

THE IMPACT OF JAVASCRIPT AND REACTJS ON SINGLE PAGE APPLICATION PERFORMANCE AND WEB SECURITY

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ABSTRACT:

The internet is accessible and indispensable, and in this age of fast technical innovation, the consequences of these advancements are enormous. Improving the visibility and user experience of single-page applications (SPAs) is the main topic of this article, which delves deeply into search engine optimization (SEO) techniques. Instead of using traditional multi-page apps (MPAs), this study compares and analyses the intricacies and difficulties of SEO optimization for SPAs. In the modern web environment, it finds important optimization techniques and assesses how well they work. Through the use of three separate projects that make use of new technologies for SPA, MPA, and a hybrid approach using Isomorphic JavaScript, the research method applies the investigated optimization strategies. It is possible to gauge the efficacy of the optimization techniques by methodically analysing and comparing these applications both before and after the optimization processes. The results show that SPAs can achieve SEO optimization levels comparable to MPAs when using a novel approach to Client-Side rendering during the first page load, along with traditional SEO practices, performance improvements, and technology-specific methodologies. Insights and practical tactics to improve exposure and performance in SERPs are provided by the results of this study, which has important consequences for web developers.

Key words: Single-page applications (SPAs), Multi-page apps (MPAs), Search engine optimization (SEO).

1. INTRODUCTION

In order to ensure the well-being of its people, Indonesia, which is the fourth most populous country in the world, must make it a priority to advance fair national development. Due to the fact that economic difficulties frequently result in social inequities between the wealthy and the underprivileged, this is of the utmost importance in the current situation. Furthermore, as a consequence of this, the government frequently intervenes through the provision of social assistance programs that are delivered by local social organizations. In spite of this, new issues have arisen as a result of the enormous number of people who have benefited from aid and the formation of organizations that profess to be

motivated by humanitarian concerns. One of these challenges is the misuse of aid monies for the purpose of gaining personal or organizational advantage. With regard to the reliability of social groups in the management of aid monies, this matter has produced public anger. This highlights the potential for misappropriation of funds, as exemplified by the corruption scandal involving former Social Minister Juliari Batubara (BBC Indonesia, 2021). According to Transparency International Indonesia (TII) and Indonesia Corruption Watch (ICW), inaccuracies in data have resulted in some affected populations not receiving COVID-19 social assistance: this highlights the potential for misappropriation of funds.

An enormous rise in the number of activities that take place online can be attributed to the rapid development of technology, particularly in this period when people are looking for instant solutions and internet usage is widespread. There were 196.7 million people in Indonesia who used the internet, according to a survey conducted by the Indonesian Internet Service Provider Association (APJII) for the year 2019-II/2020. This represents an increase of 8.9% from the previous year, with the largest usage occurring in areas such as West Java and Jakarta [1]. Indirectly, the development of web technologies is required as a result of the spike in internet usage. HTML, which stands for Hypertext Markup Language, has been the standard method for constructing web pages, while CSS, which stands for Cascading Style Sheets, has been the method of choice for styling and layout. The combination of these technologies results in the creation of comprehensive web pages that are accessible on a variety of platforms, including mobile and desktop computers [2].

When it comes to the development of technology, careful planning is absolutely necessary in order to guarantee that the newly developed technology will successfully fulfil its intended purpose. When it comes to development, systematic planning helps reduce the likelihood of errors occurring during the process. In the process of constructing the Mbantu Web, considerable consideration was given to the selection of acceptable technologies. This was done in order to not only limit the number of errors that occurred during the initial stages of development but also to make the process easier. The conclusion that resulted from this was that the Mbantu website should be built using the Single Page Application (SPA) technique. Mbantu is a startup that is part of an educational company. Its mission is to provide support to the general public in gaining access to a variety of types of social assistance, such as educational, logistical, and financial assistance, among others. Its advantages, such as the provision of an excellent user experience while minimizing page load times, are the primary motivating factors behind the selection of SPA. It has been found

through research that twenty percent of people will leave a website if it takes more than three seconds to load [3].

In contrast to Multi-Page Applications (MPA), Single-Page Applications (SPA) do not necessitate the reloading of the full page for every action taken by the user. This enables faster rendering and faster page loads. In the field of web development, there are a multitude of frameworks and libraries that provide developers with a variety of alternatives. Some examples of these include Angular, Svelte, Vue, and React. This investigation will make use of React.js, which was selected due to the fact that it possesses reusable components, which makes the process of developing and maintaining React apps much simpler [4].

