more controls than Greg. Modes are activated via query parameters in the url: Amy navigates her laptop's browser to the url of the presentation and adds the query parameter `mode=projector`. On her smartphone, which she will use to remotely control the presentation, the mode is set to `speaker`. If no query parameter is given, the application defaults to the listener mode, so Greg simply types in the address or follows the link in the url or QR code. Unveil generally offers a two-dimensional slide space, consisting of master slides (left to right) and subslides (top to bottom). Devices in speaker mode (in this example Amy's smartphone) can remote-control the presentation and navigate through said slides. All other devices (the laptop in projector mode and Greg's phone) are synchronised with the state of Amy's phone and automatically follow along in real-time.

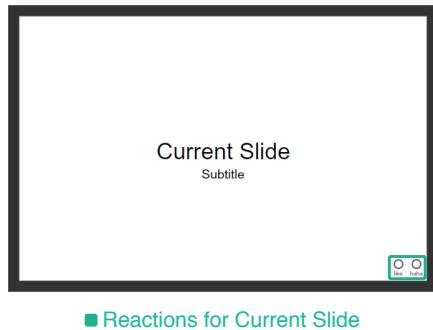


Figure 4.2: Wireframe of slide in projector mode, as seen on a projector. No visual controls are shown, only the current slide and listener reactions are displayed. The presentation progresses through the presenter mode's remote controlling feature.

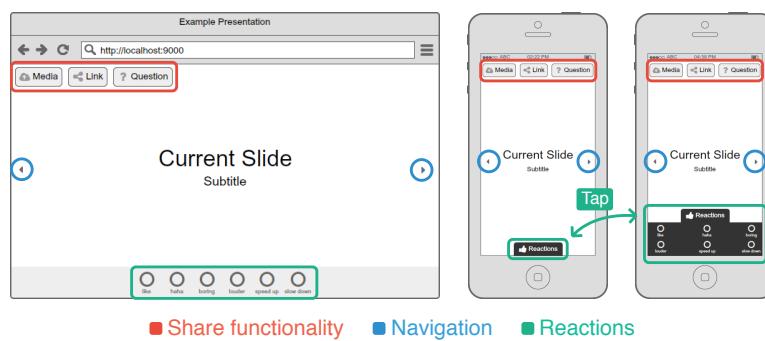


Figure 4.3: Wireframes of general interface in listener mode for mobile phones and desktops. Both offer buttons to share media, links and questions with the presenter, arrow buttons to navigate through the presentation and a possibility to react to the current slide. On mobile this feature is revealed with a tap on the *reactions* button, to not clutter the interface.

4.2 General Interface

To not restrict Amy and Greg in their choice of device, the general requirement for the interface of the application is to work in all three modes and on every device from mobile phones to desktops and even projectors. When in projector mode, only the content of the current slide, as well as listener reactions are shown (see figure 4.2). In listener mode, the interface is a lot richer and additionally features buttons for sharing media, links and asking questions, as well as six different reactions (see figure 4.3), which will be discussed in more detail in section 4.5. It also offers small arrow buttons, to navigate between slides. The speaker interface is the most intricate: Besides showing the current slide, we believe it should also include a preview of the

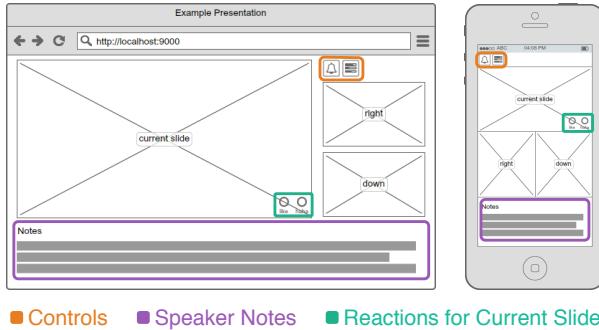


Figure 4.4: Wireframes of general interface in speaker mode for mobile phones and desktops. The interface consists of a preview of the current slide, the next main slide (*right*) and the next subslide (*down*), as well as showing presenter notes. It also offers buttons to toggle muting of incoming requests and creation of new polls.

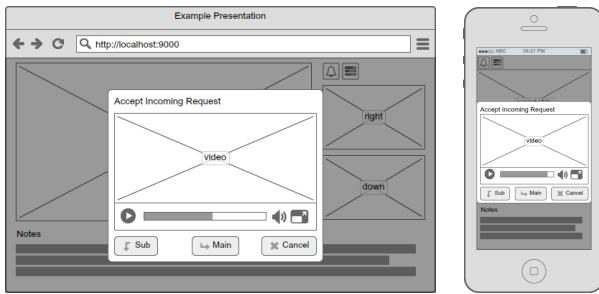


Figure 4.5: Wireframes of modal interface in speaker mode for mobile phones and desktops. The shown modal allows the presenter to add a listener-submitted video as a new main or subslide or dismiss the request. It pops up as soon as a listener wants to share content with the slide.

upcoming slides in x (master slide) and y (subslide) direction, as well as speaker notes. Additionally to this interface, already familiar from PowerPoint or similar presentation software, buttons to mute incoming requests (media, link and questions) and to create new polls are provided (see figure 4.4). Since we expect presenters to switch between devices more often than listeners for more typing-intense tasks such as creating new polls, the mobile interface is as similar as possible to the desktop one and only re-arranges the displayed information to fit on smaller screens. The main difference between the mobile and desktop version of the listener interface is the design of the reactions: While desktop computers and tablets offer ample space for the placement of all six emoji, these are hidden behind a button in the mobile interface and only slide up upon a tap on said button.



Figure 4.6: Button states, (a) normal, (b) hovered or active and (c) disabled.

4.3 General Interaction Principles

As far as the interaction design of the application is concerned, the main requirement technically is for all state changes to take immediate effect or in other words, for the software to work in real-time. This is true for interactions with the server as well as all internal state changes within the application. All transitions and animations last 200ms, a value which is both usable on mobile phones and desktops and, according to Google's Material Design Guide [18] "fast enough that it doesn't cause waiting, but slow enough that the transition can be understood". An easing curve with low outgoing and high incoming velocity is used.

The general aim for the interaction design of the application is to be as easy and intuitive to use as possible on any device, for both presenters and listeners. Especially the speaker's view has a lot of information to display and many ways of interacting with the interface. From the speaker's point of view, the main reason for negative presentation experiences stems from technical difficulties and problems [41]; we therefore decided to design a presenter interface similar to the one already known from PowerPoint, Keynote, Google Slides or reveal.js (see figure 4.4) and employ familiar visual metaphors and interaction mechanisms such as buttons and modals (see 4.5).

Another important consideration when it comes to mobile and desktop environments is the question of supported inputs. While mouse and keys are a natural and intuitive way of navigating through desktop applications, swiping gestures are faster, more accurate [25] and require less time looking at the screen on mobile devices [32], making them the ideal candidate for the remote-controlling feature. For this reason, additionally to providing visual arrow-buttons for navigation, arrow-keys and swipe gestures are also supported. The interaction with buttons is controlled by mouse clicks or taps, respectively and common visual metaphors are used to symbolise their state (pressed, hovered, disabled), as shown in figure 4.6.

Now that the general interaction principles are covered, a more detailed look is taken at the most interesting parts of the implemented features.

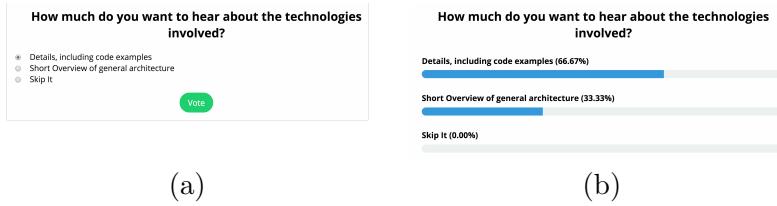


Figure 4.7: Details of polling interface for listeners before voting (a) and poll result after voting (b).

4.4 Polls

The first mechanism looked at in more detail is the polling feature. Polls can either be prepared before the start of the presentation or can dynamically be created during the presentation through the presenter interface. When Greg and the other listeners navigate through the presentation, they will already see the poll, they however cannot vote until Amy activates the voting by navigating to the slide with the poll. Polling again works in real-time: As soon as Greg chooses an option and presses the *Vote* button, the presenter, projector and all listener interfaces will be updated with his vote immediately. Every listener is only allowed to vote once per poll and the only currently supported poll type is single choice (see figure 4.7). As soon as Greg has voted, he is presented with the current results of the voting. These are displayed in horizontal bar charts (see figure 4.7), which are animated. This means, as soon as a new vote is registered, the bars will dynamically adjust their width as the percentages are updated. These results are available on the presenter and projector interfaces as well and also change in real-time. While the voting is enabled (by Amy navigating to the slide with the poll and until she navigates away from it again), all other navigation is frozen. This means, in this time, all listener navigation is disabled to ensure everybody is on the same slide and exercises their right to vote; this, however, is not mandatory and listeners can also choose not to vote.

To create a new poll, the presenter presses or clicks the *new poll* button in the controls section of the speaker interface, which opens a modal (see chapter 6 for screenshots). In the beginning, a question and two answer fields are provided, more answers can be added using the *+* button. Once the question and answer options are entered, pressing the *Create Voting* button will generate a new poll and add it as the next main slide.

4.5 Reactions

Although binary digital reactions in presentations are not an entirely new idea [39], versatile feedback that goes beyond positive and negative, to our

knowledge, has not yet been explored. The way this mechanism was implemented, our listener Greg can press a button to react to what the speaker Amy said or presented. The reactions are collected on a per-slide basis, allowing Amy to re-visit the slides afterwards, analysing which slides sparked most feedback. When Greg reacts to a slide, the feedback will immediately be displayed in the presenter view, as well as – if enabled – the projector interface.

