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BOOTSTRAP

– A Front-End Framework For Responsive Web
Design

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- A Front-End Framework For Responsive Web Design

With the rapid advancement of modern technology, web development has been regularly improving on every platform. Variation in the platforms from desktop to tablets and mobiles has rendered web development furthermore challenging. Different screen sizes determine the display and design of the websites. For this reason, the responsive design approach was created to resize the web page based on the screen size of the device. Bootstrap is a web development front-end library for creating responsive websites. Bootstrap with HTML, CSS, and JavaScript helps the web developers as it comes with free sets of tools to build a correctly functioning website.

The primary objective of the thesis was to use Bootstrap in a website and check its responsive behavior in various devices with different screen sizes. To achieve this objective, the thesis explains the method of designing a responsive website using Bootstrap. The outcome of the thesis is a fully functioning responsive website. Similarly, this thesis also discusses the development tools used for making the website including the Bootstrap framework. Other similar front-end frameworks are compared with Bootstrap in the thesis.

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LIST OF ABBREVIATIONS

3D   Three-dimensional

API   Application Program Interface

CDN   Content Delivery Network

CSS   Cascading Style Sheets

HTML   Hypertext Markup language

JS   JavaScript

LESS   Leaner Style Sheets

NPM   Node Packet Manager

PC   Personal Computer

PHP   Hypertext Preprocessor

RBGA   Red Green Blue Alpha

SASS   Syntactically Awesome Stylesheets

SEO   Search Engine Optimization

UI   User Interface

webRTC   Web Real-Time Communication

1 INTRODUCTION

Web pages now look better than they did in the past. Web pages are the primary source of information, communication and even marketing in everyday life. As the development of websites is growing, the techniques for building the websites are changing quickly. The developers need to provide the best user experience for the website visitors depending on the type and size of the device they use with the help of responsive web design. HTML, CSS, and JavaScript-based front-end Frameworks are helping the developers to develop responsive websites suitable for every kind of computing platform. Bootstrap, Semantic UI and Foundation are some of the front-end frameworks that are being used to create responsive websites.

Bootstrap is the most popular open source front-end framework for building responsive websites(Getbootstrap, 2018e). Bootstrap was launched by Twitter initially in 2011 mainly for solving the problem of interface designing and inconsistency. Because of the mobile first design and responsive functionality Bootstrap is popular among web developers. Popular companies like CNN, Netflix, CSDN use the Bootstrap framework in their websites. Components, Layout and the powerful 12 column responsive grid system are the key factors that attract the developers to use Bootstrap in their websites. Bootstrap is predesigned with HTML, CSS, and JavaScript which helps to customize the components and the layout quickly. Bootstrap is seamlessly responsive in all devices like mobile phones, iPad and Tablets which is an attractive component for the web designers as having a desktop website is not enough.

The primary goal of this thesis is to carry out detailed research into Bootstrap and to review a responsive website that was designed using the components of Bootstrap. This thesis covers six chapters with indroduction being the first one. Chapter 2 explains the development tools used while creating the website, Chapter 3 is about the Responsive web design, and its key components. In the fourth chapter, Bootstrap is clarified which is the framework used while building the website. The fifth chapter contains the comparison of Bootstrap between other similar frameworks. The last chapter overviews the website that was designed. Apart from this, the thesis focuses on understanding of Responsive web design and Bootstrap.

2 DEVELOPMENT TOOLS

Many development tools have been introduced to assist the developers in creating a website. There is a vast choice in choosing the development tools depending on the requirement and design of the website. The fundamental development tools used on the project to accomplish the objective of the thesis are described in this chapter.

2.1 HTML5

HTML5 is the 5th version of language HTML which is developed by World Wide Web Consortium (MDN Web Docs, 2018a). HTML5 is a medium for assembling and displaying the content in the web. Safari, Chrome, Firefox, Opera, Internet Explorer 9.0 and the browser in the mobile also support HTML5. The plugins are removed from HTML5, and this makes web apps more usable. Generally, most of the front-end frameworks that use HTML5 as static websites are built using HTML5. HTML5 is a set of new attributes, elements, and behavior that are arranged into a different group based on their functions. Listed below are key features of HTML5:

- Semantics: They are the elements with meaning as they clearly define the contents. <section>, <article>, <nav>, <header>, <footer>, <aside> are some of the sections and outlining elements. Beside this, it has also improved the content of the forms with elements like <input> and <output>.
- Connectivity: It helps the client to communicate with the server as efficient connectivity provides the user with better communication and faster chat and games. WebSocket and Server-sent events push the data efficiently between the user and the server.
- Offline and storage: The data of web pages on the client-side is stored and is operated offline. File API, App Cache, Local Storage, and Indexed DB are the offline resources and web standard for storage that significantly provides the high performance.
- Multimedia: The <audio> and <video> elements allow for new multimedia content. WebRTC controls video conference without any application or plugins and using the Camera API allows us to store the image from the device camera.

- 3D Graphics and effects: The users can natively render visuals in the browsers as it allows a vast range of presentations. SVG helps us to embed vector image in HTML whereas WebGL guides to import 3D to the web. The <canvas> element is used for graphics where the contents are rendered with JavaScript.

- Performance and Integration: Web Workers and XMLHttpRequest make the web applications and content fast. The drag and drop of the items are supported between the web pages.

- Device Access: Geolocation lets the browser discover the position of the user. It also provides access to using various input and output devices with audio and video access as well as local data.

- CSS3: New backgrounds, borders, animations, typography, and layout help to style the components in a right way.

HTML5 is the markup language used to build the websites as it organizes information and provides the structure to the document.

2.2 CSS3

CSS (Cascading Style Sheets) defines the style of the elements and provides control over the layout and design in an HTML document (Upwork, 2018). CSS makes formatting the document and updating the website easier. CSS was developed by World Wide Web Consortium and CSS3 is the latest version. CSS3 is nowadays not only about stylesheets and design, but it also provides simple animations and effects without the use of JavaScript. Some of the key features of CSS3 are listed below:

- Media queries are supported in CSS3 which provides a responsive design in the web pages depending on the device used by the user.

- The module-based code is divided into smaller modules like selectors, text effect, background and border, and the box module.

- CSS3 supports web fonts which are downloaded in the server to run through CSS code or connected directly from the source via script.

- The animation or transformation of the elements is possible without any Flash code or even JavaScript.

- CSS3 supports the image effects like a rounded corner or new color model RBGA with opacity and even gradient.

- Box-sizing of the elements with the properties like box-shadow, border-radius, and padding of the border is improved.

2.3 jQuery

jQuery is a JavaScript library which simplifies the JavaScript. It is an open-source programming language which has changed the way people write JavaScript complex code with comparatively less code. jQuery helps to make HTML document traversal and manipulation, event handling, animations, and Ajax much simpler with an easy-to-use API that works across a multitude of browsers. (js.foundation, 2019).   jQuery is compatible with CSS3, and also several plugins are available as an image slider, the pop-up box that saves the coding time. Saving the coding time of the developers is a benefit of jQuery as it has the moto "write less, do more" and the moto says what can be done with it.

2.4 JavaScript

JavaScript, a web scripting languages used for adding dynamic interactivity on the websites, was developed in 1995 by Netscape Communication Corporation (MDN Web Docs, 2018b). The HTML files include JavaScript directly. JavaScript mostly helps to display the message in a status line or alert boxes and validate the contents. JavaScript provides more control over the browser which maximizes the user's experience. As JavaScript is run on the client side of the web, it helps the user to animate or modify the parts of the webpage and even create the banners that communicate with the users. JavaScript is supported and enabled by default in the majority of the browsers and is integrated with HTML and CSS which makes JavaScript unique and even used in many of the environments.

