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Bachelor Thesis

Impacts of web optimization on user experience

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Impacts of web optimization on user experience

Objectives of thesis

Main objective: Analyze ways to reduce negative user experience resulting from incorrect web optimization.
Partial objectives:
- A comprehensive review of methods and tools for Web Performance Optimization, measuring and testing techniques and tools, and user experience.
- To conduct a case study demonstrating the impacts of web optimization on user experience.
- To evaluate and interpret results, make recommendations, and formulate a conclusion.

Methodology

The theoretical part of the work is based on the study and analysis of professional and scientific information sources. The practical part will be done on a specific example of a website. The author will conduct user experience testing of the website and analyze the impacts of web optimization interventions on UX. Based on the results of the practical part and literature review, the results will be interpreted, recommendations and conclusion will be formulated.

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Recommended information sources

EVERTS, Tammy. Time Is Money: The Business Value of Web Performance. ″O'Reilly Media, Inc.″. 2016.

HOGAN, Lara Callender. Designing for Performance: Weighing Aesthetics and Speed. ″O'Reilly Media, Inc.″. 2014.

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WIJNANTS, Maarten, et al. Http/2 prioritization and its impact on web performance. In: Proceedings of the 2018 World Wide Web Conference. 2018. p. 1755-1764.

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Declaration

I declare that I have worked on my bachelor thesis titled "Impacts of web optimization on user experience" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 15.03.2024 _____

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Impacts of web optimization on user experience

Abstract

The main objective of the thesis is to analyse ways to reduce negative user experience resulting from incorrect web optimization.

In the theoretical part was presented information on the main methods of website optimization and methods of testing web optimization. The knowledge obtained in the theoretical part was successfully applied in the practical part.

The practical part consisted of applying the acquired knowledge of web optimization in the development of a website in practice and testing the web optimization of the site, as well as conducting tests to assess the impact of web optimization on user experience.

Keywords: Optimization, performance, load time, testing, user experience, page size

Dopady optimalizace webu na uživatelskou zkušenost

Abstrakt

Hlavním cílem práce je analyzovat způsoby, jak snížit negativní uživatelský zážitek způsobený nesprávnou optimalizací webových stránek.

V teoretické části byly představeny informace o hlavních metodách optimalizace webových stránek a metodách testování webové optimalizace. Získané znalosti z teoretické části byly úspěšně aplikovány v praktické části.

Praktická část spočívala v aplikaci získaných znalostí o optimalizaci webových stránek při vývoji webové stránky v praxi a testování optimalizace webových stránek, stejně jako provádění testů k posouzení vlivu optimalizace webových stránek na uživatelský zážitek.

Klíčová slova: Optimalizace, výkon, doba načítání, testování, uživatelská zkušenost, velikost stránky.

Table of content

1 Introduction

The main objective of this bachelor thesis is to analyze ways to reduce negative user experience resulting from incorrect web optimization. Incorrect web optimization is one of the main reasons why a user will not spend their time browsing the site and will not be interested in its subject matter. If the user has to wait longer for the site to load than usually happens, the user will not want to spend his time browsing the site, or he will understand that if the company's website is poorly made or poorly optimized, the user will think that the company itself is not of the highest quality, if the company does not monitor the quality of their presentation on the Internet. If the user is not interested in the site, he will not be interested in the services or goods that this site provides. As a result, this will lead to the fact that the company will incur losses.

Search engine optimization (SEO) is one of the most important factors for a website. Poor search engine optimization leads to the fact that the site will not appear on the first lines of the search browser. It will be harder for the user to find the site because users prefer to follow the first links given by the browser, most users do not want to go to sites located in the search results below the first three sites. This leads to the need to improve the site optimization for search engine optimization, if search engine optimization does not bring the site to the first lines, the site loses a huge number of potential visitors and customers. If the site is not properly optimized, it will begin to lose its competitive advantage. More optimized sites will be higher in the search browser and the user will use competitors' sites, this will lead to the loss of potential customers.

Site visitors may use different types of devices or browsers to view the site, so the site must be optimized for the most commonly used browsers so that the users can view the site in a way that suits them. If the site is not optimized for some browsers, the site will not work correctly or not work at all on some browsers, which will lead to the fact that users using browsers for which the site has not been optimized will not be able to view the site correctly and the company will lose some of its potential customers.

2 Objectives and Methodology

2.1 Objectives

Main objective:

- Analyze ways to reduce negative user experience resulting from incorrect web optimization.

  Partial objectives:

- A comprehensive review of methods and tools for Web Performance Optimization, measuring and testing techniques and tools, and user experience.
- To conduct a case study demonstrating the impacts of web optimization on user experience.
- To evaluate and interpret results, make recommendations, and formulate a conclusion.

2.2 Methodology

The theoretical part of the work is based on the study and analysis of professional and scientific information sources. The practical part will be done on a specific example of a website. The author will conduct user experience testing of the website and analyze the impacts of web optimization interventions on UX. Based on the results of the practical part and literature review, the results will be interpreted, recommendations and conclusion will be formulated.

3 Literature Review

3.1 Defining the problem

Optimization has been and always will be one of the main criteria for the quality of the site, on a level with the appearance and functions of the site, A faster web page positively impacts the user experience and ultimately leads to increased user satisfaction. User traffic and repeat visits are also dependent on web page performance (Shivakumar, 2020). Programmers do what they can to improve site optimization, even though Modern webpages are often comprised of a large amount of heterogeneous resources (e.g., CSS stylesheets, JS code, fonts, images). Due to network limitations, these resources cannot all be downloaded concurrently. This leads to the need for User Agents to somehow prioritize the resource delivery order, as typically not all resources are needed to start rendering or even interacting with the page. From a user experience perspective, browsers might want to prioritize assets that have a direct visual impact on the webpage, such as images and fonts (Wijnants, 2018). The vast majority of users will not be interested in the site if it takes a long time to load or if its functions are slow to respond. Page speed is increasingly important for websites. Google search team has stated on multiple occasions that speed is a key ranking factor. They know that we want fast sites and that fast sites provide better user experience, which makes customers happy. (Love, 2018). Moreover, a slow site will not only repel users, poor site optimization will also prevent you from getting high positions in the browser due to the fact that the browser did not pass SEO, lowering the site in the SERP will lead to the fact that new users will not visit the site, because users prefer to use those sites that are high in the search engine, because this ensures that the site has been verified and adheres to the necessary search engine optimization standards. For search engine optimization, the main factor is still the quality and originality of the information provided on the site, but optimization of the response time still affects the site's ranking. As early as 2010, Google indicated that page speed is a factor in ranking websites in its search results. Though the relevance of your site's content is still the most important factor in your site's search ranking, page speed does play a role. This metrics is mainly used in KPI settings as it demonstrates the effectiveness of your SEO team to attract unique and loyal visitors. (Uzayr, 2022). Website optimization is important not only for the above reasons. Not all users will not use the site on the most modern computers and a lot of users use mobile phones to browse the browser. These factors must be taken into account in order for any user to use the site. When using weak computers or when using phones, the main problem arises, these devices can be very slow. Performance issues are amplified on mobile devices. Smartphones and tablets have underpowered CPUs compared to their desktop counterparts. And while more mobile devices use WiFi, cellular connections, even in the developed world, are still unreliable (Love, 2018). Search engines also take into account the presence of mobile optimization to increase the ranking of the site. In the modern world, more and more users, for various reasons, use phones to interact with the Internet, the percentage of mobile traffic is growing for nearly every site, and this will highlight page load time issues across the Internet, particularly for handset users. Roughly 50% of Internet users in Africa and Asia are mobile-only, in contrast to 25% in the United States. This study classified "mobile-only" users as those who never or infrequently use the desktop Internet (the study included tablets in the "desktop" category). The bottom line: lots

of people are primarily using handsets to access the Internet, and these devices present their own unique set of challenges

3.2 Searching for solution.

3.2.1 Web performance optimization (WPO)

To solve the tasks of site optimization, it is necessary to use methods to improve site optimization, for example web performance optimization (WPO). To achieve optimal performance, you need a performance optimization framework that defines the performance optimization methods and tools for end-to-end performance optimization. A web performance optimization (WPO) framework addresses various concerns of web performance optimizations and provides a blueprint for the web community to achieve performance goals.