Greg by default can choose from six pre-defined reactions: From the evaluation in [39] and [20] and from observing presentations and meetings, a pool of possible reactions has been narrowed down three emotions (approval, laughter, boredom) and three request types (louder, speed up, slow down) (see figure 4.8). The reason behind the missing disapproval on one hand is that test subjects in [39] felt less comfortable giving negative feedback, the button was generally used less than the positive one and it also included feedback such as *boredom* or *speed up* and *slow down*, which we have included own reactions for. On the other side, we hope this will encourage more elaborate feedback of disapproval using the content sharing functionality instead. This holds the potential of sparking a discussion instead of merely showing disagreement with the presented content.

The biggest challenge with displaying non-binary reactions was to find an intuitive and familiar visualisation which would not take up too much space on smaller screens. Since the introduction of emoji on Apple’s keyboard in 2011 and on Android’s one in 2013, emoji have become a ubiquitous, language-independent means of communication [5, 73]. Instagram has found that almost half of its comments and captions nowadays include emoji [73] and with Google [80] and Bing [79] adding support for emoji-search and companies such as Facebook [77] and GitHub [76] offering emoji-based reaction systems, it is safe to assume the majority of regular internet users is familiar with the concept and meaning of emoji [6]. Although it would be possible to include a complete emoji-keyboard to allow for even more versatile feedback, we feel it is easier for less technology-oriented users to be provided only with a sub-set including a short description of each reaction (see figure 4.8). However, it is worth noting that this sub-set can easily be extended or overwritten by the presenter.

When it comes to displaying the reactions sent by the audience, as the presentation of feedback in [39] was perceived as a distraction from the presentation, the feedback mechanism proposed in the present work is either only shown to the presenter or displayed without any animations, in the lower-right corner of the projector interface, with only a small badge symbolising how many people have sent this reaction for the current slide (see figure 4.9 (a)). On the side of the listener, one detail worth mentioning is the styling of the hover-state. Especially on computers it is important to offer intuitive hover-states, to give the user a sense of what they are pointing at and if they can interact with the currently focused element [72]. The

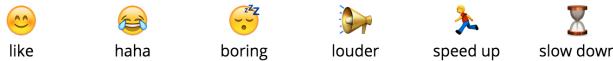


Figure 4.8: All six possible reactions and their emoji (from left): *approval*, *laughter*, *boredom*, *louder*, *speed up* and *slow down*.



Figure 4.9: Details of visualisation of reactions (a) with number of reactions as found in the presenter view and optionally the projector and (b) reaction in listener interface with (right) and without hover-state (left).

hover-state designed for this purpose includes a magnifying-effect as well as a light shadow around the emoji (see figure 4.9 (b)).

4.6 Content Sharing

The last big module developed for the present thesis is the content sharing functionality. At the time of writing, the software allows for sharing photos (via links or from the computer or phone), websites, youtube videos and free text (including questions). In an earlier iteration, only one *sharing* button was available in the interface, but feedback cycles with other web developers and designers have shown that it was not clear and intuitive enough which kind of content could be shared, which is why the functionality was now separated into three buttons: *Media*, *Link* and *Question*. Coming back to Greg and Amy, Amy has just talked about functional programming and Greg wants to share a related video. He opens the youtube app on his phone, searches for the video he wants to share and copies its link into the provided text field. When pressing the *Share* button, Amy will receive a pop-up in which she can review the request and then accept it as a new main or subslide or dismiss it (see figure 4.5). The If she accepts, the video will be inserted in a new slide relative to the slide Greg sent the request from. Youtube videos and links to websites are embedded into the presentation, similarly to images and links to images, which are also directly included into the created slide. Text is simply displayed as a second-order heading.

What was important to be able to include personal notes, is the ability to take photos and upload them to the presentation. This is possible in the *Media* part of the content sharing feature and makes use of the mobile operating system's native file uploads. Screenshots can be found in chapter 6.

Since such mechanisms can be fairly stressful for the presenter [39, 41], we also built a feature to mute incoming requests. When muted, requests are automatically added as subslides to the slide the request was sent from, allowing all contributions to be collected without disturbing the flow of the presentation for the speaker [11].

Chapter 5

Implementation

This chapter dives into the technical implementation details, gives an overview of the used technologies and explains why these were chosen over others. In summary, four libraries were developed in course of this project. The base presentation library, unveil, was extended for this purpose, moreover a layer for network synchronisation and communication with the server was developed. The interactive mechanisms described in the last chapter were then implemented in an interactive extension (see figure 5.1).

Like many other projects in this area [4, 10, 13, 19, 39, 40], this project is realised using the web as a platform. This has many advantages, from modern web technologies' quick prototyping capabilities to the web's general cross-platform and cross-device nature, the project has benefitted from the dynamicity of the internet and the rapid evolution of JavaScript over the past years. Although native sharing features of smartphones cannot be used due to the choice of platform, we believe, the merits that come with this decision outweigh the disadvantages for both users and developers. As no app has to be downloaded, it is easier to bring the audience to use the developed application [40]. The major advantage for developers on one hand is the ability to only focus on one platform instead of developing different applications for different operating systems, on the other hand the web is built for rapid prototyping as it is extremely easy and fast to roll out new updates without having to distribute them through the App Store or Play Store and without the need for users to manually update them. Since the JavaScript render layer this software was developed with [47] also offers a library which can cross-compile JavaScript applications to different operating systems [48], the core code could potentially stay almost untouched, should the application be ported to other platforms in the future.

Finally, a few words should also be said about the distribution of this project. Without the vibrant open-source community, many of the frameworks and libraries used in this project would not exist. For this reason, and to give back to the community, all the libraries developed during this

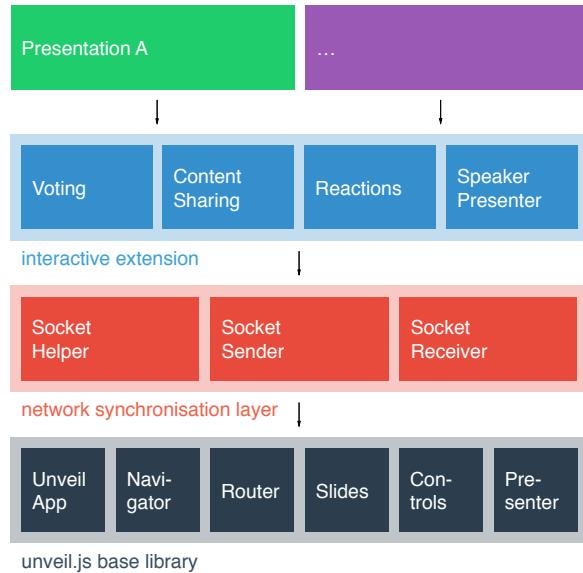


Figure 5.1: Overview of created libraries and their components. Arrows indicate dependencies. At the bottom, the extended version of unveil provides all base functionality. The network synchronisation layer adds support for WebSocket communication with the server, building upon which the interactive extension adds all interactive mechanisms. Any presentation can then use the created libraries.

project have been published as open-source on GitHub¹ and are freely available for anyone to use. We concentrated on creating an extensible system for any developer to customise, adapt, plug into and build interactive presentations with; the only requirement being basic HTML, CSS and JavaScript knowledge.

5.1 Project Scope

Before jumping into technical details, the scope of the project should be discussed. As the aim of the present work is to explore ways of incorporating mobile devices into presentation workflows, the goal of the project was to build the mechanisms described in the previous chapters on top of a JavaScript presentation library. As the focus was placed on the interaction possibilities between speaker and audience, the creation of the presentation (e.g. using a graphical user interface) or the management of slides and presentations were out of scope. As with most JavaScript presentation libraries, the resulting application is mainly aimed towards developers, both to extend the libraries further as well as to create presentations, as at least

¹<https://github.com/irisSchaffer/>

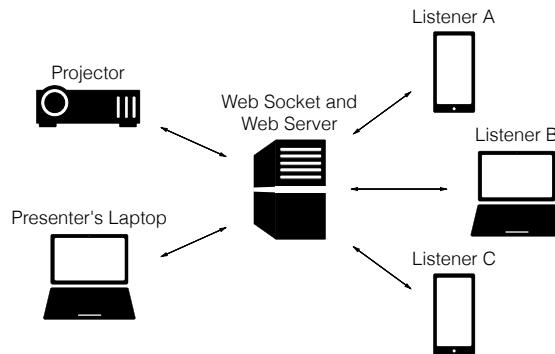


Figure 5.2: Example application setup. A server serves the presentation and connects all clients (presenter devices, listener devices and projector) through WebSockets.

basic knowledge of HTML and CSS is necessary to build slides.

In total, a front end heavy system was created which features several ways of interacting with a presentation, both from mobile and desktop devices. Emphasis was put on mobile-optimised views and navigation possibilities. The end product consists of several, highly customisable libraries which can be combined to a presentation library which synchronises navigation state and state changes between listeners and speaker(s), includes three distinct interfaces for listeners, speakers and projects and offers the possibility to dynamically add content during the presentation. In the following, the general architecture and technologies used in the project will be analysed and described to then discuss implementation details, problems and solutions for the main features.

5.2 Server Architecture

In general, the application consists of two parts: the front end web application, run on every client, as well as a web server (see figure 5.2). As described in chapter 4, this server is either publicly-accessible or – if all listeners have access to the same network – run on any computer on the local network. While special attention was paid to the front end libraries developed, the server was kept as simple as possible, allowing any developer to work with their own servers and technology stacks. However, the limitation of having such a lightweight and *dumb* server, is that in the current iteration of the prototype all state changes are only persisted on the client-side. although good for testing purposes, as a reset is only a page-reload and clearing of local storage away, this means audience members joining the presentation after any additional slides were added, will not have the same state of the presentation.

