

Research Manual

Wildfire Location & Information App

29th April 2021



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Abstract

The purpose of the Wildfire project is to develop a mobile application for the General public and professional firefighters. This application should help people who fight fires as well as protect people who don't. The application should be used as a tool to report fires, search for fires and notify people of nearby fires. It also should be able to provide the general public and the firefighters with useful information about fires and how to keep safe around them.

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1. Introduction

The following research report is intended to document all of the research completed for the Wildfire Application. The overall idea of the project and the technologies behind it should create a better understanding of the wildfire project in the following documentation.

The following document will explain the subject of wildland fires and the dangers that they can cause, Also a brief explanation of how they start, why they start and how to prevent wildfires. The platforms that this application could be on will then be discussed, both the Android and iOS operating systems will be discussed in depth.

The significance of this application will also be discussed, this will delve into the area of why this application is needed and why it is a unique application that offers the solution. This will give the reader a greater understanding of the business problem and how this solution can solve it.

Lastly, the technologies that will be used in this application will be discussed both on the front-end and the back-end. The front-end section will explore the different frameworks that could be used to build this application. The Map technology will also be discussed with the advantages and disadvantages of the possible map technologies available, and which one will benefit this application. Lastly, on the back-end, all of the different databases and storage technologies will be discussed, so I can choose the best possible back-end technology for this application.

2. Wildland Fires

2.1 - What is a Wildland fire?

A wildland fire or a rural fire is an unplanned, uncontrolled fire in a rural area of combustible vegetation starting in rural and urban areas [14]. Wildland fires can burn vegetation above and below the soil level. Vegetation such as thick roots and thick bush are often the fuel to these fires and when this sort of vegetation is left uncontrolled is when Wildland fires break out.

2.2 - How do wildland fires start?

Most of the time wildland fires are the result of one of two causes, Humans and Nature. Fortunately, one of these factors is controllable in Humans, while the nature side is mostly uncontrollable.

2.2.1 - Humans

According to iii.org[15], 90% of wildland fires in the US are caused by humans. Most of the time this is due to people being negligent. Some examples of human negligence are campfires getting out of control, uncontrolled burns (burning debris) and intentional acts of arson [15].

Fortunately, all of these examples are controllable but unfortunately people do not take enough care.

2.2.2 - Nature

Logically thinking most people may think that nature is the leading cause of Wildland fires due to the earth's ever changing climate but unfortunately it is quite the opposite.

According to [iii.org](#) only 10% of Wildland fires are caused by nature with Lightning and Lava being the main causes: [iii.org](#)[15].

2.3 - How to prevent wildland Fires?

The first point to note in the prevention of Wildland fires is humans. As according to the article mentioned above 90% of wildland fires in the US are caused by humans, it's the humans who need to be responsible. In this article by [accuweather](#) it states some guidelines on how to prevent Wildland fires [16].

- Report unattended fires.
- Extinguish camp fires.
- Use fireworks/ pyrotechnics in clear and open areas.
- Pay attention to the risk of wildland fires in your area.
- Don't throw lit cigarettes out of a moving car.

These are some very simple guidelines but can have an extremely positive effect if followed correctly.

3. Operating System

For this project I plan on developing my application on Android, by developing on Android this will allow more users to access the application and make the application available to a large group of people. According to research done by [stats counter](#) [29], as of march 2020 71% of the mobile operating system share market is Android. This shows that android controls the market in continents such as Asia and Europe. This shows that by developing my application on Android will allow me to cover the vast majority of the market.

By choosing Android this application will cover 71% of the world's mobile market, which is a very important statistic as it means that this application will be available to 71% of people who own a mobile phone.

But this also means that I am not covering every user. The other 28% of the market is held by Apple with their IOS operating system. While IOS has its advantages and disadvantages which will be discussed later, the reasoning for not developing in both Android and IOS simply boiled down to what resources were available.

In the following sections there will be a more in-depth explanation about either of the operating systems and also some advantages and disadvantages about developing with either android or IOS.

3.1 - Android

Android - is a mobile operating system that was released in 2008 [30]. Android is currently the world's most popular mobile operating system comfortably ahead of Apple's, iOS. Android is based on the Linux kernel and was developed mainly by the Open handset alliance [31] which was sponsored by google.