2.5 PHP

PHP is a widely used open source scripting language executed on the server in web development. PHP generates dynamic contents in the page, controls the user's access, collects the data of the forms, modifies the data in the database and also encrypts the

data. PHP, which is flexible for database connectivity, is compatible in the major platforms and runs on nearly all the servers. PHP is used primarily in 3 ways:

- Server-side Scripting: It executes code in the web server and then is passed in the user's browser.
- Command line scripting: PHP script runs in the command line without any server or browser. It is used in system administration task like a backup.
- Client-side Applications: PHP-GTK is an extension to PHP that can be used to write desktop applications with the graphical user interface.

In this thesis project, PHP is used to handle the forms of the website where the submitted forms data are connected in the email.

2.6 Text Editor

Various text editors depend on multiple platforms which support several programming languages. After all, text editors are essential in web development, and they should suit the workflow of the web developers. The choice of the text editor is made depending on the operating system where the work is done, essential features and extra features which are provided by the text editor. Some of the text editors are free to use, and several of them are paid depending on the quality and capability. Visual Studio code developed by Microsoft, a source code editor, is used in this project.

3 RESPONSIVE WEB DESIGN

Responsive web design was first written in the article "A List Part" by Ethan Marcotte in 2010 (Marcotte, 2010). Responsive web design refers to the design where the web pages run smoothly in different platforms having random screen height and width. It has eliminated the traditional approach of creating several versions of websites on different platforms. Having several versions of websites results in duplicate content and difficulty in maintenance. Every version needs to be tracked whereas responsive web design fixes all these problems. An example of a responsive website with different screen resolutions on multiple platforms can be seen in Figure 1 where the website is modified in various devices for the most excellent view and better user experience.

Figure 1. Responsive web design (https://medium.com/level-up-web/best-practices-of-responsive-web-design-6da8578f65c4).

Responsive web design is crucial for the organizations to satisfy their users as they prefer using the internet in tablets or mobiles rather than PCs. Responsiveness provides a boost in the search engine as Google prefers mobile-friendly websites in the search engine result page. Responsive design helps websites to fit the content in any devices without leaving out any information. Responsive web design with the aim "write once, run everywhere" is composed of three core features.

3.1 Flexible Media

Flexible media overcomes the problem of using images and videos in smaller screens. The initial configuration remains the same as the media and is not flexible in the web pages. The media exceed the width of the devices and is either vertically or horizontally cropped. Images and videos should change their size with the change of the size of the viewport. The rule coined by designer Richard Rutter is in Table 1 which forbids the media to exceed the width of the container (Rutter, 2009).

Table 1. Using maximum width to create flexible media.

```
img,
embed,
object,
video {
     max-width: 100%;
     }
```

Using "max-width: 100%;" in CSS within all types of media of any types inherits the same property of the container and scales according to the container's width. This CSS command forces the images, videos or embedded media from being smaller or bigger on the webpage and matches them with the viewport of the device. This property of making the media flexible is supported in all the modern browsers whereas Internet Explorer 6 and the lower versions take width: 100% instead of max-width:100% (Responsive Web Design, 2018). When using a background image in the webpage, using CSS command background-size helps web developers to create a fully flexible background image.

3.2 Fluid Grid

Fluid grid system uses percentage to define the dimension instead of pixels which dynamically changes the elements with the change in the screen size. Use of fluid grid does not depend on the platform where the web pages are displayed. If two elements with the width of 70 % and 20% are created, with 10% between them and are presented in PC and mobile, it doesn't matter as the elements will adapt respectively. It fixes the problem of fixed-layout as the smaller screens in the fixed-layout may also need

horizontal scrollbar depending on the width of the elements. As fluid grids adapt the user's setup eliminating the need of horizontal scroll bar, it is also more user-friendly.

Figure 2. Fluid Layout (https://www.arcwebsmac.com/blog/understanding-fluid-layout/).

In Figure 2, the fluid layout can be seen in different devices which provides a user-friendly view. Using the fluid grid, the developers need not worry about the screen sizes. When the larger screens are used to view the web pages, white space cannot be as the device maximizes the area of the elements where the proportion remains the same.

Table 2. Fluid grid formula.

```
target ÷ context=result
```

The formula of Table 2 is used to create web pages with the fluid grid. If the default font-size in the webpage is 16px and the desired font-size is 32px. When the desired value is divided by the default value, the obtained font-size 2em can be kept in the CSS where the em unit is responsive and also the relative unit of measurement based on the default element. The formula is also used to convert the width of the elements of the webpage to the percentage where the result is proportional to the original, and the elements change the size depending on the screens (Marcotte, 2009). When we want to create

the column of 600px in a 1000px width page, the result .60 is translated in 60% where a responsive column of 60% width can be seen on the webpage. The ratio is translated into CSS friendly percentages which fit the size of the all devices browsing window.

3.3 Media Queries

When the device being used matches the media type of the media query, then the CSS properties enclosed with particular media features are included. Media queries are also the logical expressions which are checked and returned in the value of true or false (MDN Web Docs, 2018c). When the browsers size of the responsive website using media queries is narrowed, and the content of the navbar doesn't fit in the narrowed browser, the navbars will receive new values which will make the elements properly positioned. This will be applied when the given logical expressions are matched in different viewports. A responsive website includes many media queries which create more flexibility in different types of devices with different screen sizes. Media queries are mainly used in three different ways in the application.

- It is placed in the head tag of the HTML page.

Table 3. Media query inside a link tag.

```
<link rel="stylesheet" media="screen and (max-device-width: 600px)" href="table3.css" />
```

- Using @media rule, it can also be inserted in CSS files.

Table 4. Media query in CSS stylesheet.

```
@media screen and (min-width: 600px) {
    div {
    float: right;
    background: black;
    }
    ....
}
```

- Using @import rules, CSS stylesheets can be imported from another stylesheet.

Table 5. Importing CSS from other files.

```
@import url("table5.css") screen and (max-device-width: 600px);
```

Media queries are used mainly to apply styles, target specific media and also to test and monitor the media state. Generally, styles are applied using @media and @import rules whereas specific media are aimed <source>, <link> and other HTML elements. JavaScript methods Window.matchMedia() and MediaQueryList.addListener() helps us to test the media state. Media queries are convenient mainly to customize the web pages based on the browsers viewport or the media type. Media types are used to define the targeted devices category where the document is presented. Media type helps to specify weather document type is intended on the screen type, suitable for the device's screen, used by the printers or for the screen readers which reads the page loud.

The media features in the media query are the expressions that explain the requirements of the display device. As media features also have specific names and value to test. The media features with their description can be seen in Figure 3. It has the list of media features with their name, summary, and the note. The notes column consists of the added level where the media queries that were added in the 4th an 5th level are shown.