Program 5.1: Very simple, possible implementation of a server running this project with Node.js and Express. [84] describes how wildcard support can be added to socket.io.

```
1 var express = require('express'); var app = express();
2 var server = require('http').createServer(app);
3 var io = require('socket.io')(server);
4
5 // directory 'client' will be served by server
6 app.use(express.static(__dirname + '/../client/'));
7
8 io.on('connection', function(socket) { // setting up socket io
9   socket.on('*', function(event, data) {
10     io.emit(event, data);
11   });
12 });
13
14 server.listen(9000, function () {
15   console.log('Unveil server listening on port 9000!');
16 });
```

The server's two only requirements are on one hand to serve the static web application to all clients, and on the other hand to connect all of these clients to enable the interaction and synchronisation between them using *WebSockets*. This technology was chosen as low response times for all network-requests were paramount and since the technology has already been successfully leveraged in the real-time features of other presentation tools [19, 40]. In our server implementation, the presentation is run from a *Node.js* [55] server, using *Express*[54] as a framework. WebSocket support is added using the popular library *socket.io* [61], which a few more words will be said on in section 5.6. To again emphasise how low the requirements for such a server are, a working example implementation can be found in program 5.1. Additionally to this, the server developed for this project also includes a `lastState`, which holds the last client state which is emitted whenever a new client joins. Once the connection between client and server is established, the server starts broadcasting all incoming requests from any client to all other ones (see figure 5.3). These requests are then processed on the clients locally, taking into consideration the mode they are currently in. Wherever possible, the clients optimistically update the interface instead of waiting for the response from the server, to make the application feel even faster.

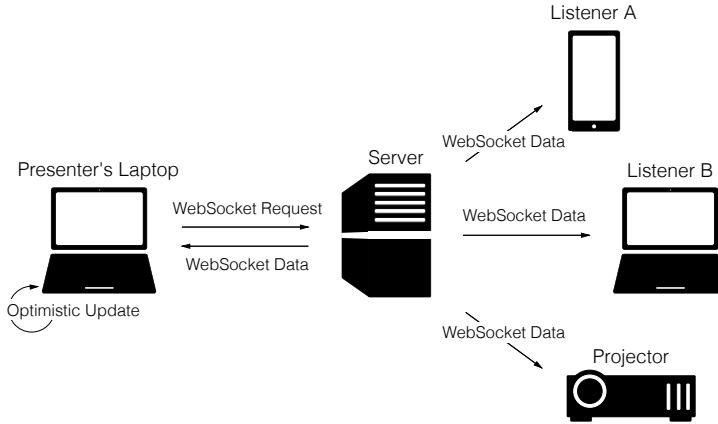


Figure 5.3: Client-server communication. The server receives the request from the client and forwards it to all clients.

5.3 Front End Technologies

The project generally follows modern best-practices in web development and utilises modern CSS3 and JavaScript features and frameworks. The software is written in *ECMAScript2015*, makes use of the *node package manager* (short *npm* [56]) for managing dependencies and *Babel* [51] to transpile the code to *ECMAScript 5*. Additionally to relying on *CSS3* features, this project also uses *Sass* [44] as a *CSS* pre-processor. The listener-interface was developed mobile-first and the speaker-view with mobile in mind; media-queries allow for these optimisations.

The JavaScript library *React* [47] serves as the render framework of choice, additionally applying the *reactive programming* paradigm using *RxJS* [53] to create a simpler interface for event-driven and asynchronous operations. These technologies will now be introduced to the reader shortly, to establish the knowledge-base necessary to understand the then following technical implementation details.

5.3.1 ECMAScript2015 and Babel

JavaScript undoubtly is an integral part of front end web development and since the emergence of server-side JavaScript with *Node.js* and its package manager *npm*, has developed into a programming language widely used by web developers [24]. Both *PYPL*² and *TIOBE*³ programming language indices rank JavaScript among the top 10 programming languages (*PYPL* at

²<http://pypl.github.io/PYPL.html>

³http://www.tiobe.com/tiobe_index

5, TIOBE at 7 at the time of writing) [24]. Stack Overflow’s 2015 Developer Survey even places JavaScript as the number 1, most-used programming language with 54.4% and JavaScript, Node.js and *AngularJS* [49] all three rank amongst the top 5 languages developers expressed an interest in developing with [82].

However, like any front end technology, JavaScript suffers from slow end user adoption, as a multitude of browser versions exist for different devices and operating systems and many people still do not auto-update their browsers. Another factor is the time it takes for browser-vendors to implement new ECMAScript standards (the standard behind JavaScript) and roll out said updates. This is exactly what is happening with the new ECMAScript standard, ECMA-262, commonly known as ECMAScript 2015 or ES6: Although the General Assembly has adopted the new standard in June 2015 [12], *Kangax’ ECMAScript compatibility tables*⁴ still show a fairly low level of support, especially among mobile browsers. ES6 makes JavaScript easier and more efficient to write by providing new semantics for default values, arrow-functions, template-literals, the spread operator or object destructuring [75]. It also makes JavaScript safer to develop with and easier to understand with the introduction of block-scoped variables (`let` and `const`) and finally offers native support of modules and promises [75]. As these features are all included in the new ECMAScript standard, it is safe to assume browser-vendors will implement them in the near future. Until then, developers who want to already make use of them, can *transpile* ECMAScript 2015 code to ECMAScript 5, which is exactly what Babel does. With almost 750.000 downloads in April 2016 [69] and companies such as Facebook, Netflix, Mozilla, Yahoo or PayPal using this transpiler [70], Babel is the de facto standard in transpiling to ECMAScript 5 and was also chosen for this project.

5.3.2 Reactive Programming

Another problem with JavaScript, although integral part of the reason for its high popularity, is its asynchronous nature. Especially when working with highly interactive parts, the prime example being user interfaces, sequential programming quickly gets too inflexible to handle complex, event-driven applications [1]. The same is true for the server where the possibility to concurrently serve a multitude of different clients is paramount. In these cases JavaScript offers *asynchronous callbacks*. These, however, oftentimes execute more asynchronous code and in turn have to wait for another callback to fire, and another one, and another one..., which can result in something known and dreaded by most any JavaScript developer: *Callback Hell* (see programm 5.2). Since this project has to fulfill many asynchronous tasks and

⁴<https://kangax.github.io/compat-table/es6/>

Program 5.2: *Callback Hell* – Nested asynchronous callbacks to create a file upload.

```

1 onChange(event) {
2   fileReader.readAsDataURL(event.file, (content, error) => {
3     uploadFile(content, (response, error) => {
4       this.refs.modal.close(() => {
5         updateSuccessMessage(response)
6       })
7     })
8   })
9 }
```

Program 5.3: *Promises* – File upload example using ECMAScript 2015 promises.

```

1 onChange(event) {
2   fileReader
3     .readAsDataURL(event.file)
4     .then(uploadFile)
5     .then((response) => {
6       this.refs.modal.close(() => promise.resolve(response))
7     })
8     .then(updateSuccessMessage(response))
9 }
```

is heavy on the user-interface and thereby JavaScript's event system, it was crucial to find a way of handling this code gracefully. In the following, different ways of handling asynchronous programming are described, the example of an imaginary file upload will be used to demonstrate the differences on code-level:

1. A file is chosen by the user
2. The file is read by `FileReader`
3. The file is uploaded
4. The file upload modal is closed with an animation
5. As soon as the animation is over, a success message is rendered

Different approaches have been employed to lower the hurdle of writing asynchronous code, one of them being *promises*: A promise is a value, yet to be computed [21]. A promise can be a) pending (if it has not been assigned a value yet), b) resolved (if it has been assigned a value) or c) rejected (if an error occurred). With ECMAScript 2015 promises, these objects can then be queued using the `then` keyword, to execute asynchronous code in a certain sequence (see programm 5.3).

Program 5.4: RxJS – File upload example with reactive programming in RxJS.

```

1 Observable.fromEvent('change', fileInput)
2   .pluck('file') // pluck event.file
3   .map(fileReader.readAsDataURL)
4   .map(uploadFile)
5   .do(() => this.refs.modal.close)
6   .subscribe(updateSuccessMessage)

```

However, promises can still create nested callbacks, especially when chaining promises that rely on other promises' resolution [21]. This is where *reactive programming* shines: The reactive programming paradigm works with streams of events, in which every event is handled as a new value and all other parts depending on that value are re-computed upon arrival of such new value. Bainomugisha et al. use the illustrative example of a simple addition to demonstrate this [1]: In sequential programming, c the expression $c = a + b$ with $a = 1$ and $b = 2$ will always be 3, until assigned a different value. With reactive programming, however, should a or b change, the value of c is automatically re-computed. JavaScript does not directly support reactive programming, but more functional languages like *Elm* [45] which can be transpiled to JavaScript, do. Another way of adding reactive programming concepts to JavaScript is using a library, such as *Bacon.js* [58] or the one chosen for this project, *ReactiveX*⁵. ReactiveX provides libraries for a multitude of different programming languages, C#, C++, Java and of course JavaScript among them. The latter, called *The Reactive Extensions for JavaScript* or short *RxJs* [53], allows for the processing of event streams (*Observables*) as if they were simple JavaScript arrays. Instead of writing sequential code, method after method, if asynchronous or not, is applied to every element in the incoming event stream, using the array-methods such as, most notably and well-known, *map* (to apply a method to every element in the incoming stream) and *filter* (to only let a subset of events pass) (see programm 5.4).

Additionally to Observables, RxJs also knows *Subjects*, which combine both a source of events and a consumer of such. Subjects are Observables but at the same time also Observers and can be used to broadcast values to several consumers [53].

5.3.3 React

As this project focuses on the front end, a mature JavaScript library for front end rendering was needed. After previous experience with the big and

⁵<http://reactivex.io/>

Program 5.5: Example code snippet using properties and state in a React component. Whenever the text input changes (i.e. a user types something), the state will be updated and the component re-rendered. The component can be used in other components as <HelloWorld greeting="Hi"/>.

```

1 export default class HelloWorld extends Component {
2   static propTypes = { greeting : PropTypes.string }
3   static defaultProps = { greeting : 'Hello' }
4
5   constructor(props) {
6     super(props)
7     this.state = { name : 'World' }
8   }
9
10  const render = () => (
11    <div>
12      <h1>{this.props.greeting} {this.state.name}!</h1>
13      <input value={this.state.name} onChange={(name) => this.setState({
14        name })} />
15    </div>
16  )

```

complex but slow AngularJS, and because of promising performance benchmarks [78] and simply to explore new JavaScript libraries, React was chosen for the rendering layer of this application. Since Facebook started developing React in 2013, it has challenged existing approaches and set new standards in front end web development [17]. Instead of creating an entire MVC framework for the front end, React really concentrates on the view by offering a way of creating independent, lightweight view components. This gives React the huge advantage of beating other front end frameworks in performance benchmarks by far [78]. Moreover, *React Native* [48], which uses the same component-based system, makes it possible to port applications to different mobile operation systems.

