User Evaluation of Mobile Browser Features Related to Information Retrieval

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Abstract

Technological advancements in mobile technologies, improved network coverage, and cheaper data plans have led to an increase in internet browsing via mobile phone. Improvements such as bigger screen sizes, higher resolutions, and touchscreens have led to a better browsing experience compared with when mobile browsing first emerged.

Most of the research concerning mobile browsing seems to focus on website design for smaller screen displays, with very limited research done on the design and functionality of mobile web browsers themselves. Due to the physical constraints and small display screens, the user interface needs to be designed so that users can perform tasks easily and information can be accessed quickly.

This thesis evaluates different features from six of the most popularly used mobile browsers (Chrome, Dolphin, Internet Explorer, Opera Mini, Safari, and the UC Browser) in order to determine which features help to improve the mobile browsing experience. Ten participants were asked to perform several tasks on two mobile browsers and evaluate the browsers based on task difficulty. After all the tasks were completed, participants were asked to evaluate the overall usability of the browser.

The results showed that participants found most tasks easy to perform on all browsers. However, during the test sessions, it was observed that several participants found the tasks of adding a bookmark and locating saved bookmarks slightly difficult. This was due to each browser implementing different designs and using different icons for the bookmarking functionality. Based on interviews concerning their everyday browsing behavior, participants acknowledge that the most used feature is the combined address bar/search bar. Other features, such as bookmarking or customized on-screen keyboards, are either ignored or go unnoticed in favor of faster and more immediate interaction with their browser.

Key words and terms: mobile phones, touch screen, user experience, mobile browser

Contents

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I have spent so many years writing this thesis and now it is finally done. The relief at being able to finally close this chapter in my life is just indescribable. I know that this would not have been possible without the people in my life and all the help and support that they have given me.

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I would like to thank Sumita for dragging me, kicking and screaming, to the finish line. Thank you for all the text messages asking me how the thesis is going and for helping me find my focus every time I started to procrastinate. I would like to thank Deepa for the numerous hours spent listening to me whine and complain about my thesis and life in general. Thank you for being there for me throughout these years. I would like to thank Marjo for all the emotional support that you have shown. I cannot say thank you enough for the strength and motivation that you have given me during the times when I felt finishing my thesis was not a possibility. And lastly, I would like to thank my parents for all the unconditional love and support that they have shown me throughout my life.

Tampere, July 30th, 2015
Misada Jantrupon

1. Introduction

In the past several years, the growing popularity of mobile phones has been undeniable. In 2014, the number of mobile phone users worldwide finally surpassed that of desktop computer users (Figure 1). Even without knowing the statistics, all one needs is a quick glance around to see the prevalence of mobile phones in today's society.

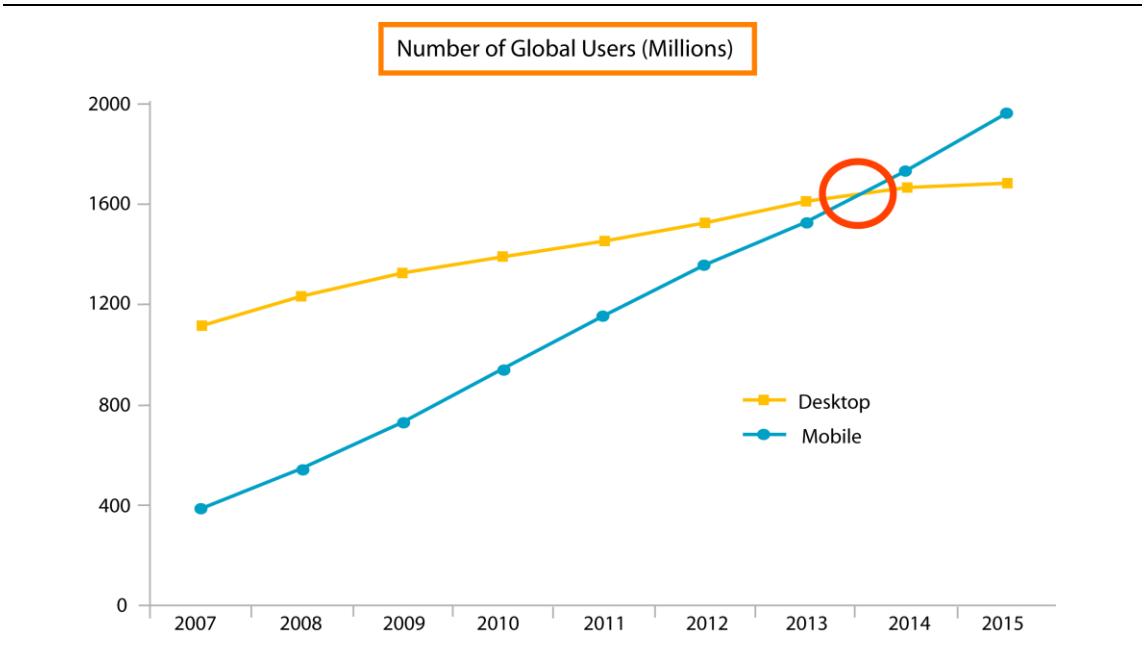

Figure 1. Comparison of the number of mobile phone users versus desktop users worldwide (graph adapted from (Morgan Stanley, 2010)).

The introduction of Apple's iPhone in 2007 changed the mobile industry and the way people browsed the mobile Internet. The iPhone had a screen-centric design, unlike previous phones where the keyboard took up 1/3 of the front panel (Frommer, 2011). While Apple did not invent the touch screen, it did revolutionize multi-touch controls by removing the stylus and allowing users to interact with the screen using their fingers. The screen-centric design and multi-touch, gesture-based user interface have now become an industry standard used by many smartphone makers (Frommer, 2009).

The iPhone greatly impacted the mobile Internet, as seen from the growth of AT&T's mobile data traffic from 2007 to 2009 (Figure 2), when it was the exclusive carrier of the iPhone in the USA (Wroblewski, 2011). The iPhone's Safari web browser was powerful and capable enough to display a full website, the same as would be displayed on a desktop computer. Companies no longer had to offer their mobile websites as a simplified version of their website without the graphics, but as mobile web applications (also known as "apps") instead (Frommer, 2011). The phone's touch screen and multi-touch, gesture based user interface offered a simple way to scroll down and zoom in and out of web pages, significantly improving the mobile browsing experience.

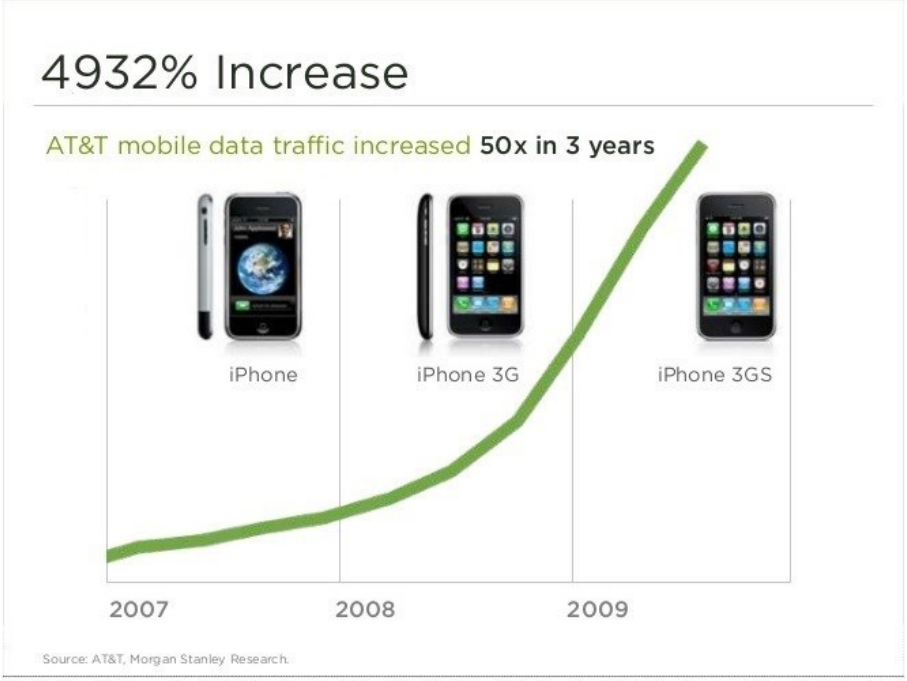

Figure 2. US mobile network carrier AT&T saw a massive increase in mobile data growth after the launch on the iPhone in 2007 (Wroblewski, 2011).

Most of the research concerning mobile browsing and the mobile Internet focuses on website design for small screen displays (Maurer, Hausen, De Luca, & Hussmann (2010), Keinänen (2011), Nielsen (2011d)); however, there is little on browser design, which can also affect the mobile user experience. To address this gap, I have designed a study that focuses on evaluating the users' perspective on mobile browser features.

This thesis will focus on smartphones and some of the more popular mobile browsers available to them. Larger displays, touch screens, powerful web browsers, and multi-touch gesture based user interfaces all play a part in enhancing the mobile browsing experience. By targeting smartphone owners for the experiment, I hope to observe how users typically interact with mobile phone browsers, paying particular attention to the different designs of features used in information retrieval.

I seek to study and evaluate the different features available on various mobile web browsers. The purpose of this study is to compare the features used in information retrieval and to determine which feature improves the user's mobile browsing experience the most. The study will take a look at common tasks used in daily mobile web browsing and see what common usage behaviors emerge when browsing the Internet on a smart phone. I hope to be able to answer the following question with the data collected from the testing sessions and user interviews:

Which browser features help to improve the browsing experience on a mobile phone?

Chapter 2 presents a review of the current literature on the mobile Internet and the mobile Internet user experience. The mobile web browser features evaluated in the study are discussed in Chapter 3. Chapter 4 describes the test sessions and the procedures used for evaluating the mobile web browsers. The results of the user evaluation and post-interview questions are presented in Chapter 5. Finally an in-depth discussion of the results and a conclusion of the studies are presented in Chapter 6.

2. User Experience of the Mobile Internet

There are many variations for the definition of user experience available in many papers and books. Tullis and Albert (2008) define user experience by distinguishing it from usability. Usability is the ability of the user to use a product or system to carry out a task successfully. User experience, on the other hand takes a look at the entire interaction with the product or system, including thoughts, feelings, and perceptions that result from the interaction. According to Tullis and Albert (2008), measuring the user experience can be done by measuring the usability of the system/product. Law (2011) agrees that a certain threshold of usability needs to be fulfilled in order to achieve a good user experience and the important aspect of measuring user experience lies in the design of the method of data collection. According to Hassenzahl and Tractinsky (2006), the three main factors that affect user experience are the user's internal state (predispositions, expectations, needs, motivation, mood, etc.), the context (or environment) of use, and the characteristics of the designed system (complexity, purpose, usability, functionality, etc.). The interaction takes place within a certain context and, in turn, that context affects the user and interaction, and sometimes the system. Kaasinen et al. (2009) expanded on this idea to apply to the mobile Internet system. When it comes to the mobile Internet, the system consists of four main components: the device, the software needed to use the Internet (such as a web browser), the network connection to transfer the data packages, and the services available on the Internet (Figure 3).

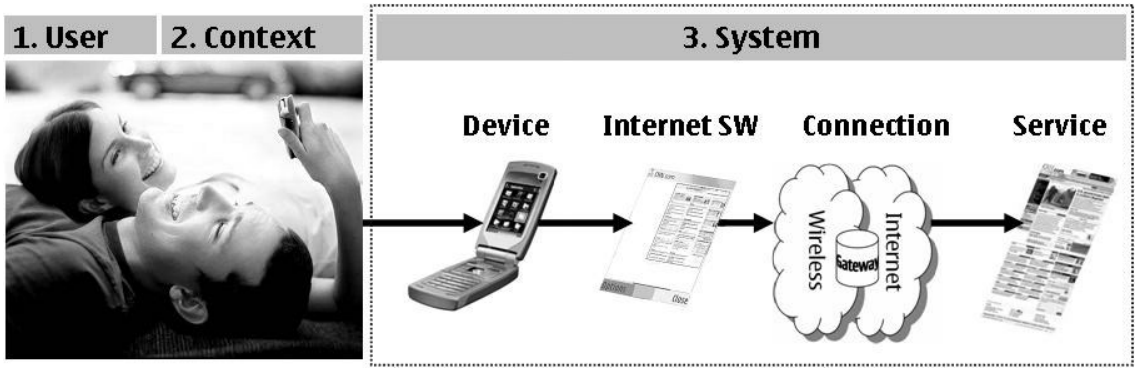

Figure 3. The factors affecting the user experience of the mobile Internet (Kaasinen et al., 2009).

The mobile device has many aspects that affect the user experience, such as the display size, the processing power, available memory, and the user interface style. The Internet software can either come preinstalled on the device, or the user can install one afterwards, similar to installing a different web browser on a personal computer (PC). Connecting the different types of mobile devices to the vast amount of Internet services requires an infrastructure of connections, proxies, and gateways (Roto, 2006). The final component of the mobile Internet are the services that the user wants to access on the

mobile device. Since all these components may come from different parties, it can be quite challenging to provide a seamless user experience (Kaasinen et al., 2009). In the following sections, these factors will be presented in more detail.

2.1. The User and Common Tasks on the Mobile Web

One of the key elements in improving the mobile user experience is to understand the user and usage situations (Roto & Kaasinen, 2008).

Between 2004 and 2007, a study was conducted on 47 participants and how they used their mobile devices to access the Internet (Cui & Roto, 2008). From that study, a mobile web activity taxonomy was proposed. According to this taxonomy, the four categories of user activities on the mobile web are: information seeking, communication, transaction, and personal space extension (Cui & Roto, 2008). The focus of this thesis will be on information seeking, since the other user activities (such as email, social networking, games, and maps) are mostly done through mobile applications.

Information seeking consists of using the Internet to gain more knowledge or entertainment, regardless of whether the user knows their intended target or goal. Information seeking can be further classified into the following subcategories: fact finding, information gathering, and casual browsing (Cui & Roto, 2008). The most common task performed by users is fact finding, followed by casual browsing and information gathering.

Fact finding is about searching for very specific information. The tasks involved in fact finding demand immediate access to that particular information. The amount of time involved in fact finding might be rather critical in order to perform the next task. Casual browsing is when a user accesses the Internet in order to obtain general information, without having a specific goal other than to be entertained or informed. Casual browsing can include using the Internet during idle working hours or accessing regularly visited websites in order to stay updated on current events. Lastly, information gathering is when a user collects "information from multiple sources to achieve a broad goal, such as making a decision, or to collect knowledge around a topic" (Cui & Roto, 2008). An example of this can be when a buyer shopping in a store uses their mobile phone to check the prices in other stores before deciding to purchase an item.

There are many different types of Internet activities that people can perform using their smartphones. Activities can be divided into two categories: those which can be performed using the phone's web browser (Figure 4) and those which people prefer using a mobile application for (Johansson, 2014). Activities where smartphone users prefer using a separate application, such as email, social networking, and maps, have been excluded from Figure 4.

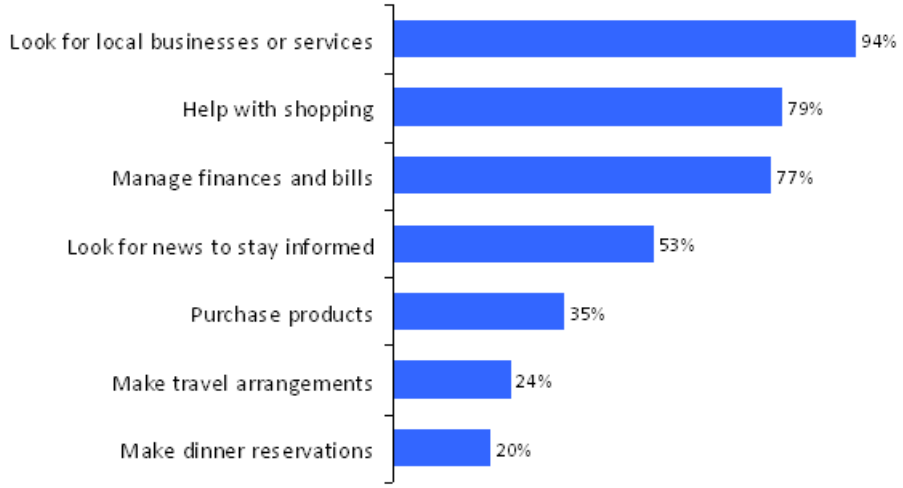

Figure 4. Different types of Internet activities performed using a smartphone's mobile browser (Johansson, 2014).

According to Johansson (2014), the most popular Internet activity performed by smartphone owners is looking for local businesses or services (94%). A local business is one that offers products and services specific to a local geographical area. Such searches include looking for a store, restaurants, beauty salons, auto repair shop, etc. Smartphones are also used to help with shopping, such as searching for or contacting a store (79%). Consumers also use their smartphones while they are inside a store; they may compare prices or perform research on an item before deciding whether to buy or not. 77% of mobile users manage their finances and pay their bills using their smartphone. While mobile applications are popular, mobile users still prefer a mobile website for personal banking. Another common activity among smartphone owners, whether on the bus or waiting in line, is looking for news to stay informed (53%). People want to stay on top of current trends and events, anytime and anywhere, and this can be done through their smartphones by reading news websites, posts and blogs, or magazine websites.

Mobile shopping is becoming more popular and 35% of smartphone owners have already purchased a product through their mobile phone. Before, the main items that were bought through a mobile phone were digital items such as music and ringtones, but nowadays, consumers are starting to also purchase physical products, such as electronics, clothing, and beauty items. Smartphones are also quite handy when it comes to last minute bookings and 24% of mobile users make travel arrangements via their mobile phone. Some of those activities include researching travel destinations, checking reviews, comparing prices, checking itinerary, and making a booking. The last popular Internet activity among smartphone users is making dinner reservations (20%). According to the 7th annual Local Search Study conducted by comScore in 2014 (Zazula & Heltai, 2014), 30% of local searches done on a mobile phone are for restaurants.

The key to improving the user experience of the mobile Internet is to understand the user and how they use the Internet. Since a mobile device can be used at anytime and anywhere, the mobile context is about the environment and circumstances of usage (Cerejo, 2012). The mobile context includes anything that affects the interaction between the user and the user interface. According to Roto and Kaasinen (2008), "With the mobile Internet, the physical, social, and temporal contexts affect the usage situation and the context may even change during the usage session" (p. 572). The mobile context can change constantly and rapidly, and includes factors such as "distractions, multitasking, motion, low lighting conditions, and poor connectivity" (Cerejo, 2012).

In order to improve the user experience, Cerejo (2012) suggests the following design guidelines for different mobile contexts:

- "Use the device's features and capabilities to anticipate and support the user's context of use". For example, voice commands can be used in the iCookbook app to proceed through the preparation steps so that the user does not have to touch the screen while cooking (itunes.apple.com).
- "Accommodate for changes in context based on the time of day and when the user is using the application". Based on the time of day, certain navigation apps automatically switch to night mode, where the color schemes are switched for night time driving.
- "Use location to identify where the user is and to display relevant nearby content and offers". Weather apps can use the device's location services to automatically update the information based on where the user is currently located.
- "Leverage information that the user has provided, and respect their preferences and settings". Travel planning apps can help plan itineraries, provide directions to boarding gates, and inform the user about any extra time they might have to kill.
- "Default to the user experience most appropriate for the device but give users the option to have enhanced features". When a separate mobile site exists, users will most likely be redirected to the mobile website if browsing from a mobile device, but most websites also offer the option to switch to the full website if needed.

2.2. The Usage Context

With a desktop computer, the normal situation is that the user is sitting in front of a computer on a desk. A laptop user could be sitting in a classroom or at a coffee shop, but one can assume that they would be sitting with two hands on the keyboard and the device is placed on a flat surface. Mobile device contexts, however, are more varied and mobile Internet usage can take place anywhere and also while on the move. Since a user rarely

goes anywhere without their mobile phone, location and time play a major role in how mobile devices are used. Designing for a mobile phone means designing for a device that can be used anytime and anywhere. When smartphones first came into the market, they were promoted as devices for the business professional, a tool to access company email, calendar, and contacts while away from the desk on travelling. Today, smartphones are integrated into our daily lives, becoming an extension, or even a replacement, for the desktop computer.

According to Bulger (2010), smartphones are being used at nearly all points of the day (Figure 5):

- 84% use their smartphones at home
- 80% use their smartphones during miscellaneous downtimes during the day
- 74% use their smartphones while waiting in line or for appointments
- 64% use their smartphones at work
- 62% use their smartphones while watching TV
- 47% use their smartphones while commuting to work.

