Towards a Functional Interface for Temporal Navigation of News Archives

MSc Thesis

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Towards a Functional Interface for Temporal Navigation of News Archives

THESIS

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by

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Towards a Functional Interface for Temporal Navigation of News Archives

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Abstract

News producers in the digital era have adopted web standards like XML for representing news stories in data stores. News stories are very time-sensitive information. When this information is archived over time, it could be analyzed to elicit trends and gauge the level of interest in particular topics. A novel way of visualizing this data would make such large datasets more approachable for the general public, and thus make it possible for publishers to extract additional value out of the available news stories. A user interface that helps the user navigate through the large document corpus would improve users’ perception of the value of the news content, and ensure continued consumption of this content. There were two aspects to building the right user interface - the usability of the interface itself, and the appropriateness of the visual metaphor used to visualize the data. This thesis adopts an iterative approach to building the most usable interface to achieve this goal. Starting with an initial design based on study of the system and literature in the field, design iterations were carried out, with a usability testing phase at the end of each iteration. The resulting interface provides a simple way to navigate news article archives in terms of concepts like people, places and organizations. It also allows users to visualize trends in news coverage for a particular concept over time.

Keywords: News Archives, Temporal Data, Data Visualization, User Interfaces, Usability
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Preface

After nine months of research, I proudly present to you my Master Thesis - 'Towards a Functional Interface for Temporal Navigation of News Archives'. The research was carried out at HintTech B.V, a company based in Delft that specializes in content and marketing technology.

This document the result of exploring the worlds of web user interfaces, usability and data visualization. While I have learned many interesting things about these topics during the course of my research, the life lessons that this experience has provided have also proved invaluable. I would like to thank all the people without whose support this thesis would have been impossible to achieve.

First and foremost, I thank Prof. Jan Hidders, my daily supervisor, whose guidance helped me find focus and direction in my research. I would also like to thank Gert-Jan van Lochem, my supervisor at HintTech, for enabling my work and providing much needed mentoring. I thank Jorg de Jong for his useful inputs regarding the technical aspects of my research, and Fenneke Mink for her honest and constructive feedback. I also take this opportunity to thank Prof. Geert-Jan Houben for giving me an opportunity to work in the Web Information Systems Group. Many thanks to Prof. Andy Zaidman for being part of my thesis committee.

Most importantly, I would like to thank my parents, who have always encouraged and supported me in all of my endeavours. Their undying support and care during the whole of my master programme could not have been done without.

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Delft, the Netherlands
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Chapter 1

Introduction

News is highly volatile information. It is the most valuable at the point in time at which it is created, and this value diminishes rapidly with time. The earlier era of news production was dominated by print media such as newspapers and magazines. Nowadays, massive proliferation of high-speed internet access, coupled with new platforms for showcasing and disseminating content, have led to the adoption of the internet as the foremost channel for news broadcasting. Most newspapers have successfully made the leap into the digital age, with websites and mobile applications that offer both free and paid news content to consumers\[3\]. Though these developments have not led to the replacement of traditional media, they have had a major impact, with large groups of consumers preferring content over digital media channels. Platforms such as Blendle\[1\], eLinea\[2\] and Yournalist\[3\] have sprung up to cater to the needs of these digital natives. The dropping cost of storage media means that this content can be persisted in data stores. Over time, archives of news articles would be created, and these could be mined for interesting information and insights. Observing this data in the temporal view could lead to a better understanding of the causes and effects of events and provide a window into trends in press coverage. The popular adoption of XML databases has helped this cause, with the majority of news producers preferring this format. The NewsML standard\[34\] has been defined for news articles stored as XML.

Newz\[4\] is a system that brings together and archives news articles from different publications in the Netherlands. It is an initiative by NDP Nieuwsmedia, and brings 12 Dutch publishing houses under its umbrella. Newz provides a platform for articles from different sources. These articles are all represented in a common format and enriched with metadata. The documents are stored in a central repository, and can be accessed conditionally using an API. This large amount of content may be used as the basis for different applications and services. This system has been operational for almost two years, and now has over 1.5 million articles.

This type of large dataset can contain valuable information, but it loses its value if not presented to users in a meaningful and usable form\[5\]. Data visualization techniques aim

\[1\]http://blendle.nl/
\[2\]http://www.elinea.nl/
\[3\]http://yournalist.com/
\[4\]http://newz.nl
to provide a solution to this problem. Data Visualization an active research area, with a considerable amount of work being done in finding innovative and novel ways to represent data\cite{15}. Providing a visual representation makes large datasets more interpretable, and allows for navigation and filtering of the data. It could also be used to look at the available data in different perspectives. Of particular interest is the temporal dimension. Most systems in the real world are temporal in nature i.e. time is an important component of their operation\cite{41}. In large document repositories, a temporal view could provide insights into patterns present in the data, which might otherwise not be discernible.

The large amount of data in the Newz repository could be made useful and navigable by the application of data visualization techniques. Visualizing the news articles in the temporal perspective would provide an overall picture of the data\cite{45}. With the appropriate visualization metaphor, information about the popularity of concepts in news media could be derived. Also, trends in press coverage for concepts could be inferred.

Another aspect to making the data useful, is the user interface available for browsing the repository. In order for the large amount of data to be easily navigated, an appropriate and usable interface is very necessary. This would ensure a functional system that allows users to easily find the information they are looking for, and learn and adopt the system quickly. The right user interface will make the Newz repository’s content accessible to the widest possible audience. Applying user testing and usability techniques will ensure the development of a usable and intelligent interface for browsing the data.

This study aims to create a functional user interface for browsing through Newz’s article archives in the temporal perspective. This would be a system that provides users with the correct amount of relevant information, while being simple and intuitive to interact with. In order to achieve this objective, several techniques from literature were applied, along with empirical research methods.

In the following section, we will look at the research goal, and the resulting research questions defined for the study.

### 1.1 Research Goal and Questions

The following research goal has been formulated for the study.

“To design a usable web interface to navigate through large corpora of news articles in the temporal perspective”

This means that the user interface that is built must provide a simple, powerful and memorable mechanism that makes it easy for users to browse and filter through the document corpus. It also has to ensure adequate visibility for each individual article in the corpus, so as to provide equal opportunity for any of the articles to be accessed. To aid research for achieving this goal, it has been simplified into two main research questions.

1. **What is an appropriate web-based user interface for navigating through a large news article archive by concept?**
1.2. Research Strategies

The user interface must adhere to the principles of usability as discussed in forthcoming chapters. It must provide an easy and learnable way to search for news articles on concepts such as people, places and organizations. It must do this in the least possible number of steps, while still being powerful enough to address users’ information needs, and being fun enough to build user engagement. This interface would be built during the course of this study.

2. What are the visualization techniques that can be applied to provide a temporal perspective on topics in a large news article archive?

The technique used to visualize the article corpus must provide two kinds of information - a temporal overview that helps users identify trends over a topic in time, and an article view that lets users access individual articles. Users must be able to navigate and filter through the data using the interface. The study will explore different techniques for visualizing large datasets, and observe their effect on the overall usability.

1.2 Research Strategies

In order to find relevant and accurate answers to the research questions, different research strategies have been used. Initially, literature in the fields of User Interfaces, Data Visualization and Web Usability was considered. This helped create an understanding of current work in these fields, as also the different approaches adopted while designing web applications which perform search, retrieval and visualization over large datasets.

During the initial design phase of the 'Newz Timelines’ application, the requirements were elicited by working with the client, and the first prototypes were created by applying principles from User-Centred Design[2].

Starting with the initial design, the application was built using an Iterative Development approach[8]. Evaluation of the application from the usability perspective was done by a selected user group testing the application with the help of a questionnaire. This questionnaire had different sections, each representing an aspect of usability as determined from the literature. The results obtained from the evaluation were then analyzed, and scores were calculated for each aspect of usability.

Therefore, the main research strategies are:

- Literature study
- User-Centred Design
- Iterative Development
- Usability Evaluation using questionnaires

1.3 Report Structure

This report presents the findings from the study in 9 chapters. **Chapter 1** provides an introduction to the study, and defines the main research goal, re-
Chapter 1. INTRODUCTION

search questions and strategy.

Chapter 2 describes the architecture of the Newz article repository, and the process by which new articles are delivered into the system.

Chapter 3 presents a brief overview of the concept of usability in user interfaces for the web. It explains the importance of usability testing in the design and development of commercial end-user oriented systems.

Chapter 4 discusses research in data visualization, and techniques for visualizing temporal information. Different approaches for visualizing time are presented here.

Chapter 5 presents the design and architecture of the proposed application, and describes the various components of the application in detail.

Chapter 6 describes the different versions of the application developed during the iterative process.

Chapter 7 discusses the methodology for user testing, and the components selected for each component of usability.

Chapter 8 presents the results from each iteration, and discusses the variation of usability scores across iterations.

Chapter 9 underlines the main contributions of the study, and recommends further work based on the thesis.
Chapter 2

The Newz Platform

Newz is a system that brings together and archives news articles from different publications in the Netherlands. It is an initiative by NDP Nieuwsmedia, and was started by TMG, Persgroep, Wegener, ANP, Mediagroep Limburg, SDU, NDC, Erdee Mediagroep, ND, BDU, Friesch Dagblad and the FD Mediagroep. Newz provides a centralized system for the publishers to deliver articles on a daily basis, with 3,500 to 6,500 articles being added every day. The system was put into operation in September 2013, and now contains over 1.5 million articles from member publishers. Most important national newspapers such as De Telegraaf, de Volkskrant, Trouw, Het Financieele Dagblad and Algemeen Dagblad are represented in the archive, along with a plethora of regional publications. This large amount of content may be used as the basis for different applications and services.

