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Hybrid Mobile Application Development

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<p>This project was carried out as a final year project and the purpose was to create a hybrid (Android and IOS) location-aware mobile application for car renting and reservation. The application created can be used by a car rental company for management of car rent and reservation.</p> <p>The mobile application was developed using Ionic open-source SDK compiled with Apache Cordova which is an open-source mobile development framework. HTML, CSS and JavaScript were used in building the user interface. Node.js was used as runtime environment and MongoDB as database.</p> <p>During the project a hybrid mobile application, capable of accessing different features like a camera and GPS and creating a reservation dynamically, was developed. The developed application can be used for renting a car. Clients can also comment and rate the car they used. For the company providing a renting facility, the application can be used to manage and monitor the system. Initially, the application is in the English language.</p>	
Keywords	Android, IOS, Ionic, Cordova, Angular, runtime, JavaScript framework, reservation, renting

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1 Introduction

Use of the internet-based web applications, computers and smartphones has immensely increased during the last decade, as well as their production. As the number of users are expanding they are also carrying more and more equipped devices that comfort them to go through. No one would have had predicted in the early 1990's that the web technology would get developed as it is now. Modern web applications which are data-driven used to be static pages with nothing more than plain text displaying in the browser. Browsers used to be a medium through which the internet was accessed along with people also used email and FTP. Nowadays people tend to use many other devices like smartphones and tablets to use the internet through a wide range of applications. Technology has immensely developed its concern towards the mobile and has taken new dimensions after development of Android and IOS operating systems for mobile phones. The mobile market started taking shape from 2007-08 and has travelled a long way in the last decade without stopping. Desktop and laptop users have been dropping slowly; they seem to be early adopters in front of mobile users.

Technology has changed with time as the number of users migrating from desktop to mobile and table suggests. The widespread adoption of smartphones and other small size devices around the globe is rocketing high. People are more attracted by small size screens for various activities like going online, sharing information and for entertainment purposes as compared to desktops. For example according service seller for pets like Morrr (Finland) suggests that more than 60 percent of the traffic comes from mobile devices and applications [1.] Moreover, at the present situation people are magnetized by the social media and internet where mobile applications play an important role.

The main objective of this project was to design and implement the front-end part of a hybrid application for iOS and Android. The project was out carried as a practice project targeting at certain companies related to the product area. The project was carried by a team of two students each with their own responsibilities. My responsibility was to complete the front-end part of the application with a UI (User Interface) design. The project is basically for car renting purposes with a selection of cars, commenting and rating, login page, adding to favorites and home page with some promotions.

2 Mobile Technology

Overall development in the mobile technology and adoptions among mobile users have achieved remarkable milestones. The dominance of the desktop for accessing the internet for two decades has been overtaken by the mobile platform. People no more use only the desktop as the primary gateway to access internet. For the first time in March 2015, desktop users were suppressed by mobile users among adults in terms of using internet [3]. Figures in 2015 say that there are 4.9 billion subscribers out of 7.2 billion subscriptions around the world. Americans seems to be fast adopters of smartphones while in Europe mixed response in terms of adoption was seen. For instance in Italy in 2014, 2 smartphones were found out of 3 household which shows growth from 2012(1 out of 3). The survey of Google suggests that “more Google searches take place on mobile devices than on computers in 10 countries including the US and Japan” [3.] By 2017 the estimated numbers of mobile users will be almost 5 billion [2].

A mobility report presented by Ericsson shows forecast data, analysis on mobile traffic and subscriptions and current market trends in the adoption of technology worldwide [22]. Moreover, a prediction made by Ericsson suggests that mobile users around the globe will reach 6.1 billion by 2020. In addition the Ericsson mobility report 2014 and 2015 also gives the following facts:

- People older than 6 years, 90 percent will have at least a mobile phone and subscriptions to a smartphone by 2020
- By 2021 more than 70 percent of mobile subscriptions will be smartphones in Europe, where mobile traffic will increase by 9 times compared to that in 2015 and reach 11 ExaBytes (EB)
- In 2014, India with 18 million subscriptions and China with 12 million subscriptions lead as fastest growing countries in terms of new mobile subscriptions with 110 million around the world
- New smartphone subscriptions were added by 800 million in 2014 spring making 2.7 billion worldwide
- There will be a 10-times increase in mobile video traffic contributing 55 percent of total mobile data by 2020.

For more information, a full and extended version of mobility report by Ericsson which is available on the official website of the company. [2]

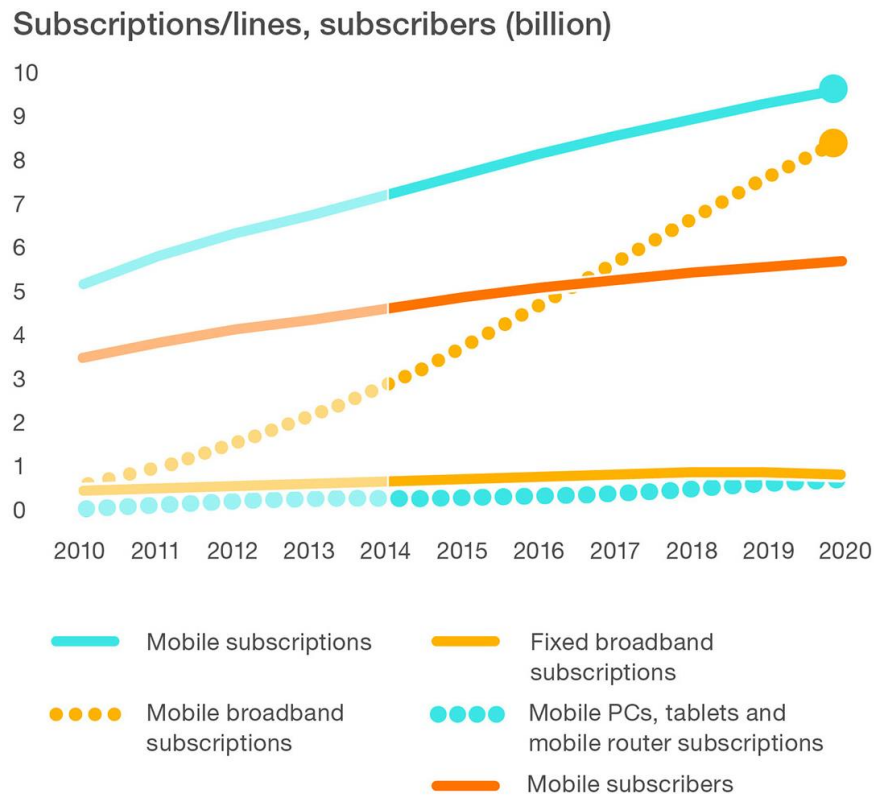


Figure 1: Fixed and mobile subscribers [2]

Figure 1 above shows the comparison of different types of subscriptions. By 2020 there will be 7.7 billion mobile broadband subscriptions. For some reason the fixed broadband will be in competition with mobiles in some segments. Due to more use in the enterprise level and for household purposes fixed broadband users will be three times more than fixed broadband connections.

2.1 Mobile Applications

Depending upon available options people use both mobile websites and applications, but again mobile application win the race as they are usually more user-friendly and easy to use. A mobile website is similar to any other websites that are built on browser-based pages supported by HTML and the CSS standard. Mobile websites are designed for small-size screens using media queries (defining separate design property) and also some of them have specific features for mobiles like click to call or location-based functionalities. But again people do not want to open a browser, type in a URL and wait for data to be rendered the in browser. They rather want to use a mobile application which

they can download once and use whenever they want. There are three options for developing a mobile application namely Web, native and hybrid applications that will be discussed in the following section 2.1.2.

2.1.1 Single Page Application (SPA)

Web applications follow a round-trip (multipage) model where a request is sent to the server through user interaction like form submission. The server sends as a response back to the browser completely new HTML documents. In this approach a series of HTTP requests are sent by the browser where the server by generating HTML documents handles the requests. Most of the web applications in the past and these days are still following the same way but not the least. There are many drawbacks with this approach like, the client has to wait for long to get the requested page loaded, managing and processing this process requires large server infrastructures and uses high bandwidth as the requested documents has to be self-contained (the same content being included in every response) [5, 44-45].