The main aspects and techniques of web performance optimization:

- Website Speed Optimization – minimalization of the time it takes for a website to load;

- Mobile Optimization – for the mobile devices responsive design is used to ensure proper rendering across different screen sizes, optimal images and media for mobile devices, and prioritizing mobile-specific user experience improvements;

- Code Optimization – optimization of the website code involves eliminating unnecessary code, minifying and compressing CSS, JavaScript and other kinds of files, and reducing the number of external scripts and dependencies in the code.

- Performance Monitoring – so that we can understand how well the site is optimized and what results the addition, change or removal of some parts of the site leads to, this is the main way to check the quality of optimization.

Web performance optimization is one of the main components of search engine optimization for both mobile and desktop devices. The majority of web traffic comes from mobile devices. Some businesses see as much as 95% of their traffic coming from smartphones. This is why Google is switching their primary search index from desktop to mobile by June 2018. The Google search team has stated on multiple occasions that speed is a key ranking factor. They know that we want fast sites and

that fast sites provide better user experience, which makes customers happy. Their goal is to provide the best resource to answer the user's question, which means that you need to provide a fast experience (Love 2018).

Web performance optimization framework provides proven ways to optimize your website.

It is designed with the following objectives.

- Provides steps and checklists from a performance standpoint at all project lifecycle stages.

- Provides the multi-layer WPO methods across the complete web request processing pipeline.

- Elaborates performance-based design, performance-focused development, performance testing, and performance monitoring.

- Optimizes performance for the entire web request processing pipeline.

- Provides performance governance describing the roles, responsibilities, and process steps in web performance optimization (Shivakumar, 2020).

The web performance optimization framework is used in the development of an optimized and personalized web site. There are different aspects of web performance that you should consider when you are delivering an online experience, such as:

- Time to first byte (TTFB) and server-side latencies

- Rendering processes

- Interactions

3.2.2 File size optimization

Among all the parts of which it consists and which are used for the operation of the site, embedded files are one of the parts that most strongly affect the speed of the site, with an excessive number or weight of files, the site will load much more slowly. For site rendering, you can prioritize the processing of parts of the site, for example, fonts and text should load on the site as quickly as possible so that the user can immediately see the main information. The least important parts of the site should have a lower download priority. This means that the user will first see important information and while he is viewing it, heavier files or less important parts of the site will be loaded. As Chris Love stated "optimizing image file sizes can reduce the overall payload size

by an average of 25%. If the page is 1 MB, 25% equals a 250 KB payload reduction" (Love, 2018).

Very often the heaviest are the video/audio/photo files used on the site. The site developer can set a download priority for such files so that they are loaded after the main information is loaded. Files should be displayed correctly on all devices and at the same time have a small file size. If you need to reduce the file size, you need to use different methods for different types of files, for example, for image files, you need to use image compression.

Images take up most of a page's size; hence, image optimizations play a crucial role in overall page optimization. The following describes a few image-related optimizations:

- Use lossless image compression to reduce the bundle size and bandwidth consumed by the application;
- Use responsive images with client hints and WebP format for images.
- Lazy load images on demand.
- Asynchronously load the images when the user needs it.
- The server should properly scale the images based on the user interface (desktop browser, mobile browser, etc.).
- Accordingly, use the proper image sizes.
- Reduce image size. You can use tools such as MozJPEG (for JPEG images), Pingo (for PNG images), and SVGO (for SVG) images.
- Use SVG images that have a lower memory footprint than JPEG images. You can style SVGs with CSS.
- Serve all the images for the page with CSS sprites.
- Load the image progressively. You can load the LQIP (low-quality image placeholders) on the initial page load to improve the FMP metric.
- Remove all unused images and replace the large-sized images with light-weight alternatives
- Image compression is usually done with the help of special tools or services that will compress the image to reduce the size of the file, while the image quality will not deteriorate and this will speed up the download of files.

JPEGs are the ideal file format for photographs or other images with a large spectrum of colors. JPEG files are designed to compress files in ways that our eyes won't notice at a high enough quality. At low quality, we'll notice artifacting, banding, and graininess in JPEG images, as JPEG is a lossy file format. However, if we need to use SVG instead can lead to worsening of optimization, because replacing images with inline SVG has the same set of downsides as replacing images with data URIs: it can add more file size to your HTML and eliminates the opportunity to cache the file. Measure the performance impact of replacing any images with SVG on your site before committing to the SVG versions (Uzayr, 2022).

You can also use assets in WebP format. The WebP image format allows you to use files that, even when compressed, will retain high image quality. At the same time, there is a condition for WebP, which is that the user's browser must support the WebP format, if the user's browser does not support this format, the files may not be displayed correctly.

The file size of HTML, images, and other content needed to load your page will have an effect on the total page load time. One way to measure the file size of each kind of content is to use the browser plug-in YSlow. By default, when various items are sent from the server to the browser, they are sent as they are, unchanged. Using compression tools such as gzip and Google's Brotli, we can decrease the file sizes of these requests exponentially. (Uzayr, 2022).

In addition to compressing images, the developer needs to compress the file sizes used for rendering and site functionality. One of the main ways to compress the size of files is to combine files. In this case, files of various types, such as several CSS and JavaScript files, are collected into one file, which reduces the number of HTTP requests to the server. This reduces server load and speeds up page loading. As with visual files, functional files can have different download priorities. For file loading priority, the developer separates JavaScript files into several groups, which are loaded individually as needed when they become visible on the page. This helps reduce load times and improve page reproducibility.

Also, for the content of the site, content chunking is generally used, this method, which is described in the book by Shailesh Shivakumar explains that the content on the site decomposes the web page into multiple smaller content sections. Each of the content sections discusses a logical topic that is potentially reusable in other pages. For

instance, on a product information page, the description chunk can be reused on the product list page to provide a brief summary. Chunks reduce network traffic and to reduce download time in mobile devices (Shivakumar, 2020).

A very important and effective optimization method is file caching. Caching is the ability to save copies of files such as images, JavaScript, CSS files on the user's computer or on the server side for later use.

When a user reloads a page they were already on, the files that were saved in the user's cache on the first visit are displayed immediately because they are already present on the user's device. A user who does not have these files in their cache will not get as fast a download because they do not have saved copies of the files.

Due to the fact that the files are received from the cache, downloading files from the server takes less time due to the reduction in the number of requests to the server.

Some iconography may not be used on all pages, but these kinds of images should still be included, because they add little to the sprite's file size. Loading them up front speeds the loading of subsequent pages, because the images will be in the browser cache by the time they're used.

However, there remains a small problem due to the fact that when using file caching it is necessary to take into account all of the changes given to files on the server, these changes of files may not be reflected in the saved copy of files in the user's cache. In order to keep cached data files up to date, various methods must be used, such as adding unique identifiers for versions to the URL of the file or using cache invalidation mechanisms such as the "Cache-Control: no-cache" HTTP header or using timestamps for cached files.

