

Comparative Analysis on Various CSS and JavaScript Frameworks

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Abstract: Web development is a huge part of the current world, affecting all parts of the world and human interaction. Learning about frameworks used in web development allows for increased development efficiency and increased website performance and functionality, based on knowing what technologies to apply when and where. This paper will examine various web framework technologies, specifically in the realm of CSS and JavaScript, and various frameworks that make use of them such as AJAX, Node JS, Bootstrap, and AngularJS, among others. This paper will provide analysis and explanation of these technologies' designs, useful features, and potential shortcomings, and recommend which technology to use depending on various situations and web development environments.

Key words: Ajax, benefits, bootstrap, css, html, JavaScript, learning, node js, survey, web, web frameworks, web technologies.

1. Introduction

Given the ever-increasing usage of the web and its impact on human interaction, web development has grown in popularity and necessity, and will certainly continue to do so. Becoming familiar with the multitude of options and tools available for web development is imperative. There are many different web technologies used today to develop modern websites. Each has a variety of features to help users make dynamic, presentable webpages, as well as query databases and allow connections between servers and webpages. These technologies include, but are not limited to, HTML, CSS, Bootstrap, PHP, and JavaScript. This paper will specifically focus on CSS and JavaScript frameworks, such as Node JS, AJAX, and AngularJS, in order to provide a better understanding of how these technologies can help create web applications. Asynchronous page loading is an important feature enabled through some of these technologies that will be discussed, such as AJAX. Additionally, some of the technologies examined are used in server connections to websites and promote seamless webpage interaction for users while providing server communication and updates. While these methodologies can come with inherent flaws, potential solutions and mitigations are proposed. Some of the technologies to be discussed also have a variety of frameworks built from them that offer specialized usage, with focuses on different aspects of the development process. JavaScript in particular has become one of the primary technologies in web development, which is why this paper will focus on it. The paper will also focus on CSS frameworks, as customizing the style of a website in order to be unique, appealing, and usable is important for a positive user experience, and CSS frameworks promote this. Multiple CSS frameworks will be provided, with features, benefits, and downsides offered for each of them. Besides CSS frameworks, JavaScript frameworks such as NodeJS and AngularJS will also have their features examined. Recognizing each technology's unique features allows for a more robust development environment and improved webpages. Before diving into the details of the multiple frameworks, general web development standards and practices

will also be discussed. Throughout this paper, the benefits and downsides to each of these technologies will be discussed, as well as usage scenarios.

2. Related Work

While developing and creating websites, choosing the best framework for the application is an important step. Because there are many different frameworks, this decision can be difficult and requires foresight and analysis of required features and functionality. If the wrong framework is chosen, this can negatively impact a website and make it harder to implement changes. With the variety of frameworks available, you have many frameworks like CSS, Bootstrap, Node JS, AJAX, and many more to choose from. When building a web application, we need to start by choosing a framework that can meet the design and application requirements of the consumer. When looking at the implementation of a framework, one needs to follow color, typography, grids, buttons, and icons. Now once this is implemented, we need to look at cloud computing, HTML design, and template frameworks [1].

- A. Cloud Computing creates a delivery service for servers, storage, and analytics. With the deployment of these services, you can have public, private, and hybrid clouds that cover necessities and better options for your website [1]. This can provide many benefits to a website such as security, performance, productivity, flexibility, and cost [1].
- B. HTML 5- this is the definition and properties of a web page. This is possible to help embed images, animation, and audio [1].
- C. Template Framework- This template design pattern is used to improve the layout and navigation of any website. Website templates help with quickness and creativeness while creating a website [1]. These are predesigned web pages with sets of pieces of HTML code that cut down the process of creating a web application.
- D. Object-related Mapping- ORM is a virtual database for objects which can be used from a program itself. This is used to reduce the complexity of code [1].
- E. Security- Open web applications need to be protected because they can hold critical data. OWASP can be used to restrain different kinds of attacks such as XSS and SQL injections which change to obtain data [1].
- F. Platform Support- picking a suitable platform for frameworks can be a significant challenge. They are designed to help with functions within operating systems like Linux and Windows [1].
- G. Debugging is a process of pinpointing and eliminating errors or mistakes within code. This can be very troublesome for developers [1].