To define how each of these re-usable, lightweight components is displayed, they implement a `render` method, returning JSX [15]. The communication with other components happens through *properties* (`props`), which are passed into the component as XML attributes. Their own internal state, which can be manipulated e.g. through user interactions, is maintained in the `state` member [14]. Every state (internal) or property (external) change causes a re-render of the component, an example `HelloWorld` component can be found in program 5.5. These updates, as well as construction and destruction of components are handled in *lifecycle methods* [14].

As an end note on React, and a transition to the core presentation library, it should be added that React components can be nested arbitrarily

deep, effectively creating semantic XML syntax which is directly linked to the rendering of the components. To make it as easy as possible for other developers to use the created libraries and components, presentations are built just as a usual HTML page, using these semantic XML tags, as will be shown in chapter 6.

5.3.4 unveil.js

Although not initially planned, due to several shortcomings of other presentation libraries, this project builds upon the open-source JavaScript library *unveil.js* [57], which we developed prior to this project and extended and adapted in an own fork [65] during the project. While other alternatives, such as *impress.js* [68] or the popular *reveal.js* [46], exist, extensive research showed that neither of the two libraries offers the flexibility necessary to easily implement the discussed interactive mechanisms. They both were not built unleashing modern web technologies' full potential and practically consist of one big file of JavaScript, handling all functionality. We therefore decided to build our own presentation platform.

Generally, *unveil.js*, like *impress.js* and *reveal.js*, is a library with which online presentations can be built. All three do not require a web server and can therefore be statically, and also locally served. Instead of building the presentation using a graphical user interface, all slides, transitions and styling are defined in HTML and CSS, meaning the presenter has to be familiar with basic front end web development techniques. Thanks to the use of React, *unveil.js*, in contrast to *reveal.js* and *impress.js*, however, does not depend on the usage of class names to identify the slide structure, but instead can make full use of semantically-named components, such as `<Slide/>` or `<Notes/>`. More details about the usage of *unveil* will be covered in chapter 6.

Like *reveal.js*, *unveil.js* operates on a 2-dimensional slide-space: Every slide can have a next and previous slide in *x* (main slide), as well as in *y*-direction (sub-slide). To generate the *y* axis, slides are nested in other slides. To be able to identify slides from a URL, slides have an optional unique name as well as an index in the slide-tree. Both the index and the name can be used to link to a certain slide, making it possible to share not only a whole presentation but also a certain slide.

The core of *unveil.js* is `UnveilApp`, which all slides and sub-slides are nested in. This component configures and sets up the entire application based on optional configuration passed in as properties. There are a few concepts we introduced in *unveil.js* to allow for maximal extensibility and adaptability, namely *presenters*, *controls* and *modes*:

- **Presenters** define the way the current slide is rendered, e.g. where to display controls, if to show notes, or whether to render upcoming slides.

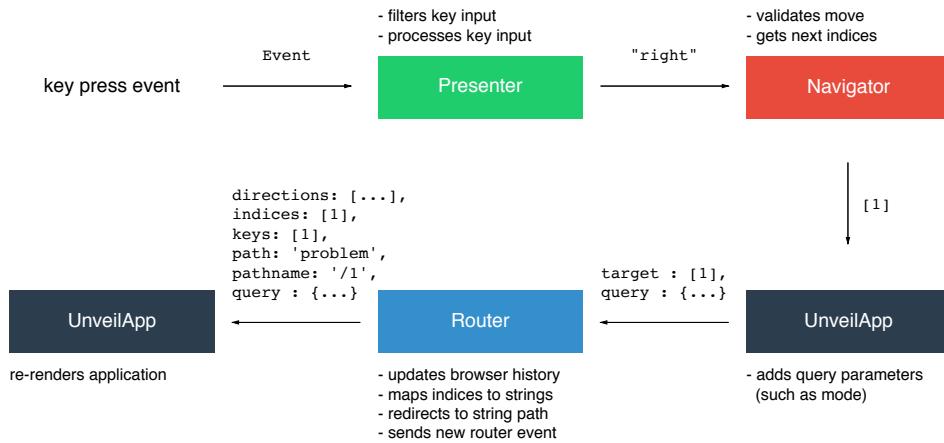


Figure 5.4: Navigation pipeline from user's key press to re-render of the presentation. The monospaced text next to the arrows symbolises the data transmitted. **KeyControls** listen for key events and process them, to then send a navigation request to go *right* to the **Navigator**. This component then maps the direction to the next slide's indices (1). **UnveilApp** then adds other information necessary for the **Router**, which then is responsible for updating the browser history, mapping the indices back to a human readable url and sending out a new router event. In the end **UnveilApp** receives this event and re-renders the presentation.

- **Controls** control a part of the application. One example would be the navigating from one slide to the next using the arrow keys on the keyboard.
- **Modes** are what allow a speaker to have a different presenter and controls from an audience member. Each mode defines its own presenter and set of controls, the mode is determined by the url query parameter `mode`.

This allows anybody using `unveil.js` to define or overwrite modes, presenters and controls and thereby extend the base library as they wish. A few of these are already defined in the base library, namely a default **Presenter**, **UIControls** to navigate using buttons, **KeyControls** to navigate using the keyboard and **TouchControls** to navigate with swipe-gestures on touch screens. In chapter 6, modes for the audience (`default`), the speaker (`speaker`) and for use on the projection device (`projector`) will be set up.

For these controls and the entire presentation to be navigatable, **UnveilApp** is responsible for the creation of two very important classes: **Router** and **Navigator**. These can be defined outside and passed into **UnveilApp** as properties, allowing other developers to customise their navigation logic. The **Router** is the class handling everything connected to the current url. It receives the slide-tree and can compute the indices of a slide by its name

and vice versa. Whenever the browser history changes, the router finds the corresponding slide-indices, computes an array of possible directions to go into from this slide and propagates the event to `UnveilApp`, which can then re-render the application. `Navigator`, in turn, receives these directions and is responsible for the mapping of directions (*left*, *right*, *up*, *down*) to slide-indices. Controls know the navigator and can push new directions to the navigator subject, thus starting the navigation process described in detail in figure 5.4.

5.4 Project Structure

As the purpose of this project was not only to experiment with different ways of interacting with presentations using mobile devices, but also to create something worthwhile and contribute back to the vibrant open-source community, the project is entirely open-source and separated into different repositories. These can be installed using npm, therefore allowing developers to rely only on the parts they really need. An overview can be found in the beginning of this chapter in figure 5.1.

Extended `unveil.js`: As discussed in section 5.3.4, the project is based on the library `unveil.js` [57]. During the development of the project, certain parts of the base library were improved to allow for even easier extensibility and new presentation logic was added. This happened in a fork of the original library, which will be examined in section 5.5.

Network Synchronisation Layer: The first library of direct importance for the interaction between speaker and audience through personal devices is `unveil-network-sync` [64]. This rather small library relies on `unveil.js` and is responsible for connecting the client and the server through web sockets and enables the synchronisation of the current slide displayed between speaker, audience and projector. The implementation of the features will be discussed in detail in section 5.6.

Interactive Extension: As the name already suggests, this library is at the core of the present thesis: It includes a dedicated presenter for the speaker, implements the insertion of additional slides and subslides and by that allows the audience to share content with the presentation. Reactions, the voting mechanism, as well as the creation of new votings on-the-fly, also live within this library. The repository, called `unveil-interactive` [63] relies on `unveil-network-sync` for the socket-interaction and will be covered in section 5.7 of this chapter.

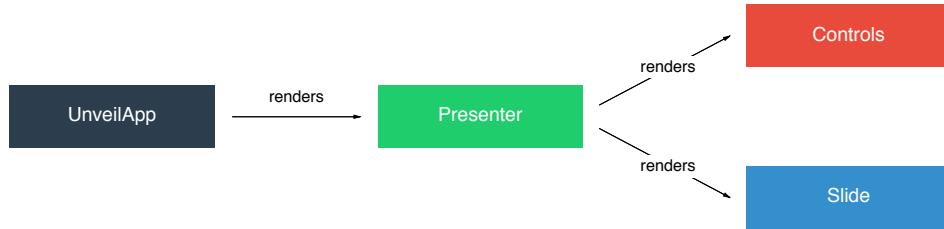


Figure 5.5: Overview over the render-flow of the application in the extended version of `unveil.js`. `UnveilApp` renders the `Presenter`, which then takes care of rendering the (current) slide and all controls.

Server and Example Presentation: The last repository connected to this thesis [62] includes a simple server as well as a real-world example of a presentation. In this chapter, one section was already dedicated to the server (5.2), a short introduction into the usage of the developed library will be given in chapter 6.

5.5 Extended `unveil.js`

The biggest adaptions and additions were necessary in the main component `UnveilApp`. A state subject was added to allow all components in the presentation to interact with the application. This subject receives an event with type and data and depending on this type starts a certain state change. Two of these state events are the `state/navigation:enable` and `state/navigation:disable` events, which set a state-variable `navigatable` to true or false. This variable is used in the controls to determine navigability, therefore making it possible to keep the audience locked to a slide, e.g. during votings. To make it possible for the audience to add subslides, as well as to dynamically add votings on-the-fly, another event is `state/slides:add`. It includes what slide to add (content), how (subslide or main slide) and where (under or after which slide). On occurrence of this event, the slide-tree has to be re-built, the router and navigator re-started and the whole presentation re-rendered, which the library also had to be prepared for. A complete list of all state events and who they are emitted by and listened to can be found in figure 5.6 and 5.8.