1.1 Examples of Single Page Applications

The speed and responsiveness of the single-page application have enticed a number of businesses to provide financial support for it. It is common for people to utilize single-page applications (SPAs) without even being aware that they are doing so. There are various SPAs and their examples are shown in figure 1. In the following section, we will look at a couple of instances of single-page applications.

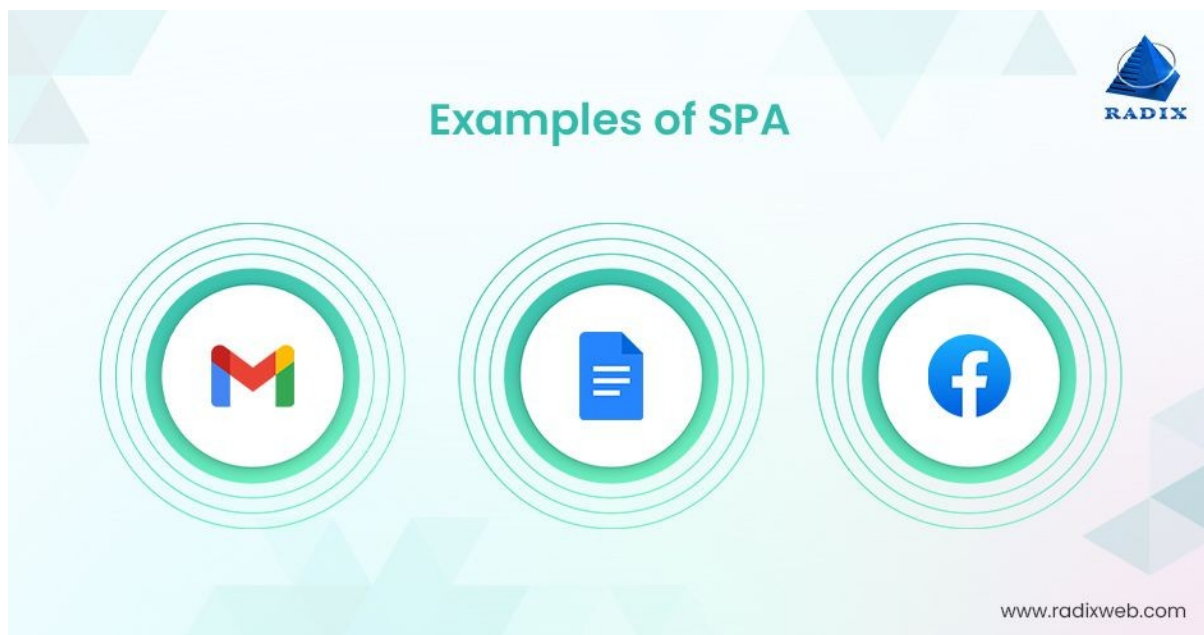


Fig 1: Example of SPA.

1. Gmail

Gmail is a great example of a program that just requires one page to use, and practically everyone uses it on a daily basis. A progress bar appears whenever you access Gmail, indicating that the page for the application is now downloading from the server. During the time that you are writing and

viewing emails after the page has loaded, the header, right and left sidebars will remain unchanged.

2. Google Docs

The Google Docs platform is one of the numerous platforms that can also operate as applications that run on a single page. The left sidebar and the settings for the header that is filled with text will remain unchanged regardless of whether you are typing or switching between tabs. The only comments that are reloaded are the most recent edit times and newest comments.

3. Facebook

There is a lot of controversy about whether or not Facebook is considered a single-page program. There is some degree of SPA in it, that is true. The material is dynamically loaded, which allows users of the news feed page to navigate, check the posts of their friends, and comment without having to reload the page. You will be able to view newly published works on this website as soon as they become available. Due to the fact that browsers cache information, items that have been downloaded, such as captions and photos, will continue to suggest that your internet connection is unavailable. There are many benefits to using single-page applications. Initially, the majority of organizations are curious about the reasons why they should choose to use a single-page application. As a result of the fact that these programs did not become popular many years ago, the situation remains the same. Also the Benefits of single page applications are shown in figure 2.