Name	Summary	Notes
width	Width of the viewport	
height	Height of the viewport	
aspect-ratio	Width-to-height aspect ratio of the viewport	
orientation	Orientation of the viewport	
resolution	Pixel density of the output device	
scan	Scanning process of the output device	
grid	Does the device use a grid or bitmap screen?	
update	How frequently the output device can modify the appearance of content	Added in Media Queries Level 4.
overflow-block	How does the output device handle content that overflows the viewport along the block axis?	Added in Media Queries Level 4.
overflow-inline	Can content that overflows the viewport along the inline axis be scrolled?	Added in Media Queries Level 4.
color	Number of bits per color component of the output device, or zero if the device isn't color	
color-gamut	Approximate range of colors that are supported by the user agent and output device	Added in Media Queries Level 4.
color-index	Number of entries in the output device's color lookup table, or zero if the device does not use such a table	
display-mode	The display mode of the application, as specified in the web app manifest's display member	Defined in the ⬈ Web App Manifest spec.
monochrome	Bits per pixel in the output device's monochrome frame buffer, or zero if the device isn't monochrome	
inverted-colors	Is the user agent or underlying OS inverting colors?	Added in Media Queries Level 5.
pointer	Is the primary input mechanism a pointing device, and if so, how accurate is it?	Added in Media Queries Level 4.
hover	Does the primary input mechanism allow the user to hover over elements?	Added in Media Queries Level 4.
any-pointer	Is any available input mechanism a pointing device, and if so, how accurate is it?	Added in Media Queries Level 4.
any-hover	Does any available input mechanism allow the user to hover over elements?	Added in Media Queries Level 4.
light-level	Light level of the environment	Added in Media Queries Level 5.
prefers-reduced-motion	The user prefers less motion on the page	Added in Media Queries Level 5.
prefers-reduced-transparency	The user prefers reduced transparency	Added in Media Queries Level 5.
prefers-contrast	Detects if the user has requested the system increase or decrease the amount of contrast between adjacent colors	Added in Media Queries Level 5.
prefers-color-scheme	Detect if the user prefers a light or dark color scheme	Added in Media Queries Level 5.
scripting	Detects whether scripting (i.e. JavaScript) is available	Added in Media Queries Level 5.
device-width 🗑	Width of the rendering surface of the output device	Deprecated in Media Queries Level 4.
device-height 🗑	Height of the rendering surface of the output device	Deprecated in Media Queries Level 4.
device-aspect-ratio 🗑	Width-to-height aspect ratio of the output device	Deprecated in Media Queries Level 4.

Figure 3. Media features with a summary (https://developer.mozilla.org/en-US/docs/Web/CSS/Media_Queries/Using_media_queries).

4 BOOTSTRAP

Twitter designed Bootstrap in 2011 is an open source library for creating responsive websites with HTML, CSS, and JavaScript. It has three significant releases after version 1 as v2, v3 and v4 the latest one. Among them in version 2 as an optional stylesheet responsive functionality was added in the entire framework whereas version 3, had a mobile-first approach where the websites are designed for the mobile in the beginning and building the way up to the desktop. In the latest version, four Bootstrap has two major changes as it has migrated from less CSS preprocess to SASS and the move to CSS flexbox.

Bootstrap consists of all the components for creating a fully functioning responsive website. The components like navbar, jumbotron, forms, carousel, buttons, tables, dropdown, and many other components are available in Bootstrap for creating a complete website. These components make front-end development much faster and save hours in the development process. With all these components and features, Bootstrap is also supported by all the latest popular web browsers it is also the most downloaded front-end CSS framework.

NPM Downloads

Bootstrap	Bulma	Foundation	UIkit	Semantic UI	Materialize
4,196,247	265,994	558,095	44,279	62,103	112,278
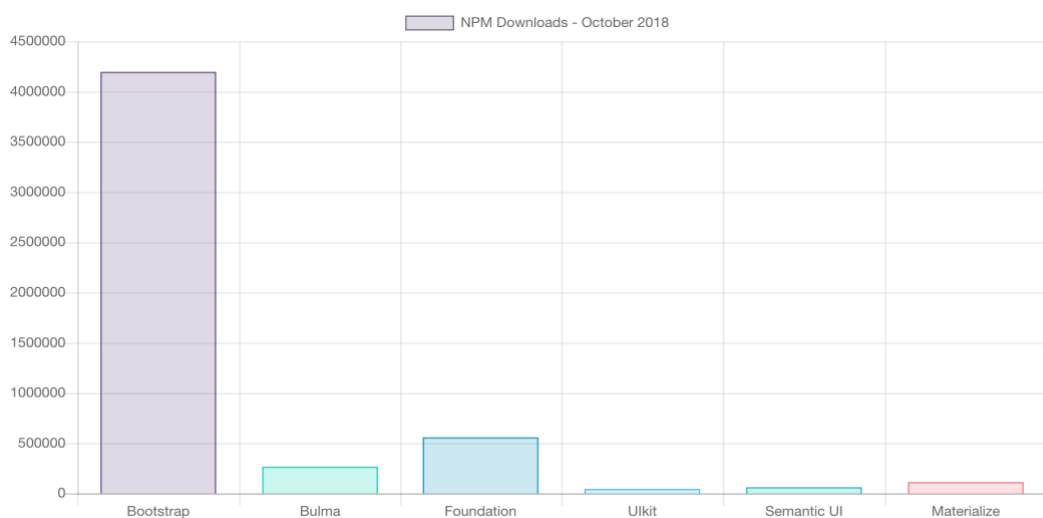
Figure 4. NPM downloads of CSS technologies (https://mdbootstrap.com/publications/front-end/best-css-frameworks-libraries/).

The numbers of download also determine active users. Bootstrap is the most downloaded CSS framework in comparison to others. It also has the most stars in GitHub in contrast to other web frameworks which also helps us to estimate the trend.