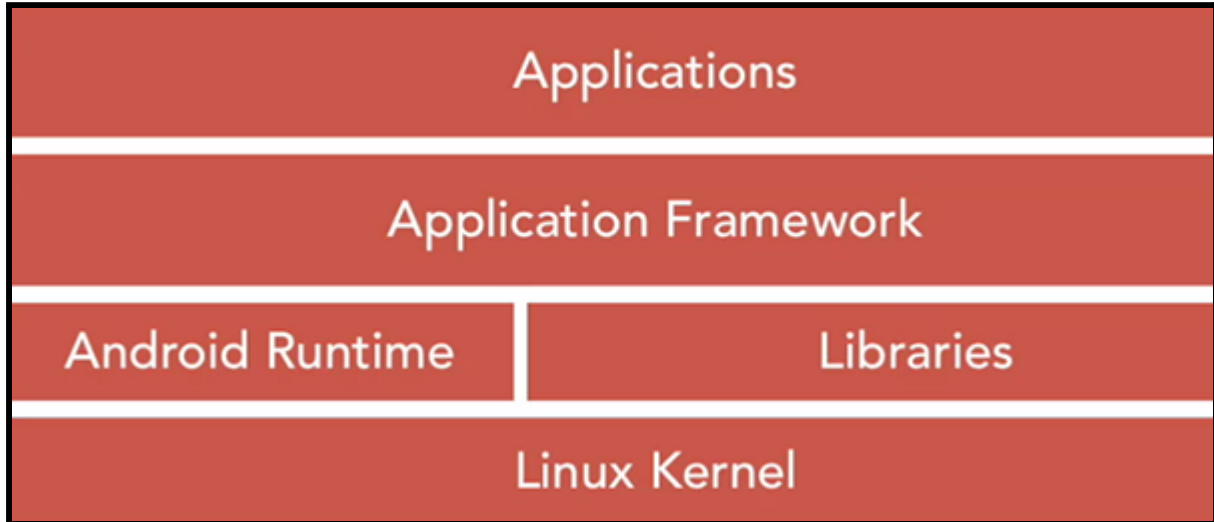


Figure 13 - Android Architecture [32].

Figure 13 displays the Android Architecture in a very high level view. Android is based on the Linux kernel and then uses the other various sections to run what we know as android.

3.1.1 - Dalvik and ART

A very important section of this diagram above is “Android Runtime”. This section is where the compilation of android occurs. There are 2 main run time compilers for Android, ART (Android Run Time) and Dalvik.

Dalvik - which is now unused by android, formerly was the main runtime process. Dalvik uses a JIT (Just in time) process which means the code needed to run a certain application was only compiled when needed.

ART - which is now the main runtime process used by android. ART uses an AOT (Ahead Of Time) process which means the code needed is compiled before it is needed.

ART is initially a slower process than Dalvik but after some time ART saves the instructions of how to compile the code and eventually is a quicker process. This works by the code being saved in the cache. A high-level example of this is if a user opens an application for the first time it will take longer, but after that initial first time of opening the application, it will open much quicker every time afterwards. Dalvik on the other hand does not save how to compile the code and the speed is the same every time.

3.1.2 - Android Permissions

Android Permissions - are permissions that are required for an application. These permissions are requested at the first time of use for an application and can be changed at any time through the app management section of an android phone.

Multiple permissions will be required to run my application. These permissions may include both hardware and software permissions. Here are some software permissions that may be required for my application [38].

- **ACCESS_NETWORK_STATE** = allows the application to access information about the device's network.
- **ACCESS_COARSE_LOCATION** = allows the application to access the device's approximate location.
- **ACCESS_FINE_LOCATION** = allows the application to access the device's precise location.
- **WRITE_EXTERNAL_STORAGE** = allows the application to write to external storage.
- **CAMERA** = allows the application to access the device's camera functionality.
- **READ_PHONE_STATE** = allows the application to access the device's state.

These permissions are used by the application to aid the application. It is also very important to state that these permissions are not being used to save the users data but only to access the users permissions when the user wishes to use certain features of the application.

3.1.3 - Android Features

Android Features - are features that can be used by the application to access some of androids key features. Here are the key android features that my application may use to fully function. These android features are very important and allow my application to run smoothly.

- **Android.Hardware.Location** = this feature accesses the built-in location android feature. For this feature to work the user must have their location turned on. The application cannot turn this feature on automatically. This would be considered a security breach.
- **Android.Hardware.GPS** = this feature uses the location feature and specifically harnesses the GPS feature of the android device. The GPS feature allows the application to get precise coordinates of the users location and this would help my application to improve its accuracy.
- **Android.Hardware.Network** = this feature may be a very important and vital feature for my application. This feature allows my application to use the androids network. The use of the network allows my application to successfully update the database which successfully updates the map on which the fires are reported on. It is very important that my application has access to this feature as it allows my application to come to life.

These features like the permissions are used to aid the application to work to its best degree. It is very important that if the user does not want to allow use of these features, my application can do nothing about that. The user's security is very important to my application.

3.2 - IOS

IOS - is an operating system which Apple designed for its mobile phones and tablets [33]. IOS is an exclusive operating system to Apple products. IOS was released in 2007 when the original iPhone was released and is currently on its 14th Version as of November 2020. IOS is a very exclusive operating system as most of the source code is kept under lock and key, as is developing applications as IOS uses its own language Swift [34]. The process of uploading an application to the App store also takes longer as it needs to be reviewed by Apple and conform to Apple terms.