2.1 Architecture

The high-level architecture for the Newz platform is as shown in Figure 2.1.
2. The Newz Platform

The main components of this system are explained in the following subsections.

2.1.1 Content Store

The publishers deliver articles into the MarkLogic XML content store on a daily basis via FTP. These articles are created in NewsML-G2, which is the accepted XML standard for storing news information. The articles contain metadata such as author, publication, date and DRM information. They are similar in format to the NewsML-G2 document shown below.

```xml
<?xml version="1.0" encoding="UTF-8" ?>
<newsItem guid="urn:newsml:acmenews.com:20131121" standard="NewsML-G2" xml:lang="en-US">
  <rightsInfo>
    <copyrightHolder uri="http://www.acmenews.com/about.html#copyright" />
  </rightsInfo>
  <itemMeta>
    <provider uri="http://www.acmenews.com/about/" /> 
    <versionCreated>2013-11-21T16:25:32-05:00</versionCreated>
  </itemMeta>
  <contentMeta>
    <contentCreated>2013-11-21T15:21:06-05:00</contentCreated>
    <language tag="en-US" />
    <slugline>Sample</slugline>
    <headline>Sample Article</headline>
  </contentMeta>
  <contentSet>
    <inlineXML contenttype="application/nitf+xml">
      <nitf xmlns="http://iptc.org/std/NITF/2006-10-18/">
        <body>
          <body.head>
            <hedline>
              <h1>Example</h1>
            </hedline>
            <byline>By John Smith, <byttl>Staff Reporter</byttl></byline>
          </body.head>
          <body.content>
            <p>Sample Article Content Paragraph I</p>
          </body.content>
        </body>
      </nitf>
    </inlineXML>
  </contentSet>
</newsItem>
```
2.1. Architecture

Listing 2.1: NewsML-G2 Document Structure

2.1.2 Document Annotation

The articles added into the repository are picked up by Concept Extraction Service, which is provided by OntoText. This service uses a proprietary ontology and named entity extraction to annotate the articles and extract concepts from them. All of this generated data is added as metadata to the respective articles, under the itemMeta tag. These recognized concepts are also added to the Newz ontology. The following is an example of the metadata that could be added to an article.

Listing 2.2: Article Metadata

2.1.3 Access Mechanism

The articles, along with the metadata, are made available for use in applications and services through an API. This interface is necessary to monetize the huge amount of information...
2. THE NEWZ PLATFORM

available as articles. It provides pay-per-article access to the repository. Applications may use this API to extract and transform content to provide to customers. The API can be used to retrieve documents in terms of concepts mentioned in them, and also browse related articles by concept. Data from the archive can be accessed either as XML or as JSON based on requirement. The API takes care of practical aspects such as licensing of the content and billing. There is also a SPARQL endpoint that provides direct access to the ontology.

2.2 The Need for Newz Timelines

The Newz platform was intended for use by application developers to provide paid access to news for end-users. Since the launch in September 2013, a demo application was created to showcase the archive. It is very important to demonstrate the different possibilities that are offered by the platform in order to improve awareness about Newz. Hence, from the perspective of the Newz organization, an application that showcases the wealth of information available in the system to end-users is vital to achieve this objective.

From the academic perspective, this exercise presents an interesting challenge as well. Since the objective is to attract users and foster engagement with the application, it is appropriate to apply principles from user-centred design and usability testing during the design and development of the application. As the starting point for the application is a broad set of requirements that are not defined in detail, an iterative approach will help drill down to the exact requirements and incrementally improve the system. Usability evaluation of the application by a user group after each iteration will provide a clear indication of the value of these improvements. Another aspect of the application is the visualization of articles. Providing a means to visualize large collections of information provides new insights into the data, which may previously have been inaccessible. Using the available temporal information of articles can enable users to visualize patterns in news production over time.

Hence, there are two parts to this study - the usability aspect and the data visualization aspect. In order to derive a suitable approach to address the problem, it is important to study literature and understand the state of the art in the field. In the next two chapters, we survey literature from the fields of Web Usability and Data Visualization so as to get a grasp of the different techniques that can be applied while designing, building and evaluating the system.
Chapter 3

Usability on the Web

As people increasingly use web services and applications, usability is now more important than ever. Usability testing will ensure that the application performs the required functions in a way that users find easy and learnable. It also helps in engaging with the users and getting a deeper insight into their interface needs and expectations. In addition, this process helps build better branding and a more complete user experience as compared to the traditional way of web application development. Even relatively inexpensive user testing techniques like questionnaires have proven effective in identifying issues with user interfaces. These techniques, when used in combination with an iterative development approach, will be powerful tools to build a significantly better interface.

Usability was the foremost concern during the design and development of the Newz Timelines application. In order to implement the principles of usability in the various phases of the design and development process, the first step was to review literature in the field in order to get better insights into current approaches in research. The different definitions of usability were studied, as were various methodologies for evaluating and improving usability. This chapter summarizes the basic concepts and terminology related to usability, and also discusses their application in different phases of this project.

3.1 Definitions

The definition of Usability has been formalized in ISO 9241-11[22] as follows.

“The effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments.”

From this definition, it can be immediately observed that there are three components to usability. Let us look at each component on its own. Frøkjær et al.[18] define these components as below.

• **Effectiveness** is the accuracy and completeness with which users can achieve set goals.
3. Usability on the Web

- **Efficiency** is the relation between the accuracy and completeness with which users can achieve set goals, and the resources expended in achieving them.

- **Satisfaction** indicates the users’ comfort with using the system, and positive attitudes towards the system being evaluated.

Nielsen defines Usability as follows\[32\].

“A quality attribute that assesses how easy user interfaces are to use”

He divides Usability into five facets.

- **Learnability**: How easy is it for users to accomplish basic tasks the first time they encounter the design?

- **Efficiency**: Once users have learned the design, how quickly can they perform tasks?

- **Memorability**: When users return to the design after a period of not using it, how easily can they reestablish proficiency?

- **Errors**: How many errors do users make, how severe are these errors, and how easily can they recover from the errors?

- **Satisfaction**: How pleasant is it to use the design?

3.2 Web Usability

Web Usability refers to the application of usability principles to enhance the ease of use of a web application or website. The overall goals of Web Usability encompass the clear and unambiguous presentation of information and choices to users. Nielsen’s definition of Usability as extended to the web has been interpreted as follows\[30\].

- **Web application learnability** must be interpreted as the ease for Web users to understand from Home Page the contents and services made available through the application, and how to look for specific information using the available links for hypertext browsing. Learnability also means that each page in the hypertext front-end should be composed in a way so as contents are easy to understand and navigational mechanisms are easy to identify.

- **Web application efficiency** means that users that want to find some contents can reach them quickly through the available links. Also, when users get to a page, they must be able to orient themselves and understand the meaning of the page with respect to their navigation starting point.

- **Memorability** implies that users are able to get easily oriented with the application, without a steep learning curve.
### 3.3 Usability in the Software Development Lifecycle

Usability techniques can be used at different points in the Software Development Lifecycle in order to make the developed application more usable.

#### 3.3.1 Design Phase

In the initial design phase for the application, the principles of user-centred design can be applied in the form of Personas, User Stories and Design Patterns.

**Personas**

A persona is a social role for a person in a specific context, which can be used to model target users in User-Centred Design. A persona may comprise of the following bits of information.

- Fictional name
- Job titles and major responsibilities
- Demographics such as age, education, ethnicity, and family status
- The goals and tasks they are trying to complete using the application
- Their physical, social, and technological environment
- Casual pictures representing that user group

**Scenarios**

Scenarios describe the stories and context behind why a specific user or user group uses an application. They note the goals and questions to be achieved and sometimes define the possibilities of how the users can achieve them on the site.

Scenarios are critical both for designing an interface and for usability testing. Good scenarios are concise but answer the following key questions:

- Who is the user? Use the personas that have been developed to reflect the real, major user groups coming to your site.
- Why does the user come to the site? Note what motivates the user to come to the site and their expectations upon arrival, if any.
• What goals does he/she have? Through task analysis, you can better understand the what the user wants on your site and therefore what the site must have for them to leave satisfied.

Design Patterns
Patterns communicate insights into design problems, capturing the essence of the problems and their solutions in a compact format. They describe in depth the problem, the rationale for the solution, the method of applying the solution, and the trade-offs involved. Van Duyne et al.[14] provide a comprehensive list of design patterns that can be used for User-Centred Design. Heuristics, which are discussed further in this chapter, can also be considered a kind of design pattern.

3.3.2 Implementation Phase
Techniques such as iterative development and user testing can be used in the implementation phase to build a user interface that is precisely tailored to the target user group.

Iterative Development
Iterative Development is an established method in usability engineering. While building user interfaces which are targeted towards a large audience, it is difficult to get the perfect interface at the first attempt. Iterative development involves refinement of the user experience over multiple runs of design and development[28]. At the end of each iteration, a suitable testing technique may be used to evaluate the built interface.

User Testing
User Testing refers to a set of techniques for evaluating the usability of an application[29]. These techniques include the following.

• Questionnaires
• Usability Inspection
• Eye-tracking studies
• Mouse Movement Tracking
These techniques are discussed in the next section.