Websites are used to fulfill consumer satisfaction and provide a service to those who engage with it. These are structures from the design and needs and wants of the person that needs the website. Different websites can have different features stemming from the website design. Much research has been done to determine which frameworks are best for which scenarios, and what positives each brings to the table, as well as their shortcomings. This paper will take a deeper dive into web frameworks that will help visualize what frameworks are best and most popular within the industry.

2.1. Final Stage

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2.2. Figures

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3. Research/Findings

3.1. CSS

When presented with a based structure on a web page that needs styling, that is where CSS (Cascading Style Sheets) can help. This web development tool helps add colors, design styles, and personal flair to websites. The most common CSS methods are color, sizing, and positioning methods. There are also more advanced CSS methods that can help stylize every part of a web page. There are three ways to implement CSS while creating a web page, which are inline, internal, or externally [2]. Adding an attribute style to any object makes it possible to write its own styling rules.

Now with the basics of CSS covered, CSS can have multiple frameworks. These frameworks are an abstract version of implementation used to help developers during the performance [2]. A CSS framework will have pre-defined classes shared with HTML code.

Some Popular CSS frameworks:

- Bootstrap- Bootstrap is one of the most popular CSS frameworks available. Bootstrap is open source and hosted on the code-sharing and version handling service GitHub [2].
- Foundation- Foundation is focused on responsive web design and was the first CSS framework supporting it back then. As the name suggests, Foundation has focused more on functionality and innovation rather than styling all user interface components [2].
- Gumby- Gumby is heavily built from code for the developer and files for the designers, trying to achieve an environment where designers and developers could work together with tools [2].
- Ingrid- Ingrid's primary goal is to reduce classes on objects. It has two breakpoints, one for the above mobile and the next on an above tablet. It has no styling and is just a responsive grid system containing no more functionality than that [2].
- Skeleton- Skeleton focuses more on the layout than other frameworks' user interface; Skeleton has only some basic styling on components and lets the developers implement the design themselves [2].

The positives of using CSS include helping with increased productivity and it being a more efficient coding style [2] as listed in Table II. Also with these frameworks, they have a basic codebase and outline format that is easy to follow. These codebases will make it easier to work within a team and can provide a more leveled approach to CSS. Being open source, the CSS framework is always worked on by the community which can lead to fewer mistakes and can be turned into a learning tool for developers.

There are, however, some downsides for using CSS frameworks. For example, there is always a learning curve that developers will need to get over in order to fully understand the framework. This could also lead to bloated code since you will often need more code for a specific project [3].

The number of different frameworks can also make it difficult to choose the one best suited for the given project. When choosing a framework, it is important to first fully outline the details of the project and research the uses of the different frameworks in order to pick the best one to accomplish the goals of the project.

3.2. Bootstrap Framework

Bootstrap is one of the most used frameworks in conjunction with HTML, CSS, and JavaScript frameworks for creating a mobile and responsive-friendly website for the user. One of the most effective uses for this framework is development speed. If you need to push out a website quickly, you want to consider Bootstrap,

as it offers many useful formatting tools [4]. Additionally, Bootstrap is always being continuously updated and fixed. Bootstrap is quick, timely, responsive, consistent, and supports the development community. which is why it is such a popular choice. Bootstrap is always being updated with different versions being released every year. Some of the positives of Bootstrap are:

- Bootstrap has a Mobile-first approach: The Bootstrap 3 framework consists of Mobile-first styles throughout the entire library instead them of in separate files [4].
- Browser Support: It is supported by all popular browsers [4].
- Easy to get started: With just the knowledge of HTML and CSS, anyone can get started with Bootstrap. Also, the Bootstrap official site has plentiful and useful documentation [4].
- Responsive design: Bootstrap’s responsive CSS adjusts to Desktops, Tablets, and Mobiles, allowing for a seamless user experience. More about responsive design is in the chapter Bootstrap Responsive Design [4].
- Open Source: This allows for a smoother, public development process with many resources available.

On top of these main positives to using Bootstrap as a developer it also has great documentation so if you get stuck you can find documentation that can help you out [4]. Bootstrap aids in avoiding cross-browser bugs. One final positive of utilizing Bootstrap is that its popularity has grown which means that’s easier to get a job as mentioned in Figure 1 and mostly used by many websites or companies as show in Table I.