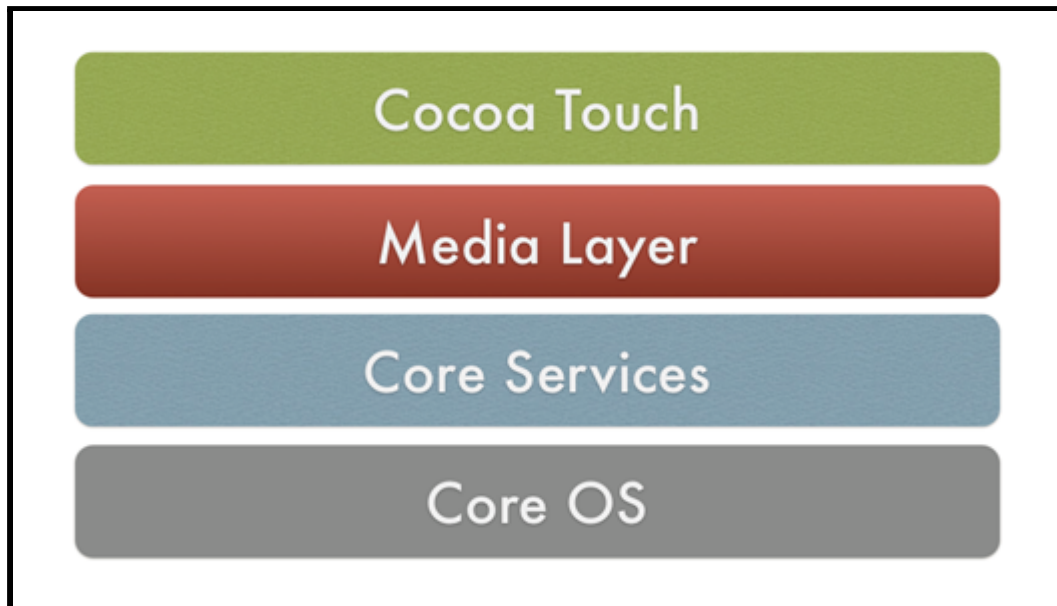


Figure 14 - IOS Architecture [35].

Figure 14 displays a high-level view of the IOS Architecture. IOS sits on top of the core OS which holds the low-level features that all come together to create the overall IOS architecture. The other layers then all combine to bring in runtime compilers and media tools.

3.3 - Conclusion

In conclusion, Android and IOS are both very powerful operating systems. From the research I have concluded that developing on android is a much easier process and android offers much more in terms of support and communication as it is mostly open source.

Advantages of Android [36] -

- Open Source - no licensing is needed to develop android applications.
- Flexibility - the open source nature allows developers a low barrier entry.

Advantages of IOS [36] -

- Performance - The iOS operating system is a very stable operating system that is constantly updated by Apple.
- Intuitive UI - The iOS interface was developed by professionals and provides a clean learning UI.

Disadvantages of Android [36] -

- Testing - Because of the various android versions it is very difficult to test all versions available.
- Cost - The testing of android testing drives up the cost as a lot of time must be spent doing quality tests.

Disadvantages of IOS [36] -

- App Release - when releasing a phone to the Apple App store the application must go through a screening process by Apple before it enters the market.
- Customization - iOS applications have very limited customizable features and must follow the rules that Apple set in place.

4. Similar Applications

In this section I will discuss the similar applications/ similar ideas that rival my application. This research is a vital section as it allows me to compare what features my application has compared to the other applications available on the market. For each application listed below, I will dive into what each application has and what they don't have, what's their main features and finally provide a link to the application on the Google play store.

4.1 - Fireguard

Fireguard [3] - is a free application on the Google Play store with the option to upgrade to a premium version, which allows the user to unlock more areas on the map. Through my experience with this application it uses the user's current location and then gives the user an overview of the fires in a certain radius. Figure[2].

The main feature of this application is to view fires. When the user sets their radius they can see all fires up to that radius. The three dots in the top right corner of the application allow the user to go to the settings page or the about page.