3.3.3 Heuristics
Heuristics can be used at multiple phases of the development lifecycle. In the design phase, they may be used as guidelines to be adhered to, to produce a usable interface. In case of iterative development, they may be used in the testing phase that follows each iteration, to evaluate usability. In his paper, Nielsen proposes the following heuristics for evaluating usability[33].
### 3.3. Usability in the Software Development Lifecycle

<table>
<thead>
<tr>
<th>Heuristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility of system status</td>
<td>The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.</td>
</tr>
<tr>
<td>Match between system and the real world</td>
<td>The system should speak the user’s language, with concepts familiar to the user, rather than system-oriented terms, and making information appear in a natural and logical order.</td>
</tr>
<tr>
<td>User control and freedom</td>
<td>Users often choose system functions by mistake and will need a clearly marked “emergency exit” to leave the unwanted state without having to go through an extended dialogue.</td>
</tr>
<tr>
<td>Consistency and standards</td>
<td>Users should not have to wonder whether different words, situations, or actions mean the same thing.</td>
</tr>
<tr>
<td>Error prevention</td>
<td>A careful design which prevents a problem from occurring in the first place is always better. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit.</td>
</tr>
<tr>
<td>Recognition rather than recall</td>
<td>Minimize the user’s memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another.</td>
</tr>
<tr>
<td>Flexibility and efficiency of use</td>
<td>Accelerators may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users.</td>
</tr>
<tr>
<td>Aesthetic and minimalist design</td>
<td>Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.</td>
</tr>
<tr>
<td>Help users recognize, diagnose, and recover from errors</td>
<td>Error messages should be expressed in plain language, precisely indicate the problem, and constructively suggest a solution.</td>
</tr>
<tr>
<td>Help and documentation</td>
<td>Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user’s task, list concrete steps to be carried out, and not be too large.</td>
</tr>
</tbody>
</table>

Table 3.1: Nielsen’s Usability Heuristics
3. Usability on the Web

3.4 Evaluation of Usability

The various methods available for testing usability are discussed in the following section.

3.4.1 Usability Inspection

In this method, an expert evaluator inspects the developed interface rather than the target user(s). This method is considered to be relatively inexpensive compared to user testing[29]. There are several inspection techniques including Cognitive Walkthroughs[9] and Heuristic Evaluation.

3.4.2 Questionnaires

Questionnaires have long been an accepted way of analyzing consumers’ reactions to products and services. This is also true for the domain of usability. Questionnaires help evaluate the usability of applications by getting the tester(s) to answer a set of questions. These questions aim to record the users’ reactions to using the application, and how they felt about certain features of the interface.

3.4.3 Eye Tracking

This relatively recent approach aims to improve the design of user interfaces by tracking the movements of users’ eyes as they use the application[13]. The data thus obtained can be visualized as heat maps or gaze plots. These will give the designers a picture of the most prominent areas on the screen which the users are looking at. These insights can then be used to modify the design accordingly. However, eye tracking studies require specialized video equipment, and are expensive to conduct.

3.4.4 Mouse Tracking

This is yet another recent approach to usability testing, and involves recording of the mouse activity of users while using the application under testing. This can be achieved by instrumenting the code of the application with capabilities for tracking mouse events, as done in [6].

3.5 Usability in Newz Timelines

Many of the above described usability principles and techniques were applied while building the Newz Timelines application. We chose a definition of usability that was a combination of the different studied definitions. It included the following components.

- Effectiveness
- Ease of Use
- Efficiency
3.5. Usability in Newz Timelines

- Satisfaction

The overall design and development of the application was carried out on the basis of this definition of usability. During the design phase of the application, user stories and personas were used to create an initial understanding of the different functions that users can perform with the application. Evaluation of the design was performed using Nielsen’s usability heuristics.

The development of the application was carried out over three iterations. Prior to this phase, a proof of concept (POC) was developed in order to check the functioning of the components in combination with each other.

Then, the first iteration of the application was made available to the user testing group. The evaluation of the application was daisy-chained with the development process. The user group tested the application with the help of several scenarios designed to use the different features of the application. They then answered a post-task questionnaire which evaluated the application on the basis of the various components of usability as defined above. This questionnaire generated quantitative as well as qualitative data about the usability of the application. This data was then used to make evolutionary improvements to the application, which were released for testing in subsequent iterations.

The data collected over the three iterations was analyzed to draw conclusions about the development process of the application, and its usability as a consequence of this process. Techniques such as eye tracking and mouse activity tracking were not applied due to the paucity of time and as they required other resources such as specialized equipment.
Chapter 4

Visualization Techniques for Large Datasets

The Newz system already contains over a million articles, and the numbers are growing by the thousands every day. In order to ensure that all of this content is made accessible to the end users, the visualization technique applied to the data is an important factor. It greatly affects the usability of the application as well. In order to choose the different visualization techniques to be used in different iterations of the application, a study of literature in this field was carried out. The following sections explain these techniques and discusses their pros and cons with respect to our solution, Newz Timelines.

4.1 Visualizing Large Datasets

4.1.1 Scatterplots

Scatterplots are a means of visualizing correlation between variables. A scatterplot is a graph that contains two variables placed in a 2-D rectangular co-ordinate system with axes as guides and represented by a point element. The axes can be used to plot one variable against another, and visualize the relationship between them. An example scatterplot showing variation in the mean sea level over a period of years is as shown in Figure 4.1. As is apparent from the figure, this visualization technique makes it easy to see patterns in the data over time. Scatterplots are highly suitable for data exploration tasks, as established by Shrinivasan et al. They are also effective for representing large data sets of over a million items. Multiple data series could also be overlaid together to provide more perspective on dependencies between distinct sets of data.

In our application, a scatterplot could be used to visualize articles with a time axis. This would result in dense clusters during periods of time during which the concept has been discussed more often in the media. A fair understanding of the trends regarding the searched concept over time would be provided by this visualization. It would aid exploration of the news archive by representing each article independently in the plot, allowing the user to pick an article of his choice. However, overlapping of points that are plotted at the same co-ordinates is a known issue for scatterplots. This problem could be worked around...
4. VISUALIZATION TECHNIQUES FOR LARGE DATASETS

Figure 4.1: Scatterplot - Sea Level Change over the Years

using a zoom mechanism with which the plot displays clearer, non-overlapping points when magnified. Another issue is the scale being used for the time axis. In case of multiple data series, the scale is to be chosen carefully to be compatible with all the sets of data being visualized, in order to avoid clutter and make efficient use of the available space.

4.1.2 Line Graphs

Line Graphs are the most common means of visualizing low-dimensional time series data[20, 19]. A line graph consists of a 2-D rectangular coordinate system with two variables as with a scatterplot, but differs in that the data points plotted are joined with a line. Figure 4.2 shows a line graph of the varying price of a stock over time. This visualization technique can be used to identify trends in time series data as well, but cannot incorporate larger amounts of information due to its dimensional limitations. However, it can be combined with another visualization technique to provide multiple views of the data. However, approaches that combine visualization techniques have been known to suffer from design flaws which could reduce their usability. Wang et al.[43] have formulated a set of guidelines to follow while building such a system.

A line graph could be useful in our application to provide an overarching, bird’s eye view of trends in the articles over large time periods. However, this graph alone, being too simplistic, would not satisfy the information needs of users. It is difficult to represent the articles themselves in such a plot. It would have to be used in combination with another visualization mechanism that presents the actual news articles to the users.
4.1. Visualizing Large Datasets

Figure 4.2: Line Graph - Stock Price over Time

4.1.3 Bubble Charts

A Bubble Chart is a variation of a scatterplot, which can be used to visualize data with higher dimensions. This type of chart contains the two axes that are available in a scatterplot, but uses bubbles to represent data points. This adds in the extra dimension of the size of the bubble, which can also be used to represent a quantity. The colour of the bubble could also be utilized to add more dimension to the data. There has been interest in bubble charts as a visualization technique in recent years. \[40\] includes work on detection of trends using bubble charts. Prof. Hans Rosling’s work\[37\] is now world-famous after being showcased in TED talks\[35\]. Gapminder\[36\] is an online tool which uses animated bubble charts to visualize data over time. Figure 4.3 shows an example from Gapminder\[1\] which plots per-capita income against life expectancy for different countries in the year 1985. It provides a wealth of information to the user, without being too overwhelming. The use of colour also aids in visual search, thus improving usability over traditional methods of visualization.

Bubble charts could be an effective method to visualize the news articles in the Newz repository. Clustering the articles by a common attribute such as publication, could let users access this information in a more organized way. Projecting these clusters on a timeline will help users get a clear picture of trends in press coverage for the chosen concept.

4.1.4 Circle Packing

Circle Packing is a visualization mechanism that is used to represent hierarchical information, which has a nested structure\[42\]. It involves the arrangement of equal or unequal sized circles on a surface, which could itself be a larger circle. These circles should not overlap.

\[1\]http://www.gapminder.org/
4. VISUALIZATION TECHNIQUES FOR LARGE DATASETS

Figure 4.3: Bubble Chart - Income against Life Expectancy in 1985

but must touch each other, as shown in Figure A.2. This technique provides an effective way to visualize very large numbers of data points in an uncluttered fashion, provided that the data follows a tree structure. This method is not directly suitable for visualizing data in a temporal perspective, but can be adapted to fulfill this requirement. It could be combined with another visualization technique, as discussed earlier, to achieve this objective.

This visualization technique could potentially be very important in our study. The article data fetched from the repository could easily be modeled in a hierarchical manner, with articles being binned by the publication they were published in, and these sets of articles divided by months in each year. Colour-coding the circles by publication could provide visual search capabilities for users, while also letting them filter and navigate. This could be combined with a line graph, which provides an overall picture of trends. This type of ‘overview+detail’ approach is the most popular for visualizing large data sets according to [21].