A single-page application follows a different approach. After user interaction the initial HTML document is still sent to the browser but it never gets reloaded again. Only some fragments of the page get reloaded asynchronously as per the user interactions while other content remains unchanged. Ajax which is somehow an old technology makes it possible to develop single-page applications by making asynchronous loading. Angular (will be discussed in following chapter) makes single-page application more efficient by a manageable code, fewer DOM dependencies, providing smooth transition and rich user experience.

2.1.2 Native, Web and Hybrid Applications

The development in the web standards has also changed the way developers think and work. HTML5 not being very smooth even very soon became first the choice for applications because of its versatility. HTML5 has in the last half decade shown its effect on also mobile applications with support of powerful JavaScript and other frameworks and tools. A mobile application is a self-contained program that pulls content from powerful internet like websites do or downloads data, depending on whether the application is

online or offline [4.] Native applications are built on platform (operating system) dependent strategy, meaning different platforms have their own tools and technology required.

Native developers need to strictly stick with specific programming languages, SDK and other tools for the target platform. For example the programming language to develop an application for iOS is objective C (recently swift), for Android it is Java and C# for Windows is required. A hybrid application can give freedom for developers to use their web development skills like HTML5, CSS and JavaScript to develop a mobile application. Once the code is created, it can be used for various platforms by editing only a small portion targeting at a specific platform. A web-based application is another type of mobile application, as websites are responsive and sometimes designed to look like a real application. Written in HTML5 (jQuery Mobile and Sencha Touch can be used) web applications follow "write-once-run-anywhere" rules.

Hybrid applications give a similar look and feel to users as native do without letting them feel as not native. A hybrid approach of application development shows its weakness when it comes to 3D gaming like applications. Hybrid applications are also considered slow while native applications are believed to perform fast. Native on the other side has access to all hardware and software functionalities. Multi-touch, documentations, fluid animations, ease of use and faster graphics feel are some of the functionalities that can be only achieved with native applications. IDE (Integrated development environment) supported with debugging, version control and other important tools required for developers is used in the development of the native application.

Table 1: Comparison of native, HTML5 and Hybrid applications based on mobile features [6].

	Native	HTML5	Hybrid
Application Features			
Graphics	native API's	HTML, canvas, SVG	HTML, canvas, SVG
Performance	fast	slow	slow
Distribution	Appstore	web	Appstore
Device Access			
Camera	✓	✗	✓
Push Notification	✓	✗	✓
Filesystem	✓	✗	✓
Geolocation	✓	✓	✓
Gestures			
Swipe	✓	✓	✓
Pinch, spread	✓	✗	✓
connectivity	Online and offline	Mostly online	Online and offline

An overview for the comparison between different types of mobile applications is shown on the basis of the features. Table1 shows that a hybrid application is somehow between native and HTML5 that support less than native and more than HTML5.

In the rapidly growing world time is an important factor and no one would like to waste money. Hence, for application developers it is very important to select a better option among the available technologies in order to deliver best and fast to the user. Native applications provide best performance and enable access to all of the underlying functionalities of the mobile phone they run on. A hybrid application on the other hand has the advantage that one application looks native on all the devices with different platforms. One codebase automatically changes the UI no matter which device it is running on. The building blocks of a hybrid applications is HTML and JavaScript. Both native and hybrid applications can be downloaded from the vendors market Play Store for Apple and Google Play for Android.

2.2 Client Server Communication

The communication in the world of computers is totally different than the real world with people. Protocols and server are two things that make it possible to exchange information. There are sets of defined rules to communicate with software, hardware and networks (internal and external). Those sets of rules for communication are known as protocols and are often known as the backbone of the network. Protocols can be different for different tasks and networks. Protocols are available in all the various layers of communication from the physical to application layer. TCP/IP, HTTP, SOAP, UDP, FDDI, FTP and SMTP are some examples of protocols.

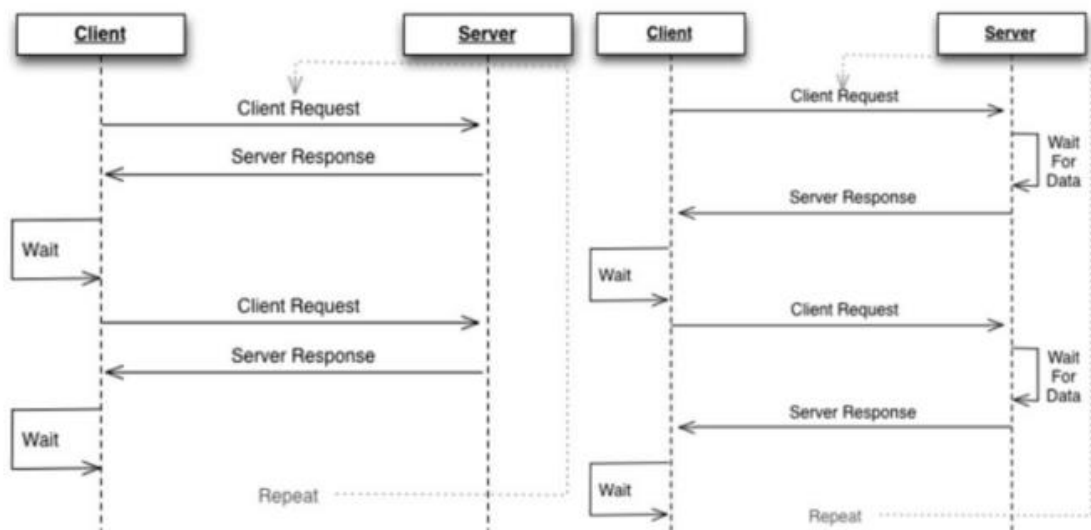


Figure 2: Sequence for basic data poll and HTTP long push [7]

Figure 2 on left shows the basic data poll sequence which is helpful for achieving near real-time performance. Standard web protocols and the ports are used to complete the communication. On the right, HTTP long data poll sequence is shown and can be used in HTML/JS. HTTP push is categorized into HTTP push and HTTP long polling.

For the communication, the server plays as important a role as protocols. Defining technically a server as a device or software depending upon use case. In other words, any program which is capable of responding requests from another program or device is known as a server. Servers may have different functions such as file server, print server,

network server, database server, email server and gaming server to mention a few. However, some of the servers also work together for services like DNS, e-mail, FTP and even web servers work together for multiple websites. If a server fails to deliver it might create problems for user so it should run continuously without shutting down.

JSON stands for JavaScript Object Notation which is a platform-independent lightweight data interchange format. JSON being easily human readable and writable works better than XML which is also used for data formatting [8.] XML having some limitations makes it a second option after JSON these days. JSON can be easily parsed by JavaScript to generate data exchange for Ajax-based web applications [9]. The Angular framework also uses JSON for the data interchanging and displaying process.

```
//creating a JSOB object

Var employeeobj = {

  "FName": "Rakesh";
  "lName": "Mahato";
  "Sex": "Male";
  "department"= "library";

};

document.write ('My first name is ' employeeobj.FName);
document.write ('Rakesh works at ' employeeobj.department);
```

Listing 1: Code for creating JSON object

Listing 1 above creates an object with variable employeeobj with four variables and their values inside curly braces using pair of name and value. To access the value of employeeobj the name of property is referred. The last two lines of list print Rakesh as employeeobj first name and library as employeeobj department.

2.3 Web Tools

Different web tools have made the life of developers and designers easy. They also help to make the hassle free working environment. Web tools like Npm and Bower help to manage dependencies in the project and task runners like Grunt and Gulp help in work automation.

Node.js

Node.js is an open-source event-driven server side platform that allows to build on scalable application using JavaScript and work as the run-time environment. It is cross-platform, lightweight as it uses non-blocking I/O model and is suitable for real-time applications. It uses JavaScript V8 engine (also used by Chrome) and builds a wrapper around to provide fast network applications.[10]

Npm

Npm is a NodeJS package manager. A package is a directory with one or more files on it. A web or mobile project depends on dozens or hundreds of such packages. Packages are generally small building blocks which make it possible for composing larger and custom solutions. [11] Using Npm, JavaScript developers can easily share the codes they have written to other developers and other developers can reuse them to their application. Once the packages are installed using Npm, it makes developers easy to check if the contributors of that package have made any changes or updates regarding that package; thus, it can be also used as a package automation tool.

Registry is a huge database of information about the packages that developers are sharing. Using Npm client, which is installed on the developer's local computer, one can share and publish the code to the registry which other developers can reuse in their application. Npm needs NodeJS to operate. Once, NodeJS is installed on a local machine, Npm can be installed globally and used from any subfolder of the project using a terminal or command prompt.