For file compression of files like HTML and CSS, several basic principles are used. Files can be compressed by removing unnecessary spaces, elements that are of no real importance. " . In HTML, the elements are the building blocks of any web page." (Uzayr, 2022)

Files can be compressed using various compression algorithms such as GZIP or Brotli. These algorithms and their settings determine how files will be compressed and restored when the site loads. These algorithms may not be supported by some users' devices, but for those users whose devices support these algorithms, files will be transferred faster due to efficient file compression when transferring over the network.

In addition to the above types of files, various video files can also be used on the site. Video files can also be compressed using specialized ones. The developer can set the resolution and bitrate of files, improving optimization when video quality deteriorates. Also, for video files, the developer can set a preload attribute so that the browser can start downloading the video in advance, even before it is actually played. This reduces playback latency and improves video file optimization. Developer can use animated WebP or HTML5 videos for optimal video rendering. Also lossy compression for videos before production deployment. Cache and serve the videos from CDN (Shivakumar, 2020).

Font Optimization

The following are some key font optimizations:

- Load fonts asynchronously.
- Leverage the font-display in the CSS for optimal page performance.
- Use font swapping to load the web fonts.

Cross-browser and cross-platform compatibility for fonts must be observed. It is necessary that the selected fonts are well-supported in different browsers and on different devices. It is necessary to test fonts to check compatibility with different devices in order to make sure that the selected fonts are displayed properly everywhere.

If the page needs to be loaded before the fonts, asynchronous font loading should be used. Asynchronous loading allows the site to render and load the page even if the fonts have not yet loaded.

3.2.3 HTTP/2

For the best optimization, the programmer should be able to use the required network protocol.

HTTP/2 provides a greater performance improvement over earlier versions of the HTTP/1.1 protocol. HTTP/2 also supports other features such as server push, parallel resource download, and so forth. Once HTTP/2 is enabled, the server can push the resources such as images, JavaScript, CSS, fonts before the browser requests for the resources, thereby reducing the round-trip time. In HTTP/2, each resource (including its request and response) is conceptually carried over a unique stream. Resource content is transmitted in relatively small chunks to enable data pertaining to concurrent

HTTP/2 streams to be delivered in an interleaved fashion over the unified TCP connection. Multiplexing data this way can however cause contention among in-light resources to emerge. In response, the HTTP/2 speciication includes a lexible resource prioritization model (Wijnants, 2018).

One of the significant improvements in HTTP/2 is multiplexing. With HTTP/1.1, web browsers could make only a limited number of requests to the server at the same time, this could lead to inefficient utilization of the user`s computing power. In HTTP/2, multiple requests can be sent concurrently over a single TCP connection, eliminating the need for multiple connections and reducing the latency of the web page. HTTP/2 connections, however, benefit from assets being served in a more granular fashion as opposed to bundling them. More-granular resources make caching more effective. "Many HTTP requests can only be performed if the cross-origin rules are positively evaluated by the browser" (Rappl, 2021).

The use of HTTP/2 offers several benefits, such as reduction of the web page load times, improvement of the server efficiency and enhanced performance over high-latency connections. At the same time, do not forget that real changes in optimization are based entirely on the choice of protocol, for some sites this change will lead to significant changes in site optimization, for other sites this change may have almost no effect on changing the speed of the site.

HTTP/2 aims to make optimal use of a single TCP connection (as opposed to the 6-17 parallel connections typically seen for HTTP/1.1) by allowing resources to be multiplexed and their data interleaved (Wijnants, 2018).

3.2.4 Responsive Web Design

While the speed of work and the quality of optimization are very important for our work, we should not forget about Responsive Web Design.

A responsive web design is the kind of design that automatically adjusts to the different screen sizes and viewports. Creating a responsive design is very important so that your website looks great on all devices. When you create a responsive web design using HTML and CSS, the website must be able to automatically resize, shrink, hide, or enlarge the website according to the screen resolution and the device of the user. The

website should be accessible from all types of devices like desktops, tablets, and mobile phones. (Uzayr, 2022).

Responsive Web Design aims to create websites that will adapt to the site user and the type of device the site user is using. Responsive Web Design is a whole complex of methods in which it is necessary to take into account a large number of parameters and the challenge with responsive web design sites is that it can be very

easy to accidentally deliver unnecessary content like too-large images

or unused CSS and JavaScript. Because the process of creating a

responsively designed site can often include adding markup and functionality to optimize your layout and content for smaller screens, it's

no surprise that many sites deliver the same page weight or additional

page weight to mobile devices without the designers and developers

even realizing it.

In order for Responsive Web Design not to degrade the quality of the site display on various devices, it must be constantly tested for compatibility and for the quality of work on various devices to check the correct display of the site.

One of the main tasks when using Responsive Web Design is to format images so that they are displayed in the correct format for all devices, "There are two approaches that developers use to create a responsive mobile design. In order to make web or application interface display all the necessary information, at first, designers provide customized versions of product for different ends." (Uzayr, 2022).

For a responsive site, you'll want to benchmark and continue to measure the same standard performance metrics like total page weight, total page load time, and perceived performance (Uzayr, 2022). All these metrics are formed using various optimization methods and must be balanced so that the user does not have to wait for content to load, but at the same time that the site has enough content for the user.

3.2.5 User experience

User experience may not seem to be the most important aspect of a site, some may think that optimization or any other parameter may be a much more important aspect, but user experience affects how a user will perceive a site. If user experience is bad, then all the effort spent on optimizing the site and improving other aspects will go to waste, because the user will simply not visit the site.

Fast web performance matters when delivering a good (aim for impressive) user experience. It is the number of efforts you put into every little detail that would make the overall, cumulative difference in the end (Uzayr, 2022).

User experience is one of the ranking factors for search engines. A good site that pleases the user and provides a good user experience is likely to rank higher in search results, leading to increased natural traffic. This means that the number of users of the site will increase due to the interest of other users, in the best case this will lead to the so-called snowball effect, where each good user experience will probably lead to attracting the attention of other users and increase the number of visits.

In addition to potentially attracting new users, a good user experience will allow you to have an advantage among other sites. Those sites that prioritize user experience attract more users than those sites that pay less attention to user experience. Even if the information provided on a site is worse than on other sites, if the site provides a good user experience, it will still be preferred by some users.

User experience may be based mostly on external beauty, but creating a site with a lot of visual parts can lead to a significant deterioration in site optimization. The page performance impacts usability and experience. The performance of landing/gateway pages and key processes is directly co-related to the overall user experience (Shivakumar, 2020). For a positive user experience, it will still be necessary to sacrifice a little bit of site optimization, but not so much that it worsens the user experience.

Improving the user experience will result in the user wanting to stay on the site for more time if the user can use the site in a format, they are comfortable with and customize the site for themselves, such as choosing between light and dark themes. It is also worth considering the user persona and adjust the site based on the persona of the potential user. If an elderly person goes to a site designed for young and advanced users, he will not have a positive user experience, as well as if a young person who uses different sites on a regular basis may not be satisfied with the excessive simplicity and monotony of the site designed for less experienced users, so it is very important to consider the potential users of the site and adjust the front-end and functional part of the site for potential users.

