Dynamic website optimization through autonomous management of design patterns

Aniel Bhulai
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doors

Aniel Bhulai

geboren te Nickerie, Suriname
promotor : prof.dr. G.C. van der Veer
copromotor : dr. S. Bhulai
Preface

My journey towards this book started about six years ago. With my interest in and passion for the Internet as foundation I started this work. However, passion is not the only ingredient for this thesis. This work has also been supported by several persons. I, therefore, would like to take this opportunity to thank those persons who helped me in one way or another in writing this thesis, realizing that I take the risk of choosing just a few names of many I want to name here.

First, I would like to express my thanks to my supervisor Gerrit van der Veer who supported me tremendously in my research activities. He has been very supportive and helpful throughout my research period, and coached me through the early steps of learning how to be a researcher. I learned a lot of research skills from him, of which conducting empirical research is a subset.

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What appears as a single book is in reality a tapestry woven to include insights that come from projects and studies done by students under supervision of the author. I would like to thank Hugo Huurdeman, Anne Mos, Peter Szekeli, Evert Visser, and all the other students who contributed to my work in some way. I could not have done it without them.

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I am greatly indebted to my parents for always being there for me. Special thanks go to my mum and dad for being such great parents and helping me in every single step in my life with their support and blessings.

Doing PhD research next to a full time job with a family is a challenge. This work would not be possible without the love and extreme patience of my wife, Sharmila, and my daughter, Divya. I am very grateful to them. In various ways I depended on them to keep me trouble free and to keep me focused on my research. I guess they will be very happy to have me back from this journey.

Aniel Bhulai
June 2011
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Chapter 1

Introduction

The World Wide Web (WWW) has accelerated the pace of information transfer throughout the world. The Internet World Stats [16] reports that the WWW has 1.663 billion users as of March 2009 which accounts for almost 25% of the world population. As such the WWW has a tremendous economic value through e-commerce. Moreover, it is estimated that the WWW also grows with 7.3 million new web pages every day [142]. Therefore, before a website truly can become economically relevant, the website first needs to be found and needs to have a navigation structure such that users can find relevant information on it easily. Website Optimization (WSO) is a new research area that addresses these issues and aims to provide more visibility to websites through better web design and management. In Section 1.1 we explain why WSO is important and is gaining momentum. We also discuss its shortcomings and problems and propose a new dynamic and autonomous WSO system to alleviate these issues. In Section 1.2 we describe our research goals and the research approach. We conclude the chapter with Section 1.3 in which we describe how this thesis is organized.

1.1 Website optimization

1.1.1 The importance of website optimization

Since the remarkable use of the WWW in 1991, its growth has been tremendous. Figure 1.1 shows that the world-wide Internet user growth from 2000 to 2009 was 380.3% (see the Internet World Stats [16]). A study by The Kelsey Group and ConStat, Inc. [12] indicates that 70% of U.S. households
in 2005 used the WWW as an information source when shopping locally for products and services. These figures do not only show us the enormous growth of the WWW population, but they also indicate that the World Wide Web has become an integral part of many people’s everyday lives.

Nowadays, it is common that people have a computer with a broadband connection and use it to gain access to information on-line to look up facts, to make on-line purchases, to do business, to entertain, to socialize, etc. With this trend, the WWW has become more and more economically relevant. It is the largest and most cost-effective source of commerce. Therefore, providers, like organizations and companies, consider it a necessity to have a website (see Lazar and Preece [136]). The goals of these providers are to serve people better, to attract people to their website for their products, and to influence people in such a way that they buy their products or make use of their services. To use the WWW for your organization’s benefit, it is therefore crucial that your website is easily found on the WWW, otherwise you can lose potential customers, clients, and prospects. There are many factors (e.g., content, load time, navigation support, appearance, coding of the page) that affect the performance and the findability [243] of a website. Even though a website can be designed nicely and intelligently, it will make no difference if no one knows about it and no one can find it.

Search engines are a primary method of searching for information for almost all WWW visitors. When they arrive on your website it is important to keep the visitors on your website. However, to ensure that visitors do find your website in the search engine, it is important to know how visitors search for information. A search with a well-defined goal (i.e., a goal which is defined precisely) is well supported on the WWW. Search engines, bibliographic databases, and digital libraries provide adequate support for visitors whose goals are well defined [238]. If you are looking, e.g., for the book ‘Web Design in a Nutshell’ written by Jennifer Niederst, then you have a big chance to find this book through a search engine because the goal is well defined. But if you, e.g., want to know where to go on vacation, search engines will not give you any answer to this question. It might help you by presenting you a list of links of several travel websites if you searched with the proper keywords. But from there on you will be on your own. Here is where ‘wild searching’ will help you further. Wild searching means “realizing a user goal which is not defined precisely or which may change, by browsing
Figure 1.1: Internet users in the world.
or surfing”\(^1\). Wild searching is useful when the visitor lacks knowledge or contextual awareness to formulate queries to realize his\(^2\) goal. This also occurs when the visitor wants to find something related to a domain in which he has a general interest but not in-depth knowledge.

**Website optimization** (WSO) is the process of improving internal (e.g., layout of webpages, content, navigation support, usability) and external (e.g., promotion of the website, link building, building personality and reputation) aspects of your webpages to increase the traffic the website receives from search engines. Website optimization is a new research area that addresses the above raised issues on findability. Website optimization is the “key ingredient” for successful web promotion campaigns and consists of many different web design techniques (e.g., techniques to program webpages, to optimize the performance of webpages, to design page layouts, and to optimize content and coding). When you combine website optimization with good web design & development and a proper website promotion strategy, you can achieve the following:

- Your website will have a high ranking in the major search engines (e.g., in Google\(^3\), Yahoo\(^4\), Ask.com\(^5\), Bing\(^6\)),
- More visitors will visit your website,
- More visitors will recommend your website to others,
- Visitors will return to your website,
- Visitors will turn into customers, and
- Customers will generate revenues.

\(^1\)Note the difference between wild searching and (web-)browsing or surfing. Browsing or surfing is moving around via links between and within documents on the WWW. Browsing, in its nature, ignores the file structure or other formal organization of information [35] (see also Section 6.2), while the organization of the information matters for wild searching (see also Section 7.3).

\(^2\)Generally we are using the masculine gender throughout this thesis without looking down on the female sex. We use both genders in the sections (e.g., results of studies) where it is important to distinguish between the male and the female sex. In all the other cases the masculine gender can be replaced by the feminine gender.

\(^3\)http://www.google.com.
1.1.2 The importance of studying search behavior

In the previous section we have argued that findability heavily depends on how people search for information. A lot of studies have tried to characterize search behavior of people in daily life and also on the WWW [25, 32, 21, 59, 211]. Most of the basic search behavior is captured by search engines. However, there are a few things that are not supported very well on the WWW. People do many things when they are searching in the physical world. One of the things they do is wild searching. The examples below are related to wild searching and illustrate the concept.

- **People change their mind** (i.e., change their goals) because of the influence of situations, events or needs. It often happens that people go to the supermarket to buy some things but come home with other things. This means that something happened in the supermarket that made people behave differently from what they initially intended to.

  Likewise, it happens that when people go to, e.g., the Free Record Shop to buy a particular CD they come home with a different CD than they had in mind. This means that something at the shop made the visitors change their mind. Probably that Free Record Shop had something better to offer to their visitors which made their visitors change their mind or they might have met a friend who told them about a very good CD he bought, or they got the opportunity to have a CD signed by the performing artist.

- **People do not always have a precise goal.** People, e.g., do not always go to the museum to look at the painting of Rembrandt only, they do not go to the cinema to watch a movie only, or they do not go to the gym to do some exercise only. They may enter the museum also to have a cup of coffee or they may also go to the cinema or gym for sociability.

- **People have goals that differ from those ‘expected’ by the provider.** People may go to, e.g., the Museum of London\(^7\), which is open on Sundays, for a cup of coffee. Or they may go there for sociability or to chitchat with others.

\(^7\)See [http://www.museumoflondon.org.uk/](http://www.museumoflondon.org.uk/).
People may go to, e.g., the Smithsonian’s National Zoological Park in Washington\textsuperscript{8}, not only to look at the animals but also to celebrate their children’s birthday, to attend some attractions, to have some food and drinks in the restaurant, to spend some time in the souvenir shop, or to learn about wildlife and its conservation.

Wild searching is not supported very well on the WWW. By optimizing the internal aspects of websites you can support wild searching better. Better support for wild searching leads to a situation in which visitors can find information more easily, visitors will stay longer on websites or come back more frequently, which may result in more revenues as more visitors will turn into customers.

1.1.3 Dynamic and autonomous management

In Section 1.1.1 we pointed to the importance of website optimization. In Section 1.1.2 we elaborated on search behavior, which is important to understand before one can apply website optimization. Even then, the successful deployment of WSO, however, is not easy due to the size of most websites. Websites are growing with more pages, especially websites that are based on a Content Management System (CMS) (a system for managing content and providing it in various formats). For example, the website of the Disney store (\url{http://www.disneystore.com}) contains 22,900 webpages, the website of the Bijenkorf store (\url{http://www.debijenkorf.nl/}) contains 49,100 webpages, the website of bol.com (\url{http://www.bol.com/}) contains 1,960,000 webpages, the website of YouTube (\url{http://www.youtube.com}) contains 769,000,000 webpages!\textsuperscript{9} Not only are websites growing in size, but they are also becoming more and more complex due to dynamic content (e.g., time-dependent content retrieved from databases, such as current weather, local news, stock prices and exchanges rates) and server-side scripting (e.g., PHP, ASP, Python). The number of webpages and the complexity make websites very difficult to manage and to maintain.

\textsuperscript{8}See \url{http://nationalzoo.si.edu/default.cfm}.

\textsuperscript{9}The numbers are gathered from Google.com on 23 July 2009, at 14.57 hours. As the WWW is growing constantly, these numbers may be different from minute to minute. The numbers are an estimate, because not every webpage of a website may be indexed by search engines. Nevertheless, the numbers give us a good impression of the number of webpages a website contains.
A lot is known about web visitors, as websites generate a lot of data (e.g., which browser is the visitor using, what webpage did the visitor previously visit, which path did the visitor follow on the website, what links/products did the visitor click on, how long did the visitor spend on a webpage, how many times did the visitor visit the website, what operating system is the visitor using, personal data like name, age, location, interests, and gender). Website owners collect these data for business purposes, e.g., business intelligence and analytics. Web designers use the data to optimize websites by, e.g., developing design patterns.

The size of current websites and the complexity of the content prohibit the straightforward use of WSO. Dynamic content leads to time-dependent behavior of visitors. Therefore, you need website optimization that takes this dynamic nature of the website into account; the techniques to handle this complexity in the content are called dynamic website optimization techniques. Moreover, to deal with the size of current websites, you also need autonomous systems that act and react to changes in content and search behavior. Note that a typical system that is dynamic and autonomous needs to carry out four steps.

1. Data gathering: the system needs to collect data on how visitors behave on the website, which links are clicked, which paths are followed, etc.

2. Model estimation: the data gathered in the first step needs to be processed and analyzed. This will result in model parameters for the website optimization system.

3. Analysis: the model estimation step yields a website optimization system that captures and reflects the current state of visitor behavior given the content of the website. With this model you can detect potential problems in findability of content. The analysis phase can be summarized as a problem detection phase.

4. Optimization: in the analysis step potential problems with the website structure or navigation might have been identified. In this step the website optimization system can change the website to deal with the identified problems.

The fourth step is not the end of the four-step process. From a mathematical viewpoint (in particular systems control theory), after the website has been altered, this provides feedback to the data gathering step. Every change
to the website triggers a potential change in behavior of visitors and that needs to be monitored. This creates a feedback loop so that the website optimization system monitors its own changes and reacts to changes caused by it. In this way the website optimization system become dynamic in nature and autonomous.

Little research has been done on dynamic optimization of websites\(^\text{10}\). That is why our research will focus on dynamic website optimization through autonomous management of design patterns. This objective will be further explained in the next paragraph.

### 1.2 Research

#### 1.2.1 Research goal

In Section 1.1.3 we mentioned that little is known about dynamic website optimization. Findability is important and heavily depends on how people search for information. In Section 1.1.2 we saw that wild searching is part of the human search process and is not very well supported on the WWW. One way to improve wild searching on the WWW is by optimizing websites. However, optimizing websites in a static and non-autonomous way is a time consuming and laborious process, which is often not feasible in practice. Therefore we focus in our research on dynamic website optimization and on an autonomous management system of design patterns. The central goal of this thesis is to develop *a model for implementing dynamic website optimization through autonomous management of design patterns*. This goal can be reached by investigating the following research issues:

1. What can we learn from searching in a “non-web” setting vs. searching in a web setting for improving search on the WWW?

2. Formulation of design patterns for static website optimization.

3. Development of models for dynamic website optimization.

The first issue is presented in Chapters 3, 4, 5, and 6. The second one is presented in Chapter 7, and the third issue is presented is Chapters 8 and 10.

\(^\text{10}\)Do not confuse dynamic website optimization with optimization of dynamic websites. Dynamic websites are database driven websites where content and design live separately. The content lives in a database and is placed on a webpage only when needed or asked for.
1.2.2 Research approach

Findability of information on websites is largely determined by the way people search for information. Therefore, it is important to study how people search, and if searching in a “non-web” setting shows search opportunities that people appreciate and that currently are not supported on the WWW. This study is useful in supporting the general search process, but also in particular wild searching on the WWW. The first research goal addresses this question. In Chapter 2 we will give an overview of user goals, and search and navigation behavior. This overview will give us insight into what is known in the literature on search behavior and on wild searching.

To further investigate the difference between searching in a “non-web” setting versus searching in a web setting, we will use three techniques:

1. observations of natural and WWW search behavior,
2. task-based experiments on searching,
3. interviews on search behavior, goals & problems.

We will do a pilot study first (see Chapter 3) to find out what problems may arise in observing people. In the pilot study we will observe people in “non-web” settings. The results of the pilot study will also identify factors that are essential in the search process. These factors can be used in WSO. After analyzing the results and adapting the methodology for the study, we will observe people and do task-based experiments in “non-web” situations (see Chapter 4). We will particularly focus on the factors which we found in the pilot study. Along with the observations and experiment, we will also conduct interviews with the participants to cross-validate the search behavior observations. The next step is to investigate search behavior on the WWW (see Chapter 5). To compare the results of both settings, we will keep the methodology of observing people on the WWW identical to observing people in a “non-web” setting. The observation results of both settings will be compared to each other to find out whether there is a fundamental difference or not (see Chapter 6). We call this phase the problem detection phase, since we explore what the problems are in the search process and web design.

In Section 1.1.1 we have mentioned that there are many factors that can influence the performance and findability of a website. In order to find out which factors we should change to optimize the website, we should study the
effects of every factor in isolation first. The factors that have the greatest impact on the performance and findability should be optimized first. In the problem detection phase we will identify the factors that should be optimized. The next step is to find design patterns that deal with the detected problems. These design patterns will be the basic components that can be used to optimize the website. We call this phase the solution phase. We will collect examples of design patterns that have been applied previously (see Chapter 7).

The problem detection phase and the solution phase are static methods that can be applied frequently. However, due to the size of websites doing this manually is a tedious process. Moreover, as content is dynamically added to the website, the characteristics of the website change with it. Consequently, visitors to the website display different behavior as the website evolves. It is thus imperative that any website optimization model is dynamic in nature. We will develop mathematical models, in particular Markov decision problems, that can support website optimization (see Chapter 8) in a dynamic manner. These models will be further extended to models for dynamic website optimization through autonomous management of design patterns (see Chapter 10). The observation results of people on the WWW will be used to estimate model parameters. Subsequently, the results of the estimate will be analyzed to optimize websites. Below we give a schematic overview of the chapters and their relations.

1.3 Outline

The remaining part of the thesis is organized as follows:

Chapter 2 provides a literature overview on user goals, and search and navigation behavior. The overview gives us insight into the general search behavior of people, and in particular, into wild searching. This chapter also provides us some factors which will be used in the pilot study in Chapter 3.

Chapter 3 presents the pilot study. In the pilot study we conduct experiments in which we observe people in “non-web” settings. We start with an introduction to ethnography. Then we describe the methodology and the results of the pilot study. The pilot study provides us additional factors on which we will focus during the observations in Chapters 4 and 5.
Chapter 4 presents and discusses the results of the search behavior observations in “non-web” situations. Based on the results of the pilot study we adapt the methodology from our pilot study for the search behavior observations in this chapter.

Chapter 5 presents and discusses the results of the search behavior observations on the WWW. The methodology used in this chapter is identical to the methodology used in Chapter 4.
In Chapter 6 we compare the observation results of Chapters 4 and 5. In this chapter we detect the problems to optimize websites and give an answer on the first research issue ‘What can we learn from searching in a “non-web” setting vs. searching on a web setting for improving searching on the WWW?’.

Chapter 7 provides solutions for the problems detected in Chapter 6. In this chapter we formulate design patterns for static website optimization.

In Chapter 8 we develop and show how mathematical models, in particular Markov processes, can support website optimization. We apply the formulated model on some examples to show how the model works.

In Chapter 9 we provide an overview of some techniques that are applied in practice for website optimization. We show some concrete examples of tools that use those techniques to optimize websites. The applicability of the techniques are discussed in this chapter.

Chapter 10 describes a model for dynamic website optimization through autonomous management of design patterns. The observation results of Chapter 5 are used to estimate model parameters. Then the results of the estimate are analyzed to optimize websites.

Chapter 11 summarizes the main points of this thesis and discusses future research directions.
Chapter 2

User goals, search and navigation behavior

In this chapter we provide a literature overview of scientific studies on user goals, and search and navigation behavior. The overview provides us insight into how achieving user goals are linked with the search and navigation behavior of users. In particular, when a user goal is not specified clearly, this leads to a distinct search behavior that is also known as wild search. The insights obtained from this chapter will be the basis for empirical investigations in Chapter 3.

2.1 User goals

Most scientific studies point out that website visitors do not visit websites without a reason; they have a specific goal in mind [44, 61, 211]. Website visitors often visit the site with a goal and they try to achieve that goal. Spool [212] did a study on what happens after visitors have achieved their goal on a site. He wanted to know how he could direct the visitors to the valuable content that they did not know was there. He found that the way you get to the target content affects whether you will continue looking or not. His research has shown that visitors are three times more likely to find the valuable content if they use the category links of the home page instead of going straight to a search engine to do a search. Visitors who started with the category links ended up looking at almost 10 times as many non-target content pages as those who started with a search engine to do
a search. Search engines only let visitors see what they are looking for: if you ask for Nike shoes, you get Nike shoes. When visitors are exposed to categories, they become unknowingly educated in the other content available on the site (e.g., advertisements that trigger new goals). In this way people get interested in other things. They may change their minds and create new goals, or completely change their goals. With search engines there is no opportunity to see what else the site has to offer. A search engine does not offer the visitor the opportunity to do a ‘wild search’.

2.2 Effectiveness of search engines

Search engines, basically, map keywords that are in the query to keywords that have been collected on web pages. Therefore, search engines are very effective when we are looking for something that is well-defined. Jansen & Spink [119] determined that queries with search engines are short sessions with session durations of typically 15 minutes. Search engines usually provide limited searching assistance to the visitor. The interaction with search engines is almost always with keywords and/or Boolean operators (like ‘AND’, ‘OR’, and ‘XOR’), or an option ‘match case’. However, search engines are less effective in situations where queries become more complex because visitors lack domain knowledge or contextual awareness to use the system effectively. Jansen & Spink [120] found that approximately 15% of visitor sessions on the WWW use more advanced search options than the ones specified above. Spool [210] found the following problems when visitors search on keywords in search engines:

- partial matches; individual keywords can be matched against keywords that are part of a bigger group of words (in which the meaning of the keywords might be different as well, e.g., searching on “Hilton Hotel in Paris” in Google\(^1\) yields among others the Wikipedia page of Paris Hilton).

- misspelled keywords; mistakes in spelling can lead to unsuccessful search results.

- vague relevance; the query can result in a list of results, of which it is not clear at first glance which ones are irrelevant to the visitor.

\(^{1}\)http://www.google.com.
It is also useful to know how effective a search process is when no search engine is used. The User Interface Engineering Group in Bradford (MA) showed that visitors receive a lower percentage of relevant search results when they search on-site on keywords than when they search by browsing on the website [210].

2.3 Factors influencing the search process

Whether users are successful in reaching their goal(s) depends on many things. We mention a few important factors that influence an effective approach to realizing user goals.

1. The number of clicks

When users are searching on the Web they follow a certain path to accomplish their goal. In this navigation behavior it is essential to know which steps and how many steps users need to find the required information. Rosenfeld and Morville [197] found that four or five clicks in a website is the maximum number of clicks that a user will complete before giving up. Favier [85] found that more than 50% of the web visitors leave a website after two mouse clicks. After five mouse clicks, 95% of the web visitors have left the website already. The reason for this behavior is that web visitors do not find the information on the website easily or quickly enough to realize their goal. Lazar and Preece [139] obtained similar results. Therefore, once a user starts browsing a website, the user should be able to access all the pages on the site by going through no more than four or five clicks.

2. Accessibility of information

Simply stated: “usability rules the web” [168]. If a customer cannot find the product he is looking for, then he will not buy it. Krug [132] says that the number one rule of usability is to not put the burden of thought on the user. A webpage should be self-evident. In order to design usable websites, guidelines are needed. Nielsen [168] has identified and named a few of these guidelines.

In a usability study, Favier [85] showed that merely 10% of web visitors rated web services in 2003 as ‘excellent’, 20% were ‘impartial’, and almost 30% indicated that they ‘disliked’ web services.
3. The structure of the website

According to the studies of Berg [41], Hardman, Bulterman, and Rossum [101], and Shneiderman [203] the success of navigation is determined by how the information is structured on the website and how the link mechanisms are designed and presented on the menu of the website.

Nielsen [168] found that one of the fundamental problems of Information Architecture is structuring the website to mirror the way the organization is structured. Wodtke [246] says that a principle for designing good information architecture is ‘you (information architect) do the thinking, not the user’. She mentions eight principles in [246], which can be seen as rules of thumb for good information design.

4. The first impression of the website

In the blink of an eye, web surfers make nearly instantaneous judgments of a website’s “visual appeal”. According to Lindgaard, Fernandes, Dudek, and Brown [140] web users form first impressions of web pages in 50 milliseconds (1/20th of a second). They claim that these quickly-formed first impressions last longer because of what is known to psychologists as the “halo effect”. If people judge a website to look good, then this positive quality will spread to other areas of judgement, such as the website’s content. Consequently, they will continue to use the website that made a good first impression, as this will further confirm and reinforce that their initial decision was a good one.

The “halo effect” can color subsequent judgments of perceived credibility, usability, and ultimately influence purchasing decisions. Creating a fast-loading, visually appealing site can help websites succeed.

5. One-size-fits-all approach

Today designers are faced with the huge challenge of designing websites for a large number of different users. Perfetti [187] observed that many designers tackle this problem by making the functionality of the website as extensive as possible. This one-size-fits-all approach worked for designers in the past. In those days the functionality of websites was simple with users confined to a very limited set of goals. Today’s websites are vastly more complex and present web designers with the unwieldy problem of trying to include functionality for thousands of
users with different goals. Perfetti also observed that by trying to satisfy the needs of all users, designers often fail to satisfy the needs of any single user.

2.4 Search behavior in the physical world

There is a lot of literature on search behavior in the physical world. Many papers focus on the buying behavior of people in the marketing sector (e.g., [106, 87, 186]) (when people are buying products they implicitly show search behavior) or on searching in the library (e.g., [34, 36, 224]). Both domains show comparable search behavior that are relevant to our research. Below we provide some results on these behaviors.

2.4.1 Impulsive search behavior

Hausman [106] states that a lot of people are buying products impulsively as an alternative to a more time-consuming rational search behavior. Impulsive buying is a spontaneous and immediate purchase behavior [87] in which the consumer buys a product that he was not actively looking for and had no prior plans to purchase [39]. Recall that wild searching (see Chapter 1 for the definition) shows something similar. People may change their mind when they get new information in their search process while realizing their goals. Imagine that someone is looking for a science fiction book in a bookstore. While he is there, he notices that one of his favorite authors, J.K. Rowling, is present to sign Harry Potter books. Presuming that this is a one time opportunity the user may change his mind and buy a Harry Potter book (an adventure genre) instead of a science fiction book. The example shows a combination of two different behaviors: a behavior in which the user changes his mind (not buying a science fiction book as intended), and a spontaneous behavior (buying a book he did not intend to buy).

2.4.2 Epistemic and hedonic search strategies

The consumer’s retail search process (CRSP) framework of Titus and Everett [223] employs epistemic search strategies and hedonic search strategies.
Epistemic search strategies

Epistemic search strategies include strategies that rely on consumer’s spatial knowledge (or cognitive map) of the shopping environment [186], or strategies that require the assistance of others (e.g., store employees, other patrons) when consumers get lost [237]. According to Babin, Darden, and Griffin [25] consumers who utilize epistemic search strategies are problem-solvers and are susceptible to “utilitarian” shopping trips. These consumers are concerned with efficiency and want to complete their shopping trips at the soonest possible time. Therefore, they plan their purchases and move through the store as quickly as they can [96].

Hedonic search strategies

Hedonic search strategies comprise the experiential aspect of the retail search activity [108]. Bloch, Ridgway, and Sherrell [51] claim that consumers often resort to a browsing activity for obtaining recreational benefits. Consumers who want to shop likely use hedonic search strategies when they are unfamiliar with their shopping environment and, thus, proceed more slowly while valuing environmental sensory stimulation. They have a higher tendency to make impulsive purchases [96].

2.4.3 Navigation types and navigation aids

Benyon and Höök [69] identify three types of navigation: wayfinding, exploration, and object identification. Svensson [216] has added social navigation to this list.

1. Wayfinding

Wayfinding is the activity of going from one place to another in which the following 5 navigation activities based on Satalich [200] are equally important:

(a) Orienting oneself in the environment,
(b) Choosing the correct route,
(c) Monitoring the route,
(d) Recognizing that the destination has been reached, and
(e) Choosing or formulating a destination.
A user who is navigating has to orient himself in the environment, choose a route, monitor the route, and finally, recognize that the destination has been reached.

2. Exploration
Exploration is navigation without a specific destination. People are not so much interested in a specific location, but they are more interested in exploring the space they are in. They are more open to following a crowd of people or randomly choosing a route; destination and correct route are of less importance.

3. Object identification
Object identification deals with new spaces. Spaces consist of objects. In new spaces the first thing people do is to identify the different objects and their respective attributes such as identifying the reference points (the so-called landmarks). Then people generalize from past experiences.

4. Social navigation
Svensson [216] has named another navigation type: social navigation. This navigation type is based on what others have done in the past or on the advice provided by others (e.g., follow people, ask a friend). Svensson [215] and Dieberger [77] make a difference between direct social navigation and indirect social navigation.

- In direct social navigation the communication is two-way (e.g., talking) between the user (i.e., the seeker) and others (e.g., a person or artificial agent). A user can ask questions like “Where am I?” or “Where can I find location X?” to someone. This person answers the user and, perhaps more importantly, can ask the user to clarify his questions. The person can, thus, help clarify a user’s goal or even change it. When a user is uncertain of where he wants to go, the adviser can support him in formulating a destination [216].
In *indirect social navigation* the communication is in one direction only. This means that advisers (e.g., a shop assistance, an employee)\textsuperscript{2} do not have to be aware of the fact that they are giving advice (e.g., by showing the user a path to a department) [216].

**Navigational aids**

When users do not have complete knowledge of a space, and hence, they have to use various navigational aids (or external sources of information) to find their way. We can group the navigational aids into three main groups: landmarks, signs, and maps.

1. **Landmarks** are objects in a space (e.g., “just behind the shopping mall” in geographic space, but these are analogies in information space) that serve as reference points to people [143]. They form the basic building blocks of our mental representations of a space. We use landmarks as a means to structure space because we seldom have complete knowledge of a space. They are key points that we can turn to when we are lost, or when we have to re-orient ourselves in the environment [216].

2. **Signs** are often used as a navigational aid in complex environments. Airports and railway stations frequently use signs as a means to aid users in finding their way in the environment. Signs are an effective way to guide people in the right direction [57].

3. **Maps** are survey representations of an environment. We typically find two variants of the basic map: you-are-here maps (a map that marks the position of the person looking at it), and route maps (maps with an explicit route marked) [216]. Maps are used in all sorts of navigational situations. The problem with maps is that they are often complex as they require a lot of training to become a good map-reader.

\textsuperscript{2}A good example of indirect social navigation is “Follow the Skoda driver” on Youtube (http://www.youtube.com/watch?v=FOM7zpEDa0c). In this video clip you see a man buying an electric drill. When this man notes at the cash desk that the man before him, who also is buying an electric drill, is a Skoda driver, he changes his electric drill and gets the same one as the Skoda driver.
2.5 Search behavior on the World Wide Web

Spool [211] mentions that according to the User Interface Engineering Group 54% of the users find their information by surfing. This is due to the many search attempts the users make during surfing compared to a search with a search engine. Users keep surfing even when they have found the information they were looking for.

Search behavior and navigation behavior are not only determined and influenced by the number of clicks but also by some other factors, like perception, vocabulary, thesaurus, spatial cognition, organizational structure, organizational schemes, cultural differences, education, cognition, memory, and senses (see also McCracken and Wolfe [153]). However, there are some commonalities in how people think and perceive that provide a useful set of considerations for web design and, in particular, for the design of navigation systems. Studies in cognitive psychology and social sciences can provide us more insight into how people perceive, learn, remember, and behave in certain circumstances.

Alvarado, Teevan, Ackerman, and Karger [21] did a study to understand what people do with their electronic information. They focused, in particular, on situations in which people reported exerting effort in locating information. They found that people often had an association between the information they looked for and the related contextual information. For example, a participant might know she could find the phone number of a restaurant in a particular email from a colleague. In many of these cases, people were able to associate their information target with a particular source. People often oriented themselves to targets they had seen before, and apparently used different contextual information than in cases when they had not seen their target previously.

Nordlie [177] has found that users have some preferred information sources like personal contacts, meetings, conferences, database searches or the library. She also found that users have a preference for verbal media or verbal communication. Therefore, most of the problems are mainly solved by asking colleagues, peers or perceived subject experts. Users also try their personal files or access external data sources to find a solution for their problem. Nordlie observed that when users search on-line, they do simple searches. Users perform short and general queries. Searches on the WWW are also short and simple. When users use search engines they use the well-known web search engines. Nordlie found a few problems in on-line searching which
include lexical problems (spelling and typing), syntactic problems (failure to comply with the system’s formal rules) and semantic problems (failure to express the problem in appropriate terminology). Fifty percent of all the errors were of semantic nature. According to Nordlie, users prefer an uncluttered presentation of the search results. The search results should be presented in a meaningful ranking, in an appropriate number, and it should be easy to interpret.

Bates [32] describes twenty nine search tactics which are ordered in four categories: monitoring, file structure, search formulation, and term. Furthermore, she distinguishes four different sorts of models of search strategy: models for idealizing searching, models for representing searching, models for teaching searching, and models for facilitating searching. The purpose of these models is to suggest tactics that are likely to improve the effectiveness or efficiency of a search. A tactic may be good in one situation and not in another. In general, it may be assumed that the most efficient search involves using sources for their intended purposes. But when such approaches fail, answers may still be found by putting in the harder work to ferret out information incidentally provided (i.e., to use a source for other than its intended purpose).

Like Nordlie [177], Bhavani and Bates [44] also found that searchers use short and simple queries on the Web. Users build little on previous experience and learn slower with age. According to a study of Lazar [136] and Nielsen [168] users do not learn from visit to visit because most users spend a small amount of time on a large number of websites.

Kelly and Cool [129] considered two types of information search behavior indicators: reading time and efficacy. Their results indicate that as one’s familiarity with a topic increases, one’s searching efficacy increases and one’s reading time decreases. There are several variables that effect reading time which Kelly et al. have not taken into account such as individual reading effort. In our opinion this should have been taken into account as it is an important aspect which influences reading time.

Dahlbäck, Höök, and M. Sjölinder [70] did a study on spatial cognition and its relationship to hypermedia navigation. Their results show that a distinction can be made between two kinds of spatial cognition. One that concerns the concomitant acting in the physical world, and one that is a pure internal mental activity.

Benyon and Murray [40] found that spatial ability determined how well users performed with different interfaces to a database system. Users with
low spatial ability performed better with an aided navigation interface with a constrained dialogue, while users with high spatial ability made better use of a non-aided navigation interface with a flexible command-based dialogue.

Vicente and Willeges [233] have shown that users with low spatial ability are helped by a system where parts of the previous state of the interface are visible after the user has made an action at the interface.

Maglio and Barrett [146] sketched a model of how people search for information on the WWW. They focused on the cognitive properties and internal representations used in the search for information. They first collected behavioral data from individuals searching for answers to specific questions on the WWW, and then analyzed these data to learn what searchers were doing and thinking. One finding was that individuals focus on key nodes when recalling their searches, and that these key nodes help structure memory. A second finding was that people tend to use the same search patterns over and over, and that they recall their searches in terms of their standard patterns - regardless of what they actually did. Overall, their results suggest that people form cognitive maps of web space in a similar way that they form cognitive maps of physical space.

Catledge and Pitkow [61] and Tauscher and Greenberg [218, 219] analyzed several weeks worth of normal web usage gathered from dozens of college students. Both studies found that web users do not often traverse the same long sequence of nodes more than once. As Maglio and Barrett [146] have shown in their study, participants were unable to recall and therefore repeat specific sequences of URLs (Universal Resource Locator) even when explicitly asked to do so. Tauscher and Greenberg also found that web users have about a 60% probability of revisiting web pages they have previously visited. In Maglio and Barrett’s study, participants were more apt to re-find anchor points than to re-find sequences. People do not follow the same trails because they do not remember their trails: they remember generic procedures and particular anchor points.

Bates [37] argued that searching becomes one behavior within a general model of human information-related behaviors (see Table 2.1). Human tendencies to use the principle of least effort, and more generally, to be quite passive in information seeking, may come about because so much needed information has come automatically from the social milieux of most people throughout the history of humanity.

Many goals of users, who are seeking for information, may be long-term in nature. These goals may not be easily decomposed into sub-goals that
can be translated into immediate actions. Suitable courses of action may not have been available at the time those goals were formed. It could also be that the user may have decided that the effort required to pursue the goal at this time outweighs the benefit of its achievement (see also Chapter 8). In this respect Zeigarnik [250] showed that uncompleted tasks are remembered better than completed ones. A glimpse can trigger the awareness of a possible solution to a problem, coupled with the typical abundance of latent interests stored in a user’s long-term memory. De Bruijn and Spence [73] define two classes of browsing for this serendipitous activity.

- **Opportunistic browsing** is an intentional browsing behavior in which the user is unaware of any goal being pursued. The user’s attitude is “let’s see what’s there”.

- **Involuntary browsing** is an unintentional browsing behavior in which the user is unaware of any latent goal that might be pursued.

De Bruijn and Spence defined a third type of browsing which is called **search browsing** and is not serendipitous in intent. Search browsing is an intentional browsing behavior in which the user is aware of the goal being pursued. The goal is defined precisely or otherwise.

### 2.6 Usability and user experience

Many aspects of the preceding sections can be summarized with the terms ‘usability’ and ‘user experience’.

What is **usability**?

Usability is a property of websites (and other systems and products) that
relates to ease of use. For websites it means that usability is making your site easy for your visitors to find the exact information they need when they need it. Anything that makes the process slower (like Flash animation served to a dial-up visitor) deteriorates usability. Conversely, easy, intuitive navigation and strong, informative text enhance usability [14]. Usability is commonly defined as having three core components: effectiveness (how well can a task be completed), efficiency (how easy or quick is it to complete the task), and satisfaction (the user’s perception or opinion of the system) [13].

What is user experience?
User experience focuses on the users’ feeling when they are visiting a website. The aim of user experience is to give users a good feeling. User should have a good feeling before, during, and after visiting a website. Different aspects should be taken into account when talking about user experience like the environment, color moods, touch, audio feedback, visual feedback, trust, branding, show-off effect, usefulness, practicality, coexistence, emotional effect, etcetera [191].

2.6.1 Usability versus user experience

Thomas Baekdal [26] clarified the difference between usability and user experience by means of roads: “A usable road is one that is wide and straight (less mental effort), with no oncoming traffic (less mistakes, less mental effort). One that enables you to get from A to B as fast as possible (more powerful) and one that has a consistent and clear use of signs (high learnability)” (see also Figure 2.1). “In short the most usable road is a freeway. But, a freeway is also directly boring in terms of user experience.”

“A road with a high level of user experience is completely different” (see also Figure 2.2). “It is a twisting mountain road (visual) with great scenery (visual, emotional). You got little friendly signs put out by the local, who sells fruits along your way (show-off effect). Every city is slightly different (branding, emotional, environment). You feel happy when you see the locals wave when you pass by, and you stop to let a sheep pass (emotional, trust, coexistence)”.

“But a mountain road is far from a usable road. It is much harder to drive on, it is difficult to learn, you can not go as fast and the risk of making a mistake (taking a wrong turn or crashing into a sheep) is much greater. But, a mountain road will give you a much better user experience than any
freeway could ever do.”

Our opinion is that usability and user experience can not be seen separately. Usability is a subset of user experience and a key aspect of user experience. Usability answers the question, “Can the user accomplish his goal?” while user experience answers the question, “Did the user have an as delightful experience as possible?”.

One can speak better of ‘less’ or ‘more’ user experience or usability in the example of Thomas Baekdal instead of a difference. In Figure 2.1 you could say that the usability is high while the user experience is low. In Figure 2.2 it is just the opposite, low usability and high user experience.
2.7 Conclusion

This chapter gave an overview on user goals, and search and navigation behavior, and insights on wild searching. The chapter provided us with some factors, which we will use as (observation) categories in the next chapters.

One of the insights we gained from this chapter is that search engines are good for keyword search, the case in which the visitor has a well-defined goal. But they are less effective for wild search, the case in which the visitor has a vague goal and does not have a well-developed plan of action.