Bower

Bower is a package manager. It manages external packages needed for a web application like Bootstrap (A CSS framework), jQuery (JavaScript library), AngularJS (A JavaScript framework). A web application is made of many dependencies like frameworks, libraries, utilities and assets. Bower works fetching and installing packages and taking care of them. [12] When we install the dependencies using Bower, we do not need to

take care of the version of the dependencies because they are automatically updated. Bower needs to be installed globally on a local machine and it needs a command line tool like a command prompt (for Windows) and terminal (for Linux and Mac OsX) to operate. Bower is a Node module. We need Node and NPM installed on our machine to install Bower. All Bower packages are Github repositories, so Bower packages needs Git also installed in our machine. We can specify the dependencies needed to the project in bower.json which works like package.json for Node. It is the manifest file for Bower. Npm is most commonly used to manage Node modules and Bower is solely for the front-end dependencies.

Grunt

Grunt is a JavaScript task runner. It helps in task automation. There are many repetitive tasks that are performed in a development environment like magnification of codes, compilation, unit testin and linting. Using Grunt, the tasks can be fixed automatically. Once we configure all the dependencies through Gruntfile, a task runner will be created which will do all the tasks with zero effort. [13] Grunt is a command-line utility tool. It can be accessed through the command prompt of wWndow or terminal of Macintosh or Linux. Most of the tasks that are needed in the development environment are already available as Grunt plugins.

We can also develop our own plugin as per necessity. It is installed in the project environment using Npm, a Node.js package manager and accessed locally as a web server. It needs stable Node.js version to operate. Grunt is installed globally, so we can run it from any subfolder in the project. Each time Grunt is run in a terminal or command prompt, it automatically looks for the installed Grunt using the node's require () function. Grunt in a project needs package.json with the dependencies required and their version for the project as metadata and a gruntfile, a JavaScript file which will access the dependencies from package.json and runs the tasks specified.

```
{
  "name": "my-project-name",
  "version": "0.1.0",
  "devDependencies": {
    "grunt": "~0.4.5",
    "grunt-contrib-jshint": "~0.10.0",
    "grunt-contrib-nodeunit": "~0.4.1",
    "grunt-contrib-uglify": "~0.5.0"
  }
}
```

Figure 3: A sample of package.json. Reprinted from gruntjs official website[13.]

```
module.exports = function(grunt) {

  // Project configuration.
  grunt.initConfig({
    pkg: grunt.file.readJSON('package.json'),
    uglify: {
      options: {
        banner: '/*! <%= pkg.name %> <%= grunt.template.today("yyyy-mm-dd") %> */\n'
      },
      build: {
        src: 'src/<%= pkg.name %>.js',
        dest: 'build/<%= pkg.name %>.min.js'
      }
    }
  });

  // Load the plugin that provides the "uglify" task.
  grunt.loadNpmTasks('grunt-contrib-uglify');

  // Default task(s).
  grunt.registerTask('default', ['uglify']);

};
```

Figure 4: Sample of Gruntfile.js. Reprinted from gruntjs official website [13.]

Gulp

Gulp is also a task runner for a development environment. It was developed after grunt. Grunt and Gulp do almost similar tasks in different ways. There are some drawbacks of using Gulp instead of Grunt. The first is speed. Gulp uses Node streams to group tasks and processes them sequentially in memory. To run four different tasks on a group of files, Gulp requires only one write to the disk but Grunt needs to configure input and output for each task returning in four separate writes. Grunt's tasks are configured in a configuration object inside the Gruntfile, while Gulp's are coded using a Node style syntax. Gulp is younger than Grunt so it is not well documented. Grunt needs to be installed globally on our local machine. It uses Gulpfile.js like Grunt uses Gruntfile.js. [14]

3 Technology Used

JavaScript is a widely used lightweight scripting language that gives foundation to dynamic web applications and mobile applications. JavaScript being main the client side scripting language for WWW (World Wide Web) is able to create interactive effects inside the browser to display the client. It is termed as major scripting language which is adopted and supported by many vendors as the client-side scripting language. JavaScript also supports PDF documents and desktop widgets which are non-web-based environment. JavaScript with help of its library has brought new changes in the WWW and has become the most popular scripting language.

3.1 JavaScript Libraries and Frameworks

There are many JavaScript libraries (collections of pre-written functions) like jQuery, MooTools, Dojo and others that makes the languages strong and increase the popularity of the language. These libraries support the wide range of functions such as events handling, animation, effects, Ajax and many more for creating dynamic web applications. To accomplish the development work in easier fashion there are various JavaScript frameworks available. Frameworks is a set of reusable code that includes collections of functions, objects and templates. Frameworks assist developers to avoid painful start of developing applications from scratch [15.] The pre-written codes can be used every time when building new applications. Most of the frameworks follow a standard way of development and have consistency.

Frameworks for mobile devices are developed considering the device sensibility. Sencha Touch is one of the mobile web application UI frameworks (often referred to library) for iOS, Android and BlackBerry. Sencha touch as its name is a touch-optimized framework that supports a wide range of touch functionalities in a mobile device. Applications built using Sencha touch can automatically detect whether we are on a mobile or tablet. It has become the developer's choice because of some other features like widget options, GUI tools, Sencha command line tool, faster and many more. Sencha touch can also be integrated with popular frameworks like PhoneGap for cross-platform applications development. [16]

Angular, React, Ember, Backbone and Polymer are some popular JavaScript frameworks. React is currently getting popularity as it is being used by a Facebook and Instagram on its UI. So it can be guessed that React is powerful frameworks and can be used for big enterprises. Frameworks make the work easier for developers by allowing them code less. Frameworks also assist the creation of an efficient code structure and maintenance with the primary function to reuse code as much as possible. Among various JavaScript frameworks Angular is getting high popularity and is being adopted in many small and big companies and for the same reason the framework was used in this project.

Table 2: Comparing the community of JS frameworks [17]

Metric	AngularJS	Backbone.js	Ember.js
Stars on Github	40.2k	18.8k	14.1k
Third-Party Modules	1488 ngmodules	256 backplugs	1155 emberaddons
Stack Overflow Questions	104k	18.2k	15.7k
YouTube Results	~93k	~10.6k	~9.1k
GitHub Contributors	96	265	501
Chrome Extension Users	275k	15.6k	66k
Open Issues	922	13	413
Closed Issues	5,520	2,062	3,350

Table 2 shows a comparison of Angular, Backbone and Ember frameworks on the basis of metric till June 2015. Angular is leading among the three, in all the above parameters. Angular questions on stack Overflow and project on GitHub are more than a combination of Ember and Backbone. From the table the current state of all three frameworks can be defined.

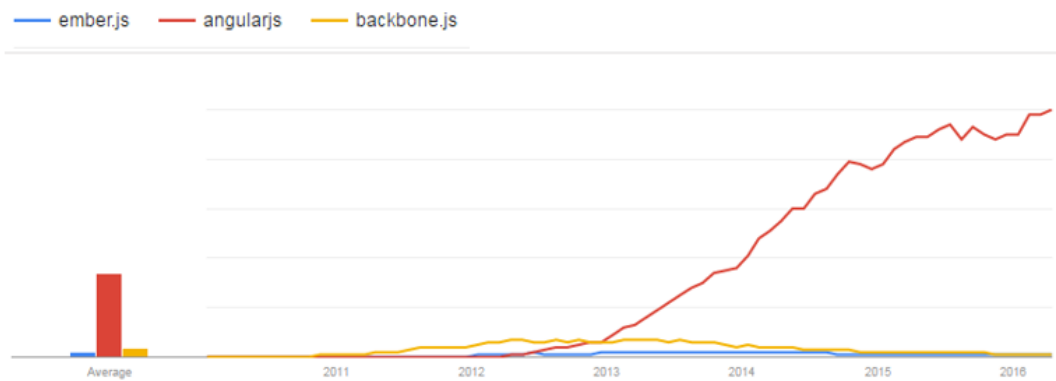


Figure 5: Search interest worldwide 2010-2016 [18]

In Figure 5 the search interest of different JavaScript frameworks has been displayed in the form of a graph from 2010 to 2016. In the past four years Angular has been the leading one in terms of popularity. In addition an average from 2010 Angular is the winner. India is the country where the framework was searched most, with the USA following the second.