4.2 Visualizing Time

While visualizing temporally-oriented data, the type of visualization used to represent time can have a profound influence on interpretability for users. Apart from choosing the appropriate visual metaphor for the data, the time scale has to be chosen wisely in order to ensure that users of the visualization are able to understand and derive insights from the data. There are two popular approaches used to represent temporal scales, as inferred from [17].
4.2. Visualizing Time

4.2.1 Timelines

A timeline is a graphical or textual display of events in chronological order and is the most used technique for interacting with time-linear visual information[24, 4]. This technique generally represents time as a horizontal line, with points marked at predetermined intervals. This is relatively simple for users to interpret, as it follows naturally from the notion of time as having a unidirectional flow. The timeline can be used to represent instants of time using a discrete set of points as seen in Figure 4.5(a), or can be used to show intervals of time, as seen in the Gantt chart in Figure 4.5(b). Many visualization techniques can be used with a timeline to add the temporal perspective. The timeline works well with these visualizations and provides a blank canvas on which they can achieve their purpose.

4.2.2 Spirals

Spirals provide an alternative to linear time scales, and can also be used to derive insights into patterns in the data. Work on spiral visualizations has been done by Carlis et al[11] and Weber et al[44]. There are different kinds of spirals such as Logarithmic, Hyperbolic and Archimedean spirals, each with their different polar co-ordinate notation. These are as seen in Figure 4.6. Spirals can be used to represent large amounts of nominal, ordinal and quantitative data. However, they may be more difficult for users to interpret than linear timelines. Also, it might not be possible to combine spirals with different visualization techniques due to restrictions on space.
4. **VISUALIZATION TECHNIQUES FOR LARGE DATASETS**

(a) Point Timeline

(b) Gantt Chart

Figure 4.5: Types of Timelines

(a) Logarithmic Spiral

(b) Hyperbolic Spiral

(c) Archimedean Spiral

Figure 4.6: Types of Spirals
Chapter 5

System Design

In order to ensure a highly usable interface, it was imperative that usability principles be incorporated across all the phases of the application’s design and development. Applying techniques such as heuristic evaluation and inspection methods in the design phase will help build a good platform upon which iterative improvements can be carried out. In the following sections, we discuss the various design decisions taken during the project.

5.1 Requirements Elicitation

The initial phase of the project included sessions with representatives from the Newz organization. During these sessions, the various possibilities for types of applications were debated on. The broad objective of building an application to explore the temporal dimension of data from Newz’s article archive was previously decided upon. The following set of preliminary requirements was drawn up.

- The system must be a web application that enables browsing of the Newz archive
- The system must provide a means to search the archive on concepts like people, places and organizations
- The system must enable viewing of individual articles
- The system must provide a visual representation of the articles in a plot
- The system must allow users to visualize trends in the news articles over time
- The system would be designed with the general public as the target audience

5.2 Interface Design

Based on the formalized requirements, the first prototypes for the system were created. We have the following concepts defined by the application of user-centred design guidelines.
1. **Persona:** As the target audience for the application is the general public, it is difficult to describe their specific characteristics. For our application, the typical user may be assumed to be a person in the 30-45 age group, as this comprises the largest population group in the Netherlands. We will call this persona 'Bob'. We also assume that Bob’s internet usage skills are at average levels.

2. **Scenario/User Story:** The next step involves charting out a possible scenario that Bob could experience while using the application. The user story created for Bob is as shown in figures 5.1, 5.2, 5.3, and 5.4. The designs for the screens were created using Adobe® Photoshop.

- As a user, I would like to visualize articles about important people over time, so that I can gain knowledge about happenings in their lives. I would also like to visualize information about trends in press coverage for people over time.
- I’d like a simple, Google-style search interface to look for items and then understand the results properly.

![Figure 5.1: User Story - Part I](image-url)
5.2. Interface Design

- If I am searching for information about a person, a timeline with important events in their life must be shown.
- The timeline will be in reverse chronological order with the most recent events on top.
- The timeline must have data such as birth date (established data), education completion etc. from the enriched database plotted on it.
- Articles from the database are plotted on the timeline.

Barack Obama

Figure 5.2: User Story - Part II
5. System Design

- On hovering on an article, a box containing important terms and sentiment of the article, along with publisher information has to appear.

Barack Obama

![Barack Obama Diagram]

Figure 5.3: User Story - Part III
5.2. Interface Design

The emphasis during the design was to create a clean, minimalistic interface which lets the user search for concepts, visualize the articles over them, and then be able to read these articles. This is an interface that brings the articles into focus, allowing users to infer patterns in reportage. Over multiple meetings with the client, the design was tailored and the final specification agreed upon. The following requirements were added to the original list of requirements.

- The system must display a short description of the topic being searched for
- The system must enable navigation of the archive through links for related concepts

Figure 5.4: User Story - Part IV

Obama, Biden to stick to vacation schedules despite Ukraine crisis

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.
5. System Design

5.3 Architectural Design

The proposed application is a mashup that combines and visualizes data from different sources. In order to aid the implementation of this system, the basic architecture of the system was formalized. The architectural diagram of the system is as depicted in Figure 5.5. The base layer of the architecture comprises the Newz article store. This data store is accessed through a query interface, with certain custom query optimizations. A data binding layer handles the fetching and processing of large amounts of data from the article store. The visualization module then takes this data as the input, and produces the temporal plot. The topmost layer is the presentation layer. The components of the presentation layer include the pages in the application, as well as styles, animations and event handling. Initially, NEWZ’s own ontology was chosen to be the data source that links concepts and provides a means for navigation between them. However, initial attempts were marred by performance issues with the large triple store, which rendered it unusable. However, further study revealed a very high overlap of concepts between this ontology and DBPedia\(^1\). Hence, the DBPedia datasets were chosen as an alternative. An auxiliary data source was definitely required to provide linking and navigation. The DBPedia datasets also contained descriptions of searched concepts, and other information such as images, which could be used to provide additional information to put the articles in perspective for the users.

5.3.1 Technology Stack

The following technologies have been used for implementing the proposed application.

- MarkLogic NoSQL database
- MarkLogic REST API
- AngularJS
- Different Visualization Libraries
- HTML5/LESS-CSS/jQuery
- DBPedia Datasets and Services

The application will communicate with the different data sources through AJAX requests. JSON was chosen as the format for data interchange, as it provides a simple and flexible data model which works well with most JavaScript/jQuery-based frameworks.

\(^1\)http://dbpedia.org/
5.3. Architectural Design

Figure 5.5: System Architecture
Chapter 6

Implementation

During this phase of development, the design created in the preceding phase was implemented as a single-page web application. The initial version of the application was created as a Proof of Concept to test the architectural design. Subsequently, three incremental versions of the application were rolled out in iterations within intervals of one month each. The following sections provide details on each of these versions and the improvements they offered.

6.1 Proof of Concept

In this initial step of the process, the design prototypes were turned into an HTML5 web application in accordance with the technical design. As the Newz system uses a MarkLogic NoSQL database as the repository, this was chosen for the new application as well. The MarkLogic REST API has been used for querying the data store, albeit with customizations for optimizing the query performance. These customizations include query filters, range indexes and metadata extraction specifications. AngularJS was chosen for the data binding layer, as it provides robust and flexible ways to make HTTP requests, and transform the incoming data.

The Google Charts API was used to create customized scatter plots visualizing the articles. As an approach to augment this data with additional facts about the concept, temporal facts were extracted from Wikipedia infoboxes and stored along with the articles. These were then presented on the scatter plot along with the articles. The idea behind this was to enable the users to visualize patterns in articles in context with events related to the concept. A local mirror of DBPedia was set up on the development server, with the Lookup Service running on it. The data from this service was used for suggesting search concepts.

The presentation layer uses HTML5 markup for the application pages, LESS/CSS for styles, and jQuery for animations and event handling.

A screenshot of the resulting interface is as shown in Figure[6.1]. It represents time in the form of a two-dimensional plot, in which articles are plotted as green circles, and temporal facts are plotted as blue squares.
This implementation validated the architecture designed for the system, and provided the initial platform upon which iterative improvements could be made. However, it also uncovered a few issues with this design, which made it difficult to achieve the intended objectives of the application.

- The time scale for the articles was very different from that of the temporal facts. While articles were only available during the past few years, the temporal facts were spread over larger timespans. This caused the presence of large empty areas on the plot.

- Multiple articles appearing during the same time period were difficult to separate using this interface.

- Patterns in news coverage appeared as thick horizontal lines of articles, which were not intuitive enough for easy understanding by users.

- Using a two-dimensional time plot also made the flow of time hard to comprehend.

- The client was of the opinion that making the application in the Dutch language would help user engagement.

These issues were addressed in the first release of the Newz Timelines application.
6.2 Iteration I

In Newz Timelines v1.0, data from DBPedia was used to make automatic suggestions while searching for concepts in the search interface. Prior to searching, the users had to select the type of concept they were going to search for - person, place or organization. This preference was used to narrow down the list of suggestions for the user, based on relevance. This is as depicted in Figure 6.2.

The automatic suggestions were implemented using the DBPedia lookup service. A local mirror of DBPedia 3.8 in Dutch was created, with the lookup service running on top of it. Information from the datasets, such as thumbnails and abstracts, was indexed for faster access. Once the user entered a search term and proceeded further, they would be directed to a page containing a picture and a short description of the searched topic, along with links to related concepts, and two timelines. The Dutch description and thumbnail for the concept are fetched from DBPedia data. The first timeline was a bubble plot containing articles by month, with time on the X-axis and relevance to the search on the Y-axis. The size of the bubbles in the plot varies directly with the number of articles in the particular month. The second timeline was a scatter plot of temporal facts about the concept. The timelines were separated in order to address the issue of disparate time scales between the two kinds of
In the article plot, clicking on a bubble would pop up a translucent window, containing links to the articles present in that month. Clicking on a link would show the full text of the article, along with some metadata. Clicking anywhere outside the window would take the user back to the result page with the plots.
6.3  Iteration II

In Newz Timelines v2.0, the search system was streamlined and eliminated the concept selection step, albeit at the cost of reduced relevance in search suggestions. Also, more information was added in the article plot, which was made easier to interpret as well. We hypothesized that adding more interactivity to the plot could lead to increased usefulness and satisfaction with the application, as there is more possibility to explore the articles in the temporal view. During the user testing round for the previous iteration, many of the users felt that the additional facts timeline was not adding value to the application. Hence, this was removed, leaving the article timeline alone as the focus of the application. The style of the interface was subtly modified to ensure that the focus on the timeline is maximized.