Since for a good user experience it is necessary to combine the external beauty of the site with good optimization, it is necessary to use methods that involve both aspects

without worsening one of them. One such method is Content Chunking. The content chunking method decomposes the web page into multiple smaller content sections. Each of the content sections discusses a logical topic that is potentially reusable in other pages. For instance, on a product information page, the description chunk can be reused on the product list page to provide a brief summary (Shivakumar, 2020).

3.2.6 User experience testing methods

To improve user experience, it is necessary to consider various methods of user experience testing. Testing methods have unique features, but they share a common theme of user experience. There are various UX testing methods to check website optimization:

Net Promoter Score (NPS): This testing involves asking users reviewing the website a question about how likely they are to recommend the site to other users. Based on user responses, users are categorized as detractors, passives, and promoters. The percentage distribution of user categories allows to obtain the Net Promoter Score. This testing will provide information not only about user experience but also about whether the website is optimized enough for the user to have such a positive experience that they are willing to recommend the site to other users.

A/B Testing: Testing is conducted among website users, who will be provided with the regular version of the site before performance improvements and the version of the site after performance improvements. In A/B testing, we introduce two variants of a feature. One is variant A, while the other is labeled variant B. While A may be the current state of the feature (usually called the baseline), B may be a new way of approaching the problem (Rappl, 2021). A/B testing is a tool that allows evaluating user experience. Users will also be asked several questions about their attitude towards the two versions of the sites, whether the optimization of the website affected the user experience. This testing will help determine which segments of the site do not need optimization improvement, which segments of the site may have deteriorated due to optimization, and will find an optimization option that will lead to the most positive user experience.

These testing methods will provide information about user experience and the effectiveness of web optimization and changes in the site experience depending on the presence of optimization on the website.

3.3   Measuring Performance

Measuring site performance is one of the most important aspects for understanding the quality and effectiveness of site optimization. Given the data from the performance measuring, the developer changes or improves various aspects of the site in order to achieve maximum optimization.

The main methods for measuring site performance are:

- Time to First Byte - the amount of time required for the user to download the first byte of information from the server, this method shows the server response time. The moment of the First Byte is the moment that starts the response download. The most important network request is for the document. Once downloaded, the rest of the network resources (images, scripts, style sheets, and so on) can be downloaded (Love, 2018).

- Speed Index - measures how quickly the visible content of the site is displayed to the user.

It provides a more comprehensive view of perceived performance rather than just focusing on page load time. It's expressed in milliseconds and is dependent on the size of the chosen viewport. In order to measure the speed index, you need to use tools like WebPageTest and Lighthouse. The Speed Index metric is an excellent one to watch as you try to measure the perceived performance of your page, as it will tell you how quickly the "above the fold" content is populated for your users. It's good to focus on how quickly your users begin to see and be able to interact with content rather than focus on how long it takes for the browser to completely finish loading your page's content. As Rappl Florian states "user interaction is meant to be quite high, however, to achieve a great user experience, a lot of technical challenges need to be tackled" (Rappl, 2021).

Page Load Time is one of the most important metrics on a website. This metric measures the amount of time it takes for a web page to fully load and be usable. To measure Page Load Time, tools such as Google PageSpeed or WebPageTest are used.

Front and center in Page Load Time (PLT)optimization is the order in which resources are downloaded and processed. The new HTTP/2 specification includes dedicated resource prioritization provisions (Wijnants, 2018). The use of different protocol types also has an impact, as "The industry standard for page load time is 2 seconds for HTTP pages and 5 seconds for HTTPS pages" (Wijnants, 2018).

In order for the server to be able to display the site correctly, you also need to optimize the rendering path, because by optimizing the critical rendering path in concert with the other aspects of total page load time, you can ensure that your user has a positive impression of how quickly your site load.

Mobile Performance - due to the significant increase in the popularity of using mobile phones to browse the browser, all modern sites must have quality mobile versions, if site owners want their company to remain competitive, the site must work on mobile devices as well as on computers, otherwise mobile phone users will not view the site. Mobile Performance also takes into account the speed of the site.

Browser rendering - a description of how exactly the browser renders the page, checking the correct display of CSS HTML and JavaScript files. In addition to checking the quality of displaying files, browser rendering also uses methods for optimizing the files used.

Sometimes, unoptimized files can drastically affect your browser rendering, slowing it down below the 60-frames-per-second threshold. For example, some animations (such as position, scale, rotation, and opacity) can be handled by modern browsers within 60 frames per second; other animations may create a junk for your user (Shivakumar, 2020).

Real User Monitoring - in addition to checking the quality of file optimization, it is also necessary to check the information received from site users, how quickly site pages are displayed for them, what is the reaction of users to the optimization carried

out on the site and user experience. For this monitoring, specialized tools are also used that will allow you to collect information from real users of the site, the main of these tools is Google Analytics.

Real user monitoring is a passive monitoring setup that records the perceived user performance, user navigations, application availability, overall performance, and application responsiveness (Shivakumar, 2020)

3.4 Weighing Performance

Weighting performance - assigning priorities or significance to different aspects or metrics of web performance based on their impact on the overall user experience. By distributing weighing performance, developers can give preference to those site segments that are most important for user experience. It is these segments that should make the best impression on the user in order for him to have the right idea of how good the site is and the products or services it provides.

When prioritizing certain site segments, other segments that are less important are given less priority and most of the optimization efforts are directed to the priority segments.

When using weighting performance, speeding up your site can have costs. You'll lose development time that you could be spending working on other areas of the user experience. You may find yourself making sacrifices in other areas of the experience (like the look and feel) in order to improve performance.

In this chapter, we wrestle with when to make tough calls about doing performance work, what it can cost you, and when it's worth it. If the developer decides to cut down on page weight, you'll make it more accessible to users on limited bandwidth. When the developer will improve perceived performance, the site will feel better.

3.5 Summary of main findings

At the moment, developers have a fairly large number of tools that they can use.

This literature review has described many applications and tools for website optimization. In addition to the above, there are also other services for optimization. Tools include web services such as Google Analytics, which allows you to obtain information about users using the site. This information can be used to improve optimization for different users.

It also uses Google PageSpeed Insights, a program that analyzes web page performance and provides suggestions for optimization. This program offers steps for optimizing on mobile and desktop versions of the site.

In addition, there are tools for optimizing files such as PNGGauntlet or JPEGmini. Such tools optimize files by compressing files without compromising the quality of the files.

Lighthouse and Sonar are linting tools you can use to audit your web pages to ensure that minimum criteria are met, including PWA, performance, hosting, and SEO requirements. PWABuilder and Workbox are very helpful in scaffolding important aspects of progressive web apps (Love, 2018).

Optimization can be carried out using addons pre-installed in the IDE, this allows you to optimize the site most efficiently, since there is no need to use different tools at the same time.

3.6   Performance measuring tools and methods

In order to properly optimize a website, you need to perform performance measurement to measure optimization data about all the factors that affect loading speed and data volume. With this data we can understand if the site is properly optimized or if changes need to be made to improve optimization. The developer will be able to know how fast users can access the site and start interacting with the content on the site, the developer can roughly understand the first impressions of users. Performance measurement will allow to determine which segments of the site take the most computing power or take the longest time to process, this will allow to change the computing power so that it is evenly distributed among all segments of the site. The developer will be able to get information about which images are the least optimized or which segments send the longest requests to the server. With monitoring, you can find out and reduce any issues with asynchronous application communication,

loading time, or other tools that overall interact and spoil users' experience (Uzayr, 2022).

The main methods for web performance measuring are Time to First Byte (TTFB) - a method that measures the time until the first byte of information is received by the browser, server response times will be considered fast if Time to First Byte is minimized. First Input Delay - measures the time before the user can interact with the page, A/B Testing - testing different variants of the site, used to determine user behavior from optimization.