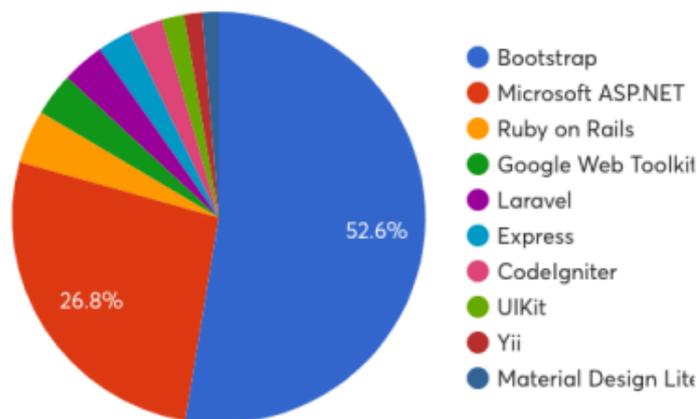


Fig. 1. Usage of Bootstrap in 2018 [5].

Despite Bootstrap’s popularity and benefits, using Bootstrap for web development can bring downsides, in that it can require a lot of style overrides. These overrides can cause a lot of code redundancy for your site which can cause the website to load slower. With Bootstrap, your websites will look the same because Bootstrap has very little customization that will set your websites up like similar website designs; however, this can be mitigated through particular style approaches. Now the final negative point with Bootstrap is that there is a learning curve for classes and workflow. There are so many component classes and combinations it can end up having you always using a Bootstrap worksheet as shown in Table I.

Table 1. Framework Statistics

Framework Name	Sites that Use
Bootstrap CSS	12,599,226
HTML5 Boilerplate	4,219,959
960 Grid System	437,120

Semantic UI	10,803
Unsemantic	74,386

Bootstrap includes HTML and CSS design flow structures that help accommodate forms, buttons, tables, and navigation. Bootstrap can cover all aspects for a developer.

3.3. Angular JS

Angular JS is a widely used framework used for web application development. Angular JS helps with dynamic view patterns within the creation of applications. Angular JS can be set with transformations that can transform a model into a coding template. When this template is created, a developer can fill in the template to customize their working applications. Angular JS is a valuable JavaScript framework in creating front-end single-page web applications. Angular JS is designed to support dynamic views to help make a web page look smooth. Some important features of Angular JS are:

- Model View Controller- this helps separate the application into three layers. First, a view for the user interface [6]. Second, the data is shown to users on views [6]. The third is the controller, and this is the logic to control the data shown to a consumer view [6].
- Template- HTML code that can be converted into a document object model while showing an interface [6].
- Two-way data building- this helps views to change for the change of the model [6].
- Dependency Injection- loads all services completely before processing [6] as shown in Table II.
- Directive- a group of templates that function as programmed by developers [6].

3.4. Node JS

Node JS is a server-side JavaScript environment based on Google's V8 engine [7]. Node prioritizes on supporting long-running server processes. In a comparative study between Node JS, Apache, and nginx, Node JS shows superior performance in I/O tests than both Apache and Nginx [8]. As shown in Figure 2, Node JS manages to handle up to 30,000 concurrent server connections faster than both of its competitors. Another important note is that Node JS also had no failed connections in this test whereas Apache began to have failed requests at around 19,000 concurrent connections [8].

As shown in Table II, Node JS also displayed superior performance when it came to CPU usage. While Nginx and Apache both use a constant amount of the CPU, Figure 3 shows how Node JS utilizes more of the CPU in order to increase processing speeds. This is beneficial for web applications that have a heavy processing requirement because web pages will be able to load faster as more of the CPU is used. In the case of both Apache and Nginx, not all of the CPU that could have been utilized was being used which would slow down the load times of web pages [8].

Node JS outperforms not only Nginx and Apache when it comes to concurrent connections to the server, but it also manages to entirely outperform both PHP and Python [9]. In terms of Requests per second, Node JS manages to have consistently higher numbers than PHP and Python. This advantage is even greater when the number of users connecting to the server grows to around 200. At this point, both PHP and Python fall to around 500 requests per second while Node JS maintains a steady 3500 requests per second [9].

In total, Node JS appears to be the most efficient method of handling server requests as the number of connections grows which is primarily due to its heightened use of CPU space. The other methods explored here (Apache, Nginx, PHP, and Python) all fail to keep up with Node JS's processing time.