A screenshot of the main page of the application is as shown in Figure 6.4.

In the article plot, the articles were grouped into colour-coded bubbles per month, based on the publisher. The main national newspapers such as De Telegraaf, Trouw and de Volkskrant were represented, as were regional publications grouped together under one label. Also, it was made possible to zoom into and out of the graph, and filter the graph by publisher. The issue of overlapping bubbles was addressed by making them slightly translucent. Hovering on a bubble pops up a tooltip, which indicates the publisher, month and the num-
6. IMPLEMENTATION

The number of articles in that month, as shown in Figure 6.5.

Clicking on a bubble brings up a modal window with links to the articles as shown in Figure 6.6. These can be clicked to access the full text and metadata of the article.
6.4 Iteration III

It was clear from the responses of the users in the previous iterations, that a novel and intuitive visualization technique for the articles would raise the levels of perceived usefulness and make users want to use the application more often. Hence, in this iteration, we adopted a two-step visualization approach. After the user searches for a concept, the result page displayed contains a line graph, which shows the trends in press coverage for this concept over the past year. This graph has time on the X-axis and the number of articles on the Y-axis. Each month on the graph is a clickable node. On hovering on a particular month node, the number of articles in that month are shown. This is as depicted in Figure 6.7.
Clicking on the node will start an animation that draws the article plot. The article plot is visualized as a set of bubbles using the circle packing algorithm, implemented in D3.js. Each bubble represents a single article, and is color coded by publisher. Hovering on the article displays the title of the article as a tooltip, as shown in Figure 6.8. The plot area can be zoomed using the mouse’s scroll wheel up and down, and panned by clicking and dragging in the desired direction.

![Article Plot - Iteration III](image)

Figure 6.8: Article Plot - Iteration III

Clicking on the bubble will show the full text in a modal window as in Figure 6.9. This ensures equal visibility for each article, as opposed to previous iterations where we had lists of articles which had to be scrolled through.
Figure 6.9: Article Text View - Iteration III
Chapter 7

User Testing Methodology

During the course of this study, iterations of application development were followed by rounds of user testing. Evaluation of the system after each phase of development provided insights into users’ perceptions of the application, and provided grounds for work in further iterations. The user group selected for the study included ten people in the age group of 30 to 45, with varying levels of self-evaluated web expertise. This ensured that the bias that may be caused due to highly experienced or inexperienced users would be kept to a minimum. According to Nielsen [31], increasing the number of users in usability tests will lead to large overlaps in observed user behaviours. Instead, he advocates increasing the number of such tests, each with fewer users. Successive tests will help corroborate findings from the initial test, and provide deeper insights.

The selected user group was presented with a set of five scenarios to complete using the application. These included information finding tasks which involved multiple steps and navigation inside the application. Apart from these scenarios, the users were also free to explore the application as they liked. After completion of the scenarios, the users answered a post-task questionnaire. The answers from all the users were collected and analyzed to understand how well the system performed with regard to usability. The following sections explain in detail the ideas behind the questionnaire and the analysis of the obtained quantitative and qualitative data.

7.1 Questionnaire

The questionnaire was designed based on research in the field of usability testing. The different methodologies studied were SUS(System Usability Scale) [10], IBM’s CSUQ(Computer System Usability Questionnaire) [25], The Purdue Usability Questionnaire [26] and the USE questionnaire [27]. To keep in line with our adapted definition of usability, it was decided that the questionnaire would have four sections, each focusing on one aspect of usability as follows from the definition. Apart from these, the questionnaire would also have a section to collect information about the users, and one for subjective responses, including suggestions and general comments about the application. After the first iteration, questions that evaluated the improvements in the application were also added to the questionnaire. The
following subsections describe the different questions in each section of the questionnaire. Most of the questions use a Likert scale to ascertain the extent to which the user agrees or disagrees with a statement about the application. These are internally coded such that higher levels of agreement are assigned higher values. These numeric values are used to calculate scores for different aspects of usability. A few questions have Yes/No answers, whereas others require users to describe in words their opinions on certain aspects of the application.

7.1.1 User Information

This section contained questions that elicited information about the users, such as age, gender and web usage experience. This information helped provide a more complete picture and also helped to make possible correlations between types of users and their preferences. Also determined was the system the user was using the application on. This included details regarding the users’ operating system, browser and screen resolution.

7.1.2 Usability Testing

This part of the questionnaire contained the scenarios that the users were required to complete using the application. The scenarios were tasks whose goal was to find a certain piece of information regarding a person, place or organization. These included both simple tasks and progressively more complex tasks which required multiple steps to be completed. On completion of these tasks, the users were required to answer evaluative questions in further sections of the questionnaire.

Effectiveness

The questions in this section aim to evaluate how well the application performs the required functions, and the users’ perceptions of the degree of usefulness of the application. This section included the following statements, to which the users had to indicate their level of agreement or disagreement.

- The application provides useful information
- The application lets me easily gain knowledge on topics I’m interested in
- I can use the application successfully every time for similar tasks
- The application provides an intuitive navigation mechanism
- The visualization technique is appropriate, and provides a good overview

Ease of Use

This section evaluates how easily the users can find the information they are looking for. It included the following statements.
7.2. Evaluation

- The application does not require me to remember information across screens
- Help/documentation is always accessible
- The system is consistent in regard to usage of terminology and symbols
- The system provides adequate feedback about it’s current state
- I could learn the usage of the system quickly, and remember what I learnt

Efficiency

The system must enable users to perform the required tasks in an efficient manner. This means that the consumption of time and other CPU resources by the application must be minimized. In this section, we evaluate users’ perceptions regarding these aspects. The following statements are part of this section.

- The application requires minimal steps in sequential menu selection
- The application provides means to recover from mistakes
- The application requires the fewest steps to accomplish what I want to do with it
- The application meets my information needs

Satisfaction

This section evaluates the degree of comfort the users have while using the application, and the extent of their positive attitudes towards the application. It also aims to evaluate the effect of serendipitous discoveries on the perceptions of usability. The following statements were used for evaluation.

- I am satisfied with the features the application provides
- The application is fun to use
- I would like to use this application more often
- The application is visually pleasing
- I discovered something new and unexpected using the application today

7.2 Evaluation

While answering the questionnaire, users could choose the extent to which they either disagree or agree with the answer. The ends of the scale were fixed at "Strongly Disagree" and "Strongly Agree", and the levels in-between were "Disagree", "Neither Agree nor Disagree" and "Agree". In order to analyze the collected data, the responses were internally assigned numeric codes. The value for "Strongly Disagree" was set as 1, while that for
"Strongly Agree" was fixed at 5. The levels in-between are assigned values between 1 and 5, exclusive. Scores for each aspect of usability were calculated using a weighted average based on the number of people who selected a particular level of agreement. These scores provided a means of comparison between different iterations of the application, and helped verify the different hypotheses made before each iteration.

7.3 Qualitative Data

Apart from quantitative data like the users’ responses to the testing sections and the scores assigned to various aspects of usability of the application, users also provided qualitative data in the form of general comments about the application, things they liked and didn’t, and suggestions for improving the application. This data was not subject to any processing, but was studied to provide insight into the users’ needs and perceptions. This feedback was used to decide on the features to be implemented in successive iterations, and to substantiate design decisions.
Chapter 8

Results and Analysis

The testing methodology discussed in the previous chapter was applied upon the release of each development iteration of the application, and the results were collected. These results were then coded and analyzed to provide the basis for the next iteration of development. There were certain hypotheses made before each iteration, which would either be validated or invalidated based on the users’ responses. The following sections discuss these hypotheses, and the results obtained after each iteration.

8.1 Iteration I

In the initial iteration, we used a two-step search process, where the user first selects the type of concept they would like to search for - person, place or organization. Once this has been selected, the user then types in their search terms into the search bar. The application then suggests relevant concepts in the selected category, which contain the typed terms. Also, the articles were visualized using a simple bubble chart with a time axis. We made the following hypotheses on users’ possible responses to the features built into the application.

**Hypothesis 1:** Displaying short descriptions and pictures of the searched concept will help put the articles in context, and enhance the perceived effectiveness of the application.

**Hypothesis 2:** A clean and minimalist design will enable users to easily learn the usage of the application.

**Hypothesis 3:** Enabling Selection of the type of concept beforehand will improve relevance of concept suggestions, thereby increasing the level of efficiency.

**Hypothesis 4:** Visualizing other facts about the concept on a second timeline will make the application more informative, resulting in improved satisfaction.

**Hypothesis 5:** Providing relevant suggestions in the search bar will increase chances of serendipitous discoveries, which will help improve user satisfaction.