Another adaption in `UnveilApp` is the introduction of the `context` object: Additionally to state and properties, there is a third way of communicating between components in React, called *context*. Instead of having to pass properties from one nested component to the other, every child component can access the context of its parents. The navigator, needed in the controls, was formerly passed from `UnveilApp` to the controls through several layers. Using context, `UnveilApp` now defines a number of different vari-

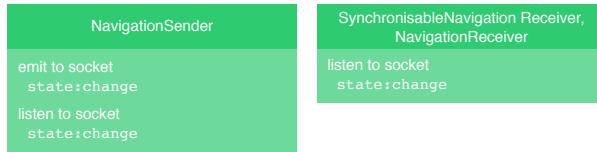


Figure 5.6: State and socket events sent and consumed by controls in the network synchronisation layer.

ables which are available through context, including current slide and router state, navigator, mode and the state subject discussed in the last paragraph. This makes it easy for new controls and presenters to access the data they need without other layers knowing about them or having to define them. This adaption was partly due to a change in the render hierarchy: Formerly, `UnveilApp` itself rendered the presenter (which rendered the current slide) and the controls. However, the presenter needs to be able to also control the rendering of controls (see figure 5.5), adding another layer between the rendering of controls and `UnveilApp`.

Another part that was added to the `unveil.js` base library is the `Notes` component. It allows adding speaker notes to each slide (see program 6.2). These, however, are not rendered by the slide, but by the presenter, as will be shown in section 5.7. One more important new feature is the possibility to configure the next slide in a certain direction (left/right/up/down) and therefore allow for jumping into different branches of the presentation, thus making a presentation even more interactive. The following code, for example

```

1 <Slide name="start" left={[0]}>
2 ...
3 </Slide>
```

means a navigation *left* (left arrow key pressed, swipe left etc.) will not go to the previous slide defined in the slide-tree, but rather jump to the first slide (of index 0).

5.6 Network Synchronisation Layer

As mentioned before, the network synchronisation layer is responsible for the communication between server and client using WebSockets. These are created using `socket.io`, a library which also provides fallbacks for browsers that do not support WebSockets yet. However, the library also has a few drawbacks, especially when it comes to corporate networks. As Rob Britton describes in [71], `socket.io` seems to have problems getting through firewalls and can be blocked by some anti virus applications. Because mobile browser

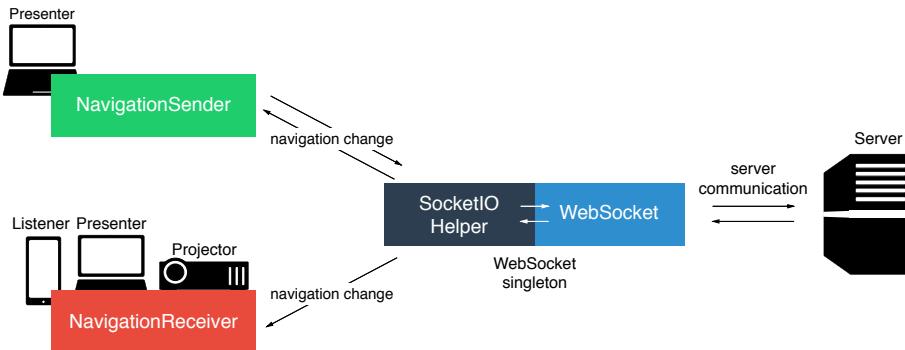


Figure 5.7: Navigation synchronisation flow. `NavigationSender` emits a navigation change, which is sent to the server via WebSockets using the `SocketIO helper` and played back to the `NavigationReceiver` which is activated on all clients by default.

support is essential for this project, we still decided in favour of this library.

The socket is created by the speaker in the main entry point of the presentation by passing the IP-address of the WebSocket server to the function `createSocket`, which is directly exposed by `unveil-network-sync`. Internally the socket connection to the server is established and the then exposed as a singleton, so every component using the same connection. Inside all controls communicating with the socket server, this connection can be imported through `SocketIO`, which internally retrieves the singleton:

The connection can then be used to listen to events or to emit them. Like the state subject events, the socket.io events used in this library follow the naming convention of scoping the object targeted in by the event separated by slashes, followed by a colon and the name of the action, e.g. `state:change` or `state/slides/voting:start`. The list of all current socket events, together with state events can be found in figure 5.6.

Besides providing a way of connecting to the server, this library also offers the components `NavigationSender` and `NavigationReceiver` for synchronising the navigation state of the presentation between speaker and audience. As the names already say, the sender broadcasts the state update, while the receiver is waiting for state updates and starts the navigation process. By default, the latter is active in all modes (default, speaker and projector), whereas the sender is only added to the speaker mode, effectively only broadcasting the speaker's navigation changes (see figure 5.7). To make sure the sender does not end up in an infinite loop of sending and receiving their own state changes, the last received state is stored and only navigation events going to a different slide are processed further.

This mechanism, though relatively simple, already enables the audience, and with that our listener Greg, to follow the presentation and the speaker

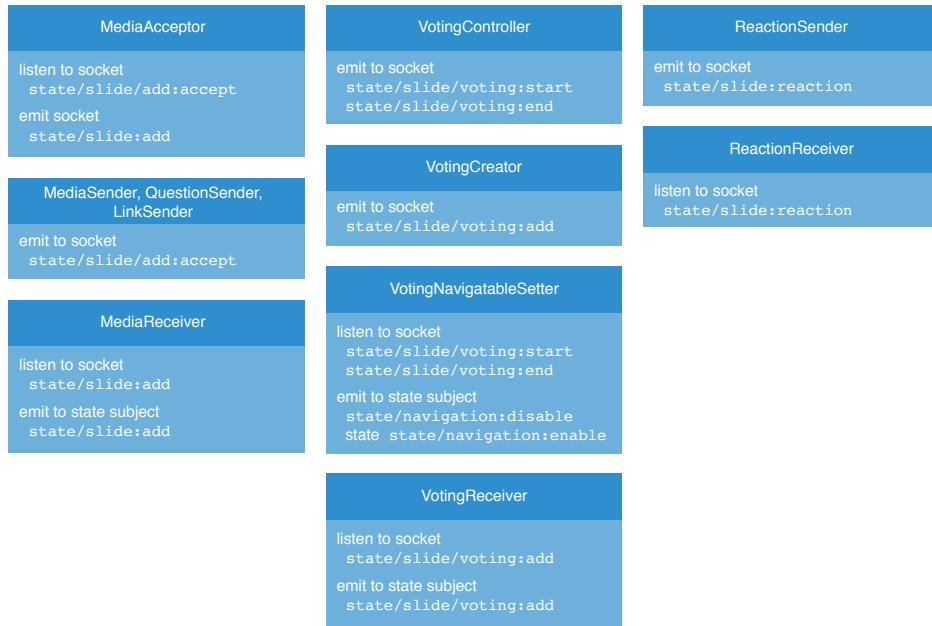


Figure 5.8: Overview of state and socket events sent and consumed by controls in the interactive extension.

Amy to use her phone or laptop as remote control for any number of connected projectors. Optionally, the `SynchronisableNavigationReceiver`, makes it possible to navigate entirely independently for listener and adds a button in the interface to switch back to the current presenter state.

5.7 Interactive Extension

The interactive library includes several parts which will be discussed here: a speaker presenter (section 5.7.1) and different components connected to reactions (section 5.7.2), sharing content (section 5.7.3), and voting (section 5.7.4).

5.7.1 Speaker Presenter

The speaker presenter, like the normal presenter, is responsible for rendering controls and slides. In speaker mode, where this presenter is used, notes as well as the upcoming slides (right and down) are also shown. This means the presenter has to find these next slides, using the router's information about the navigatable directions, and render them in a designated area. As mentioned before, special attention was paid to mobile stylesheets to make the presenter view usable on mobile devices. This ensures that everything is

big enough to be readable and all buttons are clickable (screenshot can be found in figure 6.1).

5.7.2 Reactions

As with most other unveil library extensions described in here, the components for reactions also consist of a sender and a receiver: `ReactionSender` and `ReactionReceiver`. The principle is the same as with network synchronisation (see figure 5.7): When a listener chooses to send a reaction by clicking or tapping on an emoji, a `state/slide:reaction` is sent through the WebSocket. On the other side, the receiver is listening for the event and remembers which reactions have been sent on which slide, to display them. As a default, the sender is active in listener mode and the receiver is added to speaker and projector mode. On mobile, where the reactions are hidden behind a button and only slide in when tapping said button, a state-variable is responsible for storing the status of the reaction-picker. This works using CSS3 animations on the ‘max-height’ attribute of the container.

5.7.3 Content Sharing

Another responsibility of the interactive extension is the possibility for audience members to share content with the presentation. For this to work, five different controls were created: `MediaAcceptor`, `MediaReceiver` and the three senders `MediaSender`, `QuestionSender` and `LinkSender`. The senders are used in listener mode so members of the audience can share their content, the acceptor is enabled in speaker mode, to accept or reject incoming content and the receiver in the end handles the creation of a new slide if the content was accepted and is therefore necessary in all modes (see figure 5.9). As incoming content requests could disrupt the presentation flow and distract the speaker, an option to mute the requests was built into the application. If the *do not disturb* mode is turned on, slides will silently be added as subslides, without causing the acceptor modal to open. This way the audience’ additions can be re-visited after the end of the presentation. Generally, this feature can be used to either copy and paste a link to a picture, website or youtube video, for text input (i.e. questions) or to upload images directly from the listener’s device. This works through the introduction of the presentation components `Media` and `IFrame`, which, depending on the shared content, render an image-tag, blockquote or IFrame. The differentiation of these is carried out using regular expressions. The native file upload works through the HTML5 File API, using `FileReader` [30]. Once the file is uploaded, its contents are encoded as base64 data url and sent through the WebSocket.