Goals may be influenced by usability and user experience factors. By influencing goals one can influence the search behavior in ‘non-web’ situations as well as in web situations. On the WWW this can achieved by optimizing websites for wild search. To find out how we can optimize websites for wild search, we need to know how people are searching in ‘non-web’ situations and how their goals are influenced. This can be done by observing people in ‘non-web’ situations. In Chapter 3 we will first do a pilot study to identify which problems may arise when observing people. After that we observe people in ‘non-web’ situations (see Chapter 4) and on the WWW (see Chapter 5). The categories navigation aids, orientation, epistemic and hedonic search strategies, and social navigation are used in the observations in Chapter 4 and Chapter 5. The following WWW-specific categories are used in Chapter 5: search engines, search options on the website, browser find option, Uniform Resource Locator (URL), bookmarks, and the browser back button.
User goals, search and navigation behavior
Chapter 3

Pilot study: Behavior observations in “non-web” situations

The primary goal of the pilot study, described in this chapter, is to identify potential problems that may arise in empirical studies of observing people or performing experiments. A second goal of the pilot study is to get a first impression of how people search in “non-web” situations and how their goals are influenced. This chapter will provide us additional factors which we will use as (observation) categories in Chapters 4 and 5. In Section 3.2 we give a short description on ethnography to get insight in observation methodologies. In Section 3.3 and 3.4 we respectively develop the methodology and describe the approach.

3.1 Introduction

In this chapter we describe the pilot study that we did to find out what problems may arise in the experimental design for observing people. The solutions for those problems are described in Chapter 4. The observations in this section were done in a variety of “non-web” situations like shopping in a shopping mall or finding the right bus at the bus station, etcetera. We choose for “natural”, i.e. “non-web”, situations to find out how people reason, how their reasoning leads to a particular approach in realizing their goal, and how additional information makes them deviate from their approach. The
results will be used to investigate whether searching in a “non-web” setting shows search opportunities that people appreciate but that currently are not supported on the WWW.

In Section 3.3 we develop the methodology for the pilot study. Section 3.4 describes the approach for the observations in a task-based (i.e., experiments on searching) and a natural setting. Before that, in Section 3.2, we give a description on ethnography to get insight in observation methodologies, especially in observing participants. Section 3.5.1 and 3.5.2 describe the results of the observations and the interviews which we have taken of the participants. In Section 3.6 we discuss the results and discuss the relevance of these results for web design in Section 3.7. This is followed by conclusions in Section 3.8.

3.2 Ethnography

In this section we give a short description on ethnography to get insight in observation methodologies. We discuss different approaches and their pitfalls, and describe how to record the results of ethnography.

3.2.1 What is ethnography all about?

“Ethnography is the scientific study of human social phenomena and communities, through means such as fieldwork or field research. It is considered a branch of cultural anthropology, the branch of anthropology which focuses on the study of human societies” [207]. Ethnography can be considered as a basic form of qualitative social research. The term ethnography refers to the descriptive study of people [221]. In fact, the ethnographic method to acquire knowledge, is a variant on everyday methods to get to know something of the life of other people; it is a mixture of looking at, participating in, and talking to others. This is also called participating observations [152].

3.2.2 The approach

Blomberg [52] mentions that the term ethnography refers both to the process of conducting field research and to the written text produced as a result. According to Blomberg, in the Human Computer Interaction (HCI) and system design communities, ethnography most often refers to an approach used to develop understandings of everyday work practices and technologies
in use. While there is a great deal of variability subsumed within the practice of ethnography, most practitioners share a few basic premises. These include:

- a commitment to studying activities in the “natural” settings in which they occur,
- an interest in developing detailed descriptions of the lived experience,
- a focus on what people actually do, not simply on their accounts of their behavior, and
- a concern with understanding the relation of particular activities to the constellation of activities that characterize a setting.

Blomberg also mentions that it is difficult for individuals to articulate the tacit knowledge and understandings they have of familiar activities when they are practicing ethnography. “Because of this, it is essential that the things people say about their own activities and about the activities of others be supplemented with firsthand observations of behaviors. It is equally important that these observations be made in the actual settings in which the activities typically occur since to remove an activity from its everyday setting is to alter it in fundamental ways (...). It follows, therefore, that there is a strong conviction that field studies form the basis of an ethnographic investigation”.

Observations and interviews can complement each other’s strong and weak points. One can get more information from a goal-oriented interview than from a random chat session. On the other hand a ‘careless’ way of observing subjects may provide you exactly that information of which you were unaware.

A lot of important developments took place in the field of ethnography in the passed two decades. One of those developments is to make recordings or shootings (photos, audio or video) of episodes of social lives or interviews [221, 122]. This makes a detailed study of social life possible.

### 3.2.3 Pitfalls

Initially, ethnography looks simple: participating a little bit, looking at and talking to others. But in practice it is more difficult than it looks like. A lot has been written on field research or on participating observations (among others by Bogdan and Taylor [53], Douglas [79], Hammersley and
Atkinson [99], Ten Have [220], Lofland and Lofland [141], McCall and Simmons [152], and Schatzman and Strauss [201]). All of them focus mainly on the relational side of the work, e.g., how to enter somewhere, how to make good relationships with the informers, etcetera. They also pay attention on the selection of information, the methodology, and the importance of making notes of observations.

It is human nature to describe the observed information in terms of the knowledge one already has, e.g., of the social circumstances of the observed persons, what all kinds of ‘words and actions’ mean, and what the physical environment socially means. New impressions will always and inevitably be placed in your own cognitive, emotional, and moral framework with which you already are familiar. You will automatically act from your presupposition about what is going on, what you could expect, and about what all the kinds of things (like words, gestures, and actions) are worth in the situation where they came across. The challenge is of course to replace such presuppositions slowly with the interpretation frameworks, which are used in the field of research by the observed persons themselves.

### 3.2.4 Making notes of observations and interviews

Making field notes is an essential part of field research as such. The essence of field research lies in the combination of observing and writing, of looking at and listening to on the one hand, and expressing and recording the results of the field research on the other hand. Lofland & Lofland [141] propose the following process of note taking:

A. **Mental Notes:** Focus one’s attention on the things you should note later, like the basis information of the scenes and the episodes, and the remarkable events in it.

B. **Jotted Notes:** Making short notes during or immediately after the observations; use short words or quotations as reminders. Sometimes there are opportunities to make detailed notes or to work out earlier notes.

C. **Full Field Notes:** Working out the notes to complete reports. This should not be done later than the morning of the next day because new experiences push the old ones to the background. That is why one should note the last ones first. Writing stimulates the reflection on the events which should be noted too.
Note taking is thus a way to report chronologically of what happened in the field and what you as researcher have experienced. It is a continuous description of people, events, what you heard, conversations of and with people in the field, and also descriptions of the physical environment.

One important development in the field of ethnography is to make recordings or shootings by means of photos, audio or video [221, 122]. These means give, besides a chronological report, the opportunity to study in detail what happened in the field. One should note that these means interfere with the situation if they are not put discreet or if the observed participants are not used to it.

Our study is based on field studies and interviews which we describe in Section 3.3 and 3.4. We decided not to use video, since we could not afford to accustom our observants to this situation for the relatively short duration of the actual observation. We followed the process of note taking of Lofland & Lofland [141] as much as possible for noting the observations of and interviews with the participants.

3.3 Methodology

It should be obvious from Section 3.2 that ethnography is a good way to observe and understand people. Nevertheless, we use a ‘quick and dirty’ ethnography in this pilot study as we primarily want to identify what problems may arise in empirical studies when observing people: are we asking the right questions to get the right answers for the tasks, are we using the right setting, are we approaching the people right, etcetera. Different from observing in a natural setting, to observe people in a task-based setting is in fact not ethnography; it is an experiment where we observe in a manipulated setting (i.e., people have to fulfil some tasks).

The pilot study consisted of two kinds of observations: ethnography and task-based observations. We observed people in their natural setting (group N) and in a task-based setting (group T). We added the task-based setting because sometimes people are forced to search because they are triggered by a task. After the observations the participants were interviewed to cross-validate and to understand the search behavior observations.
3.4 Approach

3.4.1 Participants in task-based setting (group T)

We observed five participants completing different tasks. Those tasks are described in Section 3.4.3. Each participant had to complete two tasks (see also Table 3.1). Three participants were computer science students (one in the fourth year and two in the third year) from the department of computer science from VU University Amsterdam in Amsterdam, the Netherlands. They were approached by email in which they were asked whether they wanted to take part in this research. When they were willing to participate in the research they were invited for an introductory meeting. In this meeting they were explained in detail what the research was all about and what tasks they were supposed to do. During the meeting an appointment was made to do the tasks. The other two participants were from the circle of friends of the author. They were approached personally. Table 3.1 shows the participants and the tasks they completed. The participants are called $P_{t1}$, $P_{t2}$, $P_{t3}$, $P_{t4}$, and $P_{t5}$ because of the anonymity.

All the participants were informed about the following:

1. The goal of this study. The participants were informed about the goal of this study and that it was a part of a major research project.

2. The observation procedure.

3. The interviews. The participants were informed that they would be interviewed after the observations and that the interview would take 5-10 minutes.

4. Their privacy. The participant were informed about the procedures to guard their privacy. No names were recorded. In the observation results the participants were referred by $P_{t1}$, $P_{t2}$, $P_{t3}$, $P_{t4}$, and $P_{t5}$.

The participants were interviewed after they had completed a task. We did this to find out why they took a certain action and how their reasoning led them to a particular approach in realizing their goal.

In section (Section 3.4.3) we give a description of the tasks the participants had to complete.
3.4.2 Participants in natural settings (group N)

We observed fifteen participants in different natural settings. All the participants were first asked for their permission to be followed and to be observed. As in the task-based setting all the participants in the natural setting were informed about the following:

1. The goal of this study. The participants were informed about the goal of this study and that it was a part of a major research project.

2. The observation procedure.

3. The interviews. The participants were informed that they would be interviewed after the observations and that the interview would take 5-10 minutes.

4. Their privacy. The participants were informed about the procedures to guard their privacy. No names were recorded. In the observation results the participants were referred by \( P_{n1} \) up to and including \( P_{n15} \).

Subsequently the observation session started. An observation session ended when the participant had realized his goal or when he indicated that he had finished. After the observation session some of the participants were interviewed. Table 3.2 shows the number of participants in the different cities. The number of observations, which in this case is equal to the number of participants, is given by \( N \).

3.4.3 Task description for task-based observations (group T)

1. \textit{CD-search 1}

For this task the participant had to answer three search questions.

<table>
<thead>
<tr>
<th>Participants</th>
<th>CD-search 1</th>
<th>CD-search 2</th>
<th>Book search in study</th>
<th>Book search in library</th>
<th>Book search in bookstore</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P_{11} )</td>
<td></td>
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<td>X</td>
<td>X</td>
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<td>( P_{12} )</td>
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<td>( P_{13} )</td>
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<td>( P_{14} )</td>
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<td>( P_{15} )</td>
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</tr>
</tbody>
</table>

Table 3.1: Participants and the tasks they had to complete.
These questions were formulated at three levels of difficulty, namely: basic, intermediate, and difficult. The observations were done in a video shop in Amsterdam that sold movies as well as CDs. This video shop had two CD boxes with approximately 300 CDs. One CD box contained CDs with movie songs and the other one contained CDs with non-movie songs. The participant did not get any explanation about how the CDs were organized in the CD boxes nor did he get the information about the difference between the two CD boxes. The participant had to find out himself.

(a) At the basic level the question was formulated as follows: Look up the CD of ‘Pretty Woman’.

(b) The formulation at the intermediate level was: Who sung the song ‘Where Are You Tonight?’ from the movie ‘Dirty Dancing’?

(c) At the difficult level the formulation was: Who sung the song ‘In the plane’?

The participant was handed all the three tasks on paper. He got three separate sheets with one task at a time. There was no time restriction to perform the tasks. The only restriction was that the participant had to use the CD boxes to look up the CDs in order to answer the above questions. The participant had to show the particular CD. In this way the possibility of giving an answer without looking up the CD in the CD box was eliminated (this might happen when the participant would know the answer by heart). For level c the participant had to figure out the movie name first in order to find the performing artist of the song. The participant was free to ask any questions to the shop assistant.
2. **CD-search 2**

This task was a modification of the first task, CD-search 1. The differences with task one were that the participant got an explanation of how the CD boxes were organized and what the differences were between the two CD boxes. Because both tasks one and two (CD search 1 and 2) were carried out by the same participant the titles of CDs and songs for this task were different from the ones used in task one. The search questions were formulated as follows:

(a) Basic level formulation: Look up the CD of ‘The Matrix’.
(b) Intermediate level formulation: Who sung the song ‘Walking On Sunshine’ from the movie ‘Daddy Day Care’?
(c) Difficult level formulation: Who sung the song ‘The Trouble With Love Is’?

3. **Book search in study**

This task consisted also of three search questions increasing in the level of difficulty like in task one (CD-search 1). The assignment was given in a teacher’s study in Amsterdam. The teacher’s study had one bookcase with four bookshelves with about 100 English and Dutch books in total. The books were arranged on disciplines instead of alphabetically by author. Two main disciplines could be distinguished at first sight: computer science and social science. The search questions were formulated as follows:

(a) Basic level formulation: Look up the book named ‘Web Design with XML’. (An English book)
(b) Intermediate level formulation: Who wrote the book named ‘Sucess door groot denken’. (A Dutch book)
(c) Difficult level formulation: On what page does the chapter ‘De magie van de stem’ start in the book named ‘Spreken is goud’? (A Dutch book)

The questions were given on paper. The participant got three separate sheets with one task at a time. No explanation was given to the participant about the organization of the bookcase. There was no time restriction to answer the questions. The participant was not allowed to ask any questions to the teacher. All information needed could be found on the bookshelves.
4. *Book search in the library*

In this task the participant was supposed to find two books, a chemistry book and a computer science book, in the faculty library of his university in Amsterdam. The title, author, and the ISBN number were given on paper. The books the participant was supposed to find were:

Title: Organic chemistry  
Author: Jones, Maitland  
ISBN: 0-393-97405-7

Title: The Java\textsuperscript{TM} programming language  
Author: Arnold, Ken  
ISBN: 0-201-63455-4

The computer science book and the chemistry book were intentionally chosen because the participants were from the computer science department. In order to find out whether they were able to find books from other disciplines a chemistry book was chosen as well. The participants were free to consult the digital database of the library which was accessible through any computer with an Internet connection. There was no time restriction or restriction to ask questions to the assistant at the counter of the library. The participants were allowed to use any pointers available in the library, like manuals for searching a book in the faculty library.

5. *Book search in a bookstore*

This task resembles the task mentioned in ‘Book search in the library’. The participants were presented three situations (see below) with little differences. In all these situations the participants were supposed to buy a book for their friend’s birthday at the bookstore of their university. The participants were supposed to select the best gift (i.e., book) based on the information they received at that moment in all the situations. The three situations are listed below:

(a) In the first situation the participants were presented the title of the book that their virtual friend wished for. The author, and the ISBN number of the book were known.
(b) In the second situation the participants were given the virtual friend’s favorite genre, “psychology”. No title, author or ISBN number were given.

(c) In the last situation the participants were given the virtual friend’s favorite author name, “Scott Vintrella”.

All the three situations were presented one by one to the participants. There were no restrictions for completing this task.

3.4.4 Observation locations for natural settings (group N)

The observations were done in shopping malls and street markets where people had the possibility to choose different things or substitutes for the things they were looking for.

Some observations were done in Utrecht (the Netherlands) because of the very big shopping mall, Hoog Catharijne. Hoog Catharijne is located at the central station of Utrecht where people can do their shopping, eat some food, have some drinks, take trains, buses, trams, and taxis for transportation, do their bank business, and many things more. Hoog Catharijne is the shopping heart of the Netherlands with around 160 shops (see Corio Nederland Retail [195]). People can choose from a big variety of fashion and food, multimedia, personal care, and specialist shops. With its elevators and the broad passageways Hoog Catharijne is easy accessible for many people. Hoog Catharijne offers a lot for a whole day of shopping.

A few observations were done in the City Center of Amsterdam (the Netherlands). The City Center has a lot of shops and some big department stores. The observations were mainly done in the big well-known shopping streets (Kalverstraat, Rokin, and Damrak) of the City Center. These streets have many souvenir shops as a lot of tourists visit this area.

Other observations were done during a visit to the Golden City in Dubai (United Arab Emirates) and the City Center of Brussels (Belgium). The Golden City is the biggest shopping mall for gold jewelry in Dubai. A lot of tourists visit this location. One of the famous tourist attractions in the City Center of Brussels is the Grote Markt. The Grote Markt has a lot of
outdoor cafes, restaurants, and hotels. In the City Center one can also find souvenir shops and sights like *Manneken Pis*.

### 3.4.5 Interviews

Almost all (some participants did not have time to be interviewed) the participants were interviewed after the observations. We interviewed the participants to cross-validate the search behavior observations about the participants (How accurate are our observations?). The interviews were also taken to find out how the participants were reasoning, how their reasoning led to a particular approach in realizing their goal, and how additional information made them deviate from their approach (What is the meaning behind our observations?). As all participants were Dutch native speakers, the interviews were held in Dutch. The answers of the participants were written down.

### 3.4.6 Recording observations and interviews for group N and T

We followed the process of note taking of Lofland & Lofland [141] as much as possible for noting the observations of and interviews with the participants.

### 3.5 Results

It was not easy to find participants who wanted to participate in the pilot study. This was probably because, in general, this kind of observations demands a lot from the participants. Another reason is that participating in the pilot study was a volunteer job. People were not rewarded in a material way for their cooperation. Many people did not have the time and therefore did not want to spend time on the pilot study. Some of them did not want to participate because of privacy reasons. Others did not like to be observed. In Chapter 4 we have adapted the methodology to get as many participants as possible. In Section 3.5.1 we describe the results of the observations and interviews of participants who had to complete a task. Section 3.5.2 describes the results of the observations and interviews of participants in their natural settings.
3.5.1 Observation of group T and their interview

In this section we describe the observation and the interview results per task (see also Table 3.1) for group T.

**CD-search 1 and CD-search 2** (see page 35 and 37).

*Observation*
Participant P4 did the CD-search 1 and CD-search 2 tasks. For the question of the basic level (see also page 35, CD-search 1, level a) of CD-search 1 the participant walked to the first CD box and inspected the CD box from top to bottom. After a while he asked the shop assistant whether the CD-title referred to a movie or not. The shop assistant answered with ‘yes’. The participant asked one or more times for help to the shop assistant in order to be successful, i.e., to complete the task. In particular this was the case for the question at the difficult level. The search time to complete the CD-search 2 task was shorter than the time to complete the CD-search 1 task (6 versus 8 min.).

*Interview*
In the interview the participant indicated that he was initially exploring the two CD boxes to find out how it was organized. Subsequently he sought the first letter of a CD-title (this was done after he had decided from what movie the song was). He read the whole CD-title when the first letter of the movie matched the first letter of the CD-title. The participant indicated that he learned from question one and two of the CD-search 1 task: he discovered that the CDs with long titles were at the top of CD box one.

**Book search in study** (see page 37)

*Observation*
This task was done by participant P5. Before looking up the books the participant stood in front of the bookshelves for a few minutes. He inspected the bookshelves from top to bottom. After that he looked up the books. To answer question c of this task he consulted the table of contents. The participant spent 13 minutes to find all three books.

*Interview*
In the interview the participant said that he could not discover any pattern or structure in the bookshelves. He had expected that the books were ar-
ranged in alphabetical order by author. Because this was not the case it was
difficult for him to find the requested books. Question c was easy to answer
for him (after he had found the book) because of the tables of contents.
According the participant it is a natural thing that chapters are listed in the
table of contents.

**Book search in the library** (see page 38)

*Observation*

This task was done by $P_{t1}$, $P_{t2}$, and $P_{t3}$. Participants $P_{t1}$ and $P_{t2}$ walked
from the bookshelves in the library to the computers to look for information.
They went to the counter to ask the employee for help when they could
not find the information they were looking for. They did this several times.
When they finally got the book code they had problems with finding the
location of the book in the library. They found the location with the help
of the employee at the counter and the signposts in the library.

Participant $P_{t3}$ consulted the digital database of the library. This par-
ticipant did a search on the ISBN number instead of the title. Participant
$P_{t3}$ did not ask anyone for help. The search time of this participant was
remarkably shorter than the search time of participants $P_{t1}$ and $P_{t2}$. He
found the book within 5 minutes.

*Interview*

Participants $P_{t1}$ and $P_{t2}$ indicated that they were not familiar with their fac-
ulty library. They expected that the books were arranged by author’s name
instead on book codes. Participant $P_{t1}$ did not know how to use the digital
database of the library while participant $P_{t2}$ did not know the difference
between ISBN and ISSN numbers.\(^1\)

Participant $P_{t3}$ was familiar with the library. This participant mentioned
that a search should not take too long. Participant $P_{t3}$ did a search on the
ISBN number because the ISBN number is a unique number. A search on
the ISBN number reduces the number of hits to one or none. According to
participant $P_{t3}$ a search should be short and simple.

\(^1\)ISBN stands for International Standard Book Number and ISSN stands for Interna-
tional Standard Serial Number.
Results 43

Book search in a bookstore (see page 38)

Observation
This task was done by four participants, \( P_{t1}, P_{t2}, P_{t3}, \) and \( P_{t5} \). Participants \( P_{t1} \) and \( P_{t2} \) initially tried to look up the book in the bookshelves (situation \( a \) of this task, see also page 38). When they could not find the book they asked the assistant at the counter for the book. Participant \( P_{t3} \) and \( P_{t5} \) did not try to look up the book themselves, but they asked the employee directly for the book.

For situation \( b \) (see page 38) all four participants asked the assistant where they could find the particular genre and looked up a book of the particular genre themselves.

For situation \( c \) (see page 38) participants \( P_{t3} \) and \( P_{t5} \) asked the assistant for a list of titles of the particular author. Subsequently they made their choice from that list. Participant \( P_{t1} \) on the other hand asked the assistant were he could find some books of this particular author. He then looked up a book at the indicated location by the assistant. Participant \( P_{t2} \) walked in the bookstore and looked around. When he found a few books of the author he selected one.

Interview
Participant \( P_{t3} \) indicated in the interview that it was more efficient to ask the assistant directly for help than to search himself first. The reason the participant gave was that the shop assistant knows better where the books are located and what books they have in house. Participant \( P_{t1}, P_{t2}, \) and \( P_{t5} \) agreed that it is sometimes better to ask the shop assistant first than to try yourself. Participant \( P_{t5} \) said that this is certainly the case when you are in a hurry or when you have little time.

Task-based observations tabulated
To get an overview of the participants' search behavior, we put the observed results based on the tasks the participants had to complete in a table (see Table 3.3). In the table we make a distinction between searching without help, searching with direct help, and searching with indirect help. We do this because we observed mainly these behaviors during our observations. In Table 3.3 “searching without help” means that the participant did not need any help from a person, while “searching with direct help” refers to that the participant asked for direct help or information from a person. “Searching
Table 3.3: Task-based observations tabulated. $N = 10$.

with indirect help” refers to that the participant has tried himself first to complete the task. But when he was not successful he asked a person for assistance in order to pursue his search. In the last column of Table 3.3 all the sources, e.g., information desk, signposts, flyers, books, computers, manuals, etc, the participant used to complete the task are summarized. The number of observations is given by $N$.

3.5.2 Observation of group N and their interview

In this section we describe the observation and the interview results per participant in their natural setting (see also Table 3.2). Most of the participants had little time to participate in the experiment. For this reason we kept the interviews very short. We did not ask more than one or two questions. Some participants were not interviewed at all because of lack of time.
Observations in Utrecht

Four participants were observed in Utrecht at different locations in Hoog Catharijne. In this section the observations and interview per participant are described. The participants are denoted by $P_{n1}$ up to and including $P_{n4}$.

Participant $P_{n1}$

Observation
This female participant was shopping in a big department store. She was looking for a ladies’ jacket. When she entered the department store she looked up the ladies department at the signpost. She went to the ladies’ department. There she tried to find the jacket section. But she could not find it. Then she asked a shop assistant for the jacket section. The shop assistant told her how to get there. While she was going to the jacket section she was distracted by ladies’ underwear. After a while she went to the jacket section. She was not so long there because she could not find a nice jacket. After that she left the department store.

Interview
We asked the woman why she stopped at the ladies’ underwear section while she was looking for a ladies’ jacket. She said that she was distracted by the ladies’ underwear because her mother-in-law sews ladies’ underwear.

Participant $P_{n2}$

Observation
This participant wanted to go to Rotterdam by train. The participant has just arrived at the bus station in Hoog Catharijne and had to buy a train ticket. At the bus station the participant asked one person where to buy train tickets. The person told the participant that he could buy tickets in the central hall of Hoog Catharijne. The person also showed the participant where the entrance was to Hoog Catharijne. When the participant entered Hoog Catharijne he did not know where to go. He asked another man the way to the central hall. This man told him the way. The participant walked in the indicated direction. But the participant did not succeed in finding the central hall. Then the participant asked another man. This man was going to the central hall. He told the participant that he could walk with him to the central hall. The participant bought a train ticket in the central hall at the ticket office. Then the participant looked up the time and track number.
at the big display with the train schedules in the central hall. After that he walked to his train.

Participant $P_{n3}$

Observation
This participant was in a food court with her child and wanted to buy a meal. She ordered French fries and a coke for herself. Her child wanted the kid’s meal. The child only consumed the drink from the meal and a few fries. The rest of the fries and the hamburger were consumed by his mother.

Interview
We asked the woman whether the child always has a kid’s meal. She answered that her child indeed always has a kid’s meal because of the toy one receives when one orders a kid’s meal.

Participant $P_{n4}$

Observation
This participant wanted to buy a nightdress for her mother-in-law. She knew her mother-in-law’s taste. She also knew in which shop her mother-in-law often bought her dresses. The participant went to that particular shop. It was a small shop. She looked at the different dresses and the sizes. She knew what size her mother-in-law was wearing. She got this information from her father-in-law. In the shop the participant’s husband saw a nightdress which he liked for his wife, the participant. The participant and her husband were discussing with each other about the dress. Finally, they agreed to buy that particular dress. The participant continued to look for the nightdress for her mother-in-law. She found one with long sleeves and beautiful designs. She was sure that her mother-in-law would like this one. She bought both dresses.

Observations in Amsterdam

Seven participants were observed in Amsterdam in the shopping streets of the City Center. This section describes the observations and interviews per participant. The participants are denoted by $P_{n5}$ up to and including $P_{n11}$. 
Participant $P_{n5}$

*Observation*

This participant was a lady. She was looking for a long dress in a big department store. When she entered the store she looked at the perfumes on the ground floor. She visited a few perfume stands and after that she went on to the section with ladies clothing. There she looked around between the other clothes. The lady did not find the long dress she was looking for in this shop. She did not ask any person for any assistance nor did she visit the other floors.

*Interview*

We asked the participant what she was looking for at the perfume stands. She said that she was just looking at the new things and the prices to compare to the prices in other shops.

Participant $P_{n6}$

*Observation*

The second participant was a man who wanted to buy a bus and tram card at the tobacconist. While he was walking in a busy street he looked left and right for a tobacconist. In his search he met someone he knew with whom he had a little chat. After that he continued his search. When he found the tobacconist he entered the tobacconist. There the shop assistant asked the participant whether she could help him. He said ‘yes’ and asked for a bus and tram card. He also bought a packet of cigarettes. After that he paid the shop assistant and left the tobacconist.

*Interview*

We asked the man why he bought a packet of cigarettes while he just needed a bus and tram card. He answered that he needed the cigarettes anyhow as he is smoking a lot. Therefore he bought it as he was at the tobacconist anyway.

Participant $P_{n7}$

*Observation*

This participant was shopping in a big department store. She was looking at the clothes in the ladies section. The woman was not looking for a particular dress. She was just looking at the different lady dresses. After that she went to the shoes section where she tried on one pair of shoes. Then
she went to the children section. There she looked at pants and pyjamas. She liked one of the pyjamas and removed that from the shelf. She looked for size 146 on the shelf. After that she continued to the sweaters, looked at a few sweaters and went on to the cashier. There she paid for the pyjamas.

**Interview**
The woman was asked why she bought the pyjamas while she was not intending to buy anything in this store. She answered that when she saw the pyjamas she liked it for her little son. That is why she bought it.

**Participant Pn8**

**Observation**
This participant was a tourist with three other men. They were going to a Chinese restaurant in the City Center of Amsterdam by tram. They asked the tram driver where they should get off. The tram driver explained to them at which stop they should get off and that he would announce it. When the tram driver did so, the participant and his companions got off. The participant walked in the direction the tram driver told him to. After a while the participant asked a pedestrian for the restaurant as he could not find the street. The participant showed the pedestrian the name of the restaurant and the address. This pedestrian did not know the restaurant but he knew the street. He showed the participant in which direction he had to walk. The participant did so. During his search the participant was looking at the street corners for the street names. The participant found the restaurant by following the instructions the pedestrian had given him.

**Participant Pn9**

**Observation**
This female participant was in a big bookstore. She was looking for the book “Inkspell” written by Cornelia Funke. When she was in the bookstore she was looking around. At a certain moment she walked to the section with newly arrived books. There she saw the book “Harry Potter and the Half-Blood Prince” written by J.K. Rowling. She took the book and glanced over the book. She said that she was going to buy this book as she has waited a long time for this book to appear. After that she was looking at some other books. Then she started to look for the book she initially wanted to buy (Inkspell). When she could not find the book she asked a shop assistant whether they had the book in stock or not. The shop assistant looked in
their computer system. Unfortunately the book was sold out. The shop assistant had to order the book. The participant said that she would look further in a different bookstore. After that she went to the cashier to pay for Harry Potter.

Interview
The participant was asked why she did not order the book. She answered that it was not that necessary to buy that book as she had Harry Potter now. She would buy that another time.

Participant $P_{n10}$
Observation
This participant wanted to buy socks. He wore socks of a particular brand. He knew exactly in which shop he could find the brand he liked. When he entered the shop he looked up the gentlemens section. He used the signpost to find the gentlemens section. Once he found the gentlemens section he looked at the socks of different colors. He first took a brown colored one. Then he put it away and took a black one. After that he also took a blue one. The striking thing was that he took exactly the right size. When he got two pairs of socks he went to the cashier to pay.

Interview
We asked the man whether he knew beforehand how many socks he wanted to buy and what color. He stated that he did not know how many socks he wanted to buy nor did he know the color. From the interview it appeared that this man’s favorite colors were dark colors, especially black and blue. That explains why he bought those colors. The participant could not indicate why he bought two pairs.

Participant $P_{n11}$
Observation
This participant wanted to buy perfume for herself. She went to a perfume shop where she wanted to buy a perfume of a particular brand. When she entered the perfume shop she did not look up her brand section. She went to a different brand section. One of the shop assistants asked her whether she would like to be helped. The participant said ‘yes’. The shop assistant asked her what kind of odour she was looking for and what kind of odour she liked. She told the shop assistant that she wanted something for
the evening and it should have a sweet odour. The shop assistant showed her a few perfumes which the participant tried. But she did not like them. Then, when she was finished, she went to her brand section and tried some perfumes. Finally, she took a small bottle of perfume and went further to the powder section. She tried some odours there. She took the powder that she liked and bought that together with the perfume. Then she left the shop.

Interview
We asked the woman why she bought the powder while initially she intended to buy perfume only. She answered that she was there anyway and she liked the powder. So, why not buy it directly instead of waiting for the next visit.

Observations in Dubai
Two participants were observed during a visit to the Golden City, the biggest shopping mall for gold jewelry, in Dubai. In this section we describe the observations and interview per participant. The participants are denoted by $P_{n12}$ and $P_{n13}$.

Participant $P_{n12}$
Observation
This participant was looking for a golden wedding set consisting of a necklace, ring, earring, and a bracelet. The participant did not want a modern set or an old-fashioned one. The set should be between a modern and a traditional one. Because of time constraints the participant could not visit all the shops. She had to make a selection of the shops she wanted to visit. This selection was mainly based on the jewelry in the window of the shop. If the shop had jewelry that had appeal for her, she entered the shop and asked the shop assistant to show her some wedding sets. The wedding sets were observed carefully on design and on errors. Besides the design, the price played an important role in making a decision to buy the set. A similar set with a similar design and weight should be cheaper in Dubai than in the Netherlands. When the participant had found a set that was appealing to her, she compared the prices to the prices in the Netherlands and to prices in other shops in the Golden City. The participant finally bought a set at the shop with the lowest price offer. The set consisted of a necklace, ring, and an earring.

Interview
In the interview the participant indicated that the price was more important to her than the number of items in the set. That is why she bought a set with three items instead of four.

**Participant \(P_{n13}\)**

**Observation**
The second participant in Dubai was a man who was looking for a photo camera. He had heard from his colleague in the Netherlands that electronic devices were cheap in Dubai. This man visited almost every photo camera shop whenever he had the chance. He wanted a digital photo camera from Nikon which should not be too expensive. He did not want to spend more than 300 euros for a photo camera. This man could not find a digital camera cheaper than 300 euros. The digital cameras he found cost as much as he would pay in the Netherlands. Therefore, he decided to buy the digital camera in the Netherlands.

**Observations in Brussels**

Two participants were observed in the City Center of Brussels in Belgium. This section describes the observations and interview per participant. The participants are denoted by \(P_{n14}\) and \(P_{n15}\).

**Participant \(P_{n14}\)**

**Observation**
This participant was a woman who was interested in lace. The area of the ‘Grote Markt’ has a lot of souvenir shops. Among these souvenir shops there were some shops specialized in lace. At the ‘Grote Markt’ she visited a few of these shops. She went into the a shop where she looked at the handkerchiefs and some blouses. In a second shop she looked again at handkerchiefs and blouses. She also looked at placemats and purses. When the shop assistant asked her whether she wanted to be helped, the participant said that she was only looking at the things. After a while the participant asked the shop assistant whether she could try on a blouse. The shop assistant said ‘yes’. Then she went with a blouse to the fitting room to try it. She liked the blouse but unfortunately the blouse was a little bit small. She asked the shop assistant whether she had a bigger size, but the shop assistant had not. Then the participant left the shop. In a third shop she saw a similar blouse. There she asked the shop assistant to try on the blouse. But this
time she asked for the proper size first. After that she got a blouse to try. This time the blouse fitted well. The participant bought the blouse but did not leave the shop. Instead of leaving she was looking around the shop. She saw a white kitchen apron which she took. Se walked to the cashpoint to pay. After that she left the shop.

Interview
We asked the participant whether she wanted to buy a particular lace cloth or not. She said that she did not intend to buy anything. She might buy something if she would see something nice. In the interview the participant also said that the blouse was for herself but that the kitchen apron was a present for her daughter.

Participant $P_{n15}$

Observation
This participant wanted to buy bread and soft drinks in a supermarket. When the participant entered the supermarket she looked around. Then she walked into an aisle with chocolates. There she looked at the chocolates. She took two boxes of chocolates. Then she walked to a different aisle. There, she took two soft drinks and walked back to the front to take a shopping basket. She put the chocolates and the soft drinks into the shopping basket. In a different aisle she took one pack of chips. Then she walked to the bread aisle. There she looked at the different breads. Finally she took brown bread. After that she walked to the cashier to pay.

Interview
We asked the participant why she bought the two boxes of chocolates and one pack of chips, when she initially wanted to buy breads and soft drinks. She answered that the two boxes of chocolates were gifts for her friends. She was attracted by the nice looking package of the chocolates. It would be a nice gift. That is why she bought the chocolates. The chips was for herself.

Search observations in natural setting tabulated

In Table 3.4 the observed results of the participants in a natural setting are tabulated to get an overview. The participants are called $P_{n1}$ up to and including $P_{n15}$ because of anonymity. The focus here is on the participant’s search behavior. Similar to the task-based observations a distinction is made
between searching without help, searching with direct help, and searching with indirect help for the tabulation of the search observations in a natural setting. In Table 3.4 “searching without help” means that the participant did not need any help from a person, while “searching with direct help” refers to that the participant asked for direct help or information from a person. “Searching with indirect help” refers to that the participant had tried himself first to realize the goal, but when he was not successful he asked a person for assistance in order to pursue his search. In the column “Used information source” all the sources, e.g., signposts, shop assistants, pedestrians, etc, the participant has used in order to reach his goal are summarized. The column “F/S” indicates whether the participants failed or succeeded in their search, i.e., whether the participant found what he was looking for or not. The last column in Table 3.4 shows whether the participant was attracted by other things or not.

Table 3.4: Search observations in natural settings. F=failure, S(success).

<table>
<thead>
<tr>
<th>Participants</th>
<th>Searching without help</th>
<th>Searching with direct help</th>
<th>Searching with indirect help</th>
<th>Used information sources</th>
<th>F/S</th>
<th>Attracted by something/events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pn1</td>
<td></td>
<td></td>
<td>X</td>
<td>shop assistant, signpost</td>
<td>F</td>
<td>X</td>
</tr>
<tr>
<td>Pn2</td>
<td></td>
<td></td>
<td>X</td>
<td>passer-by, signpost</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>Pn3</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pn4</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pn5</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pn6</td>
<td>X</td>
<td></td>
<td>shop assistant</td>
<td></td>
<td>S</td>
<td>X</td>
</tr>
<tr>
<td>Pn7</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pn8</td>
<td>X</td>
<td></td>
<td>X</td>
<td>tram driver, passer-by, street signs</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>Pn9</td>
<td>X</td>
<td></td>
<td>shop assistant</td>
<td></td>
<td>F</td>
<td>X</td>
</tr>
<tr>
<td>Pn10</td>
<td>X</td>
<td></td>
<td>signpost</td>
<td></td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>Pn11</td>
<td>X</td>
<td></td>
<td>X</td>
<td>shop assistant, shop-window, tourist guide</td>
<td>S</td>
<td>X</td>
</tr>
<tr>
<td>Pn12</td>
<td>X</td>
<td></td>
<td>shop assistant, shop-window, tourist guide</td>
<td></td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>Pn13</td>
<td>X</td>
<td></td>
<td>shop assistant, shop-window, tourist guide</td>
<td></td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Pn14</td>
<td>X</td>
<td></td>
<td>shop assistant, shop-window</td>
<td></td>
<td>S</td>
<td>X</td>
</tr>
<tr>
<td>Pn15</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>S</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 3.4: Search observations in natural settings. F=failure, S(success).
3.6 Discussion

3.6.1 Search observation in natural settings (group N)

Table 3.4 shows that 9 of the 15 participants were distracted by other things during their search. This was especially the case when they could make a connection to other things (e.g., comparing prices or because someone did mention about his goal or just curiosity). The same number of participants tried to do a search with help. This includes direct and indirect help. From the “Used information source” column it is obvious that the participants have a preference for verbal communication. This is in accordance with the results found by Nordlie [177]. In that study Nordlie showed that people indeed have a preference for verbal media or verbal communication.

When we compare the results of search observations in a natural setting with the task-based observations (the control group), we see similar behavior of the participants. Table 3.3 on page 44 shows that most participants used the help of a person in order to complete the task. The column “Used information source” in Table 3.3 indicates that the participants have a preference for verbal communication.