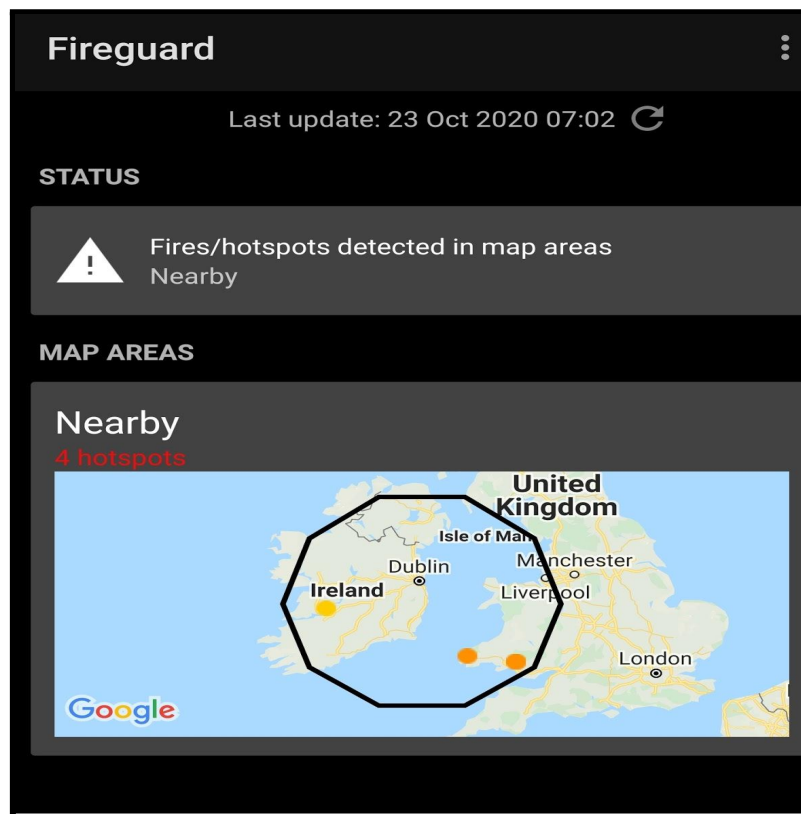


Figure 2 - Fireguard home page [18].

The radius is adjustable by pressing on the map itself and then clicking the edit icon. The default radius is 170km. You also have the ability to view the map and click on the locations. When you click on the locations you receive some information about the fires but in very high level terms. Figure[2].

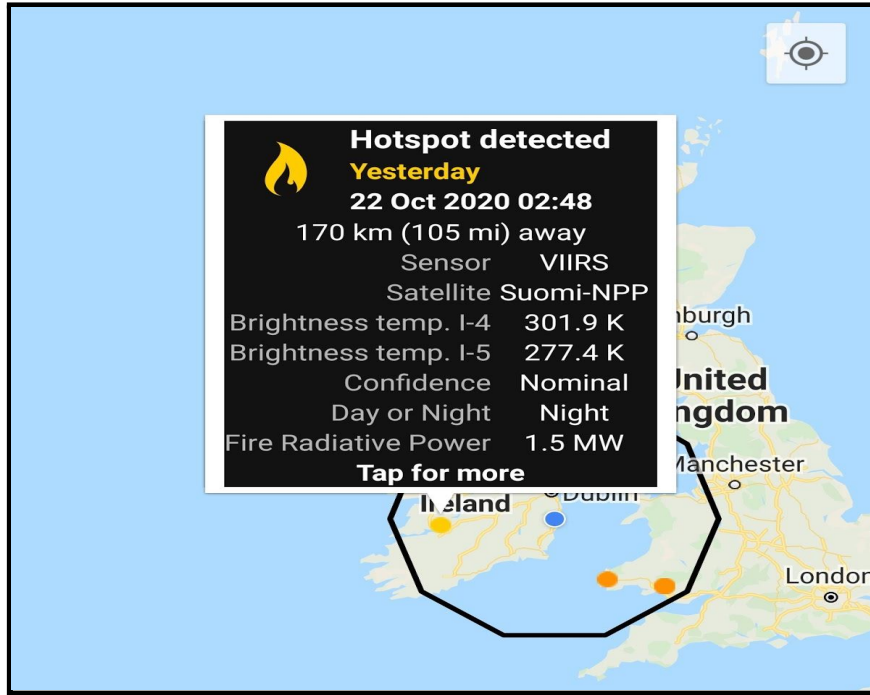


Figure 3 - Fireguard view fire page [19].

4.2 - Firemap

Firemap [4] - is also a free to use application available on the Google Play store. This application uses NASA, GeoMaps to provide a map for the users of the application. The main feature of this application allows the users to see all of the fires on the map, the application also allows the user to search and pin their exact location. Figure [3].

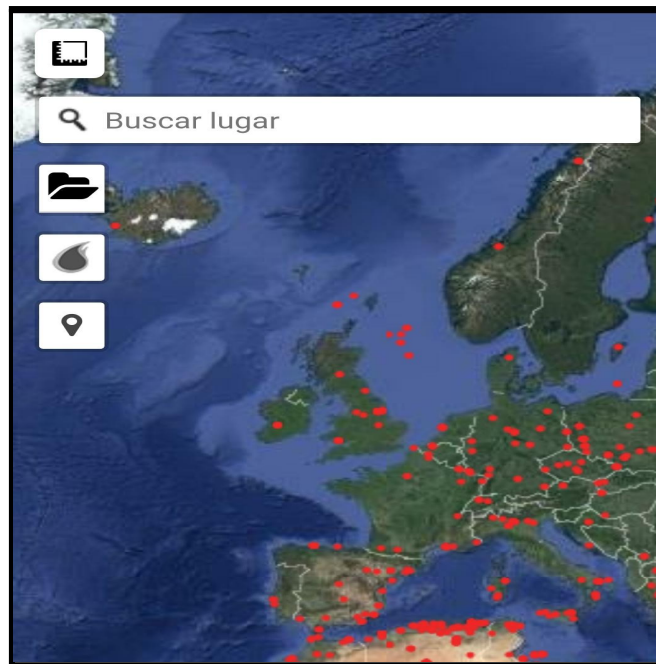


Figure 4 - Firemap homepage [20].

This application unlike the previous application allows the users to add a fire location but while using this application I was not able to achieve this as the user interface was tricky to understand and difficult to navigate through. Figure[4].