4.1 Installation

The compiled CSS and JavaScript code of the latest version of Bootstrap is easily downloadable from the website of Bootstrap and can be kept in the project. Precompiled and source code are the two structure of Bootstrap. In the precompiled Bootstrap the compiled and minified JavaScript and CSS are included when downloaded and unzipped. The source code contains SASS, JavaScript, documentation and also the precompiled Bootstrap with compiled and minified JavaScript and CSS.
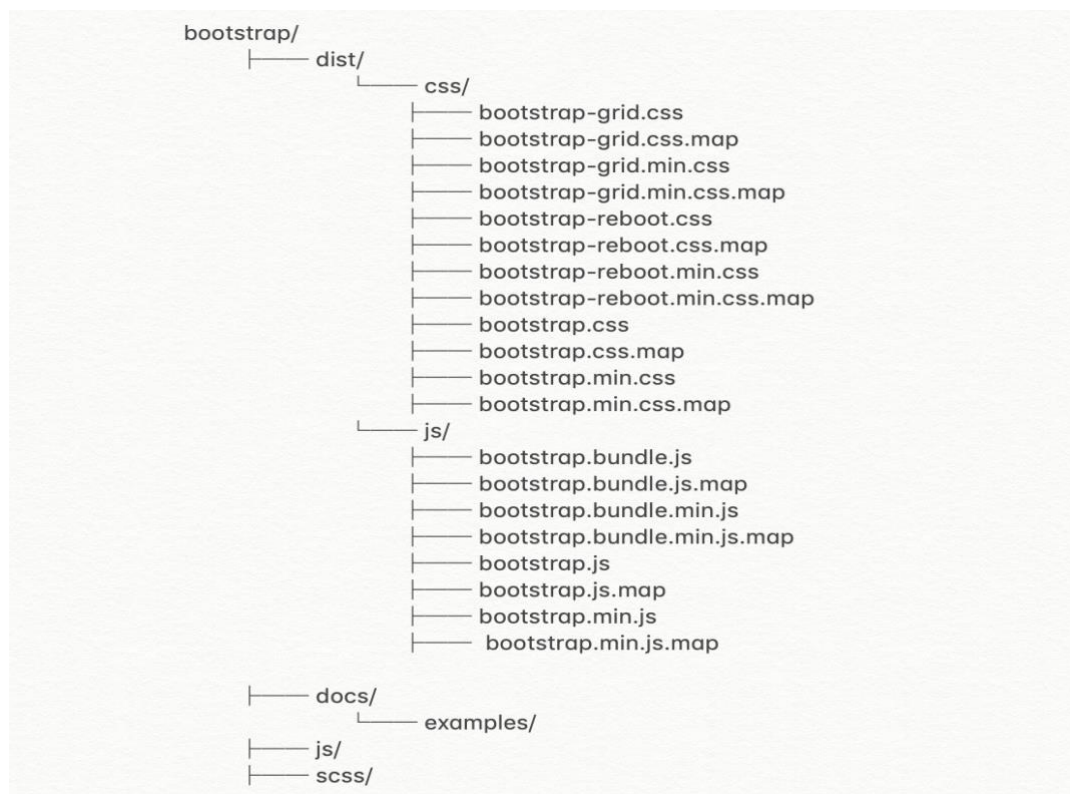
```
bootstrap/
├──── dist/
        └──── css/
                ├──── bootstrap-grid.css
                ├──── bootstrap-grid.css.map
                ├──── bootstrap-grid.min.css
                ├──── bootstrap-grid.min.css.map
                ├──── bootstrap-reboot.css
                ├──── bootstrap-reboot.css.map
                ├──── bootstrap-reboot.min.css
                ├──── bootstrap-reboot.min.css.map
                ├──── bootstrap.css
                ├──── bootstrap.css.map
                ├──── bootstrap.min.css
                ├──── bootstrap.min.css.map
        └──── js/
                ├──── bootstrap.bundle.js
                ├──── bootstrap.bundle.js.map
                ├──── bootstrap.bundle.min.js
                ├──── bootstrap.bundle.min.js.map
                ├──── bootstrap.js
                ├──── bootstrap.js.map
                ├──── bootstrap.min.js
                ├──── bootstrap.min.js.map
├──── docs/
        └──── examples/
├──── js/
├──── scss/
```

Figure 5. Bootstrap source code with the precompiled download.

Inside the Bootstrap folder, the dist/ folder contains all the flies of precompiled Bootstrap, so it has everything of the precompiled structure. All the CSS and JavaScript are included in js/ and scss/ folder, and docs/ includes all the source code of the documentation as well as the examples of Bootstrap usage (Getbootstrap, 2018b).

Bootstrap can also be used by the CDN of Bootstrap which is the quickest way to install Bootstrap as it is all about copy and paste of the lines in the HTML page. When the compiled version of JavaScript is used the page should contain the CDN of both proper.js and jQuery before JavaScript. The Bootstrap CDN should be included in the <head> tag whereas the required JavaScript files should be before closing the </body> tag.

Table 6. Compiled and minified Bootstrap CSS.

```
<link rel="stylesheet" href="https://stackpath.bootstrapcdn.com/bootstrap/4.1.3/css/bootstrap.min.css" integrity="sha384-MCw98/SFnGE8fJT3GXwEOngsV7Zt27NXFoaoApmYm81iuXoPkFOJwJ8ERdknLPMO" crossorigin="anonymous">
```

Table 7. Compiled Bootstrap JavaScript.

```
<script src="https://stackpath.bootstrapcdn.com/bootstrap/4.1.3/js/bootstrap.min.js" integrity="sha384-ChfqqxuZUCnJSK3+MXmPNIyE6ZbWh2IMqE241rYiqJxyMiZ6OW/JmZQ5stwEULTy" crossorigin="anonymous"></script>
```

Table 8. jQuery Library CDN.

```
<script src="https://code.jquery.com/jquery-3.3.1.slim.min.js" integrity="sha384-q8i/X+965DzO0rT7abK41JStQIAqVgRVzpbzo5smXKp4YfRvH+8abtTE1Pi6jizo" crossorigin="anonymous"></script>
```

Table 9. popper.js CDN

```
<script src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.14.3/umd/popper.min.js" integrity="sha384-ZMP7rVo3mIykV+2+9J3UJ46jBk0WLaUAdn689aCwoqbBJiSnjAK/l8WvCWPIPm49" crossorigin="anonymous"></script>
```

Besides using the compiled CSS and JS and Bootstrap CDN, Bootstrap offers other various techniques for installation. Bootstrap can be downloaded with the package managers like npm, RubyGems, Composer and NuGet (Getbootstrap, 2018c).

4.2 The Grid System

The grid system is the most common feature of Bootstrap which removes the trouble while designing responsive page layout. A grid layout is about the structure of rows and columns for shaping the contents in the web pages. The grid layout manages the horizontal and vertical locating of the webpage contents and also the structure of the page in various devices screen. The columns are rearranged based on the devices. The Bootstrap grid system is a mobile-first flexbox grid with 12 columns to design the layout of various shapes and sizes (Getbootstrap, 2018d). Beside rows and columns, containers are crucial in a grid system. A container is used to wrap the contents of the webpage and can be used either on the entire website or frequently in several parts of the webpage. Bootstrap provides container and container-fluid as two types of container classes. The container class includes all the contents of the webpage in a fixed width depending upon the width of the viewport and determines the way various section of the web pages are rendered whereas container-fluid is a full-width container, which covers the entire width of the viewport.

The Bootstrap grid has five different grid classes for designing flexible and dynamic layout for the screen width ranging from less than 576px for extra small devices to greater than 1200px for extra-large devices. These five breakpoints help to generate a responsive grid which is built with flexbox which without the given width will layout as regular width columns to every device.

- The class prefix ".col-" is for the extra small devices with the device width less than 576px where the maximum container width is auto.
- ".col-sm-" class is used for the small devices where the device width is equal or greater than 576px and less than 768px. This class has the maximum container width of 540px.
- For the medium devices with the device width greater than or equal to 768px and less than 992px the class ".col-md-" is used. The class prefix ".col-md-" has the maximum container width of 720px.
- The large devices with the device width greater or equal to 992px and less than 1200 px have the class prefix ". col-lg-". It has the maximum container width of 960px.
- The class prefix ". col-xl-" is for the extra-large devices with the device width greater than 1200px. It has the maximum container width of 1140px.