3.2 Angular.js

Angular is an open-source front-end JavaScript framework released in June 2012 (initially developed in 2009) by Misko Hevery (a Google employee) and currently maintained by Google. The framework became popular after becoming a part of Google offerings. Moreover, it contains some unique features for designing dynamic web applications. It is also defined as the structural framework for the web application supporting MVC (Model View Controller) pattern. Two-way data binding, directives, dependencies injection, controllers and module are some of the special features why Angular has become a widely used framework across the globe [19]. Angular is suitable for large company websites as well as for small and light enterprises.

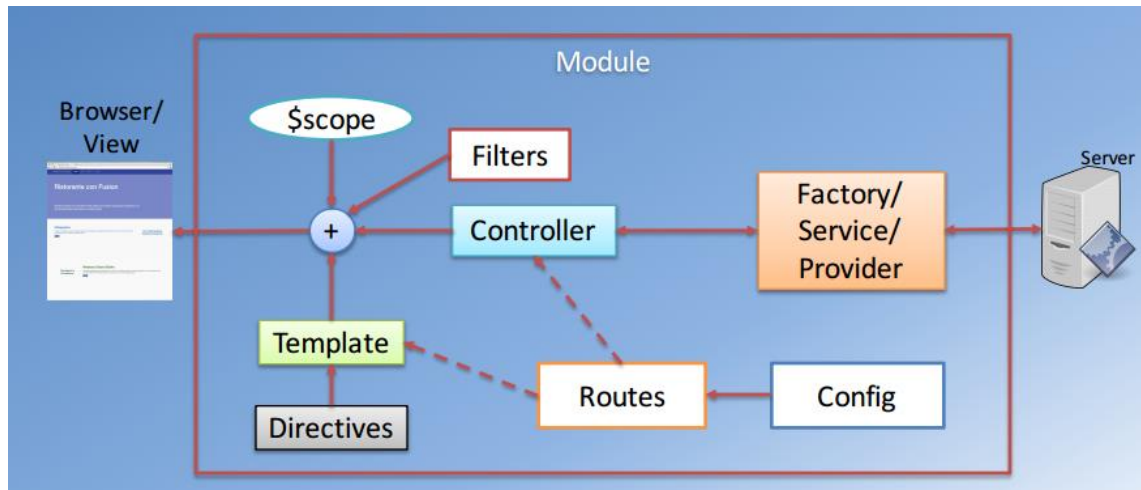


Figure 6: Overview of Angular [20]

Figure 6 shows how an angular application is built upon and supports MCV. It shows how a browser view is rendered by a template that uses directives, routes that configure single-page applications, and controllers that draw in data from a factory or service or provider. Communication with the server is handled to the factory /service/provider.

Angular have many built-in directives that custom HTML attributes. Directives start with ng hyphen (ng-name) for example ng-app, ng-init, ng-model, ng-repeat and others. Directives have their own function. To define the root of the application ng-app is applied in HTML tag. Two data binding can be created with ng-model meaning HTML and CSS property is updated together with the JavaScript variable. [19]

3.3 Apache Cordova

Apache Cordova is an open source application development framework that allows the developer to use web standard technologies like HTML, CSS and JavaScript developed in 2009 by Ntobi [21]. It is also known as a platform wrapper or container for native applications that export the JavaScript API's. Formerly known as PhoneGap owned by Adobe, it can also be termed as an engine that powers PhoneGap. Traditionally developed web applications cannot make use of native device capabilities like GPS, Camera and others. These limitations are overcome by Cordova inbuilt plugins. Chrome and Safari Dev Tools make debugging the Cordova application much easier. Developers can choose options from two application paths with Cordova namely cross-platform and native. The more commonly used is the cross-platform that uses Cordova CLI (Command

Line Interface) as primary tool. Native is another option where one has to modify some native code with Cordova components.

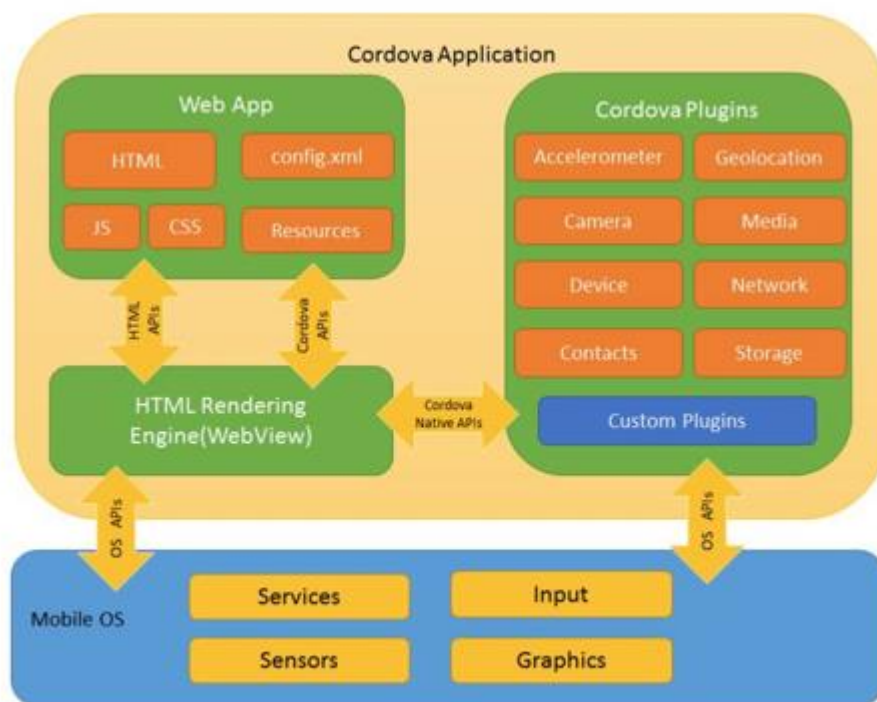
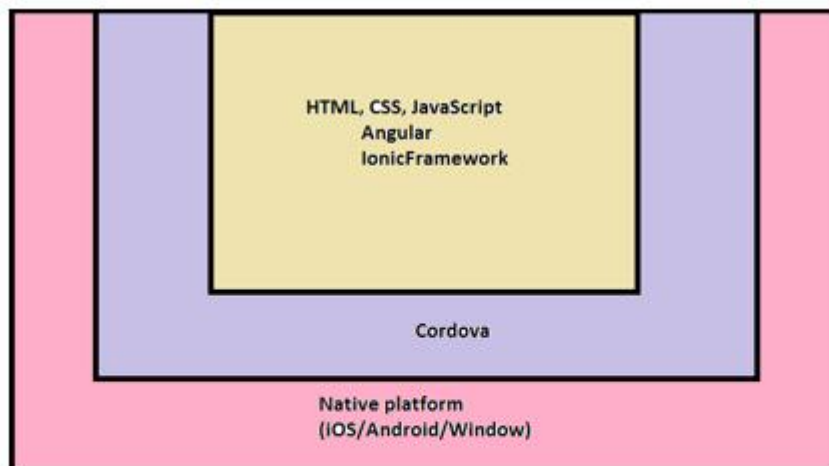


Figure 7: Overview of Cordova application [21].

Figure 7 shows the overall Cordova architecture. Any application developed upon Cordova have two primary parts as the JavaScript business logic layer and JavaScript part. The Business layer drives the user interface and its functionalities while device functionalities are controlled and accessed by the second part.

3.4 Ionic Framework

Ionic is an open-source framework for HTML5 mobile applications that can be implemented for hybrid mobile application development. It supports versions from iOS7 plus version in Apple devices and Android 4.1 plus (KitKat, V-19) with the help of Cordova-blessed and other third-party plugins. In addition it also supports HTML5 and CSS3 friendly modern browsers [22]. It uses JavaScript and CSS components, Cordova plugins and MVC architecture provided by Angular. Ionic provides zero query and less DOM manipulation which makes the framework faster for rich applications. It is built upon Angular and to make it run on the mobile ionic requires Cordova (application development framework) as wrapper. Cordova along with Angular makes the framework stronger in many ways. An application built with Ionic is clean and easy to understand. The startup application is provided with some template options which a developer finds easy to get started with.