1.2 Advantages of Single Page Applications



Fig 2: Benefits of single page applications

Fast and Flexible

First, search engine optimization (SPA) is known to significantly improve the speed of a website because it is only utilized on a single page and not the complete page. It is only necessary to load the majority of application resources, such as HTML, CSS, and JavaScript, once. Only data is being traded between the two parties. A Google study found that a website's load time of more over two seconds may have a substantial influence on the amount of traffic and sales that the website receives. The unanticipated advantage is that it decreases the amount of time that users have to wait and the amount of time that pages take to load.

Improved User Experience

With separate updates for each modular service, you can more easily play around with their look and functionality. Using SPA frameworks, you can test out your ideas for interactive, dynamic, and even animated user experiences. But there is a favourite language of programmers (JavaScript is used by many SPA frameworks). Thanks to APIs, multi-language SPA registrations can work seamlessly with multi-language back-end services.

Caching Capabilities

An application that runs on a single page can make a single request to the server, store all of the data it gets, and then use that data to cache any local data. Then, the data can be used even when the server is not asking for it, enabling offline operation. Local data can be synchronized with the server when the connection permits, even if the user has poor connectivity.

Adaptable and Simple

A single page and the script are all that are required to construct a website using SPAs. Instead of uploading each individual resource, they are able to stage several resources, such as CSS or photos. Because you are able to make minor adjustments to your website without having to remake it from the ground up, it can provide you with more flexibility.

2. LITERATURE REVIEW

The severe competition that exists in today's world is prevalent in every sector of the business world; hence, it is essential for all organizations and people to have a website that is rated highly by search engines [5]. Search engine optimization, also known as SEO, refers to the act of constructing a platform in a manner that is recognizable and understandable by search engines or search engines. Unlike sponsored or direct traffic, SEO is only concerned with directing organic traffic, which is also known as unpaid traffic. When a keyword is entered into a search engine, proper optimization is critical since it enhances the likelihood that users and, more importantly, potential buyers will reach the website. A further

benefit is that it allows frequent users to return to the website in a short amount of time, which immediately enhances the user experience.

The majority of users click on the searches that are presented on the first page, which accounts for an average of 71.33% of all clicks being made. Only 5.59% of clicks are attracted to the second and third pages. To add insult to injury, the top five results on the first page account for 67.60% of all clicks, while the results from 6 to 10 only account for 3.73% of all clicks. The fact that a page is displayed as the top result in Google also indicates that it is responsible for directing 34 percent of the organic traffic that is directed to itself [6]. The number of visitors is increased by a factor of two when moving from position 2 to position 1. In addition to being valued more than positions 5-20 at the same time, position 1 is worth as much as positions 2, 3, 4, and 5 combined. The traffic to the page improves by 143% when it moves from the second page to the first page (from the eleventh position to the tenth position).

Being displayed as the first search result is, of course, the objective of search engine optimization (SEO). The data presented above illustrate how devastating even a drop of one spot may be [7], despite the fact that this is not always attainable. The ability to be seen and recognizable online is extremely valuable in the face of intense competition, and good positioning has a direct influence on the extent of one's reach. Good search engine optimization (SEO) helps people develop a sense of confidence and reliability in the brand, and it also makes it possible to analyse the requirements of customers. Utilizing search engine optimization (SEO), tools such as Google Analytics analyse the Search Engine Results Page (SERP) and give vital information such as the number of people who visit a specific page, the length of time they spend on the page, their location, the influence of keywords, and other relevant information.

Historically speaking, the idea of search engine optimization (SEO) was initially presented in 1991, the year when the very first page was published on the internet. As a result of its application in marketing and business services, the word search engine optimization (SEO) was once known as search engine marketing (SEM) [8]. When it was first introduced, in order for a company to achieve a high ranking, it was necessary for them to ensure that the number of keywords they used was more than that of their competitors. Spam is the term used to describe these kinds of actions, which have a detrimental impact on the ranking of the website. Search engine optimization (SEO) is a cost-effective strategy for businesses. When compared to outbound strategies, it is not only more cost-effective, but it also provides the important data that was mentioned earlier: information about traffic and visitors [9]. Search engine optimization (SEO) is a

strategy that aims to attract customers who are already looking for particular products or services without incurring enormous advertising costs. When compared to Pay-Per-Click (PPC) advertisements, search engine optimization (SEO) yields durable and genuine benefits over a longer period of time without requiring additional financial investment. PPC may be able to increase traffic within a short period of time, but it is a solution that is only effective for a short period of time [11].