The Bootstrap grid has the possibility of 12 column in a row. The space between the columns is controlled by the gutter. It has the width of 30px with 15px in both the sides which can also be removed with the class ".no-gutters". The Bootstrap grid system with different numbers of columns is in the Figure 6.
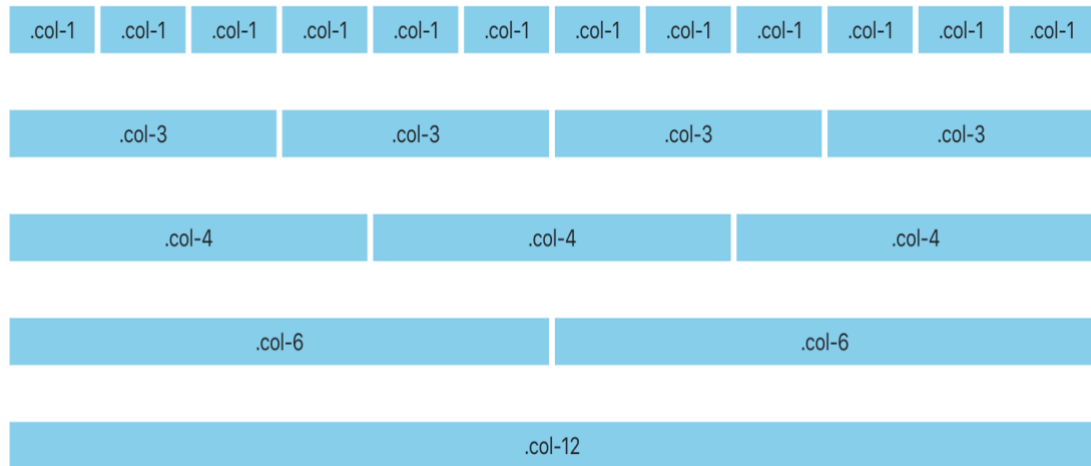
.col-1	.col-1	.col-1	.col-1	.col-1	.col-1	.col-1	.col-1	.col-1	.col-1	.col-1	.col-1

.col-3	.col-3	.col-3	.col-3

.col-4	.col-4	.col-4

.col-6	.col-6

.col-12

Figure 6. Bootstrap grid system.

As the Bootstrap grid system uses 12 columns in a page, the columns can be used together to create a wider column instead of using 12 columns separately. The columns are rearranged based on the breakpoints when the viewport width changes. Since the Bootstrap grid system is compatible with different devices, the grid layout can be modified and managed with various grid features provided by Bootstrap.

- Columns size based on the content width or the same grid layout for all devices with constantly sized columns can be created
- Merging different breakpoint classes helps to generate dynamic and flexible layout as the columns are rearranged depending on the breakpoints.
- Columns can be horizontally or vertically arranged with the use of flexbox arrangement utilities, and the content can also be nested in the default grid.
- The visual order of the content can be managed with the ".order-" class which is responsive and can also be set by the breakpoints.
- Offsetting of the columns can be done by using the class ".offset" to increase the margin of the column or by margin utilities which force the columns further from each other.

4.3 Content

Frequently used HTML elements like tables, figures, topography, images are included in the content components in Bootstrap. Bootstrap 4 also comes with Reboot which is a group of element-specific CSS changes in a file normalize.css (Getbootstrap, 2018f). More specifically, the content components in normalize.css are listed below.

- To identify the exact font size of the components in web pages Bootstrap, four has switched to rem from em while em is the relative unit to the parent element and rem is relative to the root HTML element.
- For comfortable spacing, margin-top has been removed from heading, paragraph and list components whereas margin-bottom has been added in list components, paragraph and heading by default. There is no default margin-bottom when the list components are nested inside each other.
- For the consistency in the body, Bootstrap has a default background color, font family, default web fonts, line height, and text-align.
- The forms in Bootstrap are simpler as the text area is resized vertically as in horizontal resizing the page layout is broken. Similarly, in the form borders, padding and margin has been managed which makes the use of forms simpler
- In the table <caption> has been changed for the consistent text-align in the cells.

There is more variation in typography with heading and title. From the regular header tags Bootstrap provides new display heading classes where "display-1" is the biggest and "display-4" is the smallest one. With the other tags like "text-muted" and "small", the small descriptive heading can be created from the main heading which helps in customizing the heading. The paragraph formatting is, and for the different look <lead> tag can be used where the font size is increased by 25%, and the font weight is light. Bootstrap also provides responsive topography where different font size can be selected for media queries with breakpoints.

Responsive tables and images are crucial when creating a responsive website. With Bootstrap, the basic table can be created and can be modified with the color options. With the "table-responsive" class the responsive table can be made. Likewise, either the entire table or only the table header can be converted to inverse color, and the hover state can be created in the rows, the striped table can be created and also the table with the border. Similarly, in the images, the "img-fluid" class in Bootstrap helps to create

responsive images. Using the class "img-fluid" the width of the image is set as 100% similarly the height is auto with which the image scales with the size of the screen where the website is being displayed. The shape of the image can be styled with the classes like "img-rounded", "img-circle" and "img-thumbnail". The images are also aligned in the layout with the alignment classes.

4.4 Components

Components are significant in a Bootstrap framework which quickly helps us to design and user interface with predefined CSS class and a lesser amount of code. The components with CSS classes are applied in the HTML elements and can be modified according to the requirement of the users. The appearance of the components can be altered with various modifier classes. Bootstrap provides all the essential components like alerts, buttons, carousel, dropdowns, forms, jumbotron, model, progress, etc. that are necessary for web development (Getbootstrap, 2018a). The different components of Bootstrap are discussed below in details.

- Alerts

Alert provides the predefined message with any length of text that requires the attention of the users for their action. Alert can also be used with the HTML elements like heading and paragraph. Compiling Bootstrap with JavaScript alert can be removed using the class ".alert-dismissible" with the attribute data-dismiss="alert". For the close button, the button with the class ".close" should be added.

- Badges

Badges are used to advertise the information or highlight new or unread entries in the content of the webpage. Badges can be enclosed in <a> tag for making the connected to a link with hover effect and even be modified in the border with the class ".badge-pill" which makes the border rounded.

- Breadcrumb

Breadcrumb displays the current page location to the users on a webpage. It creates convenience on the webpage with many pages. Using the class ".breadcrumb" breadcrumb layout can be generated in the webpage. With CSS, dividers are automatically added through :: before element and content property.

- Buttons

Buttons are the frequently used components with several selections like toggle, radio, button group and checkbox. Class ".btn" is a must that should be attached in various HTML tags like <button>, <a> and <input> to generate a button. When creating a button in the tag <a> the role= "button" should be specified inside the tag which would make it easier for screen readers. Instead of filled buttons, outlines button can also be created adding "-outline" in the button class name. Checkbox and radio buttons can be easily converted in regular button in Bootstrap that makes it easier in the mobile apps as it is convenient to click a button instead of using checkbox and radio buttons.

- Button group

Button group allows a group of buttons to be arranged together in a single line. When creating button group, the buttons with class ".btn" are enclosed in the class ".btn-group". The set of button groups ".btn-group" class are placed together in the class ".btn-toolbar" by which button toolbar can be created.

- Card

The card is the flexible container with header, footer, content and display options with various customization. The basic card is created with the class ".card", the content is placed inside the class ".card-body" and header and footer in the class ".card-header" and ".card-footer" respectively. All types of contents like images, texts, list group, link, etc. are supported in the card. The group of cards with uniform size either attached in card components.

- Carousel

Carousel is the way where two or more images with or without text slide automatically in a regular interval of time. The web pages use the carousel to promote the products on the homepage. The next, previous button and indicators can be added in the carousel for making it efficient but are not mandatory. The primary Bootstrap carousel is formed inside a container with the class ".carousel" and ".slide" respectively. The slides are placed in the class ".carousel-inner" and each slide with the class ".carousel-item". The ".active" class is added to make the carousel visible.

Figure 7. Carousel with caption. (https://getbootstrap.com/docs/4.0/components/carousel/).

- Collapse

Collapse component toggles the content of the webpage. When using collapse in multiple targets or a single a link or any buttons data-toggle= "collapse" is mandatory. The webpages with the contents like FAQs or overview with accordion, collapse component is used. The classes ".collapse" for hiding the content, ".collapse.show" to show the content and ".collapsing" for the transitions are the classes to handle the collapse behavior in the elements.