4 Mobile Architecture

4.1 Android

Android is a Linux kernel based operating system currently owned and maintained by Google. In 2005 Google bought the sophisticated operating system from Android Inc. owned by Andy Rubin and team. Taking over Android was first step by the giant company Google to enter into the mobile phone world. On October 22, 2008 the first mobile phone with Android OS was brought in the market as HTC Dream [23.] After the first version in 2008, there have been many updates done one after another adding new features and functionalities. Android releases its major versions in alphabetical order like Cupcake, Donut, Eclair, Froyo, Gingerbread, Honeycomb, Ice Cream Sandwich, Jelly Bean, KitKat, Lollipop and Marshmallow (the latest version released in 2015). Google has associated with companies like LG and HTC to expand the Android market. These days the OS is not just used on mobile phones but also devices like tablets, television and others. In the initial phase of its development Nokia was main rival as Symbian-based phones were mostly used by people.

In the present situation Android seems to be the leading operating system after iOS in both tablet and smartphone. It was suggested that an Android-based tablet has been the most sold tablet since 2010 [3]. In the beginning developers were uncomfortable to develop application for tablets. As a result it takes quite long for Android to grow its market in tablets. Android publishes distribution for application through Google Play known as play store. Through play store also third-party can publish their applications. There are more than one million Android applications available on Google Play. Android on the way of its development has achieved remarkable growth and has emerged to become the leader.

As Android keeps growing its market all around the planet there are also some issues relating to its trend of development. Ever since Android has become part of the flourishing giant Google many controversial actions have been marked on its name. Most recently in April 2015 the EU (European Union) has filed and taken actions for going against the EU competition law [25]. Investigation order has been issued for Android from the EU antitrust commissioner Margrethe Vestager. Google has been accused for forcing the manufacturing companies for preinstalling some applications like Google

search in their devices and in return the companies have been paid incentives. Apart from Europe regulators in countries like India, Russia and South Korea have also asked for some inquiry.

4.2 iOS

iOS developed by Apple Inc. is an operating system for smartphones and other devices like iPad and iPod. The operating system was formerly known as iPhone OS. The operating system first came into light in year the 2007 bringing a new era of smartphones. Having not strong competitor in the market the number of iPhones sold reached 70 million by the year 2010 [3.] Starting first in 2007, there are many versions of OS launched in iOSX (X is version number) form. The recent version of iOS is 9 with iOS 9.3.2 beta version recently released by Owner Company. It is one of the power OS and second popular after Android. In terms of tablet it was market leader before 2013 when Android based tablets overtook its sales. Apple distribution place Apple's App in store for application. In most of the cases Apple's devices does not accept applications downloaded from other sources. In the beginning of year 2015 100 billions applications were downloaded from the store [29.]

5 Application Development

Mobile market has grown beyond by time and anyone could have imagined. There are many platforms (like iOS, Windows and Android) and various frameworks upon which applications are built. One of the biggest challenges for the developer is how to maintain similar user experiences and trust among various platforms users. Before heading towards the development of mobile application one should concentrate on certain factors like design the UI either lightweight or heavy, types of devices supporting and other functions [5]. As there are some of limitations while building hybrid. Native application development really require more time and effort as compared to hybrid as one needs to have strong experience on platform specific skills. Whereas hybrid application gives solution to a problem of developing platform independent mobile application which can work in more than one platform. There are different tools and technologies which hybrid mobile application rely on (explained above).

5.1 Requirement Analysis

As already mentioned in the introduction part, the application was made to manage car rental. The users of the application are people who want to hire a car for some period and the administrators are the car renting companies.

Analyzing the requirements of application, the basic requirements of application are:

- An interface for administrator to add picture, details and price about the car.
- An interface for users to view the information of car, rent a car, comment and rate after using it.
- An interface for the administrator to manage bookings.

Analyzing those requirements, the application has some technology related requirements, listed below:

- The application should work on multiple platforms, Android and IOS.
- The application should be in Ionic framework.
- The application should use HTML5 and CSS3 for scripting and styling and JavaScript (Angular) for functioning.
- The application should use NodeJS and JSON server.
- The application should use MongoDB as database.

- The application should use Apache Cordova to access device's functionalities like alarm, camera and it should be compiled using Apache Cordova.

The reason for choosing a hybrid application are:

- It is cost effective as a single development process handles both Android and IOS application.
- Hybrid mobile applications are built in a similar manner as a website. Both website and application use a combination of technology HTML, CSS, and JavaScript.
- Knowledge learnt to build a website is reused here. It saves time for learning native application development technology for each platforms.
- Maintenance is cheaper and easier as we can easily get developers working on HTML5/CSS3/JavaScript.

The reason for choosing Ionic as an application development framework are:

- It is easy to install and scaffold.
- It combines AngularJS with HTML5 and CSS3 and uses Cordova to access native device functionalities.
- It is free of cost.
- There is a nice team behind this framework as they support to beginners and meanwhile support from experienced developers are growing as well.
- Using Cordova device plugin, it is easier to address multiple device size.

5.2 Development Environment Setup

The development team consists of two members. I was responsible for front-end development of the project with the role of planning and implementing front-end development. MacBook air with operating system IOS10 was used as workstation and localhost. All the project implementation and setup done was in this workstation.

Sublime text 3

Sublime text is used as a text editor as it have some attracting features like code highlighting and different options of different language. Multiple cursor is one the new features I had experienced in any editor. Loading faster of the editor, huge selection of plugins and code preview for big application are unique features of sublime text.

Google Hangout

As the project was done in the group of two people from different location, the medium of conversation was Google Hangout.

Git

Version control is very important factor in software development process. Git was used for version control.

Android SDK

Android software development kit (SDK) is the collection of software tools used for Android platform application development. SDK helps developers with components like libraries, API's, debugger, emulator and others [14]. These components can also be downloaded separately. Most of the SDKs are supplied with IDE (Integrated development environment) and comes with some text editor tool like eclipse. IDE in the case of Android is android studio (official) and in case iOS it is Xcode.

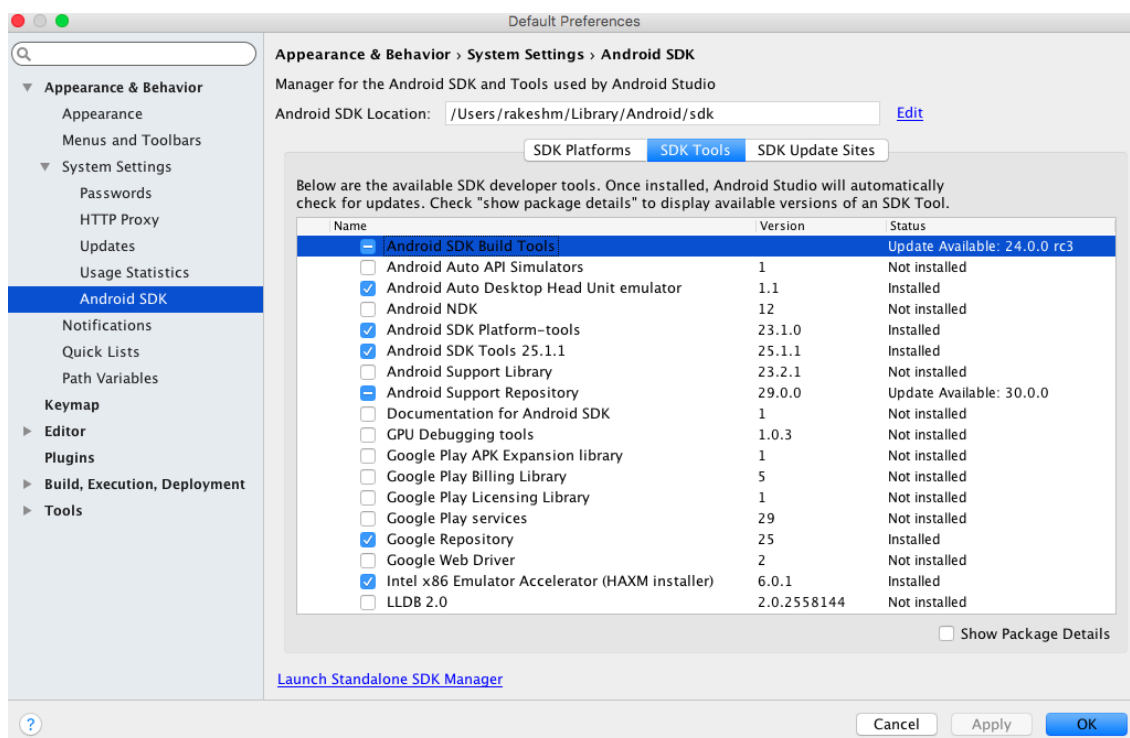


Figure 8: Snippet from Android Studio.