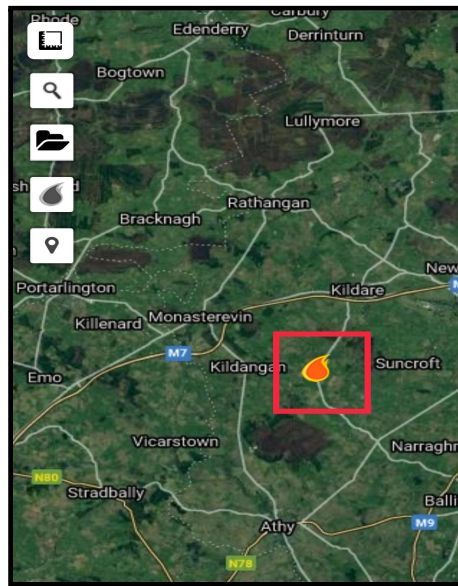


Figure 5 - Firemap fire locator [21].

Lastly, while using this application I realized that this application was partly in Spanish. This was never specified while downloading and also there is no option to change language. An example of this can be seen in the search bar of Figure 4.

4.3 - Active Wildfire Map

Active Wildfire Map [5] - is a free application on the google play store by Severe WX Warn. This application allows the user to view active wildfires in the United States of America. The map on this application is powered by 'ESRI'. It provides a clean map to the user with good color coding as this makes the map easier to view. Figure [6].

This application also allows the users to press on a fire and view information related to that fire. The information available is :

- Type of Fire.
- Discovery date.
- Acres Burned.
- Percent Contained.
- Last Update.

This information gives the user of the application a very good understanding of the fire. Figure[7].

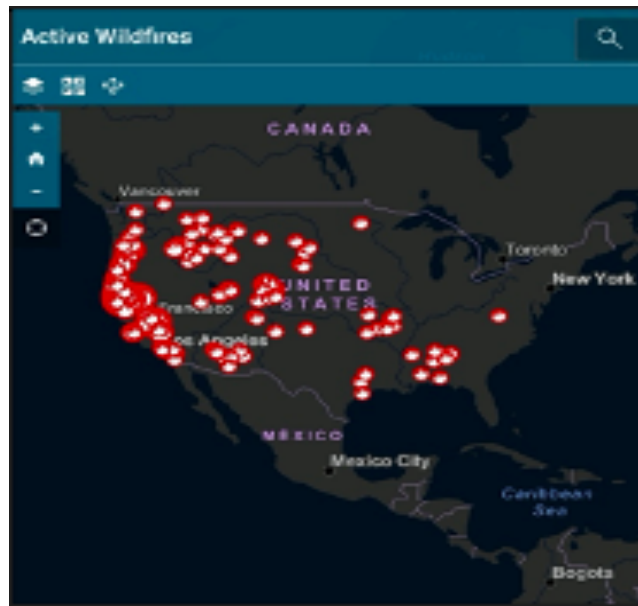


Figure 6 - Active Wildfire map home page [22].

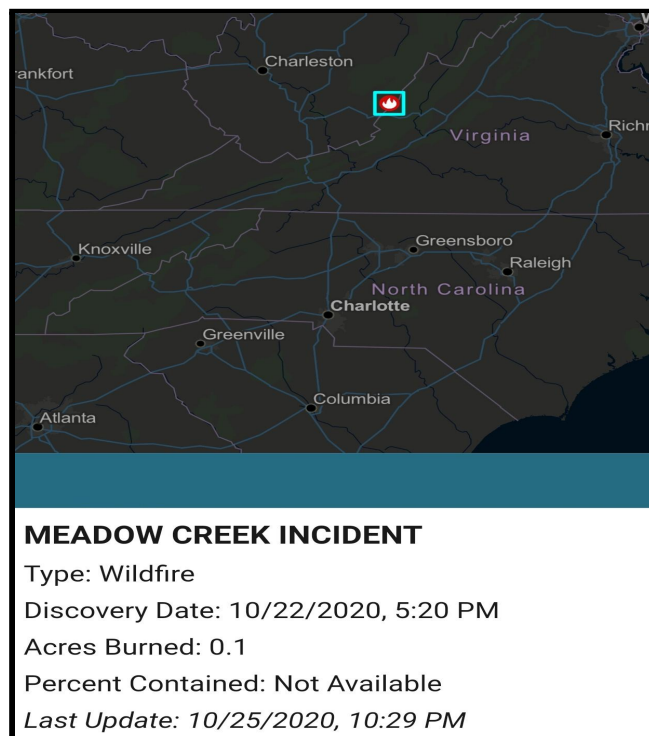


Figure 7 - Active Wildfire map view fire page [23].

4.4 - Conclusion

In conclusion out of the multiple applications that I have researched, in my personal opinion my application offers more than these solutions. I believe that the best solution out of the solutions I researched is the "Active Fire Map" in terms of its simplicity and design, but I feel like that is missing a key feature of being able to report a fire.

In terms of Design, “Active Fire Map” offers the cleanest and most polished GUI(Graphic User Interface). The information that is displayed is adequate and understandable for the general public.