Observations of participants $P_{n4}$, $P_{n6}$, $P_{n7}$, $P_{n9}$, and $P_{n11}$ show that goals of people may change. Goals change because people change their mind. The participants changed their mind because they saw something new they liked, or something that they needed or because they were reminded of something.

Observations of people in a natural setting show that people do not have always a precise goal. In the observation of participant $P_{n3}$ we saw that the mother ordered the kid’s meal for her child. Her child wanted the kid’s meal because of the toy that is served with the kid’s meal and not because of the delicious fries and drink.

Observations of participant $P_{n12}$ show that people have certain conditions when they are looking for things. All those conditions have a certain value for the person. The observation showed that people may give in a bit to their conditions, which makes them deviate a bit from their initial goal. The participant in this case bought a golden wedding set with three items instead of four. Initially, she wanted to buy a set with four items. But for her the price of the set was more important than the number of items in the set. That made her buy a set with three items.

Observations of people in a natural setting also show that when people take an action to come potentially closer to their goal, for example, to find
a nice dress (see also observation $P_{n5}$ on page 47), the action should work. People will leave if they cannot find what they are looking for. Searches should not take much time, otherwise people will leave. People that have more time or are not looking for something specific will stay longer than people looking for something specific and who have little time.

### 3.6.2 Observations task-based setting (group T)

Participants mentioned in the interviews that a search should not take much time. When a search takes too much time participants leave empty-handed. A search should be short and simple as reported by the study of Nordlie [177]. That is why participants sometimes choose an “approach of least effort”. It is easier to ask a shop assistant or some ‘expert’ than to find out the answer oneself. The participants have a preference for short and simple queries. We see indeed as Bates mentioned in her article [37] that people use the principle of least effort in their information seeking if it is more readily available.

The search observations based on tasks show that people do not read sentences word by word when doing a search but scan the word they are looking for in the sentences (e.g., in CD-search tasks 1 and 2 on page 35 and 37). This behavior is also mentioned by Bates [37] and Kwasnik [135]. Familiarity speeds up scanning when people are familiar with the situation, e.g., some people know the most likely location to find what they are looking for and thus where they should start scanning.

People need certain foreknowledge in order to search efficiently and quickly. This knowledge makes searching easier and can be obtained during the search or from some other state in the past. The fact that the participant doing the book search task in the library (page 38) knew that the Java programming language is related to computer science made him go to the computer science section in the library. Familiarity with this particular library environment made it easier for the participant to find his way in the library. This is also stated by Kelly and Cool [129] who mention that as one’s familiarity with a topic increases, one’s searching efficacy increases.

In accordance with Bhavani and Bates [44] we observed that there is a learning effect when people do several searches in the same environment. The learning effect speeds up the search. The learning effect depends on how fast the participant can learn and how easy it is to learn the tool or procedure which is being used to do the search. The environment might influence this effect.
People make use of certain patterns when they are aware of it (e.g., the book search task in the study on page 37). The observation of the participant doing the book search in the study showed that the participant expected certain things in certain places (e.g., it is a natural thing that chapters are listed in the table of contents). When this expectation turns out to be false, people get confused. The observation of the participant doing the book search in the study also shows that the participant used standards, traditional rules, i.e., assuming that books are always arranged in alphabetical order by author. In some cases this is just the easiest way to find the answer to a problem (see also Kelly and Cool [129]).

3.7 Assumptions for web design

One of the goals of this pilot study was to find out how people are searching in “non-web” situations and how their goals are influenced. We believe that the results of the “non-web” situations are also valid for web situations although we do not expect to observe the same search behavior on the WWW. This is because the WWW is an engineered environment while “non-web” situations are ‘natural’, e.g., a street market. Keeping this in mind we translated the results from the “non-web” situations to the WWW. This resulted in some assumptions which are summarized in Table 3.5 on page 57. The validity of these assumptions are disputable as this pilot study was a ‘quick and dirty’ ethnography. In Chapter 4 and Chapter 5 we will see how valid these assumptions are.
<table>
<thead>
<tr>
<th>Assumption 1</th>
<th>Expect flexibility (trade-off) of values.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explanation</strong></td>
<td>Try to establish the value of the user’s conditions and affect that; flexibility pays off.</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td>If someone wants to buy a car which should be green, not too expensive, and have a high entry, you might sell him a red car, if the color is not so important in comparison with the other conditions.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assumption 2</th>
<th>Goals may change.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explanation</strong></td>
<td>New information can lead users to a new direction; variation leads to returning of users.</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td>Instead of buying pants a user can buy an evening dress because, e.g., she is reminded by the atmosphere of the evening dress department that she has a party this weekend.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assumption 3</th>
<th>Goals may be vague or unpredictable.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explanation</strong></td>
<td>Users do not have always a precise goal or the one “expected” by the service provider/web designer. So, make sure you have something more to offer when you want to attract users to your site.</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td>In a museum you can look at paintings but some museums also have a restaurant or cafe like the Museum of London. People may also visit the museum at Sundays to have a cup of coffee.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assumption 4</th>
<th>User actions should work.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explanation</strong></td>
<td>Users have to take certain actions in order to come potentially closer to their goal. So, make sure everything on your site is working.</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td>It is very annoying when you click (the user’s action) on a link and nothing happens. Users may leave the site without reaching any goal (and not buying anything).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assumption 5</th>
<th>Keep as much as possible to the standards.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explanation</strong></td>
<td>Keeping as much as possible to the standards shortens the search time. Standards are familiar for most people and familiarity speeds up the search.</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td>In the Western culture people are used to read from left to right and to find the company logo in the upper left corner on a website. When clicked on the logo people are taken to the homepage of the site.</td>
</tr>
</tbody>
</table>

Table 3.5: First assumptions for web design.
3.8 Conclusion

From the observations of this pilot study we can draw the conclusion that foreknowledge and familiarity are necessary to make connections with the knowledge already present. Once one has made the connection, the thought process gets clearer and this makes it easier for people to perform a successful search.

Besides foreknowledge and familiarity the search is also sped up by the learning effect. The learning effect depends on how fast people can learn and how easy it is to learn the tool or procedure which is being used to do the search. The environment might influence this effect.

In order to search quickly, people do not read sentences word by word but scan the word they are looking for in the sentences. Familiarity speeds up the scanning, i.e., people know where to most likely find the subject they are looking for and thus where they should start scanning.

When people want to realize a goal they have to take certain actions. If they will not take any action the goal will not be realized. [If you are looking, e.g., for a nice ladies dress and you are not taking any actions like finding the ladies department or asking the shop assistant where you can find ladies dresses, you will not come closer to your goal, i.e., the nice ladies dress]. The actions they take are based on the information at the state they find themselves in and their expectations of the actions. Every action taken by a person brings the person into another state. The new state provides the person new information and experience. Combined with the information from the previous state the person may take another action of which he expects that it will bring him potentially closer to his goal. This cycle can go on for a while. It is also possible that people may change their mind when they get new information. This is because they are reminded of something by the new information or that they get influenced by the environment (e.g., atmosphere of a department).

People have certain conditions when they are looking for things. They give these conditions a certain value. [see also participant P_{n12} in Section 3.5.2]. Depending on how high the person values a certain condition he can give in a little bit of some conditions. This makes him deviate a (little bit) from his initial goal. [In the case of the wedding set we saw that the participant initially wanted a set consisting of four items. But she finally ended up with a set consisting of three items because of the very low price. Apparently the price was more important than the number of items in the
set and triggered the participant to buy].

Time is an important factor when people are doing a search. Searches should not take much time and should be therefore short.

Finally, people’s goals are not always clear and predictable. The results of our pilot approach show that it is very difficult to “randomly” select participants.

Based on the observations of this pilot study we can derive some state triggers and categories which we will use in Chapter 4. The following state triggers can be derived from the observations of this pilot study: shop windows, landmarks, maps, price, colors, displays/boards, location/department, and logo of the shop. The categories which can be derived are: precise goal, no precise goal, new sub goal, new unrelated goal, parallel goals and actions, search for info related to a goal, use of navigation aids to search in order to reach a goal, success, and failure. The observation results show that these state triggers and categories are involved in the participants’ search. In Chapter 4 we go into more details on the state triggers and the categories. We present and discuss also the results of the behavior observations in “non-web” situations in Chapter 4.
Pilot study: Behavior observations in “non-web” situations
Chapter 4

Search behavior observations in “non-web” situations

In this chapter we present and discuss the results of the experiments in which search behavior was observed in “non-web” situations. We observed people in “non-web” situations because this is a “natural” contextual setting. In the future, we aim to identify analogous search needs in a well-designed web context. In Section 4.1 we give an introduction of the study. In Section 4.2 we describe the approach for the study. The results and discussions are described in Section 4.3. In this section we will, for modeling purposes, classify the results into two categories: ‘goal changes’ and ‘no goal changes’. We will use this in Chapter 8 to develop mathematical models for search behavior. In Section 4.4 we summarize the results of the study. The conclusions are given in Section 4.5. Our main observation is that participants deviate from their initial goals because of parallel goals and because of state triggers that influence their interests.

4.1 Introduction

The goal of this chapter is to find out how people search in “non-web” situations and how their goals are influenced. In Chapter 3 we did a pilot study to find out, among other things, what problems may arise in the experimental setup for observing people. The results of our pilot study show that it is very difficult to select participants “randomly” (see Section 3.5 for a discussion). Therefore, we modified the methodology from our pilot study;
Search behavior observations in “non-web” situations

we decided not to aim at representativity for a well-defined population of people that search, but aim at results from a collection of readily available cases. We do not want to describe a population precisely. Instead, we want to describe the relevant phenomena on searching in context. This is only possible when we choose the right context. So we choose to approach our friends and relatives. Consequently, we were familiar with almost all of the participants. After the study, we will formulate design patterns for wild searching (see also Chapter 7) based on the results of this chapter and Chapter 5. The formulation of design patterns is only possible when we know how people search and how their goals are influenced.

Our study consists of two kinds of observations: ethnography and task-based observations. We observed people in a natural setting (group N) and in a task-based setting (group T). By observing people in these two settings, we wanted to know what the search behavior of people is. We included the task-based setting because sometimes people search when they are triggered by a task. We call the search behavior of people in their natural setting “natural search behavior”. Similarly, we call the search behavior of people that are completing a task “triggered search behavior”.

We choose as relevant context for the “non-web” situations shopping in shopping malls, city centers, book stores, and shopping streets. Here people have many possibilities in showing search behavior. Moreover, these locations are natural, relevant, and acceptable for our participants. The participants indicated that they did not want to be observed in, e.g., a museum (quote: “Better not in a museum because I will be there with my family”, “I do not mind observing my shopping behavior as I am doing that daily”). Observing people in a museum or during leisure is seen as a more private occasion while shopping is seen as a daily event. Since our goal is to study how people search in “non-web” situations and how their goals are influenced, it is not essential to our study to include observations in a museum.
4.2 Approach

4.2.1 Participants

In our study we have two observers ($O_1$ and $O_2$)\(^1\) who in total observed 40 participants in “non-web” situations of which 12 were relatives and 28 were friends and acquaintances of the observers. All participants were native Dutch speakers. From the 40 participants, 20 participants were randomly selected to participate in the ethnography study (group N: 12 males and 8 females). The other 20 participated in the task-based study (group T: 11 males and 9 females) (see also Section 4.2.3). The observers explained and informed the participants the following:

1. **The goal of this study.** The participants were informed about the goal of this study and that it was a part of a bigger research project.

2. **The procedure.** The observers explained the participants that they would only observe them and that they would not answer any questions during the observation sessions. The participants were informed that an observation session would end after 30 minutes or when they would make a purchase (group N) or when they would finish a task (group T).

3. **The interviews.** The participants were told that they would be interviewed after the observations and that the interview would take 5-10 minutes.

4. **The privacy of the participants.** The observers informed the participants about the procedure to safeguard their privacy. No names were recorded. In the observation results the observers referred to the participants by $N_i$ for the ethnography study (group N) and $T_i$ for the task-based observation study (group T), where $i$ denotes the $i$-th participant in that group. In both notations, $N_i$ and $T_i$, $i \in \{1, \ldots, 20\}$.

The text (translated to English) to inform the participants can be found in Appendix C.

\(^1\)The two observers ($O_1$ and $O_2$) each observed 10 participants in a natural setting and 10 in a task-based setting.
4.2.2 Ethnography study (group N)

For the ethnography study, one of the observers asked the participants to let them know when they were going out, e.g., to a shopping mall or to the city center. They both agreed upon a location to meet each other. The observations started at that chosen location. Twenty participants took part in group N.

4.2.3 Tasks for the task-based observation study (group T)

In order to formulate tasks that could be successfully performed in regular Dutch shopping malls and shops, we (the observers and the author) identified products that we could ask the participants to search for. We identified 4 products that are listed in Table 4.1.

This table also presents the tasks the participants had to complete and the locations where the observation took place. Every participant had to complete one task and each task was assigned to 5 participants which makes a total of 20 participants (4 × 5) for group T. The observers agreed with the participants on a convenient time to do the task. The location was determined by the observers themselves.
<table>
<thead>
<tr>
<th>Tasks</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find a Dyson vacuum cleaner. (location: shopping mall)</td>
<td>![Dyson vacuum cleaner]</td>
</tr>
<tr>
<td>Find a Black iPod Nano cover. (location: department store)</td>
<td>![Black iPod Nano cover]</td>
</tr>
<tr>
<td>Find the book ‘Ecuador &amp; the Galápagos Islands’ from Lonely Planet. (location: a big book store)</td>
<td>![Ecuador &amp; the Galápagos Islands]</td>
</tr>
<tr>
<td>Find a home tap for “Hertog-Jan” beer. (location: city center)</td>
<td>![Home tap for Hertog-Jan beer]</td>
</tr>
</tbody>
</table>

Table 4.1: Identified products.
4.2.4 Recording observations for group N and T

To record the observations of the study, we developed an observation form (see Appendix B.1 for the translated form) for both groups N and T. The form consists of five parts.

1. **General part**
   In the general part of the observation form we recorded the

   (a) **Participant number.** Instead of recording the name of a participant, the observers gave the participants a number $i$ with $i \in \{1, \ldots, 20\}$. The participants in group N (ethnography) are then identified by $N_i$, and participants of group T (task-based observation study) are identified by $T_i$.

   (b) **Gender.**

   (c) **Location.** In the location field the observers noted where they observed the participant. This was the name of a mall, city center, or the shopping street name.

   (d) **Date and time.** In the date and time field the observers recorded the date and the time when they started to observe the participant.

   (e) **Duration.** In this field the observers recorded the duration of the observation in minutes.

2. **What is the participant focused on?**
   From our literature study (see also Chapter 2) we found two search strategies for users searching for a product or information: epistemic and hedonic search strategies (see also Section 2.4.2). To find out whether our participants show one of these search strategies, we included these in the observation form.

   (a) **Epistemic.** In epistemic search strategies the participant is focused on his goal. Participants who utilize epistemic search strategies are problem solvers [25]. They are concerned with efficiency and want to complete their shopping trips at the soonest possible time. Therefore, they plan their purchases and move through the store as quickly as they can [96].

   (b) **Hedonic.** In hedonic search strategies the participant is unfamiliar with the environment, which is often the case in shopping
environments. They proceed slowly while valuing environmental sensory stimulation. These users have a high tendency to make impulsive purchases [96].

3. **What is the participant drawn to?**
   In this part the observers have recorded the state triggers at which the participants were looking at when they were shopping. The state triggers below are derived from the observations from our pilot study (see Chapter 3).

   (a) **Shop windows.** People often look at shop windows at items that are displayed. Sometimes they are triggered by these items which they did not want to buy initially. The observers recorded whether the participants looked at the shop windows or not.

   (b) **Landmarks.** Landmarks are reference points to find a way to reach one’s goal.

   (c) **Maps.** The observers recorded this to see whether the participants used maps (in the shop or on street) to reach their goal.

   (d) **Price.** Sometimes people are triggered by the price to buy something. When the participants were looking at the price for some reason the observers recorded that.

   (e) **Colors.** People are also triggered by colors. This can be the color of items or the color of the environment. In the situations in which the participants were notably triggered by colors, the observers recorded that.

   (f) **Displays/boards** on the location. When the participants were triggered by displays or boards, e.g., displays or boards with the word “Sale” or “New”, the observers recorded that.

   (g) **Location/department.** People are sometimes triggered by the atmosphere of the location or the department. The observers recorded this when they observed it.

   (h) **Logo of the shop.** Many people use the shop’s logo to locate the shop. The observers recorded this in the cases they observed this.

4. **The participant’s behavior.**
   In this part of the observation form the observers recorded the participant’s behavior.
5. **Does social navigation take place?**

As mentioned in Section 2.4.3, social navigation is a navigation type that is based on what others have done or the advice provided by others (e.g., follow people, ask a friend) [216]. From the pilot study we learned that people sometimes choose an “approach of least effort” in order to gain time and to keep the search duration short. Therefore, the observers recorded this navigation behavior.

### 4.2.5 Interviews

The author and the observers developed interview questions for group N and group T. We did this to cross-validate the search behavior observations of the participants. In addition, we developed some questions (about, e.g., familiarity with the location or goal, participant’s age, etc.) to get extra information to build insight into the participant’s search behavior. The interview questions (translated to English) for group N can be found in Appendix A.1 and for group T in Appendix A.2. As all participants were native Dutch speakers, the interviews were held in Dutch. The observers interviewed the participants after the observations. The answers of the participants were written down.

### 4.2.6 Raters and categories

**Raters**

All the written observations were scored on *atomic observation units* in categories of goal-related behavior (see further for a scoring example). An atomic observation unit is a relevant observation described in a single sentence. This was done by two raters ($R_1$ and $R_2$). Rater $R_2$ was the same person as observer $O_2$. Rater $R_1$ was the author of this thesis. The atomic observation units were categorized because we wanted to know if, and how often, the participants changed their goals, had parallel goals, succeeded in the search (see ‘Categories for group N’ below for the complete list). The raters categorized the atomic observation units from the observations which were written down.
Categories for group N

The following categories were used for group N to structure the atomic observation units:

1. **Precise goal.** A precise goal is a well-defined goal; the goal is clear and unambiguous. Each participant did have at least one precise goal at the beginning of an observation session. For example, the participant wants to buy a hair dryer.

2. **No precise goal.** The participant did not have any goal at the time. For example, the participant is just walking in the city center.

3. **New sub goal** (triggered by an event such as the perceived state like the price, a sound, an advertisement, etc.). A sub goal is defined as a part of the initial goal (=super goal). For example, a participant is triggered by low prices for a pair of pants, while his initial goal was buying a nice sweater for a party.

4. **New unrelated goal** (triggered by a state or an event). For example, a participant is triggered by nice shoes in a shop window, while his initial goal was buying a nice book.

5. **Parallel goals and actions** (a trade-off between two actions). For example, a participant is reminded by a shop window that he also needs a jacket for the coming party besides the nice shoes he was looking for.

6. **Search for info, related to a goal** (like using a shop map; often based on a well-defined goal). For example, a participant is looking for the ladies department and uses the shop map.

7. **Use of navigation aids to search in order to reach the goal** (like maps, displays, sounds). For example, a participant wants to buy a vacuum cleaner. In the shop he follows the boards to find the section where vacuum cleaners are located.

8. **Hedonic** (=fun/entertainment) (the participant shows a hedonic search strategy). For example, the participant just wants to enjoy shopping. The participant has no particular goal to buy something.

---

2 Only the atomic observation units that were found by both raters were counted.
9. **Epistemic** (the participant shows an epistemic search strategy). For example, the participant is moving quickly through the store.

10. **Social navigation.** For example, the participant follows the crowd or asks a friend to realize his goal.

These categories are derived partially from the literature study (see Chapter 2) and partially from the pilot study (see Chapter 3). Categories 3 and 4 were combined into one category, ‘goal changes’. We did this because it was very difficult to distinguish the difference between these two categories. These categories are considered equivalent for modeling purposes.

The following two categories are not an atomic observation unit. We call them *summary observation units* as they are a summary of the total observation.

- **Success** (i.e., the participant realized his goal). For example, the participant found what he was looking for.

- **Failure** (i.e., the participant did not realize his goal). For example, the participant did not find what he was looking for.

**Scoring example**

The example below is part of an observation. In this example the participant is looking for a present for her nephew. She wants to buy something from Playmobil\(^3\). With this example we show how the raters scored the atomic observations units in categories of goal-related behavior.

...The participant walks fast down the streets. She looks at the shop displays. Then she enters the Bart Smit toy shop. She looks quickly around on the ground floor and walks to the stairs. She walks to the first floor and looks at the wall with Lego\(^4\) and Playmobil toys. She walks to that wall. She picks different Playmobil boxes from the wall and looks at the price tickets...

Based on the observation above rater \(R_1\) and \(R_2\) score as follows (see Tables 4.2 and 4.3).

---

\(^3\)Playmobil is a line of toys produced by the Brandstätter Group (geobra Brandstätter GmbH & Co KG), headquartered in Zirndorf, Germany [242].

\(^4\)Lego, officially trademarked LEGO, is a line of construction toys manufactured by the Lego Group, a privately held company based in Billund, Denmark [240].
### Table 4.2: Scores of rater $R_1$.  

<table>
<thead>
<tr>
<th>Atomic observation units</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>The participant walks fast down the streets</td>
<td>Epistemic</td>
</tr>
<tr>
<td>She looks at the shop displays</td>
<td>Search</td>
</tr>
<tr>
<td>Then she enters the Bart Smit toy shop</td>
<td>Use of navigation aids</td>
</tr>
<tr>
<td>She looks quickly around on the ground floor</td>
<td>Epistemic</td>
</tr>
<tr>
<td>She looks at the wall with Lego and Playmobil toys</td>
<td>Use of navigation aids</td>
</tr>
<tr>
<td>She walks to that wall</td>
<td>Epistemic</td>
</tr>
<tr>
<td>She picks different Playmobil boxes</td>
<td>Precise goal</td>
</tr>
</tbody>
</table>

### Table 4.3: Scores of rater $R_2$.  

<table>
<thead>
<tr>
<th>Atomic observation units</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>The participant walks fast down the streets</td>
<td>Epistemic</td>
</tr>
<tr>
<td>She looks at the shop displays</td>
<td>Search</td>
</tr>
<tr>
<td>Then she enters the Bart Smit toy shop</td>
<td>Use of navigation aids</td>
</tr>
<tr>
<td>She looks quickly around on the ground floor</td>
<td>Epistemic</td>
</tr>
<tr>
<td>She looks at the wall with Lego and Playmobil toys</td>
<td>Use of navigation aids</td>
</tr>
<tr>
<td>She picks different Playmobil boxes</td>
<td>Precise goal</td>
</tr>
</tbody>
</table>

From these scores we identify the atomic observation units that were found by both raters (see also Section 4.3.1). The other scores we discard.

**Categories for group T**

For group T we can only apply the following categories:

1. **Navigation aids.** For example, the participant follows a shop map to find the ladies department. (This relates to category 7 of group N).
2. **Orientation.** For example, a participant wants to buy a pair of pants. When he enters a shop, he looks around to see what departments the shop has before going to the pants department. (This relates to category 6 of group N).

3. **Goal changes.** For example, a participant is triggered by a nice iPod\(^5\), and buys the iPod instead a sweater, which was his initial goal. (This relates to categories 3 and 4 of group N).

4. **Expecting.** For example, the participant expects the book ‘Ecuador \& the Galápagos Islands’ from Lonely Planet to be located in the section with country books. (This relates to category 9 of group N).

These categories are applicable for group T as this group had to complete a task. The first two are derived from the literature study (see Chapter 2) and the latter two are derived from the assumptions of the pilot study (assumptions 2 and 5, see Chapter 3.7).

### 4.3 Results and discussions

#### 4.3.1 Reliability of raters’ scores

Observations can be scored differently by different persons. This is not invalid if the different observations can be considered to belong to a homogeneous group. Homogeneous in this case means that the observations can be considered to belong to the same category for modeling. (This concerns in essence only the categories ‘goal changes’ and ‘no goal changes’). Therefore, we classify the observations of group N into two categories: ‘goal changes’ and ‘no goal changes’ (see Table 4.4). ‘Goal changes’ consist of the categories 3 and 4. All the other categories are considered to be ‘no goal changes’.

From Table 4.4 we can calculate that 95\% of the observations\(^6\) the raters judged belong to the same category. Based on this we conclude that the observation of goal changes is reliable. Therefore, we decide it is sufficient for modeling to use only rater 1 to score for group N and T.

---

\(^5\)The iPod is a digital media player from Apple Computer.

\(^6\)\((1 - ((2 + 6)/148)) \times 100\% = 95\%\).
Table 4.4: Reliability of scoring atomic observation units in the categories ‘goal’ and ‘no goal’ changes. $N = 148$ atomic observation units.

<table>
<thead>
<tr>
<th>Rater 1 (=$R_1$)</th>
<th>Rater 2 (=$R_2$)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal changes</td>
<td>Goal changes</td>
<td>52</td>
</tr>
<tr>
<td>No goal changes</td>
<td>No goal changes</td>
<td>90</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>148</td>
</tr>
</tbody>
</table>

4.3.2 Analysis of natural search behavior (group N)

In this section we analyze the natural search behavior of the participants of group N. We want to find out how people search in ‘non-web’ situations in their natural settings. We analyze the behavior to find out how and why the participants deviate from their initial goal. We analyze the interviews to find out whether the observed behavior matches the way the participants experienced their behavior (we call this the subjective search behavior).

Search behavior

The search behavior of group N (ethnography) is presented in Table 4.5. The number of ‘goal changes’ are given in black and the number of ‘no goal changes’ in gray.

From Table 4.5 we can see that 9 of the 20 participants had a precise goal and 7 had no precise goal. Seventeen of the 20 participants changed their goals during their search. These participants were triggered by events or information at the state they found themselves in. Fourteen of the 20 participants had parallel goals. Eight of the 20 participants searched for information related to their goal. Navigation aids were used by nine of the 20 participants. Seven of the 20 participants showed a hedonic search strategy. The others (13/20) showed a epistemic search strategy. Social navigation was observed at 8 of the 20 participants. Table 4.5 shows that goal changes took place in 31% of the total atomic observed units ($N = 180$).

---

7We use the $(x/y)$ notation to indicate $x$ from $y$ participants. Consequently $(13/20)$ means 13 from the 20 participants.
Table 4.5: Search behavior for group N.

State triggers

Table 4.6 shows the observed occurrence of the state triggers. This table shows that the popular state triggers are price (17/20), displays/boards (17/20), landmarks (14/20), and shop windows (9/20). Nobody in group

Table 4.6: Observed occurrence of the state triggers for group N.
N used the logo of a shop in his search. Maps were used by 5 of the 20 participants. Two of the 20 participants were triggered by color. One of the 20 participants was triggered by the location/department.

**Realized goals and search strategy**

We observed that 11 of the 20 participants in group N realized their goal(s). 13 of the participants used an epistemic search strategy and 7 used a hedonic search strategy (see Table 4.5). To find out whether there is a significant relationship with realizing one’s goal and the search strategy we did a chi-square test. The null hypothesis is taken to be $H_0$: there is no significant difference, and the alternative hypothesis is taken to be $H_1$: there is a significant difference. The results are presented in Table 4.7.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Goal reached</th>
<th>Goal not reached</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epistemic strategy</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Hedonic strategy</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 4.7: chi-square test: $\chi^2 = 3.04$, $p = 0.08$, $df = 1$.

From this table we see that we cannot reject the null hypothesis $H_0$. Thus, there is no significant relationship between realizing one’s goal and the search strategy.

**Subjective search behavior**

From the data summarized in Table 4.8 we read that 7 of the 20 participants were very familiar with the location. Three of the 20 participants considered themselves unfamiliar with the location. The other participants classified themselves between unfamiliar and familiar.

Fourteen of the 20 participants mentioned in the interview that they had reached their goal while we observed that 11 of the 20 participants realized their goal. In the interview all the 11 observed participants indicated that they realized their goal. Three additional participants, which we did not observe, indicated that they had realized their goal. We will come back to this in the conclusion section (see Section 4.5).
From Table 4.8 we can see that 7 of the 20 participants mentioned that they deviated from their initial goal. Eight of the 20 participants said that they gained information on their goal somewhere else.

<table>
<thead>
<tr>
<th>Familiar with location</th>
<th>Numbers of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Total unfamiliar)</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>5 (Very familiar)</td>
<td>7</td>
</tr>
</tbody>
</table>

| Did you reach your goal? | Yes | 14 |
| Did you deviate or adapt your goal? | Yes | 7 |
| Did you gain information on your goal somewhere else? | Yes | 8 |

Table 4.8: Scores for familiarity with location and successful goal(s) gathered from interview with participants from group N.

In Section 3.6 we discussed that familiarity with the location speeds up the search. To find out whether there is a significant relationship with being familiar with the location and realizing the goal we did a chi-square test. In order to do so we labeled all the participants who scored on familiar with location 1, 2, and 3 (see Table 4.8) as “not familiar with location”. The participants who scored 4 and 5 were labeled as “familiar with location”. The results are presented in Table 4.9.

<table>
<thead>
<tr>
<th>Goal Reached</th>
<th>Familiar with location</th>
<th>Not familiar with location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Goal not reached</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Goal Reached</th>
<th>Familiar with location</th>
<th>Not familiar with location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4.9: chi-square test: $\chi^2 = 0.85$, $p = 0.36$, $df = 1$.

From Table 4.9 we see that we cannot reject $H_0$. There is no significant
Results and discussions

relationship between being familiar with the location and realizing the goal.

We did a chi-square test to find out whether there is a significant relationship with being familiar with the location and the speed of realizing the goal. We calculated the average speed of realizing the goal. The average speed of realizing the goal was 18 minutes. Every participant who scored less than 18 minutes to realize his goal we labeled ‘fast’. The participants who needed 18 minutes or more we labeled ‘slow’. Table 4.10 presents the results.

Table 4.10: chi-square test: $\chi^2 = 0.04$, $p = 0.85$, $df = 1$.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Familiar with location</th>
<th>Not familiar with location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Realized goal fast (&lt; 18 min.)</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Realized goal slow (≥ 18 min.)</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>7</td>
</tr>
</tbody>
</table>

We see that we cannot reject $H_0$. There is no significant relationship between being familiar with the location and the speed of realizing the goal.

To find out whether there is a significant relationship between the gained information about a goal and having a precise goal we did a chi-square test. The gained information about the goal means that the participant is informed about the object he wants to buy, like the guarantee of the object, where he can buy the object, and the price of the object. The results are presented in Table 4.11.

Table 4.11: chi-square test: $\chi^2 = 4.85$, $p = 0.03$, $df = 1$.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Gained information</th>
<th>Not gained information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precise goal</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>No precise goal</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>12</td>
</tr>
</tbody>
</table>
78 Search behavior observations in “non-web” situations

Table 4.12: chi-square test: $\chi^2 = 1.94, p = 0.16, df = 1$.

From Table 4.11 we see that we can reject $H_0$. There is a significant relationship between the gained information about a goal (i.e., buying an object) and having a precise goal. This means that people who have a precise goal are often informed about the goal.

We did a chi-square test to find out whether there is a significant relationship between the gained information about a goal and realizing the goal. From Table 4.12 we see that we cannot reject $H_0$ which means that there is no significant relationship between the gained information about a goal and realizing the goal. Apparently the gained information about a goal does not guarantee that one would realize the goal.

4.3.3 Analysis of triggered search behavior (group T)

We want to find out how people are searching in ‘non-web’ situations when they have to complete a task. This means we want to find out how people reason, how their reasoning leads to a particular approach in realizing their goal, and how additional information makes them deviate from their goal. Therefore, we analyze the triggered search behavior of the participants of group T in this section.

Search behavior

The search behavior of group T (task-based observations) are given in Table 4.13.

We observed that 18 of the 20 participants used ‘navigation aids’ to complete the given task. This is 35% of the total atomic observations units ($N = 137$). Besides ‘navigation aids’ we observed that the participants were orienting (17/20) and expecting (19/20) things at a certain place often in
the search process. Table 4.13 shows that 12 of the 20 participants changed their goal, which means that they deviated from their initial goal.

Table 4.14 shows state triggers gathered from the observations. The most popular state triggers are displays/boards (18/20) followed by landmarks (15/20).

<table>
<thead>
<tr>
<th>State Triggers</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shop windows</td>
<td>6</td>
</tr>
<tr>
<td>Landmarks</td>
<td>15</td>
</tr>
<tr>
<td>Maps</td>
<td>8</td>
</tr>
<tr>
<td>Price</td>
<td>8</td>
</tr>
<tr>
<td>Color</td>
<td>8</td>
</tr>
<tr>
<td>Displays/Boards</td>
<td>18</td>
</tr>
<tr>
<td>Location/dept.</td>
<td>4</td>
</tr>
<tr>
<td>Logo</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 4.14: Scores for state triggers gathered from observations of group T.

The scores of the other state triggers are shop windows (6/20), maps (8/20), price (8/20), color (8/20), location/department (4/20), and logo (9/20).

**Subjective search behavior**

Table 4.15 shows that many participants (score 1, 2, and 3) were not familiar with the goal. This means that they were not familiar with the objects.
Despite the unfamiliarity with the goal, 14 of the 20 participants said that they realized their goal easily.

Table 4.15: Scores for familiarity with location, familiarity with goal, and successful goal(s) gathered from interview with participants from group T.

<table>
<thead>
<tr>
<th>Familiar with location</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Total unfamiliar)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>5 (Very familiar)</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Familiar with goal</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Total unfamiliar)</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5 (Very familiar)</td>
<td>1</td>
</tr>
</tbody>
</table>

| Did you reach your goal easily? | Yes | 14 |

Table 4.16: chi-square test: $\chi^2 = 0.05$, $p = 0.83$, $df = 1$.

We initially thought that this was because of the familiarity (score 4 and 5) with the location where they had to complete their task. Because of the familiarity with the location the participants could predict where they could find the items. To find out whether our hypothesis was true we did a chi-square test (see Table 4.16). For the chi-square calculation we labeled all the participants who scored on familiarity with location 1, 2, and 3 (see Table 4.15) as “not familiar with location”. The participants who scored 4 and 5 were labeled as “familiar with location”. From this table we see that we cannot reject the null hypothesis $H_0$. There is no significant relationship
between being familiar with the location and realizing the goal easily.

We did a chi-square test to find out whether there is a significant relationship with being familiar with the location and the speed of realizing the goal for the task-based observation study. We calculated the average speed of realizing the goal. The average speed of realizing the goal was 14 minutes. Every participant who scored less than 14 minutes to realize his goal we labeled ‘fast’. The participants who needed 14 minutes or more we labeled ‘slow’.

We did a chi-square test to find out whether there is a significant relationship with being familiar with the location and the speed of realizing the goal for the task-based observation study. We calculated the average speed of realizing the goal. The average speed of realizing the goal was 14 minutes. Every participant who scored less than 14 minutes to realize his goal we labeled ‘fast’. The participants who needed 14 minutes or more we labeled ‘slow’.

The results are presented in Table 4.17. We see that we cannot reject $H_0$. There is no significant relationship between being familiar with the location and the speed of realizing the goal.

4.4 Summary

In this chapter we presented and discussed the results of the behavior observations in “non-web” situations. The methodology was adapted from our pilot study in Chapter 3. We observed people in their natural settings (group N) and people who had to complete a task (group T). We analyzed the natural search behavior of group N and the triggered search behavior of group T.

In both groups we observed the following:

1. The participants deviate from their goals. We found two different reasons:

   (a) many people have parallel goals or not well-defined goals (no precise goals), and
(b) people’s interest are influenced by state triggers or navigation aids.

2. Navigation aids are used often when people search or when they want to realize their goals. In “non-web” situations the state triggers, price, display/boards, and landmarks are most important. These are especially important when people are not so familiar with the location and when they do not know their goal precisely.

3. We did not find any relationship between being familiar with the location and realizing the goal (easily).

4. We did not find any relationship between being familiar with the location and the speed of realizing the goal.

5. We observed that people expect things at certain locations.

The following two apply only to group N:

1. We found a correlation between the gained information about a goal (the thing you want) and having a precise goal: people who have a precise goal are often informed about the goal.

2. We did not find a correlation between the gained information about a goal and realizing a goal. Apparently the gained information about a goal does not guarantee that one will realize the goal.
4.5 Conclusion

The conclusions regarding people’s search behavior, based on the results of this chapter, can be listed as follows:

**Search behavior in “non-web” situations**

1. **People’s goals may be vague and sometimes unpredictable**  
   We observed that the participants in our study do not always have well-defined goals. Sometimes they have parallel goals.

2. **People are attracted by state triggers**  
   People’s goals are influenced by state triggers. This makes them deviate from their goal(s).

3. **People expect things at certain locations**  
   People follow the standard. Standards are familiar for most people. They therefore expect things at certain locations.

There is a methodological problem when observing whether people realized their goal or not. Following the participant and watching what he is doing and how he is reacting to the environment gives us objective information about how someone is searching. This observation is not always the same with what the participant is searching for or doing. We therefore cannot model the search behavior completely.

It is clear that the state people find themselves in may change over time. New states provide people with new information and experiences that influence the goal people want to realize. We observed that participants, influenced by state triggers, changed goals. People take actions based on the information at the state they find themselves in and their expectations of certain actions. This search behavior we model mathematically in Chapter 8. Once we have a mathematical model for the search behavior we can apply that to “non-web” and “web” situations (e.g., buying CDs at a record shop or visiting a website) to predict the user’s search behavior.

This chapter was about people’s search behavior in “non-web” situations. The WWW is a relatively new context for people to search in. We do not know whether the search behavior will be the same as the search behavior in “non-web” situations. In Chapter 5 we therefore observe the search behavior of people on the World Wide Web.
Search behavior observations in “non-web” situations
Chapter 5

Search behavior observations on the World Wide Web

In this chapter we setup a study to observe the search behavior of people on the WWW. In Section 5.1 we give an introduction of the study. In Section 5.2 we describe the approach for the study. The results and discussions are described in Section 5.3. Section 5.4 gives an overview of the observations and interview results of this chapter. In Section 5.5 we summarize the results of the study. The conclusions are given in Section 5.6.

Our main observations are that

• the participants are irritated by 404 page-not-found errors,

• the participants deviate from their initial goals because of parallel goals and because of state triggers that influence their interests, and

• the participants find unrelated content behind the page links or menu items.