Figure 8 show the options available for API level through SDK manager in Android Studio. It shows that various APL required for Android and emulator was installed. API label 21, 22 and 23 was installed for supporting respective version of Android emulator.

Java Development Kit (JDK)

JDK is an environment for application development and running Java application that includes java runtime environment (JRE) on top of operating system. In other words it is a collection of tools like JRE, java as an interpreter, javac a compiler, jar an archiver, debugger and other required tools for the developer.

Xcode

Xcode is IDE (integrated development environment) developed by Apple Inc. for developing applications and games for Apple product development. It was used to compile and deploy the applications in an iOS environment.

To develop any application one should have some requirements and settings. The Ionic framework has been used in this project targeted for iPhone and Android. For the Android ionic support 4.1 plus version and iOS7 plus version with native SDK. After developing, Cordova application must be deployed for native dependent upon the desired platform. The process of development and deployment for Android and an iOS is different using specific tools like SDK.

6 Implementation

The implementation phase of the project involves an installation and developing process. In the installation process, Node.js that comes with NPM was first installed globally in the workstation for server site environment. NPM is also most important for ionic and cordova to get working. Ionic and cordova were installed along with web tools (mentioned above), following installation documentation from respective websites. For the ionic side menu templates was taken as default and various folders were organized. The default templates brings on some files and folders automatically. The JSON file that serves as data exchanging was also organized in the same folder where main file (CAR_RENT) for application was located.

The server setup was is another part that cannot be skipped or application development. As this project only explains front-end application development s simple server was used. Node module known as json-server was used that serve JSON data stored in simple text file also provide static support to application. Being a node mode module command “sudo npm install json-server -g” was used to install the server globally.

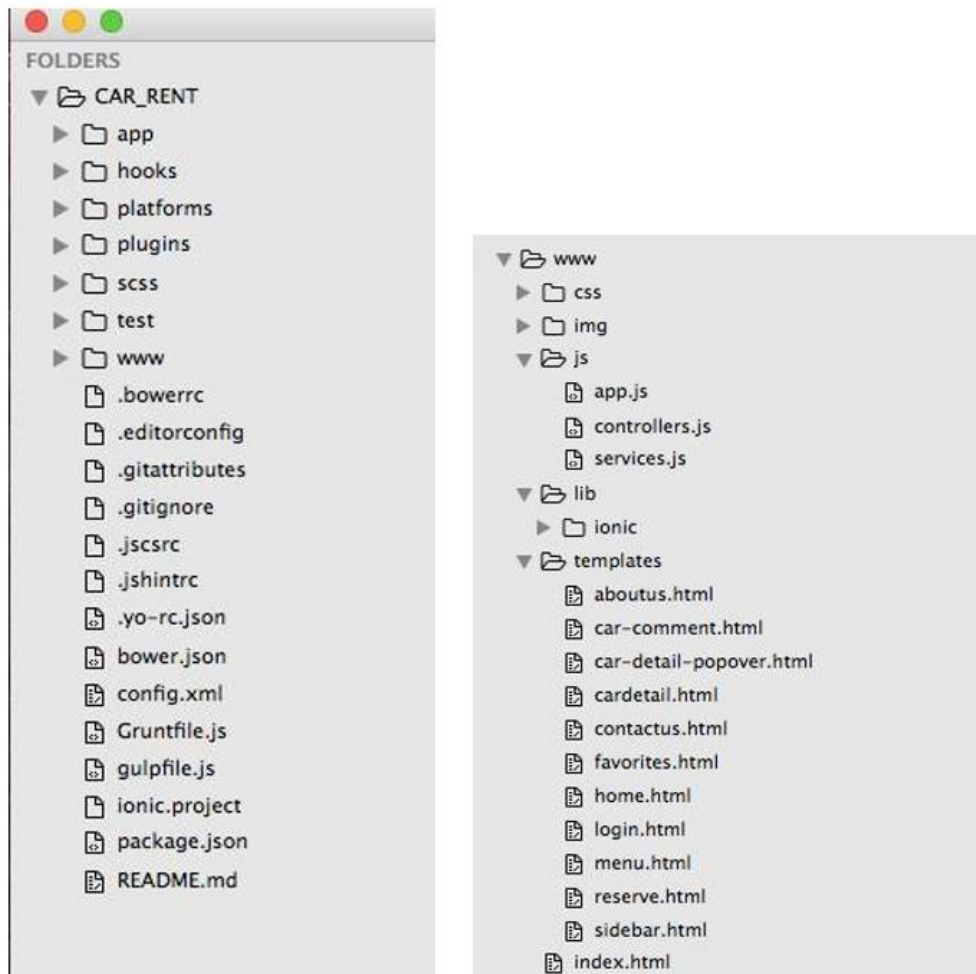


Figure 9: Overview of application folder.

Figure 9 shows an overall file and directory of the project viewed in the sublime text. The WWW is being the root directory that contains application file related to HTML in .html, JavaScript in .js and CSS in .css folder. Application dependencies are handled by Bower and NPM that are mentioned in bower.json and package.json. There is also library (lib) that passes the downloaded library to index.html file. File named ionic.project contains the general configuration information about the project

All the different Angular module are defined separately according to ionic standard. All the starting information is included in index.html file. It holds reference to CSS, JavaScript for ionic and Cordova. The file also contain controller.js and app.js file which is some configuration for project. In the body of index.html some angular modules are included with ionic own angular directives. Configuration for single page angular application is mention in app.js file in WWW root directory.

Navigation scaffolding

The navigation menu is the first thing in any application a user looks for. It gives a kind of idea for the user where to navigate and what to do in the application. The Ionic application comes with the default navigation with it and can be scaffolded it as per necessary. At the starting all required information for project is included in index.html file. It holds reference to CSS, JavaScript for ionic and cordova. The file also contains the reference for controller.js and app.js file. In the body of index.html some angular module is included with ionic own angular directives. Ionic has its own markup tags for different elements used in an Ionic application. The navigation items of the applications are in separate file sidebar.html enclosed inside the tag ion-side-menu which is like a container for the menu items. Menu items are kept inside ion-list tag.

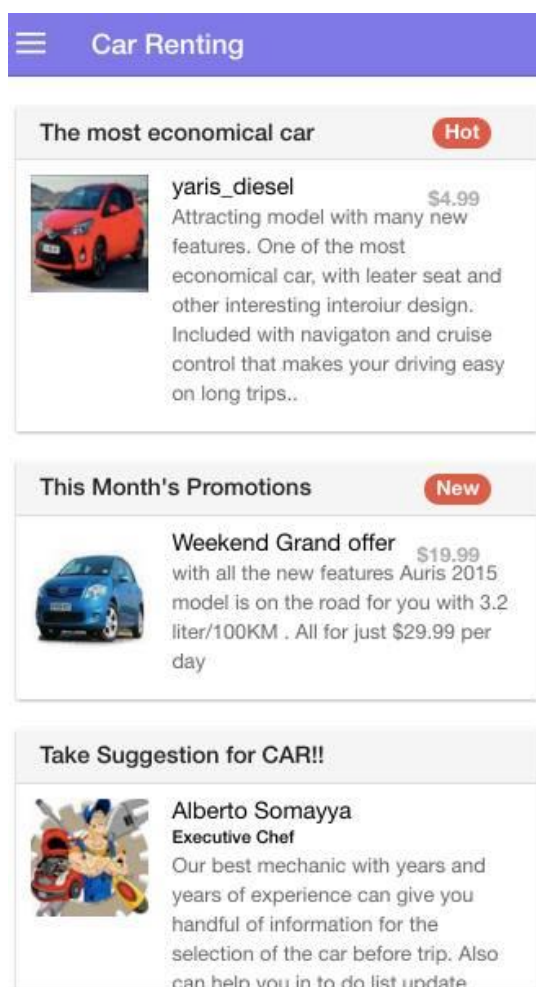


Figure 10: Home page of car renting application

Ionic Form and Modal

The application uses forms for various purposes like user sign up, user sign in, reservation and so on. Forms are usually grouped as list elements and labelled as item-input. The default form input in Ionic is of 100% width and has no borders. It uses placeholder attribute to simulate the input's label. Once, the user begins to enter text into input field, placeholder labels will be automatically hidden [22]. Inline label has been applied in the forms and supported by modal. Login page and reservation page in the application uses forms with various ionic elements. Two-way data binding was used to tie input different in the form. Toggle button for insurance was added which function as normal toggle in web pages. Modal is a service provided by ionic injected inside controller by declaring name.