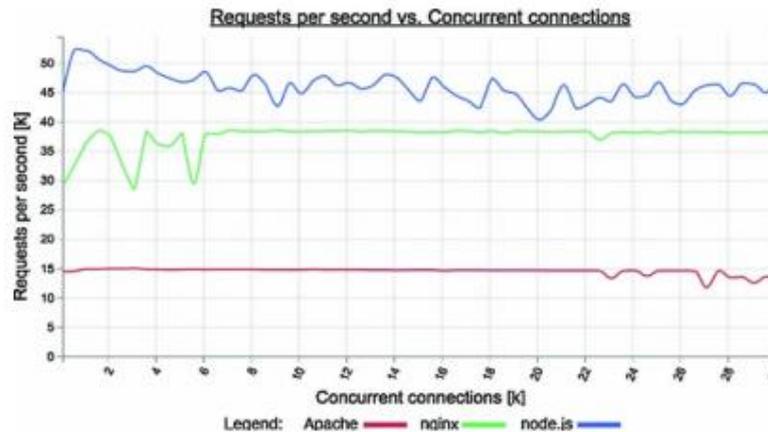


Fig. 2. Concurrent Connections Vs. Requests per second [8]

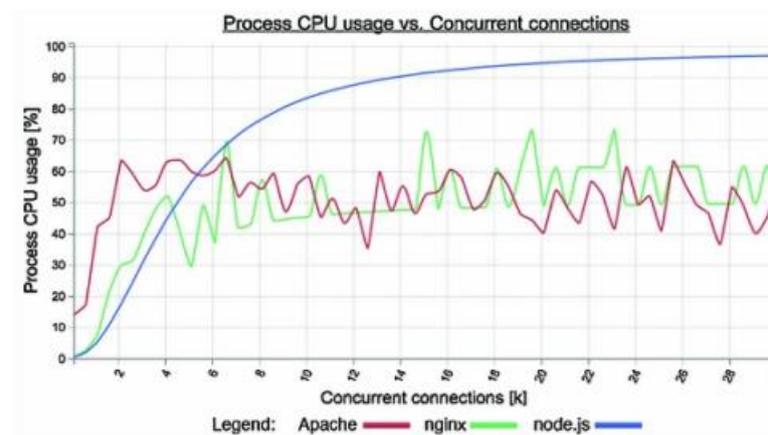


Fig. 3. CPU Usage Vs. concurrent connections [8].

3.5. AJAX

AJAX is a web development technique that stands for "Asynchronous JavaScript and XML," and it assists in reducing webpage load times and increasing functionality. As shown in Table II below, the asynchronous aspect is one of the more important features, as it allows for other web processes to continue while a request goes through, providing a more seamless user experience that does not require a page refresh. Through the use of JavaScript Object Notation (JSON), encoding of requests can be used to translate data across different formats. The primary working piece of AJAX development is the XMLHttpRequest object, which JavaScript uses to communicate between the server and browser. This does not require the reload of a page, saving time and creating a better user experience; this is achieved through XMLHttpRequest objects. AJAX incorporates multiple technologies in its approach, including JavaScript, DOM, XML, XHTML, CSS, and HTML. Although AJAX's components have existed for a fair amount of time before its inception, its release allowed for an overhaul of the web with much less page reloading and more rich web applications.

AJAX's versatility and popularity have allowed it to potentially usher in improvements in many different places. AJAX has been shown to bring improvements into applications such as GIS. Utilizing Web Services allowed some researchers to avoid some difficulties related to Google Maps with data sizes, which resulted in making the GIS application faster with more efficient visualizations [10]. AJAX was also used to improve GIS in another application, in combination with Microsoft's Silverlight technology, in order to improve intractability and performance [11].

Some have also discussed utilizing AJAX in regard to the Internet of Things (IoT). Combining AJAX with a variety of other technologies, such as HTML, and JavaScript, can allow a device connected to the Internet of Things to send data to a client application in a more organized and usable fashion, in order to be displayed in a presentable manner [12].

Table 2. Different Frameworks Compared

Technology	Pros	Cons
CSS	Increased productivity, more efficient coding style Basic codebase and outline format More leveled approach to CSS being open source	Learning curve Bloated code since you will often need more code
Bootstrap	Open Source Helpful formatting tools Responsive Design	Require many styles overrides Needs extra effort in order to not look nearly identical to other sites
AJAX	Communication between webpage and servers asynchronously Popularity means plenty of documentation Less bandwidth usage	Some issues with increasing data sizes Reduces searchability of website
Node JS	Handles many concurrent connections Utilizes more CPU for faster processing Reusable code	Unstable API Difficult to maintain code Disadvantageous on heavy computing tasks
Angular JS	Two-way data binding Dependency Injection Model/View/Controller - helps with development process	JavaScript Support Mandatory Requires Experience with MVC Difficult to Learn