The digitization of digital resources in museums, archives, and libraries is currently in full swing and continues to expand. At this point in time, the widespread availability of digital vehicles on the internet, such as websites and social media platforms, which are shaped by users for users, are more than capable of marketing the services offered by LAMs [12]. The three pillars that make up a metaverse are currently experiencing a countermarch that is more intense than ever before. A stronger user experience with materials (libraries), holdings (archives), collections, and artefacts (museums) is needed, and there is a need to preserve and safeguard, to experience and engage, and to assess and optimize the content of the LAMs.

There are times when websites are one of the most prominent vehicles that can be used to market the services and activities that are being offered by the LAMs organizations without any restrictions. With the goal of disseminating the included information to stakeholders and interested parties with as much as possible optimized usability levels, each webpage within a website is capable of accepting full customization and the addition of material in quantity. From a purely practical standpoint, websites make it possible for LAMs to increase the number of visitors they receive and the audience paths they can navigate [13].

They also allow for alternate ways of interaction with the content, holdings, and collections [14], which is particularly advantageous in comparison to physical attendance. In addition, the websites of LAMs have the potential to further enhance educational and cultural content, sometimes surpassing the actual volume of information that is contained within the buildings of museums, archives, and libraries [15]. The websites of LAMs not only provide information to online visitors by means of the huge amount of educational and cultural content that they include, but they also cultivate both the prior-visit and the post-visit experience visit experience level [16].

In spite of this, previous study methodologies have already shed light on the low levels of visibility and usability that are associated with LAMs websites accessible over the internet [17]. When it comes to the level of

usability, the speed at which the website loads is one of the most basic qualities that pertain to this element [18]. It is possible for visitors to get unsatisfied with slow loading times, which can significantly reduce their engagement with the material that is given on the website, both in terms of the amount of time they spend exploring it and the amount of time they spend there.

Because of the lengthy amount of time it takes for webpages to load, a variety of unfavourable outcomes have been identified, both in the context of practical applications and study. For example, a decrease in the number of user engagements, a decrease in the amount of traffic acquired [19], a rise in the cost per click when paid advertising is involved, and an increase in bounce rates. It has been argued that a faster loading speed for a webpage is associated with a longer visit length and a greater number of pages per visit, a higher organic search traffic and a greater number of sign-ups, a lower cost-per-click, and an increase in online revenues [20].

3. REACT SECURITY, SCALABILITY, MAINTENANCE & PERFORMANCE: A COMPREHENSIVE

One of the most effective JavaScript libraries is called React, and the technology behind web development is undergoing significant transformations at the moment. It is able to assist you in developing app interfaces that are user-friendly. The fact remains, however, that it presents a number of difficulties and complications. Prior to immediately using React, every Chief Technology Officer (CTO), developer, and manager is required to have a comprehensive understanding of the fundamental features concerning the management, maintenance, scalability, and performance of React. In this section, we are going to investigate everything there is to know about React and its capabilities, as well as its overall performance, scalability, maintenance, and security.

3.1 What is React?

React is a JavaScript package that is open-source and provides assistance to developers in the process of creating user interfaces for applications. Developers, chief technology officers, and managers have an option when it comes to the construction of an application interface. UI development can benefit from the availability of a wide variety of pre-built React components that can be reused. It was created by Meta, and in a relatively short amount of time, it achieved an enormous amount of popularity.

3.2 History of React

Facebook was confronted with a significant obstacle in 2011: how to manage its enormous user base. When it was discovered that the

Document Object Model (DOM) is slow, they decided to work on making it faster. One of the software engineers at Facebook, Jordan Walke, came up with the idea for React in order to overcome this obstacle. Facebook's development team came up with the idea for React by implementing a virtual document object model (DOM) in order to make the code more efficient. As time went on, the process of developing user interfaces with React grew less difficult for developers. In the past, Facebook utilized React JS development for its own news feed. Subsequently, it became a component of web development and was incorporated as a JavaScript that is extensively utilized by the open-source community.