- Dropdowns

Dropdowns built on the library popper.js are togglable where the links are shown in list format. Dropdowns mainly used in the menu should be enclosed in ".dropdown" class and with the role="menu". Not just in the menus, dropdowns are used in the forms with the selections of additional input or even in the search fields. Headers, dividers, text, active or disabled items can be created by Bootstrap dropdown components that can be expanded in any directions not just down but up, left and right as well with the relevant classes.

- Forms

Bootstrap forms have the default styling where the text elements such as <input>, <textarea> and <select> have the width 100%. The text elements should be wrapped in the class ".form-control" and all the form controls are inside the class "form-group". Bootstrap helps to design various layouts of forms like the vertical form, horizontal and inline forms.

- Input group

Input group allows inserting buttons, icons or text before or after the input area. Class container ".input-group" assists by improving the input whereas using class ".input-group-prepend" the text or button is before of the input and the class ".input-group-append" displays text or buttons after the input field. Input group with an additional content addon like checkbox, radio buttons, buttons with dropdowns and even segmented buttons can be added with several sizing options.

- Jumbotron

Bootstrap jumbotron is a flexible component that may contain unique content like the marketing messages on the websites. The contents are kept inside the ".jumbotron" class and for having a full-width jumbotron class ".jumbotron-fluid" is added with either ".container" or "container-fluid" class inside the jumbotron class.

- List group

List group displays a series of customized and complex content in the form of a list. In the basic list group, the class ".list-group" is added in the element <ul> following the elements in <li> are given with the class ".list-group-item". The JavaScript plugin when used in list group the content can be toggled by specifying data-toggle="list" in the list group item.

- Modal

Bootstrap modal is a window displayed over the parent window with popups or any customized content from a different source without leaving the parent window. Nested modals are not supported in Bootstrap, and only one modal window is supported at a time. Bootstrap provides various types of modal with different sizes like static modal, vertically centered modal, scrolling long content modal, modal with tooltips and popovers, modals using grid and also similar modal varying the content. The Bootstrap modal with tooltips and popovers is in the figure 8.
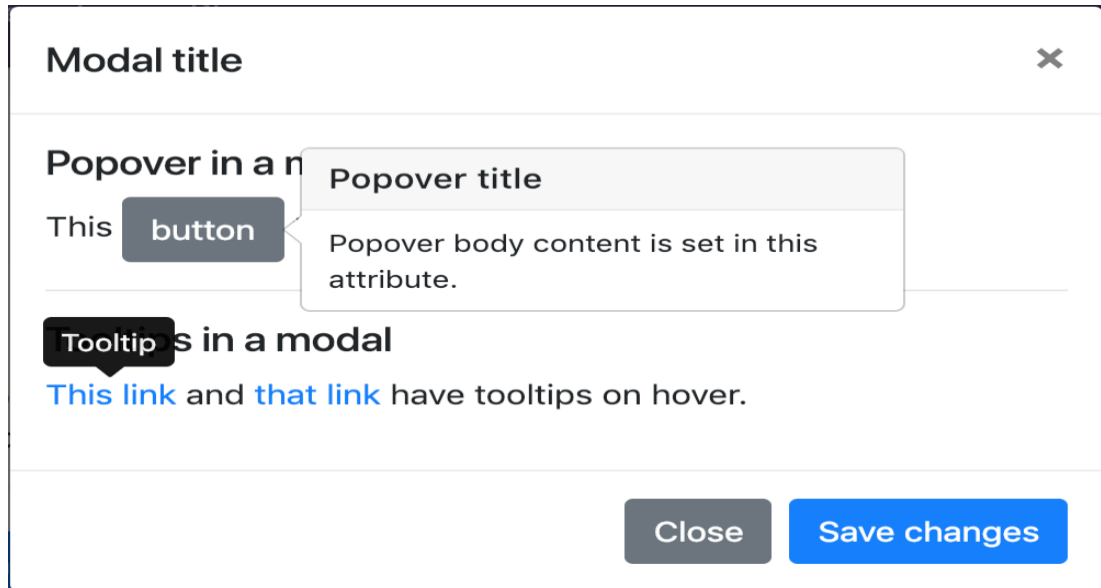
Figure 8. Popover and Tooltip modal.
(https://getbootstrap.com/docs/4.0/components/modal/).

- Navs

Bootstrap navigation is created with the base class ".nav" and each component with the class ".nav-tabs" or ".nav-link". The navs can be modified on own as required or on various styles like horizontal alignment, vertical, pills with class ".nav-pill" and dropdowns along with JavaScript plugin "Bootstrap.js" the navs with tabbable panes of the content.

- Navbar

Bootstrap provides powerful nav bar, the header of the webpage that collapses in mobile view and turns out to be horizontal once the width of the device is increased. The navbar is enclosed in the class ".navbar" with class ".navbar-expand{-sm | -md | -lg | -xl}" aimed for responsive collapsing of the navbar that depends on the preferred breakpoints namely small, medium, large or extra-large. Bootstrap navbar supports following contents for its components as needed.

- ♦ The company or the project name can be placed in the navbar with the class ".navbar-brand".
- ♦ Class ".navbar-nav" for full-height, lightweight navigation and the support for the drop-down menu as well.
- ♦ Class ".navbar-toggler" supports the toggling behavior in the navigation bar.
- ♦ The form controls and actions are included with the class ".form-inline".

◆ ".navbar-text" for adding a string of text in the navbar.

◆ The grouping and hiding of the content of the navbar with a parent breakpoint are made with the class ".collapse.navbar-collapse".

- Pagination

Pagination on each page specifies having linked content in several pages. Pagination provided by Bootstrap supports several icons, active and disabled state can be customized in the link and different sizes and alignment of the pagination components.

- Popovers

A popover provides information about the element to the users with the popup box on request of the user. Bootstrap's popover plugin relies on Popper.js and works after including popper.min.js before bootstrap.js. A popover is enabled with the attribute data-toggle="popover" and can be directed in all four directions.

- Progress

A progress bar indicates the action is taking place as loading or in progress despite showing the elements in the web pages. The class ".progress" specifies the maximum value of the progress bar while the class ".progress-bar" denotes the progress so far. Multiple progress bar can be included in single progress having different backgrounds or even animated.

- Scrollspy

Scrollspy is used with Bootstrap nav component or list group which updates the position of the link active in the device based on the scroll position. The element must be given the position: "relative", on the body of the HTML and for the elements other than the body overflow-y: "scroll", and a height set should be applied.

- Tooltips

Tooltips are the small pop-up box that emerges when the pointer is shown in a link or an element. The attribute data-toggle="tooltip" is used to design a tooltip and are primarily suitable on describing a link. Like popovers, tooltips rely on Popper.js and appear on the top of an element by default but can also be directed in all directions.

5 COMPARISON BETWEEN DIFFERENT FRAMEWORKS

There are several front-end CSS frameworks similar to Bootstrap for designing responsive websites. Frameworks have default HTML and CSS files which supports in rendering web pages in the web browser and having the layout it is needless to write the code from the beginning that benefits in the workflow. The comparison of Bootstrap with other five different CSS frameworks with their features, popularity based on GitHub stars and forks till 2018 and the released date along with the creators of the framework is in the Table 10 (Altexsoft, 2018), (Arsenault, 2018), (Gerchev, 2018).