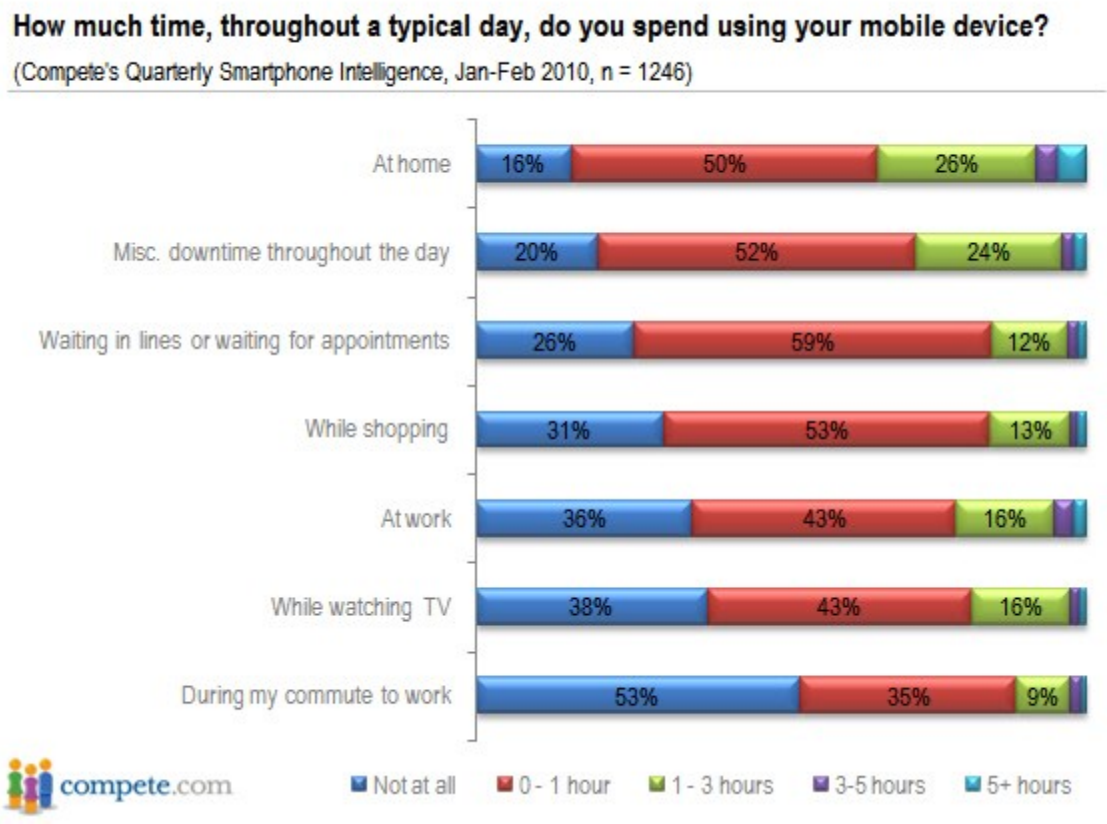

Figure 5. Smartphones are integrated into users' daily lives (Bulger, 2010). Whether they are at home or commuting to work, a user's smartphone is always within reach.

No matter the location of where people are using their mobile phone, one thing these situations have in common is that users are giving only partial attention to their devices

(Wroblewski, 2011). Designers need to realize that while on the mobile phone, users need to be aware of what is happening around them instead of being fully immersed in their device.

Designing websites and applications for mobile phones come with constraints that should always be taken into consideration: smaller screens, slower connections, and users giving partial attention or short bursts of their time (Wroblewski, 2011). Designers need to embrace these constraints to develop a solution that is appropriate for mobile use. The small screens force designers to prioritize what really matters for the user. Slow, unreliable, and expensive data connections require designers to focus on performance in order for web pages to load faster. Location and time force designers to think about how users will interact with their mobile phone throughout their day and how to engage those users.

2.3. Devices and Network Connections

There are many definitions of what is considered as a mobile device. This is due to the fact that the features of a mobile device are constantly changing, therefore, it becomes difficult to define the term "mobile device". In this thesis, I follow Firtman's definition: a device is considered as a mobile device when it has the following features (Firtman, 2010): it is portable, personal, with you all the time, fast and easy to use, and has a network connection. Portable means that a user can carry the device with them everywhere and all the time. By personal, it means that the user is the only person that uses the device (and is not a shared item, for example, among family members). A mobile device is constantly with the user all the time and will always be one of the items that the owner remembers to bring with them when leaving their home. Mobile devices also need to be fast and easy to use. A notebook, on the other hand, is also portable and has a network connection, but is not considered as a mobile device according to Firtman (2010), since you do not need to sit down or find a flat surface to set your mobile device on in order to start using it. The last feature of a mobile device is connectivity and a mobile device should be able to connect to the Internet when needed, so the classic iPod (non-touch) is not considered as a mobile device. Tablets fall somewhere in the middle, since they are not as personal or portable as a mobile phone but are more mobile than a notebook.

Firtman (2010) categorized mobile devices based on mobile web capability. Mobile devices can be categorized into the following:

Mobile phones – These are phones with call and SMS support. They do not have web browsers or connectivity, and users are not able to install applications into the device.

Low-end mobile devices – These mobile devices do have web support, but usually it is a very basic browser. These devices are intended for people who are not heavy

Internet users. They do not have touch support, have limited memory, and include a basic camera and music player.

Mid-end mobile devices – These mobile devices are the mass-market option for a good mobile web experience. They maintain the balance between a good user experience and moderate costs. The devices typically have a medium-sized screen, basic HTML-browser support, a decent camera, music player, games, application support, and possible 3G connectivity. The operating systems of these devices are not well-known, but they will have a proprietary one without portability across vendors.

High-end mobile devices – This category was originally the smartphone category. They are better than mid-end mobile devices, but are not on the same level as a smartphone. Generally, they are non-multitouch but have advanced features (such as an accelerometer, good camera, and Bluetooth) and good web support. The difference between a high-end device and a smartphone is the enhanced user experience.

Smartphones – The definition of a smartphone evolves every year so it is quite difficult to define this category. For example, the simplest mobile device today would have been considered a smartphone 10 years ago. Based on what is on the market today, a smartphone has a multitasking operating system, a full desktop browser, WLAN (wireless LAN), 3G connectivity, a music player, and several other advanced features such as GPS (Global Positioning System) or A-GPS (Assisted Global Positioning System), a digital compass, video-capable camera, TV out, Bluetooth, touch support, 3D video acceleration, and accelerometer.

Non-phone devices – These mobile devices have all the features mentioned in the definition of a mobile device, but lack voice connection support. Some examples are Apple's iPod Touch, the iPad, and some e-book readers. These devices can be considered as personal, portable, fast and easy to use, having a network connection, and can be kept with the user at all times, so while they are not considered as phones, they can be considered as mobile devices.

Smart Personal Object Technology (SPOTs) – The only difference between a SPOT and other mobile devices is the size. An example of a SPOT device is the LG GD910, which is a watch with 3G support, touchscreen, and video-capable camera.

Tablets, netbooks, and notebooks – These devices have at least a minimum display size of nine inches and are more like desktop computers rather than mobile devices. Some have desktop operating systems and browsers, and some have mobile software. With a full operating system, users will need to install an antivirus program and firewall onto the device, so it might not fit the mobile device feature of being fast and easy to use. Tablets, netbooks, and notebooks usually require the user to sit down in order to use it, so the portability feature might also not be met.

Mobile web browsing is dependent on improved network technologies and network speeds. The evolution of mobile network technologies has led to new functionalities over the past 30 years (Figure 6).

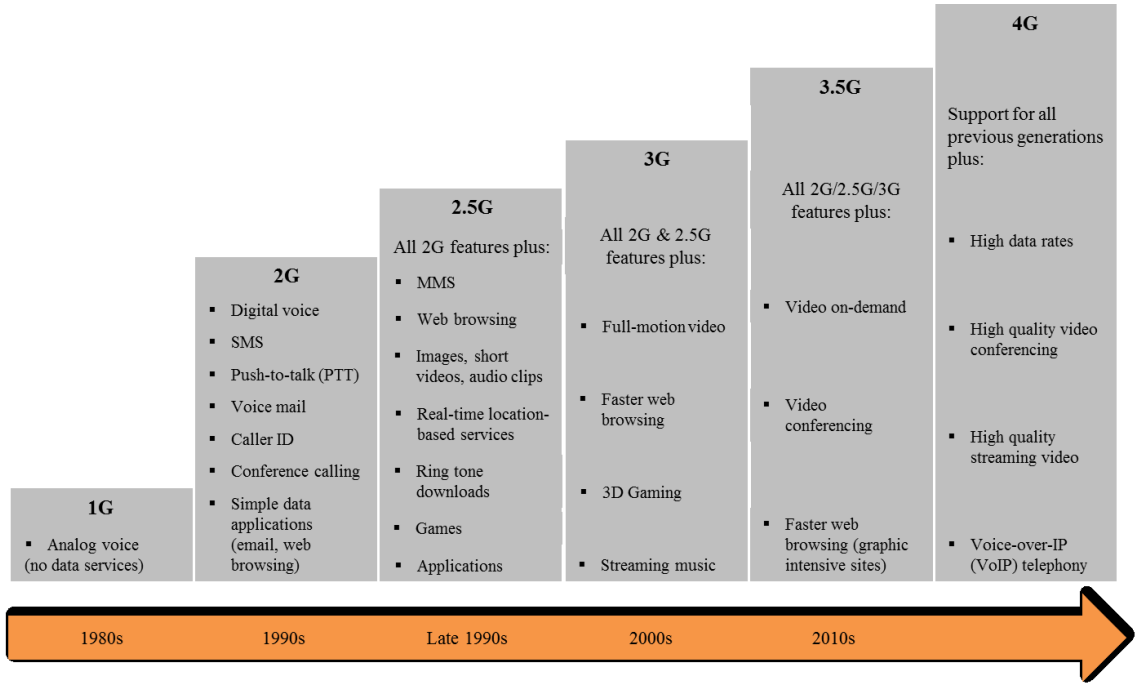

Figure 6. New supported features emerging due to the evolution of mobile network technologies (Motorola, 2011).

From 2G (second-generation) network speeds of up to 20 Kbps to 3G (third-generation) network speeds of up to 3.1 Mbps and now, 4G (fourth-generation) speeds that promise download and upload speeds of 35 to over 100 Mbps (Motorola, 2011) (Figure 7). Some of the major mobile network technologies are described below.

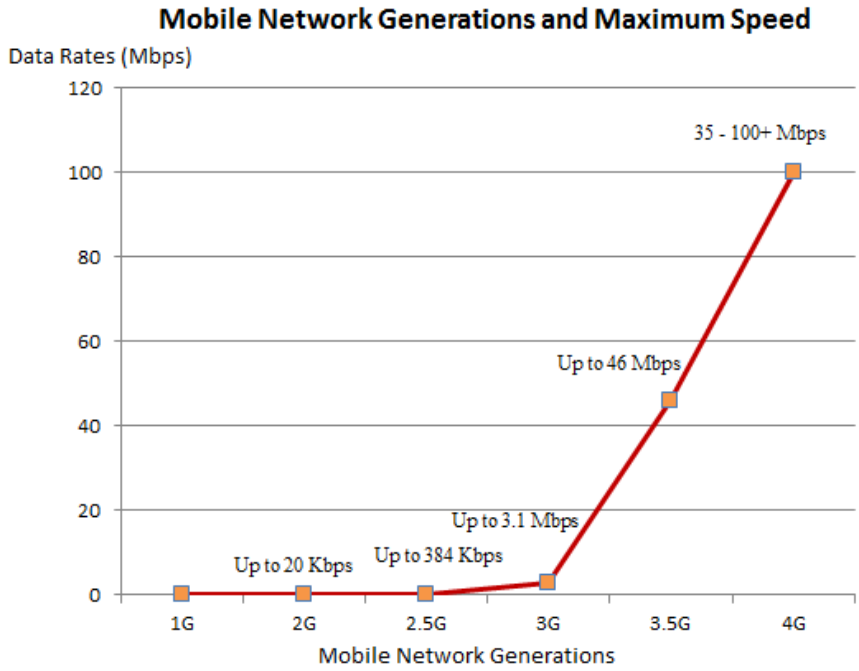

Figure 7. Mobile network generations and their maximum data rates (Motorola, 2011).

First-generation (1G) mobile phones were introduced in the late 1970s and had only voice capabilities. The phone signals were analog radio transmissions and the devices were comparatively less heavy and expensive than previous devices (Nubarrón, 2011).

The second-generation (2G) mobile networks emerged in the 1990s and the information carried over the phone signal changed to digital. Phones on the 2G networks were smaller and had better battery life because they were not required to emit strong radio signals (Krum, 2010). 2G mobile phones also had the added capabilities of fax, data, and text messaging and email services (Ashiho, 2003). Though the voice quality was better than 1G, the phones were dependent on proximity to a cell phone tower, and calls would be dropped if users moved too far away (Krum, 2010).

2.5G, introduced in the late 1990s, offered improvements over 2G networks, but were not as fast as 3G networks. 2.5G usually describes cellular networks that combine GPRS (General Packet Radio Services) and other services not found in 2G or 1G networks. The GPRS standard enabled high-speed data transfer capabilities to existing 2G networks. Users could also send graphics-rich data.

The third generation of mobile technology provided more advanced services and higher network capacity than 2G technology. They provided mobile phones with broadband speed transmission and function similarly to Wi-Fi but covered a much wider area. Mobile phones could use audio, graphics, and video applications and made it possible to watch streaming videos and engage in video telephony (Ashiho, 2003). Download speeds reached 5.8 Mbps and upload speeds were 14.4 Mbps (Krum, 2010).

4G provides broadband speeds that are 10 times faster than 3G networks and promise both mobility and high-speed connections for users. Mobile users will be able to receive richer content on their phones such as IPTV (Internet Protocol television), streaming audio and video, digital video broadcasts, and video chat, at a higher data rate than previous generations (Krum, 2010). Transmission rates are expected to be 20 Mbps and deliver wider bandwidth to vehicles and devices moving at high speeds within the network area (Nubarrón, 2011).

The widespread availability of high-speed networks and Wi-Fi has led to an increase in mobile web browsing (Radwanick & Aquino, 2012). More base stations are being deployed, leading to a worldwide increase in mobile network coverage (Ericsson, 2012). According Ericsson's Traffic and Market Report (2012), by 2017, 85% of the world's population will have 3G coverage and 50% will be covered by 4G. By the end of 2020, LTE (Long Term Evolution) will be available in all regions (Ericsson, 2015). LTE is a technology that phone companies are adopting for their next generation high speed networks (Ante & Troianovski, 2012). LTE offers high speeds and low latencies over long distances.

2.4. Internet Software and Services

Internet software is used by the mobile device to connect to the Internet and can be either pre-installed or installed by the user afterwards. Internet software includes mobile applications such as browsers, email clients, and feed readers, however, this paper will focus only on mobile browsers.

The interface of a mobile browser needs to be simplified and optimized so that web content can be displayed effectively on a small screen display. The browser software itself is lightweight in order to address the low memory capacity and bandwidth of a mobile device. Three aspects of the browser affect mobile user experience (Roto, 2006): usability, functionality, and content support. Browser usability includes features such as how a web page is displayed (for example, a narrow layout or a full website), or how the user interacts with the web page (touch, stylus, or keypad). Browser functionality includes features that are specifically useful for a mobile device, such as pinching and spreading gestures for zooming in and out, or on-screen keyboards that change depending on the input field. Content support refers to the browser's ability to display the various types of content available on the Internet, whether it is an embedded video or a Macromedia Flash animation.

Sahami Shirazi, Henze, Dingler, Kunze, and Schmidt (2013) developed a widget for the Android platform in order to study how users hold and move their mobile devices while using different apps and browsing the Internet. The widget, which was downloaded from the Google Play store, collected data from 1330 unique devices. The study showed that 31% of the users used at least one additional web browser, in addition to the Android

default web browser. Sahami Shirazi et al. (2013) suggest that developers should not only focus on the default browser, but should also support other common mobile browsers.

2.4.1. Mobile Web Browsers

Mobile web browsing is defined as any access to the Internet via a mobile device (Kaikkonen, 2009). Before examining the current situation of mobile web browsing, it is important to consider the past development of mobile browsing. In 1999, the Nokia 7110 was introduced to the public as the world's first media phone for Internet access (Nokia, 1999). This was the first mobile phone compliant with the Wireless Application Protocol (WAP), which was, at that time, used for accessing mobile Internet services such as banking, email and news. However, due to limited bandwidth and screen size displays, WAP sites had to be kept simple and more about information than presentation (Figure 8).

Figure 8. Examples of two WAP sites. "Travel News" on the Nokia 3650 mobile browser (FileSaveAs.com, 2015a) and "The Times" on the Windows Mobile (FileSaveAs.com, 2015b).

In May 2014, the most popular mobile browsers according to StatCounter Global Stats (StatCounter, 2014) were, in order of the most popular to the least: the Android browser, iPhone's Safari, Chrome, the Opera browser, the UC Browser, the Nokia browser, Internet Explorer, the BlackBerry browser, and Netfront (Figure 9). StatCounter Global Stats is a web traffic analysis tool where the statistics are derived from the StatCounter network of over 3 million websites, which total to over 15 billion page views per month. Aside from the usual built-in web browser that comes pre-installed with each mobile device, there are also many third-party web browsers available for mobile phones owners to download on the market today.

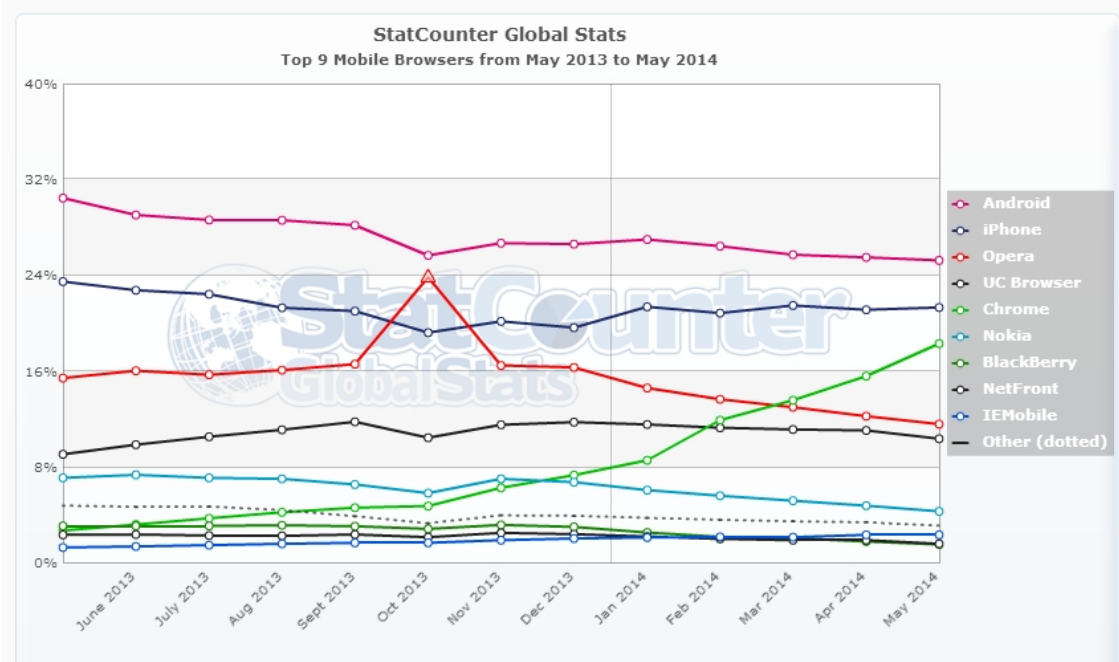

Figure 9. The top 9 most popular mobile browsers according to StatCounter Global Stats (gs.statcounter.com)

Table 1 lists some of the mobile browsers available for various device platforms.

Browser	Mobile Platform	Installation (Default or User-installable)
Android Browser	Android	Default browser (Android version 1.5 to 4.1)
Blackberry Browser	Blackberry	Default browser
Chrome	Android, iOS	Both (default on Google devices from Android version 4.2 onwards)
Dolphin Browser	Android, iOS	Both (default on Bada devices)
Internet Explorer	Windows Mobile	Default browser
Netfront	Android, S60, Windows Mobile, Others	User-installable
Opera Mini	Android, Blackberry, iOS, S60, Windows Mobile, Others	User-installable
S60 Web Browser	S60	Default browser
Safari	iOS	Default browser
UC Browser	Android, iOS, S60, Windows Mobile, Others	User-installable
Firefox	Android, Firefox OS	Both (default for Android and Firefox OS devices)

Table 1. Various browsers available on different mobile platforms.

2.4.2. Variations in Web Services

According to Kaikkonen (2009), web access from mobile phones can be divided into browser-accessed and client-accessed (Figure 10). Client-accessed means that an application connects to a service and information that is relevant in the application's scope is retrieved from the service. Browser-accessed can be further divided into full websites, where the website is identical to that which is accessed via a desktop computer, and mobile tailored websites, where the content is tailored for a mobile platform. This thesis focuses on the left branch in Figure 10 of mobile web access, which will be further explained in more detail in this chapter.

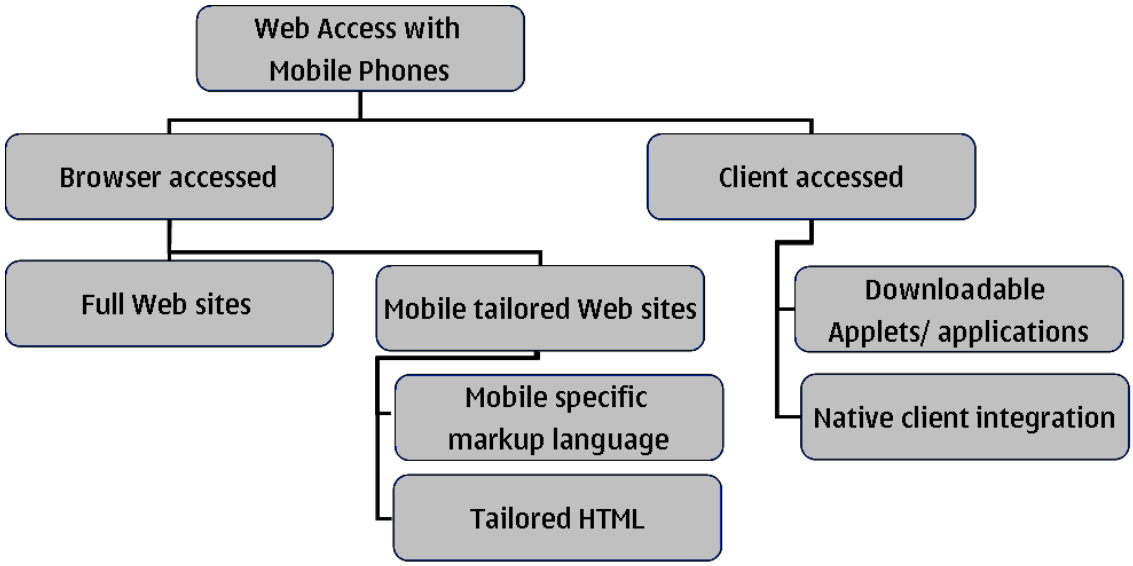

Figure 10. Different ways to access the Internet via mobile phones (Kaikkonen, 2009).