We conclude that the observations can be distinguished into web design problems and issues related to search behavior of website visitors. We have listed both in Section 5.6.
5.1 Introduction

5.1.1 Natural versus engineered

In Chapter 4 we saw that people in our study often deviate from their goals during their search process. Sometimes they have parallel goals and sometimes they are triggered by the state they find themselves in, the so-called “state triggers”. Moreover, we saw that people in our study did not always have a precise goal, and also expect things (information, objects, etc.) at certain locations. It is not clear that search behavior of people on the WWW has the same features, or is the same as search behavior in “non-web” situations, because the WWW is an engineered environment and a relatively new medium, while “non-web” situations are ‘natural’ like, e.g., a street market. In fact, a street market is also an engineered environment, but its development over time has resulted in a natural environment for people. In Figure 5.1 one can see the street market Albert Cuyp in Amsterdam. Features like the visiting hours, the market booths, and the market supervisors are “engineered” over the course of time based on the development of social structures of behavior of buyers and sellers, and on the evolution of market culture.
The way the things are arranged at the market booths, like, e.g., the fruits and flowers in Figure 5.1, are “redesigned” over the course of time and people experience this as ‘natural’. It is ‘natural’ that the Albert Cuyp street market is closed on Sundays and that the flower booth is the first booth on the right side of the market.

5.1.2 The origin of the WWW

The WWW was originally conceived as a way for physicists to share their research data [113]. In 1989, Tim Berners-Lee led a team at Switzerland’s European Particle Physics Laboratory (CERN) (Figure 5.2) in developing the initial World Wide Web standards.

Key among these was the use of hypertext or “hot” portions of an online document that, when selected, took the user to a related, or “linked”, document. The next great innovation for the WWW came in 1992, when programmers from the National Center for Supercomputing Applications (NCSA) (Figure 5.3) at the University of Illinois developed the Mosaic browser, a software application that displayed not only the text of a Web document (or page), but embedded graphic elements as well.

By bringing multimedia to the Web, Mosaic vested it with enormous potential. The WWW is relatively young and still in development. It is a relatively new context for people to search in. People need to get used to the WWW. So to speak, they have access to the whole world from their computer screen. They do not need to leave their room to get, e.g., a book from the library. It is all there on their computer screen.
Figure 5.3: Plaque at The National Center for Supercomputing Applications (NCSA) commemorating Mark Andreessen and Eric Bina [105].

The goal of this chapter is to find out whether, and in what appearance, we can observe the ‘natural’ search behavior in “non-web” situations also on the WWW.

5.1.3 Methodology

The methodology that we use to gather observations in a WWW setting is identical to the methodology used in “non-web” situations in Chapter 4. This study consists of two kinds of observations: ethnography and task-based observations. Each participant was observed twice: once in their natural setting (situation N) and once in a task-based setting (situation T). First, we observed the participants in their natural setting. After that, we observed the participants in a task-based setting. Both the natural search behavior (natural setting) and the triggered search behavior (task-based setting) observations were done at the participant’s house. By doing so, the participants could work on their own computer in a familiar context. While the participants were searching on the WWW, they could, e.g., sit down as they wish, take a coffee, take care of their children, etc. We wanted the

\[^1\] Each participant had a double role: once as a participant in situation N, and once as a participant in situation T.
participants’ behavior to be as natural as possible.

5.2 Approach

5.2.1 Participants

Twenty participants (15 males and 5 females) were observed by observer \(O_1\) and \(O_2\). All participants were native Dutch speakers. Six of the participants were relatives, the others were friends and acquaintances of the observers. Seventeen observations were done at the participant’s house. Three participants were observed at the author’s university because it was not possible to observe them at their house. The observers made an appointment with the participants to observe them at home or at the author’s university. We asked the participants beforehand to collect their searches on the WWW for that appointment.

5.2.2 Explanation and information

The observers explained and informed the participants about the following:

1. **The goal of this study.** The participants were informed about the goal of this study. They were informed that this study was a part of a bigger research project.

2. **The observation procedure.** The observers explained to the participants that they would only observe them and that they would not answer any questions during the observation sessions. The participants were informed that an observation session would end after 30 minutes or when they would realize their goal (situation N) or when they would finish a task (situation T).

3. **The interviews.** The participants were told that they would be interviewed at the start and after each of the two observations, and that the interviews would take 5-10 minutes.

4. **The privacy of the participants.** The observers informed the participants about the procedure to safeguard their privacy. No names were recorded. In the observation results the observers referred to the

---

2The two observers \((O_1 \text{ and } O_2)\) observed 10 participants each.
participants by $N_i$ for the ethnography study (group N) and $T_i$ for the task-based observation study (group T), where $i$ denotes the $i$-th participant in that group. In both notations, $N_i$ and $T_i$, $i \in \{1, \ldots, 20\}$.

The text (translated to English) to inform the participants can be found in Appendix C.

5.2.3 Tasks for the task-based observation (situation T)

For the task-based observation we (the observers and the author) formulated three questions. Question 1 and 2 consisted of two subquestions. We assumed that finding the answers to the three questions would take approximately 30 minutes. The participants were supposed to find the answers to those questions using the WWW.

Below is the list of questions \(^3\) (translated to English).

1. (a) Who was Bilderdijk?
   (b) What is the address of the Bilderdijk Museum in the Netherlands?

2. (a) In which year did Ajax win the European Cup 2?
   (b) Who scored a goal during that match?

3. Find a notebook stand for a 15 inch screen notebook on the Dynabyte website.

We formulated questions that were not that easy to search for on the WWW: typing a keyword in a search engine would not result in the first link to be a correct pointer. The link to the answer could be, e.g., on the next 50 hits of the search results or deeper in the website relevant to the particular question. We used the Google\(^4\) search engine to test the questions.

\(^3\)Answers to the questions:

1. (a) Willem Bilderdijk (1756-1831) was a Dutch historian, poet, and lawyer.
   (b) Vrije Universiteit Amsterdam, Rm 1B-21 (bilderdijkmuseum.vu.nl).

2. (a) 1987 or season ’86/’87.
   (b) Marco van Basten.


5.2.4 Recording observations for situations N and T

To record the observations we developed an observation form (see Appendix B.2 for the form translated to English) for the situations N and T. This form is identical to the form we used in Chapter 4 (see Appendix B.1) with one exception: we adapted the ‘What is the participant drawn to?’ part in the form used in this chapter. We choose state triggers which were suitable for the WWW. For example, shop windows are not suitable for the WWW. Therefore, we replaced shop windows with advertisements. The state triggers “Display/Boards” and “Department” were omitted. The other state triggers were left unchanged. We use the same categories of atomic observation units for both studies (search behavior observations in “non-web” situations and on the WWW) in order to be able to compare the results of both studies.

The participant’s search behavior was observed by one observer who sat next to the participant. To record the observations he wrote everything that he observed on the form. In order to collect precise observations, he followed the cursor on the computer screen and listened to what the participant was saying during the observation session. He also observed the expressions on the participant’s face. All these observations were written down (see example below).

The next example is a part of an observation. This example shows how we recorded the observations.

...The participant clicks with her mouse on the Internet Explorer shortcut on her desktop. She moves her mouse to the address bar in Internet Explorer and types the following address: www.lego.nl. The browser redirects her to www.lego.com. She looks at the website. In the beginning she looks only at the top of the page. Then she scrolls down by using the scroll bar of Internet Explorer. She says: “I am looking for a Dutch button. It’s weird that the Lego site is only in English, French, and German”. She clicks on the shop button at the top of the page...

5.2.5 Interviews

The author and the observers developed interview questions for situations N and T. Appendices A.3 (interview before observation) and A.4 (interview...
after observation) show the interview questions (translated to English) for situation N. The interview questions for situation T are described in appendix A.5 (translated to English). As the participants in situation N were the same as in situation T and the interview questions before the observations were the same for both situations, it was not necessary to repeat the questions before the observation. The order of the observations and interviews was as follows:

1. Interview before observations in situation N (see Appendix A.3)
2. Observations in situation N
3. Interview after observations in situation N (see Appendix A.4)
4. Observations in situation T
5. Interview after observations in situation T (see Appendix A.5)

All the answers of the participants were written down.

5.2.6 Raters and categories

Raters

All written observations were scored on atomic observation units in categories of goal-related behavior (see also Section 4.2.6 for a scoring example). This was done by rater 1 ($R_1$) who also scored the atomic observation units in categories of goal-related behavior for the search behavior observations in the “non-web” situations in Chapter 4. The atomic observation units were categorized because we wanted to know if, and how often, the participants changed their goal, had parallel goals, succeeded in the search, used search engines, and used bookmarks (see ‘Categories for situations N and T’ and ‘Search units for situations N and T’ for the complete list).

Categories for situation N

To compare the results of this study with the results of the study from Chapter 4 we kept the labels to categorize the atomic observation units the same as in Section 4.2.6 (Categories 1 to 10 for group N). We added the categories ‘orienting’ (11) and ‘expecting’ (12) to the list of categories. We added these categories for two reasons:
1. We expect this behavior on the WWW as many web sites have different, or even unique, look and feel, and navigation support. Many first time, or incidental, web visitors (may) have to orient first in order to know how to proceed.

2. From the study from Chapter 4 we learned that people expect things at certain locations. We predict to see expectation-based behavior on the WWW because many unwritten “rules” on the Internet are followed by the masses [82]. Masses of visitors, e.g., expect blue underlined text or words to be a hyperlink. They expect that a logo is always clickable. Masses of websites follow the rules (design patterns), e.g., that clicking on the label “Home” or the logo should bring the web visitor to the homepage [231, 225] or that the login link or login form should be at the right top corner [225].

Categories for situation T

In order to allow comparison with the results from Chapter 4, the labels to categorize the atomic observation units for situation T are the same as in Section 4.2.6 (Categories for group T).

Search units for situations N and T

We detailed the observation of category 6 into ‘search units’ (A to F) for situations N and T. Search units are specific unambiguous categories to search which can only occur on the WWW or in browsers. So, search units are also atomic observation units. The search units, derived from the literature study (see Chapter 2), are listed below.

Search units for situations N and T:

A. URL (the participant typed the URL of a particular site in the browser’s location bar).
B. Bookmarks (the participant used his bookmarks).
C. Search option on the sites (the participant used the search option on the site).
D. Browser find option (the participant used the find option in the browser, e.g., CTRL+F in Mozilla FireFox\(^6\)).

E. Browser back button (the participant used the browser’s back button).

F. Search engine (the participant used a search engine, e.g., Google\(^7\)).

This category was added to the categories of situation T.

5.3 Results and discussions

5.3.1 Analysis of natural search behavior on the WWW (situation N)

In this section we analyze the natural search behavior of the participants in situation N. We want to find out how people search on the WWW in their natural setting. We analyze the observed behavior to find out how and why the participants deviate from their initial goal.

Search behaviors

The scores of the participants’ search behavior in situation N (ethnography) are given in Table 5.1. All participants had precise goals, since we asked the participants beforehand to collect their searches on the WWW for this observation study. Nine of the 20 participants deviated from their initial goal(s). None of the participants had parallel goals. We observed that all the participants searched to realize their goal. From Table 5.1 we can see that 19 of the 20 participants used navigation aids to reach their goal(s). This category seems to be important to the participants. None of the participants used a hedonic search strategy. They all used an epistemic search strategy. This was not surprising since we asked the participants beforehand to collect their searches on the WWW for this observation study. Social navigation did not take place at all\(^8\). The categories orienting (17/20), and expecting (14/20) also seem to be important to the participants.

We itemized the category ‘Searches’ into search units.

Table 5.2 shows the behavior scores for the searches, itemized into search units for situation N.

\(^7\)http://www.google.com.

\(^8\)Social navigation could take place on the WWW, e.g., by means of e-mail, by calling with Skype (http://www.skype.com), or a chat application like MSN (http://www.msn.com/).
Many participants (16/20) typed the URL of the site. We observed this in 43% of the total search units ($N = 119$). The URL was not always the one the participants expected. For example, the website ‘Flight Centre’ did not have the logical URL http://www.flightcentre.com but
Table 5.3: Observed occurrence of the state triggers for group N on the WWW.

<table>
<thead>
<tr>
<th>State triggers</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advertisements</td>
<td>13</td>
</tr>
<tr>
<td>Landmarks</td>
<td>8</td>
</tr>
<tr>
<td>Maps</td>
<td>0</td>
</tr>
<tr>
<td>Price</td>
<td>0</td>
</tr>
<tr>
<td>Color</td>
<td>0</td>
</tr>
<tr>
<td>Logo</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 5.3: Observed occurrence of the state triggers for group N on the WWW.

had http://www.flightcentre.com.au instead. Bookmarks and search options on the site were used by one (the same) participant. Nobody used the browser find option. The browser back button was used frequently by the participants (31% of the total search units). Fourteen of the 20 participants used the browser back button. Search engines were used by 14 of the 20 participants.

State triggers

Table 5.3 shows the observed occurrence of the state triggers for group N. Thirteen participants clicked on advertisements (banners and textual advertisements). Some of these participants indicated in the interview that they initially did not know that they clicked on textual advertisements (e.g., Google ads). Eight participants clicked on landmarks (e.g., home, faq, about button). We have not been able to observe anyone who was triggered by maps, prices, or colors. Two participants clicked on the logo to go to the homepage of the visiting website.

Realized goals

We observed that 15 of the 20 participants realized their goal(s).

Subjective search behaviors

In Table 5.4 we have summarized the interview results. On the question ‘How would you classify yourself as computer user?’, 3 participants considered themselves as novice and 5 as expert. The other 12 classified themselves
Results and discussions

Table 5.4: Scores on interview questions before and after the observations gathered from interview with participants in situation N.

<table>
<thead>
<tr>
<th>Computer experience</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Novice)</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>5 (Expert)</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internet experience</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Novice)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5 (expert)</td>
<td>7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you use search engines? *</td>
<td>Yes</td>
<td>20</td>
</tr>
<tr>
<td>Do you ever click on banners? *</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Did you reach your goal?</td>
<td>Yes</td>
<td>16</td>
</tr>
<tr>
<td>Are you satisfied with the result(s)?</td>
<td>Yes</td>
<td>14</td>
</tr>
<tr>
<td>Did you deviate from or adapt your goal?</td>
<td>Yes</td>
<td>6</td>
</tr>
<tr>
<td>Did you experience any problems in your search?</td>
<td>Yes</td>
<td>7</td>
</tr>
<tr>
<td>Do you like a website with dark background color and light font color?</td>
<td>Yes</td>
<td>5</td>
</tr>
<tr>
<td>Do you like an animation introduction on a website?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Do you like many images on a website?</td>
<td>Yes</td>
<td>7</td>
</tr>
</tbody>
</table>

* Interview questions before the ethnography

between novice and expert. For calculation purposes we considered all the participants who scored on computer experience 1, 2, and 3 (see Table 5.4) as “non-experts”. The participants who scored 4 and 5 were considered as “experts”. This means that we had 9 computer non-experts and 11 computer experts. We did the same for internet experience; all the participants who scored on internet experience 1, 2, and 3 were considered as “non-experts”. The participants who scored 4 and 5 were considered as “experts”, which means that we have 8 internet non-experts and 12 internet experts.

All the participants used search engines. In the interview all the participants indicated that they in particular use the Google search engine. One participant indicated that he clicks on banners. Although 16 of the 20 participants indicated in the interview that they realized their goal(s), only 14 participants said that they were satisfied with the results. This was mainly because of unexpected content behind the links or menu items. Another reason was that the participants could not always find the information they were looking for easily on the websites. Six of the 20 participants deviated from their goal(s). Seven of the 20 participants experienced problems

---

in their search. Five participants said that they like websites with a dark background color and a light font color. In general the participants did not like an animated introduction on a website. Just one person answered that he does not mind an animation as introduction on websites. Seven of the 20 participants prefer many images (> 3) on websites. The participants indicated that many images or animations on a website slow down the website. According to the participants, 2 or 3 images on a webpage is acceptable.

We did chi-square tests to find out whether there is a significant relationship between computer experience and realizing one’s goal, and between internet experience and realizing one’s goal. The null hypothesis is taken to be $H_0$: there is no significant difference, and the alternative hypothesis is taken to be $H_1$: there is a significant difference.

From Tables 5.5 and 5.6 we can see that we cannot reject $H_0$ for computer experience and for internet experience. There is no significant relationship between computer experience and realizing one’s goal, and between internet experience and realizing one’s goal.

We did chi-square tests to find out whether there is a significant relationship between the speed of realizing one’s goal and computer experience, and between the speed of realizing one’s goal and internet experience. We calculated the average speed of realizing the goal. The average speed of realizing the goal was 20 minutes. Every participant who scored less than 20 minutes to realize his goal we labeled ‘fast’. The participants who needed

<table>
<thead>
<tr>
<th>Interview (computer experience)</th>
<th>Experts</th>
<th>Non-experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal reached</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Goal not reached</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 5.5: chi-square test: $\chi^2 = 1.82$, $p = 0.17$, $df = 1$.

<table>
<thead>
<tr>
<th>Interview (internet experience)</th>
<th>Experts</th>
<th>Non-experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal reached</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Goal not reached</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 5.6: chi-square test: $\chi^2 = 0.47$, $p = 0.49$, $df = 1$. 
Results and discussions

Table 5.7: chi-square test: $\chi^2 = 0.09, p = 0.77, df = 1$.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Experts</th>
<th>Non-experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Realized goal fast (&lt; 20 min.)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Realized goal slow (≥ 20 min.)</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 5.8: chi-square test: $\chi^2 = 0.16, p = 0.69, df = 1$.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Experts</th>
<th>Non-experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Realized goal fast (&lt; 20 min.)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Realized goal slow (≥ 20 min.)</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>8</td>
</tr>
</tbody>
</table>

20 minutes or more we labeled ‘slow’. The results are presented in Table 5.7 and 5.8.

The chi-square tests show that there is no significant relationship between the speed of realizing one’s goal and the computer experience, and between the speed of realizing one’s goal and the internet experience.

5.3.2 Analysis of triggered search behavior (situation T)

We want to find out how people search on the WWW when they have to complete a task. This means that we want to find out how people reason, how their reasoning leads to a particular approach in realizing their goal, and how additional information makes them deviate from their goal. In this section we therefore analyze the triggered search behavior of the participants in situation T.

Search behaviors

The participants’ search behavior observations in situation T (task-based observations) are given in Table 5.9.

This table shows that 19 of the 20 participants used navigation aids. This behavior concerns 38% of the total atom observation units ($N = 325$).
Seventeen of the 20 participants oriented on the visited websites. Two participants changed their goal. Nineteen of the 20 participants had expectations on the visited websites. All participants searched to realize their goal. We itemized the category ‘Searches’ into ‘Search units’ in Table 5.10 for situation T.

We observed that 15 of the 20 participants typed the URL of the websites in their browser. Nobody used bookmarks. This was not so surprising as the chances were low that the websites we choose for the tasks would be in the participants’ bookmarks. A search possibility on websites seems important to realize goals. Five of the 20 participants used the search option on the visited websites. Seven of the 20 participants used the browser search option
Table 5.11: Observed occurrence of the state triggers for group T on the WWW.

<table>
<thead>
<tr>
<th>State triggers</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advertisements</td>
<td>9</td>
</tr>
<tr>
<td>Landmarks</td>
<td>12</td>
</tr>
<tr>
<td>Maps</td>
<td>0</td>
</tr>
<tr>
<td>Price</td>
<td>0</td>
</tr>
<tr>
<td>Color</td>
<td>0</td>
</tr>
<tr>
<td>Logo</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 5.11: Observed occurrence of the state triggers for group T on the WWW.

(e.g., CTRL+F in Mozilla Firefox\(^{10}\)), especially when the websites did not have search possibilities or when the search option the websites provided did not give keyword-related results. We observed that 14 of the 20 participants used the browser back button. Eighteen of the 20 participants used search engines to complete their tasks.

**State triggers**

Table 5.11 shows the observed occurrence of state triggers for group T. Nine participants clicked on advertisements (banners and textual advertisements). 5 of these 9 participants indicated in the interview that they did not know that they clicked on textual advertisements (e.g., Google ads). Twelve participants clicked on landmarks (e.g., home, faq, about button). We have not been able to observe anyone who was triggered by maps, prices, or colors. Three participants clicked on the logo to go to the homepage of the visiting website.

**Subjective search behaviors**

Table 5.12 shows that none (score 1, 2, and 3) of the participants considered themselves familiar with the goals. Four of the participants expected the navigation (i.e., the main menu) at the top of the webpage, fifteen expected the navigation on the left side of the webpage, and one participant expected it on the right side of the webpage. None of the participants expected the navigation at the bottom of the webpage.

\(^{10}\text{http://www.mozilla.org/}\)
Table 5.12: Scores on interview questions after the observations gathered from interview with participants in situation T.

```
<table>
<thead>
<tr>
<th>Familiar with goal</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Total unfamiliar)</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5 (Very familiar)</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Navigation position on the web</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Top</td>
<td>4</td>
</tr>
<tr>
<td>Left</td>
<td>15</td>
</tr>
<tr>
<td>Right</td>
<td>1</td>
</tr>
<tr>
<td>Bottom</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you reach your goal?</td>
<td>15</td>
</tr>
<tr>
<td>Did you search differently?</td>
<td>1</td>
</tr>
<tr>
<td>Did you experience any problems in your search?</td>
<td>11</td>
</tr>
</tbody>
</table>
```

Even though none of the participants considered themselves familiar with the goal, 15 of the 20 participants indicated that they realized their goals. Only one participant indicated that he searched differently for this study. Eleven of the 20 participants said that they experienced problems in realizing their goals. In the interview the participants said that the Dynabyte website was not user friendly. The participants said that the button names in the menu were not chosen properly. Some of the participants said that the content behind the links or menu items were not the expected ones. This led them into a different direction/location. Sometimes this was irritating for the participants. A few participants mentioned that they did not know on what page they were in the Dynabyte site. This caused irritation as they had to start from the homepage again or they had to click many times on the browser back button to find a page in the website from where they could go on. Another thing that irritated the participants were the 404 error pages (the page not found errors).
5.4 Overview of results

In this chapter we presented and discussed the results of the behavior observations on the WWW. We used the same methodology as we used in Chapter 4. We observed and analyzed people’s natural search behavior (situation N) and their triggered search behavior (situation T) on the WWW. Each participant in our study had a double role: once as a participant in situation N, and once as a participant in situation T.

In both situations we observed the following:

O-1 Most participants (19/20 in both situations) in our study used navigation aids on the visited websites to search or to realize their goal(s).

O-2 In both situations in our study the participants tried to predict the content behind a link or menu item. The interviews showed that this was because the participants expected certain content behind certain links or on some location in the website (14/20 in situation N and 19/20 in situation T).

O-3 We observed that participants in our study took a few seconds before they started to navigate on the website. We interpreted this as orienting to get familiar with the visited webpage (17/20 in both situations).

O-4 Search engines are used often in our study (14/20 in situation N and 18/20 in situation T). The Google\textsuperscript{11} search engine is very popular with the participants. All the participants said in the interview that they use the Google search engine.

O-5 Many participants (16/20 in situation N and 15/20 in situation T) first tried to guess the URLs of the websites mentioned in the tasks before they used a search engine.

O-6 Many participants clicked on advertisements (13/20 in situation N and 9/20 in situation T). Some of these participants, who clicked on advertisements, indicated in the interview that they initially did not know that they clicked on textual advertisements.

\textsuperscript{11}http://www.google.com.
O-7 The browser back button was used by 14 of the 20 participants in both situations.

O-8 The participants in our study used the browser search option when the visited websites did not have any search options or when the provided search option did not give keyword-related results.

O-9 The observed participants in our study were irritated when they encountered the 404 error pages and when they found unexpected content behind menu items or links.

O-10 Participants in our study deviated in both situations from their goal.

O-11 State triggers make participants deviate from their goal.

O-12 We did not find any significant relationship in our study between computer experience and realizing one’s goal.

O-13 We did not find any significant relationship in our study between internet experience and realizing one’s goal.

O-14 We did not find any significant relationship in our study between the speed of realizing one’s goal and internet experience.

O-15 We did not find any significant relationship in our study between the speed of realizing one’s goal and computer experience.

From the interviews we found the following:

I-1 Many participants (15/20) in our study expect the navigation main menu on the left side of the webpage. Some of the participants (4/20) expect the navigation main menu on the top of the webpage.

I-2 Most participants (19/20) in our study do not like an animated introduction on websites.

I-3 About one third (7/20) of the participants in our study prefer more than three images on websites.
5.5 Summary

Below we give a summary of the observation and interview results. The results are related to the following aspects:

- Navigation behavior: O-1, O-4, O-6, O-7, and O-8
- Expecting: O-2, O-3, O-5, and I-1
- Goals: O-10 and O-11
- Emotions: O-9, I-2, and I-3
- Experience: O-12, O-13, O-14, and O-15

These aspects will be used for modeling the visitor’s search behavior and to formulate design patterns to optimize websites.

5.6 Conclusion

In this chapter we observed that problems in web design can cause website visitors to adapt their search behavior. Therefore, the observations of this chapter can be distinguished into web design problems and problems in search behavior of website visitors. Below we give a list of website problems and issues in search behavior.

5.6.1 Website problems

1. **Web visitors do not get the expected information behind links or menu items.**
   We observed that the participants in our study got irritated when they found other information behind the link or menu item than the expected one.

2. **Web visitors face 404 error pages.**
   Web visitors get this error code when the page is not found or does not exist. This causes irritation.

3. **The navigation support is not at the expected location of the website.**
   The navigation support of the website is not located at the expected
part of the web page. Most participants in our study expected the main menu on the left side of the web page.

4. **Web visitors cannot find a search option on the visited website.**
As websites are growing and becoming more complex, a search option on websites is essential. A website without a search option makes it difficult for the web visitor to find the information he is looking for.

5. **Web visitors get lost in the structure of the website, because they do not know where they are in the website.**
Web visitors are off-track when they do not know where they are in the website. We observed this behavior on the Dynabyte\(^{12}\) website in our study. The participants in our study got irritated when they got off-track and lost in the structure of the website.

6. **Web visitors cannot guess the URL of the visited websites, because the URL is not chosen logically.**
Many participants in our study tried to guess the URLs of websites. We observed that most of the time the guessed URLs were not correct.

7. **There are too many images or animations on the visited website which makes the website slow.**
Too many images on a website makes a website slow (i.e., it takes a while before the web visitor sees something on his screen). In the interviews, the participants in our study said that they do not like waiting too long for the webpage to see something on their screen.

5.6.2 Search behavior on the WWW

1. **Web visitors may change their goal(s).**
New information can lead web visitors in a new direction. Web visitors can be triggered by state triggers (e.g., advertisements), which means that they may deviate from their initial goal(s).

2. **Web visitors predict the content behind a link or menu item.**
We observed that the participants in our study expect certain content behind a link or menu item. When the prediction is not true, they

\(^{12}\)http://www.dynabyte.nl/.
get disappointed and irritated. This behavior is related to website problem 1.

3. **Web visitors use navigation aids on the visited websites.**
   Good navigation seems important. Our participants used the navigation aids on the visited websites frequently. We observed that the participants in our study wanted to realize their goal easily. This means that they should not need a manual to navigate through a website. They depend on good navigation aids and a good search system on the website to realize their goal. This behavior is related to website problem 3.

4. **Web visitors orient on the website first before they proceed.**
   Web visitors want an overview of the website at a single glance. We observed that the participants in our study orient on the website first before they proceed. This behavior is related to website problem 5.

5. **Web visitors try to guess the URL of websites.**
   Many participants in our study tried to guess the URL of websites they wanted to visit. This behavior is related to website problem 6.

6. **Web visitors use search engines to realize their goals.**
   Search engines seem important to find a website especially when website visitors cannot guess the URL of a website. We observed that all our participants used search engines. This behavior is related to website problem 6.

7. **Web visitors use the browser search option when the visited websites do not offer a search option.**
   A search option on websites makes it easier for website visitors to realize their goals. When a website lacks this search option, web visitors use the browser search option. This behavior is related to website problem 4.

   In Chapter 6 we develop an approach to reduce the website problems to a minimum and to accommodate to the website visitors’ search behavior. We work this out in Chapter 8 and further.
Search behavior observations on the World Wide Web
Chapter 6

Problem detection phase

In Chapters 4 and 5 we observed people in “non-web” situations and on the WWW, respectively. We observed that the participants in our study faced some problems in reaching their goals. In Section 6.1 we give an overview of website problems web visitors face to reach their goals. We give an overview of search behavior on the WWW in Section 6.2 and in “non-web” situations in Section 6.3. Then, in Section 6.4, we address the first research issue ‘What can we learn from searching in a “non-web” setting vs. searching in a web setting for improving searching on the WWW?’ Finally, we develop in Section 6.5 an approach to reduce the website problems and to accommodate the website visitors’ search behavior. We discuss this in the next chapters.

6.1 Website problems

The results of Chapter 5 showed that website visitors regularly encounter problems in finding the information they look for. These problems can cause irritations to participants, who consequently will leave the website unsuccessfully. Below we give a list of website problems that the participants in our study encountered (see Section 5.6).

1. Web visitors do not get the expected information behind links or menu items.

2. Web visitors face 404 error pages.

3. The navigation support is not on the expected location of the website.
4. Web visitors can not find a search option on the visited website.

5. Web visitors get lost in the structure of the website because they do not know where they are in the website.

6. Web visitors cannot guess the URL of the visited websites, because the URL is not chosen logically.

7. There are too many images or animations on the visited website which makes the website slow.

6.2 Search behavior on the WWW

Below we provide a list of search behaviors we observed on the WWW (see Section 5.6).

1. Web visitors may change their goal(s).

2. Web visitors predict the content behind a link or menu item. This behavior is related to website problem 1.

3. Web visitors use navigation aids on the visited websites. This behavior is related to website problem 3.

4. Web visitors orient on the website first before they proceed. This behavior is related to website problem 5.

5. Web visitors try to guess the URL of websites. This behavior is related to website problem 6.

6. Web visitors use search engines to realize their goals. This behavior is related to website problem 6.

7. Web visitors use the browser search option when the visited websites do not offer a search option. This behavior is related to website problem 4.

In this list we observe that website problems 2 and 7 are not related to any of the observed search behaviors on the WWW.
6.3 Search behavior in “non-web” situations

Below we provide a list of search behaviors we observed in “non-web” situations (see Section 4.5).

1. **People’s goals may be vague and sometimes unpredictable.**
   This behavior is similar to search behavior 1 on the WWW.

2. **People are attracted by state triggers.**
   This behavior is similar to search behavior 1 on the WWW.

3. **People expect things at certain locations.**
   This behavior is similar to search behavior 2 on the WWW. Note that this behavior can be related to search behavior 5 as well when one interprets a URL as a location.

6.4 Searching in “non-web” setting vs. searching in a web setting

Referring to our first research issue ‘What can we learn from searching in a “non-web” setting vs. searching in a web setting for improving searching on the WWW?’ in Section 1.2, we conclude that we observe similarities when we compare the results of searching in a “non-web” setting with searching on the WWW. The search results teach us that the search behaviors in “non-web” situations are the same as the search behaviors on the WWW. This implies that some rules, which are valid in “non-web” situations, also apply on the WWW. Natural search behavior should be possible on the WWW as well. To improve searching on the WWW, the WWW should support all search behaviors that are accepted in our daily life outside the WWW. The WWW should not show any obstacles to support behavior that is accepted elsewhere too. Below we give some examples of natural search behavior on the WWW.

1. **Unpredictable goals**
   The airport is mainly used for traveling purposes. For example, people go to the airport when they are going on holiday, picking up some family or friends from the airport or taking someone to the airport. Some airports have nice restaurants with nice panoramic views of airplanes.
People may go to the airport to have dinner with their friends and to enjoy the panoramic view. This is an unpredictable goal.

On the WWW this is not different. Web visitors may visit the Walt Disney World Resort\(^1\) website not solely because they want to plan their vacation to Disney World, but also to play a game or to watch a movie of their favorite Disney hero. In Figure 6.1 we can see that web visitors can play games and watch movies besides booking a holiday at the Walt Disney World Resort.

Figure 6.1: The website of Walt Disney World Resort. Web visitors can play games and watch movies besides booking a holiday.

2. Attracted by triggers
Suppose someone invited a friend home for dinner. He wants to serve him lasagna, but he does not have all the ingredients at home to make

\(^1\)http://www.disneyworld.com.
the lasagna. He decides to go to the supermarket to buy the ingredients. On his way to the supermarket he sees a restaurant with nice pictures of Chinese food in the window. The smell of the nice food triggers his attention even more, and he finally decides not to make lasagna at home but to have dinner with his friend at this restaurant. This is an example of attraction by state triggers in a “non-web” situation.

On the WWW web visitors are attracted by similar things as in “non-web” situations, for example, by advertisements, colors, blinking text, images, animations, headers, font sizes, font types, movies, etcetera. In Figure 6.2 we see a screenshot of the games.com website. Several advertisements are incorporated in this website. Web visitors may be triggered by, for example, the CenterParcs advertisement on the right side of the website. A web visitor may book a vacation instead of playing a game.

3. Expectation on location
At the street market people expect certain things at certain location. They expect, e.g., at the Albert Cuyp street market (see Section 5.1), that the flower booth is the first booth on the right side of the market (see Figure 5.1). They expect the salesman, who is selling oranges, is on the left side of the street market.

On the WWW web visitors usually expect that the logo of the company is at the left top corner. They expect that clicking on the logo will take them to the homepage of the website (see Figure 6.3).

Taking into account that the above rules are valid in both situations, “non-web” and web situations, we develop an approach to optimize websites.

6.5 Approach

We now know the problems web visitors mostly face when they visit websites. We also know the natural search behavior of people on the WWW and elsewhere. We will use this knowledge to optimize websites, and to better support wild searching. To this purpose, we will use the following approach.

Some of the website problems that we detected can be solved by applying user interaction design patterns (in short: design patterns). A design
pattern\(^2\) is a formal way of documenting a solution to a common design problem [244]. Interaction design patterns are a way to capture optimal solutions to common usability or accessibility problems in a specific context [248]. They document interaction models that make it easier for users to understand an interface and accomplish their tasks [222, 230].

In Chapter 7 we formulate design patterns to overcome the observed website problems and for the observed web visitors’ search behavior. The design patterns will be the basic components to optimize websites, including support for wild searching. We collect existing examples of the formulated

\(^2\)The architect Christopher Alexander is the father of the Pattern Language movement in computer science. He and his colleagues originally developed patterns in a groundbreaking book called “A Pattern Language: Towns, Buildings, Construction” [20] in 1977. He believed that he could create an entire pattern language that was greater than the sum of the individual parts by connecting related patterns, and by showing how they intertwine and affect one another.
In Chapter 8 we model the web visitor’s search behavior in terms of Markov decision problems (MDP). With the mathematical model we can analyze the web visitor’s click behavior, and consequently where he is looking at. We show how we can influence the web visitor’s goal, and hence his click behavior, with state triggers. We show that this model can be applied to the different categories which we used to observe people in Chapters 4 and 5. This model can be used to optimize websites for wild searching. We apply the model to some examples on the WWW and to “non-web” settings to show how the model works. We finally show how the model can be used to describe the web visitor’s wild search behavior.

In Chapter 9 we provide an overview of some techniques that are applied in practice for website optimization. We show some concrete examples of tools that use those techniques to optimize websites. The applicability of the techniques are discussed in this chapter.

In Chapter 10 we describe a model for dynamic website optimization through
autonomous management of design patterns. The observation results of Chapter 5 are used to estimate model parameters. Then the results of the estimate are analyzed to optimize websites.

In Chapter 11 we present the conclusions of our research and we make recommendations for future work.
Chapter 7

Solution: design patterns for static website optimization

In this chapter we provide solutions for the problems listed in Chapter 6. Section 7.2 describes the structure of a design pattern. In Section 7.3 we first formulate a design pattern for wild searching. Then in Section 7.4 we formulate design patterns for static website optimization to overcome the observed website problems and to support wild searching. These design patterns will support the observed web visitor’s search behavior on the WWW (see Section 6.2). The design patterns will be the basic components to optimize websites and to better support wild searching. Besides our empirical studies, we will collect existing examples of design patterns that are applied in practice for static website optimization. We reformulated some of the design patterns because in our opinion some of them could be formulated more precisely. In Section 7.5 we show by means of transition diagrams how design patterns may influence the success of wild searching.

7.1 Introduction

By optimizing websites one can provide better support for wild searching. The design patterns in this chapter are based on the results of our empirical studies in Chapter 4 and 5. In addition to these results, some projects were done by students [160, 217]. These projects were supervised by the author. In the project “Path breadcrumbs in practice” (see also Appendix D.2) we worked on the actual path followed by a visitor on a website. We wanted
to know whether it was possible to make the actual path followed by a web visitor visible and if we could provide the actual path in a usable way to provide backtrack facilities. This study showed that using path breadcrumbs is a possible way to follow the visitor’s path on a website. Path breadcrumb is also a benefit for the visitor as he can see which path he has taken to reach the current page. The disadvantage of path breadcrumbs is that there is limited space available on the screen to display all the steps taken by the visitor. Therefore, only a limited number of pages can be displayed in the path breadcrumb on the current page. This can be solved by a “more results” link by which the visitor can see his whole browsing history on the website. In this way we can provide with path breadcrumbs a means to backtrack.

In the project “User’s search and navigation behavior in non-profit domains” (see also Appendix D.1) we investigated the users’ search and navigation behavior in non-profit websites in the Netherlands and the U.S.A. A so called Total Review™ method was used by the consultancy company Cemit to advise organizations in making their website more effective. This method was most suitable for e-commerce websites and needed to be made applicable for non-profit organizations. The study tried also to assess how successful the websites are in facilitating users in reaching their goals, in order to reach the non-profits organizational goals. In the study we focused on two non-profit sectors: local government and charities. The study showed that the websites involved in this study should be optimized and made also accessible for users doing a wild search. This is important because the success of non-profit websites is mainly dependent on finding the desired information easily. An elaborate description of these projects is presented in Appendices D.1 and D.2.

Design patterns can be useful for both website visitors and web designers. When applying the design patterns, website visitors will be supported better in performing a wild search. This will result in website visitors spending more time on the optimized websites, and be more satisfied as they can realize more goals, especially the goals that are not well defined and the new goals.

The design patterns can be useful to web designers as well. Website owners usually have a specific target in mind or a specific goal for their web visitors. Web designers can use the design patterns to steer the web visitor in the right direction. In particular, for e-commerce websites (see Chapter 1) steering the web visitor in the right direction might have the objective, e.g.,
to sell a product or to make money by making the web visitor click on banners. It can also be important to make the web visitor enthusiastic for new things (creating new user goals or making web visitors deviate from their initial goals).

In the next sections we formulate design patterns for static website optimization that benefit both the web visitor and the web designer while taking into account the observed website problems. These design patterns will support the observed web visitors intended search behavior (see also 6.2) and improve wild searching.