Ionic Filter

Angular filters can connect the things together with the view and model without writing huge code for controllers. Angular matches different attributes and displays using filters. In this project filters are used to list items in the side menu and main menu page. Filters have also been applied to list specific items under all, diesel, petrol and hybrid named attributes.

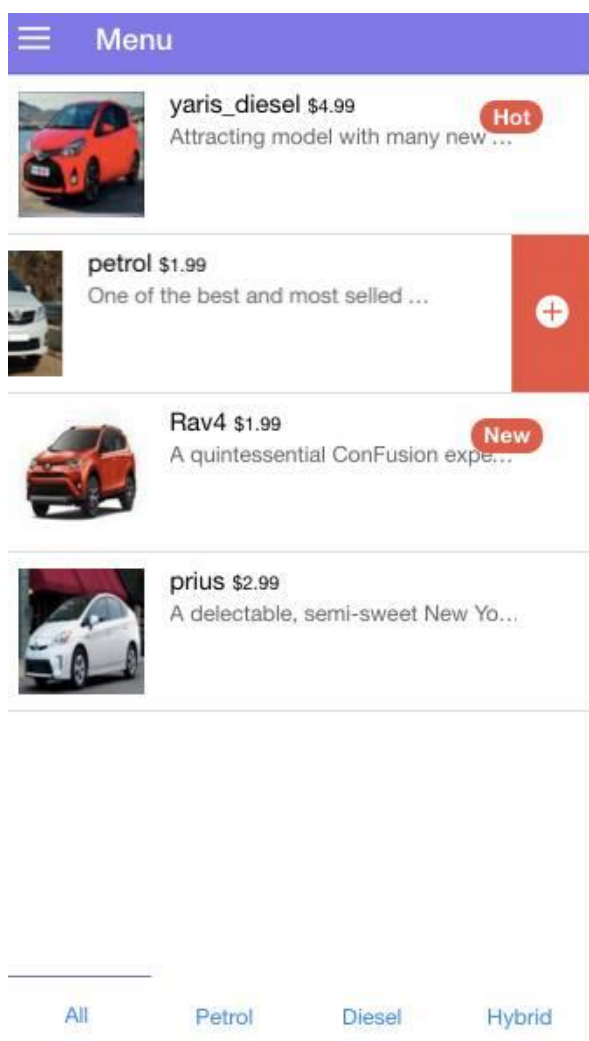


Figure 11: Menu by content filtered

Ionic template and side menu

Templates are designed using ionic CSS and JavaScript classes and ionic's own directives for displaying data. All the templates under WWW folder are designed one by one independently. Ionic tag `ion-nav-view` is used to render templates. Default template with `<ion-side-menu>` directive gives side menu as well as main page where all the information is displayed. In this application all the templates are named according to their function for example `menu.html` gives the menu, `aboutus.html` gives contact information and so on. Side menu content custom is custom directive by ionic hold whole content of the application. Top navigation bar of side menu can be designed with various Ionic CSS classes (`bar-royal` in this application) and back button for native appearance with `nav button` directive. Side menu is most important in UI design in this application with item like home, contact us, about us, login, menu and favorite inside `ion item` tag. Any

changes in the item of side menu should must be configured and updated in the app.js file under state property.

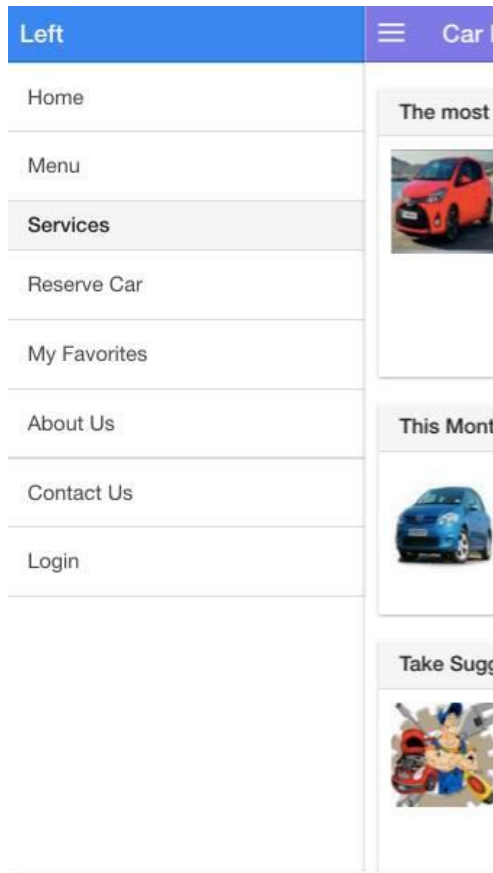


Figure 12: The left side menu of the car renting application

Controllers

The Controller works as bridge between view and services by serving data for templates. The application has features to add items in the favorite list and for this under menu controller play addFavourite function was implemented.

Service

Services enable ionic application to use angular resource to go and the data from the server later data is used in controller for actual data accessing. Base URL for the application development was use as localhost:3000/ but which need to be changed while testing in mobile device to IP address. Also angular module required dependencies injection (ngResource) as application services uses angular resources and require access to server. Correspondingly angular-resource was imported to index as angular-resource

do not come with ionic bundle and need manual import. Service.js file must be included in index.html file as services.js is the part of application.

The screenshot shows a mobile application interface for reserving a car. At the top, there's a status bar with '3G', '37%' battery, and '21:59'. Below it, the form is titled 'Reserve car' with a 'Close' button on the right. The form consists of several sections separated by horizontal lines: 'Number of Days' with a dropdown arrow, 'Insurance' with a toggle switch, 'Pick-up Date', and 'Time'. At the bottom of the form is a prominent blue button labeled 'Reserve'.

Figure 13: The reservation page for car

Reservation page is shown in figure 13 above from the car renting application. User can go to reservation page from side menu where they have some required field to be filled before they can confirm their reservation. Number of days, extra insurance can be choose by shifting button to right, pick-up day and time of arriving are the input fields for the reservation process.

app.js

App.js is the location where single page Angular application is configured with angular.module controller with various parameter. This file also include other controllers like ionic, starter and others. Single page application configuration parameters like stateProvider , urlRouterProvider and states have been defined here.

Local Storage

Mobile applications sometimes have to store and retrieve some data within local device known as local storage. In Ionic application the HTML5 standard that supports local storage, is used. As local storage only supports string storing, for JavaScript object to get stored it first needs to be converted to JSON string. Window service can be called in Angular for browser window followed by calling local storage. Local storage service then can be used later to remember user information.

Development of ionic application follow next step for deployment into native and requires some setup. Android studio as SDK tool for android was downloaded and installed from official website. Whole process was completed with help of documentation available in official cordova website. Installing cordova shell is an optional. Certain environmental variable through terminal was setup for example .bash file. Configuration for emulator (Android) for testing and Android device configuration was completed too. With the emulator there are some restriction as emulator do not support all the functionalities as real device do.

```
'use strict';
/*global angular*/
angular.module('conFusion.services', ['ngResource'])
  .constant("baseUrl", "http://IP Address:3000/")
  .factory('menuFactory', ['$resource', 'baseUrl', function ($re-
source, baseUrl)
```

Listing 2: Code from service.js file for localhost configuration.

Listing 2 explains the setting for localhost as baseUrl in services.js file. BaseURL when running application on local machine is localhost that need to replace with IP address (not visible on code) of MacBook (workstation of project). As emulator is a separate virtual machine, it will recognize the localhost as emulator itself to access data from server.

7 Testing and Debugging

Testing and debugging is one of the unskippable parts of any project. Testing after development and deployment of the project is a major step which takes quite a long time depending upon the number of bugs found. The documentation for testing and debugging was done for future reference. While testing in iOS (the real device) it required some license from Apple, and was skipped, and all testing was executed in an Android real device. Testing with Samsung Galaxy s4 (I9505) with Android version 5.0.1 and Samsung A500 with 5.0.2 Android was performed. While testing with real device the application functioned fine except small errors. One of the small error, the reservation page was not getting closed without user reserving something. This issue was occurring because of spelling mistake in the close function in the reservation template.