The user experience of mobile services (Internet services accessed via a mobile device) can be improved by 1) taking mobile users into consideration when designing the main site, 2) by implementing a separate version of the site for mobile users, or 3) by developing a native application for the service (Kaasinen et al., 2009). Service providers need to decide whether to grant mobile users access to the existing web service or whether to provide a separate mobile service or application. Services that are specifically designed for mobile use not only take into account the limitations of mobile devices and networks, but can also access system resources (Wroblewski, 2011) such as the address book or camera, and contextual information such as location or tag-based information in the environment (Kaasinen et al., 2009). Figure 11 shows the difference between accessing Yelp, a social networking website that offers reviews about local businesses (www.yelp.com), via the mobile application, the full website, and the mobile optimized website.

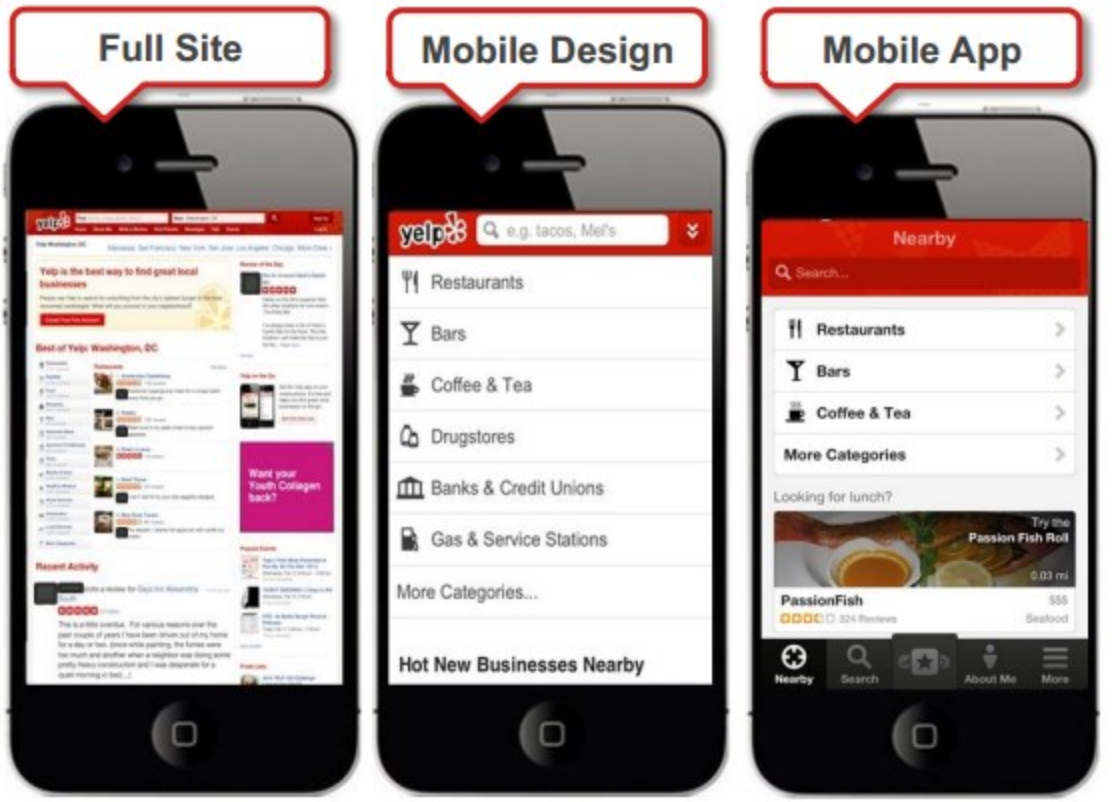

Figure 11. Comparison between a full website, mobile-optimized website, and a mobile application for Yelp (Zazula & Heltai, 2014)

Since the launch of the Apple App Store in 2008, there has been an ongoing debate on which is a better solution for mobile Internet users: a web browser or a native application (Pyke, 2014). Today, there are several more options than listed in Figure 10 on how users can access web services (Pyke, 2014):

Mobile Dedicated Website:

This is a website created purely for use on mobile devices and exists separately from the main website, often having a domain extension to itself (Pyke, 2014). When the main website is accessed via a mobile device, code will read the device's size and either redirect the user to the mobile website automatically or ask the user for their preference.

Responsive Website:

A responsive website is coded to respond to a device's screen size and orientation, and create dynamic changes to the appearance of the website accordingly (Schade, 2014). Responsive design is one solution to the problem of designing for a wide variety of devices. In responsive design, page elements reshuffle as the screen size grows or shrinks, so a three-column design on a desktop might reshuffle to two

columns when viewed on a tablet, and one column when viewed on a smartphone (Schade, 2014).

Mobile Web App:
Web apps are actually websites that look and feel like a native application (Budiu, 2013). They run in the browser and are designed and coded in web languages such as HTML5, CSS, and Javascript. Due to advances in coding, web apps can also access device features such as the camera and GPS (Pyke, 2014). Users can bookmark the URL of the website and have it displayed on the device's home screen, similar to a native app.

Native App:
Native apps are installed on the mobile device through an application store (such as Google Play or Apple's App Store). They are developed specifically for one platform and can take full advantage of all the device features such as the camera, the GPS, the accelerometer, and the list of contacts (Budiu, 2013).

Hybrid App:
Hybrid apps are part native and part web app. They use "a combination of HTML5 and native coding to enable further native functionality, which allows them access to all native device capabilities" (Pyke, 2014). Hybrid apps run using the device's web browser engine, but without having to load in a browser. They are essentially a web app in a native wrapper, which allows them to be sold in an application store. Hybrid apps also allow cross-platform development, which reduces development costs (Budiu, 2013).

The study by Sahami Shirazi et al. (2013) showed that browsing sessions started directly by launching the browser app lasted 1.5 times longer than sessions started from other apps, such as by selecting a link in an email or text message. The shorter browsing sessions indicate that users switch back and forth between apps and web browsers. Sahami Shirazi et al. (2013) suggest that in order to improve the overall usability, a smoother integration between web browsers and native apps is needed. Developers should include in-situ web views in their apps or provide users with means to easily recover after switching back to the app. Furthermore, in order to help users accomplish their goals, it should be easy to move content back and forth between browsers and apps.

2.4.3. Website Design for Mobile Use

Recent studies on mobile browsing seem to be divided on whether a separate mobile-optimized website is needed in addition to a full website. Studies done on non-touch

phones (before the release of the iPhone in 2007) usually resulted in suggestions for a separate mobile website. Recent studies that involved smartphones with multi-touch displays have been rather limited.

The Nielsen Norman Group has conducted two studies on the usability of mobile websites and applications, the first one in 2009 and the second in 2011. In their summary, Nielsen states that mobile user experience has been improving since the first study conducted in 2009 (Nielsen, 2011d). In the first study, the average success rate was 59%, and in the second study, 62%. However, the success rate was dependent on whether the participant used a mobile-optimized website or a full website. Mobile websites had a higher success rate (64%) than a full website (58%). Nielsen suggested that a separate mobile website needed to be designed in order to improve the mobile user experience.

Keinänen (2011) conducted a study consisting of three expert evaluations of several websites and a usability test with 18 mobile web users. The study was carried out using six different mobile and desktop devices. The study showed that most of the participants preferred using the mobile website over the full website when using mobile devices, but usability testing did not show any significant difference in success rates between the two website versions. Keinänen (2011) suggested that a separate mobile website might not necessarily be needed, but the mobile user experience of full websites needed to be improved.

Maurer, Hausen, De Luca and Hussmann (2010) questioned the usefulness of having a mobile website based on the technological advances of newer hardware and multi-touch enabled browsers. The study was done in two parts: first an online survey was conducted with 108 participants to investigate user expectations, and second, a follow-up study was done with 24 participants. The results of the study showed that more and more users prefer to use the full website, especially if they owned a new generation mobile device such as the iPhone or an Android phone. No significant performance increase was found when comparing a mobile website with a full website.

Schmiedl, Seidl, and Temper (2009) compared the usability of the mobile websites and full websites of five different websites. Three to four tasks were performed, first on the full version and then on the mobile version. Although the participants were 30-40% faster on the mobile version, all users stated that the limited features of the mobile website were annoying, even if the more complicated tasks were better suited to being performed on a desktop computer. The researchers found that although the latest generation of mobile devices is capable of displaying a full website, users prefer a mobile-optimized website and benefit more from a mobile version. Even with the results showing that users prefer a mobile website, Schmiedl, Seidl, and Temper (2009) stated that tailoring a website for mobile phones no longer seems to be mandatory, with the latest devices having the capability of displaying full websites, but the user experience is still limited due to the smaller displays.

According to Nielsen (2012b), organizations face two opposing approaches to mobile user experience design: repurposing and platform optimization. The repurposing strategy is to make as few designs as possible and reuse them across different platforms. The platform optimization strategy is to design a different user interface for each platform and to integrate the user experience layers as tightly as possible. Repurposing is the more cost effective strategy, since most of the work is done only once. The end result, however, is a substandard user experience, especially if the design was optimized for one platform and then ported into another platform with minimal changes. The benefits of having a platform-optimized user interface are: 1) usability is increased, 2) users are more likely to accomplish their goals, 3) conversion rates (the percentage of visitors that can be converted to customers) increase, and 4) more money is made (Nielsen, 2012b). Since optimization is more costly than repurposing, the benefits of increased usability need to be compared to the cost of designing different platform-optimized user interfaces. According to Nielsen (2012b), in many cases, the cost-benefit analysis favors a unified design and the benefits of having several platform-optimized designs are too small, leading to the decision of repurposing the mobile site instead of optimizing.

When designing for a desktop website, there is no need to have different versions for a PC or for a Mac computer. The same can be said for designing a mobile website for an iPhone or for an Android phone. But when considering about designing a website for a mobile phone versus designing for a PC, the platforms are so different that the benefits of creating two separate designs are substantial (Nielsen, 2012a). If both platforms have wealthy users, profits from maximizing conversion rates are considerable. To determine whether the cost-benefit analysis would support two different websites or a single website, the organization's size and how much business is conducted with mobile and desktop users need to be considered. Sometimes the organization is so small that a higher conversion rate would not produce enough profitability to justify two websites. At other times, the company might provide services that solely target either mobile users or desktop users and profits would not suffer much from the few users on the opposite platform. Some argue that having two separate mobile and desktop designs would cost too much and recommend responsive web design instead.

In responsive web design, the design adapts to the capabilities of the user's specific platform (Nielsen, 2012b). However, in terms of interaction design, coding, and implementation, responsive web design might not be the cheaper option for every website. Also, creating a responsive website still involves creating a distinct user interface for each platform. Since the differences between designing for a mobile and desktop go beyond layout issues, simply modifying the layout by moving, enlarging, or reducing elements on the screen is not enough (Nielsen, 2012b):

- The content should be different.

- The information architecture should change to defer secondary content to secondary pages on mobile devices (Nielsen, 2011a).
- Interaction techniques change due to different input methods.
- Mobile devices require reducing the feature set in order to lower complexity and to fit on smaller screens.

The content should be different. For smaller screens, the content should be shorter and use simpler writing. Nielsen (2011c) discovered that users tend to use their mobile phones to kill time while waiting for something. In the same study, it was also discovered that those same users were rushed and impatient and would get angry at websites that had too much content, since it is harder to understand content on smaller screens than it is on larger desktop displays (Nielsen, 2011b). Small screens affect understanding because users can see less at any given time and must rely on their short-term memory when trying to understand content that is not explained in the viewable space. On a small screen, users must also scroll around to refer to other parts of the content instead of being able to glance at the text like on a desktop. Scrolling takes more time (which degrades memory), diverts attention from the problem at hand to locating where the content is on a page, and introduces the new problem of having to scroll back to the previous location on the page (Nielsen, 2011b). In other words, for mobile phones, the content should be less complicated in comparison to content on a desktop. Only the essential information should be shown on the first screen and the extra content, or "filler" content, should be cut out. In addition to simpler content, other content formats should also be designed for that platform. For example, small images should also be cropped and zoomed differently than large images to emphasize salient details (Nielsen, 2012b).

The information architecture should change to defer secondary content to secondary pages on mobile devices (Nielsen, 2011a). Background material and additional content should be placed on secondary screens for users who have the extra browsing time or are particularly interested in the topic. To give an example, in Figure 12, the first page shows a Groupon deal displayed on a mobile phone. The content is simple and easy to read, which is suitable for a mobile user who is in a hurry and only wants a quick glance at what is on offer. Additional details on the Groupon deal are displayed on a secondary page, only shown when the user presses the "More about this deal" button. Displaying the additional information on the first page would not be suitable for mobile users since not everyone would be interested in the deal and would result in too much unnecessary content to be displayed.

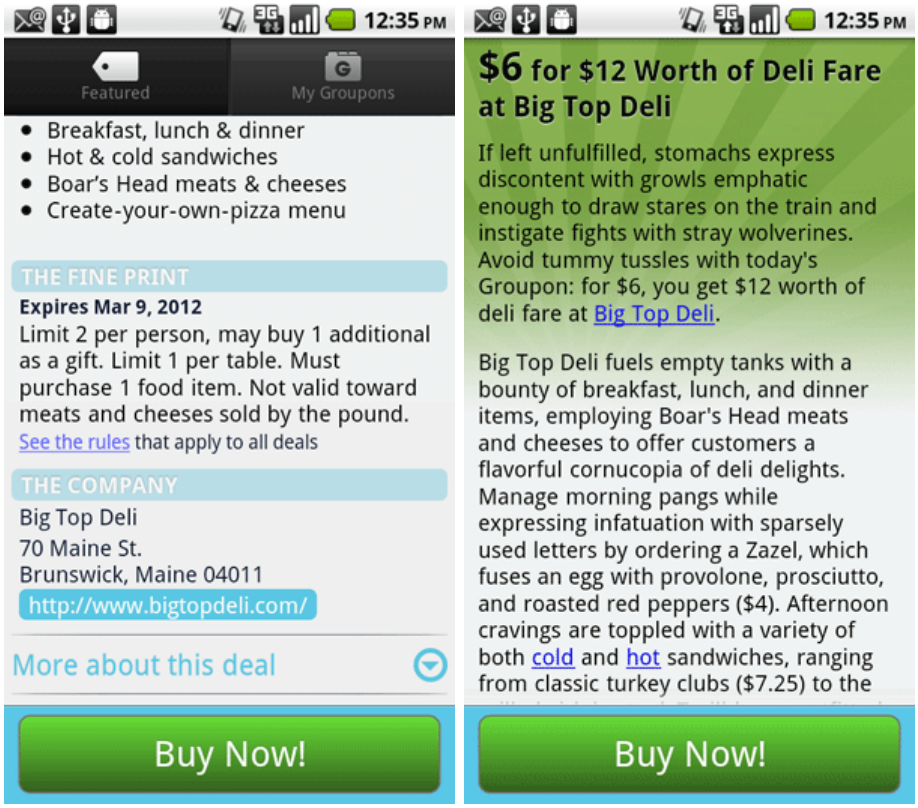

Figure 12. The left picture is a Groupon deal as displayed on a mobile phone. The right picture shows additional details about the deal when the user presses the "More about this deal" button (Nielsen, 2011a).

These differences can be supported by responsive web design, but a design is not responsive enough if it does not offer a solution for all the important platform differences.

2.5. Interaction in Mobile Browsing

There have been significant technological improvements in mobile phones during the past decade. Most smartphones today sport a screen-centric design with a multi-touch, gesture-based user interface. The key for the improved user experience of modern smartphones lies in the touch display. Besides allowing for more intuitive interactions with the device, this also addresses the issue of small screen displays by turning the entire mobile device into an interactive surface (Wroblewski, 2011).

The growing popularity of smartphones with multi-touch displays is increasing the amount of Internet browsing done via mobile phones. The user experience of mobile browsing has improved compared to non-touch screen phones, and the latest generation of touch screen phones are fully capable of displaying a full website.

Touch-enabled mobile phones allow us to browse the Internet using our fingers, the interaction making sense since the devices are small and fit into our hands. In spite of the many different mobile phone platforms, there is a set of core touch gestures that are consistent in most multi-touch browsers. Multi-touch refers to a touchscreen's ability to

recognize two or more points of contact on the screen. There are several common touch gestures which people have come to expect while browsing on a mobile device (Wroblewski, 2011): tap, double tap, drag, flick, pinch, and spread (Figure 13).

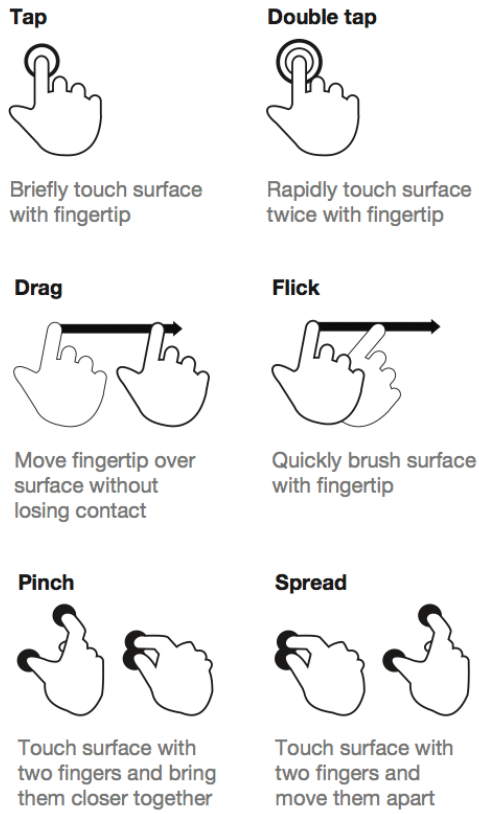

Figure 13. Common touch gestures on mobile browsers and native apps, adapted from (Wroblewski, 2011).

Users mainly hold their phone in portrait mode while web browsing, but briefly rotate the phone to landscape mode to read or enter text or to watch a video (Sahami Shirazi et al., 2013). Developers should, therefore, optimize their websites for portrait mode. Data on how much the phones moved while using various apps showed that the device is less in motion when the web browser is in use (Sahami Shirazi et al., 2013). This suggests that mobile browsers are rarely used on the go.

3. Mobile Web Browser Features

The browsers chosen for the experiment were based on popularity and mobile device availability. The devices available for my study were the iPhone 4 and the Nokia Lumia 900, therefore, the browsers chosen were the ones that came pre-installed on those devices and those which could be installed onto those particular devices. Those browsers were Chrome, Dolphin, Internet Explorer, Opera Mini, Safari, and the UC Browser. The features were selected based on their involvement in mobile browsing and also on how differently they were implemented in the selected mobile browsers. The browser features selected for the study were: 1) the on-screen keyboard, 2) the search field, 3) the behaviour of the address bar while browsing, 4) bookmark management, and 5) tabbed browsing. The following sections describe each feature in detail along with screenshots taken from the browsers. The screenshots, other than Internet Explorer, are from browser versions listed in Table 2 (page 36), installed on the iPhone 4.

3.1. On-Screen Keyboard

HTML5 has introduced several new input types for forms, which can be used to improve the usability of filling out forms (West, 2012). The new input types in HTML5 are: color, date, datetime, datetime-local, email, month, number, range, search, tel, time, url, and week (W3Schools, 2014). Many mobile browsers have taken these new input types into use to display customized on-screen keyboards for typing URLs, thereby enhancing the mobile browsing experience. The "url" input type can be used to help users type web addresses, which can be tricky on a mobile phone. When the web address field of a mobile browser is activated, certain keys on the mobile phones on-screen keyboard changes to accommodate the input type.

On Windows Phones (OS 7.1 onwards), a **.com** key is added to Internet Explorer's keyboard (Figure 14). When the user presses and holds the **.com** key, additional options are displayed (**.com**, **.org**, **.edu**, **.net**). The period key can also be long-pressed to reveal additional options **(- + & " : . /)**.

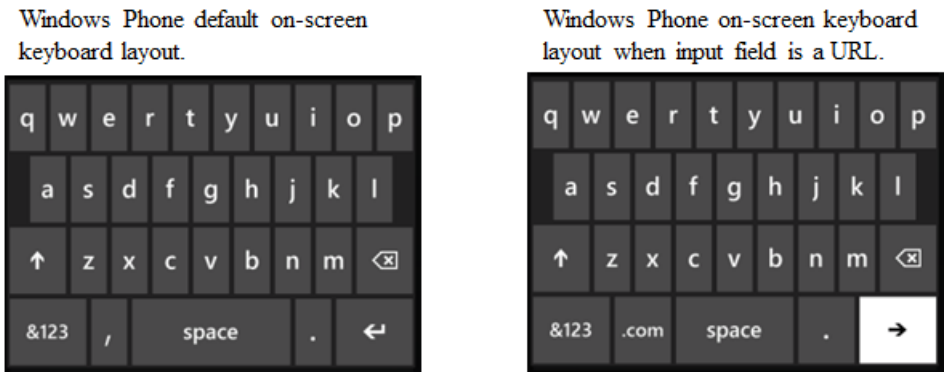

Figure 14. Default Windows Phone keyboard (left) and when the input field is a web address (right). Images retrieved from: (Microsoft, 2014).

When entering a web address in the Safari browser on the iPhone (iOS 7 onwards), the space bar is shortened to make room for the appearance of the period button on the right. Long-pressing the period button reveals additional URL extensions such as **.org** and **.net** (Figure 15).

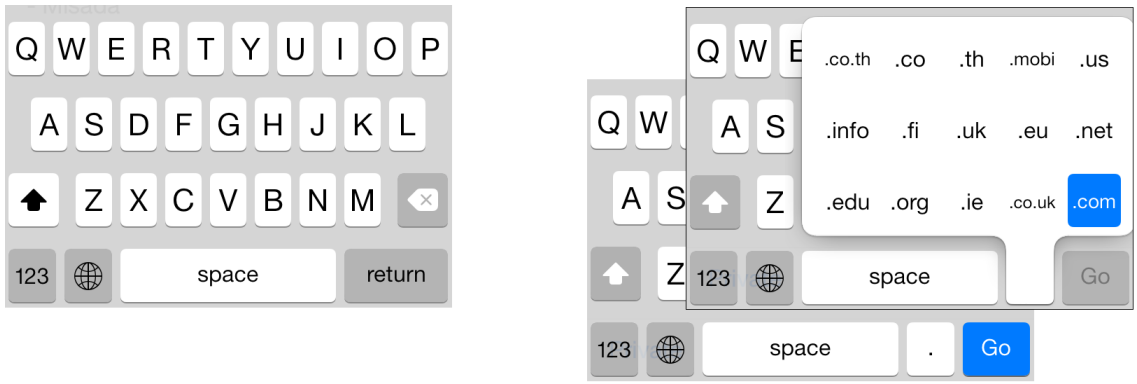

Figure 15. Default iPhone on-screen keyboard (left) and when the input field is a web address (right).