In terms of functionality, “Firemap” offers the report fires feature, but the way in which they implemented this feature is flawed and very hard to understand. I believe that if this feature is implemented correctly it will allow users to take action and alert people immediately.

5. Project Significance

The need for this application is urgent as the amount of unreported wildland and bush fires is out of hand. Due to the lack of resources the climate is being diminished, people are losing their homes, cities/ towns are being evacuated and the most important reason is that people are losing their lives.

My solution offers the fix to a lot of these problems. By giving people the ability to report a fire in a small amount of clicks is important. This application will give people no excuse not to report a fire because it will be so simple. The ability of reporting a fire will allow people to be proactive and not reactive. This application is targeted towards those who live in remote areas as well as those who have an interest in keeping the planet safe. This application isn't about wasting your valuable time but about gaining more. This app is not designed to create an addiction but to allow you to quickly play your part if a fire breaks out.

My Application will provide a unique solution that is not yet available on the market. The application I plan to build will cover all of the areas that the similar solutions missed or failed to recognise. My application will provide a clean self learning interface that will attract the users and not scare them away. This will be a very significant feature to work on as creating an application is one thing but making the users use the application is another.

6. Technologies & Software Research

6.1 - Front end Technologies

6.1.1 - Xamarin forms

Xamarin Forms - is an open source cross platform tool built by Microsoft. It allows developers to build IOS, Android and Windows applications on the same code base. Xamarin uses the markup language 'Xaml' on the front end as well as C#. On the backend, these two combined allow the developers to build applications very easily.

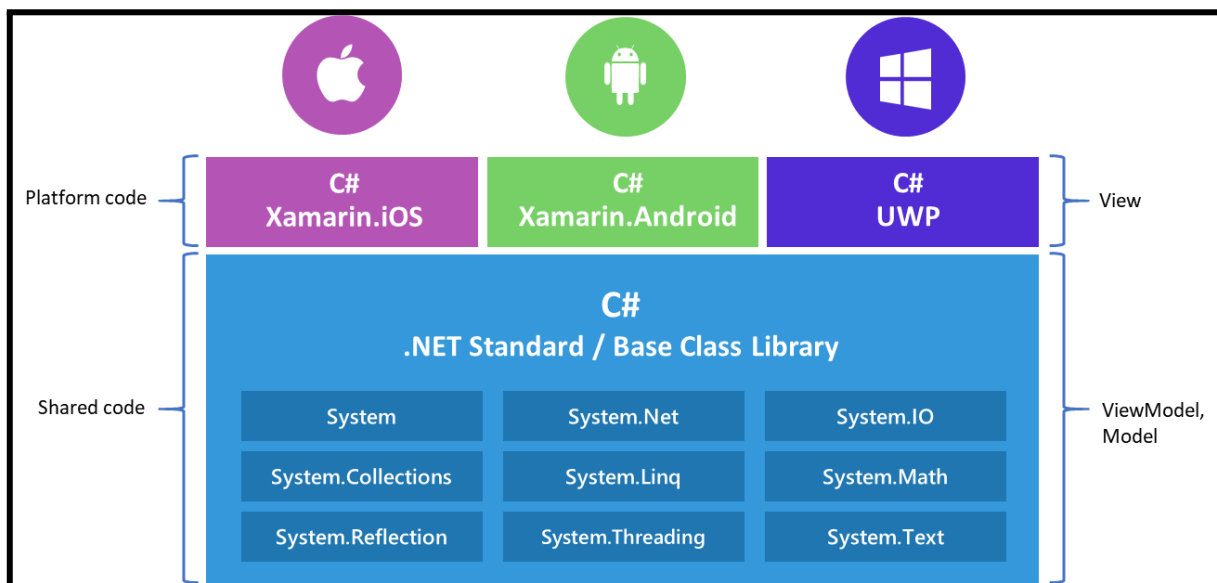


Figure 1 - Xamarin Forms Architecture [17].

As seen in Figure[1], is an overview of the architecture that xamarin uses, it allows the developers to build on three different platforms IOS, Android and Windows with the same shared code base.

NuGet Packages

NuGet packages is a package manager that delivers compiled source codes [39]. The use of NuGet packages are extremely useful as they give the developer the opportunity to use packages that have been professionally developed by other developers in their code.

NuGet packages encourage the developer to use more reusable code. Some of the NuGet packages that are extremely useful and I plan to use in this application include;

- **Newtonsoft.json** = converts .NET to JSON [40].
- **Xamarin.Forms.GoogleMaps** = allows implementation of Google Maps in a Xamarin Application [41].
- **Xam.Media.Plugin** = allows Xamarin to easily access the device's media functionality [42].

Xamarin Advantages -

- One code base for all IOS, Android and Windows.
- Multiple different API's and Layouts available.
- A lot of Resources available for developers.
- Easy to use nuget packages allow for quick integration of API's.

Xamarin Disadvantages -

- High costs for professional usage.
- Strictly app development, not for games development.
- User interface development can be slow.
- Can be difficult to learn at first.

6.1.2 - Kivy

Kivy - is an open source cross platform development tool built on python. Kivy makes use of innovative user interfaces such as multi touch apps. [1] This makes development on IOS and Android easier as it uses the same code base.