### 7.2 Structure of design patterns

Many experts [231, 4, 248, 225, 2] structure a User Interface (UI) design pattern in 4 to 6 steps, which always include the following:

1. Problem (what),
2. Solution (how),
3. Context (where/when), and
4. Implementation (how).

The structure of Welie [231] consists of six different steps. If one wants to solve a problem, questions like when, how, and why to use the solution arise. We will follow Welie’s structure, because his word choice is in our opinion more natural and clear. Below we give an overview of the different steps and provide a short description of each step.

1. **Problem**
   In this step we give a concise description of the situation or website problem the web visitor is facing that potentially calls for the design pattern.

2. **Solution**
   In this step we give a concise description or solution of what this design pattern entails in addressing the website problem.

3. **Use when**
   In this step we describe conditions and considerations that help you know when to use the design pattern.
4. How
In this step we describe how to implement this design pattern.

5. Why
In this step we explain why the design pattern works; why it is an effective solution.

6. More examples
In this step we provide more examples of how others have used the design pattern to create inspiration and a better sense of the design pattern.

7.3 Design pattern for wild searching

We discovered the following design pattern for wild searching.

1. Problem
Natural search behavior, like wild searching, should be possible on the WWW as well. To improve searching on the WWW, the WWW should support all search behaviors, in particular wild searching, that are accepted in our daily life outside the WWW. Web visitors who lack knowledge or contextual awareness to formulate queries to realize their goal should also be able to search on the WWW.

2. Solution
Create a website that support wild searching and design it through the perspective of your web visitors. Web visitors should be able to search in a natural way. Make the same information on the website as much as possible accessible in many ways (see example Figure 7.1).

3. Use when
Wild searching should be made possible whenever it is possible, especially when you want to give your web visitors the feeling that they can search on your website in a natural way. If you have an e-commerce site then wild searching is a must as you want your web visitors to turn into customers. This is only possible when web visitors will find the product that they are looking for on your website.
4. How

(a) Make the same information on your website as much as possible accessible through various ways besides navigation (Note: this solution is related to the observed search behavior 1 on the WWW (web visitors may change their goal(s)). See Section 5.6.2):

i. Offer a search option on your website (see Section 7.4.5 for a design pattern). A search option is a must for medium to large sites. Web visitors who can not find the information through the menu or navigation (see, e.g., [231] for menu and navigation design patterns), may find it through a search option.

ii. Offer a tag cloud (see, e.g., [248] for a design pattern). Most used and popular tags are shown by different font size and weight to reflect the relative number of times each tag was used. With a tag cloud web visitors quickly get an overview of a large amount of information that has been tagged by
other web visitors and their popularity.

iii. Offer a search cloud. A search cloud is a large list of words. Like in a tag cloud each word in a search cloud is a link, and they are all different sizes. Each word is something that someone searched for when they came to your website. If a lot of web visitors searched for a certain word, then that word will appear bigger in the cloud. A search cloud gives web visitors a quick overview of what other web visitor searched for on the website. The design pattern for a search cloud is the same as for a tag cloud (see, e.g., [248] for a design pattern).

iv. Offer a news section (see, e.g., [231] for a design pattern). The news section could be implemented in a newsbox (see, e.g., [231] for a design pattern). In this section web visitors get a quick overview of the new information, additions, and updates on the website. Other news like press releases are also shown in this section.

v. Offer a site map (see, e.g., [231] for a design pattern). A site map functions as a table of contents of the website and as a navigation alternative. Web visitors can reach pages in one click. A site map gives an overview of all the available pages on the website.

vi. Offer a section related items (see Section 7.4.10 for a design pattern). The section related items is based on the topic of the page the web visitor is visiting. The section related items shows what is also available on the website about the current topic or pages related to the current topic. The section offers web visitors to see more about certain topics on the website that web visitors normally would not see if they would not search for it. The related items could be presented as hyperlinks (see also Section 7.4.1 for a design pattern for tooltips in hyperlinks), images, or videos (see also Section 7.4.9 for a design pattern to optimize a website for speed).

vii. Offer a recommendations section (see Section 7.4.11 for a design pattern). This section is a list of topics recommended by the site owner. The section offers web visitors the opportunity to change their mind and deviate from their initial goal.
It can make web visitors curious to see what the site owner has recommended.

viii. Offer a section with most viewed pages (see Section 7.4.12 for a design pattern). This section might be called, e.g., top 5 or top 10 or popular lately. The section gives web visitors an idea of which pages and topics where popular recently. It gives web visitors the opportunity to change their mind by following the mass.

ix. Offer a section called what’s new or latest addition (see Section 7.4.13 for a design pattern). The section shows web visitors the latest additions on the website. In that respect it shows an overlap with the news section (see, e.g., [231] for a design pattern). The section can make web visitors curious to see what is new on the website.

(b) Use tooltips (see Section 7.4.1 for a design pattern). It is a good habit to use tooltips for hyperlinks or menu items (see, e.g., [231] for menu design patterns). Tooltips give web visitors an idea what is behind a hyperlink or menu item. Tooltips help web visitors in their search. (Related to website problem 1, web visitors do not get the expected information behind links or menu items).

(c) Use snapshots (see Section 7.4.2 for a design pattern). Snapshots are useful when you want to give web visitors an impression or preview of the page or content behind a hyperlink or menu item (see, e.g., [231] for menu design patterns). Snapshots facilitate web visitors in their search. (Related to website problem 1, web visitors do not get the expected information behind links or menu items).

(d) Use local breadcrumbs (see Section 7.4.6 for a design pattern). Local breadcrumbs show the route from the homepage to the current page. Local breadcrumbs give web visitors insight into the hierarchical structure of the website which is helpful in the web visitors’ search. Web visitors understand where they are in relation to the rest of the website. (Related to website problem 5, web visitors get lost in the structure of the website).

(e) Use navigation support on the proper position in your website (see Section 7.4.4 for a design pattern). Web visitors from, for example, the western cultures expect the navigation support on
the left side. Take your target group into account when you are designing the navigation support. Web visitors will appreciate that because they have to spend little time to look for the navigation support. (Related to website problem 3, the navigation support is not on the expected location of the website).

5. Why
A website which is optimized for wild searching makes it possible for web visitors to search in a natural way. For e-commerce sites an optimized website for wild searching enhances the chances to turn web visitors into customers. In general all websites owners want their visitors to come back and a high ranking in the major search engines. Wild searching can be helpful in this.

6. More examples

Figure 7.2: An example of a ‘Latest addition’ section. From K2joom (http://www.k2joom.com/).
Figure 7.3: An example of most viewed pages (here: top songs, top movies, and top tv shows.). From Apple (http://www.apple.com/).
for advanced users.

Some examples of what can be accomplished with the module:

- The module can be used to embed into a node’s body the teasers or bodies of nodes with related content.
- In conjunction with the Simplenews module, RelatedContent can be used to compile newsletters out of already existing nodes.
- Using its API, the module can make it display a block with content related to the node currently being viewed.

Read more about the RelatedContent module in the handbook.

RelatedContent was developed by Thomas Barrientos. The author can be contacted for post-customizations of the module and as Drupal consulting, installation and development. The development of this module has been sponsored by:

- Spoon Media
- CODEDO
dNodeOne

RelatedContent was ported to Drupal 9 by Peter Barenem, in comparison to the ES version, this one supports a simple block that shows the related content. For feedback report an issue.

## Downloads

**Recommended releases**

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**Development releases**

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<td>Download  (12.7k ex)</td>
<td>2019-Dec-19</td>
<td>Notes</td>
</tr>
</tbody>
</table>

Figure 7.4: An example of a ‘Recommendations’ section. From Drupal (http://www.drupal.org/).
7.4 Design patterns to overcome the observed website problems and to support wild searching

7.4.1 Use tooltips

We discovered this design pattern for website problem 1 (*web visitors do not get the expected information behind links or menu items*) which also supports wild searching (see 4b of Section 7.3).

1. **Problem**
   Web visitors do not get the expected information behind links or menu items.

2. **Solution**
   Use tooltip feature for links or menu items. Figure 7.5 shows a tooltip example.

   ![Figure 7.5: An example of a tooltip.](image)

3. **Use when**
   Use tooltips for all the links or menu items when it is not clear on which page the visitor will arrive when he clicks on the link or menu item.
4. **How**
A simple way to create tooltips is by using the “title” attribute of the HyperText Markup Language (HTML)\(^1\). Give a short description in the tooltip of what web visitors can expect when they click on the link or menu item (see, e.g., [231] for menu design patterns). Show the URL of the page to which the link points. Other techniques for creating tooltips are Javascript, AJAX, or CSS.

5. **Why**
Web visitors can get irritated when they find unrelated information behind a link or menu items. To avoid that web visitors are surprised by unexpected information behind a link or menu item one should use tooltips for links or menu items.

6. **More examples**


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\(^1\)See the World Wide Web Consortium (W3C) at [http://www.w3c.org](http://www.w3c.org).
Design patterns to overcome the observed website problems

Figure 7.7: From http://www.google.com.

Figure 7.8: From http://bueltge.de/wp-bubble-tooltips-plugin/142/.
7.4.2 Use snapshots

We discovered this design pattern for website problem 1 (web visitors do not get the expected information behind links or menu items) which also supports wild searching (see 4c of Section 7.3).

1. Problem
   Web visitors do not get the expected information behind links or menu items.

2. Solution
   Use snapshots to give web visitors a preview in advance of the website behind a link or menu item.

3. Use when
   Use snapshots for all the links or menu items when it is not clear on which page the visitor will arrive when he clicks on the link or menu item. Snapshots are also nice when you want to give web visitors a preview or an impression in advance of the page or content behind a link or menu item.

4. How
   A simple way to create snapshots is by using the free tools of service providers (e.g., Snap\(^2\)). There are also add-ons available for browsers.

like Mozilla FireFox\textsuperscript{3} that can be installed by web visitors. Web designers can provide a link to these add-ons. Other techniques for creating tooltips are Javascript, AJAX, or CSS.

5. **Why**

Web visitors can get irritated when they find unrelated information behind a link or menu items. To avoid this surprise, one should use tooltips for links or menu items.

6. **More examples**

![Figure 7.10: An example of an audioshot.](https://addons.mozilla.org/en-US/firefox/addon/5479)
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Figure 7.11: An example of a movieshot.

Figure 7.12: An example of a mapshot.
7.4.3 Check your links

We discovered the following design pattern for website problem 2 (*web visitors face 404 error pages*).

1. **Problem**
   Web visitors face 404 error pages or links which are not working properly.

2. **Solution**
   Check your website regularly for dead links.

![Image of Mozilla Firefox add-on to check dead links on webpages.](image)

Figure 7.13: An example of a Mozilla Firefox add-on to check dead links on webpages. This add-on uses colors to indicate which links are good and which are dead links.

3. **Use when**
   Information on the Internet changes rapidly. It is therefore wise to check your website regularly for dead links, especially when you have external links.
4. **How**
   There are several tools (e.g., link validators), software, and add-ons available to automate link checks on websites. A few examples are the linkchecker (see Figure 7.13) add-on for Mozilla Firefox⁴ and the online linkchecker dead-links.com⁵.

5. **Why**
   Web visitors do not like error pages. They get irritated or annoyed when they face 404 pages or links that are not working properly.

6. **More examples**

![Image of Dead-Links.com - Free Broken Link Checker](http://www.dead-links.com/)

Figure 7.14: An example of an on-line link validator spider (http://www.dead-links.com/).

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Figure 7.15: Example of the software AM-Deadlink to check links (http://aignes.com/deadlink.htm).

Figure 7.16: An example of an on-line link checker at W3C (http://validator.w3.org/checklink).
7.4.4  Pay attention to the position of the navigation support

The following design pattern (related to website problem 3, the navigation support is not on the expected location of the website) was discovered by experts [231, 4]. This design pattern also supports wild searching (see 4e of Section 7.3).

1. **Problem**
   
   The navigation support is not on the expected location of the website.

2. **Solution**

   Use the left side or the top of the website for main navigation support for people from western cultures.

3. **Use when**

   Web visitors from western cultures expect the navigation support on the left side or the top of the website. Therefore it is wise to put the navigation support on the left side or the top when you are designing a website for people from western cultures.

4. **How**

   Place the main navigation support on the left side or the top of the website. There are many ways to design the main navigation for your
Design patterns to overcome the observed website problems

website. The most common ones are the horizontal, vertical, or the inverted L menu. See, e.g., [248, 231] for main navigation design patterns.

5. **Why**
   In western cultures people read from left to right, and from top to bottom. They therefore expect the navigation support on the left side or the top of the website.

6. **More examples**
   See [231, 4] for more examples.
7.4.5 Offer search options

The following design pattern (related to website problem 4, web visitors can not find a search option on the visited website) was discovered by experts [231, 248]. In this design pattern we added some examples (see Section 7.4.5, 6 ‘More examples’) to show how search results can be presented better to support web visitors in their search. (See also Appendix D.1)

1. Problem
   Web visitors cannot find a search option on the visited website.

2. Solution
   Offer web visitors a search option.

![Figure 7.18: Offer a search option. From Apple (http://www.apple.com/itunes/).](http://www.apple.com/itunes/)

3. Use when
   Offer web visitors a search option, especially when you have a website with many pages and topics. A search option is a must for medium to large websites.
4. How
Use a small rectangular area that contains the search functionality. Place this area in a prominent position on the web page. It may help web visitors when a search engine highlights the searched keywords and gives the relevance of the link, e.g., in percentages, or puts the most relevant link (see Section 7.4.1 for a design pattern) at the top. A few lines of description of what one might expect behind the link is essential.

5. Why
A search option on websites makes it easy for web visitors to look up the information easily and quickly. A search engine provides web visitors an alternative way to lookup and access information on websites.

6. More examples

Figure 7.19: An example of a search engine with highlighted keywords (here: website optimization and wild searching) and the relevance in the search results. From searchcloud.net (http://www.searchcloud.net/).
Figure 7.20: This is an example where the search can be narrowed (see left side of the webpage). The web visitor also has the option to see more results per page (see upper right corner of the webpage). From Lonely Planet (http://www.lonelyplanet.com/).
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Figure 7.21: This is an example where the search engine comes up with related concepts (see top of the webpage) besides the search results. This is another way to narrow the search. From Yahoo! Search (http://search.yahoo.com/).
7.4.6 Use local breadcrumbs

Many people talk about breadcrumbs (see, e.g., [231, 4, 248]), while they mean local breadcrumbs. We think that one should specify what breadcrumb to use as there are two types of breadcrumbs: path and local breadcrumbs. Our contribution in the breadcrumbs design pattern is that we separated the two types of breadcrumbs. We reformulated the breadcrumbs design pattern. The following reformulated design pattern is for website problem 5 (web visitors get lost in the structure of the website). This design pattern also supports wild searching (see 4d of Section 7.3) (See also Appendix D.1)

1. Problem
Web visitors get lost in the website because they do not know where they are in the website due to a lack of the insight into the hierarchical structure of the website. Web visitors need to know where they are in relation to the rest of the website; they need insight into the hierarchical structure of the website.

2. Solution
Give web visitors an opportunity to know where they are in the website and how to navigate from the home page to the current page.

3. Use when
Use local breadcrumbs on medium to large websites, especially sites with a hierarchical information structure with more than 3 levels deep. Local breadcrumbs are useful to give the web visitor insight into the hierarchical structure of the website.

4. How
The local breadcrumb is a static breadcrumb that displays the route from the home page (see, e.g., [231] for a homepage design pattern) to the current page. Each level in the local breadcrumb functions as a link to that level. The levels are often separated by a >, >>, | or \ sign. The current page should not be a link. The local breadcrumb should preferably be placed above the content area but below the page header. In order to distinguish between local breadcrumbs and path breadcrumbs (see Section 7.4.7 for a path breadcrumb design pattern) we suggest to place a hierarchy symbol behind the local breadcrumbs
Design patterns to overcome the observed website problems

Figure 7.22: An example of local breadcrumb. From VU University Amsterdam (http://www.vu.nl).

like in Figure 7.23. In this way web visitors will recognize that the breadcrumbs are local breadcrumbs and that they give information about the hierarchical structure of the website.

Figure 7.23: A hierarchy symbol behind the breadcrumbs indicates that we are dealing with local breadcrumbs.

5. **Why**

A local breadcrumb shows the route from the home page to the current page. Local breadcrumbs should show the website hierarchy, not the web visitor’s history. They are useful because they show the current location. This helps web visitors understand where they are in relation to the rest of the website. Local breadcrumbs give the web visitor insight into the hierarchical structure of the website. Local breadcrumbs can be used as a secondary navigation aid. With local breadcrumbs web visitors have the possibility to access higher site levels with one
click.

6. **More examples**
   See [231, 4, 248] for more examples.
7.4.7 Use path breadcrumbs

The following reformulated design pattern is for website problem 5 (*web visitors get lost in the structure of the website*). (See also Appendix D.1 and Appendix D.2)

1. **Problem**
   Web visitors get lost in the website because they do not know where they are in the website and how they arrived on the current page. Browser back buttons do not remember all the visited websites and consequently does not show always the route to the current page. Another drawback of the browser back button is that endlessly clicking back can be tedious. Web visitors need a means to step back and to see what route they have taken to arrive at the current page.

2. **Solution**
   Give web visitors an opportunity to know where they are in the website and how they arrived at the current webpage.

3. **Use when**
   Use path breadcrumbs on medium to large websites, especially sites with a hierarchical information structure with more than 3 levels deep. Path breadcrumbs are important when you want to visualize the route the web visitor has taken to arrive at the current page.

4. **How**
   Show the web visitor’s browsing history in the website, i.e., the actual route the web visitor has taken to reach the current page. So, the path breadcrumb is a dynamic breadcrumb instead of a static one (see Section 7.4.6 for a local breadcrumb design pattern). Each level in the path breadcrumb functions as a link to that level. The levels are often separated by a >, >>, | or \ sign. The current page should not be a link. Use a label “More results” if the path breadcrumb becomes

Figure 7.24: From Hollywood.com ([http://www.hollywood.com](http://www.hollywood.com)).
too long (see Figure 7.26). The path breadcrumb should preferably be placed above the content area but below the page header. In order to distinguish between local breadcrumbs and path breadcrumbs we suggest placing a foot steps symbol behind the path breadcrumbs like in Figure 7.25. In this way web visitors will recognize that the breadcrumbs are path breadcrumbs and that they give information about the route the web visitor has taken to arrive at the current page.

Figure 7.25: A foot steps symbol behind the breadcrumbs indicates that we are dealing with path breadcrumbs.

5. Why
A path breadcrumb shows the actual route that the web visitor has taken to arrive at the current page. It visualizes the web visitor’s browsing history on the website. In this way, path breadcrumbs provide the web visitor a means to step back and to see what route he has taken to arrive at the current page.

6. More examples

Figure 7.26: This is an example of a path breadcrumb implemented by one of our students [217]. The label “more results” is used here because the path breadcrumb became too long. This example shows that the web visitor visited some pages, and finally returned to the PHP main page again.
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Figure 7.27: An example of a browser history in Mozilla Firefox v3.6.3 (http://www.mozilla.org) which could be used as a path breadcrumb. A counter displays how many times a page is visited. This is a drawback as you can not see in which order you visited this page. Nevertheless, this browser history gives you an impression of the path you have followed to arrive at the current webpage.

Figure 7.28: Another example of a browser history in Mozilla Firefox v3.6.3 (http://www.mozilla.org) which could be used as a path breadcrumb. Here the history is displayed in a sidebar (like most of the popular browsers do) which is more convenient to be used as a path breadcrumb. The web visitor can choose from the different view options (e.g., view by the last visited webpage) to display the webpage he visited.
Figure 7.29: An example of a history list on an iPhone (http://itunes.apple.com/ca/app/fonolo/id348228086?mt=8) which could be used as a path breadcrumb. From the history the user can see to whom he made the phone calls and when.
7.4.8 Use logical URLs

We discovered the following design pattern for website problem 6 (web visitors cannot guess the URL of the visited websites).

(see also Appendix D.1).

1. **Problem**
   Web visitors cannot guess the URL of the visited websites, because the URL is not chosen logically.

2. **Solution**
   Choose a URL which is logical or which reflects the website’s title.

![Figure 7.30: Choose a URL which is logical. From Youtube (http://www.youtube.com).](image)

3. **Use when**
   A logical URL should be chosen whenever it is possible, especially when you want to be easily found on the WWW.

4. **How**
   A logical URL looks like www.[website title].[top-level domain]. The website title is the title of the website and the top-level domain is the last part of an Internet Domain Name.

5. **Why**
   When web visitors visit a website they first try to guess the URL of the website. A logical URL makes it easier for web visitors to guess the website URL. If they fail to guess the URL, they will try search engines to find the website. It is likely that web visitors will arrive at other websites, rather than the intended one when using search engines.

6. **More examples**
Figure 7.31: This is an example of the webshop Wehkamp from the Netherlands. It uses .nl as the top-level domain to indicate that the shop is located in the Netherlands. From Wehkamp (http://www.wehkamp.nl).

Figure 7.32: Paris Hilton is using her name in her website. From parishilton (http://www.parishilton.com).
Figure 7.33: This is an example of Massachusetts Institute of Technology (MIT). They are using the .edu top-level domain indicating that they are an educational institution. From MIT (http://www.mit.edu).
7.4.9 Optimize website for speed

We discovered the following design pattern for website problem 7 (there are too many images or animations on the visited website which makes the website slow).

1. **Problem**
   There are too many images or animations on the visited website which makes the website slow.

2. **Solution**
   The download speed of a webpage depends on many things, like images, coding of the webpage, bandwidth, internet traffic, etc. Keeping the use of images to a minimum contributes to optimizing speed. There are several tools available on the Internet to check the download speed of your webpage. Use those tools to check where you can gain speed by optimization. See Figure 7.34.

![Website Speed Test](http://www.iwebtool.com)

Figure 7.34: The website of iWebtool provides a service called “Website Speed Test” to test the download speed of a webpage. From iWebtool ([http://www.iwebtool.com](http://www.iwebtool.com)).
3. **Use when**
Reduce images and animations on webpages when you want to improve the performance and download speed of your website.

4. **How**
Do not use unnecessary images or animation on your website. Keep the size of the images and animations as small as possible when you use images or animations. Use compression methods to keep the image size small. Test the download speed of your website with one of the available tools on the Internet. Check on which point(s) you can gain speed by optimization, and optimize the webpage at that point(s).

5. **Why**
Web visitors do not like slow websites [162, 167, 138]. When they have to wait too long for a webpage, they can get frustrated and irritated, and consequently leave the website.

6. **More examples**
Figure 7.35: The website of websiteoptimization provides a service called “Web Page Analyzer” to test the performance and download speed of a webpage. The output of the test gives a lot of information about the submitted webpage. From websiteoptimization (http://www.websiteoptimization.com).

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</tr>
<tr>
<td>CSS Images</td>
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<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Total Images</td>
<td>11384</td>
<td>2.81</td>
<td>0.66</td>
</tr>
<tr>
<td>Javascript</td>
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<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>CSS</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Multimedia</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
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Figure 7.36: On the website of “test everything!” one can do a lot of tests on webpages. This website uses services from other websites. From “test everything!” (http://tester.jonasjohn.de).
Figure 7.37: The website of pingdom provides, among others, a tool to test webpages. It tests, e.g., the download speed of the webpage, it gives the number of CSS, RSS including HTML files, and the number of images used on the webpage included their size. From pingdom (http://tools.pingdom.com).
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7.4.10 Related items

We discovered the following design pattern that supports wild searching (see 4(a)vi of Section 7.3).

1. Problem
Web visitors need to know what is more available on the website related to the visited topic.

2. Solution
Offer a section of related items based on the topic the web visitor currently is visiting.

3. Use when
Use the section of related items to give web visitors the opportunity to do wild search and to know what is more available on the website related to the topic they currently are visiting. In particular, this section is important for e-commerce and for medium to large sized websites.

Figure 7.38: An example of related items. Here it is called ‘Related products’. From Adobe (http://www.adobe.com).
4. How
Show in your navigation menu (see, e.g., [231] for menu design patterns) or at the end of the webpage a section of related items (e.g., related articles, products, galleries). The items in this section should be related to the current topic the web visitor is visiting. Give the section a name (e.g., related articles) from which it is obvious that the items are related to the current topic. Often this section is built dynamically from a database in which the content of the website is stored.

5. Why
The related items section offers web visitors to see more about certain topics on the website than what web visitors would normally see if they had not searched for the additional information explicitly. Web visitors may be triggered by the related items to visit the related topics. A related items section supports wild searching better.

6. More examples

Figure 7.39: An example of related items. Here it is called ‘Related Links’. From Azrul (http://www.azrul.com).
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Figure 7.40: An example of related items. Here it is called ‘Related galleries’. From Wikipedia (http://en.wikipedia.org).

Figure 7.41: An example of related items. Here it is called ‘Related Articles’. From Travels.com (http://www.travels.com).
7.4.11 Recommendations

We discovered the following design pattern that supports wild searching (see 4(a)vii of Section 7.3).

1. **Problem**
   Web visitors need to know what is recommended by the site owner or by other web visitors.

2. **Solution**
   Offer a section with a list of recommended items (e.g., recommended links, articles or products).

3. **Use when**
   Use a recommendation section to offer web visitors an opportunity to do wild search and when you want to show more topics from your website. A recommendation section is also convenient when you want to personalize a webpage by, e.g., a section called “Recommended for you”. This section is very suitable for e-commerce and medium to large sized websites.

4. **How**
   Show a section with a list of recommended topics. Call the section, e.g., “We recommend”, “Recommendations” or “Recommended for you”.

![Figure 7.42: A recommendation example. From Youtube (http://www.youtube.com).](image-url)
Include this section in your navigation menu (see, e.g., [231] for menu design patterns) or at the end of the webpage.

5. **Why**
A recommendation section supports wild searching better. It offers web visitors the opportunity to change their mind and deviate from their initial goal. It can make web visitors curious to see what is behind the recommended link(s). With a recommended section web visitors get an opportunity to see more from a website than what they would normally see if they had not searched for the additional information explicitly.

6. **More examples**

![Figure 7.43: A recommendation example. From iJoomla (http://www.ijoomla.com).](image-url)
Figure 7.44: A recommendation example. From CNN (http://www.cnn.com).

Figure 7.45: A recommendation example. From Joomplace (http://www.joomplace.com).
We discovered the following design pattern which supports wild searching (see 4(a)viii of Section 7.3).

1. **Problem**
   Web visitors need to know which topics are popular lately.

2. **Solution**
   Offer web visitors a section with a list of popular items (e.g., articles, products or links).

3. **Use when**
   Use a section with popular items to offer web visitors an opportunity to do wild search. This section is also convenient when you want to show more topics from your website.

4. **How**
   Offer a section with a list of top 5 or top 10 most viewed webpages. Preferably this section should be listed at the top of the page so that
web visitors will see this first. Give the section a name like, ‘Top 5’, ‘Top 10’, ‘Most viewed’, ‘Popular’ or ‘Popular lately’.

5. Why
A section with a list of popular items gives web visitors an idea of which pages and topics were popular lately. It gives web visitors the opportunity to change their mind by following the mass. This section contributes to a better wild search.

6. More examples

Figure 7.47: From Linux Journal (http://www.linuxjournal.com).
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Figure 7.48: From Sweets Lyrics (http://www.sweetslyrics.com).

Figure 7.49: From ServerWatch (http://www.serverwatch.com).
7.4.13 Latest addition

We discovered the following design pattern that supports wild searching (see 4(a)ix of Section 7.3).

1. **Problem**
   Web visitors need to know what the latest additions are to the website.

2. **Solution**
   Provide a section with the latest addition.

3. **Use when**
   Offer a section with the latest addition when you want to inform your web visitors about the new items (e.g., topics, articles or products) you recently added to your website. This section is also useful when you want to offer web visitors an opportunity to do wild search. The section is highly recommended for blog websites and websites with many articles (e.g., websites for journals or magazines).

4. **How**
   Provide a section with a list of recently added items (e.g., topics, articles or products). Call it, e.g., ‘What’s new’, ‘Latest additions’, ‘New
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releases’. Preferably this section should be listed at the top of the webpage so that web visitors will see this first.

5. Why
A section with a list of recently added items gives web visitors insight into what was added recently to the website. It can make web visitors curious to see what is new on the website. It gives web visitors a reason to explore the website further. The section contributes to a better wild search.

6. More examples

Figure 7.51: From MSDN Magazine (http://www.msdn.microsoft.com).
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Figure 7.52: From iJoomla (http://www.ijoomla.com).

Figure 7.53: From The Karaoke Channel (http://www.thekaraokechannel.com).
7.5 Transition diagrams for the observed problems

In this section we use the problems listed in Chapter 6 and the provided solutions in this chapter to draw transition diagrams. We will model how appropriate use of design patterns changes the expectations of user success and the perspective on the problems that we identified. The transition diagrams visualize the relationship between the problems and the proposed solutions. In Chapter 8 we develop and show how mathematical models, in particular Markov processes, can support website optimization based on these transition diagrams. The transition diagrams in this chapter will help us to understand these mathematical models better.

The transitions diagrams are presented below. Each transition diagram starts with with two rectangles, the initial states. In the rectangles we give two opposite statements, e.g., ‘The website uses a link checker’ (related to a solution, the design pattern) and ‘The website does not use a link checker’ (related to the problem we observed). An arrow in the diagram presents the transition from one state to another. In the diagrams we see that the initial states transit to other states (ovals). These ovals are the effects of what is mentioned in the rectangles. Finally, this results in a state in which the web visitor did reach his goal or did not reach his goal.

Below we discuss each diagram briefly.

7.5.1 Use tooltips or snapshots

The transition diagram in Figure 7.54 is related to website problem 1 (web visitors do not get the expected information behind links or menu items). We see that web visitors can get the expected information behind the links or menu items when a website uses tooltips or snapshots for preview. Based on this state web visitors may decide to leave the website or to continue their search on the website if they have not realized their goal at this state. When they continue their search they may or may not realize their goal.

It might also happen that web visitors do not get the expected information behind the links or menu items although a website uses tooltips or snapshots for preview. From this state web visitors may decide to leave the website or to continue their search on the website. When they continue their search they may or may not realize their goal.

Three things may happen when a website does not use tooltips or snap-
shots for preview. First, web visitors get the expected information behind the links or menu items. Second, web visitors do not get the expected information behind the links or menu items. Third, web visitors have no idea what is behind the links or menu items. In the latter state web visitors may decide to continue their search on the website or they may decide to leave the website without realizing their goal. In all the three states web visitors may or may not realize their goal.

### 7.5.2 Check your links

The transition diagram in Figure 7.55 is related to website problem 2 (*web visitors face 404 error pages*). From this diagram we can see that web visitors do not get 404 error pages if a website uses a link checker. From
this state web visitors may decide to leave the website or to continue their search on the website. There is also a possibility that web visitors go back to the previous webpage. This transition is given with a dotted arrow in the transition diagram as this does not occur often. Web visitors may or may not realize their goal when they continue their search on the website.

Web visitors may face 404 error pages if a website does not use link checkers. From this state web visitors may decide to leave the website or to go back to the previous webpage. When the web visitors go back to the previous webpage they may decide to continue their search on the website or to still leave the website. In the latter state web visitors will not realize their goal. When they continue their search they may or may not realize their goal.
7.5.3 Pay attention to the position of the navigation support

The transition diagram in Figure 7.56 is related to website problem 3 (the navigation support is not on the expected location of the website). From this diagram we can see that web visitors may or may not mind the location of the navigation support, either a website has or has not the navigation support on the top or on the left side. If web visitors do mind the location of the navigation support then they may expect or may not expect this on the top or on the left side. In both cases web visitors may decide to continue their search on the website or to leave the website. In the latter state web
visitors will not realize their goal. When they continue their search they may or may not realize their goal.

### 7.5.4 Offer search options

![Transition Diagram](image)

Figure 7.57: Transition diagram for website problem 4 and the corresponding solution.

The transition diagram in Figure 7.57 is related to website problem 4 (web visitors can not find a search option on the visited website). From this diagram we can see that either a website offers or does not offer a search option, web visitors may or may not look for a search option. Web visitors can or cannot find a search option if a website offers a search option. If web
visitors can find a search option they may decide to continue their search on the website or to use the search option. After using the search option web visitors may decide to continue their search on the website or to leave the website. When they continue their search they may or may not realize their goal.

It is obvious that web visitors will not find any search options if a website does not offer any search possibilities. Web visitors may decide to continue their search on the website or to leave the website. If they leave the website then they will not realize their goal. They may or may not realize their goal if they continue their search.

7.5.5 Use path or local breadcrumbs

The transition diagram in Figure 7.58 is related to website problem 5 (web visitors get lost in the structure of the website). From this diagram we can see that if a website offers breadcrumbs this may be local or path breadcrumbs. Web visitors know where they are in the website if a website uses local breadcrumbs. Web visitors know or do not know the path they took to the current webpage if a website uses local breadcrumbs.

Web visitors know or do not know where they are in the website if a website offers path breadcrumbs. Web visitor know for sure the path they took to the current webpage if a website offers path breadcrumbs.

There are four options if a website does not offer any breadcrumbs:

1. The web visitors know where they are in the website.
2. The web visitors do not know where they are in the website.
3. The web visitors know the path they took to the current webpage.
4. The web visitors do not know the path they took to the current webpage.

From all the four states web visitors may decide to continue their search on the website or to leave the website. They may or may not realize their goal if they continue their search. If they leave the website then they will not realize their goal.
7.5.6 Use logical URLs

The transition diagram in Figure 7.59 is related to website problem 6 (web visitors cannot guess the URL of the visited websites). From this diagram we can see that web visitors can guess the URL if a website uses a logical URL. There is also a possibility that some web visitors cannot guess the URL. These web visitors will use either search engines or their bookmarks to find the website. This is also the case when a website does not use logical URLs. Web visitors will not realize their goal if they cannot guess the URL.

In the other cases they may or may not realize their goal.
7.5.7 Optimize website for speed

The transition diagram in Figure 7.60 is related to website problem 7 (there are too many images or animations on the visited website). From this diagram we can see that either a website is or is not optimized for speed, web visitors may or may not mind the speed of the website (i.e., the time that it takes to display a webpage on the web visitor’s computer screen). Either web visitors mind or do not mind, they may continue their search or leave the website. They may or may not realize their goal if they continue their search. If they leave the website then they will not realize their goal.
Figure 7.60: Transition diagram for website problem 7 and the corresponding solution.
7.6 Conclusion

In this chapter we provided solutions (see Section 7.3 and 7.4) for the website problems listed in Chapter 6. We formulated design patterns for static website optimization. The design patterns can support the observed web visitors search behavior (see also Section 6.2) on the WWW and can improve wild searching.

In Section 7.5 we drew transitions states to visualize the detected problems and the solutions proposed in our design pattern list, and their relationship. In Chapter 8, we develop and show how mathematical models can support website optimization. The transition states in Section 7.5 will help us to understand these mathematical models better.
Chapter 8

Mathematical formulation of search behavior

8.1 Introduction

Search behavior of people is a complex process. In order to quantify this so that a systematic study of search behavior is possible, one can model search behavior in the framework of Markov decision problems. Markov decision problems are a widely used class of models that have been used particularly in behavioral ecology, communication models, inventory management, and economic planning and consumption models (see [192] and [49]). In this chapter we will introduce the basic components of a Markov decision problem and discuss some mathematical and notational subtleties in order to formulate search behavior in terms of a Markov decision problem. At the end of the chapter, we will apply the formulated model on some examples to show how the model works. These examples are meant to familiarize oneself with Markov decision models. This will be generalized in the Chapter 10 to deal with autonomous management of design patterns for website optimization.

8.2 Markov Decision Problems

The results of the empirical studies in Chapter 4 and 5 refer to sequential decision problems that can be modeled by ‘Markov decision problems’
In a Markov decision problem we are given a dynamical system whose state may change over time. This is exactly what we saw in Chapter 4 and 5; the actions that the users take are based on the information of the state they find themselves in and their expectations of the outcome of the actions (e.g., users expect certain information behind certain links, see also Section 5.6.1). Every action taken by the user at a certain point in time brings the user to another state. The new state provides the user new information and experience. Users get new ideas, new goals, or they even may change their goal. Combined with the information from the previous state the user may take another action of which he expects that it will bring him potentially closer to his goal. These steps continue until the goal is reached or the user states another goal or the user stops. The next section formalizes this idea.

8.3 Mathematical framework

In this section, we provide a formal mathematical description of Markov decision problems that will serve as a basis for describing search behavior and website optimization. A Markov decision problem is characterized by the tuple \((\mathcal{S}, \mathcal{A}, \mathbb{P}, r)\). The set \(\mathcal{S}\) describes the state, i.e., the information that a user is provided with, of the system that is being modeled. Suppose that at time \(t\) the user is given the information \(s_t \in \mathcal{S}\). Then we can decide to take action \(a_t \in \mathcal{A}\) to influence the system to move closer to his goals. When an action \(a_t\) is chosen based on the observed state \(s_t\), two things happen. First, the user incurs some reward \(r_t\) (i.e., utility to the user) based on the state and the action, denoted by \(r_t(s_t, a_t)\). Second, due to action \(a_t\), the state of the system moves to a new state \(s_{t+1}\) according to some probability law \(\mathbb{P}_t\), that depends on the state and action as well. In this new situation, the user is faced with a similar problem structure as before; he observes a state \(s_{t+1}\) and has to choose an action \(a_{t+1}\) that brings him closer to his goal, after which the system moves on according to the probability law \(\mathbb{P}\). These steps continue until the goal is reached or the user stops (see also Figure 8.1).

The abstract framework above is sufficiently rich to model search behav-

\(^{1}\)Note that Markov decision theory is a relatively new field of which the roots can be traced back to the 1950s [234]. MDPs are an extension to the much older field of Markov chains, of which initial results were published in the 1900s [149].
ior and support website optimization. By giving the elements of the Markov decision problem different interpretations, different situations of search behavior and website optimization can be modeled, both in “non-web” situations and in web situations. For example, in order to model shopping behavior, the system of the Markov decision problem could be taken to be a supermarket. The set $\mathcal{S}$ could represent the different products that are present in your shopping cart, and $\mathcal{A}$ the actions that apply to the shopping cart (e.g., add products or remove products). In this case, based on your shopping cart and your decision, the probability law $\mathbb{P}$ is not random and completely deterministic, and leads to a reward (i.e., a sum of utilities that could represent user satisfaction and monetary costs) that is modeled by $r$. In Section 8.4.1 (the supermarket example) we formalize this example to illustrate the concept of Markov decision problems. In Section 8.4.2 (the Free Record Shop example) we use the Markov decision problem to study search behavior of users, in particular, we show how the framework can formalize
the situation in which users have parallel goals.