The Chrome and Dolphin browsers both display the same feature when the user begins typing in the web address field; a row of additional keys appear above the default on-screen keyboard. In the Chrome browser, the additional keys are **: . - / .com** and in the Dolphin browser, the additional keys are **www. / . - .com** (Figure 16). One might wonder whether or not the "www." key available in the Dolphin browser is obsolete or not, since most websites redirect users to the main page even without having to type in the "www" before the web address.

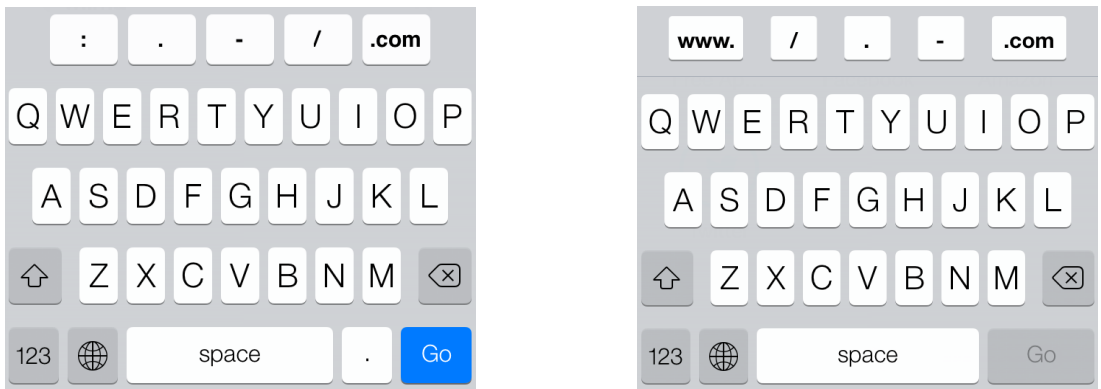

Figure 16. The Chrome browser (left) and the Dolphin browser (right) both display additional keys when the input field is a web address.

In the Opera browser, long-pressing the **.co.uk** key results in a set of extra top level domains, such as **.com** and **.org** (Figure 17).

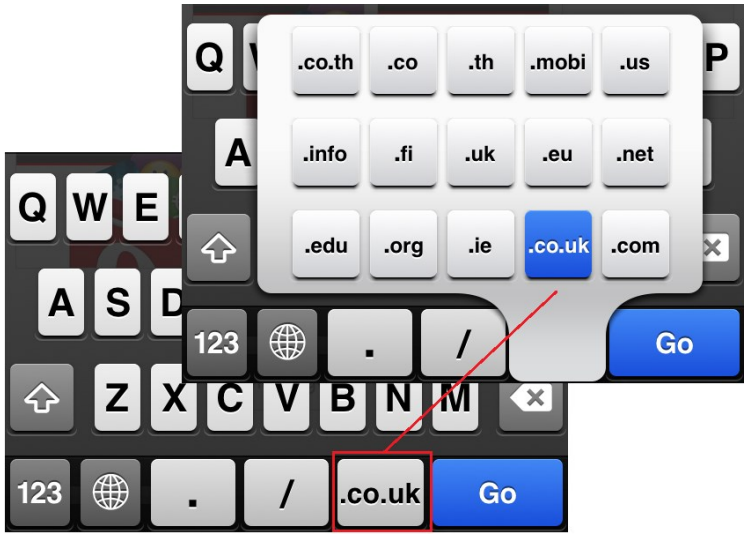

Figure 17. An extra set of top level domains when the **.co.uk** key is pressed in the Opera browser.

The UC Browser combines features from the Chrome, Dolphin, and Opera browsers. When the input field is a web address, the space bar is replaced by the following keys: **. / .co.uk**. Removing the space bar is a rather practical feature which frees up more space on the keyboard, since spaces aren't necessary when typing a web address. Long pressing the ".co.uk" button results in an extra set of top level domains to choose from. Another change to the on-screen keyboard is the additional row of keys that appear above the keyboard: ← → **www. / _ - .com .net** (Figure 18). The left and right arrow keys can be used to move the cursor through the web address.

Figure 18. The UC Browser incorporates both an extra row of buttons above the default keyboard and a button with several top level domains.

Each browser has its own different feature for improving web address typing. Due to the limited screen size of mobile phones, these features are usually hidden from the user until needed. The extra buttons related to typing a web address only appear when the input field allows a web address to be typed.

3.2. Search Field

When it comes to the search field, mobile browsers are divided into two designs. In the first design, borrowed from PC browsers, there is a separate, dedicated search field at the top of the browser. Opera Mini and the UC Browser have a separate search field located on the right side of the URL field (Figure 19).

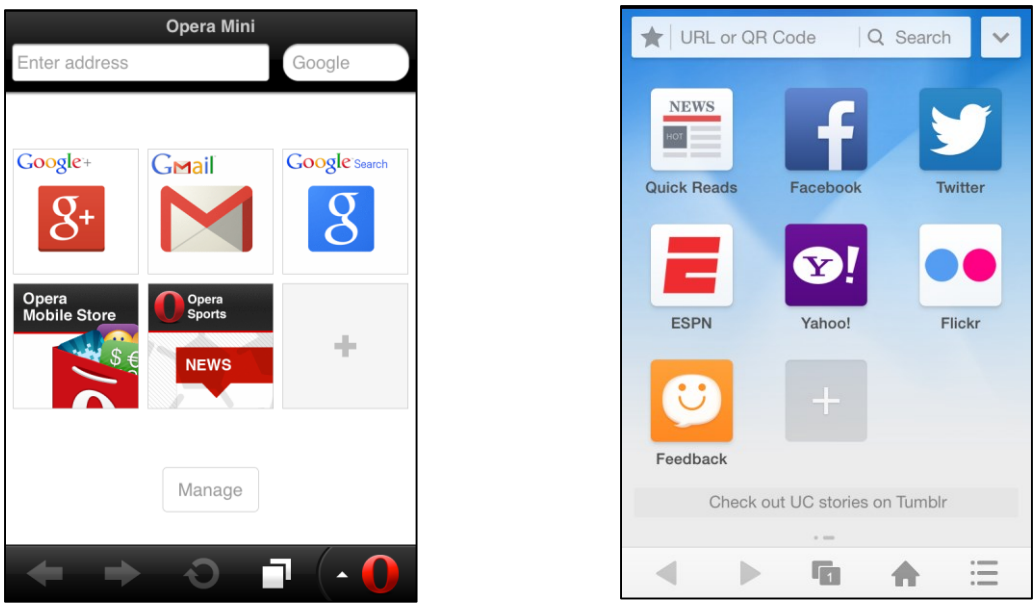

Figure 19. Opera Mini (left) and UC Browser (right) have separate fields for entering a web address and searching the Internet.

Dolphin also has a separate search field, however, it is located below the URL field (Figure 20).

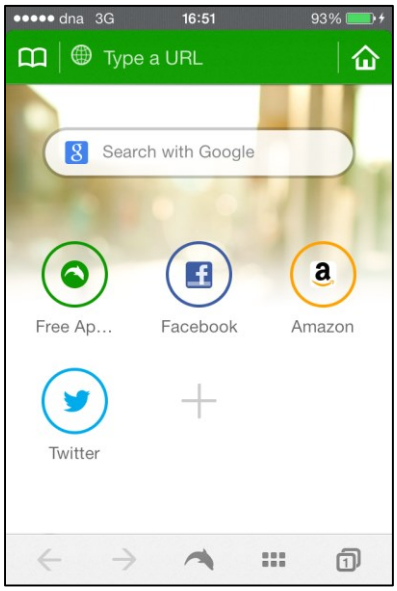

Figure 20. Search field in Dolphin is located below the address bar.

But over the years, developers began to combine the address bar and the search field, leading to one field that can be used for both searching and navigating to a website (Figure 21).

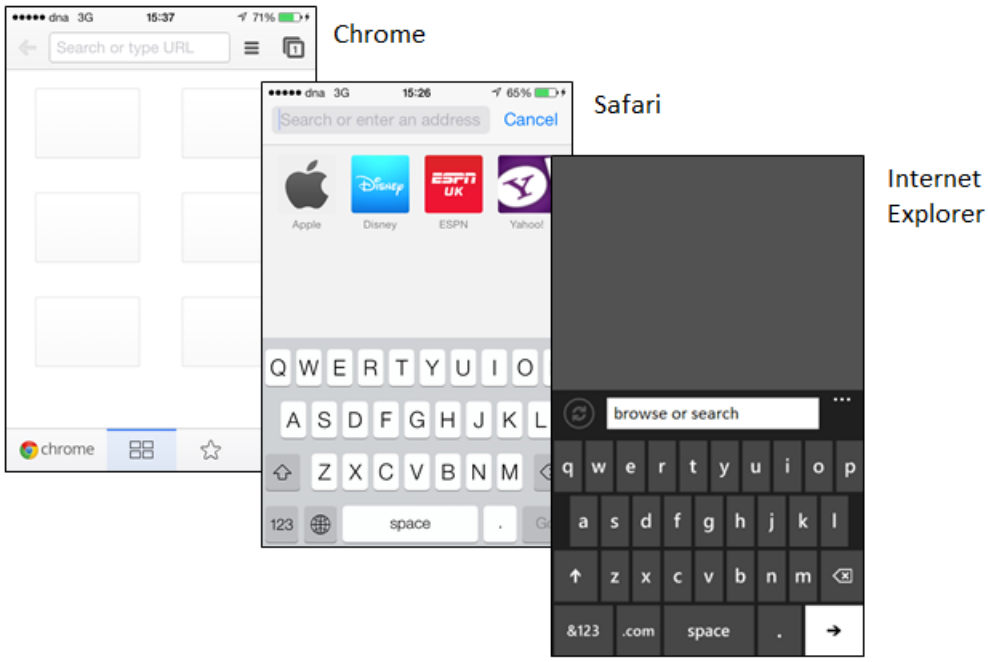

Figure 21. Combined search field and address bar.

3.3. Address Bar Behavior

One constraint that affects mobile web browsing is the limitation of how much screen size is available to display the website. For a mobile phone, screen real estate is a precious commodity where every pixel matters. When viewing a website on a mobile phone,

browser functions, such as the address bar, further detract from the already limited amount of space. While a user is scrolling down a web page and reading the contents, having the address bar displayed becomes unnecessary. Most browsers automatically hide the address bar when the user scrolls down the web page, allowing the page to be displayed in full screen (Figure 22). However, there are some slight differences in the interactions that make the address bar reappear.

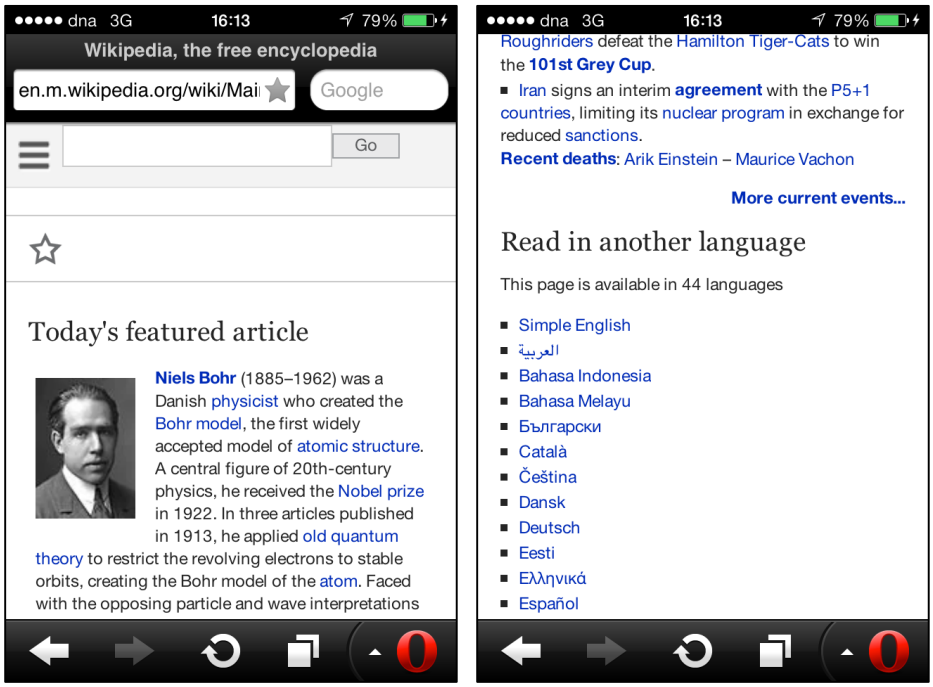

Figure 22. In Opera Mini, the browser automatically hides the address bar when scrolling down a web page.

For the Chrome and the UC Browser, the address bar disappears when the user is scrolling down the page. It will only reappear when the user starts to scroll up again. For Safari (Figure 23) and Dolphin, as the user is scrolling down, the address bar shrinks to display only the website address. The user can make the address bar reappear by either scrolling back up, tapping on the website address, or by dragging the bottom of the page up slightly.

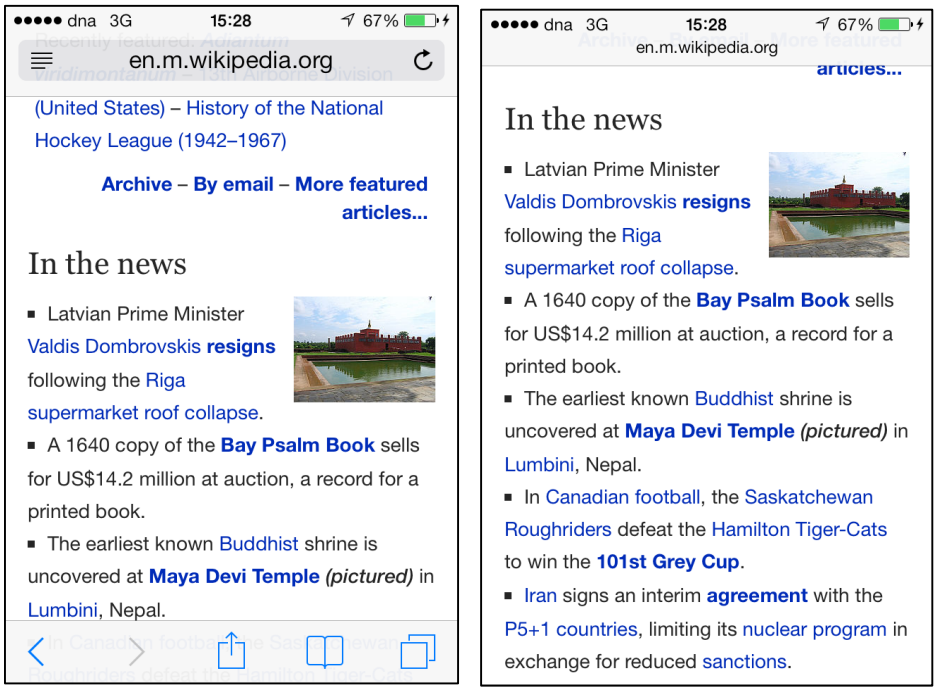

Figure 23. In Safari, only the top level web page address is displayed.

Internet Explorer's address bar is placed at the bottom of the browser, and it is always visible to the user (Figure 24). While the permanent placement of the address bar does take up a certain amount of screen real estate, this design does eliminate the effort required to scroll back up to the top of the page in order to enter in a new web address.

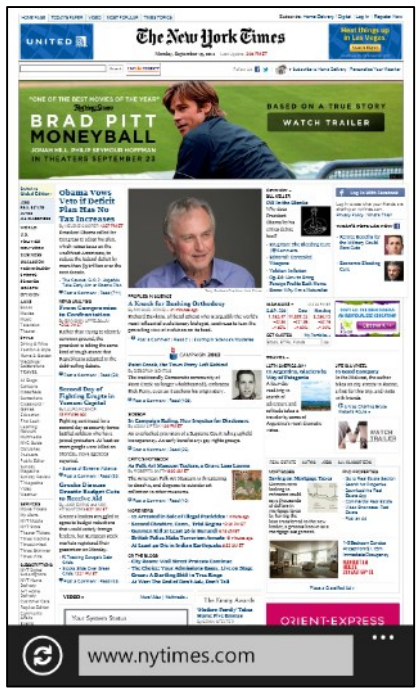

Figure 24. Internet Explorer's address bar is permanently displayed at the bottom of the browser (Lakhani, 2011).

3.4. Bookmark Management

Bookmarks enable web browsers to function in a more useful manner by allowing users to save website addresses for quicker access in the future. In the tested browsers, the Chrome browser used a tile layout to display saved bookmarks (Figure 25), while the rest of the browsers used a list display with slightly different designs.

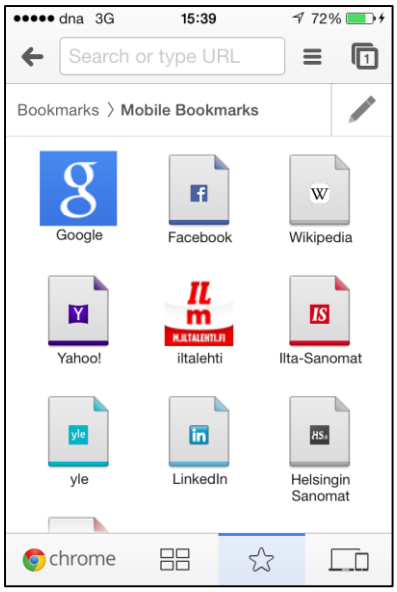

Figure 25. Tiled display of saved bookmarks on the Chrome browser.

The Dolphin and Opera browser bookmark manager displays the name of the bookmark along with a graphical icon of the website (Figure 26).

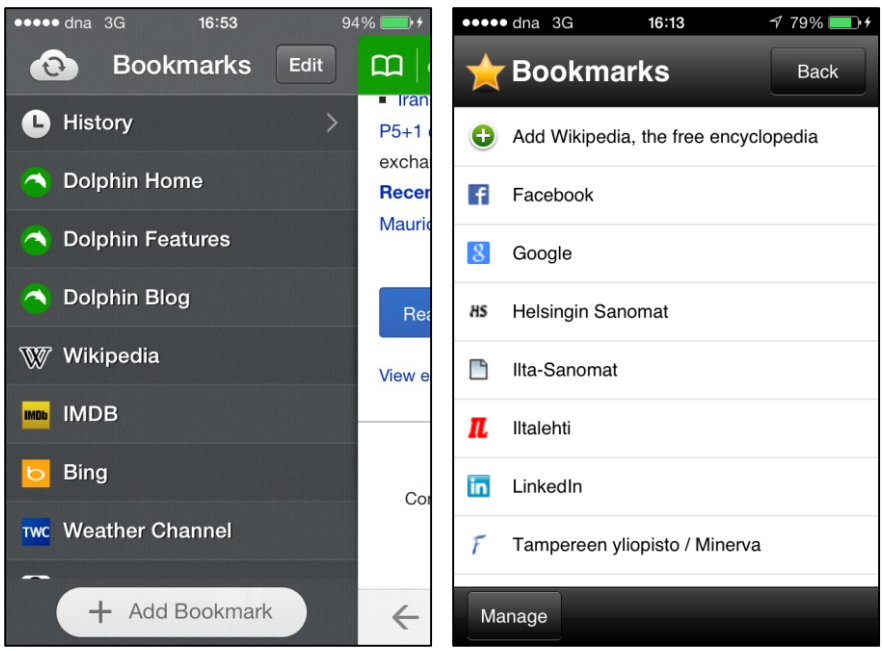

Figure 26. The Dolphin (left) and Opera browser (right) both display the graphical icons of saved websites in the bookmark manager.

The Safari, Internet Explorer, and UC browser have a more simplified and clean design, with only the name of the bookmark displayed (Figure 27). The graphical icons used by Safari and the UC browser are the browser's own icons for indicating that the saved item is a bookmark.

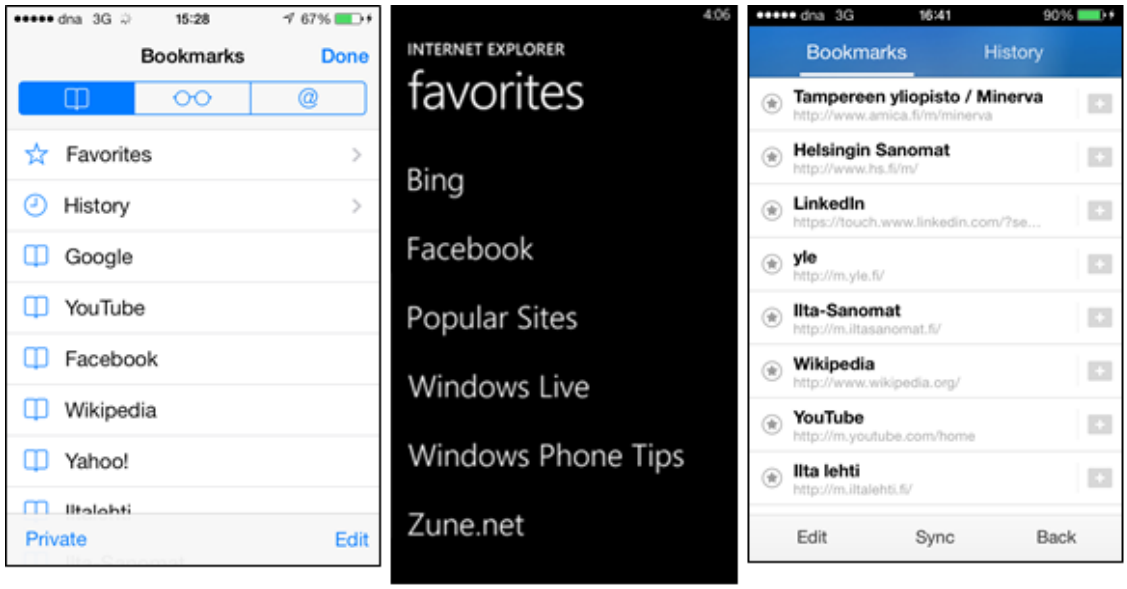

Figure 27. Bookmark manager in Safari (left), Internet Explorer (middle), and the UC browser (right).