Every website needs to have data to reflect upon and indicate how well or not the business behind the webpage is doing. The metrics system, monitoring application, and approaches vary depending on directly and clearly assigned objectives (Uzayr, 2022).

3.7   Related studies

In producing this literature review, several books were used as sources of study. These books describe ways and step-by-step steps to optimize the site and associated files. In addition to information about optimization methods, it also describes the tools that should be used to carry out the best optimization.

Listed below are the related study books that were used and the main topics of these books:

General Web Performance Optimization Methods by Shailesh Shivakumar.

The book describes performance patterns, performance testing and presents real-world performance optimization case studies. The book covers the topic of Web Performance Optimization Recommendations. The important information from this book was minimalization of HTTP calls and gzip of static elements and visual elements in form of videos and images inside of the database.

The main topic of the book by Shailesh Shivakumar is the development and optimization of the finance application that is built on legacy portal technology. Aside from web performance optimization the author covers the structure of application and it's connaction with the databases.

Progressive Web Application Development by Example by Chris Love

The book lists a very large number of optimization tools, use cases and methods for tool usage.

In this book, Chris Love covers the general topic of web development and introduces progressive web apps through examples of creating websites and applications like a podcast application and a basic game website. The book also provides information on the management of web assets and security.

From the chapter "The importance of WPO" information about the importance of optimization for a website, as most users are unwilling to use a website if the main page takes more than 4 seconds to load. Thanks to this book, information was learned about how much the code of CSS and JS files can significantly impact the performance of a website and about methods of optimizing the code.

The Art of Micro Frontends by Florian Rappl

The book covers micro frontends in general, their primary areas of use, as well as the challenges and problems they bring. The book describes how to leverage Web Components to compose one website from different fragments in the user's browser. From this book, the detailed information was learned about optimizing the backend part, database optimization, and the usage of JSON on the site. One of the most useful parts of the book was the implementation of A/B testing.

Frontend Development: The Ultimate Guide Sufyan Uzayru

This book describes why the user experience is the primary focus of frontend development and the process of creating user-interactive components.

Despite the fact that the book by Sufyan Uzayru mostly consisted of information already known, namely the chapters on the basics of coding and web development, useful information was recived from the chapter "Categories of Optimization." In this chapter, the author covers not only code optimization but also space optimization and time optimization.

The chapter revealed information about prioritizing the most efficient functions and removing functions the execution of which deteriorates performance or takes a lot of resources.

HTTP/2 Prioritization and its Impact on Web Performance by Maarten Wijnants

This research paper mainly describes how network protocols affect website optimization, its page load time and possible Web Performance Optimization. The protocol HTTP/2 was designed to enhance the performance of websites by optimizing how data is transmitted between web browsers and servers.

3.8 Research question

The research question of this bachelor thesis is about finding the best way to optimize the site and improve user experience without compromising the functionality of the site. In order to answer this question, it is necessary to study the selected text materials, as well as continue to search for other information materials that allow you to gain knowledge about the solution to the main requirements of improving user experience by improving the optimization and speed of the site.

4 Practical Part

4.1 Case study of web optimization testing

Web optimization testing involves the process of evaluating different parts of the website, ensuring that all components are examined and optimized to operate as efficiently as possible. If any parts of the site are not optimized to the same level as the main site, it may not result in significant optimization loss, but it will still slightly decrease the overall site optimization. Therefore, it is necessary to evaluate the optimization of each functioning part of the site and then improve the quality of optimization.

The website that was tested is an online store selling electronic devices such as mobile phones, tablets, and similar products. This type of store is one of the best examples for testing various testing and optimization methods since it includes various types of content and features, allowing for the utilization of different optimization and testing methods. Different optimization methods are required for various functions of the website. A large number of functions on the site are necessary to provide users with a wide range of capabilities, as modern websites in this domain should have many useful functions that work efficiently and quickly. This is necessary to enhance the user experience when interacting with the site. User experience is highly important for such types of websites, thus creating a successful site in this domain requires thorough optimization to ensure users stay on the site and do not encounter inconveniences during use. High-quality optimization is necessary for an online store website as it includes components whose usability heavily depends on optimization. The site comprises textual, video, and photo information, as well as several features. The product catalog contains numerous product cards with photos, videos, and other information, all of which need to be optimized. Since there are a large number of cards on the site, special features need to be added to enhance product viewing without overloading the user's device. The site also features search and shopping cart functions. To ensure that these and other functions do not deteriorate the user experience due to poor optimization, it is necessary to optimize as many functions and files on the site as possible. This requires conducting comprehensive testing of web optimization.

4.2 Testing of web optimization

Web optimization testing begins with an analysis of the website's design, functionality, and performance to identify areas that can be optimized. When improving optimization, one must not forget about the website users. Even if a feature can be optimized, if the optimization leads to a deterioration in user interaction with that feature, significant optimization should not be carried out.

The primary focus should be on ensuring that users can fully utilize the website, and the goal of optimization is to increase the speed of the website. Ensuring convenience for users and improving speed are among the most important aspects of websites, as poor optimization quality may deter users from using the site due to the site taking too long to function properly.

In addition to optimizing website functions, it is necessary to pay the most attention to optimizing website content, as content plays a primary role in engaging the users and is one of the main purposes of the user when visiting the site. Content optimization consists of refining various elements of the website's textual, visual, and multimedia components to enhance their quality, relevance, and effectiveness. Content optimization consists of checking the optimization of content elements such as videos, photos, textual content, and other types of content. After the website is checked, many applications and programs that evaluate web optimization provide information on how optimized the content is and how much the optimization of content affects the overall speed of the website. Additionally, some applications provide recommendations on what can be done to optimize the content. Most of the content can be optimized by using applications for compression and reducing file size. Such applications work best with photo and video files, significantly reducing file sizes with minimal loss of quality. Reducing file sizes will speed up website loading times, as large files take up a lot of space on the server. In turn, reducing file sizes can save network bandwidth, especially for users with slow internet connections or users browsing the site from a mobile phone.

Content optimization plays a significant role in achieving high levels of performance and usability. By improving the optimization of various parts of a website's content, developers can significantly enhance the user's experience with the site. Content optimization requires the use of specialized tools but greatly improves overall web optimization testing metrics.

Reducing file sizes leads to faster loading times, but if users frequently navigate to a page, such as the homepage of an online store, when users browse product pages but always return to the homepage, files will be reloaded each time. To save time spent on re-downloading, caching files is necessary. With file caching, browsers retrieve files already saved in the cache instead of downloading them again. This enhances optimization for websites where users frequently revisit pages they have previously accessed.

To improve the user experience, it is also necessary to enhance the experience of users browsing the website from mobile phones. For this, the website should be optimized for mobile devices as well as it is optimized for standard devices. Mobile optimization includes responsive design to accommodate different screen widths; the page layout adjusts to fit specific screen widths. It is also important to ensure that optimization is applied effectively and consistently across all devices to provide a consistent user experience. This also involves optimizing images and adapting fonts on the site.

After connecting the website to the database and transferring it to the hosting, the applications to check the optimization of the website were used. For testing, one of the most popular and advanced applications for checking website optimization - Google Pagespeed Insights, was used. In addition to the basic optimization data, the application also provides recommendations for improving optimization.