3.3 Some Key Features of React

1. JSX (JavaScript Syntax Extension)

It is an extension to the JavaScript syntax that enables developers to write code that is similar to HTML within the application of JavaScript. The user interface (UI) of an application can be more quickly and easily created with the help of JSX. Within the developer community, JSX comes highly recommended.

2. Virtual DOM (Document Object Model)

The performance of your application can be improved with the help of React's Virtual DOM. The demand on virtual memory is reduced, and your application is able to function without any hiccups.

3. One-way Data Binding

The data that is being provided by React is in a single direction, from top to bottom. You will have full control over the application, and its performance will be enhanced as a result.

4. Simplicity

With its pre-built components, React has the potential to simplify the process of developing mobile applications. While you are constructing the application, you can reuse these components, which will help you reduce the complexity to a minimal.

3.4 Here are some major reasons why React is most popular:

1. Small Learning Curve

A great number of developers have discovered that the learning curve for React is very simple. After you have completed essential fundamentals, you are able to immediately begin developing applications. In addition, they

make available a wide range of materials and APIs that are detailed and well documented in order to speed up the learning process.

2. Pre-build Components Support

React provides a wide variety of pre-built components that simplify the process of developing an application as a whole. At this point, all you need to do is select the components and put them into action when you are constructing your application.

3. Improve Performance

As a result of the React Virtual DOM, which has the ability to transfer load to virtual memory and increase the overall performance of your application. Keeping your app's performance at a higher level and providing a seamless experience for users may be accomplished with the help of React.

4. Easy to Build Responsive Web Apps

React is a web application framework that provides a components-based design that enables developers to create responsive web applications with fewer complications. You may construct user interfaces that are responsive to mobile devices with the assistance of its libraries.

5. Versatility

The versatility of React allows it to be utilized in the development of a wide variety of applications, including those for the web, mobile devices, and desktop settings. When it comes to simplifying and maintaining the development process, many developers believe that React is the greatest option currently available.

3.5 React Security

VDOM and a variety of APIs are utilized by React to continuously identify and mitigate threats such as cross-site scripting (XSS). Using React, you are able to analyze the interface of your web application on a regular basis and reduce the risks.

3.6 React Scalability and Maintenance

The libraries that React provides contain a variety of pre-built React components that you may reuse to simplify the process of developing your web applications. Developers are able to scale the application without compromising its performance because it is so simple for them to add these components. During the process of constructing the application, React will guarantee good performance if the majority of the pre-built components are utilized.

3.7 React Performance

Virtual Document Object Model (DOM) can assist you in improving the speed of your application by lowering the load. It does this by shifting the burden to virtual memory, which in turn ensures that your application runs more quickly. It is a cross-platform environment in which application programming interfaces (APIs) deal with HTML, XML, or XHTML. Having a virtual domain name system (DOM) makes the entire procedure more streamlined and quicker.

3.8 React Modularity and Reusability

Using React, you are able to divide the user interfaces of your application into smaller React components. When you are constructing different applications, you can reuse these components whenever you want. Because of this modularity and reusability, the process of app development on the part of developers is significantly simplified.

3.9 Is the React Right Solution for your app?

The consideration of React is an excellent choice. It's equipped with all the tools that a developer needs to have in order to construct a web app interface much more quickly. When you are building the interface for your project, you are free to use their pre-built React components whenever you like. React is a library that is utilized, and the need for it is also increasing over the course of time.

3.10 React Limitations

1. It uses JSX

A syntax extension to JavaScript, JSX is utilized by the React framework. There are a lot of developers that are unfamiliar with this idea because it is a new notion for them.

2. Lack of Updated documentation

In the realm of React, new tools and upgrades are being introduced on a daily basis. The documentation gradually becomes out of current as a result of these fast changes, which in turn has an impact on the performance of applications.

3. Not Support SEO

Due to the fact that React does not enable search engine optimization, you will need to have some level of skill in order to optimize your app for search engines.

4. Fast Development Speed

Regular updates that have an impact on the learning cycle of React are distributed by the open-source community that supports React.

4. PERFORMANCE ANALYSIS

There were significant studies that were conducted on the "performance" part, and the purpose of these studies was to gather information on the degree of optimization that each application possessed. PageSpeed gives data for a variety of factors, including FCP, LCP, CLS, and others. As was said earlier, performance has an impact on search engine optimization. In the event that the direction of internet traffic shifts, the score itself may be subject to change. As a result, measurements were obtained at various times throughout the day, and the findings were then averaged. Applications that already had the methods described in Table 1 were considered for analysis as input data. However, applications that did not have any of the methods mentioned in Table 1 implemented were not taken into consideration. With regard to the investigated parameters, this table also provides a listing of which of the actions that were described had a direct impact on which of the parameters that were marked by the tool.