The debugging process was quite interesting part of this project as I came across new technologies for debugging which helped me to enhance my skills. Hybrid application is somehow easy to debug when compared to native as to get results the developer does not have to wait for compilation of source code. There are various tools and extension available for debugging. In addition, as this project is an Ionic application which is built on the top of Angular, it has the advantage of tools developed by team of Angular like ng-inspector. In the Chrome browser F12 key is a shortcut for debugging options which can also be achieved by right click and inspect.

The Chrome developer tools make debugging JavaScript easy with breakpoint (Intentional pause in program) option in developer code. Angular Batarang (used in this project) is one of the powerful Chrome extensions for debugging Angular applications [27]. Batarang is developed at Google and it integrates to make debugging simple. Properties like scope, dependencies, performance and models can be inspected using the extension. For example we can find what our longest expression is and how much time it takes by looking (absolute and overall application) into performance tab. Scope tab captures all the data for particular scope (parent or child). Scope variable can also be made available into console by selecting any part of the application. Emulator and real device was used for the debugging, Chrome tools in mobile and browser in workstation.

8 Result and Discussion

The project was successfully completed according to initial planning and design. The resulted application was tested in Android in an emulator and real device mentioned above whereas for iOS only an emulator was used. Application screenshots are presented here (also above in the Implementation chapter 6) to represent what was developed. All the files are stored in the localhost and git account of the developer for sharing with the second team member. It would be pleasant to see a user review when it will be released in the market for actual use. Due to the limited resources available (two devices) the application was more emulator-dependent while testing. The performance level of the application was different in an emulator and real device. The emulator also had some limitation like slow performance. To find out the actual performance of the application real device can be better option over the emulator. Here are some images of the application:

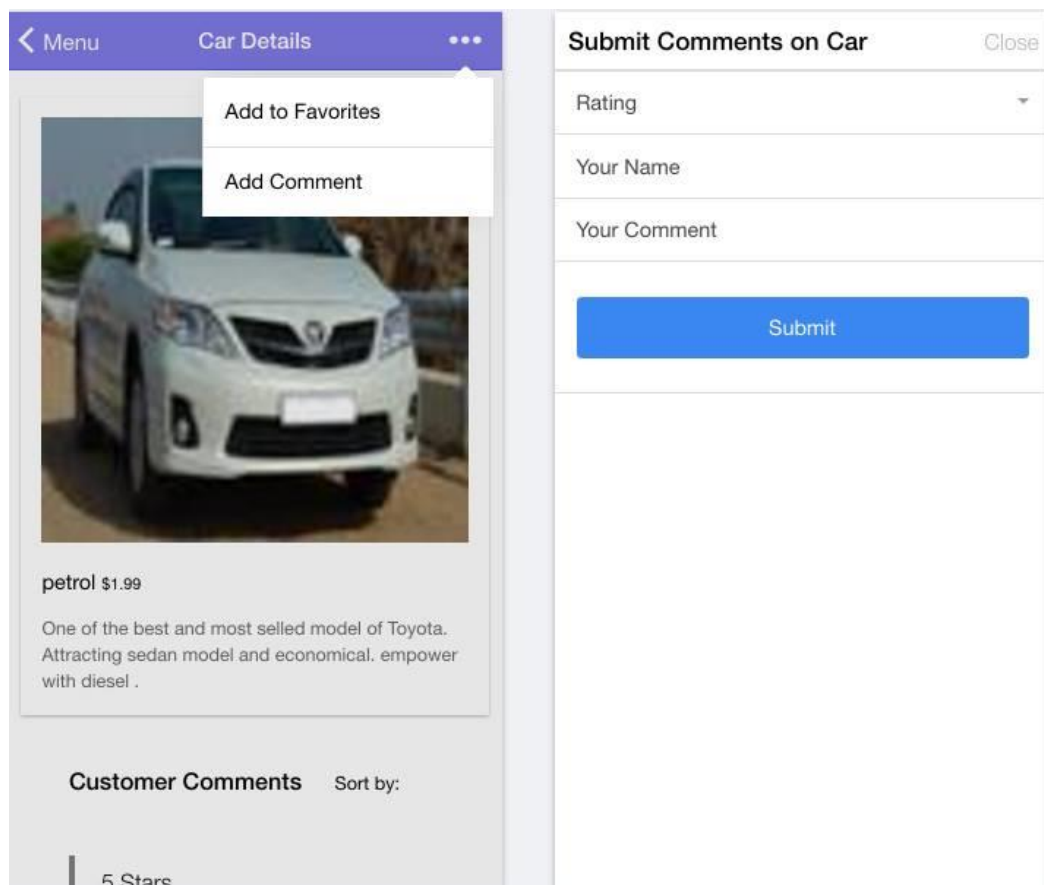


Figure 14: Favourites and comment features in the application

Figure 14 shows the options available for commenting and adding to the favourite list of items. On clicking on top of the page in the right corner the user can get the drop-down option. On selecting the option add comment, the user can rate the item where user have to put required field as rating (between 1 to 5), user name and any comments they wish. Commenting will appear on the list of comments by other users below an item. Taking “add to favourite” will mark the item the user’s favourite which they can later view in the favourite page.

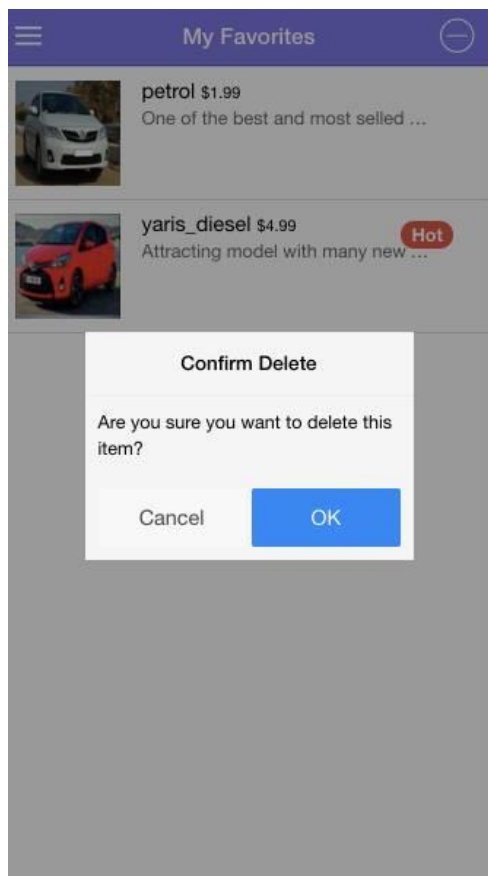


Figure 15: Pop-up for delete confirmation

Figure 15 shows a small pop-up appearing when the user wants to remove any item from the list. This confirmation pop-up asks for the user’s confirmation either for cancel or ok command. The Favourite list is the place where users can view their previous items they had added from the menu page.

There are some improvement plans that will be implemented in future. As the project will be released in the real word the security portion will be the first aspect to be considered and some other plans can be the following;

- Improve the search filter on the basis of other parameters like car makers, car features and year model
- Modify the reservation page to allow the user to use a location-based reservation
- Some minor changes in the side menu with some more options
- Features to add multiple images for car and zoom options can be considered
- Testing with an iOS device in the future can help develop the quality of the application in an Apple device.

9 Conclusion

In a nutshell, the project was successfully completed and the goals set in the beginning were achieved after some difficulties. The main objective of the project which was to build a front-end for a hybrid mobile application for car renting purposes was retained. There is some important work that still needed to be done on the interface of the application before exposed to the production level. There was some delay in project completion due to some technical issues. During the project some studies were done on trending mobile users and what kind of applications are used by people. It shows that rapid development on the internet and remarkable changes in web standard tools are playing important roles in mobile application development. There are a number of options which developer need to study and select their choice. To get started with a mobile application one does not have to have specific platform skills, but rather one just uses the web related skills.

For this particular project most of the technology and tools I used were new to me. It takes longer to grasp the working methods of frameworks (Ionic, Cordova and Angular). Web technologies like HTML5, CSS and JavaScript were familiar besides the SDK (Android) which I had some experiences of. The Framework and node module gave me some trouble and I had to polish my skills on it which took some time. Angular along with Cordova and Ionic framework have very large developer communities. These technologies suit circumstances where there are limited skills, time and budget. However one should keep in mind that native is always the best implementation when it comes to better overall performance.

A hybrid or cross-platform approach is an alternative for application development. For any types of application development suitable frameworks, libraries, APIs and developing and debugging tools play important roles. One should not forget that these are the factors which the end result relies on.

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