In Section 8.4.3 (the look and click behavior example) we show how the framework can be used to study search behavior in web situations. To this purpose, we take a website as the system in our framework. In this case, the set $S$ represents the different webpages of the website, and $A$ denotes the action of clicking on a particular hyperlink on a webpage. The probability law $P$ is again a deterministic function, that translates the action into a new state. The reward $r$ represents the utility of the information found on the webpage, i.e., did the user find the particular information he is looking for on the webpage or not. We illustrate, within this framework, how navigation aids can lead to goal changes and to better support wild search.

The three examples (the supermarket, the Free Record Shop, and the look and click behavior example) above illustrate how Markov decision problems can be used to model and study search behavior in different settings. In Chapter 4 we observed the search behavior of people in “non-web” situations. The supermarket (see Section 8.4.1) example fits well in that context. In Chapter 5 we observed the search behavior of people on the WWW. In both settings (web and “non-web”) we used categories (see Section 4.2.6) to score the observation results. We randomly chose for the parallel goals (trade-off) category to illustrate the concept of Markov decision problems. We elaborate on this in the Free Record Shop Example (see Section 8.4.2). In the look and click behavior example we zoom in on the WWW. We use the categories navigation aids and goal changes and show how Markov decision problems can also be used to influence search behavior. With this example we also show that the mathematical model is applicable for wild searching.

### 8.4 Applications of Markov decision problems

#### 8.4.1 Markov decision problem for shopping behavior in a supermarket

Imagine a user that is faced with the problem of buying items from a shopping list in a supermarket. He starts out with an empty shopping cart and needs to decide which products he is going to buy. Every decision to buy a product brings with it a certain cost, expressed in the time to obtain the product, the effort the user spends obtaining the product, and the price of the product. Hence, the user can evaluate the cost of every decision as a
function of the three factors time, effort, and price.

The objective of the user is to satisfy the demands described by the items on the shopping list. However, the items on the shopping list can be described in various ways. The list may contain specific items (e.g., a certain product of a specific brand), but can have less specified items as well (e.g., a product group). The latter group of items can therefore be substituted by multiple products in the supermarket. Consequently, the decision to buy a certain product must be weighted against the cost that the user attaches to the decision to buy it. Moreover, the decision cannot be seen in isolation, since a decision now may affect a decision in future (e.g., due to constraints on the budget). The user is thus faced with a sequential decision problem of buying optimally given his shopping list.

In order to study behavioral aspects of the user, we formulate the problem as a Markov decision problem. Assume that the supermarket sells \( M \in \mathbb{N} \) different products. The so-called state space or problem space \( \mathcal{S} \) denotes all the combinations of products that the user can buy, and is defined by the power-set

\[
\mathcal{S} = \mathcal{P}\left(\{1, \ldots, M\}\right).
\]  

(8.1)

Note that a state \( s \in \mathcal{S} \) can be seen as the content of the shopping cart. The process of buying items can be modelled in discrete time. Every time the user takes an action the time is incremented by one unit of time. Thus, the situation that the user has an empty shopping cart at time \( t = 0 \) is represented by state \( s_0 \in \mathcal{S} \) given by

\[
s_0 = \{\} = \emptyset.
\]  

(8.2)

At every time \( t \) the user has to make a decision. He can choose to add a product to his cart, to remove a product from his cart, or to do nothing. The actions available to the user are given by the so-called action space \( \mathcal{A} \) defined by

\[
\mathcal{A} = \{-M, \ldots, 0, \ldots, M\},
\]  

(8.3)

where action \( a_t \in \{1, \ldots, M\} \) means that the user decides to buy product \( a_t \) at time \( t \) and adds this product to his shopping cart. Action \( a_t \in \{-M, \ldots, -1\} \) means that at time \( t \) the user decides not to buy product \( a_t \) and removes the product from his shopping cart. Action 0 means that the user decides to buy nothing. The action set may also depend on the state of the system. We might want to model that the user does not buy the same product multiple times, and that he cannot remove a product that is
not in his shopping cart. Suppose that the user has \( n \) products \( s^1, \ldots, s^n \) in his shopping cart. Then the action space \( \mathcal{A}_s \) when the system state is \( s = \{ s^1, \ldots, s^n \} \in \mathcal{S} \) is given by

\[
\mathcal{A}_s = \{-s^1, \ldots, -s^n\} \cup \{0\} \cup \{1, \ldots, M\} \setminus \{s^1, \ldots, s^n\}.
\] (8.4)

Here, the first set in the definition of \( \mathcal{A}_s \) denotes that one can only remove products \( s^1, \ldots, s^n \) from the shopping cart. The second set is the action when the user buys nothing. The last set denotes all the products minus the products already in the shopping cart, and models that no product can be bought multiple times.

At every time \( t \) the user makes a decision the state of the system changes. The change in the system can be described by a transition law \( \mathbb{P} \) which relates the current state \( s_t \), the chosen action \( a_t \), and the next state \( s_{t+1} \) to each other. Since, in our case the contents of the shopping cart is known with certainty the transition law is deterministic, i.e., \( \mathbb{P} \) is either 0 or 1. Thus,

\[
\mathbb{P}(s_t, a_t, s_{t+1}) = 1 \text{ if and only if } \begin{cases} 
  s_{t+1} = s_t \setminus \{a_t\} & \text{if } a_t \in \{-M, \ldots, -1\}, \\
  s_{t+1} = s_t & \text{if } a_t = 0, \\
  s_{t+1} = s_t \cup \{a_t\} & \text{if } a_t \in \{1, \ldots, M\}\). 
\] (8.5)

where \( s_t \in \mathcal{S} \) is the content of the shopping cart at time \( t \), \( a_t \in \mathcal{A}_{s_t} \) is the action the user has chosen at time \( t \), and \( s_{t+1} \in \mathcal{S} \) is a new content of the shopping cart after the decision. To illustrate the transition law, suppose that at time \( t = 0 \) the state of the system is \( s_0 = \{ \} \). Suppose that the user takes the following decisions, \( a_0 = 1, a_1 = 5, a_2 = 0, a_3 = -1, \) and \( a_4 = 4, \) then it follows from the transition law that the subsequent states are \( s_1 = \{1\}, s_2 = \{1,5\}, s_3 = \{1,5\}, s_4 = \{5\}, \) and \( s_5 = \{4,5\}. \) These states describe that the user buys product 1, product 5, does nothing, removes product 1, and finally adds product 4, respectively.

Next to the fact that choosing action \( a_t \in \mathcal{A}_{s_t} \) results in a new state determined by the transition law, the user also receives a reward or cost \( r \) defined by the real-valued function \( r_t(s_t, a_t) \) for \( s_t \in \mathcal{S} \) and \( a_t \in \mathcal{A}_{s_t} \) at time \( t \). In our example the user evaluates a decision based on three factors: time, effort, and price. For every state and action pair the cost of these resources can be specified through utility functions. These are given by the following functions:
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\[ T(s_t, a_t) = \text{the utility of the time the user spends when taking action } a_t \]
\[ \text{in state } s_t, \]
\[ E(s_t, a_t) = \text{the utility of the effort the user spends when taking action } a_t \]
\[ \text{in state } s_t, \text{ and} \]
\[ M(s_t, a_t) = \text{the utility of the amount of money the user spends when} \]
\[ \text{taking action } a_t \text{ in state } s_t. \]

Based on the functions \( T, E, \) and \( M \) the reward function \( r \) can be formulated
as a weighted sum of the utilities, i.e.,

\[ r_t(s_t, a_t) = \alpha_1 T(s_t, a_t) + \alpha_2 E(s_t, a_t) + \alpha_3 M(s_t, a_t), \quad (8.6) \]

where \( \alpha_1, \alpha_2, \) and \( \alpha_3 \) are constants that denote the priority the user gives
to a resource or the importance of a resource. The higher the constants the
higher the user values a resource.

The description of the Markov decision problem is almost finished. We
need to include the formulation of the shopping list to finalize the description.
The shopping list puts constraints on the last state \( s_N \) of the system. We
can distinguish between two types of constraints. These constraints are due
to the fact that the shopping list may contain specific items to buy (e.g.,
a certain product of a specific brand), and less specific items to buy (e.g.,
product groups).

The mathematical formulation of the first type is as follows. Let the
shopping list \( L \) denote the set of specific items to buy, say the list contains
\( n \) products, thus

\[ L = \{l^1, \ldots, l^n\} \subset \{1, \ldots, M\}. \quad (8.7) \]

Then we require that \( L \subset s_N \), i.e., the products of the list should be part of
the contents of the shopping cart in the last state \( s_N \). Since after time \( t = N \)
no actions follow, this constraint can be enforced by having no additional
cost when \( L \subset s_N \), and by adding a huge cost in the other case. Thus the
cost function \( r \) at time \( N \) can be given by

\[ r_N(s_N) = \begin{cases} 
0, & \text{if } L \subset s_N, \\
\infty, & \text{otherwise.} 
\end{cases} \quad (8.8) \]

The second type of less specific products can be formulated as well. Suppose
that the user wants to buy a product from a certain product group (e.g.,
the user wants to buy bread, but the shopping list does not specify whether it
is a baguette, Italian bread, or a croissant). Let $\mathcal{K}$ denote the set of products that belong to that product group. Then we require that the shopping cart contains at least one product from the product group consisting of products in the set $\mathcal{K}$. Thus we require

$$\mathcal{K} \cap s_N \neq \emptyset.$$  

Therefore, similar to the first case, the cost function $r$ at time $N$ can be given by

$$r_N(s_N) = \begin{cases} 0, & \text{if } \mathcal{K} \cap s_N, \\ \infty, & \text{otherwise}. \end{cases}$$  

The collection of objects $(S, A_s, P, r_t)$ refers to the Markov decision problem (see Puterman [192]) for our buying problem. Suppose that the user has a buying strategy $\pi$ that tells the user what permissible action $a_t \in A_{s_t}$ to take at every time $t$ given a state $s_t$. Thus, the strategy $\pi$ can be seen as a function

$$\pi(s_t) = a_t \in A_{s_t}.$$  

When the user starts in state $s_0$ and adopts a strategy $\pi$, then the total cost $C^\pi(s_0)$ that he incurs is given by the total sum of all the direct costs $r_t$ at every time $t$. Thus,

$$C^\pi(s_0) = \sum_{t=0}^{N} r_t(s_t, \pi(s_t)).$$  

The objective of the user is to determine a strategy such that Equation (8.12), also called the criterium function, is minimized. In our problem this means choosing the actions such that the resources time, effort, and money are optimally used. The criterium function can be minimized using a technique called dynamic programming\(^2\). The optimal strategy $\pi^*$ can be obtained through solving the optimality equations for the criterium function. The optimality equations are given by

$$C(s_t) = \min_{a_t \in A_{s_t}} \left[ r_t(s_t, a_t) + \sum_{s_{t+1} \in S} P(s_t, a_t, s_{t+1}) C(s_{t+1}) \right],$$  

for $t = 0, \ldots, N - 1$, and

$$C(s_N) = r_N(s_N).$$  

\(^2\)Dynamic programming is a mathematical technique to solve sequential decision problems. Recursion is the main solution concept that appears in every formulation.
The optimality equations can be interpreted as follows. Give $C(s_t)$ the interpretation of the expected incurred cost when buying optimally when starting the system in state $s_t$. Then, an action $a_t$ yields a direct cost $r(s_t, a_t)$ and the state changes to $s_{t+1}$ according to the transition law. The expected cost that we get from thereon when continuing optimally is given by $C(s_{t+1})$. Thus, the optimality equation tells us that the expected cost $C(s_t)$ can be calculated by the sum of the direct costs of the minimizing action and the expected cost of continuing optimally in the next state.

8.4.2 User with parallel goals (trade-off): buying CDs at the Free Record Shop

In the next example we make a model using Markov decision problems\(^3\) for a user with parallel goals. There is a trade-off of values when users have parallel goals. In this example we imagine a user that is going to the Free Record Shop to buy a CD. Imagine that the user has a limited budget. The objective of the user is to buy a particular CD he likes, i.e., a CD that adds to his utility, which is modelled as pleasure here. The trade-off behavior of the user can now be modelled as follows. Assume that the Free Record Shop sells $M \in \mathbb{N}$ different CDs. Then the state space $S$ denotes all the combinations of CDs that the user can buy, and is defined by the power-set

$$S = \mathcal{P}(\{1, \ldots, M\}). \quad (8.15)$$

The action space $A$ is then defined by

$$A = \{1, \ldots, M\}, \quad (8.16)$$

where action $a \in \{1, \ldots, M\}$ means that the user decides to buy CD $a$. In this example the user evaluates a decision based on two factors: the feeling (i.e., the pleasure he gets from listening to the CD) and the price of a particular CD. For every action the cost function $r(a)$ for $a \in A$ of these resources can be specified through utility functions. These are given by the following functions:

---

\(^3\)The theory of Markov decision problems (MDPs) studies sequential optimization of stochastic systems by controlling their transition mechanism over time. Markov decision problems are an extension of Markov Chains. In mathematics, a Markov Chain, is a discrete-time stochastic process with the Markov property. In such a process, the information at present is sufficient for predicting the future independent of the past (see Puterman [192]). The collection of objects $(S, \mathcal{P}, r)$ refers to the Markov Chain.
$U(a) = \text{the utility representing the feeling the user gets from listening to CD } a, \text{ and}$

$C(a) = \text{the utility based on the price the user has to pay when buying CD } a.$

The user wants to buy a CD which satisfies him and thus gives him the best feeling. This means that $U(a)$ should be maximal for the user. Thus

$$\max_{a \in A} [U(a)].$$

(8.17)

From the fact that the user has a limited budget we can gather that the price of a CD should be below or equal to the budget. Thus

$$C(a) \leq \alpha,$$

(8.18)

where $\alpha$ is the maximum amount of money the user can spend on a CD. Given these conditions we can formulate the cost function $r(a)$ as follows:

$$r(a) = U(a) - \gamma C(a).$$

(8.19)

In the function $r(a)$, $\gamma$ is a constant that denotes the value or importance the user gives to a CD price. The cost function $r(a)$ in our example describes the trade-off between the user’s feeling and the price for a particular CD. Imagine that the user can take 3 actions (e.g., $M = 3$, thus the user can buy CD 1, 2, or 3) and that the value of the utility function is as follows for the subsequent actions:

action 1 $\Rightarrow U = 0, C = 0$ (the user buys CD 1),

action 2 $\Rightarrow U = 1, C = 1$ (the user buys CD 2), and

action 3 $\Rightarrow U = 2, C = 4$ (the user buys CD 3).

This means that the cost function $r(a)$ is respectively $0, 1 - \gamma, \text{ and } 2 - 4\gamma$. We get the following figure when we draw the cost function $r(a)$ against $\gamma$. From Figure 8.2 we gather the following$^4$:

$^4$Only the line segments between coordinates $(0,2), \left(\frac{1}{3}, \frac{2}{3}\right) \text{ [the intersection of the reward functions } 1 - \gamma \text{ and } 2 - 4\gamma], (1,0), \text{ and } (\gamma, 0), \text{ where } \gamma > 1, \text{ are interesting, since they represent the maximum reward for a given value of } \gamma.$
What does this information mean? This means that when the price is not so important (very small $\gamma$ in comparison with the value of $\gamma$ at action 2 and 1) for the user, he will buy CD 3 even though the price for CD 3 is high ($C$ is higher for action 3 than for action 2 or 1). The user will choose CD 3 because this CD gives him a very good feeling ($U$ is higher for action 3 than for action 2 or 1). In this case the user’s feeling for a particular CD is more important than the CD’s price.

On the other hand when the price is very important ($\gamma > 1$) for the user, he will buy CD 1 even though he does not feel much for CD 1 ($U$ is 0 in comparison with the value of $U$ at action 2 and 3). In this case the CD’s price is more important than the user’s feeling for a particular CD.

The user will buy CD 2 when the trade-off between the importance of the feeling and the price are more in balance for the user ($\gamma$ is not too small, and $U$ and $C$ are not so small or big in comparison with the values of $U$ and $C$ at action 1 and 3). In Figure 8.3 we have visualized the areas in which the user decides to buy a particular CD.

In this example we have modelled a situation in which a user has to choose between several products. To evaluate each product the user has
several criteria modelled as utility functions. Since every product leads to
different evaluations on the different criteria, there is a trade-off to be made
here. In this example we have shown that the importance the user assigns
to a criteria determines his behavior. Therefore, for general problems, it is
important to know what criteria the user has and how important they are. Empirical studies can reveal these data.

8.4.3 Look and click behavior of web visitors

In the next example we provide a model to study click behavior of web vis-
itors, and consequently where they are looking. This model is quite flexible
and allows us to study different settings. First, we can study a setting that
can be used to decide how to aid a web visitor in achieving its search goal
by placing navigation aid(s) on the website. Second, we can also study how
web visitors can be triggered to change their goal. Finally, we will show how
the model can be used to describe the web visitor’s wild search behavior.
We start with the description of the first setting.

Navigation aids

In this example we imagine the following site map of a website. In Fig-
The state space, $S$, denotes the collection of webpages and is defined by

\[ S = \{S_0, S_1(1), S_1(2), \ldots, S_3(9), S_3(10)\}. \]  

(8.21)

We assume that the goal of the web visitor is to reach page $S_3(1)$. This can be realized by taking actions in the system (which correspond to clicking on a link). The action space $A_s$ when the system state is $s \in S$, i.e., the web visitor is viewing webpage $s$, is given by

\[ A_s = \{a \mid (s, a) \in E\} \quad \forall \quad s \in S \setminus \{S_3(1), \ldots, S_3(10)\}. \]  

(8.22)

Here, $A_s$ denotes the set of webpages where the web visitor can go starting from page $s$, the webpage which is shown on the web visitor’s display. The action $a \in A_s$, means that the web visitor decides to go to a new webpage. Note that when the web visitor reaches a final state, i.e., states $S_3(1), \ldots, S_3(10)$, then no action is possible. We assume that in these states,
no further actions are taken. The action space can also be written as

\[
A_s = \begin{cases} 
\{S_1(1), S_1(2), S_1(3)\} & \text{if } s = S_0, \\
\{S_2(1), S_2(3)\} & \text{if } s = S_1(1), \\
\{S_2(2), S_2(4), S_2(5)\} & \text{if } s = S_1(2), \\
\{S_2(2), S_2(3), S_2(6), S_2(7)\} & \text{if } s = S_1(3), \\
\ldots
\end{cases}
\]  

(8.23)

In this example we made two assumptions:

1. The web visitor is not clicking on a link to go back to a previously visited page, and

2. The web visitor has to click on a link to go to a new page.

Since the current state (i.e., the current webpage) is known with certainty the transition law \( P \) in this example is deterministic, i.e., \( P \) is either 0 or 1. Thus,

\[
P(s, a, s') = \begin{cases} 
1 & \text{if } s' = a \text{ and } (s, a) \in E, \\
0 & \text{otherwise},
\end{cases}
\]  

(8.24)

where \( s \in S \) is the current state (i.e., the current webpage on the web visitor’s display), \( a \in A_s \) is the decision the web visitor takes to go to a new page, and \( s' \in S \) is the new state (i.e., the new webpage on the web visitor’s display) after the decision has been taken.

The reward function \( r(s, a) \in [0, 1] \) gives the web visitor perception for the relevance of a link or webpage. If the web visitor’s goal is to navigate to \( S_3(1) \), the relevance for this page will be high for the web visitor. Then the reward function might be \( r(s, a) = 1 \) if \( a = S_3(1) \) and \( r(s, a) = 0 \) for all \( a \neq S_3(1) \) given that \( (s, a) \in E \). This means that when reasoning from the web visitor’s perception the probability, \( P \), to click on a link depends on the relevance for a link or webpage for the web visitor.

We first consider a situation in which the web visitor cannot infer any information regarding on which link to click to reach \( S_3(1) \). Therefore, this situation corresponds to a web visitor clicking randomly on one of the links presented on its current page. Hence,

\[
P(s, s') = \begin{cases} 
\frac{1}{n_s}, & \text{if } (s, s') \in E, \\
0, & \text{otherwise},
\end{cases}
\]  

(8.25)
with \(s, s' \in S\), where \(n_s\) is the number of links on webpage \(s\). Therefore the probability of consecutively visiting webpages \(s_0, s_1, \ldots, s_k\) is given by

\[
P(s_0, \ldots, s_k) = P(s_0, s_1) \times \cdots \times P(s_{k-1}, s_k).
\]

The probability to go from \(S_0\) to a page on \(S_1\) is given by

\[
P(S_0, S_1(j)) = (A_0)_j.
\] (8.26)

The probability to go from a page on \(S_1\) to a page on \(S_2\) is given by

\[
P(S_1(i), S_2(j)) = (A_1)_{ij}.
\] (8.27)

Likewise, the probability to go from a page on \(S_2\) to a page on \(S_3\) is given by

\[
P(S_2(i), S_3(j)) = (A_2)_{ij}.
\] (8.28)

In Equations (8.26), (8.27), and (8.28), \((A_0), (A_1)\), and \((A_2)\) are matrices, which are given below.

\[
A_0 = \left( \begin{array}{ccc} \frac{1}{3} & \frac{1}{3} & \frac{1}{3} \end{array} \right),
\] (8.29)

\[
A_1 = \left( \begin{array}{ccccccc} \frac{1}{2} & 0 & \frac{1}{2} & 0 & 0 & 0 & 0 \\ 0 & \frac{1}{3} & 0 & \frac{1}{3} & \frac{1}{3} & 0 & 0 \\ 0 & \frac{1}{4} & \frac{1}{4} & 0 & 0 & \frac{1}{4} & \frac{1}{4} \end{array} \right),
\] (8.30)

\[
A_2 = \left( \begin{array}{cccccccc} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{1}{3} & \frac{1}{3} & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{1}{2} & 0 & 0 & \frac{1}{2} & 0 & 0 & 0 \\ 0 & 0 & \frac{1}{3} & \frac{1}{3} & 0 & 0 & 0 & 0 \\ \frac{1}{6} & 0 & 0 & \frac{1}{6} & 0 & \frac{1}{6} & \frac{1}{6} & \frac{1}{6} \\ 0 & 0 & 0 & 0 & \frac{1}{2} & \frac{1}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{2} & \frac{1}{2} & 0 & 0 \end{array} \right).
\] (8.31)

With these matrices we can calculate the probability to go from \(S_0\) to a page on \(S_3\) by calculating \(A_0 \times A_1 \times A_2\), which results in

\[
P_{S_0 \rightarrow S_3} = \left( \begin{array}{cccccccc} \frac{13}{72} & \frac{13}{72} & \frac{35}{216} & \frac{11}{216} & \frac{7}{72} & \frac{17}{216} & \frac{1}{72} & \frac{1}{72} \end{array} \right),
\] (8.32)

where \(P_{S_0 \rightarrow S_3}\) is the probability from \(S_0\) to a page on \(S_3\).

The calculation above shows that the probability to reach page \(S_3(1)\) is \(\frac{13}{72} \approx 0.18\). This is quite a low probability to realize the web visitor’s goal. Based on this information one can design navigation support to aid the web
Mathematical formulation of search behavior

visitor in clicking the right link (the navigation support can be designed with the help of the transition diagrams of Section 7.5). For example, suppose that the navigation support on \( S_0 \) increases the probability that the web visitor will click on the link \((S_0, S_1(1))\). Assume the probability increases from \( \frac{1}{3} \) to 1 (thus the web visitor clicks with certainty on \( S_1(1) \)). Then the probability to arrive on a page at \( S_3 \) starting from \( S_0 \) is

\[
P_{S_0 \rightarrow S_1(1) \rightarrow S_3} = [1, 0, 0] \times A_1 \times A_2 = \left( \frac{1}{2}, \frac{1}{4}, \frac{1}{4}, 0, 0, 0, 0, 0 \right).
\]

From Equation 8.33 we can conclude that the web visitor will visit pages \( S_3(1) \) with a probability of respectively \( \frac{1}{2} \). Hence, the navigation support has increased the probability to realize the web visitor’s goal. Similarly, when the probability increases to \( \frac{3}{4} \), the probability to reach \( S_3(1) \) starting from \( S_0 \) is \( \frac{73}{192} \approx 0.38 \). Consequently, the model that we have described can be used to determine how the navigation support can be designed to support web visitors in achieving their goal.

Goal changes

In the example we have seen how the model can support the design of navigation support. However, the example can also be used to influence the goal of web visitors. Consequently web visitors may change their goals. The increase in probability can then be seen as a state trigger (e.g., an advertisement, price, logo, or color) to influence the web visitor’s goal and hence his search behavior. Thus, a web visitor starts at page \( S_0 \) and is presented with a state trigger that increases his probability to click on \( S_1(1) \). Consequently, the probability to reach \( S_3(1) \) increases as well.

Wild search

Note that the probabilities to reach pages within \( S_1, S_2, \) or \( S_3 \) describe the wild search behavior of a web visitor. The more vague the search, the more uniform the probability distribution is, e.g., \( P_{S_0 \rightarrow S_1} = (\frac{1}{3}, \frac{1}{3}, \frac{1}{3}) \). The more precise the search is (the case in which a web visitor has a precise goal), the more the distribution tends to select one outcome with certainty, e.g., \( P_{S_0 \rightarrow S_1} = (1, 0, 0) \). The distributions in between reflect the continuum of stages of wild search, such as a web visitor having parallel goals or a web visitor having a hedonic search strategy.
Feasibility of the approach

The Markov decision problem presented in the subsection is a natural way to model click behavior of web visitors. Although, the modeling approach seems natural, i.e., taking the webpages as states and the links between them as possible transitions, it is formulated from the viewpoint of a web designer. Hence, in practice, it is very difficult to make the reward function $r(s,a)$ concrete, since it is unknown what the web visitor is searching for. Instead, when a modeling approach is used which is formulated from the viewpoint of the web visitor, this problem disappears. Then it is possible to differentiate between groups of web visitors with different search behavior.

In the next chapter, we study examples of website optimization that are used in practice. However, in the discussion we will show that all these methods do not differentiate between different user groups. Therefore, we will develop a model that addresses this problem in the chapter thereafter.

8.5 Conclusion

Search behavior is a complex process that is difficult to study. In order to systematically study search behavior, there is a need for models that quantify features of search behavior. Markov decision problems provide a framework in which this can be established. Therefore, we have introduced the basic components of a Markov decision problem in this chapter. We modelled the user’s search behavior in the framework of Markov decision problems, which we applied in both “non-web” and web situations. We have developed a model for the click behavior of web visitors, which was applied to the category navigation aids. We then discussed the applicability of the model to different categories (e.g., precise goals, goal changes, parallel goals, hedonic search strategy), which we used in Chapter 4 and 5. We also observed that this model also describes the wild search behavior of a web visitor.

The examples in this chapter are meant to familiarize oneself with Markov decision models. In the Chapter 10 we develop a model for dynamic website optimization through autonomous management of design patterns based on the concepts developed in the chapter. The observation results of Chapter 5 are used to estimate model parameters. Then the results of the estimate are analyzed to optimize websites.
Mathematical formulation of search behavior
Chapter 9

Techniques and tools for website optimization

9.1 Introduction

In Chapter 8 we introduced the basic components of a Markov decision problem. We discussed mathematical and notational subtleties in order to formulate search behavior in this framework. In particular, we modeled look and click behavior of web visitors. At the same time, we identified that there are some practical issues to overcome before that model can be applied in practice for website optimization. In this chapter, we provide an overview of some techniques that are applied in practice for website optimization. We can categorize these techniques into categories, which are described in Section 9.2. In Section 9.3 we refer to some concrete examples of tools that use these techniques to optimize websites. We end the chapter with a discussion on the applicability of the techniques in Section 9.4.

9.2 Techniques to optimize websites

There are many commercial parties that offer tools for optimizing websites. However, the techniques that are used by these parties do not differ that much from each other. In fact, one can identify two categories of optimization techniques that are used in practice.

The first technique focuses on web analytics, see, e.g., [64, 161, 226, 23]. The tools that adopt these techniques analyze the logfiles of the webserver
and gather various other statistics to answer questions on the performance of the website and provide insight into the behavior of web visitors. For example, typical questions that can be answered are ‘How many unique web visitors per month are attracted by my website?’, ‘How popular is my website?’, ‘Where do my web visitors come from?’, ‘Which browsers do my web visitors use?’, ‘Which keywords are used to land on my website?’.

It is also possible to analyze the behavior of the web visitor as he visits the website. This analysis is carried out by placing the popularity of each section of the website in different activity maps (e.g., click maps, mouse move maps, scroll reach maps, and attention maps). In addition, statistics are also collected by recording all actions and mouse movements of the web visitor as a movie that can be watched back (an example of such a system is [64]). The first technique mainly provides a passive manner on the collected statistics which have to be evaluated by a web designer to decide on adjustments to improve the website.

The second technique deals with tools for website testing and optimization. In this setting, several versions of a website are created. Then, the different versions are tested on their performance by presenting them to the web visitors. The methods to test these versions are A/B testing and Multivariate Testing (MVT). A/B testing (used by, e.g., [180, 206, 232, 181]) is used to test different versions of an entire website, whereas MVT is used when different components of the website are varied to determine the best combination. Since these two techniques are quite relevant to our research, we elaborate more on A/B testing in Section 9.2.1, and on multivariate testing in Section 9.2.2.

### 9.2.1 A/B testing

A/B testing (also known as split testing or bucket testing [245, 235]) is the simplest model of testing. It is defined as testing two (or more, the so-called A/B/n testing) different versions, say A and B, of the same variable (e.g., a green theme vs. a red theme). A/B testing is not designed to test multiple variables simultaneously. The influence of the different variables on the outcome cannot be determined and the interaction between the variables can also not be measured.

A/B testing can be done consecutively or simultaneously. In consecutive testing, one tests the performance of version A first, and then tests the performance of version B. When you test consecutively, it is possible that
the test results are influenced by time effects. It is therefore better to test simultaneously. In simultaneous testing, one mixes both versions to assess the performance of both versions.

The main purpose of A/B testing is to improve conversion rates (the percentage of web visitors converted to customers) of, for example, websites. A/B testing clearly shows the effect of different versions. When you test a new page design compared to the existing page design, then you can test whether the new page design scores better and how much better than the existing page design. One advantage of A/B testing is that web visitors do not know that they participate in an experiment. Web visitors are in their natural setting and show natural behavior that is not influenced by their awareness of being involved in an experiment.

A/B testing schemes are easy to set up and the results are easy to interpret. They often provide quick results, because there are in total less variations or combinations compared to MVT (see also Section 9.2.2). A/B testing can therefore be used if you want quick results. Although A/B tests provide quick results for one variable or an entire webpage, MVT is quicker and more accurate when you are testing multiple variables. Even if you have a webpage that generates few web visitors, an A/B test can sometimes be better than a MVT. This is because MVT forms more combinations. With a small number of web visitors the duration of the test would be too long in order to obtain reliable results.

A/B testing is also suitable for testing the layout (e.g., logo and navigation positions), the look and feel (e.g., images and colors), and the content of a webpage.

### 9.2.2 Multivariate Testing (MVT)

In contrast to A/B testing where only one element on a webpage at a time is varied, multivariate testing considers various multiple different elements at the same time. In multivariate testing, different sections or elements on a webpage are identified which affect the conversion rate. Different variations of those elements are created, which are then combined to give rise to multiple different versions of the website.

Multivariate tests take more time than A/B tests to show results, but are more likely to produce better results. MVT not only tests which elements affect the conversion rate and which ones do not, but it also is able to identify the optimal combination of page elements that achieves the highest response.
rate. Note, however, that the method is considerably more complicated than A/B testing because the different elements are correlated, i.e., two elements together may have a strong effect on the conversion rate, whereas a single element alone may not. This is a difficult problem to resolve, and in practice many websites use A/B/n testing on the collection of versions without taking the correlated effects into account. This creates the net effect of doing many simple experiments at the same time.

9.3 Examples of some tools to optimize websites

In Section 9.2 we discussed two categories of techniques. Examples of tools that belong to the realm of web analytics are Clicktale [64], Mouseflow [161], Userfly [226], and Google-analytics [23]. These tools try to optimize websites by analyzing website statistics generated by web visitors. In Section 9.3.1 we elaborate on some of these tools in greater detail.

Google Website Optimizer [180], SiteSpect [206], Visual Website Optimizer [181], and Vertster [232] belong to the second technique of website testing and optimization. These tools use A/B testing and MVT to select the best version from a given number of website versions that are prepared in advanced. We discuss some of these tools in Section 9.3.2

9.3.1 Web analytics tools

Figure 9.1 shows an example of website statistics that is presented by the Google Analytics tool. The figure shows a part of all the collected website statistics. In the Site Usage part of the website statistics we see, e.g., the number of web visitors (Visits) that visited this particular website, the number of webpages that are visited (Pageviews), and the percentage of web visitors that left the website after visiting the first webpage (Bounce rate). The website statistics give insight into the demographics of the web visitors, i.e., from which part of the world are web visitors browsing from (Map Overlay). This Map Overlay can be zoomed in to city level. The Traffic Sources Overview provides information of how the web visitor reached the website (e.g., by search engines or by typing the URL direct in the webbrowser). In the Content Overview we can see how many times a webpage was viewed.

Clicktale [64], Mouseflow [161], and Userfly [226] all work in the same way, where Clicktale is more comprehensive than the others. Therefore, we will highlight some features of Clicktale here. Clicktale uses, among other
Examples of some tools to optimize websites

Figure 9.1: An example of website statistics that is presented by the Google Analytics tool.

Figure 9.2: An example of a click heatmap, which shows where web visitors clicked on a webpage. By aggregating the mouse movements of thousands of visitors on a webpage, Clicktale creates a visual representation (a mouse move heatmap) of what visitors are looking at and focusing on within the page. The attention of visitors can be observed through these heatmaps, providing valuable insights for website optimization.

The table below illustrates the browser usage statistics for the month of January 2007:

<table>
<thead>
<tr>
<th>Browser</th>
<th>Visits</th>
<th>% visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet Explorer</td>
<td>13,136</td>
<td>81.55%</td>
</tr>
<tr>
<td>Firefox</td>
<td>2,349</td>
<td>14.58%</td>
</tr>
<tr>
<td>Safari</td>
<td>393</td>
<td>2.44%</td>
</tr>
<tr>
<td>Netscape</td>
<td>116</td>
<td>0.72%</td>
</tr>
<tr>
<td>Opera</td>
<td>55</td>
<td>0.34%</td>
</tr>
</tbody>
</table>
Figure 9.2: Example of three types of heatmaps: the attention heatmap in the upper left corner, the click heatmap in the lower left corner, and the mouse move heatmap on the right.

A heat map is an extension of the mouse move heatmap and is in particular applicable to long parts in websites. This heatmap shows how far web visitors scroll down the webpage and on which parts of the webpage they stay the longest. Besides heatmaps, Clicktale can record mouse clicks, mouse movements, keystrokes, and scroll actions of a web visitor as a movie to see the web visitor’s activities on the website.

9.3.2 Website testers and optimizers

Google Website Optimizer [180], SiteSpect [206], Visual Website Optimizer [181], and Vertster [232] use A/B testing and MVT test methods to select the best version from a given number of website versions, which are prepared in advance. Before testing the various versions of a website, one should define various hypotheses on which elements on the website might be successful. This could be, e.g., different backgrounds, headers or design patterns. The tests can start if the various versions have been created. Google Website
Examples of some tools to optimize websites

Optimizer, e.g., tests the different versions simultaneously. In this way the influence of external factors and seasonal variations will be equal for all website versions. To test all the versions simultaneously, Google Website Optimizer splits all the traffic to the website. This means that not every web visitor gets the same version of the website to see. A cookie takes care that the web visitor always gets to see the same version once he has been presented a website version (conversion can take place after multiple visits). If the tests have run long enough then the results will look like Figure 9.3. There is a graphic area in the figure that shows how much better or worse

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Original</td>
<td>17.2% ± 6.4%</td>
<td>—</td>
<td>0.04%</td>
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</tr>
<tr>
<td>Combination 11</td>
<td>30.9% ± 13%</td>
<td>89.3%</td>
<td>37.0%</td>
<td>79.3%</td>
</tr>
<tr>
<td>Combination 6</td>
<td>26.5% ± 12%</td>
<td>87.8%</td>
<td>28.3%</td>
<td>71.1%</td>
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<tr>
<td>Combination 9</td>
<td>28.8% ± 10%</td>
<td>88.4%</td>
<td>19.2%</td>
<td>66.8%</td>
</tr>
<tr>
<td>Combination 6</td>
<td>26.7% ± 9.5%</td>
<td>84.8%</td>
<td>8.88%</td>
<td>54.7%</td>
</tr>
<tr>
<td>Combination 6</td>
<td>24.4% ± 10%</td>
<td>77.9%</td>
<td>4.21%</td>
<td>41.3%</td>
</tr>
<tr>
<td>Combination 1</td>
<td>22.4% ± 10%</td>
<td>70.3%</td>
<td>2.25%</td>
<td>29.9%</td>
</tr>
<tr>
<td>Combination 4</td>
<td>21.6% ± 9.8%</td>
<td>68.1%</td>
<td>1.30%</td>
<td>25.4%</td>
</tr>
<tr>
<td>Combination 10</td>
<td>20.7% ± 9.2%</td>
<td>65.1%</td>
<td>0.60%</td>
<td>20.2%</td>
</tr>
<tr>
<td>Combination 7</td>
<td>19.5% ± 6.0%</td>
<td>60.1%</td>
<td>0.31%</td>
<td>13.2%</td>
</tr>
<tr>
<td>Combination 3</td>
<td>15.1% ± 8.7%</td>
<td>40.2%</td>
<td>0.01%</td>
<td>-12.6%</td>
</tr>
<tr>
<td>Combination 2</td>
<td>11.2% ± 7.0%</td>
<td>22.3%</td>
<td>0.00%</td>
<td>-34.8%</td>
</tr>
</tbody>
</table>

Figure 9.3: An example of the results collected for the different website versions by Google Website Optimizer.

a particular variation is performing above the original control version, the baseline without any alterations. The following colors can occur in the graph:

- Red: It is certain that this combination does not perform well.
- Yellow: This combination performs a little better or worse than the original, but it is still uncertain.
- Green: It is certain that this combination performs well.
- Gray: This combination performs as good as the original.
9.4 Conclusion

In this chapter we have explored several techniques for website optimization in practice. A first category of techniques is rather passive and analyzes web logs and user behavior. These statistics are relevant to obtain insight into how a user came about to visit the website and what he does during his visit. However, the analysis requires that a web designer looks and interprets the data and then devises an improvement to the website.