Table 10. Comparison of CSS frameworks.

Frameworks	Features	Popularity	Release Date
Bootstrap	- Sass instead of LESS for source CSS files. - Addresses 5 grid classes for columns focusing on smaller devices. - Angular, React, jQuery and Vue JS version is available. - Responsive utility classes. - Provides prebuilt UI components.	129,764 GitHub stars and 63,734 forks.	August 2011 created by Mark Otto and Jacob Thornton
Foundation	- They are optimized for mobile devices. - Has pricing for business support or training. - Uses Sass as a CSS preprocessor. - Supports the right to left languages feature. - Can be used with back end particularly for Rails implementation.	27,886 GitHub stars and 5,820 forks.	September 2011 created by ZURB

Table 11. (continued).

Frameworks	Features	Popularity	Release Date
Bulma	• Open source built with Sass and based on flexbox. • Well-crafted UI components that can be customized and are reusable. • Imports only the required features as it is modular. • Includes readable classes and is easy to understand. • Does not have JavaScript options and focuses on CSS.	32,064 GitHub stars and 2,529 forks.	February 2016 created by Jeremy Thomas
Semantic UI	• Codes are self-explanatory, and the classes are human words. • Contains simplified debugging and has well-organized documentation. • Has implementation for Angular and React, Ember and Meteor. • Components are designed using em and rem. • Uses the principle of the plurality for the similarities and avoids repetition.	44,040 GitHub stars and 4,707 forks.	September 2013 created by Jack Lukic
Materialize	• CSS framework which is device-agnostic. • Based on Google's Material Design language. • Enhances the animation effect for better user experience. • Compatible in all the browser as it carries Sass mixins. • Various components and IZ column grid feature for website layouts.	34,770 GitHub stars and 4,698 forks.	November 2014 created by Alvin Wang, Alan Chang

CSS Frameworks addresses the problems linked with responsiveness, modularity, and speed of the web pages. Most of the frameworks are free and open source aswell, however, while some of them are paid based on the services offered. Based on the popularity and features Bootstrap is an open source project that considered as best CSS framework for front-end development. Bootstrap has the largest variety of components and is updated regularly with rich features. With a 12-column grid system and responsive utility classes of Bootstrap, web pages adapt to suitable devices, the result being uniform. Bootstrap is one of the most stable frameworks and has the approach of "mobile first" which is a prerequisite in the modern websites. In comparison to the other frameworks, Bootstrap provides unique features and components for creating a responsive website quickly and easily.

6 THESIS PROJECT WEBSITE OVERVIEW

6.1 Objective

The main purpose of this thesis project was to create a responsive website on all the platforms using the techniques of modern web development. The main idea behind designing a responsive website was to solve the problems of maintenance of the website according to the device viewpoint and also be familiar with the Bootstrap framework. With these approaches in mind, the outline of the website was designed.

6.2 Method

The first step in creating a website is sketching the sitemap and wireframe. Sitemap explains the relationship between the pages of the website which helps to evaluate how quickly the users can navigate to find the information from a specific page and understand the structure of the website. Similarly, a wireframe is the sketch of the website and its elements in their respective location. The sitemap and the wireframe of the project website were created as well. The wireframe of all the pages was created using Mockingbird. The wireframe of the homepage is in Figure 9.
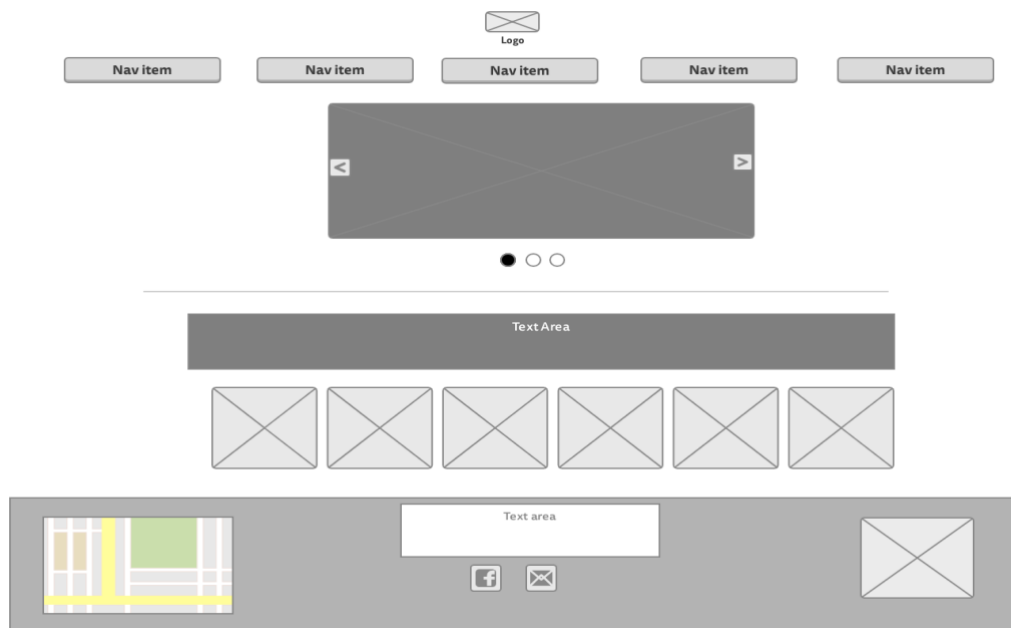
Figure 9. Wireframe of the homepage.