Even though AJAX is a very popular technique, improvements can still be made, and other options are available for certain situations. Some researchers have tried to compare AJAX and WebSockets, which both handle asynchronous website and server communications, in order to hopefully find potential improvements. A study was performed using the OASIS middleware to compare the two technologies and found that while WebSockets is more complex than AJAX in some cases, it can provide a faster experience with less memory usage [13]. Additionally, AJAX provides challenges to search engines that try to crawl through webpages to index them. Even so, AJAX is still a popular option, and some have worked to improve its usage and compatibility with other technologies. One such example is the usage of the Model View Controller pattern to design a framework suited to better connect PHP and AJAX, allowing for streamlined web development. This framework is called "MadeLine," developed by researchers from Universitas Klabat in Indonesia [14]. Researchers have also looked into the idea of "asynchronous predictive fetching," which entails analyzing user data and actions in order to determine which calls to make [15]. One example discussed was mousing over a link to initiate a request. This could initially make extra, unnecessary requests that slow response time. Their solution involved adding a delay time to the mouse-over, in a way confirming the user's intention to click the link. The researchers noted that some issues could still come up involving large data sizes and accidental extra requests but affirmed this technique of prefetching can increase performance. Overall, AJAX is a popular and helpful technology that allows communications between webpage and servers in an asynchronous manner to facilitate a positive, seamless user experience, but is not infallible.

4. Results

Web development has a massive industry in today's world. Learning web frameworks will help increase development cycles that aid in assisting a functional and scalable website. Learning CSS, JavaScript, AJAX,

Node JS, Bootstrap, and AngularJS is a part of this process. With the basics of creating an available website, one should remember that many things are needed, such as cloud computing, HTML5, template a framework, object-related mapping, security, platform support, and a debugging platform. These features fulfill consumer satisfaction and provide a service to those who need to use the website. Cascading Style Sheets presents a fundamental framework which helps implement color, design styles, and personal flair to websites. Now within CSS, there are different frameworks that follow the styling sheets of CSS, and these are Bootstrap, Foundation, Gumbo, Ingrid, and Skeleton. The positive of using CSS is that it can help increase productivity, more efficient coding style, is easy to follow, open source, and looks for communities to create improvements as shown in Table II. Now stepping into the first framework, Bootstrap was examined. Bootstrap is one of the most popular HTML, CSS, and JavaScript frameworks. Bootstrap offers many advantageous formatting conditions. Bootstrap is quick, timely, responsive, consistent, and has a great supportive community. Bootstrap's mobile-first approach means it has excellent browser support. Bootstrap can run on many web platforms. It also has a responsive design adjusted to desktops, tablets, and mobile tech. Angular JS is another framework that is used to help aid application development. Angular JS helps with dynamic view patterns within the creation of applications. Angular JS helps template developers customize to fit their working applications. Angular JS is valuable and designed to support dynamic views to help make a web page look smooth. Some of the essential features of Angular JS are Model View controller, templates, twoway data building, dependency injection, and directive. Node JS is a server-side JavaScript environment that uses Nodes. The best thing about Node JS is that it provides efficiency and overall developer productivity, code sharing, speed and performance, and many free tools to help implement within the web platform. AJAX is a JavaScript and XML framework that helps with reducing webpage load times that increases functionality. The best qualities of AJAX are that connection and communication between webpages and servers are made asynchronously. AJAX also has much documentation, which means there is a popular following within this framework. The combination of AJAX and other frameworks like HTML and JavaScript can send data to client applications.

5. Conclusion

5.1. Figures and Tables

Throughout this paper, the most used frameworks within web development have been covered. These findings make it very tough to decide which web development tools are the most useful because each website will have these functional properties working together. CSS is used to stylize a website and provide a framework. While Bootstrap, Angular JS, and Node JS are used for functionality and customizing a website. AJAX connects to the server with the pass of data through the website. In conclusion, all frameworks are beneficial, but you need to make sure you pick the proper web framework that will help with scalability, efficiency, and productivity for your website. We hope to also explore and compare other frameworks in the future as new frameworks are been created.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgment

The preferred spelling of the word "acknowledgment" in American English is without an "e" after the "g." Use the singular heading even if you have many acknowledgments. Avoid expressions such as "One of us (S.B.A.) would like to thank" Instead, write "The first author thanks"

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