In the following subsections, we will see how the application performed in the actual tests, with charts indicating the numbers of people who gave a particular response to each question. The responses have been coded using numerical codes, with 1 representing "Strongly Disagree" and 5 representing "Strongly Agree".
8. RESULTS AND ANALYSIS

(a) Statement 1: The application provides useful information

(b) Statement 2: The application lets me easily gain knowledge on topics I’m interested in

(c) Statement 3: I can use the application successfully every time for similar tasks

(d) Statement 4: The application provides an intuitive navigation mechanism

(e) Statement 5: The visualization technique is appropriate, and provides a good overview

Figure 8.1: Effectiveness - Iteration I

8.1.1 Effectiveness

The users’ responses to questions about the effectiveness of the application are as shown in the bar graphs in Figure 8.1. Weighted averages of responses per statement were calculated, and then averaged to give a single numeric value, which is the overall effectiveness score for this iteration. Most users were in general agreement with Statement 1, which has an average score of 3.2 out of 5. Comments by the users appreciate the additional information presented about the searched concept, hence validating our first hypothesis. However, opinions were divided on Statement 2, as clear from the graph as well as users’ comments. Some users felt that the two-step search process helped them narrow in on their search subjects better, whereas others felt that the concept selection was an extra step that could be avoided. The average score for Statement 2 was 2.8 out of 5. Statement 3 elicited users’ opinion on the reliability of the application. This score was dragged down to 2.5 out of 5 due to initial technical problems, which resulted in errors for the users. Statement 4 scored 2.7 out of 5, with a number of users expressing the need for better navigation between articles.
8.1. Iteration I

(a) Statement 1: The application does not require me to remember information across screens
(b) Statement 2: Help/Documentation is always accessible
(c) Statement 3: The system is consistent with regard to use of terminology and symbols
(d) Statement 4: The application provides adequate feedback on its current state
(e) Statement 5: I could learn the usage of the system quickly, and remember what I learnt

Figure 8.2: Ease of Use - Iteration I

Many users commented regarding the inadequacy of the visualization technique in providing adequate information to easily spot trends in coverage. They also felt that the zooming mechanism for the plot was counter-intuitive and did not work well. It can be surmised that these were the reason behind the low score of 2.6 out of 5 on Statement 5. These numbers work out to an overall effectiveness score of 2.8 out of 5 for the first iteration.

8.1.2 Ease of Use

The users also responded to statements regarding how easy the application is to use. These responses are as depicted in the bar graphs of Figure 8.2. Starting from the initial design phase leading into phases of development, usability heuristics were adhered to, in order to ensure the easiest possible interface for the average person. The resulting application was found by most users in the group to be reasonably easy to learn and use. The average score for Statement 1 was 3.2 out of 5. We inferred that this was due to the interface for reading articles. The articles per month would be displayed as continuous lists, and as a result
8. Results and Analysis

(a) Statement 1: The application requires minimal steps in sequential menu selection  
(b) Statement 2: The application provides means to recover from mistakes

(c) Statement 3: The application requires the fewest steps to accomplish what I want to do  
(d) Statement 4: The application meets my information needs

Figure 8.3: Efficiency - Iteration I

were not very intuitive to navigate for some users. However, there was almost unanimous agreement on Statement 2, which scored 4 out of 5. Some users felt that the help page should not be displayed as a modal window, but in a page that can be left open while the user is free to still browse articles, which may have affected scores. Consistency in usage of fonts and layouts has been inferred as the reason for reasonable ratings for consistency as reflected in the results from Statement 3, but issues with the content such as duplicate articles and missing headlines led to the lowering of this score to 3.4 out of 5. Errors and warning messages, even though implemented, were deemed insufficient by the users. Their responses worked out to a score of 2.7 on 5 for Statement 4. The responses for Statement 5, with an average rating of 3.1 out of 5, show a strong correlation with those for Statement 3. This proves the value of clean and consistent design, thus validating the second hypothesis. This adds up to a cumulative Ease of Use score of 3.3 out of 5.

8.1.3 Efficiency

Users’ perceptions of the efficiency of the application were tested with a section of the questionnaire. The results are summarized in Figure 8.3. As explained earlier, some of the users were happy with the two-step search mechanism as it gave them more relevant results, but others felt that this could be accomplished in a single step. This split in opinion led to a score of 3.4 out of 5 for Statement 1. However, users’ comments and feedback suggested that making this a one-step process would bring benefits with respect to usability, thus invalidating Hypothesis 3. Being a single page application, Newz Timelines disabled the use of the browser’s back button, as all the data was fetched using AJAX requests and
did not alter the URL of the page. Also, a page refresh would take the user back to the main page, thus causing a break in the user’s experience. This meant a lower score of 2.5 out of 5 on Statement 2. Statement 3 scored an average of 3 out of 5, which indicates the users’ dissatisfaction with aspects of the article viewing mechanism. Multiple users also expressed that the second timeline containing facts about the concept was out of place, and that it did not add value to the application per se. They were of the opinion that historical facts were not highly relevant while browsing through news articles, which were on a much more recent and smaller time scale. This led to a lower score of 2.8 out of 5 for Statement 4, and invalidated Hypothesis 4. The application had a cumulative score of 2.9 out of 5 for efficiency.

8.1.4 Satisfaction

The final section of the questionnaire tested the users’ levels of satisfaction after using the application. The results are summarized in Figure 8.4. As seen from graph 8.4(a), many of the users felt that their experience of the application was marred by the issues discussed in the previous sections. As a result, most users did not agree with Statement 1, rating it only 2.4 out of 5. However, most users agreed that the application was fun to use, and that the design was visually pleasing. Some, however did not approve of the way the information was presented. Statement 2 obtained an average of 3.2, and Statement 4 scored 3.3 out of 5. Users also expressed the desire to use the application again as it improves in features and performance. The value of serendipitous discoveries is illustrated by the responses to Statement 5 in Figure 8.4(e). A large majority of users discovered unexpected bits of trivia during the course of performing tasks, which made them perceive the application as useful, thus helping build engagement with the application. The overall satisfaction score for Iteration I was 3 out of 5.

8.1.5 Conclusions

Figure 8.5 indicates the overall usability scores for the application in Iteration I. The interpretation and the reasons behind these scores have been discussed in the above sections. The application scored well on the ease of use and the fun and serendipity factors, but lost out on efficiency and effectiveness due to several technical issues. This reduced the overall satisfaction the users felt using the application. Based on this analysis, the following decisions were made regarding the implementation of the second iteration.

- Single-step procedure for search
- Improved visualization technique which provides deeper insight into press trends
- Easier way to zoom and move around the article plot
- Technical improvements to improve performance and reliability
- Processing search results to remove duplicates and articles with missing information
- Better Help/FAQ page with language switching option
8. Results and Analysis

(a) Statement 1: I am satisfied with the features the application provides

(b) Statement 2: The application is fun to use

(c) Statement 3: I would like to use this application more often

(d) Statement 4: The application is visually pleasing

(e) Statement 5: I discovered something new and unexpected using the application today

Figure 8.4: Satisfaction - Iteration I

Figure 8.5: Overall Usability Scores - Iteration I
8.2 Iteration II

The application was reworked based on the feedback and lessons learnt from the first iteration, and made available again to the user group for testing. The following hypotheses were made about the incremental improvements in the application.

**Hypothesis 1:** Clustering the articles by publisher will lead to an improvement in effectiveness, as it provides more levels of information and possible inferences for users.

**Hypothesis 2:** Providing appropriate error messages and easier access to documentation will make the application easier to use.

**Hypothesis 3:** A single-step search process will, at the cost of reduced accuracy, improve efficiency.

**Hypothesis 4:** The intuitive zoom function and the ability to filter and narrow into articles of interest will enhance the fun factor and improve user engagement.

8.2.1 Effectiveness

The users’ responses regarding the effectiveness of the application’s second iteration are as shown in Figure [8.6]. As can be seen from the graphs, the improvements made to the application have been acknowledged by the users as enhancements to usability. Statement 1 scored an average of 3.5 out of 5 and Statement 2, 3.3 out of 5, which can be attributed to the removal of the second timeline and also the enhanced visualization method. However, a subset of users had issues with overlapping bubbles on the timeline, which needed an additional filtering step to access. This has inhibited further improvement in effectiveness scores. As a result of technical work including query optimization and appropriate indexing applied, the reliability of the application has improved, thus yielding Statement 3 an average score of 3.1 out of 5. As the articles are clustered by publication, they are divided into smaller, more manageable chunks of information. This makes it slightly easier to navigate between articles, improving the score for Statement 4 to 3.2 out of 5. As can be expected, the score for Statement 5 also went up to 3.1. This makes an average effectiveness score of 3.2 for Iteration II, which is an improvement of 12.5% over the last iteration, thus validating Hypothesis 1.