As far as the implementation of the other controls is concerned, like the already discussed ones, they make use of the `SocketIO` helper to communi-

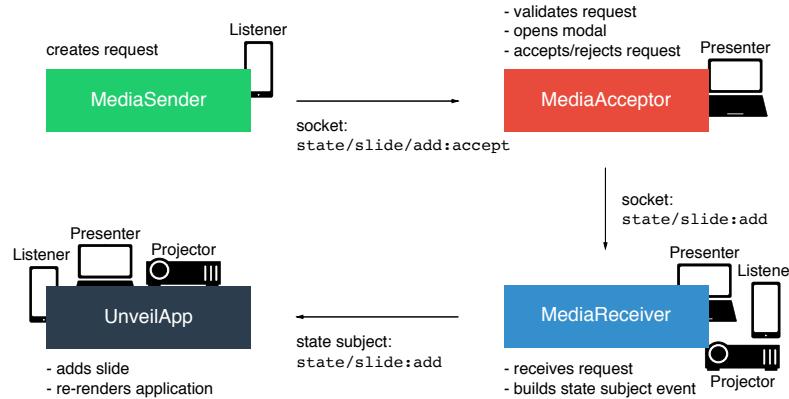


Figure 5.9: Flow of adding content, monospaced text symbolises type and name of events. First the **MediaSender** of the listener mode sends a request, which the speaker mode's **MediaAcceptor** listens to. If the request is accepted by the speaker or requests are muted, another socket event is broadcast, which the **MediaReceiver** waits for. This component is enabled in all modes and emits the state subject event to add a new slide, which **UnveilApp** finally reacts to.

cate with the server (see figure 5.8). Additionally they use the **UnveilApp**'s state subject to start the process of adding a new slide. The sent **state/slide:add** event includes details regarding where to add the new slide, its content, as well as how to add it (main or sub-slide). **UnveilApp** then inserts the new slide into the slide tree, re-computes the slide-map for the router and re-renders the entire presentation. The flow of the process is also outlined in figure 5.9.

The controls used for sharing content are also responsible for rendering the all necessary buttons and modals. The three senders render one **share** button each, which toggles a **sharingMode** state variable and opens and closes the respective sharing modal. Something similar happens in the **MediaAcceptor**, which uses the **render()** method to display the **mute** button and controls the modal for accepting new content, listening for incoming data. If a request arrives while another one has not yet been dealt with by the speaker, the request will be queued in the acceptor's internal state.

5.7.4 Voting

The last group of components connected to the interactive extension covered in this chapter allows speakers to create votings – both during in the preparation of the presentation and on-the-fly – and members of the audience to vote.

The main presentational component involved in the voting process is **Voting**, which keeps track of the current voting scores and has a **Question**

and a number of **Answer** components as children. **Voting** also remembers if the current user has already voted and if so, displays the **Results** instead of the form. In speaker and projector mode these results are shown at all times.

The audience can start submitting their votes as soon as the speaker navigates to the slide with the voting and until then the vote button is not rendered. Once the voting has started the possibility for all audience members to navigate to a different slide is disabled. The **VotingController** is active in speaker mode and checks the currently displayed slide for votings. If a new voting is active, the voting start event is emitted via the WebSocket. On the side of the audience, the **VotingNavigatableSetter** listens for this event as well as the voting end event and uses the state subject to enable and disable navigation in the presentation.

Once the voting has started, internally, the **Voting** component remembers which answer the user has clicked and once the submit button is pressed, fires a `state/slide/voting:answer` socket event. These in turn are used in the **Voting** components of the other clients to update the internal voting statistics. As the results of the voting should be available throughout the whole presentation and not be reset when leaving the slide, **Voting** also handles the communication with local storage, to persist the current results and voting status (voted or not). This happens in the update and mount lifecycle methods of the component using the name of the voting to identify the stored results. For votings created with the **VotingCreator**, this name is automatically created using the current timestamp. This component again renders a button in the speaker interface which toggles a modal. The creator internally stores a question and an array of answers, which can be filled in and added through the dialogue clicking the “Create Voting” button (see figure ?? in chapter 4). This fires a socket event which the **VotingReceiver** is listening for to create a new slide from the sent details and start the adding process using unveil’s state subject.

After discussing all important components of the developed application, it is time to have a look at how the library can be used and customised from the speaker’s point of view.

Chapter 6

Results

This chapter offers insight into the outcome of our work. First, the final presentation system is presented, to then go over to the results of our early user studies. Since one of our objectives was to create a re-usable set of libraries, the usage of the unveil ecosystem from a developer's point of view will also be part of this chapter.

6.1 Application

In course of this thesis, we have developed three designated interfaces, one for the listener, one for the speaker and one for the projector. While the projector interface does not have any specific requirements, both the listener (see figure ?? in chapter 5) and presenter view (see figure 6.1) were optimised for devices with small screens.

Our system offers several ways of interacting with a presentation using ones personal, mobile devices:

- remote controlling slides,
- following slides,
- different paths through presentations,
- voting and voting creation (on-the-fly),
- instantaneous reactions and
- multi-media content sharing.

With these mechanisms in place, presenters can navigate through slides without the need for proprietary hardware and capture the mood of the crowd through emoji. This is especially useful with increasing audience sizes, as it gets harder to address every participant. The same is true for votings, which can help the speaker to get an idea of the audience' knowledge and interest. When combined with different paths through the application, the progress of a talk or meeting can be controlled by the listeners, tailoring the experience to their needs. Due to our anonymous polling implementation,

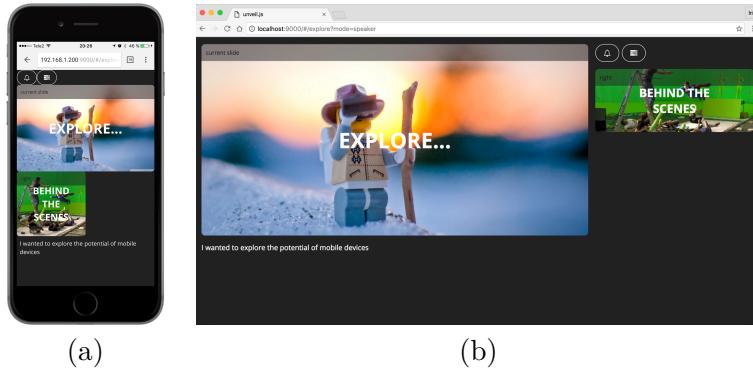


Figure 6.1: Speaker Presenter on mobile (a) and desktop (b).

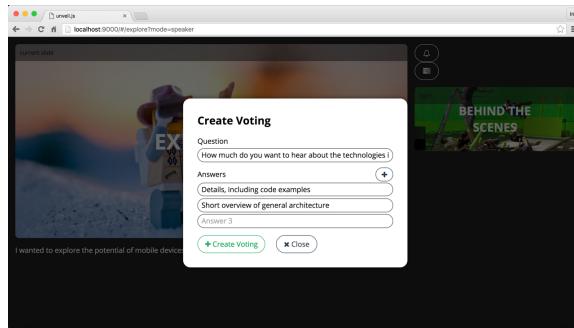


Figure 6.2: Poll creation modal in presenter mode on tablets, laptops and desktops.

votings also offer an advantage over hand-raising in smaller audiences. In these settings, the content sharing mechanism shines: by inserting new main and sub-slides, listeners are given full control over the development of a presentation. Related content, notes, questions and comments can all be added by members of the audience, making presentations a collaborative effort. As all these features can be stressful for the speaker, all of them can be enabled or disabled, to their liking. As the reaction feature of the application has already been covered in detail in chapter 4 and the other mechanisms are fairly self-explanatory, we will now take a detailed look at the voting and content sharing functionality.

6.1.1 Voting

Votings can be prepared beforehand or on-the-fly – during the presentation in the speaker interface (see figure 6.2 (a)). After the creation of a poll, the voting is started as soon as a presenter navigates to it. To ensure as many listeners as possible use their right to vote, all participants are locked to

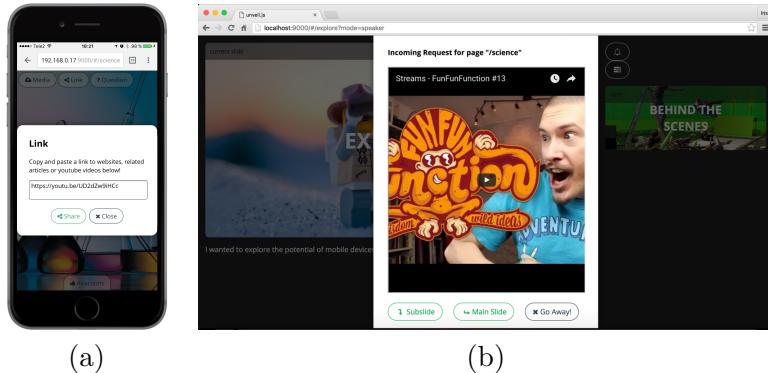


Figure 6.3: Sharing of a youtube video. Request from listener on a phone (a) and accepting-modal in presenter-view on a computer (b).

the voting screen for the time of the voting (i.e. until the speaker navigates away from the slide again) and cannot navigate individually anymore. Once a listener votes (see figure 6.2 (b)), they are presented with the current voting results, which are also displayed on the projector. Currently, only single-choice votings are supported by the system, however, free-text or multiple-choice questionnaires as well as any other kind of form elements could easily be added in the future.

6.1.2 Content Sharing

The seemingly biggest mechanism implemented in course of this thesis is the multi-media sharing feature. Three types of content can be shared in the current implementation:

- free text (comments and questions),
- links (to websites, youtube videos or images) and
- images from the filesystem.

The last also includes access to the camera and camera roll on smartphones (see figure 6.4) and through that offers a simple interface for uploading hand-written presentation notes, sketches and other related material.