A second category of techniques is focused on website testing and optimization. In principle, variations on A/B testing and MVT are used. The main question that is raised when using these techniques is when one should stop testing (in, e.g., Google Website Optimizer and similar systems). Moreover, a website version is not chosen autonomously. Furthermore, the moment at which a website version should be chosen is not always the same and has to be determined by the web designer. These shortcomings are rather prohibiting in deployment of these techniques in practice for obtaining the full benefit of website optimization. Therefore, there is a need for new models that resolve these issues. In the next chapter, we present our solution to overcome these problems.
Chapter 10

Model for dynamic website optimization

In this chapter we develop a mathematical model for dynamic website optimization. The model is designed to optimize websites through autonomous management of design patterns via analysis of user behavior. To incorporate autonomous management in our model, the model needs to infer user preferences through the click behavior of web visitors when presented with pages with different design patterns. At the same time, the model needs to select the design patterns that result in optimized web pages. Hence, there is a tension between exploration (learning) and exploitation (optimal selection). We start by explaining this tension in Section 10.1 and resolve this issue by developing a Bayesian Markov decision model. The model is hard to solve in practice, however, we develop an efficient implementation of which the details are discussed in Section 10.2. A proof of concept of the model has been build to optimize websites in practice. This is discussed in Section 10.3. In Section 10.4 we illustrate how a website with two different groups of web visitors can be optimized for wild searching. By means of numerical experiments we evaluate in Section 10.5 the performance of our algorithm for dynamic website optimization. Finally, in Section 10.6 we end the chapter with conclusions.
10.1 Mathematical model

In this section we develop a mathematical model that on the one hand analyzes user behavior for a given website, and on the other hand dynamically optimizes the website given the analysis of the user behavior. This requires the model to provide a balance between learning and optimization. To illustrate the tension between learning and optimization, we discuss the following example first.

Consider two versions, say A and B, of the same website, i.e., two websites with the same content but with different looks using potentially different design patterns. Suppose that we present 30 web visitors with the two different versions, and 10 of the web visitors like version A better and 20 like version B better. Is this conclusive to rank version B higher than version A? What if the ratios were 20 to 40? In both cases twice as many people like version B better, but the latter case provides more information than the former. Statistically, the case with the 20 to 40 ratio is based on a larger sample size and provides a better estimate for the preference in the population. In this example, both websites were shown to the web visitors, however, in practice, only one website can be shown. It this case one needs to make a decision: does one present the ‘better’ version of the website, or does one need to gather more information on the other version to form a better judgement on the rankings of both versions. It is this tension between learning (i.e., gathering more information by potentially not choosing the website with the highest ranking) and optimization (i.e., choosing the best website based on the estimates) that the model should take into account.

10.1.1 The theory and practice of website optimization

As we have seen in the previous chapter, website optimization is still in its infancy and a few commercial companies already offer basic tools to support website optimization. For example, Clicktale [64], Mouseflow [161], and Userfly [226] are three companies that record user behavior on webpages by storing mouse clicks and mouse movements. Based on this data, a heat map is generated. This data, however, is not used in an optimization algorithm that solves the webpage selection problem. Google Website Optimizer [180] provides website optimization functionality that comes closest to our objective. They present different versions of websites and generate reports that provide statistics on the different website versions. Google Website Opti-
mizer gathers data and generates report, and does not solve the website selection problem in which the tension between learning and optimization is addressed.

We have also seen in Chapter 8 that in the model for the click behavior of web visitors the reward function was difficult to specify in practice. Therefore, there is a need for a model that is specified from the viewpoint of the web visitor. From this viewpoint, it is mainly relevant if the web visitor has achieved his goal, whereas his complete history of click behavior is of minor importance. Thus, one can make a model in which the number of successful visits (the visitor has reached his goal) and the number of failed visits (the visitor did not reach his goal) can be counted. Based on this information, the right website can then be selected.

From a mathematical point of view, the website selection problem, in its simplest form, can be classified as a standard class of problems, known as the class of multi-armed bandit problems [42]. Multi-armed bandit problems are selection problems in which the decision maker is faced with several one-armed bandits (i.e., slot machines that are found in the casino), each having their own payout rate which is unknown to the decision maker. The decision maker has the objective to maximize his revenues while he learns about the uncertain payout rates of the different arms. In our case, the one-armed bandit can be identified with a version of the website, and the payout rate is equivalent to the success probability.

The multi-armed bandit problem is a hard problem for which the optimal strategy cannot be stated explicitly. Sondik [209] develops algorithms to numerically compute the optimal strategy. Gittins [93] characterizes the optimal selection strategy through Gittins indices, but the indices are hard to compute as well. Kumar [134] gives an overview of several methods to deal with the unknown parameters. Several authors have tried to exploit the relationship between learning and optimization to develop simple selection rules [94, 43, 50]. However, despite all the literature, there is no analytical characterization of the optimal policy for the multi-armed bandit problem.

In the sequel, we cast the website selection problem as a multi-armed bandit problem. We incorporate learning in our mathematical model by using the Bayes’ rule. This, however, leads to a high-dimensional state space so that numerically deriving the optimal strategy becomes intractable. To overcome this problem, we develop sufficient statistics to reduce the dimensionality of the state space, which leads to an efficient numerical procedure to solve the website selection problem. In the following subsection we explain
all the intermediary steps.

10.1.2 Bayes’ rule

In our website optimization problem, we want to create a model that forms a judgement of different versions of a website based on data on user behavior. We will use Bayes’ rule to model learning based on the data. To intuitively explain the formula, let $X$ denote the judgement of the websites, and let $Y$ denote the data, i.e., user behavior. Then, Bayes’ rule states that

$$P(X | Y) = \frac{P(Y | X)P(X)}{P(Y)}.$$  \hspace{1cm} (10.1)

In words, the formula states that in order to form a judgement of the website given the data (i.e., $X|Y$), one needs to explain the data where we take the judgement as given (i.e., $Y|X$). The formula represents, in a discrete probabilistic setting, the way both situations are related to each other. In a continuous probabilistic setting (using probability densities $f$), the equivalent of Bayes’ rule above is given by

$$f_X(x | Y = y) = \frac{f_Y(y | X = x)f_X(x)}{f_Y(y)}.$$  \hspace{1cm} (10.2)

10.1.3 Markov decision problem

We now proceed to the formulation of the Markov decision problem for website optimization. To this purpose, we assume that we have $N$ versions of a website. This represents different versions with different uses of design patterns; these versions are generated automatically and use a mix of design patterns that address well-known website issues as described in the transition diagrams in Section 7.5. To each website $i$, we assign a probability $\theta_i \in [0, 1]$ that plays the role of the utility of the user for the website for $i = 1, \ldots, N$. Intuitively one can say that the probability that a user will achieve his goal when presented with website $i$ is represented by $\theta_i$, the utility. This utility represents the overall user judgement of the website, where 1 is the highest ranking and 0 the lowest. Alternatively, when $\theta_i$ is multiplied by 10, then this could be seen as a grade attached to that website. In practice, the utility vector $\theta$ cannot be observed.

Each time a web visitor wants to visit the website, we need to decide which version $i$ to display, for $i = 1, \ldots, N$. This decision is based upon
the utility vector $\theta$ that is not available. Therefore, we formulate a Markov
decision problem that learns the value of $\theta$ while at the same time tries to
optimally select the versions of the website to display such that the utility
is maximized. In this decision making we need to incorporate the tension
between learning the value of $\theta$ and maximizing the utility as discussed
above.

To use Bayes’ rule in our formulation, we need to assume a prior distri-
bution $f_i$ on the possible values of $\theta_i$. This prior distribution will then be
used in Equation (10.2) to derive an updated distribution, called the pos-
terior distribution. In general, starting with an arbitrary prior distribution
can lead to a posterior distribution that does not follow an easy mathemat-
ical description. However, for mathematical tractability, we want to have a
class of distributions from which we choose the prior distribution such that
the posterior distribution remains within the same class. This class of dis-
tributions is called a conjugate family of distributions. In our setting, this
conjugate family is given by the class of all Beta distributions (see, DeG-
root [74]). The Beta distribution for $\theta_i$ is parameterized by $\alpha_i$ and $\beta_i$ to
determine the shape of the distribution. The probability density is given by

$$f_i^{\alpha_i+1,\beta_i+1}(x) = \frac{(\alpha_i + \beta_i + 1)!}{\alpha_i!\beta_i!} x^{\alpha_i} (1-x)^{\beta_i}, \quad (10.3)$$

for $\alpha_i, \beta_i \geq 0$ and $x \in [0, 1]$.

Now suppose that version $i$ is shown to a web visitor, and the web visitor
has a positive evaluation (i.e, a success, denoted by $Y = 1$) of that version.
Then the posterior distribution given this outcome is calculated as

$$\mathbb{P}(x \leq \theta_i \leq x + h \mid Y = 1) = \frac{\mathbb{P}(x \leq \theta_i \leq x + h, Y = 1)}{\mathbb{P}(Y = 1)}$$

$$= \frac{\mathbb{P}(x \leq \theta_i \leq x + h) \cdot \mathbb{P}(x \leq \theta_i \leq x + h, Y = 1)}{\mathbb{P}(Y = 1)}$$

$$= \frac{\mathbb{P}(x \leq \theta_i \leq x + h) \cdot \mathbb{P}(Y = 1 \mid x \leq \theta_i \leq x + h)}{\mathbb{P}(Y = 1)}.$$

Dividing by $h$ and taking the limit $h \to 0$ gives (with $f_Y$ denoting the density
of $Y$)

$$f_{\theta_i \mid Y = 1}(x) = \frac{f_{\theta_i}(x) \mathbb{P}(Y = 1 \mid \theta_i = x)}{\mathbb{P}(Y = 1)} = \frac{x f_{\theta_i}(x)}{\mathbb{P}(Y = 1)}.$$
Hence, this result tells us that when we have a Beta distribution with parameters $\alpha_i$ and $\beta_i$, the update when a success is observed is given by a Beta distribution with parameters $\alpha_i + 1$ and $\beta_i$. Similarly, the same line of argument shows that when a failure is observed then the posterior distribution is given by a Beta distribution with parameters $\alpha_i$ and $\beta_i + 1$. This is a useful result, since it allows us to formulate a Markov decision problem without the need to store complete distributions. Instead we can suffice with only the parameters of the distributions, where $\alpha_i$ and $\beta_i$ count the number of successes and failures, respectively.

We now have all ingredients to formulate the Markov decision problem for website optimization. Define the state space by $S = \{0, 1, \ldots\}^{2N}$. An element $s \in S$ is represented by $s = (\alpha_1, \beta_1, \ldots, \alpha_N, \beta_N)$ providing information on the parameters of all the different versions of the website. Define the action space by $A = \{1, 2, \ldots, N\}$, i.e., the different versions of the website that can be selected to display. The transition probabilities are given by

$$p(s' \mid s, a) = \begin{cases} \frac{\alpha_a + 1}{\alpha_a + \beta_a + 2}, & \text{for } s' = s + e_{2a - 1} \\ \frac{\beta_a + 1}{\alpha_a + \beta_a + 2}, & \text{for } s' = s + e_{2a} \\ 0, & \text{otherwise} \end{cases}$$

where $e_i$ is the vector with all zeros except with the $i$-th entry a 1. The transition probabilities determine how the posterior distribution is determined based on the observation. Given that in state $s$ action $a$ is chosen, the probability of observing a success is given by the expectation of the Beta distribution with parameters $\alpha_a$ and $\beta_a$. This expectation is exactly $(\alpha_a + 1)/(\alpha_a + \beta_a + 2)$. In that case $s + e_{2a - 1}$ results in a state in which $\alpha_a$ is changed to $\alpha_a + 1$. Similarly, a failure is observed with probability $(\beta_a + 1)/(\alpha_a + \beta_a + 2)$. The posterior distribution is then reflected by state $s + e_{2a}$ which updates $\beta_a$ to $\beta_a + 1$. Finally, we take as reward function the utility of the website in case of a success. Thus $r(s, a) = (\alpha_a + 1)/(\alpha_a + \beta_a + 2)$.

The tuple $(S, A, p, r)$ determines the Markov decision problem for the website optimization problem. The description of the Markov decision problem is now completed by describing the criterion function. For that purpose, let $\gamma \in (0, 1)$ be the discount factor, and $\pi$ be a fixed strategy. Then the discounted reward criterion function $V^\pi(s)$ is defined by

$$V^\pi(s) = \mathbb{E}^\pi_s \sum_{t=0}^{\infty} \gamma^t r(S_t, A_t),$$
Implementation

with $S_t$ and $A_t$ the random variables denoting the state and action at time $t$, respectively. The Markov decision problem is to find a strategy $\pi^*$ such that $V(s) = V^{\pi^*}(s) = \sup\{V^\pi(s)\}$. Since the rewards are bounded by 1, it follows that there exists an optimal deterministic stationary strategy. Moreover, $V^{\pi^*}$ is the unique solution to the optimality equations that are given by

$$V(s) = \max_{i=1,\ldots,N} \left\{ \frac{\alpha_i + 1}{\alpha_i + \beta_i + 2} \left[ 1 + \gamma V(s + e_{2i-1}) \right] + \frac{\beta_i + 1}{\alpha_i + \beta_i + 2} \gamma V(s + e_{2i}) \right\},$$

where $V(s)$ denotes the optimal discounted reward starting from state $s \in S$ satisfying $s = (\alpha_1, \beta_1, \ldots, \alpha_N, \beta_N)$.

The optimality equation provides a full characterization of the website optimization problem. However, the description is rather abstract and not directly implementable in real websites. In the next sections, we provide more intuition into how the model works and how it can be implemented in real-time web servers.

10.2 Implementation

In the previous section we have cast the website optimization problem as a Markov decision problem. The idea behind the model is to store two numbers $\alpha_i$ and $\beta_i$ for version $i$ of the website. When a new visitor visits the website, the model determines based on the state $s = (\alpha_1, \beta_1, \ldots, \alpha_N, \beta_N)$ which version of the website to show. This decision is based on the values of $(\alpha_i + 1)/(\alpha_i + \beta_i + 2) [1 + \gamma V(s + e_{2i-1})] + (\beta_i + 1)/(\alpha_i + \beta_i + 2) \gamma V(s + e_{2i})$ for version $i$. Hence, to obtain this value, it is necessary to evaluate the unknown function $V$ in several states. The function $V$ can be obtained by solving the set of optimality equations. Since it is cumbersome to solve this set of equations online in the present form, there is a need for a more efficient procedure to obtain the desired values to make the optimal decision.

From a mathematical perspective, the optimality equations have a nice structure. The equations are so-called contraction mappings and due to the fixed-point theorem it has a unique solution [28]. Moreover, the fixed-point theorem also provides an efficient iterative algorithm to find the solution. Let $V_0(s) = 0$ for all $s \in S$, and define

$$V_{k+1}(s) = \max_{i=1,\ldots,N} \left\{ \frac{\alpha_i + 1}{\alpha_i + \beta_i + 2} \left[ 1 + \gamma V_k(s + e_{2i-1}) \right] + \frac{\beta_i + 1}{\alpha_i + \beta_i + 2} \gamma V_k(s + e_{2i}) \right\},$$
for all $k = 0, 1, \ldots$. Then the solution to the optimality equations can be obtained by recursively calculating $V_k$ and is given by $V = \lim_{k \to \infty} V_k$. However, (nearly) optimal policies can be obtained for relatively low values of $k$. The following pseudo-code provides an algorithm, called value iteration, for deriving policies that differ $\varepsilon$ from the optimal values.

1. Set $V_0$ to 0 for all states $s \in \mathcal{S}$, and let $k = 1$.
2. Calculate (by recursion) $V_k$.
3. Calculate $M = \max_s[V_k(s) - V_{k-1}(s)]$ and $m = \min_s[V_k(s) - V_{k-1}(s)]$.
4. If $M - m > \varepsilon$ then set $k$ to $k + 1$ and continue with step 2.
5. The value of $V_k$ is accurate enough to yield policies that are optimal within $\varepsilon$ difference with respect to the optimal value.

This value iteration algorithm is a very efficient algorithm to solve the optimality equations. It has quadratic performance, i.e., the convergence of the algorithm to the solution is quadratic in the number of iterations. Hence, it can be done in real-time on web servers.

From a computer science perspective, the implementation of this algorithm requires little effort. One way to implement the ideas in this chapter would be to store every version of the website in its own subdirectory along with the $\alpha_i$ and $\beta_i$ in a separate file for version $i$. In the top directory one could build a webpage that reads all the variables from the different subdirectories and invokes the value iteration algorithm. Note that the value iteration algorithm does not need to be run with $s = (\alpha_1, \beta_1, \ldots, \alpha_N, \beta_N)$, the complete vector of parameters simultaneously. Instead, one could run the value iteration algorithm several times for pairs of websites so that gradually the best website emerges. Thus, define $i_1 = 1$, then one could start with $s = (\alpha_{i_1}, \beta_{i_1}, \alpha_2, \beta_2) = (\alpha_1, \beta_1, \alpha_2, \beta_2)$ and denote the index of the best website by $i_2$. Then the algorithm can be run with $s = (\alpha_{i_2}, \beta_{i_2}, \alpha_3, \beta_3)$ after which one denotes the index of the best website by $i_3$. Hence, in the $k$-th run, one would compare $s = (\alpha_{i_k}, \beta_{i_k}, \alpha_{k+1}, \beta_{k+1})$. After the $N$-th iteration, the value of $i_N$ would point to the best website. In this way, the dimensionality of the problem is further reduced so that the algorithm becomes efficient and scalable for large numbers of websites (i.e., $N$ large). Based on the outcome of the algorithm the webpage redirect the browser to the right subdirectory. In addition, each version of the website analyzes the user behavior and determines if the web visitor has successfully reached his goal. Based on this
information each version updates the values of the Beta distribution in its own subdirectory. Hence, every web visitor provides information that is used in determining which version to show when the next web visitor arrives.

The ideas of this chapter have been implemented and tested on a real web server. In the next section we illustrate the ideas based on experiments on this web server.

### 10.3 Website optimization: an illustration

In the previous sections we have outlined the mathematical algorithm and the implementation details. In this section we discuss the results of the implementation of the mathematical model for a real website. For illustrative purposes we will restrict ourselves to two versions of the website, so that the inner workings of the model become more clear. Figure 10.1 shows a website of the Joomla\(^1\) community. In this version of the website the navigation support is on the left side.

Figure 10.2 shows the same Joomla community website with a different design pattern. The difference with version 1 (Figure 10.1) is that the navigation support is on the right side in version 2 (Figure 10.2). To make the difference clearer we use a green background and green text color in version 2. On the top of both websites we see a link “About Joomla” (see red oval on the top in Figures 10.1 and 10.2). The information behind this link is about what requirements you need to run the Joomla CMS. Figures 10.3 and 10.4 show a screenshot of the “About Joomla” page. In the navigation support on the left and right side of version 1 and 2, respectively, we see a link with the name “More about Joomla” (see red oval on the left and right side in Figures 10.1 and 10.2). The information behind this link is about the Joomla project. Figures 10.5 and 10.6 show a screenshot of the “More about Joomla” page. Suppose we want to find out which version of the website is optimal to find the information about the Joomla project. Among the other links, the web visitor can click on the “About Joomla” link or on the “More about Joomla” link to look for that information. To optimize the website, and thus to find out which design pattern (navigation support on the left or on the right side) we should use, we have defined the link “More about Joomla” as a successful action (because the project information is be-

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\(^1\)Joomla is an award-winning content management system, which enables you to build websites and powerful online applications. See also <http://www.joomla.org>. 

hind this link). Each time when a web visitor clicks on this link a success is stored in a text file. For illustration purposes we show the successes and failures below the header “MDP” in both versions (see Figures 10.5 and 10.6). Successes and failures are just two numbers that increase dependent on the success or failure of a web visitor. The mathematical model, which we have implemented, reads these numbers in the text file. Dependent on the successes and failures its shows dynamically the version of the website that maximizes the expected utility.

In our setting of the example, the state of the website is described by the vector \((\alpha_1, \beta_1, \alpha_2, \beta_2)\). We initialized this vector to \((0, 0, 0, 0)\) before web visitors could visit the website. Note that this choice of the parameter results in a uniform distribution for both \(\theta_1\) and \(\theta_2\), i.e., no information is available on the quality of the two versions of the website (see also Figure 10.7). When the vector \(s = (0, 0, 0, 0)\) is used to calculate the best version of the website to display, it turns out that both versions are optimal. This is not strange, since we have the same information on both versions. Hence, we choose...
version 1 to display. Suppose that the web visitor that is presented with version 1 finds the right page and thus reaches the goal. Then the updated vector \( s \) is then set to \( s = (1, 0, 0, 0) \). The distributions are now different for both websites, see Figure 10.8. When this new vector \( s \) is given to the algorithm, the optimal version to display turns out to be 1. This is not strange as version 1 is doing better than version 2. A rough estimate of \( \theta_1 = 2/3 \) and \( \theta_2 = 1/2 \). Suppose that the next web visitor also finds the webpage, resulting in \( s = (2, 0, 0, 0) \). Then, obviously, by the same line of reasoning the algorithm will show version 1 again. The distributions now look as depicted in Figure 10.9. Suppose that the next web visitor is not able to find the webpage and thus results in a failure. Then the vector \( s \) is updated to \( s = (2, 1, 0, 0) \). Figure 10.10 shows that the distribution for \( \theta_1 \) is shifting to the left, so that lower utilities become more likely. However, version 1 still seems to be the better choice. Now suppose that the next web visitor also fails to find the webpage. This will result in \( s = (2, 2, 0, 0) \). Thus, both version have an equal number of successes and failures. Therefore, a
rough estimate of the parameters would be $\theta_1 = 1/2$ and $\theta_2 = 1/2$. However, as Figure 10.11 shows, there is more uncertainty in the estimate of $\theta_2$. Based on the new vector $s$ the algorithm chooses to examine version 2. Note that the example above seems to imply that when $\alpha_1/(\alpha_1 + \beta_1) > \alpha_2/(\alpha_2 + \beta_2)$, thus when the estimate of $\theta_1$ is greater than the estimate of $\theta_2$, it is optimal to show version 1. However, this is not true, since in state $s = (3, 2, 0, 0)$ the estimate for $\theta_1 = 4/7 > \theta_2 = 1/2$, but the optimal version to display is 2. This displays that the algorithm takes the uncertainty into account of the other version.

The previous discussion tries to provide insight into how the algorithm works. In the initial phase, when the algorithm starts with $s = (0, 0, 0, 0)$, the algorithm explores the different versions to gain more information on the success rates of the versions. As the algorithm gains more information, the algorithm converges to one version, since the distinction between the two distribution is clearer. To illustrate this, Figure 10.12 shows the distribution for $s = (40, 10, 20, 30)$. Hence, the algorithm starts with an exploration phase in which it gathers information in a smart manner. Then, it moves on...
Website optimization for wild searching

In the previous section, we have shown how the mathematical model can be used to dynamically select the best version of a website based on the user click behavior. In the illustration, we assumed that we had a homogeneous group of web visitors, i.e., all web visitors had the same interest and user behavior leading to consistent estimates of what the best version of the website is. However, in practice, there are multiple heterogeneous groups of web visitors. Different groups might prefer different versions of the website and the model needs to account for this. In this section, we show how the model can deal with this situation so that the model can be valuable in practice.

In this section, we are faced with the challenge of optimizing websites for wild searching. In Chapter 7.3 we have discussed that two common
Figure 10.5: The information behind the link “More about Joomla” in version 1.

Figure 10.6: The information behind the link “More about Joomla” in version 2.
design patterns to support wild searching are tooltips and snapshots. These solutions are related to problem 1 from Chapter 6: “Web visitors do not get the expected information behind links or menu items”. Based on the web visitor’s domain knowledge, the tooltips or snapshots can be presented, e.g., in technical jargon for experts or in simple and elaborated language for laymen or non-experts.

To illustrate how a website with two different groups of web visitors can be optimized for wild searching we address in the next example a website (e.g., the Oxford Journals website\(^2\)) of which the main web visitors are scientists (e.g., web visitors from universities or scientific institutions). Next

\(^2\)http://www.oxfordjournals.org/.
to scientists, the website may be visited by people who have not in depth knowledge of the scientific topics presented on the website, but who are just interested in a particular topic.

Before we can subject the website to our mathematical model we have to distinguish the two groups of web visitors. This can be done by monitoring and comparing IP addresses. For example, a list with IP addresses of different universities and scientific institutions should be compared against the IP addresses of the web visitors. Note that the information can also be inferred from the network prefix of the IP address so that the list is reduced significantly in size. If a web visitor’s IP address matches an IP address from the list we can be sure that this web visitor is visiting the website through
a computer from a university or scientific institution\textsuperscript{3}. In this way we can distinguish the two different groups of web visitors.

For both groups of visitors we run their own copy of the mathematical model. Thus, we have a set of model parameters for each group separately. Once we know to which group a web visitor belongs to, the model parameters for this group are retrieved. This information is fed into the mathematical model for optimization for this specific group. Then, we can present the web visitor a specific version of the website based on their model parameters. From here on the principle is the same as described in Section 10.3.

\textsuperscript{3}It is also possible to trace the name of the university or scientific institution from the IP address by requesting the hostname from a DNS server.
The above procedure leads to a system that learns the specific preferences of the two groups and presents a version of the website that matches these preferences. For example, let version 1 be the scientific version and version 2 the non-scientific version. Suppose that the model parameters of the universities and scientific institutions are given by $(\alpha_1, \beta_1) = (40, 10)$ and for the non-experts by $(\alpha_2, \beta_2) = (10, 30)$ after 90 visits (50 by experts and 40 by non-experts). This means that web visitors belonging to the scientific group (experts) are presented a website with tooltips or snapshots in technical jargon. Web visitors belonging to the non-expert group are presented a website with tooltips or snapshots in simple and elaborated language. Based on the web visitor’s behavior, the model observes either a success or a failure and will learn the best version for each group. Note that it could well be that there is little difference between the groups (e.g., this could happen if the model parameters for the non-expert group were $(\alpha_2, \beta_2) = (30, 10)$). However, this is not a problem, since the model adapts to the behavior of the groups. The web visitor’s behavior is the basis on which the model will dynamically determine whether it will present a version with tooltip or a version with snapshot for each of the two groups. The process of website optimization for wild searching for this example is illustrated in Figure 10.13.

![Diagram showing the process of website optimization](image-url)

**Figure 10.13:** The process of website optimization for wild searching for two types of groups of web visitors.
In general, one could create a database of web visitors and store unique identifiers to identify the visitors. Based on available information, e.g., IP addresses translating to country, internet providers, and universities, one can cluster the identifiers into homogeneous groups of which the web visitors are expected to behave nearly homogeneously. When a user visits the website, then two things can happen: either his identifier is stored in the database, or he is classified as a new web visitor. If the identifier is in the database, then his parameters $\alpha$ and $\beta$ for the prior distribution can be retrieved. For every new web visitor, one could try to match the groups to the characteristics of the new visitor. If such a group is found, the parameters of this group can be used for the prior distribution of the new visitor. If such a group is not found, then the overall behavior of the web visitors in the database can be used for determining the parameters of the prior distribution. The identifier for the new web visitor is then added to the database along with his determined parameters. In this way, a revisit to the website customizes the appearance tailored to the behavior of each individual web visitor, but the initial parameters on which the algorithm works are determined by the group behavior.

10.5 Numerical experiments

In this subsection, we evaluate the performance of our algorithm for dynamic website optimization by means of numerical experiments. For this purpose, we assume that we have a homogeneous group of web visitors and two versions of a website only. These assumptions enable us to compare our algorithm to A/B testing, which is a leading method for dynamic website optimization in which only two versions are compared. Note that this is a special case of multivariate testing in which multiple versions with overlapping changes are compared. However, as described in the previous chapter, many website optimization algorithms in practice use A/B testing (in modified form) to assess the best version in a multivariate setting as well. Hence, it is insightful to benchmark our dynamic website optimization algorithm against A/B testing.

Our experimental setup consists of two versions of a website. In practice, the behavior of our homogeneous group of web visitors determines the probabilities $\theta_1$ and $\theta_2$ for the two versions. However, since a large-scale experimental setup with web visitors is not feasible, we simulate the behavior
of web visitors on a computer. Thus, before starting the experiment, we fix the values of $\theta_1$ and $\theta_2$. We hide these parameters from our algorithm, so that the algorithm still has to make decisions without this knowledge. We then generate web visitors. For every web visitor, we run the algorithm and determine the version of the website that has to be displayed. If the algorithm decides to show version $i$, then the visit of the web visitor to version $i$ results in a success with probability $\theta_i$ and in a failure with probability $1 - \theta_i$ for $i = 1, 2$. This information, i.e., if the version generated a success or a failure, is fed back into the algorithm for better decision making. This process continues for all the web visitors. In our experiments we generate 100 web visitors. Since this simulation is just one realization of a stochastic process, we need to redo this several times to collect reliable statistics on the number of times that the version with the higher probability was chosen, the number of successes obtained, and the estimates of the parameters. In our experiments, we redo each experiment 100,000 times.

The A/B testing method has been set up in a similar fashion. We generate 100 web visitors. In practice, most A/B testing methods are conducted in a static fashion, i.e., a dashboard displays the performance of the previous visitors and based on those statistics one can choose the best version. In order to have a fair comparison, we implement a dynamic A/B testing method. In this method, after every web visit, the method looks at the estimate $\hat{\theta}_i$ for $\theta_i$, which is the number of successes for version $i$ divided by number of times version $i$ has been shown. The next web visitor is then presented version 1 if $\hat{\theta}_1 \geq \hat{\theta}_2$, and version 2 otherwise (note that this algorithm corresponds to our algorithm in which no learning takes place, i.e., $\gamma = 0$). We collect the same statistics on the number of times that the version with the higher probability was chosen, the number of successes obtained, and the estimates of the parameters by repeating the experiment 100,000 times.

In our first experimental setup, we choose $\theta_1 = 0.3$ and $\theta_2 = 0.7$. These parameter settings correspond with two versions of which one is obviously not as well evaluated by the web visitors than the other. Hence, any website optimization algorithm should find that version 2 is the better version, and should display that version as many times as possible. The A/B testing algorithm starts with $\hat{\theta}_1 = \hat{\theta}_2 = 0.5$. These probabilities are then updated as described before. Our dynamic website optimization algorithm starts in state $s = (0, 0, 0, 0)$ and uses the policy generated in the previous section. However, we need to specify how much exploration is done by the algorithm to learn more about the uncertainty in the estimates. This exploration is
Figure 10.14: The number of times the best version is displayed, $\theta = (0.3, 0.7)$.

represented by the parameter $\gamma$. We first start the algorithm with a little exploration by setting $\gamma = 0.1$.

Figure 10.14 shows a histogram in which the number of times that the best version (i.e., version 2) is displayed both under A/B testing and the algorithm for dynamic WSO. The results show that A/B testing has quite a good performance with a mean equal to 90.6. However, the graph also shows that the A/B testing method goes wrong sometimes by pure chance and results in cases in which almost never the best version is selected. This is the root cause for a variance equal to 492.7. The algorithm for dynamic WSO has a mean of 84.1. This seems to be worse than under A/B testing. Note that this is to be expected, because the algorithm tries to learn a bit more about version 1 to assess that it is really not the best version. Since the difference between $\theta_1$ and $\theta_2$ is rather big, a greedy approach suffices here and in fact no exploration is necessary. However, in light of the variance, which is equal to 49.5, the algorithm does give a guaranteed good performance. Hence, the performance of the algorithm for dynamic WSO is quite well as compared to the A/B testing method.

In Figure 10.14 we compared the number of times the best version was shown. However, for most websites the conversion rates are of importance. Hence, one is interested in the number of successes that have occurred both
The number of times a success is obtained, $\theta = (0.3, 0.7)$. 

under the presentation of the good and bad versions. Therefore, in Figure 10.15 we study the number of times a success has been observed both under the presentation of version 1 and version 2. The mean number of successes under A/B testing is equal to 66.2. However, as we saw in the previous graph, not always the best version is chosen. This results in a variance of 94.5. The algorithm for dynamic WSO has on average 63.7 successes that are obtained. This is not a big difference as compared to the mean number of successes under A/B testing. However, the variance in this result is much lower and is equal to 24.1. Hence, this graph again shows that the algorithm for dynamic WSO has a more consistent performance and guarantees good performance.

Finally, we turn our attention to the estimates of $\theta_1$ and $\theta_2$. In Figure 10.16 we show the graphs of the estimates under the A/B testing and the algorithm for dynamic WSO. The A/B testing method has a mean estimate of $\hat{\theta}_1 = 0.33$ and $\hat{\theta}_2 = 0.67$. The algorithm for dynamic WSO has a mean estimate of $\hat{\theta}_1 = 0.28$ and $\hat{\theta}_2 = 0.70$. The variance of the estimate of $\theta_1$ under the A/B testing method is smaller than under the dynamic WSO method with 0.0035 and 0.014, respectively. However, the variance of the estimate of $\theta_2$ is larger for the A/B testing method with 0.011 as compared to the variance of 0.0025 under the dynamic WSO method. This is to be expected when the previous graphs are studied. The algorithm for dynamic
WSO selects the best version more consistently than under the A/B testing method. Hence, the estimate of $\theta_2$ is more accurate under the dynamic WSO method.

Our first experimental setup shows that under the choice $\theta_1 = 0.3$ and $\theta_2 = 0.7$ a greedy algorithm slightly outperforms the algorithm for dynamic WSO. This is, as mentioned already, not that surprising, because no exploration is needed to make a well-informed decision on the best version of the website. However, the greedy algorithm does not have consistent performance, as the fluctuations in the results are rather larger. Hence, when both the performance and the consistency thereof are taken into account, then the algorithm for dynamic WSO is preferred over the greedy algorithm. In our next experimental setup, we take $\theta_1 = 0.6$ and $\theta_2 = 0.7$ and compare both algorithms. In this case, the two versions are somewhat more similar, and it is harder to distinguish which version is the best. We again compare both algorithms on the points discussed so far.

Figure 10.17 shows the number of times that the best version has been shown to the web visitor. The A/B testing method has shown 46.5 times the best version with a variance of 2289.0. The algorithm for dynamic WSO has shown the best version 72.7 times with a variance of 149.8. Hence, the algorithm for dynamic WSO clearly outperforms the A/B testing method here. Apparently, since $\theta_1$ and $\theta_2$ are so close to each other, the A/B testing method has a hard time distinguishing the best version of the website.

In Figure 10.18 we can see the results of the experiments with respect to the number of successes obtained under both algorithms. On initial sight, the two graphs look similar, however, there are a few differences to be observed. First, the A/B testing method has a mean number of successes equal to 64.6 with a variance of 39.4. The algorithm for dynamic WSO has a mean number of successes that is equal to 67.3 with a variance of 22.9. The algorithm for dynamic WSO is thus better in distinguishing which version is better, and as a result also obtains more successes. Again, we can observe that the algorithm for dynamic WSO has a consistent performance and has a good performance with higher guarantees.

Figure 10.19 depicts the estimates for $\theta_1$ and $\theta_2$ under both methods. The A/B testing method has estimates $\hat{\theta}_1 = 0.49$ and $\hat{\theta}_2 = 0.57$ with variances of 0.018 and 0.021, respectively. The dynamic WSO method has estimates $\hat{\theta}_1 = 0.59$ and $\hat{\theta}_2 = 0.70$ with variances 0.013 and 0.0030, respectively. It is clear that the algorithm for dynamic WSO has estimates the probabilities $\theta_1$ and $\theta_2$ better than the A/B testing method and with higher accuracy as well.
Hence, we can conclude that the algorithm for dynamic WSO outperforms the A/B testing method.

Extensive numerical experiments for different values of $\theta_1$ and $\theta_2$ consistently show that the A/B testing method provides results with a higher variance and with less precise estimates. The algorithm for dynamic WSO provides good performance over the broad range of parameters values of $\theta_1$ and $\theta_2$, and thus outperforms the A/B testing method. The previous experiments were all conducted under the parameter setting $\gamma = 0.1$. When $\gamma$ increases, the algorithm for dynamic WSO explores the different versions a bit more than for lower values of $\gamma$. We have also studied the performance under different values of $\gamma$, and the results suggest that the best value for $\gamma$ is found for $\gamma$ within the interval $0.1$ and $0.2$. There does not seem to be significant differences in the results obtained for the values within this interval. Hence, $\gamma = 0.1$ is a good choice to run the algorithm for dynamic WSO.

10.6 Conclusion

In this chapter we have dealt with the problem of autonomous management of design patterns for website optimization. Websites can significantly improve through the right selection of design patterns. However, the actual implementation of design patterns is based on a lot of choices, e.g., color, position, and style. Moreover, the combination of different design patterns might enforce each other or might have adverse effects that are not known beforehand. Therefore, there is a need to automatically select the right version of the website out of a set of versions with different implementations of the design patterns based on automatic analysis of user behavior.

We have developed a mathematical model that learns which design patterns lead to an optimized website through the click behavior of web visitors. In this setting, the model typically needs to balance the exploration problem (learning) versus the exploitation problem (optimal selection) in a dynamic setting. The learning algorithm is modeled by a Bayesian algorithm, and the optimal selection is modeled by a Markov decision problem. We combined the two parts leading to a Bayesian Markov decision model. The resulting model, however, has a high-dimensional state space prohibiting both tractable analytical and numerical solutions to the problem. We resolve this issue through the reduction of the dimensionality of the state space by de-
veloping sufficient statistics. This sufficient statistic is essential to derive a computationally efficient algorithm for website optimization. We have discussed the implementation details of the model that scales well with the number of design patterns and the size of the website. Moreover, we have shown a proof of concept on a real web server. Experiments on the web server show that the model has very good performance and automatically selects the website version with the highest expected utility. We have described how the mathematical model can be applied to optimize websites for wild searching.
Figure 10.16: Estimates of $\theta_1$ and $\theta_2$, $\theta = (0.3, 0.7)$. 
Figure 10.17: The number of times the best version is displayed, $\theta = (0.6, 0.7)$.

Figure 10.18: The number of times a success is obtained, $\theta = (0.6, 0.7)$. 
Figure 10.19: Estimates of $\theta_1$ and $\theta_2$, $\theta = (0.6, 0.7)$. 
Chapter 11

Summary

Websites have become an essential part of every profession, making a strong impact on the image of every company. Therefore, it is of high importance that websites are designed such that users can find the information they seek easily. However, good design and management of websites is not straightforward as websites are growing in size and becoming more and more complex due to dynamic content. The number of web pages and the complexity make websites very difficult to manage and to maintain. Therefore, optimizing websites in a static and non-autonomous way is a time-consuming and laborious process, which is often not feasible in practice. In this thesis, we bridge this gap by developing a model for dynamic website optimization through autonomous management of design patterns.