8.2.2 Ease of Use

Though the application had usability principles integrated into it since the design phase, the first round of user testing uncovered many issues which made the interface more difficult to use. The users felt that the system could offer better feedback indicating loading operations and better error messages in exceptional cases. Adding these improvements has resulted in higher scores for Statement 2 (4.5 out of 5) and Statement 4 (3.5 out of 5), thus validating Hypothesis 2. Preprocessing the search results to remove duplicates and missing information has also had an effect on the ease of use, with Statement 3 averaging 4.3 out of 5. The simplification of the search process has also impacted ease of use, with Statement 5 scoring an average of 4.1 out of 5. Statement 1 also has slightly improved responses, with an average score of 3.7. These figures gave the application an overall ease of use score of 4 out of 5.
8. Results and Analysis

(a) Statement 1: The application provides useful information
(b) Statement 2: The application lets me easily gain knowledge on topics I'm interested in
(c) Statement 3: I can use the application successfully every time for similar tasks
(d) Statement 4: The application provides an intuitive navigation mechanism
(e) Statement 5: The visualization technique is appropriate, and provides a good overview

Figure 8.6: Effectiveness - Iteration II

8.2.3 Efficiency

There were a number of minor improvements and bug fixes done to improve the performance of the application. A particularly popular concept could have tens of thousands of articles associated with it, and thus may affect response times for the application. The query optimization and indexing have improved performance in this regard, which has driven up the overall efficiency rating. As can be seen from Figure 8.8(a) and (c), the elimination of one step in the search process has had a considerable impact on the efficiency. Statements 1 and 3 scored 3.9 and 3.7 out of 5 respectively. The drop in accuracy of the suggestions is not considerable while searching for terms that are names of people and places, and hence did not have a major effect on the usability. Improving the navigation mechanism with the addition of a 'Back' button in the application has bumped up the score for Statement 2 to 3.6 out of 5. The users were also in consensus that the second iteration better addresses their information needs. However, some users felt that there was not enough information per topic to hold the users’ interest. Statement 4 had an average score of 3.7 out of 5. The
8.2. Iteration II

(a) Statement 1: The application does not require me to remember information across screens
(b) Statement 2: Help/Documentation is always accessible
(c) Statement 3: The system is consistent with regard to use of terminology and symbols
(d) Statement 4: The application provides adequate feedback on its current state
(e) Statement 5: I could learn the usage of the system quickly, and remember what I learnt

Figure 8.7: Ease of Use - Iteration II

Overall efficiency score works out to 3.7 out of 5 for Iteration II, which translates to an improvement of 21%.

8.2.4 Satisfaction

The addition of several features and performance improvements has enhanced the level of satisfaction that users feel with the application. This is evident from Figure 8.9. More users indicated their satisfaction with the features provided, with Statement 1 obtaining an average rating of 3.6 out of 5. The performance improvements and more sophisticated visualization technique also impacted the fun factor and user engagement as hypothesized, with Statement 2 scoring 3.7 out of 5 and Statement 3 scoring 3.5 out of 5. The new visualization technique finds a way to represent large amounts of articles as coloured clusters, which could be filtered by the users. They appreciated the look and feel of the application, which was much smoother than the previous iteration. This translated into a better rating for Statement 4, with 3.9 out of 5. Clustering the articles by publisher also improved chances of
8. RESULTS AND ANALYSIS

(a) Statement 1: The application requires minimal steps in sequential menu selection
(b) Statement 2: The application provides means to recover from mistakes
(c) Statement 3: The application requires the fewest steps to accomplish what I want to do
(d) Statement 4: The application meets my information needs

Figure 8.8: Efficiency - Iteration II

accidental discoveries of information, which translated to a score of 4 out of 5 for Statement 5. Overall, this led to a satisfaction score of 3.7 out of 5, with an improvement of 25% for Iteration II.

8.2.5 Conclusions

As can be observed in the graph of Figure 8.10, there has been a significant improvement in usability scores across all measured attributes. For this kind of application, the visualization technique is a very important factor that influences the usability and user engagement. A novel technique for visualizing the articles will build user engagement. The visual metaphor used must be at the right level of complexity to ensure usability for all kinds of users. On the technical end, keeping load times short will result in a more responsive and fun experience for the user. The true potential of the application is realized when all the relevant articles in the archive are available, and can be easily ‘mined’ by the users. The key to achieving this objective is to apply a visualization technique that equally represents each article in the archive, while being uncluttered and easy to navigate. The following features were decided to be added for the third and final iteration.

- Richer visual interface with levels of information for different users
- Uncluttered visualization of large numbers of articles
- Pan and zoom functionality using the mouse and scroll wheel
- Article metadata display along with full text
8.2. Iteration II

(a) Statement 1: I am satisfied with the features the application provides

(b) Statement 2: The application is fun to use

(c) Statement 3: I would like to use this application more often

(d) Statement 4: The application is visually pleasing

(e) Statement 5: I discovered something new and unexpected using the application today

Figure 8.9: Satisfaction - Iteration II

Figure 8.10: Overall Usability Scores - Iteration II
8.3 Iteration III

A completely overhauled interface for visualizing articles in two views was built using the D3.js framework. The first view provides a temporal view of the trends in coverage for the searched concept in the past two years. The articles, on the other hand, are visualized using a D3 implementation of the circle packing algorithm. It is possible to pan and zoom into the plot intuitively with mouse gestures. We made the following hypotheses regarding the usability of this version of the application.

- **Hypothesis 1:** Visualizing each article separately improves chances of finding interesting information, thereby improving effectiveness and efficiency.
- **Hypothesis 2:** Technical fine tuning will lead to performance improvements, which improve the reliability of the application.
- **Hypothesis 3:** Intuitive navigation around the plot will enhance effectiveness.
- **Hypothesis 4:** Enabling navigation between topics using the browser’s navigation buttons will positively impact the ease of use and effectiveness.
- **Hypothesis 5:** The richer experience of the new interface will aid the user engagement and fun factor, thus increasing users’ satisfaction.

8.3.1 Effectiveness

There is a considerable improvement in the effectiveness of the application in providing information the users require. This is apparent from the graphs in Figure [8.11] More users felt that the information provided by the application was relevant and useful, while also being easily accessible, giving scores of 4.2 and 4.4 out of 5 for Statements 1 and 2 respectively. This is in line with hypotheses 1 and 2. Reliability of the application has also improved as perceived by the users, with a score of 4.1 out of 5. More and improved navigation mechanisms enable users to easily move between articles, publications and topics, driving up the score for Statement 4 to 4 out of 5. These results are in strong correlation with the responses for Statement 5, with a score of 4.3 out of 5. This gives the application a final effectiveness score of 4.2 out of 5, an improvement of nearly 24% over Iteration II. These findings verify the importance of the visualization technique as a factor that affects the usability as a whole.

8.3.2 Ease of Use

Navigation using the browser’s navigation buttons was enabled by implementing HTML5 URL rewriting. This has made it easier for users to jump between topics and explore the archive more effectively. As there is now a single result page with all the articles visualized, there is no need to remember information such as the title of an article, or its publisher, between interactions with the system. The visualization technique represents all articles equally, so the user has an equal chance of picking any article up for reading, based on the interest the title generates. This has translated into higher scores for ease of use, with Statement 1 scoring 4.1 and Statement 3 scoring 4.2 out of 5. More documentation was made available in terms of new features and how to use them. This, along with the intuitiveness of
8.3. Iteration III

(a) Statement 1: The application provides useful information
(b) Statement 2: The application lets me easily gain knowledge on topics I’m interested in
(c) Statement 3: I can use the application successfully every time for similar tasks
(d) Statement 4: The application provides an intuitive navigation mechanism
(e) Statement 5: The visualization technique is appropriate, and provides a good overview

Figure 8.11: Effectiveness - Iteration III

The interface itself, made the usage of the system easier to learn as expressed by the users. Statement 5 scored 4.2 out of 5. This resulted in a combined ease of use score of 4.3 for the application’s final iteration.

8.3.3 Efficiency

More users now agree that the application has the minimum required steps for operation. This is evident from clearly higher scores for Statements 1 and 3 with 4.1 and 4.2 out of 5 respectively. It is also easier to recover from mistakes using the browser navigation, or by navigating to another article easily. This has ensured a better score for Statement 2, with 4.1 out of 5. Users were also appreciative of the new visual metaphor of packed bubbles, which enabled them to visualize large amounts of information at a time. Statement 4 thus had a rating of 4.1 out of 5. Collectively, this adds up to an efficiency rating of 4.1 out of 5 for the application, which is an improvement of 10%.
8. RESULTS AND ANALYSIS

(a) Statement 1: The application does not require me to remember information across screens
(b) Statement 2: Help/Documentation is always accessible
(c) Statement 3: The system is consistent with regard to use of terminology and symbols
(d) Statement 4: The application provides adequate feedback on its current state
(e) Statement 5: I could learn the usage of the system quickly, and remember what I learnt

Figure 8.12: Ease of Use - Iteration III

8.3.4 Satisfaction

A larger section of users indicated their approval of the features provided by the application, with Statement 1 scoring 4 out of 5. The new interface also drove up the fun element and user engagement as hypothesized. Statement 2 and Statement 3 scored 4.2 and 4.1 out of 5 respectively. All round, the users felt that this was a much improved interface, giving Statement 4 an average score of 4.3 out of 5. The serendipity factor also got a bump up with more articles being visible to the user at any given time. Users were in strong agreement with Statement 5, giving it a score of 4.5 out of 5. The overall satisfaction score worked out to 4.2 out of 5.

8.3.5 Conclusions

As expected, the improvements made to the visualization interface have had a high positive impact on the usability. The incremental improvements between iterations are as seen in
8.3. Iteration III

(a) Statement 1: The application requires minimal steps in sequential menu selection
(b) Statement 2: The application provides means to recover from mistakes

(c) Statement 3: The application requires the fewest steps to accomplish what I want to do
(d) Statement 4: The application meets my information needs

Figure 8.13: Efficiency - Iteration III

Figure [8.15] In the last iteration, the new visualization mechanism was mostly responsible for higher scores across all aspects of usability. This has enabled users better access to the article archives and provided an interesting way of visualizing articles. Giving users a multitude of options for interaction with the visualizing interface ensures more user engagement as the users spend more time using the application. The interface implemented was at the right level of complexity according to the users. It offered the possibility to skim through topics with the temporal overview, or drill down into the actual articles themselves. A zoom and pan interface that was very simple and natural also contributed to improved usability. These features have yielded a highly usable application that meets the client’s needs, while the iterative approach has helped understand different interaction methods and their effect on usability.