The general process of sharing content is as follows: When a user presses one of the three content sharing buttons in the interface, a modal opens with a text area (free-text and link) or a file-upload (media). After filling in the necessary information, pasting a link or choosing a picture and confirming the action, the presenter instantly receives a content request (see figure 6.3). If the speaker enables the *do not disturb* mode, incoming requests will automatically be added as subslides to the page the request came from. Otherwise

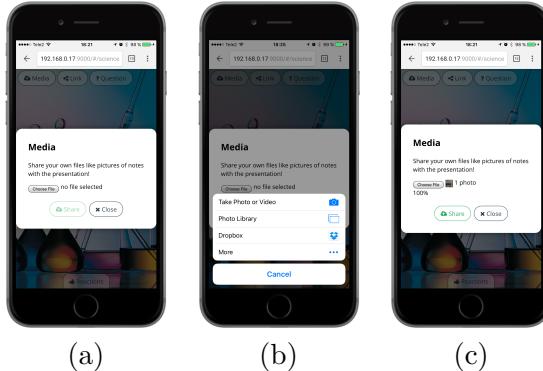


Figure 6.4: Sharing of a picture from an iPhone's browser (Google Chrome on iOS 9.3.4) in listener mode. First, the listener opens the *Media* sharing feature (a). Then a file can be chosen from different sources, such as the camera roll, or a new picture can be taken (b). In a last step, the picture is uploaded to the application and can then be shared (c).

6.2 Early User Study

6.3 From a Developer's Perspective

Since one of our declared goals was the creation of reusable, extensible presentation libraries, a few words should also be spent on the usage of the system by other developers. This chapter will therefore go into details of how to set up an unveil presentation (section 6.3.1), use the components (section 6.3.2) and lastly ways of customising, overwriting and extending behaviour (section 6.3.3). The code-examples of this chapter are based on [62].

6.3.1 Setup

Since the entire created code is available on npm, the first step in setting up an unveil presentation is to require the necessary libraries `unveil`, `unveil-network-sync` and `unveil-interactive`. In the entry point of the presentation (usually `index.html`), all bundled JavaScript and CSS-files are included and an HTML document is created which offers a tag that can be used to render the presentation (e.g. a `div` with the class `unveil`). For lower the page loading time [85], script tags should generally placed in the `body` tag, usually before closing said tag. As soon as this initial page is set up, the actual presentation can be built in an JavaScript file which should also be included here. In this file, we will call it `index.js` from now on, all necessary libraries and components are imported: `React`, `ReactDOM`, as well as all unveil components that should be used. If any libraries which rely on the

Program 6.1: Example styling unveil slides using Sass. In this particular piece of code, the font family of all slides is set and a background image is added to the slide of name `start`.

```
1 .slide
2   font-family: 'Open Sans'
3 #start
4   background-image: url('../img/explore.jpg')
```

communication with the WebSocket server should be used in the presentation, the `SocketIO` singelton also has to be configured with the address of the server:

```
1 import { createSocket } from 'unveil-network-sync'
2 createSocket('http://192.168.0.17:9000')
```

6.3.2 Building a Presentation

Once all libraries are imported, the actual presentation can be created. The most important component in this context is `UnveilApp`, which is imported from `unveil`. This component holds all the `Slides` and is responsible for the configuration of the application (see section 6.3.3). Inside the `Slide` components, all content of the slide and the `Notes` are placed. Each of the slides will be rendered as common HTML and can include any number of other HTML tags and custom React components (see programm 6.2). Although strictly-speaking not necessary, it is recommended to give slides (unique) names, since their name will be the id of the rendered HTML component and makes it possible to style components with CSS (see programm 6.1). Additionally, if provided, unveil uses the name of the current slide as the url, allowing for text-based rather than index-based routes.

Other than that, slides can have a `left`, `right`, `up` and `down` property to allow for several paths through a presentation: All slides are provided as normal slide-sets, but the `left` and `right` attributes of the first and last slide of each path point to the previous and next slide shared by the entire presentation. `Links` (available in the `unveil-interactive` package) can be used to access the first slide of each path. Additionally, the interactive extension also offers the components for preparing votings: `Voting`, `Question` and `Answer` (see programm 6.3). The only necessary property for `Votings` is the `name` attribute, which uniquely identifies the voting, as well as exactly one `Question`-child and an arbitrary number of `Answers`.

Program 6.2: Creation of a presentation. Sets up two slides as an example. The DOM will be attached to the element of id `unveil` in the base HTML document.

```

1 ReactDOM.render((
2   <UnveilApp modes={modes}>
3     <Slide name="start">
4       <h1>Unveil</h1>
5       <h2>a meta presentation</h2>
6     </Slide>
7     <Slide name="intro">
8       
9       <Notes>Explain initial situation</Notes>
10    </Slide>
11    ...
12  </UnveilApp>
13 ), document.getElementById('unveil'))

```

Program 6.3: Creation of votings in unveil. The necessary components have to be imported from `unveil-interactive`.

```

1 <Voting name="like">
2   <Question>Do you like these slides?</Question>
3   <Answer value="yes">Yes</Answer>
4   <Answer value="no">No</Answer>
5 </Voting>

```

6.3.3 Customisation and Extension

Thanks to unveil’s base architecture, it is possible for speakers to entirely customise the entire presentation logic. The most important step is to define the available modes and the presenter and controls which should be loaded in each of them (see figure 6.4). Additionally to the existing controls in unveil and its current extensions, new (presentation) logic can be added by defining ones own React components and assigning them to modes. To interact with the WebSocket server, `SocketIO` is available from the network synchronisation layer. Data such as the current router state or slide, and the navigator or state subject are accessible through `UnveilApp`’s context. For examples of existing controls and presenters, the reader is advised to refer to the implementation of the components discussed in chapter 5 [63–65].

Moreover, the `Router` and `Navigator` can also be entirely replaced by providing ones own functionality as `router` and `navigator` properties in `UnveilApp`. They only have to follow the same interface as the default implementations. If any additional configuration should be necessary (such as with setting the address of the WebSocket server or customising emoji),

Program 6.4: Mode definition for setting up an unveil.js presentation. Default (i.e. listener) and speaker modes are omitted to keep the example short, but generally follow the same pattern as the projector mode.

```
1 const modes = {
2   default: {...},
3   speaker: {...},
4   projector: {
5     controls : [
6       NavigationReceiver, MediaReceiver, ReactionReceiver,
7       VotingNavigatableSetter, VotingReceiver
8     ],
9     presenter: Presenter
10   }
11 };
```

singletons or static methods of the components can be used.

Chapter 7

Discussion

A system such as the one developed in course of this thesis can be evaluated in many ways: The performance of the software can be quantified by measuring response times of the application, as happened in [34] or [19], the usability can be assessed quantitatively through usability tests, measuring error rates and time to complete certain tasks and qualitatively using *loud thinking* and interviews [36]. If the expectations laid out in chapter 3 were actually met, if listeners feel more engaged and whether the perception of phone usage in presentations has changed with unveil can also be estimated using qualitative and quantitative evaluation methods. We feel, however, that valid results can only be achieved observing the usage of the presented tool over a longer period of time and involving control groups. Since this would go beyond the scope of this master thesis, we decided to refrain from a formal study and instead rely on the informal observation and evaluation of the system, both during and after working on the project. Throughout the process of developing the different libraries, several informal presentations and meetings have been held using unveil, both in academic and business settings. This allowed for several iterations of the design, as well as the gradual introduction of more and more interactive mechanisms. Our findings and the strengths and the shortcomings of the project will be discussed in this chapter, followed by an outlook on future work.

7.1 Early User Study

We were pleased to see that all listeners have so far understood the base interface of the application, both on their phones and on the laptop. We have however not had a single tablet user in any of the presentations yet and most of the mobile phones were iPhones running Chrome or Safari. Some users experienced glitches in the navigation of the slides in Safari and could scroll within them, moreover local storage is disabled in Safari's *private mode* (thus making it impossible to persist voting results). On bright side,

initial concerns regarding the usage of socket.io have not come true, since the presentations were always held in networks we had full control over (so corporate firewalls did not play a role).

As far as the response time of the application is concerned, with up to 30 concurrent users, no noticeable declines in performance have been experienced so far and the real-time features feel instantaneous. The only current limitation to this is the transmission of base64-encoded media content through the WebSocket. Since the delay is between listener and speaker, however, the transmission time is not critical for the application to feel responsive. Another point connected to sharing media is the absence of a native sharing feature for phones, which was an anticipated limitation of creating a web application over a mobile one.

The implemented functionalities were generally received well by the users, but utilised a lot more during meetings than informational presentations. The sharing mechanisms in particular seem to have caused most excitement about unveil. In our trials, however, we experienced a large amount of test-data being sent through the mechanisms, especially in the beginning of the presentation. We therefore advice others to provide one or two empty slides in the beginning of the presentation if the audience is new to the software, so the application and its functionality can be explored. Since some users mixed textual content with links in the early tests, we separated media upload, link sharing and questions (or other text) into distinct buttons. We were very pleased to see that some of the people who had used unveil in meetings before, later actively mentioned wanting to have the ability to share links and thoughts in meetings without the technology. Resulting from this feedback, an unexpected way of using the software emerged: Instead of enriching an existing presentation, an empty slide was provided, allowing anyone in a meeting to add their own content in the 2-dimensional space in a brainstorming-like fashion.

The reaction-system was the one implemented last, which is why we are still missing more thorough insight into how listeners use it. In informal feedback rounds about the mechanism, the usage of emoji seemed to be understood well, however, these conversations were held with digital professionals and it will require further analysis to see the acceptance beyond other users. Another observation we made, is that although listeners generally reacted exceedingly positively to QR-codes (linking to the address of the presentation), it was usually faster for them to type the address into their browsers directly. This usually caused a few minutes of interruption, which should be accounted for.

The voting mechanism was also understood by users and no questions have yet arisen from it. To our surprise this functionality, like the possibility of having different paths through the presentation, did not seem to impress or excite users too much. This on one hand shows the implicitness of forms and voting mechanisms on the internet, on the other hand might indicate a

potential for improvement.

The biggest weakness of unveil for most users was the inability for the presentation to be permanently altered. Especially in meetings and informational presentations, many listeners asked for a link to the collaboratively created presentation afterwards, some users were forced to reload the website due to cross-browser compatibility issues and lost the current state of the slides, late-comers also did not have the possibility to jump into an already altered presentation. This will make it necessary to create a more intelligent and opinionated back end in the future.