6.3 Website

Based on the sketch, elements designed in the previous stage were transformed for the website. The website is responsive to different devices. Depending upon the size of the device the navigation bar was hidden, and a drop-down menu was visible in the smaller devices. The homepage of the website in the desktop version and the mobile version is in the Figure 10.
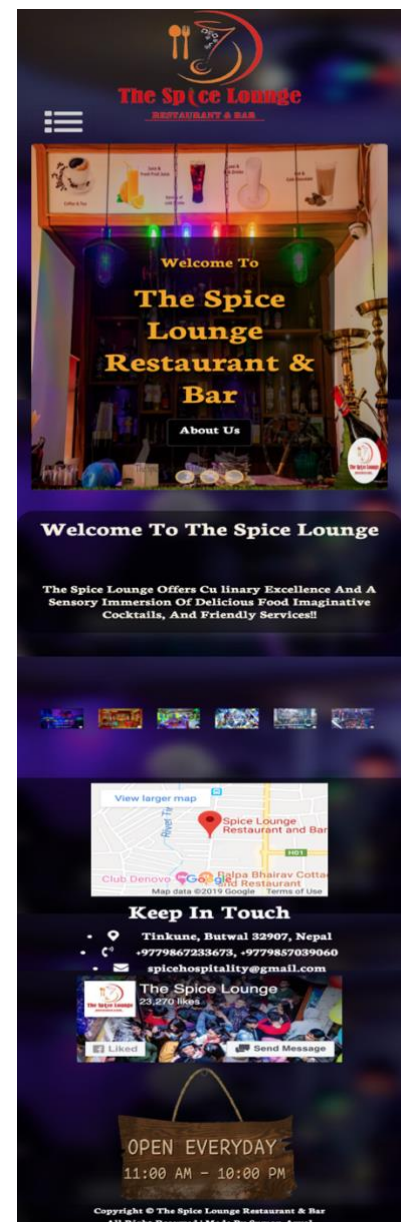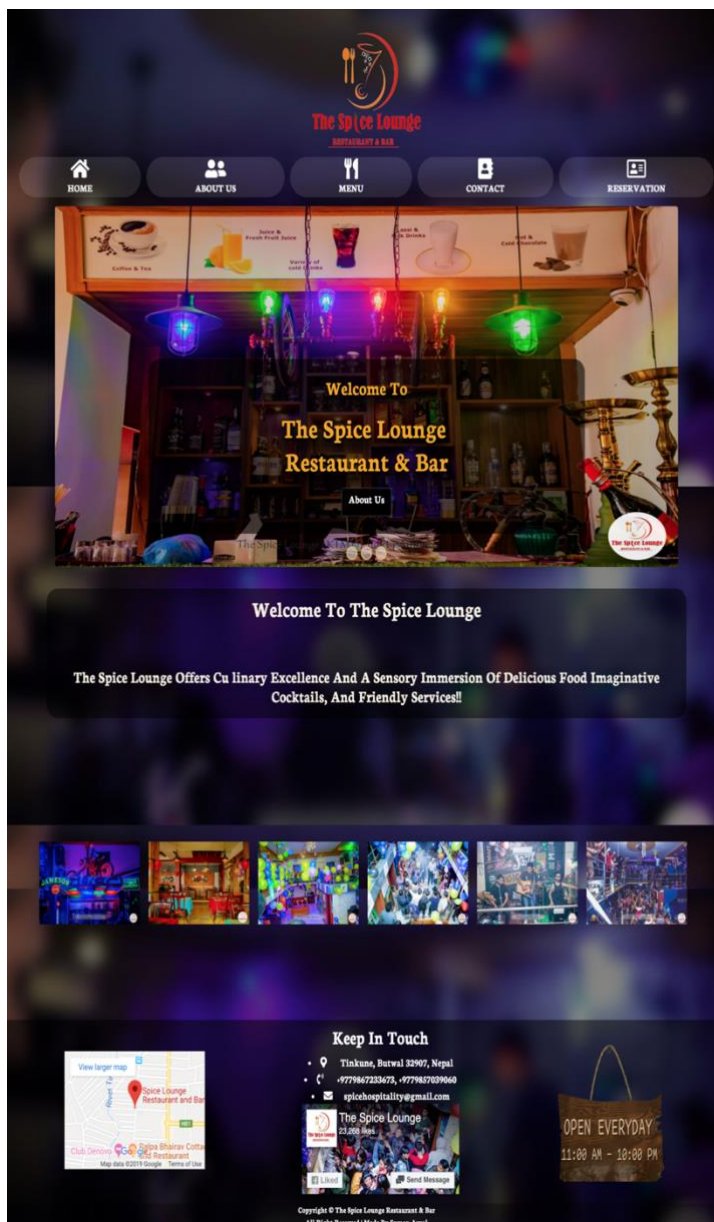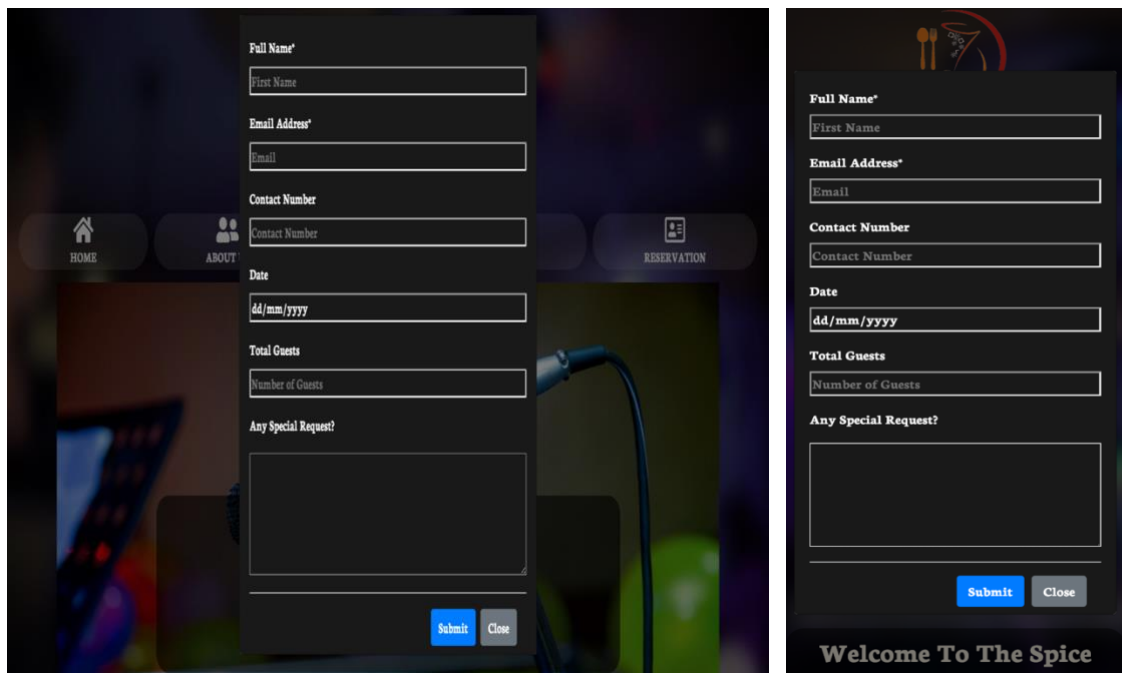

Figure 10. Desktop site vs. Mobile site.

Besides the homepage, the website has three more pages and a reservation form which appears in a Bootstrap modal. Bootstrap navbar and carousel are used in the homepage. The pictures in the carousel have the link that directs the users to the different page. Similarly, responsive images are used in the homepage that is displayed after they are clicked according to the device width. Likewise, about us is the information page of the restaurant. The Menu page has the food items the restaurant serves and is separated into five main divisions and further into sub-division that makes it simpler for the users to choose the food items. The contact page has the necessary information and also the contact form for any inquiries or requests regarding the services. The reservation form and the contact form are connected to the restaurant's email so the restaurant would receive the feedback and the booking information directly. The form is connected to the email using PHP. Figure 11 below has the screenshot of the reservation form in mobile and the desktop.

Figure 11. Reservation form desktop version and mobile version.

7 CONCLUSION

Web development frameworks are drastically changing the design of the websites with new techniques. The Bootstrap framework with the principle of responsive web design and mobile first have improved the web design providing accessibility from desktop to mobile, improved SEO and less cost in designing the websites instead of creating separate websites based on devices. As the usage of mobile and tablets is overtaking desktop over the use of the internet, responsive web design in the websites will have single sets of code which makes updating and creating the changes in the web pages easier.

Bootstrap being freely accessible and customizable provides HTML, CSS, and JavaScript-based templates for the wide range of components that are supported in the latest version of all the major browsers. Bootstrap is an open source framework which offers handy templates with proper responsive behavior in all the devices with a range in their sizes. The Bootstrap grid system makes the design and development process efficient, and also content can be modified by the developers easily. With all these features, Bootstrap is also known as the most popular front-end framework as 18.75% of the websites in top 1,000,000 websites which is approximately 187,500 are using Bootstrap in their websites (Trends, 2019).

In conclusion, Bootstrap provides all the features and components to design a fully functioning responsive website consistent in all the browsers. The powerful responsive 12-column grid system with responsive utilities, endless customization of the components and breakpoints by viewports makes Bootstrap popular and is preferred by the developer's other frameworks as the best choice for responsive web design.

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