The application provided information about the heaviest files that were slowing down optimization, about redundant and unused code in the project. Additionally, the application provided information about the poor optimization of the mobile version of the website. All data is presented both in the form of textual descriptions of optimization quality and in the form of graphs showing the impact of non-optimized parts of the website on overall optimization and speed. It also includes the amount of information that will be freed up and the increase in speed that can be achieved by following the application's instructions.

In case of serious errors that may not be displayed in the development console but are identified by using Google Pagespeed Insights, the program will provide data about a segment of code that may be functioning but not correct or may degrade the quality of the website's performance. Because the function is operational, the development console will not flag it, but the application will consider not only the functionality of

the functions but also their impact on the overall website performance. Therefore, if such functions exist, the application will explain how they degrade the overall performance and provide recommendations for resolving the issue.

4.2.1 Refactoring code

Optimizing the code of the application for both the computer version and the mobile version improved performance, as additional resources were not spent on processing unused code or executing unoptimized functions. In addition to the basic description of recommendations, Google Pagespeed Insights also described specific issues and proposed solutions, such as removing unnecessary rules from style sheets and using deferred loading of CSS code. The tool flagged unnecessary rules in style sheets that contribute to bloating the site CSS files. By removing these extraneous rules, developers can trim down the size of the CSS files, resulting in faster loading times and improved rendering performance. Google Pagespeed Insights provided detailed explanations of each recommendation, along with steps for implementing of the new updated code.

The largest amount of code for refactoring was found in the mobile version of the website. Due to the significant number of unused or improperly written functions for the version's adaptability, the mobile version encountered far more optimization issues than the regular version of the website.

To reduce the site's traffic overhead, it was necessary to remove unnecessary rules from the style sheets and utilize deferred loading of CSS code that was not utilized in the visible part of the page. In addition, parts of the code related to the content on the website were suggested for refactoring. For example, advice was given on adding caching for files that were not being cached. Explicit width and height attributes were set for some images to ensure that the image content displayed correctly on all types of devices, which also led to saving mobile traffic for users and speeding up page loading.

4.2.2 Changing website files

To ensure that the website does not spend much time on initial loading, all files were optimized and compressed to minimize the time it takes to load the page initially. Photo and video files added to the site are stored on the Amazon RDS service, which is one of the best applications providing servers for storing database data and other types of files.

For maximum improvement in website optimization, applications offer various methods for modifying files, requiring a series of changes to the website's file structure, content, and settings. Images added to the website's database were optimized using specialized tools and services, reducing file sizes without compromising quality. In addition to compression, other file types for content were utilized, such as the WebP file format, which is more suitable for compression. Furthermore, changes were made to the website's files themselves. Removing comments, spaces, and unnecessary characters from CSS and JavaScript files resulted in file size reduction, thereby reducing the overall size of the website.

The font formats of the website were also modified and optimized to formats that support compression, allowing for a reduction in font file sizes and consequently speeding up their loading times.

4.2.3 Mobile Adaptability

To improve mobile adaptability, it was necessary to simplify website navigation so that users wouldn't have to spend much time searching for the segments they were interested in on the site. Content needed to be made compact to fit on the small screens of phones; compactness also improved mobile optimization by reducing the amount of data. Interactive elements on the site were adapted for ease of use on mobile devices. Responsive design was applied to the site, eliminating the need to change many elements on the page. After reaching a certain screen width, elements would adjust according to settings specifically written for various screen widths.

Google Pagespeed Insights indicated in one of its messages that some resources were blocking the first rendering of the page. The application's recommendation was to embed the critical part and defer the loading of all secondary resources, as well as to

minify the CSS file. Minifying CSS files for mobile optimization involves removing all spaces, comments, and unnecessary characters in the file that do not affect the visual presentation of styles. This results in streamlined code, reduces file size, decreases the amount of data transmitted, and speeds up page loading.

4.2.4   Cross-Browser optimization

To enhance user experience, it is necessary to conduct cross-browser web optimization for the website because different users use different browsers to view websites. A website that displays correctly in one browser may appear incorrectly in another. Since the main goal is to improve user experience, it is important to provide a good experience when using the website to all users, including those who use different browsers. To achieve this, the website needs to be adapted for all popular browsers to avoid situations where users do not have a good experience using the site because they are using an unsuitable browser.

This includes using CSS and HTML standards to ensure consistent styling of the website across different browsers without changing the layout of site blocks. To prevent differences in CSS properties and styles, compatibility testing of CSS is necessary, as some CSS properties and selectors may have different implementations and support in different browsers. This can be done by checking compatibility using the MDN Web Docs resource. This resource has identified several minor CSS property errors that have been corrected. After fixing all potential issues that may arise when displaying the site in another browser, it is necessary to conduct testing on different browsers to identify possible errors. This involves checking how the site is displayed in browsers such as Chrome, Firefox, Edge, and others. After completing Cross-Browser testing, it is not sufficient to leave the site unchanged. All browsers are constantly updated, and updates may cause sites that displayed correctly in the old version to be displayed incorrectly in the new version. To prevent this, it is essential to monitor browser updates and update the site when updates are identified that conflict with the old version of the site. Otherwise, if the developer does not control new browser versions, the site will become obsolete, and users of the browser in which the site is obsolete will stop using this site.

4.2.5 Performance Testing

One of the most crucial factors that developers need to consider when creating a website that should provide users with a positive user experience is the site's performance. The speed of operation directly affects the user experience, so it is necessary to conduct performance testing of the site. Performance testing is one of the most crucial components of website development. It is used for assessing the speed, responsiveness, and stability of the site under various conditions. It involves the evaluation of its performance metrics, such as First Contentful Paint.

First Contentful Paint is one of the main performance metrics used to measure the effectiveness of optimization and the speed of a website. This metric measures the amount of time it takes for the website to start displaying the first piece of content to the user who opened the website page. It signifies the moment when the user begins to see any information, such as text or images. First Contentful Paint is one of the most important metrics because it provides insights into how much time it takes for the user to start seeing the website, which directly impacts the user experience. Users experience poor website usability if the website content takes too long to load, forcing them to wait for the page to load.

First Contentful Paint measures the moment when the first content, such as text or images, is displayed, but it does not measure the rendering of CSS styles on the website, such as web fonts. Therefore, for better First Contentful Paint results, more attention should be paid to textual and visual content, and only after their optimization should attention be given to CSS style optimization. After optimizing the visual content, the First Contentful Paint time was reduced compared to the site without optimization.

Developers can deliver a positive user experience by speeding up the appearance of content for users, thus avoiding the need for users to wait for the website to load for a longer period.

4.3 User Experience Testing

User Experience (UX) Testing is one of the most crucial segments in the creation and optimization of a website, as the majority of websites are designed to be used and visited by users. Users will not visit a website that does not provide them with what they expect, and they will not frequent a website that is difficult or unpleasant to use. Instead of using such a site, users will seek alternative options and may switch to competitors' sites, leading to the loss of users and customers for the company for which the website was created.

To gather information about the user experience, it is necessary to conduct tests with website users to obtain their opinions on the site and whether their user experience has changed when using the optimized version of the site. Testing will be conducted with user personas representing potential users of the e-commerce website.

During User Experience Testing, a group of users with various user personas is selected, and this group is referred to as user-testers. User-testers represent different user personas because for comprehensive testing of the user experience on a website, tests need to be conducted for all user personas representing potential website users. If testing does not consider representatives of one of the user personas groups, the testing will be incomplete, and after the website is launched, some real visitors may be dissatisfied with the functionality or design of the site because their user group was not considered during UX testing in the development phase. This can happen, for example, with representatives of the older users group, who may be dissatisfied with the site because developers did not consider the characteristics of all users during testing.