3.5. Tabbed Browsing

Tabbed browsing is a feature that enables users to open multiple websites in a single browser window. Web pages can be opened in new tabs and users can easily switch between them by selecting the tab they want to view. On a desktop browser, the open tabs are clearly visible at the top of the browser window. However, due to limited screen space and the reduced precision of touch, tabbed browsing can be rather difficult on a mobile browser (Warr & Chi, 2013). All the tested browsers required the user to execute a single interaction, such as selecting a button or swiping (the Dolphin browser), in order to enter the web page switching interface.

Each of the tested browsers used a different design for displaying multiple tabs. Chrome, Safari, and the UC browser both had similar designs where the opened web pages were stacked on top of each other, similar to a deck of cards (Figure 28). Users navigate the pages using vertical scrolling gestures.

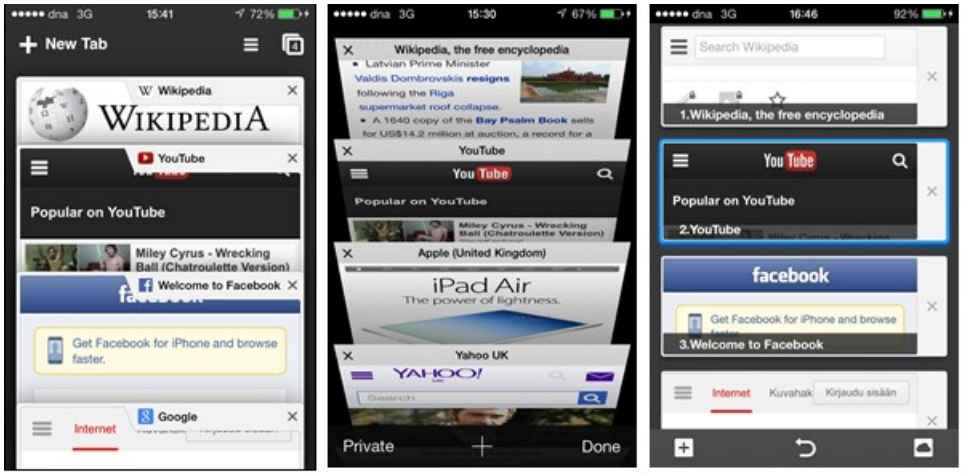

Figure 28. Tabbed browsing in Chrome (left), Safari (middle), and the UC browser (right).

Internet Explorer displays the opened web pages as tiles, with the name and screenshot of the web page (Figure 29). The amount of tabs that users can open is limited to six.

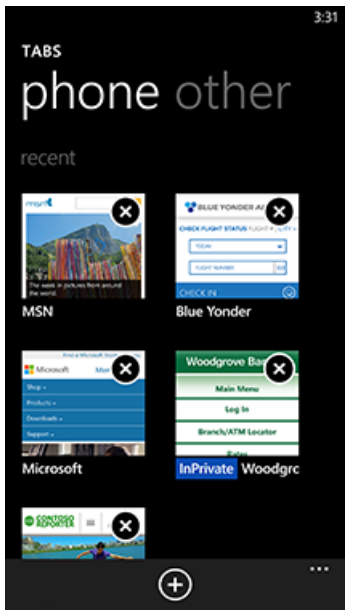

Figure 29. Tabbed browsing in Internet Explorer (Microsoft, 2015).

The Opera browser also uses a “stacked-cards” design similar to Chrome, Safari, and the UC browser, except that when the user activates the web page switching interface, a small pane appears at the bottom of the browser, displaying a horizontally stacked deck of opened pages (Figure 30). Users navigate the tabs using a horizontal swiping gesture.

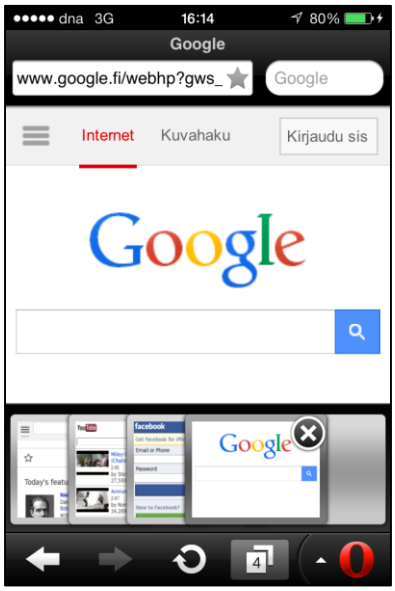

Figure 30. Tabbed browsing in the Opera browser.

The Dolphin browser displays opened pages similar to how it displays saved bookmarks, with name of the opened page along with a graphical icon of the website (Figure 31).

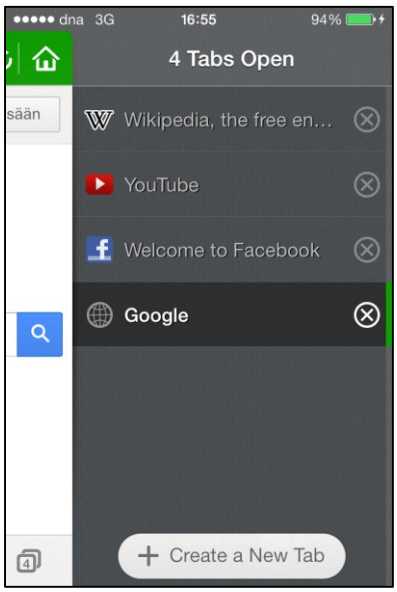

Figure 31. Tabbed browsing in the Dolphin browser.

4. Method

This chapter covers the methods used in data collection for the experiment. Section 4.1 provides an overview of the study settings. The following sections will cover the different aspects of the user testing in more detail. Section 4.2 describes the testing environment in more detail. An overview of the procedure starting from when participants entered the usability laboratory to the end of the testing session is described in Section 4.3. The data collection methods used for the experiment are discussed in Section 4.4. The test tasks along with the purpose of each task are covered in Section 4.5. A brief background information of all the participants are given in Section 4.6.

4.1. Study Setting

This thesis seeks to evaluate the different features available on various mobile web browsers. The purpose of this study is to compare the features used in information retrieval and to determine which feature improves the user's mobile browsing experience the most. The study will take a look at tasks used in daily mobile web browsing and see what common usage behaviors emerge when browsing the Internet on a smartphone. I hope to be able to answer the following question from the testing sessions and user interviews:

Which browser features used in information retrieval help to improve the browsing experience on a mobile phone?

The methods used for data collection were questionnaires (both post-task and post-test), recorded test sessions inside a laboratory, and user interviews. A combination of three data collection methods was used for the experiments: the Single Ease Question (SEQ), the System Usability Scale (SUS), and interview questions after the test session. Task times and task success rates were not included in the data collection due to the SEQ data. Sauro (2012) found that the correlation between user responses and task-time and task-completion is around r = ,5. This means that users tend to rate tasks as more difficult if they take longer to complete it or do not complete it at all.

Five features from six different browsers were evaluated in the test sessions. The tasks were based on the following features:

- Customized On-screen keyboard layout
- Combined or separated address bar and search field
- Address bar behavior
- Bookmark management
- Tabbed browsing

The browsers used were Chrome, Dolphin, Internet Explorer, Opera Mini, Safari, and UC Browser. These browsers are among the top nine most popular browsers in the world (Figure 9). These browsers also include various designs of the features chosen to be tested. Due to a lack of devices, the Android browser and Blackberry browser were not

chosen, even though they are among the most popular browsers on the market. Participants were provided with the devices to test with. The devices used in the experiment were the iPhone 4 and the Nokia Lumia 900. Chrome, Dolphin, Opera Mini, and the UC Browser were installed only on the iPhone 4. The Nokia Lumia 900 was used only for testing Internet Explorer. Testing on the Safari browser was done with the iPhone 4, since it is the default browser of the mobile platform.

Participants were asked to perform 7 tasks based on the above mentioned features on two different browsers (Table 2). The browsers were randomly assigned to participants based on two criteria: 1) the browser was not currently used by the participant, and 2) all browsers were to be tested at least three times. Due to the limited availability of the usability laboratory, and the amount of time participants were willing to allocate to the experiment, all test sessions took no more than one hour, though a few participants managed to complete the tasks faster than others. I assumed that the allocated one hour would be enough for the participants to test at most two different browsers, with enough time for filling out questionnaires and answering the interview questions. The reason for having participants test on unfamiliar browsers was to observe any issues participants might have in performing the tasks. The first two tasks were practice tasks, and therefore are not presented in the results.

Browser used (version)	# of Participants
Chrome (30.0.1599)	3 (P1, P6, P7)
Dolphin (7.5.1)	3 (P3, P7, P9)
Internet Explorer (IE9)	4 (P1, P4, P5, P8)
Opera Mini (7.0.5)	3 (P2, P9, P10)
Safari (9537.53)	3 (P2, P5, P6)
UC Browser (9.3.0.326)	4 (P3, P4, P8, P10)

Table 2. Browsers used and participants assigned to test them.

Before each test session, the browser data of all browsers would be deleted. Bookmarks added from the previous test session would also be deleted. The decision on which participant tested on which browser was made based on the browser they were currently using on their mobile phone. I wanted the participants to test a browser which had features that were different from their current browser. Furthermore, since there were 10 participants, I also wanted all the browsers to have been tested by at least 3 of the participants.

4.2. Testing Environment

The tests were conducted at TAUCHI's Usability Laboratory. Each test session lasted for approximately one hour. While performing the tasks, the participant's onscreen interactions with the web browser were recorded via a small web camera.

There are several methods for recording mobile screens and interactions (Pena & Tyers, 2011). Wearable equipment, such as microphones and hats with cameras, can be used for field testing. A screen capture application can be installed on the device, though these tend to be expensive and not compatible with all operating systems. A mounted camera can be pointed at the screen while the participant performs the task. This requires the participant to keep the mobile device in camera range and does not allow a lot of movement. The final method is a mounted device with a camera, which allows for natural interaction with the mobile device, but has a tendency to be heavy and bulky, which might make it difficult to interact with. I looked at several camera mounted rigs for mobile usability testing. Mr. Tappy (www.mrtappy.com) is an adjustable camera rig made out of lightweight aluminum that can be used for filming mobile phones, tablets, and other handheld devices (Figure 32a). Brignull (2010) made a guide on how to build a usability testing sled using a 3mm transparent acrylic sheet (Figure 32b). Santos and Evans (2011) created a usability sled with a flexible neck where a camera could be mounted (Figure 32c). Most of the usability rigs that I researched were made from materials that were either expensive or difficult to find. In the end, I improvised and built my own usability rig using a small lamp and a piece of cardboard.

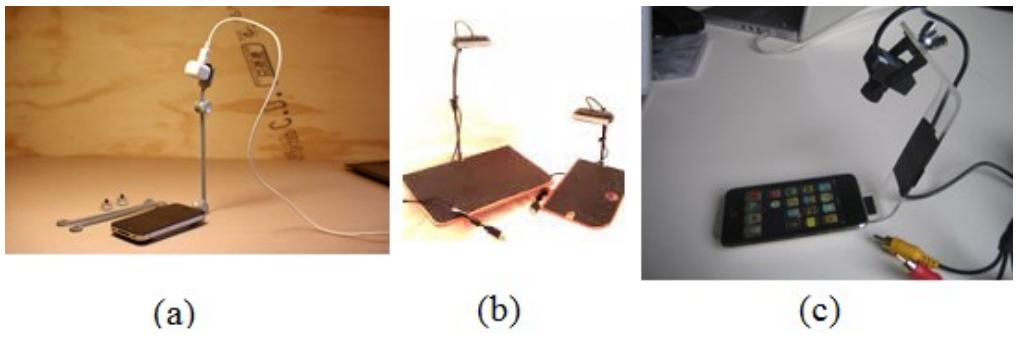

Figure 32. Camera mounted rigs for usability testing.

A Microsoft HD LifeCam was attached to a gooseneck lamp, which was mounted onto a piece of cardboard small enough to be held by one hand (Figure 33). In the middle of the cardboard was a rubber adhesive pad to prevent the mobile phone from slipping off the surface. The idea behind this setup was that even if there was movement from the participant's interactions, the video would not be shaky since the camera is mounted onto the cardboard. However, the camera was slightly too heavy to be stably supported by the gooseneck lamp, therefore, I did not inform any of the participants that lifting the

usability rig was an option and all participants performed the test tasks with the usability rig placed on the table.

Figure 33. Usability testing rig used in the experiment, consisting of a web camera attached to a gooseneck lamp, mounted on a piece of cardboard that had a rubber adhesive pad.

4.3. Procedure

After the participant arrived, they were given a brief introduction to the usability laboratory. The participant was informed that only their voice and interactions on the mobile device would be recorded via the camera mounted on the mobile testing rig. Two chairs were stationed in the recording lab, one for me and one for the participant. I asked the participant to sit down in the chair in front of the mobile testing rig. The participant was then asked to fill out a consent form for recording the test session and a background questionnaire (Appendix 1). After the participant filled out the background questionnaire and two copies of the consent form (one for me and one for the participant), the purpose of the study was then explained to the participant.

Next, I explained about the think-aloud protocol. In the think-aloud protocol, participants verbalize their thoughts as they are performing the tasks (Tullis & Albert, 2008). I demonstrated thinking aloud to the participant by folding a paper airplane and saying aloud what I am currently doing and what I am trying to accomplish. After the demonstration, I asked the participant to practice thinking aloud. The participant was then given the iPhone 4 with the Puffin browser (version 3.2.3) opened on the starting page The Puffin browser was selected for the practice task since it was not one of the tested browsers. The participant was then handed a piece of paper with the practice task printed on it. I asked the participant to read the task aloud and reminded them to use the think-

aloud protocol while performing the task. The aim of the practice task was to help the participant become familiar with thinking aloud during the testing session.

After the participant finished the practice task, the test session and video recording began. The participant was then given the first mobile phone to test with. Before handing the mobile phone to the participant, I would have opened the browser app to be tested, so the participant was given the phone with the browser app opened to the starting page (Figure 34).

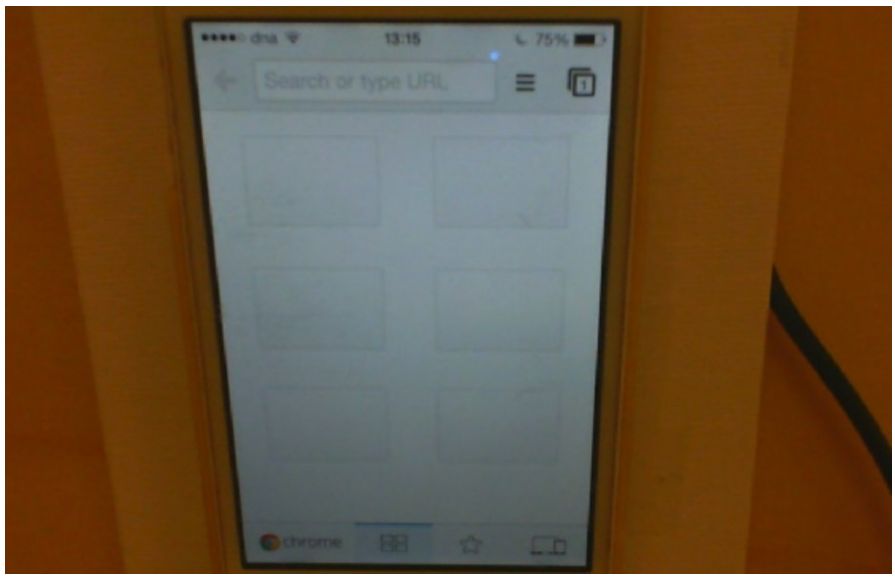

Figure 34. Starting page of the Chrome browser.

The test session consisted of a starting task (Task 0), and 6 test tasks (Tasks 1-6, detailed in Section 4.5) that were used for the results. The starting task, or Task 0, was an easy task aimed at relaxing the participant, and did not test any mobile browser feature. The test tasks, each printed out on a piece of paper, were given one by one starting with the practice task. The end of the task was determined by the participant when they thought they had found the information asked for in that task. After each participant's attempt at a test task, they were given the questionnaire from Appendix 4, which contains the SEQ questionnaire for each task on one sheet of paper.

After the participant completed the final task, they were given the SUS questionnaire (refer to Appendix 5) to answer evaluating the overall usability of the browser they had just tested. After the questionnaire was filled, participants were asked whether or not they would like to take a break or continue with the next test browser. When continuing with the next browser, I would have handed the mobile phone to the participant with the browser to be tested opened to the starting page. The participant was then given the piece of paper with Task 0 printed on it and asked to perform the task using the second browser. The test tasks for the second browser were the same as the first.

4.4. Data Collection Methods

A combination of three data collection methods was used for the experiments: the Single Ease Question (SEQ), the System Usability Scale (SUS), and interview questions after the test session. The SEQ is a post-task questionnaire which is used to assess how difficult or easy users find a task. However, since the SEQ does not give an overall assessment of the usability of a product, I also included the SUS after each participant was finished with all the test tasks of the browser. Interview questions were asked at the end of the test session in order to explore the participant's general attitudes toward the tested browsers and also in case anything interesting occurred during the test session.

Single Ease Question (SEQ)

One way to measure user satisfaction in a usability test is by using a post-task questionnaire or rating (Sauro & Dumas, 2009). Post-task ratings can be used to give insight into which tasks the participants thought were most difficult, which can then be used to pinpoint the part of the system or product which needs to be improved (Tullis & Albert, 2008).

The Single Ease Question (SEQ) is a 7-point rating scale that asks users to assess how difficult or how easy a task was (Sauro, 2012). After each participant's attempt at a test task, they are immediately asked to answer the question (Figure 35): Overall, this task was? Sauro and Dumas (2009) compared the SEQ to several other post-task ratings and found that it performed as well or better than other more complicated methods. Sauro (2012) found that the correlation between user responses and task-time and task-completion is around r = ,5. This means that users tend to rate tasks as more difficult if they take longer to complete it or do not complete it at all.

I chose to use a semantic differential technique with the anchor terms "Very Difficult" and "Very Easy", but other scales, such as a 5-point scale or the traditional Likert scale, can also be used based on personal preference. A form with the SEQ was given to each participant after each task (Appendix 4).

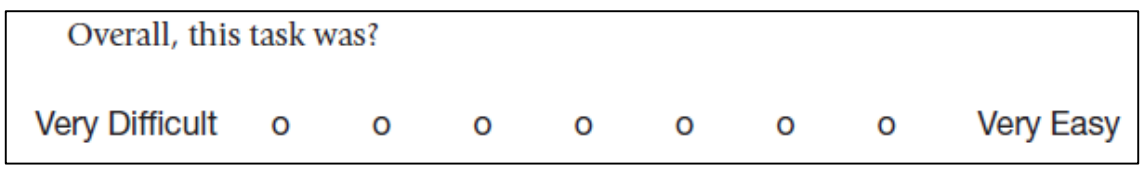

Figure 35. SEQ with 7-point scale for rating task difficulty (Tullis & Albert, 2008).

Post-task questions can be valuable in providing diagnostic information about usability issues and since the question is answered immediately after completing a task, this increases its validity (Sauro & Dumas, 2009).

System Usability Scale (SUS)

The System Usability Scale (SUS) is one of the most widely used tools for measuring the perceived usability of a system or product (Tullis & Albert, 2008). It consists of 10 statements with a 5-point scale of agreement, from "Strongly disagree" to "Strongly agree", for each one (Brooke, 1996). Half of the statements are worded positively and half are worded negatively and the participant needs to indicate their degree of agreement or disagreement with the statement (Figure 36).

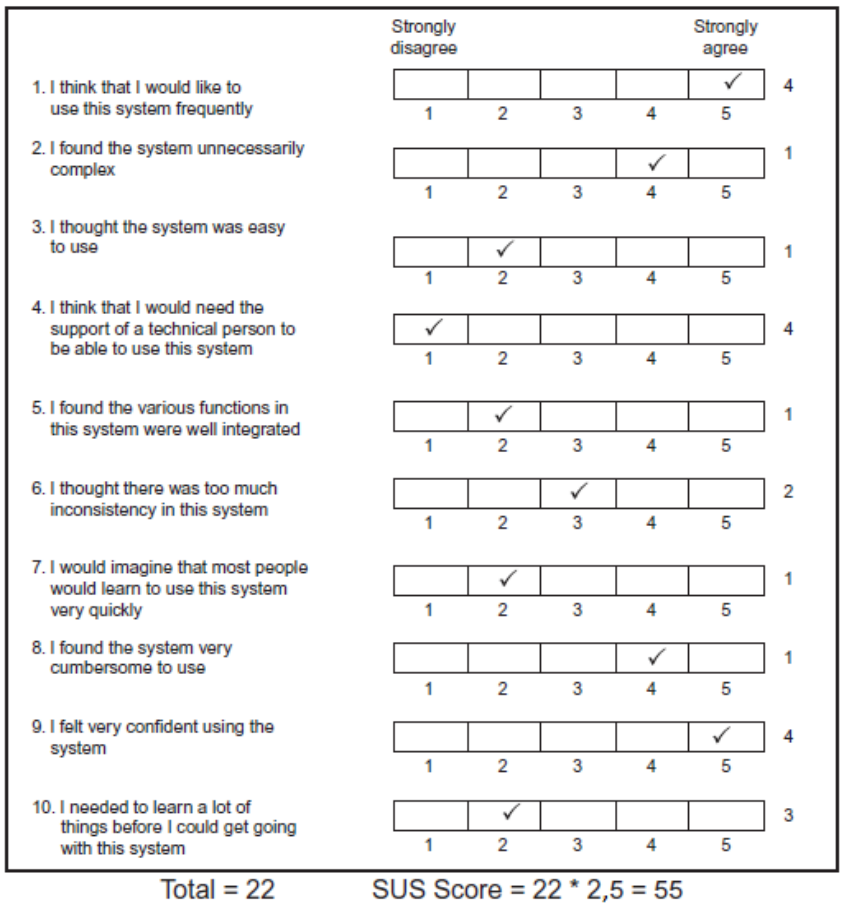

Figure 36. The System Usability Scale and an example of scoring it (Tullis & Albert, 2008).