TABLE 1. SEO optimisation methods - analysis with PageSpeed tool.

Action	Parameter(s)
The default width and height of the image	CLS
Elimination of resources blocking rendering i.e., css and js files	FCP, LCP
Lazy loading	LCP
Preloading the largest rendered image	LCP
Changing image extensions from <i>.jpg/.png</i> to <i>.webp</i>	not assigned
Changing image size depending on screen width	not assigned

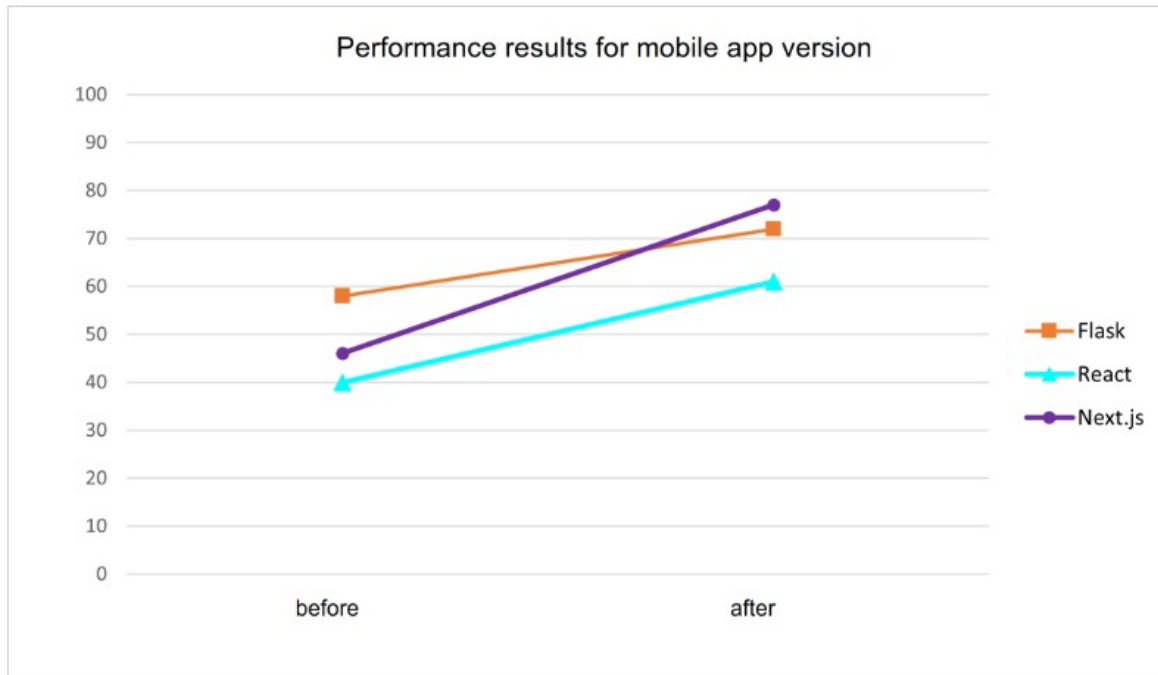


FIGURE 4. Performance score for mobile application - analysis with PageSpeed tool.

Figure 4 illustrates the rise in performance score attained by each technology for mobile devices both prior to and following the implementation of optimization. Following the implementation of optimisations, applications written in Flask and Next.js earned a score that was comparable to one another (with Next.js receiving a little better score), with the page that was implemented in Next.js demonstrating a more significant improvement in performance. The application that was constructed in React had the lowest final result, but it also had the lowest score when it was first created. When compared to Flask, the gain in its performance is greater than what it was in Flask. The fact that this framework makes use of a large number of JS files may be the cause of the difference in the final score that is attributed to React's disadvantage. In the case of some of them, it is feasible that delayed loading might be implemented.