11.1 Search behavior & design patterns

The World Wide Web (WWW) is growing with millions of web pages every day. It has an enormous economic value through e-commerce. But, before a website becomes economically relevant, the website has to be found first and needs to have a navigation structure such that users can find relevant information easily. Website optimization (WSO) is a new research area and is a process of improving internal (e.g., layout of web pages and content) and external (e.g., promotion of the website and link building) aspects of web pages to increase the traffic the website receives from search engines. Findability heavily depends on how people search for information. Therefore, we first observed people in “non-web” situations (e.g., shopping malls and
city centers) to find out how people search in “non-web” situations and how their goals are influenced (see Chapter 4). Our main observation was that participants deviated from their initial goals because of parallel goals and because of state triggers that influenced their interests.

The WWW is a relatively new context for people to search in. We did not know whether the search behavior on the WWW would be the same as the search behavior in “non-web” situations. Therefore, we observed the search behavior of people on the WWW (see Chapter 5). We observed that web design problems can cause website visitors to adapt their search behavior. We also observed similarities between searching in “non-web” settings and searching on the WWW. To improve searching on the WWW, the WWW should support all search behaviors (e.g., wild searching) that are accepted in our daily life outside the WWW. To make this possible we formulated design patterns for static website optimization. We also formulated a design pattern for wild searching as wild searching is not supported very well on the WWW.

11.2 Dynamic website optimization

Many design patterns are suggested by experts for common design problems [231, 4, 248, 225, 2]. In this thesis we have defined some new design patterns and discussed the relevance of those design patterns. It is very hard to decide which design pattern optimizes your website the best as there are many design patterns. A combination of different design patterns might enforce each other to improve the website or might have adverse effects that are not known beforehand. Moreover, the design patterns (or sub patterns) can also be used in different styles leaving room for a lot of freedom in usage. It is often not feasible to try all the combinations of the design patterns in a static and non-autonomous way to optimize websites. This would be a time-consuming and laborious process. Therefore, we have developed a mathematical model to optimize websites dynamically (as opposed to Google Website Optimizer) through autonomous management of design patterns. We discussed and implemented the model (see Chapter 10) and built a proof of concept on a real webserver. Our model automatically selects the right website version out of a set of versions with different implementations of the design patterns based on automatic analysis of web visitor behavior (see Section 10.3 and 10.4 for examples). Experiments demon-
strated that the model has very good performance and automatically selects the optimized website. With this model we contribute to the WSO area as there is little to none dynamic and autonomous ways to optimize websites until now.

11.3 Future directions

Our adaptive and self-learning model optimizes websites on the basis of the search behavior of web visitors. We know that websites generate a lot of data (e.g., which browser the web visitor is using, what webpage the visitor previously visited, the path that the visitor followed on the website, what links the visitor clicked on, how long the visitor spent on a webpage, how many times the visitor visited the website, what operating system the web visitor is using, what is the web visitor’s IP address). Website owners use these data to build profiles for the different web visitors and to show them content based on this profile (see e.g., http://www.amazon.com). Based on these profiles it is possible to personalize websites to match the interests of the web visitor. Hence, by extending the model with more information, the model is able to optimize websites based on a population of web visitors in which it differentiates based on profiles. We described such an example in Section 10.4 to illustrate how a website could be optimized for two different types of groups of web visitors who have different domain knowledge.
Samenvatting

Dynamische website optimalisatie door middel van autonoom beheer van design patterns

Websites zijn een essentieel onderdeel geworden van elke bedrijfstak en laten een sterke indruk achter van het bedrijfsbeeld. Het is daarom van groot belang dat websites goed ontworpen zijn zodat gebruikers de informatie makkelijk kunnen vinden. Echter, goed ontwerp en beheer van websites wordt bemoeilijkt door de groei in omvang van websites en door de toenemende complexiteit ten gevolge van dynamische inhoud. Het aantal webpagina’s en de complexiteit maken het erg moeilijk om websites te beheren en te onderhouden. Daarom is het optimaliseren van websites op een statische en niet-autonome wijze een tijdroevende en moeizaam proces, dat vaak niet haalbaar is in de praktijk. In dit proefschrift richten we ons op het ontwikkelen van een model voor de uitvoering van dynamische website optimalisatie door middel van autonoom beheer van design patterns.

Zoekgedrag & design patterns

Het World Wide Web (WWW) groeit dagelijks met miljoenen webpagina’s. Het heeft een enorme economische waarde door middel van e-commerce. Echter, voordat een website economisch relevant wordt, moet de website eerst gevonden worden. De website moet tevens een zodanige navigatiestructuur hebben dat gebruikers de relevante informatie gemakkelijk kunnen vinden. Website optimalisatie (WSO) is een nieuw onderzoeksgebied. WSO is een proces om de interne (bijvoorbeeld lay-out van webpagina’s en inhoud) en externe (bijvoorbeeld het promoten van de website en link building) aspecten van webpagina’s te verbeteren, zodanig dat het aantal bezoekers
dat via zoekmachines de website bezoekt, verhoogd wordt. Vindbaarheid is sterk afhankelijk van de manier waarop mensen zoeken naar informatie. We hebben daarom eerst mensen geobserveerd in “niet-web” situaties (bijvoorbeeld winkelcentra en stadscentra) om uit te zoeken hoe mensen zoeken in “niet-web” situaties en hoe hun doelen beïnvloed worden (zie hoofdstuk 4). Onze belangrijkste observatie was dat de deelnemers afweken van hun oorspronkelijke doelen vanwege parallelle doelen en wegens state-triggers die hun interesses beïnvloeden.

Het WWW is een relatief nieuw medium voor mensen om erop te zoeken. Het is bij voorbaat niet duidelijk of het zoekgedrag op het WWW hetzelfde is als het zoekgedrag in “niet-web” situaties. Daarom hebben we het zoekgedrag van mensen op het WWW geobserveerd (zie hoofdstuk 5). We namen waar dat webbezoekers hun zoekgedrag aanpasten door problemen in de web design. We hebben ook overeenkomsten waargenomen tussen het zoeken in “niet-web” situaties en zoeken op het WWW. Om het zoeken op het WWW te verbeteren, zou het WWW alle zoekgedragingen (zoals wild searching) moeten ondersteunen, die in onze dagelijkse leven zijn geaccepteerd buiten het WWW om. Om dit mogelijk te maken hebben wij design patterns geformuleerd voor statische website optimalisatie. Tevens hebben wij een design pattern geformuleerd voor wild searching, omdat wild searching nog niet goed ondersteund wordt op het WWW.

**Dynamische website optimalisatie**

Er zijn veel design patterns voor algemene design problemen voorgesteld door tal van deskundigen [231, 4, 248, 225, 2]. In dit proefschrift hebben wij enkele nieuwe design patterns gedefinieerd en de relevantie ervan besproken. Het is moeilijk te bepalen welke design pattern je website het beste optimaliseert omdat er zoveel design patterns zijn. Een combinatie van verschillende design patterns kan elkaars werking versterken om de website te verbeteren. Het zou ook nadelige effecten kunnen hebben, die niet op voorhand bekend zijn. Daarnaast kunnen de design patterns (of sub patterns) ook nog eens in verschillende visuele stijlen gebruikt worden waardoor het aantal mogelijke manieren in gebruik erg veel vrijheid toelaat. Het is vaak niet haalbaar om alle combinaties van de design patterns op een statische en niet-autonome manier uit te proberen om websites te optimaliseren. Dit zou een tijdrovend en moeizaam proces worden. We hebben daarom een
wiskundig model ontwikkeld om websites dynamisch (in tegenstelling tot de Google Website Optimizer) te optimaliseren door autonoom beheer van design patterns. We hebben dit model besproken (zie hoofdstuk 10) en een proof of concept gebouwd op een echte webserver. Ons model selecteert, op basis van automatische analyse van het gedrag van de website bezoeker, automatisch de juiste website versie uit een set van versies met verschillende implementaties van de design patterns (zie hoofdstuk 10.3 en 10.4 voor voorbeelden). Experimenten tonen aan dat het model goed presteert en dat het automatisch de geoptimaliseerde website selecteert. Met dit model leveren we een bijdrage aan het WSO onderzoeksgebied, omdat er tot nu toe nog weinig tot geen dynamische en autonome manier was om websites te optimaliseren.
Appendices
Appendix A

Interview questions

A.1 Interview questions for group N in ‘non-web’ situations

Below you will find the interview questions we used for group N (ethnography) in “non-web” situations described in Chapter 4.

1. How familiar are you with this location?

Total unfamiliar 1 2 3 4 5 Very familiar

2. Did you reach your goal?

   (a) Yes. Why do you think that you have reached your goal?
   (b) No. Why did you not reach your goal?

3. Is the goal (purchase) for yourself or for someone else?

4. Did you deviate from or adapt your goal?

   (a) Yes. Why you deviated from or adapted your goal?
      (e.g., background noise, display influence, etc.)
   (b) No.

5. Did you gain information on your goal somewhere else?
   (e.g., inquiry in other shops, friends, etc.)

   (a) Yes. Where?
(b) No.

6. Which resources did you use to reach your goal? 
   (e.g., boards, maps, consulting personal, etc.)

7. To which age group do you belong?

   Age group: 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 55+

8. Where are you from?

A.2 Interview questions for group T in ‘non-web’ situations

Below you will find the interview questions we used for group T (task based observation) in “non-web” situations described in Chapter 4.

1. How familiar are you with this location?

   Total unfamiliar 1 2 3 4 5 Very familiar

2. How familiar were you with the goal?

   Total unfamiliar 1 2 3 4 5 Very familiar

3. Did you reach your goal easily?

   (a) Yes. Why?
   (b) No. Why?

4. Which resources did you use to reach your goal? 
   (e.g., boards, maps, consulting personal, etc.)

5. What is your highest education level?

6. What is/was your occupation?

7. To which age group do you belong?

   Age group: 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 55+

8. Where are you from?
A.3 Interview questions for situation N on the WWW before observation

Below you will find the interview questions we used for situation N (ethnography) on the WWW described in Chapter 5. The interview was held before the observation.

1. How would you classify yourself as computer user?  
   (novice to expert on a scale from 1 to 5)

2. How would you classify yourself as internet user?  
   (novice to expert on a scale from 1 to 5)

3. What are you going to do (what is your goal)?

4. What is/was your occupation?

5. What is your highest education level?

6. What is your start page/homepage in your browser?

7. Do you use search engines?  
   (a) Yes. Which one?  
   (b) No.

8. Do you ever click on banners?  
   (a) Yes. Why?  
   (b) No.
A.4 Interview questions for situation N on the WWW after observation

The following interview questions we used for situation N (ethnography) on the WWW described in Chapter 5. The interview was held after the observation.

1. Did you reach your goal?
   (a) Yes. Why do you think that you have reached your goal?
   (b) No. Why did you not reach your goal?

2. Are you satisfied with the result(s)?
   (a) Yes.
   (b) No. Why?

3. Did you deviate from or adapt your goal?
   (a) Yes. Why you deviated from or adapted your goal?
   (b) No.

4. Did you experience any problems in your search?
   (a) Yes. Why?
   (b) No.

5. Do you like a website with dark background color and light font color or vice versa and why?

6. Do you like an introduction animation on a website?
   (a) Yes. Why?
   (b) No. Why?

7. Do you prefer many text or images on websites and why?

8. To which age group do you belong?
   Age group: 16-20  21-25  26-30  31-35  36-40
              41-45  46-50  51-55  55+
A.5 Interview questions for situation T on the WWW

The following interview questions we used for situation T (task-based observation) on the WWW (see Chapter 5). The interview was held after the observation.

1. How familiar were you with the goals?

   Total unfamiliar  1  2  3  4  5  Very familiar

2. Did you reach your goal easily?

   (a) Yes. Why?
   (b) No. Why?

3. Did you searched differently than usual or is this the approach you always use on the Internet when you are searching for things?

4. Where should the navigation support appear on a webpage (right, left, top, or bottom) and why?

5. Did you experience any problems in your search?

   (a) Yes. Why?
   (b) No.
Appendix B

Forms

B.1 Observation form for group N and T

The following form we have developed and used to observe the search behavior of participants in ‘non-web’ situations in Chapter 4.
### General part

<table>
<thead>
<tr>
<th>Participant number:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender:</td>
<td></td>
</tr>
<tr>
<td>Location:</td>
<td></td>
</tr>
<tr>
<td>Date and time:</td>
<td></td>
</tr>
<tr>
<td>Duration:</td>
<td></td>
</tr>
</tbody>
</table>

#### What is the participant focused on?

| Focused on goal (Epistemic) |  |
| 'Shopping for fun' (Hedonic) |  |

#### Where is the participant drawn by?

| Shop Windows |  |
| Landmarks    |  |
| Maps         |  |
| Price        |  |
| Color        |  |
| Displays/Boards |  |
| Department   |  |
| Logo         |  |

#### Description of the participant's behavior:

|  |
|  |

#### Does social navigation take place?

|  |
|  |

---

**Figure B.1:** Observation form for search behavior in ‘non-web’ situations.
B.2 Observation form for situation N and T (WWW)

The following form we have developed and used to observe the search behavior of participants on the WWW in Chapter 5.
Figure B.2: Observation form for search behavior on the WWW.
Appendix C

Text used to inform participants

In this appendix you will find the translated text which is used to inform the participants about the study. The participants were informed orally.

1. The goal of this study is to find out how people are searching and how their goals are influenced. This study is a part of a major research project which investigates how to optimize websites.

2. During the observation I will not answer any questions. You can ask questions after the observation session. An observation session ends after 30 minutes or when you make a purchase or complete a task.

3. After the observation I will take a short interview. The interview will take 5 to 10 minutes.

4. We do not record any names or personal data in this study. The observation and interview data will be linked to a number. In this way your privacy will be guaranteed. Everything that I observe and that I will discuss with you in the interview will be treat confidentially.

5. Do you have any questions right now?
Text used to inform participants
Appendix D

Related studies

In this appendix we give a summary of some projects which were done by students [160, 217] and which were supervised by the author. We mention these projects here because they are related to our research.

D.1 User’s search and navigation behavior in non-profit domains

D.1.1 The study

We were approached by a consultancy company Cemit\(^1\) that focuses on optimization of websites to do this study. The study investigated the users’ search and navigation behavior in non-profit websites in the Netherlands and the U.S.A. This company advises organizations in making their website more effective, which is done among other things with the so called Total Review\(^{\text{TM}}\). This method was most suitable for e-commerce websites and needed to be made applicable for non-profit organizations. The study tried also to assess how successful the websites are in facilitating users in reaching their goals, in order to reach the non-profits organizational goals. The study focused on two non-profit sectors: local government and charities.

\(^1\)Cemit is an abbreviation for Customer Experience Measurement Improvement Techniques. [http://www.cemit.nl](http://www.cemit.nl).
D.1.2 Approach

For local government we chose Dutch provinces because there are a manageable number of provinces (12) in the Netherlands. All these provinces have their own website, all with the same goals. One of the guidelines of the government was that by the end of 2005 45% of the services of the Dutch provinces needed to be available on-line. This percentage needed to be 65% in 2007 (see also [133]). Province websites are visited and used mainly with the purpose of utilizing public administrative services.

Charity websites are different: visitors voluntarily approach a website mainly by motivations related to the domain of interest of the charity. They are supposed to find information about the charity’s goal and are often stimulated to make a donation. Some of these organizations have a long history and business is done (like with provinces) on-line as well as off-line. Other charity organizations are pure on-line organizations.

Two methods were used to evaluate and review websites.

1. The consultancy company that commissioned the study has developed the so-called Total Review™ method. This method was originally designed for e-commerce websites and needed to be adapted for non-profit organizations.

2. We also applied a user questionnaire that was developed for this study.

The Total Review™ method applies information collected from the sites by a usability expert who answers standard questions that are chosen from a database. The user questionnaire asks actual users of a website to perform certain tasks and to answer questions in relation to the interaction.

Selection and identification of the sites

The official websites of the Dutch provinces were identified. In most cases other websites existed that were related in different ways to the local provincial government. Those websites had different goals, like acquisition of tourism or of industrial enterprises. The official government websites can be found in Table D.1.

The selection of the charities websites was based on company’s commission for our project: the company supports Net4Kids and asked us to assess their website. We choose ten other non-profit organizations to compare with Net4Kids, based on our knowledge of their reputation and because they all
User’s search and navigation behavior in non-profit domains

Table D.1: URLs of the official Dutch province websites.

<table>
<thead>
<tr>
<th>Province</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drenthe</td>
<td><a href="http://www.drenthe.nl">www.drenthe.nl</a></td>
</tr>
<tr>
<td>Flevoland</td>
<td><a href="http://www.flevoland.nl">www.flevoland.nl</a></td>
</tr>
<tr>
<td>Friesland</td>
<td><a href="http://www.fryslan.nl">www.fryslan.nl</a></td>
</tr>
<tr>
<td>Gelderland</td>
<td><a href="http://www.gelderland.nl">www.gelderland.nl</a></td>
</tr>
<tr>
<td>Groningen</td>
<td><a href="http://www.provinciegroningen.nl">www.provinciegroningen.nl</a></td>
</tr>
<tr>
<td>Limburg</td>
<td><a href="http://www.limburg.nl">www.limburg.nl</a></td>
</tr>
<tr>
<td>Noord-Brabant</td>
<td><a href="http://www.brabant.nl">www.brabant.nl</a></td>
</tr>
<tr>
<td>Noord-Holland</td>
<td><a href="http://www.noord-holland.nl">www.noord-holland.nl</a></td>
</tr>
<tr>
<td>Overijssel</td>
<td><a href="http://www.prv-overijssel.nl">www.prv-overijssel.nl</a></td>
</tr>
<tr>
<td>Utrecht</td>
<td><a href="http://www.provincie-utrecht.nl">www.provincie-utrecht.nl</a></td>
</tr>
<tr>
<td>Zeeland</td>
<td><a href="http://www.zeeeland.nl">www.zeeeland.nl</a></td>
</tr>
<tr>
<td>Zuid-Holland</td>
<td><a href="http://www.zuid-holland.nl">www.zuid-holland.nl</a></td>
</tr>
</tbody>
</table>

Table D.2: URLs of charities websites.

<table>
<thead>
<tr>
<th>Organization</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net4Kids</td>
<td><a href="http://www.net4kids.org">www.net4kids.org</a></td>
</tr>
<tr>
<td>Children international</td>
<td><a href="http://www.children.org">www.children.org</a></td>
</tr>
<tr>
<td>Global Giving</td>
<td><a href="http://www.globalgiving.com">www.globalgiving.com</a></td>
</tr>
<tr>
<td>Habitat</td>
<td><a href="http://www.habitat.nl">www.habitat.nl</a></td>
</tr>
<tr>
<td>Heifer</td>
<td><a href="http://www.heifer.nl">www.heifer.nl</a></td>
</tr>
<tr>
<td>KWF</td>
<td><a href="http://www.kwfkankerbestrijding.nl">www.kwfkankerbestrijding.nl</a></td>
</tr>
<tr>
<td>Net Aid</td>
<td><a href="http://www.netaid.org">www.netaid.org</a></td>
</tr>
<tr>
<td>Plan Nederland</td>
<td><a href="http://www.plannederland.nl">www.plannederland.nl</a></td>
</tr>
<tr>
<td>Unicef</td>
<td><a href="http://www.unicef.nl">www.unicef.nl</a></td>
</tr>
<tr>
<td>Warchild</td>
<td><a href="http://www.warchild.nl">www.warchild.nl</a></td>
</tr>
<tr>
<td>WNF</td>
<td><a href="http://www.wnf.nl">www.wnf.nl</a></td>
</tr>
</tbody>
</table>

have projects people can donate for. All charity websites in our study do their business on-line, so they need a very effective website. The charity organizations and their associated websites are provided in Table D.2.
The evaluation and review methods

**Total Review™ method**
The so-called Total Review™ method is used by the consultancy company to evaluate and review websites. The Total Review™ method is based on a database with questions about so-called main categories like usability, quality of information, functionality, thoroughness, charisma, branding, trust, content, etc. The questions were composed by Cemit, based on well-known guidelines like described in [168]. The Total Review™ method applies effectiveness criteria, categories, questions and weighing factors. Categories belong to one or more effectiveness criteria and have weighing factors for each effectiveness criterion they contribute to. Questions are assigned to categories and again have a weighting factor. The average of the scores of the effectiveness criteria is considered to measure effectiveness of the website. For details on the Total Review™ method, see [1].

The Total Review™ method as we used it was adapted for non-profit organizations. In order to make the Total Review™ method applicable for non-profit websites like the provincial and charity websites, many questions specifically about e-commerce and questions around selling products were deleted from the database.

For the research about the Dutch provinces the criteria were based on the strategic goals for the websites of the Dutch provinces. The guidelines and requirements [133, 183, 184] the government has officially declared for websites of Dutch provinces were used for this study. Based on this, questions were added about e-government and participation. Questions about e-government were not relevant for the charity organizations. For both the charity organizations and the Dutch provinces questions were added about participation. On the basis of these changes effectiveness criteria resulted that are described in Table D.3.

**User test**
The second method was developed to empirically evaluate and review Dutch province websites. It consists of a User Test in the form of a questionnaire. This questionnaire could be answered at each user’s convenience. The User Test was intended to complement the results of the Total Review™ method. The original User Test is in Dutch, because all intended participants would be living in the Netherlands and Dutch websites intended for Dutch users had to be evaluated. The User Test consists of five assignments. These questions
Table D.3: Effectiveness criteria and explanation for Dutch provinces.

<table>
<thead>
<tr>
<th>Effectiveness criterion</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usability</td>
<td>The ease of interaction with the website.</td>
</tr>
<tr>
<td>Quality of information</td>
<td>The amount and accessibility of the information on the website.</td>
</tr>
<tr>
<td>Functionality</td>
<td>The functionality that the website offers to get information and the facilities that the websites offer to contact the Dutch province and charity.</td>
</tr>
<tr>
<td>Thoroughness / Charisma</td>
<td>Does the website appear trustworthy, simple to use and good readable.</td>
</tr>
<tr>
<td>E-government (for provinces only)</td>
<td>Is a Provincial Product Catalogue (PPC) available and how well is the service.</td>
</tr>
<tr>
<td>Participation</td>
<td>To what extent can the user participate in the interaction intended by the Dutch province or charity.</td>
</tr>
</tbody>
</table>

had to be answered twice, for two different provinces. The investigation ends with a question about which of the two websites is the best according to the participants. The participants were asked to record the time needed for each assignment. To this end users were asked to use a stopwatch or other time measuring device. This timer should be started on arrival at the homepage of the visited website and stopped as soon as the information was found that was needed for the assignment. Participants were allowed to stop the task if the information could not be found within three minutes. This limit was chosen to prevent participants from dropping out in case they might not be able to accomplish some of the assignments. Writing down the answers to the questions was not timed.

User Test procedure

The User Test was only applied to the websites of the Dutch provinces and presented to internet users known by at least one of the authors. All were approached through email and, consequently all were known internet users. We wanted to compare each province with each other and we did not want the user to visit more than two provinces. So we needed 132 participants to compare a unique pair of Dutch provinces ($12 \times 11 = 132$). Of the 132 participants, 62 were either university students in a faculty of science, or ICT professionals (so-called ‘heavy’ users), and 70 participants were known to use internet only for domestic and leisure purposes (so-called ‘light’ users).

For two different Dutch provinces, these participants were asked to com-
complete five assignments. These Dutch provinces were randomly assigned to each participant.

The participants received a personal email with a MS Word document that contained both series of assignments and questions. They were asked to return it as soon as possible. The content of the returned document was put in a database in order to calculate the statistics we needed.

**User Test score**

The questions in the User Test were usually answered with ‘Yes’ and ‘No’. ‘Yes’ was coded 1 and ‘No’ was coded 0. In some cases users could also answer ‘I do not know’, which was scored 0.5. The aggregated answers to the User Test were expressed in percentages. 100% means that all users were able to find the specific information or to complete an assignment. By counting how many times each Dutch province was elected as “best Dutch province”, divided by the times a Dutch province could be nominated, the preference score for each Dutch province was calculated.

**D.1.3 Description of the assignments**

1. **Assignment 1: find the URL of province X.**
   We asked the participants to indicate whether they knew they were at the official website of the Dutch province or not. Next, the participants were asked to write down the URL of the website. This was used to check which website the participants visited.

2. **Assignment 2: find the physical address and telephone number of province X.**
   The participant had to indicate if he could find the address and telephone number, and how many seconds it took him to find that information.

3. **Assignment 3: find the risk map of province X.**
   The participant had to go to the homepage and find the webpage with information about the risk map. Then the participant had to find out how the risk map could be consulted. If the risk map was on-line, the participant could stop with the assignment and write down the seconds needed to find the webpage. If the risk map was not on-line available,
the question for the participant was if it was clear for him how he could consult the risk map off-line.

4. Assignment 4: find a possibility to submit a complaint about the environment.
The participant had to go to the homepage and find the webpage with information about submitting environment complaints. Then the participant had to find out how he could submit an environment complaint and if he could submit his complaint on-line. After finding the webpage with information the timer was stopped.

5. Assignment 5: apply for a subsidy request.
The participant had to go to the homepage and find the webpage with information about applying for a subsidy for culture and welfare. Then the participant had to find out how he could apply for a subsidy request and if he could apply it on-line. Applying on-line means that the participant had to find an on-line interactive form for completion. So a MS Word or PDF document was not sufficient. After finding the webpage with information the timer was stopped.

After these assignments the participants had to answer which Dutch province in their opinion had the best website, compared to the other Dutch province they did the assignments for. If a participant had a comment, he could write this down.

D.1.4 Results

We found the following results:

- Visitors were frequently unable to find the information they were looking for on the websites. This was often due to the lack of a search and good navigation support, and not optimal search facilities provided by the websites.

- Visitors had difficulty with navigation through the websites because the menu names were not chosen from the point of view of the visitors.

- Visitors got lost easily because they did not know where they were in their search in the website.
• Visitors indicated that the written information on the websites was not easy to understand for the average citizen.

• Visitors indicated that the URL of some websites was not logical. This made it difficult to guess the organization’s URL.

D.1.5 Conclusion

The study showed that the average score of effectiveness for the Dutch provinces is 54% vs. 58% for the charities. This is not good. The results of the Total Review™ Method for the websites of the provinces showed us that the websites of the provinces score poor on the effectiveness criteria. The average score on usability is 57%. This means that the interaction with the province websites was not very well. Together with a poor functionality (45%) of the websites this makes it for the users very difficult to find the desired information. This is also true for the website of the charities. The websites of the charities scored on the effectiveness criterion usability and functionality a little bit better than the websites of the provinces; respectively 65% and 56% vs. 57% and 45%. We see that the results of the Total Review™ Method for the province websites are in line with the results of the User Test for the province websites when we compare the results of the Total Review™ Method for the province websites.

The User Test showed that the websites of provinces do not always have clear information for their users. They do not explain very well how to obtain information when it is not available on the web (e.g., risk map). The navigation is not always easy due to the meaningless terms chosen for the buttons or links. The search facilities provided by the websites are not optimal. Bad navigation and lack of search support make it difficult for the user to find the desired information. It takes too much clicks and therefore time to find the information (if it is available on the website). The consequence is that users will be irritated, annoyed and leave the site unsuccessfully.

As the success of non-profit websites is mainly dependent on finding the desired information easily, the websites involved in this study should be optimized (in particular on the points we found in the results section) and made also accessible for users doing a wild search.
D.2 Path breadcrumbs in practice

D.2.1 Research question

How can we make the actual path followed by a visitor visible on a website and can we provide this as a usable way to provide step back facilities?

D.2.2 Study

The goal of this study was to collect information about breadcrumbs and to show the possible ways to implement path breadcrumb. We created a framework for path breadcrumbs which showed the visitor’s history in the website, i.e. the path the visitor has taken to reach the current page. So, path breadcrumbs are dynamic instead of static.

D.2.3 Approach

We implemented 5 frameworks and worked them out:

1. A PHP framework with sessions,
2. A PHP framework with cookies,
3. A PHP framework with external file,
4. A JavaScript framework, and
5. A PHP framework with database support.

The advantages and the disadvantages of all the frameworks were discussed and compared with each other on performance.

D.2.4 Results

Table D.4 shows the advantages and disadvantages of the implemented frameworks.

D.2.5 Conclusion

This study showed that using path breadcrumbs is a possible way to follow the visitor’s path on a website. Path breadcrumb is also a benefit for the visitor as he can see which path he has taken to reach the current page. The
disadvantage of path breadcrumbs is that there is limited space available on the screen to display all the steps taken by the visitor. Therefore, only a limited number of pages can be displayed in the path breadcrumb on the current page. This can be solved by a “more results” link by which the visitor can see his whole browsing history on the website. In this way we can provide with path breadcrumbs a means to step back.
Bibliography


# List of acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AJAX</td>
<td>Asynchronous JavaScript and XML</td>
</tr>
<tr>
<td>CMS</td>
<td>Content Management System</td>
</tr>
<tr>
<td>CRSP</td>
<td>Consumer’s Retail Search Process</td>
</tr>
<tr>
<td>CSS</td>
<td>Cascading Style Sheets</td>
</tr>
<tr>
<td>HCI</td>
<td>Human Computer Interaction</td>
</tr>
<tr>
<td>HTML</td>
<td>HyperText Markup Language</td>
</tr>
<tr>
<td>MDP</td>
<td>Markov decision problems or Markov decision processes</td>
</tr>
<tr>
<td>MVT</td>
<td>Multivariate Testing</td>
</tr>
<tr>
<td>NCSA</td>
<td>National Center for Supercomputing Applications</td>
</tr>
<tr>
<td>RSS</td>
<td>Really Simple Syndication</td>
</tr>
<tr>
<td>TLD</td>
<td>Top-Level Domain</td>
</tr>
<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
<tr>
<td>URL</td>
<td>Uniform Resource Locator</td>
</tr>
<tr>
<td>WSO</td>
<td>Website Optimization</td>
</tr>
<tr>
<td>WWW</td>
<td>World Wide Web</td>
</tr>
<tr>
<td>XHTML</td>
<td>Extensible Hypertext Markup Language</td>
</tr>
</tbody>
</table>
XML      Extensible Markup Language
<table>
<thead>
<tr>
<th><strong>Glossary</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AJAX</strong></td>
</tr>
<tr>
<td><strong>Atomic observation unit</strong></td>
</tr>
<tr>
<td><strong>CMS</strong></td>
</tr>
<tr>
<td><strong>CSS</strong></td>
</tr>
<tr>
<td><strong>Glossary</strong></td>
</tr>
<tr>
<td>------------------------------------------</td>
</tr>
<tr>
<td><strong>Design pattern</strong></td>
</tr>
<tr>
<td><strong>Direct Social Navigation</strong></td>
</tr>
<tr>
<td><strong>Dynamic website</strong></td>
</tr>
<tr>
<td><strong>Epistemic Search Strategy</strong></td>
</tr>
</tbody>
</table>
Ethnography

Ethnography is the scientific study of human social phenomena and communities, through means such as fieldwork or field research. It is considered a branch of cultural anthropology, the branch of anthropology which focuses on the study of human societies.

Exploration

Exploration is navigation without a specific destination. People are not so much interested in a specific location, but they are more interested in exploring the space they are in. They are more open to following a crowd of people or randomly choosing a route; destination and correct route are of less importance.

Findability

Findability refers to the quality of being locatable or navigable. At the item level, we can evaluate to what degree a particular object is easy to discover or locate. At the system level, we can analyze how well a physical or digital environment supports navigation and retrieval.

Full Field Notes

Working out the notes to complete reports. This should not be done later then the morning of the next day because new experiences push the old ones. That is why one should note the last ones first. Writing stimulates the reflection on the events which should be noted too.

Hedonic Search Strategy

A search strategy that comprises the experiential aspect of the retail search activity. Consumers who want to shop likely use hedonic search strategies when they are unfamiliar with their shopping environment and, thus, proceed more slowly while valuing environmental sensory stimulation. They have a higher tendency to make impulsive purchases.
<table>
<thead>
<tr>
<th><strong>HTML</strong></th>
<th>HyperText Markup Language or HTML is a markup language for web pages. It provides a means to describe the structure of text-based information in a document by denoting certain text as links, headings, paragraphs, lists, and so on and to supplement that text with interactive forms, embedded images, and other objects. HTML is written in the form of tags, surrounded by angle brackets. HTML is constantly undergoing revision and evolution to meet the demands and requirements of the growing Internet audience under the direction of the W3C, the organization charged with designing and maintaining the language.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impulse Buying</strong></td>
<td>Impulsive buying is a spontaneous and immediate purchase behavior in which the consumer buys a product that he was not actively looking for and had no prior plans to purchase it.</td>
</tr>
<tr>
<td><strong>Indirect Social Navigation</strong></td>
<td>In indirect social navigation the communication is in one direction. This means that advice providers (e.g., a shop assistance, an employee) do not have to be aware of the fact that they are giving advice (e.g., by showing the user a path to a department).</td>
</tr>
<tr>
<td><strong>Involuntary browsing</strong></td>
<td>Involuntary browsing in an unintentional browsing behaviour in which the user is unaware of any latent goal that might be pursued.</td>
</tr>
<tr>
<td><strong>Javascript</strong></td>
<td>A scripting programming language most commonly used to add interactive features to web pages. JavaScript is a trademark of Sun Microsystems.</td>
</tr>
<tr>
<td>Glossary Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Jotted Notes</td>
<td>Making short notes during or immediately after the observations; some words or quotations as reminder. Sometimes there are opportunities to make detailed notes or to work out earlier notes.</td>
</tr>
<tr>
<td>Landmark</td>
<td>Landmarks are objects in a space (e.g., information space) that serve as reference points to people.</td>
</tr>
<tr>
<td>Local breadcrumb</td>
<td>Location breadcrumbs convey the position of the page within the site hierarchy. This is the most common type of breadcrumb on the web because with static pages, this is the only reasonable implementation. Users can often take several different routes to a page, but the breadcrumb will tell them “where they are.”</td>
</tr>
<tr>
<td>Map</td>
<td>A survey representation of an environment. We typically find two variants of the basic map: you-are-here maps (a map that marks the position of the person looking at it), and route maps (maps with an explicit route marked).</td>
</tr>
<tr>
<td>Mental Notes</td>
<td>Expressly focus one’s attention on the things you should note later, like the basis information of the scenes and the episodes, and the remarkable events in it.</td>
</tr>
<tr>
<td>Natural Search Behavior</td>
<td>Search behavior of people in their natural setting.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Object Identification</td>
<td>Object identification deals with new spaces. Spaces consist of objects. In new spaces the first thing people have to do is to identify the different objects and their respective attributes such as identifying the reference points; people have the ability to generalize from past experiences.</td>
</tr>
<tr>
<td>Opportunistic browsing</td>
<td>Opportunistic browsing is an intentional browsing behaviour in which the user is unaware of any goal being pursued. The user’s attitude is ‘let’s see what’s there’.</td>
</tr>
<tr>
<td>Participating Observation</td>
<td>The ethnographic manner to acquire knowledge which is a variant on everyday manners to know something of the life of other people; this ethnographic manner is a mixture of looking at, participating in, and talking with the others.</td>
</tr>
<tr>
<td>Path breadcrumb</td>
<td>Path breadcrumbs show the path the user has taken within the site to get to the current page. The same content from the site can be presented with different breadcrumbs because users can take different routes.</td>
</tr>
<tr>
<td>Pay-Per-Click</td>
<td>Pay-Per-Click (PPC) is an advertising model used on search engines, advertising networks, and content websites/blogs, where advertisers only pay when a user actually clicks on an ad to visit the advertiser’s website. Advertisers bid on keywords they predict their target market will use as search terms when they are looking for a product or service.</td>
</tr>
<tr>
<td>Plugin</td>
<td>A plugin or add-on is a small program that often provides additional functionality that is not available in the standard application.</td>
</tr>
<tr>
<td>Precise goal</td>
<td>A well-defined goal; the goal is clear and unambiguous.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RSS</td>
<td>Really Simple Syndication (RSS) is a family of web feed formats used to publish frequently updated works such as blog entries, news headlines, audio, and video in a standardized format.</td>
</tr>
<tr>
<td>Search browsing</td>
<td>Search browsing is an intentional browsing behaviour in which the user is aware of the goal being pursued. The goal is defined precisely or otherwise.</td>
</tr>
<tr>
<td>Search unit</td>
<td>Search units are specific unambiguous categories to do searches which can only occur on the WWW or in browsers. Consequently search units are also atomic observation units.</td>
</tr>
<tr>
<td>SEO</td>
<td>Search Engine Optimization (SEO) is the active practice of optimizing a website by improving internal and external aspects in order to increase the traffic the site receives from search engines.</td>
</tr>
<tr>
<td>Social Navigation</td>
<td>Navigation which is based on what others have done or the advice provided by others (e.g., follow people, ask a friend).</td>
</tr>
<tr>
<td>State Trigger</td>
<td>Thing that triggers people at the state in which they are finding themselves in.</td>
</tr>
<tr>
<td>Subjective Search Behavior</td>
<td>The way the participants experienced their behavior.</td>
</tr>
<tr>
<td>Summary observation unit</td>
<td>A summary of the total observation.</td>
</tr>
<tr>
<td>TLD</td>
<td>Top-Level Domain (TLD) is the last part of an Internet domain name, that is, the group of letters that follow the final dot of a fully qualified domain name (the absolute domain name). For example, in the domain name <a href="http://www.example.com">www.example.com</a>, the top-level domain is com.</td>
</tr>
<tr>
<td>Triggered Search Behavior</td>
<td>The behavior we observe when people are completing a task.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>URL</td>
<td>Universal Resource Locator is the full unique address of websites/pages/files on the Internet e.g., the URL of the Google website is <a href="http://www.google.com">http://www.google.com</a>.</td>
</tr>
<tr>
<td>Usability</td>
<td>Usability (a subset of user-experience) is a property of websites (and other systems and products) that relates to ease of use. For websites this means that usability is making your site easy for your visitors to find the exact information they need when they need it. Anything that makes the process slower (like Flash animation served to a dial-up visitor) inhibits usability. Conversely, easy, intuitive navigation and strong, informative text enhance usability.</td>
</tr>
<tr>
<td>User-experience</td>
<td>User-experience focuses on the users' feeling when they are visiting a website. The aim of user-experience is to give users a good feeling.</td>
</tr>
<tr>
<td>Wayfinding</td>
<td>Wayfinding is the activity of going from one place to another.</td>
</tr>
<tr>
<td>Website optimization</td>
<td>Website optimization is the process of improving internal (e.g., layout of webpages, content, navigation support, usability) and external (e.g., promotion of the website, link building, building personality and reputation) aspects of your webpages to increase the traffic the website receives from search engines.</td>
</tr>
<tr>
<td>Wild Searching</td>
<td>Realizing a user goal, which is not defined precisely or which may change, by browsing or surfing.</td>
</tr>
</tbody>
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