The SUS has become an industry standard with noted benefits such as being easy to administer to participants, the ability to be used on small groups of participants with reliable results, and its validity (Usability.gov, 2015). However, the scoring system of SUS is rather complex. Each statement's score will range from 0 to 4. For statements 1, 3, 5, 7, and 9, the score is the scale position minus 1. For statements 2, 4, 6, 8, and 10, the score is 5 minus the scale position. To obtain the overall SUS score, the sum of the scores is multiplied by 2,5 which changes the scores from 0-40 to 0-100. It is convenient to think of the scores as percentages since they are on a scale of 0-100, but they are not.

Based on their analyses of SUS scores from a wide variety of studies, Bangor, Kortum, and Miller (2009) suggest the following interpretation for SUS scores:

- < 50: Not acceptable
- 50-70: Marginal
- > 70: Acceptable

Bangor, Kortum, and Miller (2009) also added an adjective rating scale and a school grading scale to the SUS (Figure 37). The idea was to help practitioners interpret the scores and to aid in explaining the scores to people not working in the field of human factors. The grade scale uses the traditional school grading scale, where 90-100 = A, 80-89 = B, etc. The adjectives used to describe the SUS scores were: Worst Imaginable, Poor, OK, Good, Excellent, and Best Imaginable.

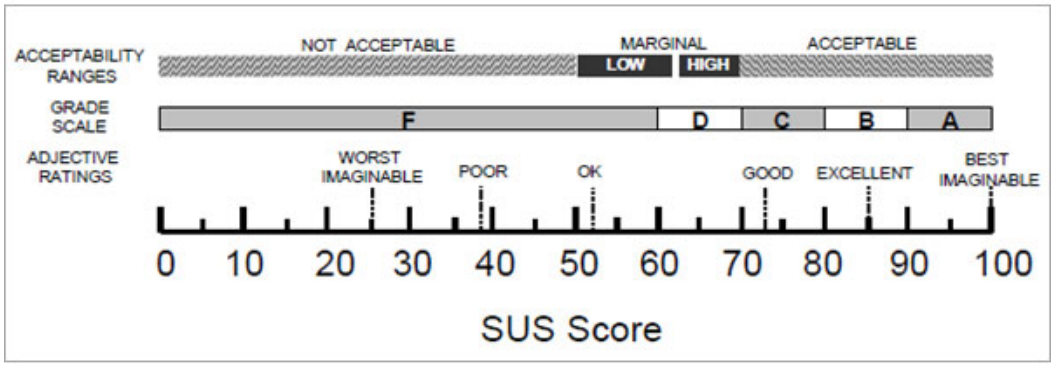

Figure 37. Acceptability ratings, grade scales, and adjective ratings and their corresponding SUS score (Bangor, Kortum, & Miller, 2009).

Interview Questions

According to Nielsen (2010), "Interview questions are useful when you want to explore user's general attitudes or how they think about a problem". The interview questions at the end of the test sessions were semi-structured. The interview questions were divided into two themes: 1. Information needs and search behavior when looking for information and 2. User's opinions about different browser features. The list of interview questions asked can be found in Appendix 3.

4.5. Test Tasks

The test tasks used in the test sessions along with the purpose of each task are discussed in this section.

Practice Task	*Go to the Finnkino website and find out what are some of the movies shown today at Finnkino (Tampere) after 18:00.*

The purpose of this task is to help participants practice thinking aloud.

Task 0	*Find out what are the opening hours of the Metso Library.*

This supposed to be a relatively easy task aimed at relaxing the participant before the actual test tasks were given.

Task 1	*1. Open a new blank page in the browser.* *2. You need to cancel your dental appointment at the student healthcare center (YTHS).* *Find out what is the phone number of the oral health department by typing in the following web address:* http://www.yths.fi/en/contact_details/units/tampere

The purpose of Task 1 is to have participants type out a web address with special symbols, such as the slash (/), colon (:), and underscore (_), and to see whether the participants make use of the URL specific keys that appear on the on-screen keyboard when a user is typing out a web address in the browser.

Task 2	*1. Open a new blank page in the browser.* *2. Your company has sent you to Oulu for an on-site project. You arrive at the train station around 10 at night. Your hotel is quite far from the train station and you will need to take a taxi to get there.* *Search for the number of the taxi service in Oulu.*

The purpose of Task 2 was to evaluate how participants perform a search on their mobile browser, whether they used the specific search field, the combined search field and address bar, or whether they opened a search portal, such as Google.

Task 3	*1. Open a new blank page in the browser.* *2(a) Open en.wikipedia.org and scroll down to the section titled "In the news". What is the first news headline?* *2(b) From the same page, go to the BBC news site (www.bbc.co.uk) and see what the first news headline is.*

The purpose of Task 3 was to evaluate how the address bar behaves when a participant is scrolling down the page and whether participants would have any issues with finding the address bar at the bottom of a lengthy web page.

Task 4	*1. Open a new blank page in the web browser.* *2. All your classes for this semester are in the Pinni B building, so most of the time, you have lunch at Amica's Minerva restaurant.* *Find the website with the restaurant's lunch menu and bookmark it.*

The purpose of Task 4 is to evaluate the task difficulty of adding a bookmark in various web browsers. This is a two-part task that evaluates bookmark management, with the second part continuing in Task 5.

Task 5	*Go to the saved bookmarks list and open the website that you would use to upload, share, and view videos.*

The purpose of Task 5 is to evaluate how bookmarks are displayed in various browsers and whether any design affects the task difficulty. This is a continuation from the previous task, where participants are asked to search for a bookmark among a list of added bookmarks.

Task 6	*You're starting to feel really sick and your throat is extremely sore. You should call and make an appointment at the student health care service (YTHS). You remember seeing the phone number of the general health department when you cancelled your dental appointment.* *Go to the previously opened YTHS web page and find out the number for the general health department.*

The purpose of Task 6 is to evaluate tabbed browsing in various browsers. In each of the previous tasks, participants were asked to open a new blank page in the browser and by Task 6, each participant would have 4 pages open. The task asks the participant to open the web page they had typed out in Task 1.

4.6. Participants

The participants were chosen based on the fact that they owned a smart phone with a touch screen and that they browsed the Internet on their mobile phones on a daily or almost daily basis. Ten students from the Tampere region were recruited to participate in the user evaluation. Nine participants attended University of Tampere (UTA) and one participant attended Tampere University of Applied Sciences (TAMK). The participants from UTA were recruited through the course Introduction to Interactive Technology, where participating in a usability test is required for passing the course. The participant from TAMK was recruited through my social network. Five participants were male and five were female. The ages of the participants ranged from age 19 to age 42, with the average age being 24,4 (SD = 6,69).

The smartphone brands used by the participants and the browsers were quite varied (Figure 38), but the used mobile browser seemed to be related to the mobile phone brand. Seven of the participants used the default browser that ships with the mobile phone, while only three had downloaded a third-party browser (Firefox, Dolphin, and Chrome). All participants who owned either the iPhone or the Windows Phone used the default browser available in their phones (Safari and Internet Explorer respectively).

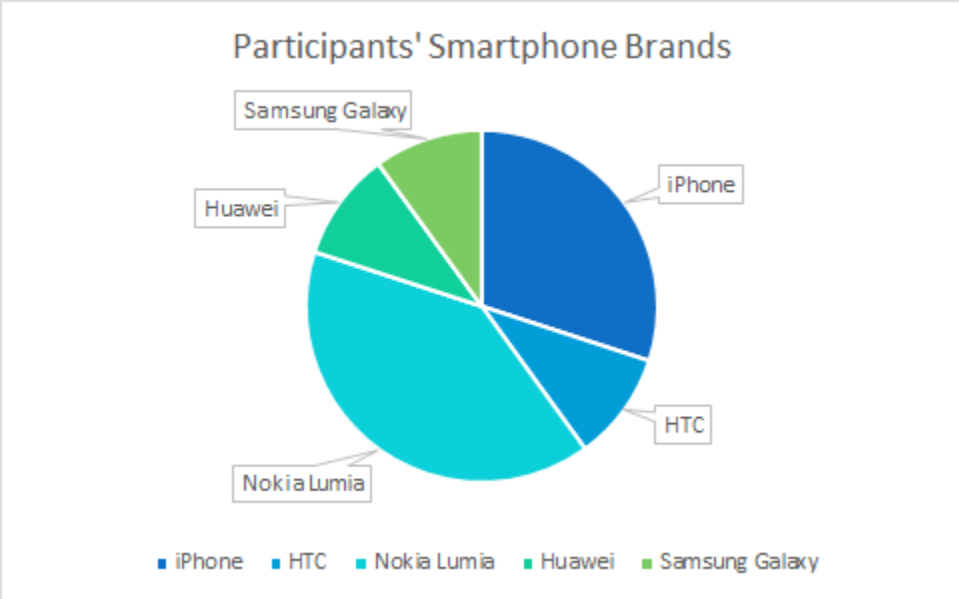

Figure 38. Mobile phone brands used by the participants.

It was a different story where browsing on their home computers or tablets were concerned. None of the participants used the default browser that came with the OS of their desktop or tablet. Only two browsers were used by the participants on their desktop or tablet: Firefox (4 participants) and Chrome (6 participants).

The most browsed websites among the participants could be categorized into the following: 1) Social media and networking websites, 2) various news websites, and 3) websites for accessing email (Table 3). Since all the participants were students, the fourth most accessed website was the university website, which students mentioned using for class schedules and lunch menus.

Websites	# of Participants
Social media and networking	7 (P2, P3, P4, P5, P8, P9, P10)
News	7 (P1, P2, P4, P5, P7, P8, P10)
Email	7 (P1, P2, P4, P5, P7, P9, P10)
University website	7 (P1, P3, P4, P5, P6, P7, P9)

Table 3. Top websites visited by the participants.

Participants were also asked to select for what purposes they used their mobile browsers in the background questionnaire (Table 4). The participants were asked to select the activities from a list of most likely scenarios. The results were as follows:

Purpose of browsing	% of participants
Information retrieval	90%
Reading and sending email	80 %
Reading the news	80 %
Socializing (e.g. IM, Facebook)	70 %
Entertainment	50 %
Electronic chores such as banking	20 %
Electronic shopping	20 %

Table 4. Most popular mobile browsing activities among the participants.

Table 5 shows the background information of all the participants that took part in the testing and the mobile browsers they were assigned for the test session.

Participant	Age	Gender	Smartphone brand/model	Current mobile browser	PC/tablet browser	Tested browser 1	Test browser 2
P1	24	male	iPhone 4	Safari	Firefox	Chrome	Internet Explorer
P2	25	male	HTC Legend	Chrome	Chrome	Opera Mini	Safari
P3	19	male	Nokia Lumia 720	Internet Explorer	Chrome	Dolphin	UC Browser
P4	20	female	iPhone 4s	Safari	Chrome	Internet Explorer	UC Browser
P5	28	female	Huawei Ascend G300	Firefox	Firefox	Internet Explorer	Safari
P6	21	female	Samsung Galaxy Note N7000	Dolphin	Chrome	Chrome	Safari
P7	27	female	Nokia Lumia 720	Internet Explorer	Chrome	Chrome	Dolphin
P8	19	female	iPhone 4s	Safari	Firefox	Internet Explorer	UC Browser
P9	19	male	Nokia Lumia 720	Internet Explorer	Chrome	Dolphin	Opera Mini
P10	42	male	Nokia Lumia 820	Internet Explorer	Firefox	UC Browser	Opera Mini

Table 5. Background information of the participants and mobile browsers that they tested. Participants were assigned browsers which they were currently not using.

5. Results

This chapter presents the data from the SEQ results, organized by browser feature, and the SUS evaluations found during the study (Sections 5.1 and 5.2). A summary of the interview questions are discussed in Section 5.3. The interview questions, SEQ, and SUS can be found in Appendix 3, 4, and 5 respectively.

5.1. Single Ease Question (SEQ) Results

The first task evaluated the on-screen keyboard layout of the used browsers. Each browser had one or several keys that would appear when the address bar was activated. The purpose of this feature is to facilitate the user in typing on a device without a keyboard.

Chrome and Safari scored the highest on the SEQ results (both had a score of 6,33) where participants were asked to rate the difficulty of the task (Figure 39). Internet Explorer scored the lowest with a task difficulty score of 4,25.

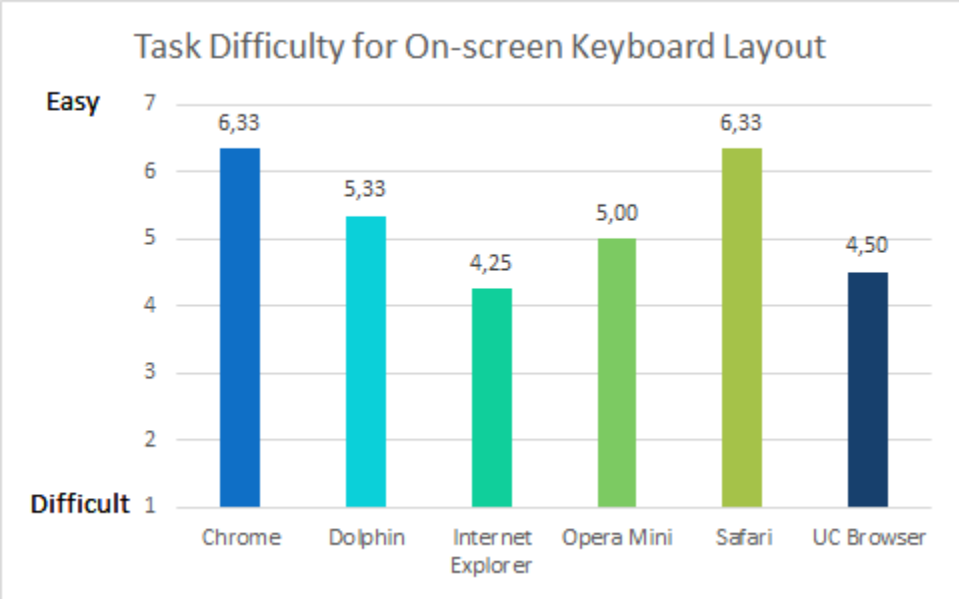

Figure 39. Task difficulty results for the on-screen keyboard layout.

Task 2 evaluated the search field of the selected browsers. Participants were asked to search for the phone number of a taxi company. The purpose of this task was to discover whether having a combined search field and address bar versus having a separate search field and address bar would affect the browsing experience in any way. There was not much variation in the task difficulty results (Figure 40), with the lowest being Dolphin (score of 6,00) and the highest being Safari (score of 7,00).

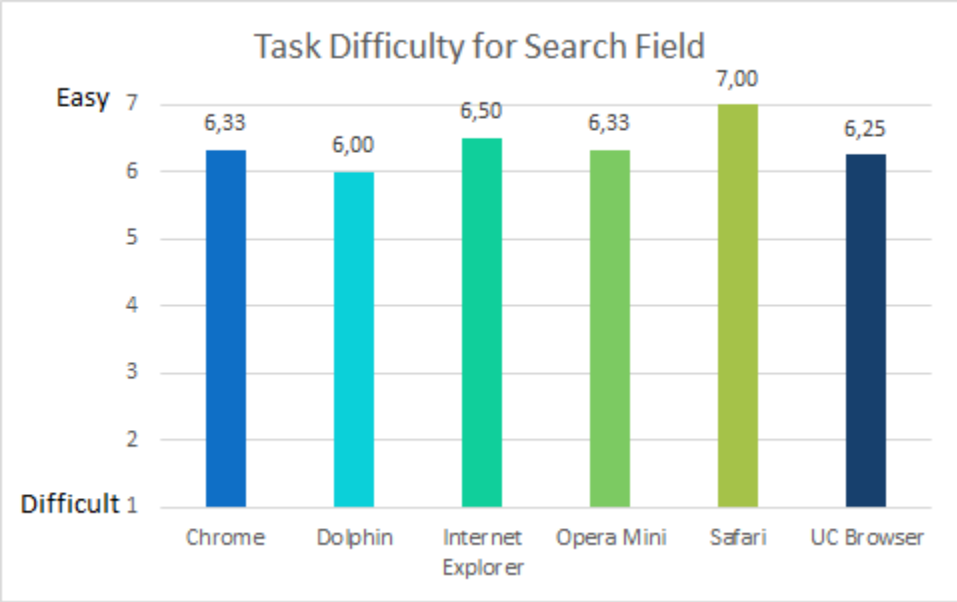

Figure 40. Task difficulty results for the search field.

Task 3 evaluated how the address bar of the selected browsers behaved. For some browsers, the address bar disappears when the user starts scrolling downward on the web page, which increases how much of the website is displayed. For others, the address bar is static and always visible to the user.

Again, there was not much variation in the task difficulty scores (Figure 41), with the lowest score being Opera Mini (6,00) and the highest being Chrome and Safari with a score of 7,00.

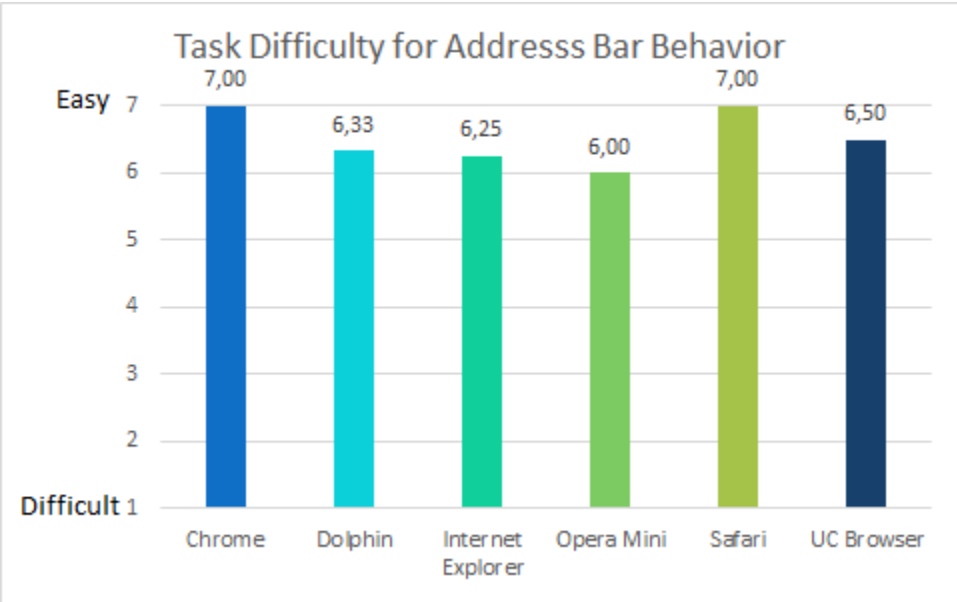

Figure 41. Task difficulty results for the behaviour of the address bar while scrolling.

Tasks 4 and 5 both evaluated the browser's bookmark management. In task 4, participants were asked to open a website and bookmark it.

The results for the task difficulty varied significantly among each browser (Figure 42), with the lowest score being Chrome (3,67) and the highest score being Internet Explorer (6,25).

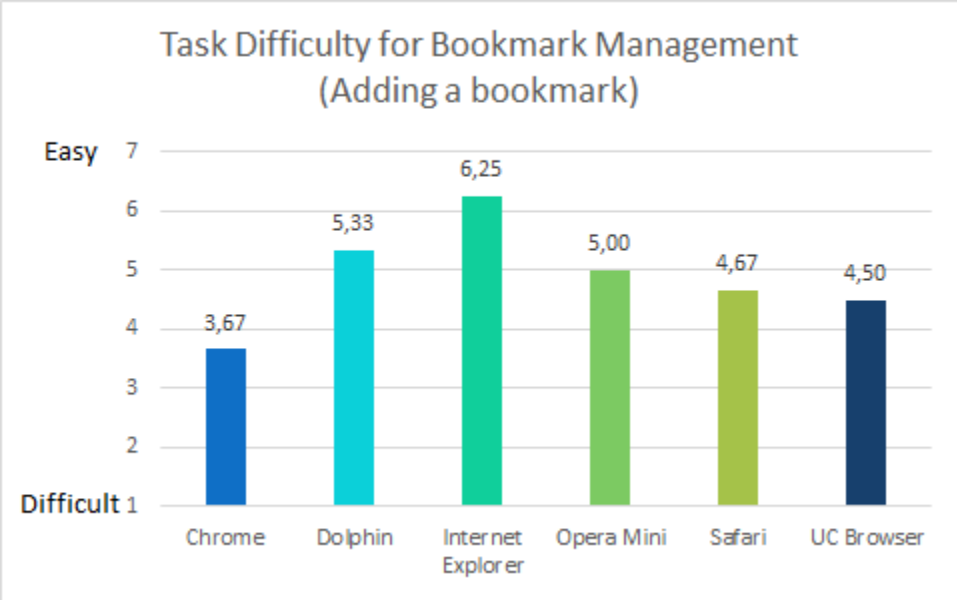

Figure 42. Task difficulty score for adding a bookmark.

Task 5 was a continuation of Task 4, where users were asked to find and open a bookmark (YouTube).

Most of the browsers scored relatively high for this task, with scores between 6,00 and 7,00 (Figure 43). The exception being Dolphin, which had a score of 4,00. The reason for the low score was because participants could not locate the button to open the saved bookmarks view. The Dolphin browser actually has two ways of opening the saved bookmarks view: users can press the bookmarks button or use a horizontal right-swiping gesture to reveal the list of saved bookmarks.