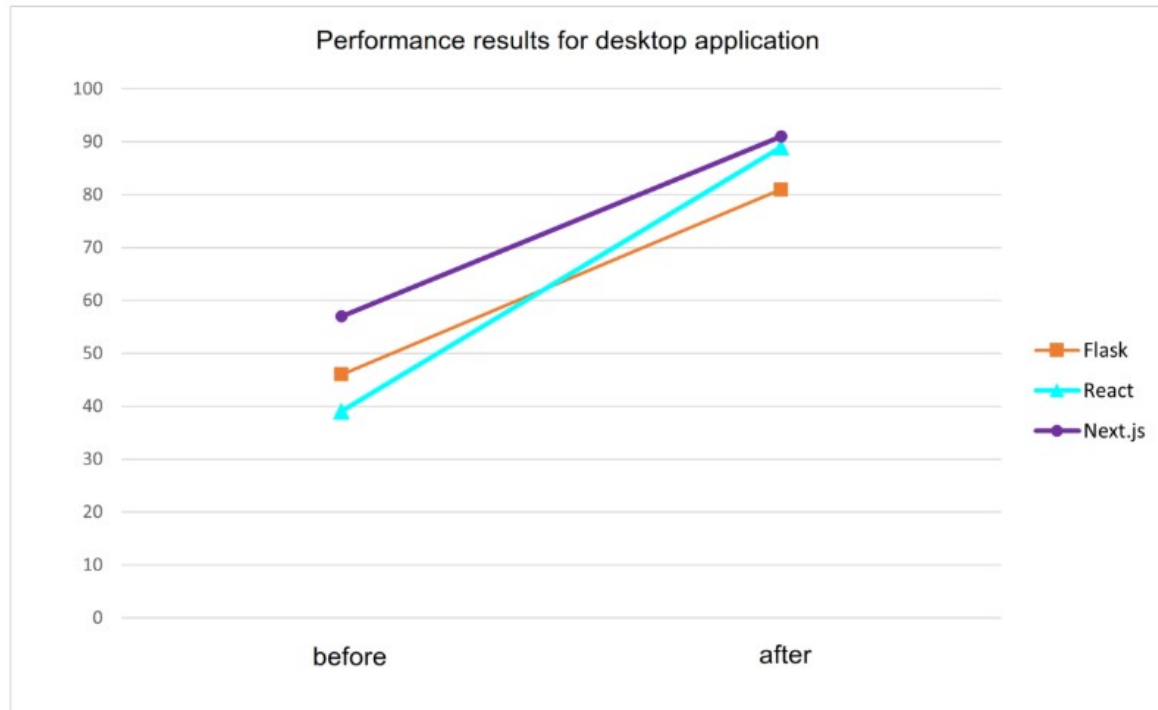


FIGURE 5. Performance score for desktop application - analysis with Page Speed tool.

Figure 5, on the other hand, illustrates the outcomes of an improvement in performance for desktop devices. Here, the technology of React and Next.js has a score that is comparable, whereas Flask has a somewhat lower score. The performance of the react application was found to have increased the most significantly, whereas Flask and Next.js both had increases that were comparable to the one shown in the react application.

CONCLUSION

Consequently, throughout the design phase of web development, it is essential to place a strong emphasis on search engine optimization (SEO). In the end, even the most beautifully designed and expertly developed web application is pointless if it does not have a target audience. Single-page online apps came into existence around the beginning of the 21st century as a result of the development of web technology. These applications simplified user interfaces and placed an emphasis on providing positive user experiences. The large professional group that is responsible for creating, implementing, and promoting websites is faced with a new challenge as a result of this growth. Additionally, the growth of SPAs brought up a new arena for the investigation of search engine optimization as well. It is necessary to take into consideration a number of aspects while developing techniques, one of which is the development of search engine bots throughout the course of time. As bots become more capable of

understanding JavaScript code, this is, on the one hand, a positive development. On the other side, solutions that have already been implemented can need additional development in order to keep the same results. In the field of web development, the year 2024 is characterized by substantial advancements and emerging patterns and trends. The proliferation of serverless computing has fundamentally altered the process by which applications are constructed, providing developers with unprecedented levels of efficiency and scalability. Moreover, the growing popularity of TypeScript highlights the significance of this programming language in terms of improving the quality of code and making it easier to maintain. In addition, the combination of WebAssembly with JavaScript is a step in the direction of getting improved performance. In addition to this, it assists in improving communication between various programming languages.

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