During User Experience Testing, user-testers from different user persona groups will perform actions on the website, such as accessing the site, navigating through it, and using its features. After conducting UX testing, users will respond to several questions to determine whether they had a positive user experience while using the site, whether the site and its navigation were clear to all users, or if some users encountered issues. If the user experience was poor, developers will receive information about what displeased users on the site and will be able to rectify errors or modify parts of the site that users did not like.

If User Experience Testing with all user types is successful, developers can be confident that their site is properly optimized and ready for use by real target users.

After completing the development of the site, if a new significant feature needs to be introduced to the site during the site's lifecycle, developers will need to conduct testing of the new feature again, using user-testers from all user personas, to ensure that the new feature they are planning to implement on the site does not spoil users' perception of the site.

4.3.1   A/B Testing

During user experience testing, to ensure the quality of optimization and its impact on the site user experience, it is necessary to conduct A/B testing. A/B testing is a testing method in which two versions of the website are provided to user testers: one version has undergone a large number of web optimization methods, while additional web optimization methods have not been applied to the other version. The goal of this testing is to gather information from user testers about which version of the site they prefer. This testing is necessary because the version of the site that has undergone a large number of optimization methods, despite being faster and more optimized, may not be liked by some users. For example, excessive optimization may degrade the visual appearance of the site or may have lost some features due to their negative impact on overall optimization.

This testing is used to understand if all the web site optimization methods were beneficial or if some of them worsened the user experience. If, for example, in the optimized version, user testers did not like that the quality of photos deteriorated due to excessive optimization, developers will have to adjust the optimization of photos so that they do not worsen users' perception of the site, as good user experience is more prioritized than complete optimization.

Two different versions of the Mobilehub website were created for conducting A/B testing. Version A included the baseline version of the site with the optimization methods applied to maximize the website's speed and performance. Version B consisted of the baseline version of the site without any optimization methods applied. All users were asked questions about their experience using the site, including their page loading speed, the duration of completing tasks using the site's core functions like site browsing, search usage, product page navigation, adding product to cart., the time spent on the site, how much they liked the visual design of the site on a scale from

one to ten and rating of optimization from one to ten. All the data collected for each metric were summed up and divided by the number of testers to obtain the average metric value. These measurements were conducted for both versions A and B of the site.

4.3.2 Net Promoter Score (NPS) Testing

Net Promoter Score is a method of testing user experience in which users are asked a question about whether they are satisfied enough with the quality of the website to recommend the site to other people or their friends. Users must rate their satisfaction with using the website on a scale from 0 to 10, and depending on the rating received. After receiving the results from all user-testers, users are divided into groups based on the score they gave to the site. The groups include: promoters - people who gave the site a high Net Promoter Score, neutral users who gave average scores to the site, and Detractors - users who were not satisfied with the optimization of the site, they gave a low Net Promoter Score and instead of recommending the site to other people, such users may tarnish the site in the eyes of other potential users because they didn't like it.

After obtaining the results and dividing users into groups, it is necessary to calculate the Net Promoter Score. To do this, subtract the percentage of detractors from the percentage of promoters. After this calculation, the Net Promoter Score will be obtained, which will show whether the optimization of the site was in vain, whether the site is optimized enough to be liked by users to the extent that they could recommend this site to other people.

5 Results and Discussion

5.1 User personas

For testing user experience, user personas representing customers of similar online stores were selected.

These user testers represented groups of potential website users. The groups included different age categories and types of website users to cover a wider range of potential user types during site testing.

When it comes to testing a website's user experience quality, developers need to utilize user personas as they provide specific information about the requirements, preferences, and goals of different user types. User personas enable developers to see how potential users will behave and perceive the visual and functional design of the site.

Developers will find it much easier to understand which direction to take when developing the site and how to modify the site if they see how the site is perceived by users. Additionally, user personas aid in identifying parts of the site or features and functionalities that are of most interest to users. Based on user needs, developers can understand which parts of the site or features and functionalities should receive more attention during site development, focusing on the most impactful solutions that address the most critical user issues.

UX testing using user personas provides website developers with the opportunity to enhance the user experience for future users by prioritizing the most useful features and identifying previously undiscovered usability issues.

The following user personas were used for the user testing:

Young Tech-Enthusiast User:
Age 18-35
This type of user is proficient in using various types of technology, so technical specifications of devices are important to them. This type of user is one of the most frequent buyers in online stores with this theme. They have no problems in navigating on any kind of website. They value speed of the site the most.

They prioritize websites that offer modern design, with intuitive navigation and quick access to details of the product.

User personas:

Joseph

Age: 24

A young technologically proficient user, works as a C++ programmer, values functionality and speed of operation more than the visual aspect of the website. Buys a lot of electronic devices for himself, so he is a frequent visitor to websites selling electronic devices;

Nina

Age: 31

Works as a graphic designer, prefers to spend time choosing from the list of products and comparing information from the product descriptions. Nina navigates through websites with ease, moves around pages frequently, and dislikes when pages take too long to load;

Average User:

Age 25-50

Unlike the Young Tech-Enthusiast group, the Average User persona is not as technologically advanced and may have a limited understanding of the offered products. In rare cases, they might encounter difficulties navigating the website. However, this persona still possesses fundamental knowledge of technology. This user type values practicality and functionality more than visual aesthetics because, for them, the quality of website performance outweighs its appearance.

For the Average User, critical factors influencing the user experience include the ease of use, reliability, and the ability to swiftly locate necessary information or products. They prefer websites that are user-friendly and responsive, ensuring that their time is not wasted on unnecessary complexities. Understanding the requirements of the Average User persona is paramount for developers as this group represents the largest portion of the website's user base. Users belonging to this group will be the most

frequent visitors to the site. Therefore, it is crucial to pay special attention to the preferences and needs of this user segment during the development process.

This user persona is a working individual who values efficiency and reliability in electronic devices, represents a significant portion of the target audience. These users are not as technically advanced as younger users, but they will not have any issues using the website either.

User personas:

Elizabeth

Age: 40

Values efficiency and reliability in her electronic devices. Has limited knowledge of the technical aspects of devices or websites, sometimes encounters difficulties navigating certain websites. Prefers functionality and clarity over visual elements or speed of operation;

Carl

Age: 37

Works in IT for a long time. Speed and functionality are very important factors for him, he also enjoys visually appealing websites but does not consider visual design a crucial aspect of a website. He wants to access content as quickly as possible through good website navigation and fast site speed;

Older user:

Age 50+

This user persona is older than other users and may not be as tech-progressive as younger users but still needs devices that the store can offer. For this group of users, simplicity and functionality are more preferable over the latest technological advancements. They seek devices that are easy to use, with clear instructions and intuitive interfaces. They might take longer to go through the website and they do not value the web optimization, but more the ease of use. In addition to simplicity, ease of use and comprehensibility are also crucial for this user group. They may spend more time figuring out the functions of the website.

Because simplicity and slower but stable website performance are much more important for this group, web optimization or the visual attractiveness of website content is not important for these users.

Although users with the older user persona are not as frequent visitors to such websites as those from the two previous groups, they are still part of the customer base for websites selling electronic devices, so the existence of users with such preferences must be taken into account.