Here are some advantages and disadvantages on why and why not to use kivy [2]:

Advantages -

- Uses Python which is extremely powerful.
- Uses a shared code base.
- Contains widgets with multi-touch support.

Disadvantages -

- Lack of documentation.
- Small community.
- User interface is confusing.

6.1.3 - Ionic

Ionic - is like all the other researched technologies, open source. It also uses a shared code base to allow development on multiple platforms concurrently. Ionic offers a library of optimized UI components, gestures tools for building fast and highly interactive applications [3]. Ionic uses HTML, CSS and JavaScript to build applications but can also be used with new modern technologies such as React JS and Vue JS.

Below is a detailed view of how ionic is structured [Figure 8].

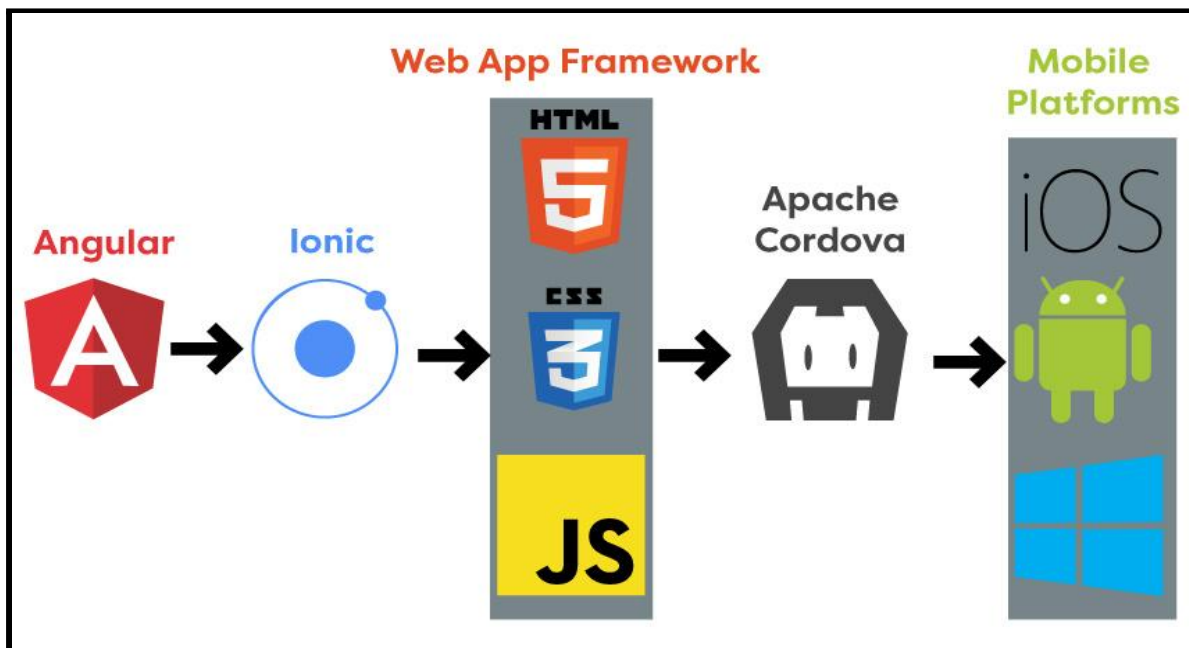


Figure 8 - Ionic Structure [24].

Here are some advantages and disadvantages on why and why not to use Ionic [4]:

Advantages -

- Quick Development times.
- Little knowledge required to start developing.
- Lots of plugins.

Disadvantages -

- Some plugins are not stable and may conflict.
- Debugging is unclear as error messages are unclear.

6.1.4 - Conclusion

In conclusion with my little experience with the three of these frameworks, I have come to the conclusion that I am going to develop my project using Xamarin forms. I have come to this decision because of the following reasons.

- **Resources** - because of the limited timeframe in which we have to undertake this project, I believe that the main tool I wish to use should have a lot of available resources such as Forums, Webpages and much more. I think I will benefit from this immensely as when I'm facing issues while coding I can simply look it up rather than wasting time trying to find my issue.
- **Accessibility** - While researching these tools I found out that Xamarin forms is the only framework tool out of the tools I researched that runs on Visual studio, as Ionic runs best on Visual studio code and Kivy runs on python which required a linux machine.

- **Features** - when researching Xamarin I discovered that it has multiple layouts and easy access to API's. This will come in very handy and I wish to use different API's and layouts to develop my application.

6.2 - Back-end Technologies

6.2.1 - Firebase Database

Firebase - is a back-end realtime cloud database developed by Google. The noSQL database allows developers to store and sync data quickly and securely[5]. The data is stored using the language JSON, this data can then be viewed using their website. Figure [9].

Some advantages and disadvantages of the Firebase database tool [6]:

Advantages -

- Easy Integration of the database.
- Firebase accounts are free to use and they offer 1GB of stored data to users.
- Firebase has a large community.

Disadvantages -

- You cant query the database, so you must manually search for the data.
- Data is stored in a different format to other databases such as SQL or AWS.