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8. Results and Analysis

(a) Statement 1: I am satisfied with the features the application provides
(b) Statement 2: The application is fun to use
(c) Statement 3: I would like to use this application more often
(d) Statement 4: The application is visually pleasing
(e) Statement 5: I discovered something new and unexpected using the application today

Figure 8.14: Satisfaction - Iteration III

Figure 8.15: Overall Usability Scores - Iteration III
Chapter 9

Conclusions and Recommendations

9.1 Conclusions

We set out to find the most usable interface to enable web-based browsing of NEWZ’s repository of news articles in the temporal perspective. The application of usability techniques such as User Stories and Heuristic Evaluations during the design phase ensured that we had a stable platform on which experiments could be performed to find the best possible interface. The subsequent work involved the formulation of a methodology for user testing of the application, and identifying the right metrics for evaluation of usability. The test process elicited users’ perceptions with the help of a questionnaire. Intertwining the testing with the actual build process of the application helped create a completely functioning system even without a clear set of requirements as the starting point. The users’ responses to the questionnaire helped identify issues and see the areas in which the application is performing well. This resulted in an application with high usability and visual appeal, which has been demonstrated to be useful and engaging to the target users.

In the following sections, we discuss the answers to the research questions formulated earlier in the study.

RQ1: What is an appropriate user interface for navigating through a large news article archive by concept?

The final delivered application has a smooth and usable interface as expressed by the users, with none of the issues faced in earlier versions. The iterative approach has given us the opportunity to incrementally improve on the features and working of the application, thus resulting in an experience that is tailored for the users. This has led to progressively higher usability scores across iterations, with the final version obtaining the highest scores from users. As the developed system works with data in the standard NewsML-G2 format, it is flexible enough and could possibly be adapted to work with other archives that use the same format. Though the study ended with the third iteration, it is not possible to conclude that this is the best possible interface for the task at hand. Conducting more iterations of development and user testing would definitely improve the application further, making it more engaging and usable.

RQ2: What are the visualization techniques that can be applied to provide a temporal
9. CONCLUSIONS AND RECOMMENDATIONS

perspective on topics in a large news article archive?

The delivered application has a rich visualization interface, with views that provide both an overview and an in-depth article map for exploration. The powerful and simple interface was appreciated by users and scored high on the fun factor and user engagement, which were the exact attributes we were attempting to achieve. This interface is simple enough to be used by all kinds of users, while being capable enough to display different types of information in a simplistic and uncluttered manner. There are more visualization techniques for time-oriented data, which could possibly yield better results with this application, and exploring them would be a worthwhile exercise.

9.2 Recommendations

Based on the experience from this study, we believe that further work in the following areas would offer major contributions in improving different usability aspects of the application.

- Spiral visualization has been adopted in various approaches that deal with temporal data. It could be interesting to visualize the articles as clusters on a time spiral.

- Integrating with other information such as tweets from Twitter and pictures from Flickr would add more value to the application as current sentiments and opinions about concepts could be learnt.

- Implementation of a payment mechanism for the system to be used on a commercial basis.

- Enabling sharing of articles on social networks à la Blendle could increase visibility and open the application up to a wider audience.

- Exploring the possibility of using the application with the NEWZ ontology instead of DBPedia would ensure a complete system that only makes use of NEWZ’s in-house services.
Bibliography


[12] Alan Cooper et al. The inmates are running the asylum: [Why high-tech products drive us crazy and how to restore the sanity], volume 261. Sams Indianapolis, 1999.


Appendix A

News Publishers in the Netherlands

The following table shows the different news publishers in the Netherlands, along with their publications.

<table>
<thead>
<tr>
<th>Publisher</th>
<th>National Newspapers</th>
<th>Regional Newspapers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telegraaf Media Groep N.V.</td>
<td>De Telegraaf, Spits</td>
<td>Dagblad De Limburger, Noordhollands Dagblad, Limburgs Dagblad, Haarlems Dagblad, IJmuider Courant, Leidsch Dagblad</td>
</tr>
<tr>
<td>De Persgroep</td>
<td>Algemeen Dagblad, De Volkskrant, Trouw, Het Parool</td>
<td></td>
</tr>
<tr>
<td>NRC Media</td>
<td>NRC Handelsblad, nrc.next</td>
<td></td>
</tr>
<tr>
<td>FD Mediagroep</td>
<td>Het Financieele Dagblad</td>
<td></td>
</tr>
<tr>
<td>Wegener Groep</td>
<td></td>
<td>De Gelderlander, De Stentor, Brabants Dagblad, Tubantia, BN DeStem, Eindhovens Dagblad, Provinciale Zeeuwse Courant,</td>
</tr>
<tr>
<td>Nederlands Dagblad</td>
<td>Nederlands Dagblad</td>
<td></td>
</tr>
<tr>
<td>Metro Holland</td>
<td>Metro</td>
<td>Dagblad van het Noorden, Leeuwarder Courant</td>
</tr>
<tr>
<td>Noordelijke Dagblad Combinatie</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table A.1: News Publishers in the Netherlands

Apart from these publications, there are a number of local newspapers such as the Haagsche Courant in The Hague and Rotterdams Dagblad in Rotterdam. However, the national newspapers are of the most interest as they are read by larger numbers of people, and thus have a higher impact. The most popular national and regional newspapers by circulation are shown in the following charts[7].
A. News Publishers in the Netherlands

Figure A.1: Top Ten National Newspapers in the Netherlands by circulation

Figure A.2: Top Ten Regional Newspapers in the Netherlands by circulation
Appendix B

User Testing Data

B.1 User Information

The following table describes the information collected about the ten users in the testing group.

<table>
<thead>
<tr>
<th>User</th>
<th>Age</th>
<th>Gender</th>
<th>Web Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45</td>
<td>Male</td>
<td>Good</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>Female</td>
<td>Average</td>
</tr>
<tr>
<td>3</td>
<td>46</td>
<td>Male</td>
<td>Very Good</td>
</tr>
<tr>
<td>4</td>
<td>23</td>
<td>Male</td>
<td>Good</td>
</tr>
<tr>
<td>5</td>
<td>26</td>
<td>Male</td>
<td>Very Good</td>
</tr>
<tr>
<td>6</td>
<td>24</td>
<td>Female</td>
<td>Good</td>
</tr>
<tr>
<td>7</td>
<td>28</td>
<td>Male</td>
<td>Very Good</td>
</tr>
<tr>
<td>8</td>
<td>33</td>
<td>Male</td>
<td>Average</td>
</tr>
<tr>
<td>9</td>
<td>38</td>
<td>Female</td>
<td>Very Good</td>
</tr>
<tr>
<td>10</td>
<td>25</td>
<td>Female</td>
<td>Average</td>
</tr>
</tbody>
</table>

Table B.1: User Information

Data was also collected regarding the users’ web browsers and screen resolutions. 7 out of the 10 users used Google Chrome as their web browser, with 2 users preferring Mozilla Firefox and 1 user with Microsoft Internet Explorer. With regard to screen resolution, there was not much variation, with most users having screen resolutions of 1920x1080px, and a few having slightly lower resolutions of 1600x900px and 1366x768px. The application was built to be compatible with different systems, and users did not report any changes in experience across browsers and screen resolutions. However, it was observed that users with better experience using the web were more critical of the application’s usability.

In the following tables, the raw data from the three user testing iterations is presented.
### B. User Testing Data

<table>
<thead>
<tr>
<th>User</th>
<th>Effectiveness</th>
<th>Ease of Use</th>
<th>Efficiency</th>
<th>Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
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<td>3</td>
<td>5</td>
<td>5</td>
</tr>
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<td>2</td>
</tr>
<tr>
<td>S5</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Table B.2: Collected Data: Iteration I
## B.1. User Information

<table>
<thead>
<tr>
<th>User</th>
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<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
</tr>
</thead>
<tbody>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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</tr>
<tr>
<td>Satisfaction</td>
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<td>3</td>
<td>4</td>
<td>5</td>
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</table>

Table B.3: Collected Data: Iteration II

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77
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<th>Ease of Use</th>
<th>Efficiency</th>
<th>Satisfaction</th>
</tr>
</thead>
<tbody>
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<td>User</td>
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<td>S1 S2 S3 S4 S5</td>
<td>S1 S2 S3 S4 S5</td>
</tr>
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</tbody>
</table>

Table B.4: Collected Data: Iteration III
Appendix C

Glossary

This appendix contains an overview of frequently used terms and abbreviations.

C.1 Abbreviations

ANP: Algemeen Nederlands Persbureau
API: Application Programming Interface
CSS: Cascading Style Sheets
D3: Data Driven Documents
DRM: Digital Rights Management
FD: Financieele Dagblad
FTP: File Transfer Protocol
HTML: HyperText Markup Language
ISO: International Organization for Standardization
JSON: JavaScript Object Notation
ND: Nederlands Dagblad
NDP: De Nederlandse Dagbladpers
NoSQL: Not Only SQL
REST: REpresentational State Transfer
SDU: Staatsdrukkerij en -Uitgeverij
SPARQL: SPARQL Protocol and RDF Query Language

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C.2 Frequently Used Terms

**Single Page Application:** A web application or web site that fits on a single web page with the goal of providing a more fluid user experience akin to a desktop application.

**Mashup:** A web page or application that uses content from multiple sources to create a single new service displayed in a single graphical interface.

**MarkLogic:** MarkLogic is an enterprise NoSQL database that can handle transactions involving large amounts of data.

**AngularJS:** AngularJS is a Javascript-based UI and data binding framework used in web and mobile application development.

**D3.js:** D3.js is a visualization library based on jQuery, which offers multiple layouts to visualize large corpora of data.

**SVG.js:** SVG.js is a jQuery-based framework which enables drawing of vector graphics in web applications.

**Less CSS:** Less is a CSS preprocessor that extends the CSS specification to simplify style definitions.