User personas:

Robert

Age: 62

An elderly individual who wants to buy a phone as a birthday gift for his grandson. Rarely uses websites, values only ease of use. Finds it difficult to navigate a website if it has complicated navigation;

Anastasia

Age: 54

Sometimes encounters problems with using the latest technologies but is generally an advanced user. Wants to purchase a new phone because the old one stopped performing tasks effectively. Anastasia enjoys beautifully designed websites with clear navigation and fast speed, but it is not important for her that all optimization parameters are maximally accelerated;

5.1.1 A/B Testing results

After gathering groups of users with different user personas, collected for testing user experience while using the Mobilehub website, the A/B Testing phase begins. Each test user of the website was asked several questions about the site, such as the amount of time the user prefers to spend on the site, how long it took the user to navigate the site to use basic functions, and how much time would be spent due to the lack of optimization. A question was asked about the visual design of the site to determine if optimization affects the visual appeal of the site. Users were also asked to rate the optimization of the site.

The test results showed the following: all users noted that the optimization of the site sped up the loading time. Thanks to the faster loading, several users wanted to stay on the optimized version of the site longer than on the non-optimized one. The users' interaction time with the functions accelerated, especially with the product search function, as optimizing output and reducing file sizes allowed for displaying search results without delays. The visual aspect did not undergo significant changes, although some users noticed a deterioration in the quality of images and videos.

Overall, the test results showed that optimizing the website improves the user experience, as users do not need to spend much additional time waiting for the site's functions to load.

Table 1 results of A/B Testing

Metric	Version A	Version B
Average loading time (seconds)	1,48	3,42
Average time on site (minutes)	8,00	6,83
Average time to perform functions (seconds)	13,00	15,00
Visual aspect of the site (1-10)	7,00	7,83
Rating of optimization (1-10)	7,67	6,17

Source: author.

5.1.2 Net Promoter Score (NPS) results

After calculating the Net Promoter Score Testing result, the obtained Net Promoter Score was 33.33%. The main reason for the lowered website ratings was the insufficient number of features on the site and minor deterioration in the visual aspects of the site. This indicates the need for implementing changes in optimization methods to enhance the user experience.

Table 2 results of Net Promoter Score (NPS) Testing

promoters	neutral users	detractors
Nina (8)	Joseph (6)	Carl (4)
Anastasia (9)	Robert (7)	
Elizabeth (9)		
Percentage of detractors = (1 / 6) * 100 = 16.67% Percentage of promoters = (3 / 6) * 100 = 50% Net Promoter Score: 50% - 16.67% = 33.33%		

Source: author.

5.2 Results of web optimization with applications

During web optimization with applications, tools such as Google PageSpeed Insights and GTmetrix were utilized. Google PageSpeed Insights is one of the most effective applications for testing web optimization. Compared to other tools, PageSpeed Insights provides a report on the web optimization of the requested site much faster. The additional information about errors and detailed optimization recommendations greatly assist in the development process.

It was thanks to Google PageSpeed Insights that a large number of optimization errors were corrected. Additionally, after implementing the recommendations from the application, which included changing file types and minifying certain files, the optimization of the website and its mobile version significantly improved.

The GTmetrix application allowed us to determine the page size and how much unoptimized content files were slowing down the website's performance.

5.3 Comparison of results

In the literature used, there is a common theme of web optimization, but this theme is applied to different projects in different materials. Some describe optimization of local or other types of systems. In addition to methods of file optimization, the materials also describe ways of interacting with and optimizing databases.

For the Mobilehub website, preference was given to the Amazon RDS database. Despite the fact that this database and its usage were not extensively described in most materials, preference was given to this particular database because Amazon RDS is a highly popular database service with a large amount of educational materials available. Although connecting to and using this database system may not be as straightforward as with its counterparts, Amazon RDS surpasses competitor systems because it is part of the Amazon Web Services ecosystem, providing seamless integration with other services within the platform, such as the Amazon S3 file storage system. This integration allows for easy coordination between the database and file storage system. It is for this reason that preference was given to the use of Amazon RDS as the database system.

In his book "Web Performance Optimization: A Practical Approach," Sufyan bin Uzayr mentions the use of caching for optimizing websites and speeding up the performance of frequently visited pages. Caching is one of the most effective methods of web optimization.

In his material "Modern Web Performance Optimization Methods, Tools and Patterns to Speed Up Digital Platforms," Shailesh Kumar Shivakumar not only covers the main segments of web optimization but also touches on the topic of testing web optimization and tools that can be used for optimization testing, including the Google Chrome Lighthouse tool.

The Google Chrome Lighthouse tool was used during the testing of the Mobilehub website, but the majority of the testing work was done using Google PageSpeed Insights. This program provides a vast amount of information during testing, as well as detailed recommendations for improving web optimization.

5.4 Limitations of the study

For the Mobilehub website, a significant limitation was the hosting constraints under which the site operated. The hosting utilized a free-tier plan with limitations, making it impossible to conduct a comprehensive evaluation by testing the site's load through visits from a large number of users. The hosting plan would not support a site experiencing too large a traffic influx or too many requests.

Another limitation of the study was the inability to test the mobile version of the site on all types of mobile platforms due to a lack of access to different devices. Additionally, testing of the mobile version was not conducted under conditions of slow internet connectivity.

6 Conclusion

The main purpose of this bachelor thesis was to explore methods of optimizing a website for subsequent application on the site to examine the impact of web optimization on user experience. The theoretical part of this bachelor thesis was used to study the main methods of website optimization and the influence of optimization on user experience. In addition to this, specific techniques for optimizing websites and testing optimization and user experience were also thoroughly examined.

After establishing the foundation of the website and implementing basic optimization methods, the process of deploying the site on the internet using hosting was studied, as well as connecting a MySQL database to this hosting using Amazon RDS.

After completing the optimization of content, code, and website files, deploying the site on hosting, and connecting the database to the site, full-scale testing of the live site began. All main parameters of the site's operation, as well as its functions, were tested. In addition to testing the desktop version of the site, the mobile version was also tested. After studying possible solutions, issues related to slow performance on mobile devices and lengthy content loading on the desktop version of the site were addressed and resolved.

After completing the web optimization testing of the site, work began on testing the user experience. Initially, a team of user testers was assembled, comprising representatives of groups with different user personas. These personas were based on potential users of the Mobilehub site. The groups differed in their levels of technological knowledge and age. After forming the groups, the testing methods were selected for testing the user experience were A/B testing and Net Promoter Score testing. In the first testing method, users were provided with two versions of the site: one optimized using all the studied web optimization methods, and the other version without any additional web optimization methods applied. The goal of this testing was to understand the user experience when using the site with web optimization. The result of this testing was the evaluation of both versions of the site. The assessment of the optimized site surpassed that of the regular site.

The second method of testing the user experience was the Net Promoter Score testing. The result of this testing provided information that some users would prefer the site to have more features, some users were satisfied but remained neutral in recommending the site to others, and some users were satisfied and indicated they would recommend the site to others. The result of this testing was obtaining a Net Promoter Score of 33.33%.

It was concluded that the user experience when using a website is dependent on web optimization. Therefore, optimization should be applied to the fullest extent possible, while considering that some optimization methods may alter the perception or quality of content for users. In order for websites to provide users with a positive user experience, it is always essential to pay close attention to website optimization during development.

7 References

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Appendix

A/B Testing questions:

1. What was your site loading time in seconds?
2. How much time did you spend on the website in minutes?
3. How many seconds did it take you to perform the main functions of the website?
4. Rate the visual design of the website on a scale from 1 to 10.
5. Rate the optimization of the website on a scale from 1 to 10.

Net Promoter Score (NPS) testing question:

Were you satisfied enough with the quality of the website to recommend it to other people or your friends? Rate your satisfaction with the website on a scale from 0 to 10