7.2 Library Usage for Developers

Most of the feedback we have collected about unveil over the last months came from listeners. This has two reasons: Firstly, the creation of presentations requires knowledge and experience with front end web development technologies, secondly, we have not started promoting the resulting libraries yet, as we feel the system is not stable and mature enough to be used outside our internal settings. However, external developers have provided us with their feedback regarding the syntax used for defining slide decks and seem to not have had any problems understanding the usage of the libraries. This validates our decision to choose semantically-named tags rather than HTML class names to identify different components. On the downside, we seem to have overestimated the level of knowledge necessary to create own presentations, as a few developers were not entirely familiar with the new ES6 syntax and the process of bundling JavaScript and CSS files, so an easier way of importing all necessary libraries should be provided in an example presentation. In the long run, this product will only be able to increase its popularity if a visual editor for authoring slides, as well as a system to manage (i.e. host) them will be available. Some users also raised the question of how and if it was possible to import PowerPoint presentations, to be able to use the created mechanisms in connection with already existing software.

7.3 Architecture

Generally, it has to be said that the project is still only a prototype and does not provide the stability necessary for us to feel confident promoting the product. One particular problem we have been experiencing seemingly randomly is the navigation getting stuck in an infinite redirect loop when two or more connected presenters try to navigate at the same time. Moreover we have so far ignored security concerns such as adding password protection to the presenter mode. Although the chosen architecture allows for a lot of flexibility and freedom for developers and in that sense fulfils the criteria impress.js and reveal.js did not, we have discovered more powerful, stream-

lined and widespread patterns when working with React over the last half year. Since we had no experience with React prior to the start of the development, best practices oftentimes only became apparent throughout the project and through the work on and with other React applications. To make the libraries yet easier to use and extend and more easily debuggable, future iterations of unveil will likely be based on *Redux* [43], with the presentation state globally accessible. This will make it easier to decouple components from each other through the introduction of a centralised state container.

Chapter 8

Conclusions and Future Work

In this thesis, we present *unveil*: an extensible JavaScript presentation ecosystem with a multitude of interactive mechanisms, aiming to make presentations more engaging, memorable and collaborative. At its core stand four React libraries, connecting presenters, listeners and projectors through a WebSocket server, making it possible for both audience and speakers to alter 2-dimensional slide-sets in real time. Different types of presentations were analysed to find their weaknesses and establish ways of enhancing the presentation experience: To make it easier to estimate the listeners' level of knowledge, a real-time voting mechanism was implemented, allowing for both prepared polls and ones created on-the-fly during the presentation. Furthermore, the audience can instantaneously react to slides via emoji, giving the speaker an impression of the current mood. To account for individual learning-pace and late-comers, members of the audience can moreover browse and follow the slides on their personal devices as well as send questions to the presenter. These questions, along with other multi-media content, such as pictures and links to websites and youtube videos, can then be embedded into the presentation as new main or sub-slides, effectively enabling the audience to truly shape the presentation using nothing but the mobile devices they carry on them. This holds the potential of engaging listeners in the presentation, steering it towards certain topics, connecting members of the audience with each other and the speaker and adding related content for further reference.

Despite making presentations more memorable for the audience, this approach poses new challenges and requires more flexibility from the speaker, which is why all realised mechanisms can easily be activated and deactivated. Since the created libraries were generally designed for other developers to reuse, modify and extend, we moreover offer ways of tailoring and configuring every last detail, from the routing logic over the emoji displayed to the

mechanisms enabled for each user group (presenter, listener, projector).

Although long-term studies will be necessary to validate our approach and verify and quantify their success, initial observation and evaluation of the system showed promising results. The users understood the interface and were especially excited about the possibility of sharing their own content and thoughts with the presentation. This mechanism was particularly well-accepted during informal meetings, where the usage organically evolved into a brain-storming like activity, involving all participants. The initial evaluation of our prototype also showed room for improvement, amongst others, the persistence of the created presentation and the absence of native sharing features on the phone. In future iterations of the libraries, the stability and testability of the platform will be improved as well as offering a way of permanently altering the presentation. Moreover, a graphical user interface for the creation of slides is desirable, effectively opening interactive presentations to non-developers. The trials also gave way to ideas for future projects, most notably the combination of these interactive mechanisms with existing presentation software, with canvas-based ones being of special interest.

8.1 Future Work

The biggest outstanding improvement is definitely the persistence of updates to the presentation state for later revision by both listeners and presenter. For the presenter to profit even more from the new possibilities of interactive presentations, we would like to provide some analytics: When did the audience interact with the presentation most? When exactly were which reactions triggered? Which slides provoked the most input or questions and how long did audience members stay on each slide when browsing through them individually?

As far as the interactive mechanisms implemented in this project are concerned, initial tests have shown potential for improvement as well: the question sharing tool was used very seldomly, but instead the wish for a commenting or annotating functionality was mentioned by some users. Votings could offer several types (e.g. multiple choice, open questions, ratings), as well as different ways of visualising the results (e.g. pie charts, stars, clusters of answers). They could moreover be more tightly linked to paths through the presentation, so the result of a voting could directly link to a path. Reactions generally need more testing and although we are content with the current functionality for the scope of this thesis, analytics for the presenter and time-based rather than slide-based display of reactions are desireable. Overall, more animations could make the presentation feel even more responsive and offer a more *native* feel for mobile users [18].

From an architectural point of view, it is our declared objective to deliver a stable first version of the unveil ecosystem within the coming months.

Redux and even further separation of concerns will make it easier to automatically test the application and add new features, such as the persistence of presentation state to local storage or a database. Moreover, porting the existing system to React Native and adding native sharing possibilities is worth a consideration. While one of the presentations held with unveil so far has been remote, the possibilities of using this project with distributed audiences has yet to be studied. However, the opportunity of reacting to slides as well as adding content (potentially after a talk or meeting) are a promising foundation for remote presentations [10, 20].

A possibility not at all touched in the present work is the development of an authoring and hosting tools for unveil presentations. This would make it easier to create slide decks and render the necessity for front end development knowledge obsolete; effectively giving anyone a tool to create interactive presentations. This would also be possible offering imports of PowerPoint presentations or even re-building the interactive mechanisms as PowerPoint plugins.

Another opportunity which arose from the users' desire to share to a blank presentation during meetings as well as questions about annotations, would be to follow a canvas-based rather than a slide-based approach in future projects. That way meeting participants could effectively use the platform as a tool of collaboratively creating and sharing content, to brainstorm and take notes from any device in a shared working space.

Finally, more formal observations and long-term studies will be necessary to quantify the success of the developed mechanisms. Currently, the tool is mostly in use for informal Monday morning presentations with other digital professionals; the acceptance and usability of the application will have to be re-visited and re-evaluated when assessed with less technologically versed users.

Appendix A

CD-ROM/DVD Contents

Format: CD-ROM, Single Layer, ISO9660-Format

A.1 General

Path: /
_DaBa.pdf Master Thesis

A.2 Copies of Online References

Path: /references/
about-iclicker.pdf About i>clicker [74].
babel-users.pdf See who's using Babel [70].
bing-emoji.pdf Do You Speak Emoji? Bing Does [79].
creative-bloq-hover.pdf . . Hover is dead, long live hover [72].
cu-clickers-faq.pdf CUClickers / i>clickers - FAQ [83].
ecma-262.pdf ECMAScript 2015 Language Specification [12].
facebook-reactions.pdf . . Reactions Now Available Globally [77].
github-reactions.pdf . . Add Reactions to Pull Requests, Issues, and Comments [76].
google-emoji.pdf Google now also allows you to search using emoji characters [80].
instagram-emoji.pdf . . . Emojineering Part 1: Machine Learning for Emoji Trends [73].
jsx-specification.pdf . . . Draft: JSX Specification [15].
mozilla-file-api.pdf Using files from web applications [30].
npm-babel.pdf npm's babel package page [69].

prezi-presentations.pdf	The Science of Effective Presentations [81].
react-benchmarks.pdf	More Benchmarks: Virtual DOM vs Angular 1 & 2 vs Mithril.js vs cito.js vs The Rest [78].
sm-es6.pdf	ECMAScript 6 (ES6): What's New In The Next Version Of JavaScript [75].
so-developer-survey.pdf	2015 Developer Survey [82].
socketio-problems.pdf	Why We Ditched Socket.IO [71].
socketio-wildcards.pdf	Answer to Stack Overflow Question “Socket.io Client: respond to all events with one handler?” [84].
yahoo-performance.pdf	Best Practices for Speeding Up Your Web Site [85].

A.3 Graphics

Path: /graphics/

screenshots/*	Screenshots of unveil
wireframes/*.pdf	Annotated Wireframes
wireframes/*.png	Original Balsamiq Wireframes
*.jpg, *.png	Original Raster Graphics
*.pdf	Original Vector Graphics
*.sketch	Original Sketch Files

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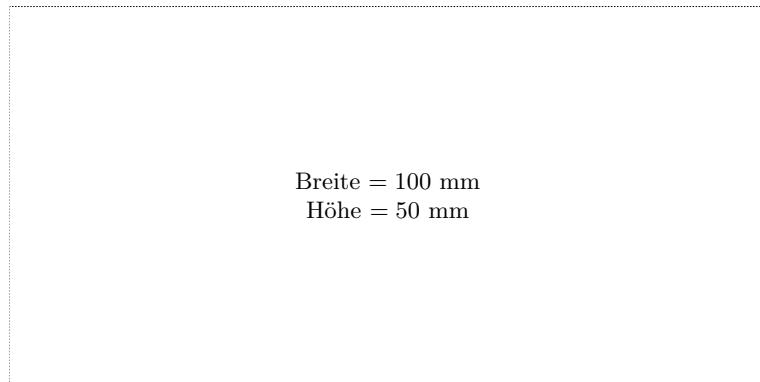
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