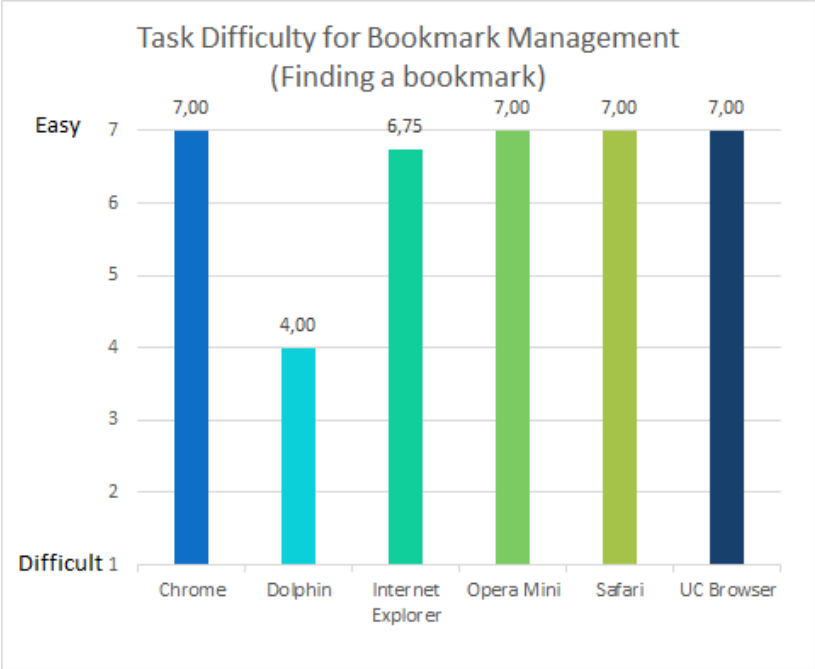

Figure 43. Task difficulty score for finding and opening the YouTube bookmark.

The final task (Task 6) evaluated how multiple pages were displayed in the browser. Since the beginning of the testing, participants were always asked to open a new browser page at the beginning of each task. By Task 6, each participant should have 4 opened web pages.

Most of the browsers scored relatively high, with scores between 6,00 and 7,00 (Figure 44). The lowest scoring browser was the UC Browser, with a score of 5,50.

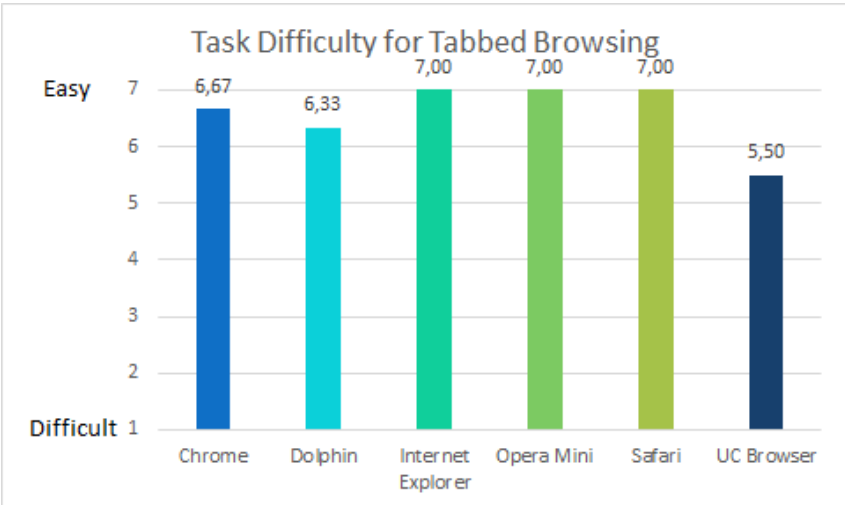

Figure 44. Task difficulty score for locating a previously opened page from the browser's multiple page display.

5.2. System Usability Score (SUS) Results

None of the browsers scored below a 50, so none were considered as "not acceptable". Internet Explorer, Opera Mini, and the UC Browser scored above a 70, which is considered as acceptable. Chrome, Dolphin, and Safari all scored between 50 and 70, which is considered as marginal.

Using the adjective rating scale developed by Bangor, Kortum, and Miller (2009) produces more distinctive results, with all the browsers scoring in the "Good", "Excellent", and "Best Imaginable" range (Figure 45). The SUS scores of the Safari (54,17), Dolphin (65), and Chrome (67,5) browsers are considered as "Good", with the Safari browser in the low end of the range. The SUS score of the UC Browser (76,25) hovers between "Excellent" and "Good". Opera Mini (86,67) and Internet Explorer (85) scored a "Best Imaginable" rating.

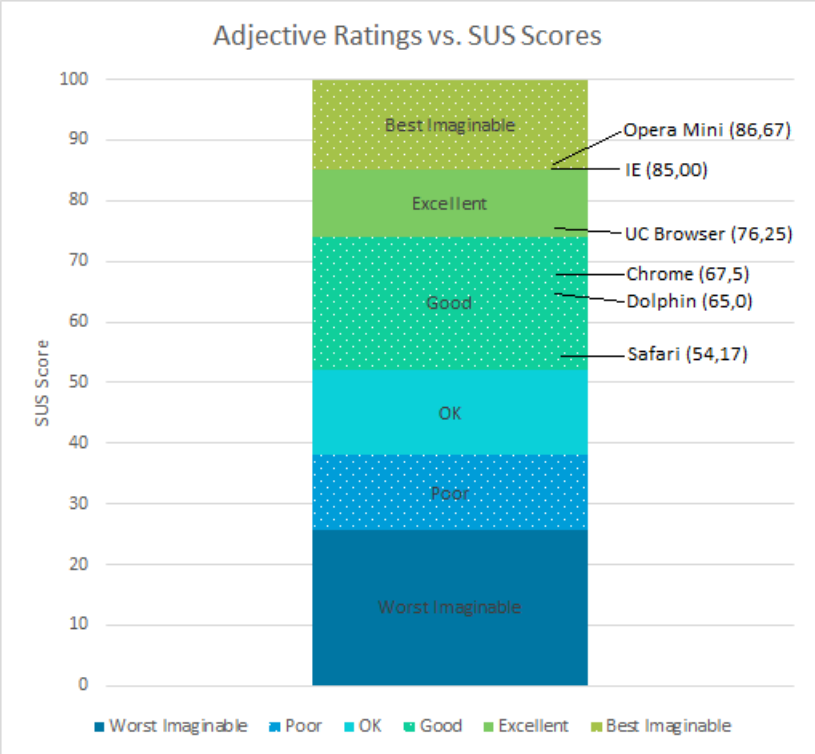

Figure 45. Adjective rating scores of the tested browsers.

5.3. Interview Questions

The interview questions at the end of the test sessions were semi-structured and divided into two themes: 1. Information needs and search behavior when looking for information and 2. User's opinions about different browser features.

Participants did not seem to notice two of the tested browser features: changes in the keyboard layout when typing and behavior of the address bar while browsing a web page. Based on the answers to the interview questions concerning these two features, the changes were too subtle for any participant to notice. However, five out of the eight

participants that tested a browser with specific keys for URL entry did use them, though they did not recall their appearance when asked about this feature in the interview.

Eight out of ten participants all mentioned that they did not type full website names, even for websites that they knew the whole address for. Participants P1 and P10 mentioned that they typed in the name of the website and the extension (".fi" or ".com"), but never the "www." prefix. Most participants prefer to type in a few letters into the address/search bar and select the website from the list of suggestions.

Four of the participants (P4, P6, P7, and P8) mentioned that they used bookmarks in their own browser. P1 said he did not use bookmarks because he just memorized the addresses of frequently used websites. The other participants who did not use bookmarks mentioned that they would just type a few letters into their browser's search bar and select the website from the list of suggestions. P3 felt that there were too many buttons to press in order to access the bookmarks. P10, who has a Windows Phone, pins favorite websites to the home screen instead of using browser bookmarks. P8, who was one of the participants that uses bookmarks, mentioned that even though she does save bookmarks of frequently accessed websites, she finds herself sometimes typing the name of the website into the search bar and selecting from the list of suggestions.

Participant P6 was the only participant that used a different browser other than the pre-installed one. P6 did not like the pre-installed Android browser, so she searched on the Google Play app store and downloaded the Dolphin browser, since it had a high user rating. The rest of the participants all used the pre-installed browser that came with the phone. P4 mentioned that she did not really like her current browser (Safari), but was not aware that it was possible to install and use a different one. Most participants mentioned that since the pre-installed browser works, they felt no need to look for a new one.

6. Browser Feature Comparison and Discussion

Six of the most popular mobile browsers were tested in the experiment: Chrome, Dolphin, Internet Explorer, Opera Mini, Safari, and the UC Browser. Based on the overall SUS scores, Opera Mini and Internet Explorer scored the highest with a score of 86,67 and 85, respectively. Safari scored the lowest compared to the other five browsers with 54,17, however, this is considered a perfectly acceptable score (Bangor, Kortum, & Miller, 2009).

Sections 6.1 – 6.3 discuss the results and observations concerning the different mobile browser features from the test sessions. Observations from the user interviews are discussed in Section 6.4. Lessons learned from the experiment setup and test sessions are covered in Section 6.5. Section 6.6 is a brief summarization of the main results from the experiments.

6.1. Text Entry

Many mobile browsers are utilizing the HTML5 input types to facilitate data entry. When an input field is focused in a browser, a customized on-screen keyboard will be displayed based on the input type of the focused field.

For Opera Mini, the extra slash (/) button was used when entering the website URL in the address bar by all three participants that tested with the browser. For Internet Explorer and Safari, this feature was not used by the participants because accessing the additional customized keys requires pressing and holding the ".com" and the "." button. Because the customized keys are not visible to the user, the additional features were overlooked by all seven of the participants that tested on these two browsers.

For Chrome, Dolphin, and the UC browser, when the input field is a web address, an extra row of buttons is displayed above the on-screen keyboard (Figure 16 and Figure 18). Out of the eight participants that tested this design, three (P1, P8, and P9) did not use any of the special keys from the extra row of buttons. This could be due to the web address they were asked to type for the task: http://www.yths.fi/en/contact_details/units/tampere. Participants became so focused on not making a mistake while typing, and the complexity of the web address acted as a distraction, preventing them from noticing the changes in the keyboard layout. When asked about this during the interview, all mentioned that they have never had to use those symbols because either the browser's auto-completion feature displays the name of the website they intend to access or they type in what they are looking for in a search engine and select the website from the results list.

Task 2 required participants to search for the number of the taxi company in Oulu, Finland. All participants typed the strings "taxi" and "oulu" into the search field (Figure 46).

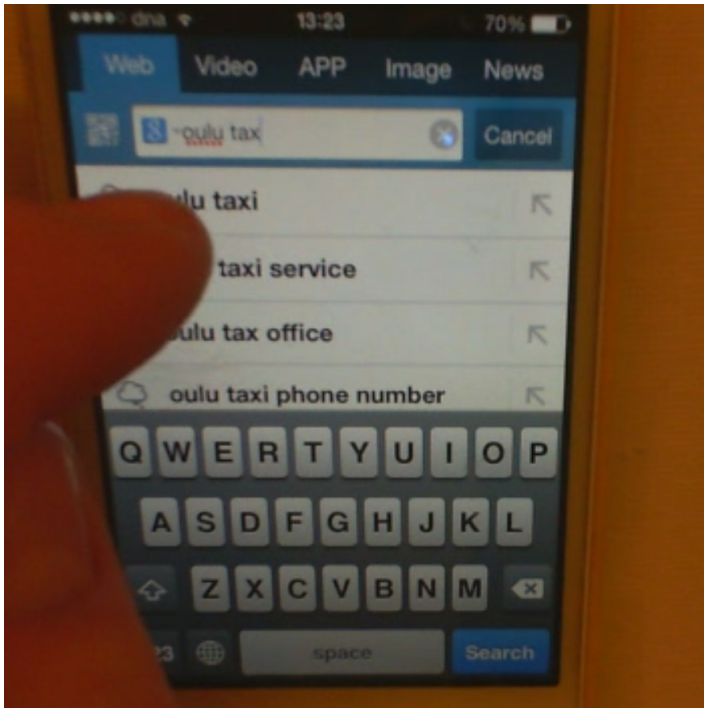

Figure 46. List of suggestions provided by the browser while typing in the Search field.

There were two designs among the tested browsers when it came to the search field feature: a search field clearly separated from the address bar and a single field which combines both the address bar and the search field. Both Opera Mini and the UC browser have a search field located to the right of the address bar, while Dolphin has the search field located below the address bar. Seven participants tested on these three browsers and six of them (except for P4) used the separate search field for the task.

Participant P4, who was testing on the UC browser, typed in the URL field instead of the search field and since the UC browser customizes the keyboard layout when entering in web addresses, there was no space bar. The test task required searching for the number of the taxi service in Oulu, so the participant had to cancel typing and instead opened a search engine website to find the information. Unlike the Opera Mini and Dolphin browsers, the separation between the URL field and the search field is not so distinct in the UC browser (Figure 19). In this aspect, the customized keyboard layout actually became a slight hindrance to completing the test task.

All seven participants that tested on the combined URL and search field immediately used the combined field to complete the task. None of them opened a search engine website first.

Most browsers (Chrome, Dolphin, Opera Mini, UC browser, and Safari) automatically hide the address bar when the user scrolls down the web page, allowing the page to be displayed in full screen. The address bar is displayed again when the user taps the navigation pane at the top, scrolls down to the bottom of the page, or starts scrolling up. The address bar of Internet Explorer, on the other hand, is located at the bottom of

the browser and is always visible. For this feature, the interactions were more interesting for the four (P1, P4, P5, P8) participants that tested on Internet Explorer. Except for one participant (P5), the rest all scrolled up to the top of the browser before realizing that the address bar of Internet Explorer is located at the bottom of the browser. For second part of Task 3, Participant P1 thought that the website's (Wikipedia.com) search bar was the address bar and typed "www.bbc.co.uk", which opened the Wikipedia page of the BBC News website.

Based on the average SEQ for this task (mean = 6,5 and SD = 0,83), most participants found this task quite easy to complete on all browsers. Participants who tested on Internet Explorer expected the address bar to be on top and would automatically scroll up before realizing the address bar was located at the bottom of the browser. However, none of the participants made any remarks about the address bar's unique location. Participants who tested on the other browsers were able to make the address bar reappear easily and access it quite quickly.

When asked during the interviews, none of the participants noticed the extra row of URL specific character keys that appeared when typing in the address bar. However, five out of the eight participants that tested on a browser with this feature did use them. Another feature that participants did not notice was the disappearing address bar while browsing longer web pages. Based on the answers to the interview questions concerning these two features, the changes were too subtle for any participant to notice.

6.2. Bookmark Management

Evaluating this feature was divided into two test tasks. The first task (Task 4) involved adding a bookmark and the second task (Task 5) involved finding the YouTube bookmark among the saved bookmarks. What I did not anticipate was the difficulty that some participants would have with locating the button to add a bookmark, which differed between the browsers.

Only four out of the ten participants use bookmarks in their own browser. The other six mentioned that instead of using the bookmarks feature, they prefer to type in a few letters of the website name and select the website from the list of suggestions provided by the browser. According to Cui and Roto (2008), fact finding is the most common task performed by users and the task demands immediate access to very specific information. Due to the time-critical nature of fact finding, participants might deem navigating to a feature such as bookmarking, which is hidden within the browser menu, as simply an act that requires too much effort and time.

Chrome, which had the lowest SEQ score (M = 3,67 and SD = 2,52), uses a star symbol for bookmarking a web page and the word "Bookmarks" for accessing saved bookmarks (Figure 47), both located within the browser's menu list. This made it difficult for participants P1 and P7 to bookmark the webpage in the task. Participants P1 and P7

did not realize that the star symbol was used to add a bookmark and proceeded to select "Bookmarks", thinking that the functionality to add a bookmark would be located here. It was only when asked how they usually bookmarked a web page on their desktop browser, did they remember that the star symbol meant adding a bookmark. P6 went through the menu list, at first, but then remembered that Chrome uses the star symbol for bookmarking and managed to complete the task easily.

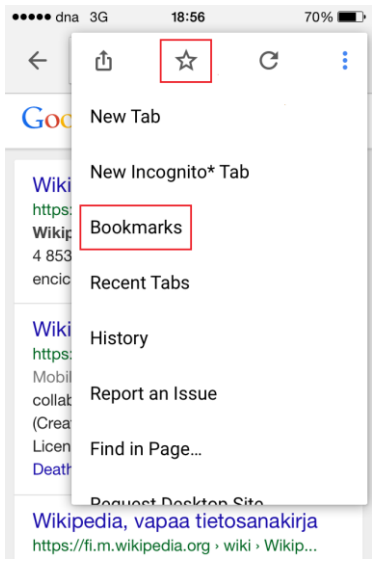

Figure 47. In Chrome, the star symbol is used to bookmark a page, while the "Bookmarks" item in the Options list is used to access saved bookmarks.

The UC browser also uses a symbol for accessing the button for adding a bookmark. Users can access the "add bookmark" button by pressing the star symbol located to the left of the address bar (Figure 48). Participants P3, P4, and P8 first opened the menu of the browser and selected the "Bookmarks" option, which opened the saved bookmarks list. There is no option to add a bookmark in this view, and participants proceeded to look for the option elsewhere. However, since the star symbol was located next to the address bar, and not within a submenu as in the Chrome browser, the participants eventually noticed the symbol, without any guidance, and were able to complete the task. For this task, the UC browser received a mean SEQ score of 4,50 (SD = 1,73).

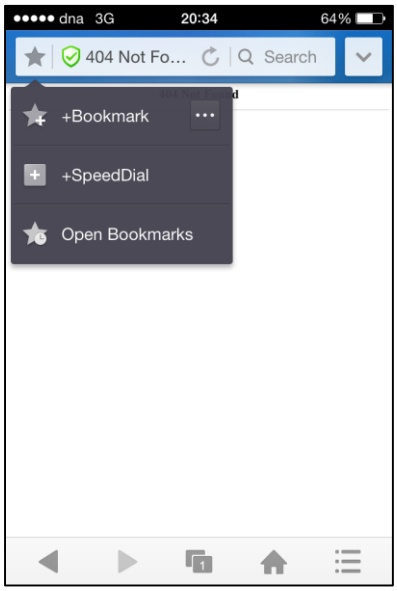

Figure 48. The UC browser uses the star symbol for saving a web page to bookmarks.

For Safari, pressing the Share symbol opens the option to save the web page as a bookmark (Figure 49). Participant P2 had no issues with completing this task and correctly found the Bookmark button in the Share menu. Participants P5 and P6 both selected the Bookmarks button, and spent some time looking for the add bookmark functionality in the saved bookmarks view. Both participants mentioned that since the icon looks like a book, they expected the option to add a bookmark to be located here. It was only after exhausting all possibilities, did the participants decide to open the Share menu and that is how they found the Bookmark button. For this task, Safari received a mean SEQ score of 4,67 (SD = 2,52).

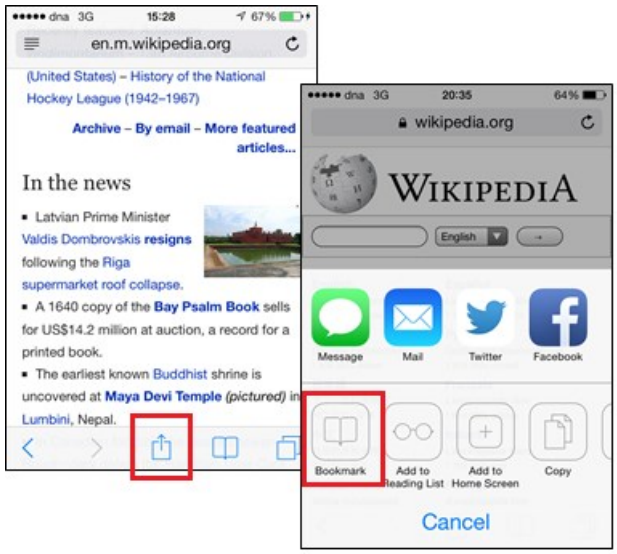

Figure 49. On Safari, saving a web page as a bookmark can be done via the Share menu, which opens by tapping the icon in the navigation bar.

Opera Mini and Dolphin both have several ways to add a bookmark. In Opera Mini, users can either use the star symbol or add the bookmark from the saved bookmarks view. In Dolphin, users can access the option via the Bookmarks symbol located next to the address bar or from the Add Page button located in the Menu options. Due to the flexibility of these designs, participants that tested on these browsers managed to complete the task without any issues.

Internet Explorer had the highest SEQ score for Task 4 (M = 6,25 and SD = 0,96). In Internet Explorer, users add a bookmark by tapping the Menu button and selecting the option "Add to favorites". Since the navigation pane of Internet Explorer only contains three items (the Refresh button, the address bar, and the Menu button), participants that tested on this browser managed to complete the task without any issues.

Proper use of graphical elements is one way to optimize communication with users, especially on mobile devices with limited screen displays (Gatsou, Politis, & Zevgolis, 2012). Symbols can sometimes be very difficult to interpret correctly without training or experience. Users draw upon real world experience to interpret the functions of icons (Gatsou, Politis, & Zevgolis, 2012). In the case of the Safari browser, participants would select the Bookmarks icon (which opens saved bookmarks), thinking that it would contain the option to add a bookmark. According to Gatsou, Politis, and Zevgolis (2012), "a symbol should display a strong, direct association with the desired meaning, in the mind of both designer and user" (p.14).

For accessing bookmarks (Task 5), most browsers received a high SEQ score, between 6,00 and 7,00 (Figure 43). The exception was Dolphin, which had a mean score of 4,00 (SD = 2,65). Most participants had already accidentally stumbled upon the saved bookmarks view while searching for the function to add a bookmark, so Task 5 was completed with relative ease.

Dolphin scored the lowest in this task due to participants not being able to locate the bookmark manager. There are two ways to open the bookmark manager in the Dolphin browser: 1) by pressing the bookmark symbol located to the left of the address field (Figure 50), or 2) by pressing on the left side of the screen and using a right-swiping gesture to reveal the view. However, since participants started the task while in the middle of the web page from the previous task, the address bar was not visible to them. The disappearing address bar is part of the design of the Dolphin browser, the purpose being to display web pages in full screen mode to fully utilize the limited screen space on a mobile device. Due to this feature, participants that tested on this browser had some difficulty in locating the bookmark management button.

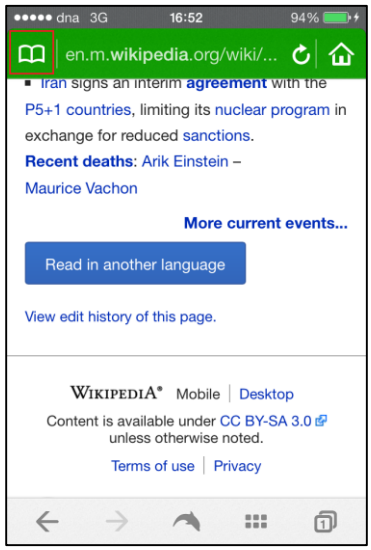

Figure 50. Bookmarks button is located at the top left of the Dolphin browser.

Another issue observed was that participants assumed the features of adding a bookmark and viewing bookmarks would be located under the same menu option. If the word "Bookmarks" was available in the browser, many participants would tap the word "Bookmarks" and open the bookmark viewing page, thinking they would also find the option to add a bookmark. This issue happened to participants testing on Chrome and the UC browser, both of which use the star symbol for adding a bookmark and the word "Bookmarks" to open saved bookmarks. Since all participants were non-native speakers of English, this could also be a language issue. Participants might not have recognized the label as a noun and thought it was the verb "to bookmark".

In the case of Safari, participants would tap the Bookmarks symbol, thinking this is where the option to add a bookmark would be located. The add bookmarks button is actually located under the Share button, to the left of the Bookmarks button (Figure 51).

Figure 51. In Safari, symbols are used for the Share button and the Bookmarks button.

6.3. Tabbed Browsing and Browsing History

None of the participants had a problem with the task of opening the tabbed browsing view and locating a previously opened web page. The browsers scored relatively high, with scores between 6,00 and 7,00 and the lowest being the UC Browser, with a score of 5,50

(SD = 1,29). Participant P4, using the UC browser, gave the task an SEQ score of 4 due to the fact that the participant had accidentally closed some of the previously opened web pages, including the one that was required to accomplish the task. Participant P10 interpreted the task to mean opening the web page from the UC browser's history instead of the tabbed browsing, but was unable to locate the history view. The participant then proceeded to press the Back button until the page was displayed, which was a total of 12 times. The participant gave the browser an SEQ score of 5 since he was unable to locate the history view. In the UC browser, the browsing history can be found in the same view as the saved bookmarks, only it is located on the other tab in the view (see Figure 27, page 32).

In hindsight, this test task was probably not designed well enough to test out the different designs of the tabbed browsing feature, resulting in such unexpected interactions from the participants. The test task (Task 6) did not specifically ask the participant to select the page from the opened tabs. The task also did not take into account what would happen if the participant accidentally closed the page that was opened for Task 1. The task was designed on the assumption that participants would automatically go to the open tabs view of the mobile browser and select the correct page from there. P10 understood the task as asking him to locate the page from the browser history. From the interview session, six participants (P1, P4, P5, P6, P7, and P8) use tabbed browsing on their own mobile phone. I did not take into account that the participants who never use the tabbed browsing feature of their mobile phones might misinterpret the task to mean something else.

6.4. Observations on Mobile Browsing Behavior

During the interview portion of the sessions, I noticed a reluctance from the participants to use the browser features for better user experience. The main feature that was used among the participants was the search bar/address bar. This feature was used instead of using the bookmarks feature for revisiting websites. Users would type in several letters of the website, and the user's most frequented websites would appear in the list of results. This was interesting since this method requires more key presses to open a favorite website instead of choosing the website from a list of saved bookmarks. One explanation could be the adage "out of sight, out of mind". In order to accommodate the limited screen displays of mobile phones, an emerging design trend is to collapse the entire menu structure into an icon that expands when tapped (Laubheimer, 2014). On the tested browsers, features were hidden off-screen, accessible via an icon in the corner. This icon is also referred to as the side menu button, a navigation drawer, or even the hamburger button, since the icon is sometimes a three-lined button resembling a hamburger. Users seemed reluctant to go beyond the starting page of their mobile browser and instead, opted for faster and quicker results that could be immediately observed. Users perceive

typing to be faster and more efficient than pressing buttons on the user interface. The cognitive load of searching by the use of icons seems to require more effort than typing familiar letters or words in order to open a website. Using a feature such as bookmarks seems to require too much effort from the user's point of view.

Out of the ten participants, three (P2, P5, and P6) had downloaded a new browser to use on their mobile phone. The mobile devices of the participants were running on the Android platform, so the default browser is the Android browser. This is interesting since the Android browser was most popularly used browser (see Figure 9, page 15), however, the three participants recruited in the study were dissatisfied enough with the browser that they installed another one. The rest used the pre-installed mobile browser. Participants said that since the pre-installed browser works properly, they felt no need to change to a different browser. This was also interesting since none of the participants used the pre-installed web browser on their PC, and took the effort to download another browser (Chrome or Firefox). Since the mobile browser works and websites can be opened, users do not feel the need to download a new browser. This could also be due to the context of the browser usage. Searches are done during another activity, such as waiting for the bus or on the commute to work. The searches are very specific and any additional effort on searching for information would be saved for the PC.

When asked about the features tested, three features went unnoticed by the participants: the optimized keyboard layout that changed when typing in the URL field, the disappearing address bar when browsing long web pages, and the separated or combined address bar and search field. The changes were too subtle for the participants to take notice and the participants seemed more focused on accomplishing the task.

Six out of ten participants mentioned that they do not use bookmarks on their own browser. Instead, the participants prefer to type a few letters into the search field and then select the website from the browser's list of suggestions. This could be due to the nature of the fact finding activity, which usually requires immediate access to very specific information. The participants found the act of opening the browser's menu and navigating to the saved bookmarks as simply requiring too much time and effort.

Sahami Shirazi et al. (2013) mentioned that results and observations gained from lab studies may differ vastly from those observed in real life situations. User interactions also vary depending on the user and the apps they use. As previously mentioned, six participants did not use bookmarks in their own browser. Instead of using bookmarks, the participants found it faster and easier to type in a few letters of the website they wished to open and select it from the browser's suggestion list. This difference in user interactions was also particularly evident in Task 6. Participants P4 and P10 both gave a low SEQ score for this task. P4 had accidentally closed the webpage required for completing the task, and P10 had interpreted the task to mean opening the webpage using the browser history instead of from the list of opened tabs, which he was unable to locate.

This also brings up issues with SEQ scores and whether participants can separate between task difficulty due to system functionality versus difficulty due to task misinterpretation or unexpected results due to human error.

Sahami Shirazi et al. (2013) also mention that "attention span dramatically drops when comparing controlled interactions in the laboratory with interactions in mobile situations". Since the test tasks were exactly the same for the first and second browsers tested, the participants might not have been as focused when testing the second browser compared to the level of focus of the first browser. I did notice, however, that the simpler tasks, such as finding out the opening hours of the Metso library (Task 0) and searching for the number of the taxi company in Oulu (Task 2) performed with the second browser went more smoothly and participants completed the tasks with less hesitation.

The study by Sahami Shirazi et al. (2013) was done based on only one platform (Android), and only included the Android default browser, Chrome, Firefox, and Opera Mini. This study also includes the iOS and Windows Phone platforms, which serve to complement the study done by Sahami Shirazi et al.

In addition, in the same study, Sahami Shirazi et al. (2013) found that web browsers are rarely used on the go, meaning that users are stationary when using the mobile browser. If browsers are mostly used when stationary, then in this respect, results from lab studies should be just as viable as those gained from mobile in-situ usage.

When the experiments for this study were conducted, the most popular mobile browsers according to StatCounter Global Stats (StatCounter, 2014) were, in order of the most popular to the least: the Android browser, iPhone's Safari, Chrome, the Opera browser, the UC Browser, the Nokia browser, Internet Explorer, the BlackBerry browser, and Netfront (see Figure 9, page 15). Based on the current statistics from StatCounter Global Stats, the most popular mobile browser is now Chrome, followed by Safari, the Android browser, UC browser, Opera, Internet Explorer, Blackberry, the Nokia browser, and Netfront (Figure 52). This change could be due to the popularity of Android devices, which uses Chrome as the default browser in version 4.2 onwards. According to data from the International Data Corporation (IDC), a total of 334.4 million smartphones were shipped worldwide in the first quarter of 2015, with Android dominating the market with a share of 78% (IDC, 2015). Another reason for the change could be due to users wanting a consistent experience across multiple devices. With Gmail and Google+, users are constantly signed into Google's ecosystem, and the Chrome browser offers a consistent interface with sharable bookmarks between desktop and mobile devices (Adobe Digital Index, 2015).

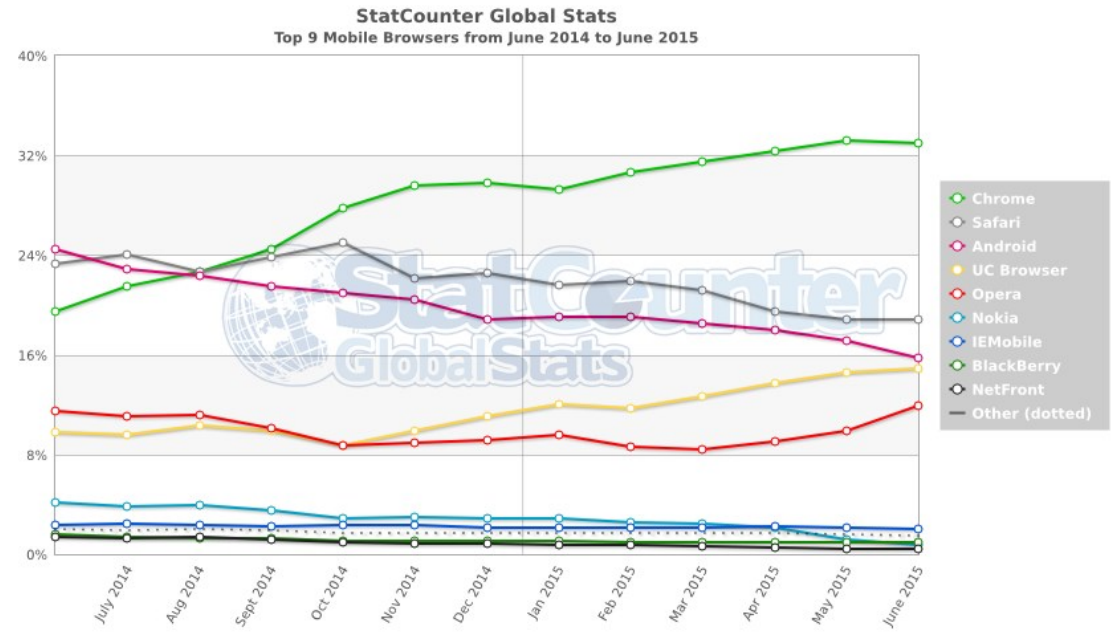

Figure 52. Chrome is now the most popular mobile browser according to StatCounter Global Stats (gs.statcounter.com)

6.5. Lessons Learned

Setting up the experiment was an interesting part of the thesis and full of lessons learned. In retrospect, certain tasks could have been setup better in order to truly test the usability of the associated feature. For instance, Task 1, which tested how browsers customize the keyboard layout based on different input types. Instead of having the participant type in one extremely long and complicated website address, the task should have been to type out several shorter addresses. With this setup, I would have been able to observe whether the participant eventually started using the input specific keys that appeared on the keyboard or if they would have continued using the shift key to get to the special character they needed. Another task which could have been improved is Task 6, which tested the tabbed browsing feature. Instead of having participants open a new tab after each task, participants could have been asked to open several tabs all at once as part of Task 6. It was rather error-prone and risky to have a task based on actions from the previous tasks, since participants might have accidentally closed the opened web pages from the previous tasks.

Another lesson learned from the experiment setup was the pitfall of being overly ambitious. In hindsight, perhaps fewer browsers could have been tested, maybe three instead of six. With only three browsers, each participant might have been able to test all three browsers within the one hour test session. The results would have been more uniform and more focused. In addition, another issue resulting from the small group of participants was the use of the System Usability Scale (SUS). Since each browser was

tested by three to four of the participants, the SUS data collection method might not be so relevant in this study. The reason so many browsers were chosen was to be able to cover all the different features offered by each one. It might have been better to exclude certain features instead of trying to cover all of them using such a small group of participants.

The SEQ results of each test task were tallied and analyzed at the end of each test session. According to Sauro (2012), the average SEQ score is around 5. What I should have done was to note what score participants gave each task and if the participant gave a score lower than a 5, to pause before the next test task and ask the participant why they gave that score. This would have helped in analyzing the SEQ data, instead of only relying on the recorded video and interview sessions.

I was quite satisfied with how the usability rig captured the recordings of user interactions on the screen. The videos were very clear, even when the participant was tapping on the screen. Even though the web camera turned out to be a bit heavier than anticipated when taped onto the gooseneck lamp, the usability rig held throughout all ten testing sessions. The flexibility of the gooseneck lamp made the camera easy to adjust before the start of each test session, since the usability rig had to be moved into storage at the end of each day.

6.6. Summary of the Main Results

Technological advancements in mobile technologies, improved network coverage, and cheaper data plans have led to an increase in Internet browsing via mobile phone. Mobile phones have better processing power and touch screen displays with improved multi-touch interfaces. Users have access to better network coverage and high-speed internet connections, leading to an increase in Internet browsing and better mobile browsing experiences. Mobile optimized websites and apps are providing users with better internet services.

The factors that affect user experience are the user, context, and the system. When it comes to the mobile Internet, the system consists of four main components: the device, the software needed to use the Internet, the network connection to transfer the data packages, and the services available on the Internet. Improving the mobile Internet user experience requires improvements in the following aspects: better understanding of the user and usage situations, mobile devices, mobile services, and infrastructures. There have been significant improvements in mobile devices and network coverage and speed. However, there seems to be a lack of studies and research that focus specifically on the mobile browser and its features. The mobile browser is the gateway through which people can access the mobile Internet. And although browser functionality and usability might not be as noticeable as a website or mobile app to the user, it still does affect the user experience of mobile browsing.

The aim of this thesis was to study and evaluate various mobile browser features used in searching for information. The browsers used for testing were Chrome, Dolphin, Internet Explorer, Opera Mini, Safari, and UC Browser, which are among the top nine most popular browsers in the world. In the test session, participants were asked to perform six tasks on two different mobile browsers which was not a browser they were currently using. During the testing, participants were asked to use the think-aloud protocol while performing each task. In addition to the recorded usability tests, a combination of three data collection methods was used for the experiments: the Single Ease Question (SEQ), the System Usability Scale (SUS), and interview questions after the test session.

Based on SEQ scores, participants found the task of saving a web page as a bookmark the most difficult task to perform (mean SEQ score for the task was 4,95, SD = 1,82). The reason that participants found this task more difficult than others was because in order to access this option, users had to open the correct menu list, and then locate the option to add a bookmark. On some browsers, such as Chrome and the UC browser, the add bookmark button was a symbol, which some participants did not associate with the function of adding a bookmark.

During the test session, most participants had difficulty in accomplishing the two tasks concerning bookmarks: adding a bookmark and viewing saved bookmarks. This was due to misinterpretation of language and symbols used in the browsers. Some of the test browsers used the term “Bookmarks”, which would open the saved bookmarks view. Participants either thought this meant the verb “to bookmark” and would select this option, expecting it to be the “add bookmark” function or they expected to see the option to add a bookmark also available in the saved bookmarks view. Another issue was that each browser had its own design for adding a bookmark. Some browsers used a symbol (such as a star symbol or the icon of a book). Some participants did not associate the symbol with the function of adding a bookmark.

Based on the answers to interview questions concerning the on-screen keyboard, separate or combined address bar and search field, and address bar behavior, the changes were too subtle for any participant to notice. When asked, none of the participants noticed the extra row of URL specific character keys that appeared when typing in the address bar, even though five out of the eight participants that tested on a browser with this feature did use them. Participants also did not notice was the disappearing address bar while browsing longer web pages. Since all participants managed to complete Task 2 successfully, the design difference between a combined address bar and search field versus a separate address bar and search field also went unnoticed by the participants.

Based on this study, each feature is far more complex than initially anticipated and could be broken down into more detailed studies. Currently, the multitude of designs, interactions, and symbols used in each browser cause more confusion among users and lead to difficulty in learning how to use a new browser. For PC browsers, the core

functionalities and interaction designs are extremely similar, so installing a new browser and learning how to use it is a fairly simple task to do. While different designs and functionalities are to be expected between different browsers, the differences should not prevent users from accomplishing simple tasks such as saving a page as a bookmark or opening a new tab in the browser. The functionality of icons and symbols used in the browser should be easily interpreted by the user. A standardization on the basic functionalities, symbols, and interactions is needed in order to facilitate learnability for new users. so that the choice of which browser to use comes down to personal preference, just like choosing a PC browser, and not based on what is preinstalled by the device's manufacturer.

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Appendix 1: Background Questionnaire

Participant: _____

Age: _____

Gender: [ ] Male [ ] Female

Occupation: _____

Education: [ ] Comprehensive or elementary school

[ ] High School

[ ] College/University

[ ] Else: _____

Smartphone brand and model: _____

Mobile web browser used: _____

Browser used on PC/tablet: _____

How often do you spend time browsing on a mobile phone?

[ ] Daily or nearly daily

[ ] Few times a week

[ ] Few times a month

[ ] Rarely, not more than a few times a month

[ ] Never

Background Questionnaire (continued)

For what purposes do you use your mobile web browser?

[ ] Information retrieval

[ ] Electronic chores such as banking

[ ] Reading and sending email

[ ] Electronic shopping

[ ] Reading the news

[ ] Socializing (e.g. IM, Facebook)

[ ] Entertainment

Please list your top most visited websites:

1. _____
2. _____
3. _____
4. _____
5. _____

Appendix 2: Task List

Go to the Finnkino website and find out what are some of the movies shown today at Finnkino (Tampere) after 18:00.
Find out what are the opening hours of the Metso Library.
1. Open a new blank page in the browser. 2. You need to cancel your dental appointment at the student healthcare center (YTHS). Find out what is the phone number of the oral health department by typing in the following web address: **http://www.yths.fi/en/contact_details/units/tampere**
1. Open a new blank page in the browser. 2. Your company has sent you to Oulu for an on-site project. You arrive at the train station around 10 at night. Your hotel is quite far from the train station and you will need to take a taxi to get there. Search for the number of the taxi service in Oulu.

1. Open a new blank page in the browser.

2(a) Open ***en.wikipedia.org*** and scroll down to the section titled "In the news". What is the first news headline?

2(b) **From the same page**, go to the BBC news site (www.bbc.co.uk) and see what the first news headline is.

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1. Open a new blank page in the web browser.

2. All your classes for this semester are in the Pinni B building, so most of the time, you have lunch at Amica's Minerva restaurant.

Find the website with the restaurant's lunch menu and bookmark it.

Go to the saved bookmarks list and open the website that you would use to upload, share, and view videos.

You're starting to feel really sick and your throat is extremely sore. You should call and make an appointment at the student health care service (YTHS). You remember seeing the phone number of the general health department when you cancelled your dental appointment.

Go to the previously opened YTHS web page and find out the number for the general health department.

Appendix 3: Interview Questions

Theme 1: Information needs and search behavior when looking for information (5 features covered in the tasks).

Optimized keyboard when typing web addresses:

- Certain browsers display a different keyboard when the user is typing in the address field. When the user is typing, the keyboard might display a "/" or ".com" key.

Ask about typing behavior of the participant. Do they type a lot in their browser? How do they open a new website?

Address bar that doubles as a Search bar

- Having an address bar that doubles as a Search bar saves up on valuable screen real estate.

Ask about how the user searches for information. Do they use a search engine or the browser's search field?

Placement/behavior of the Address bar

- Internet Explorer has an address bar at the bottom of the browser while most other browsers have the address bar placed at the top.
- Disappears when scrolling

Ask the user if they noticed the Address bar behavior while browsing. Ask about what their browser does.

Bookmark management

- Some browsers display a text only list of bookmarks while others display the icon of the website

Do they use bookmarks? How are the bookmarks displayed in their browser? How do they know which one they are choosing?

Web Page Switching (Tabbed browsing)

- Stacked cards-based switching using vertical scrolling, stacked cards-based switching using horizontal scrolling, thumbnails, or list with icons.

Do they often have multiple pages opened in the browser? Out of the browsers they tested today (including their own) which one was easiest to navigate and view the open web pages?

Theme 2: The user's opinions about the different browser features.

Was there a particular feature not available in your current browser that you found useful?

Was there a particular feature available in your browser that you prefer over the tested ones today?

If something interesting happened in test, you can ask about that.

Appendix 4: Single Ease Question (SEQ)

Participant: _____

Date: _____

Time: _____

Post-task Questionnaire

Task 0. Overall, this task was…								
Very difficult	O	O	O	O	O	O	O	Very Easy
Task 1. Overall, this task was…								
Very difficult	O	O	O	O	O	O	O	Very Easy
Task 2. Overall, this task was…								
Very difficult	O	O	O	O	O	O	O	Very Easy
Task 3. Overall, this task was…								
Very difficult	O	O	O	O	O	O	O	Very Easy
Task 4. Overall, this task was…								
Very difficult	O	O	O	O	O	O	O	Very Easy
Task 5. Overall, this task was…								
Very difficult	O	O	O	O	O	O	O	Very Easy
Task 6. Overall, this task was…								
Very difficult	O	O	O	O	O	O	O	Very Easy

Appendix 5: System Usability Scale (SUS)

System Usability Scale

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5