Figure 9 - Firebase storing structure [25].

Firebase Auth - Firebase also offers an authentication service. This will be extremely useful as my application will be able to link to this service to register users for my application. By using the firebase authentication service, the application will have the use of a very secure authentication service. That looks after the password storage and hashing. Also the

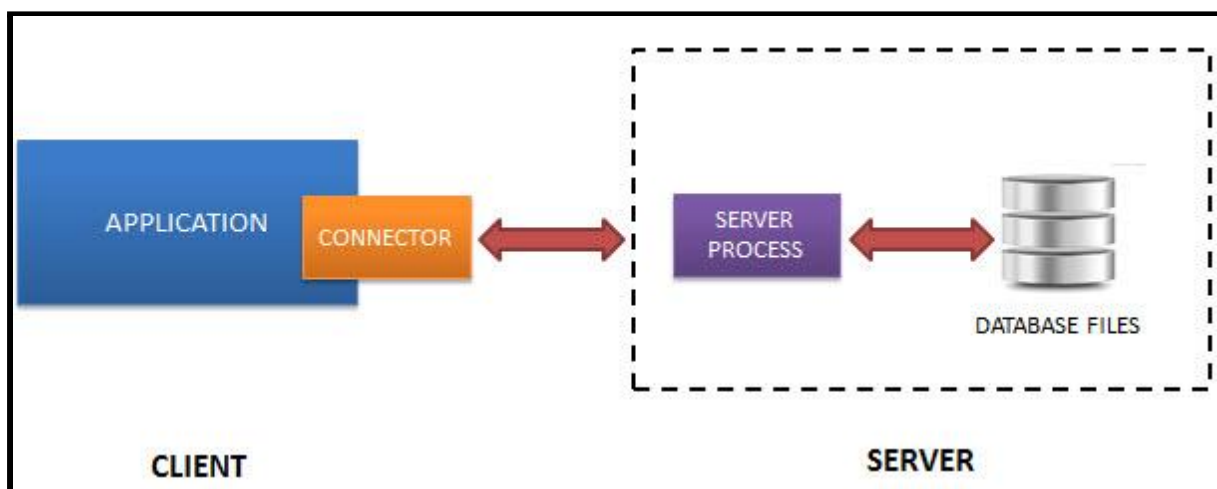
application will have a proven authentication system that has been tried and tested by multiple users. This will ensure that all of the major bugs have already been fixed.

Firestore Storage - this is yet another service that firebase offers. This service allows the application to store media files such as music files or images. This feature will allow this application to easily link users to their uploads in the shape of an image.

2.2 - SQLite

SQLite - is a relational database management system(RDBMS) in the C- library that implements a fast, small and highly reliable SQL database engine [7]. SQLite is integrated with the application that accesses the database. This means that SQLite is serverless and is self-contained. This means that it has zero configuration and can be set up very quickly Figure [10].

Figure 10 - SQLite Architecture [SA20].



Here are some advantages and disadvantages on why and why not to use SQLite [8] :

Advantages -

- SQLite is very lightweight, because it stores the data on the device.
- No installation needed.
- SQLite is reliable and is rarely down for maintenance.

Disadvantages -

- Database size is restricted to 2GB..
- Unable to query the data in the stored database file.

6.2.3 - Amazon AWS

Amazon AWS - offer a wide range of different storage mechanisms. Amazon Aurora is a high performance relational database while they also offer serverless options in the form of

Amazon DynamoDB. Amazon DynamoDB is a noSQL database similar to Firebase but comes at a cost [9]. Amazon Aurora and DynamoDB would be great options for a project on a much bigger scale and also the price of these services cost a lot of money.

Here are some advantages and disadvantage of Amazon Aurora and DynamoDB [10][11]:

Advantages of Aurora & DynamoDB -

- Easy backups.
- High speeds.

Disadvantages of Aurora & DynamoDB -

- Difficult to get up and going may require training.
- Cost.

6.2.4 - Conclusion

In conclusion with all of the options available I have decided that I will use Firebase by Google. I have made this decision because of a number of factors:

- **Cost** - the major factor which it has come down to is cost. Firebase offers a free account with no subscriptions or hidden add-ons and you can pay as you go unlike amazon which requires credit card information and can charge you if you go over the limit.
- **Resources** - is a massive deciding factor, overall firebase is the easier tool to use but also offers a lot of resources in terms of forums and community tutorials. While the amazon services are more powerful they also sometimes require dedicated courses to learn their full functionality.
- **Data** - the data in Firebase may not be queryable but it is in a simple form. Meanwhile the data for SQLite is not usable only with great hassle and with amazon's pricing factoring them out, Firebase is the option I will be going with.

6.3 - Map API's

6.3.1 - Google Maps API

Google Maps API - is an interactive map supplied by Google. Google maps includes many features such as street view, terrain view and satellite view. Google maps can be accessed using an API key but does come with a cost. The first \$200 worth of calls are free and then you pay as you go. Google maps is a good option as it is tried and tested by Google, but the price factor is a deciding factor.

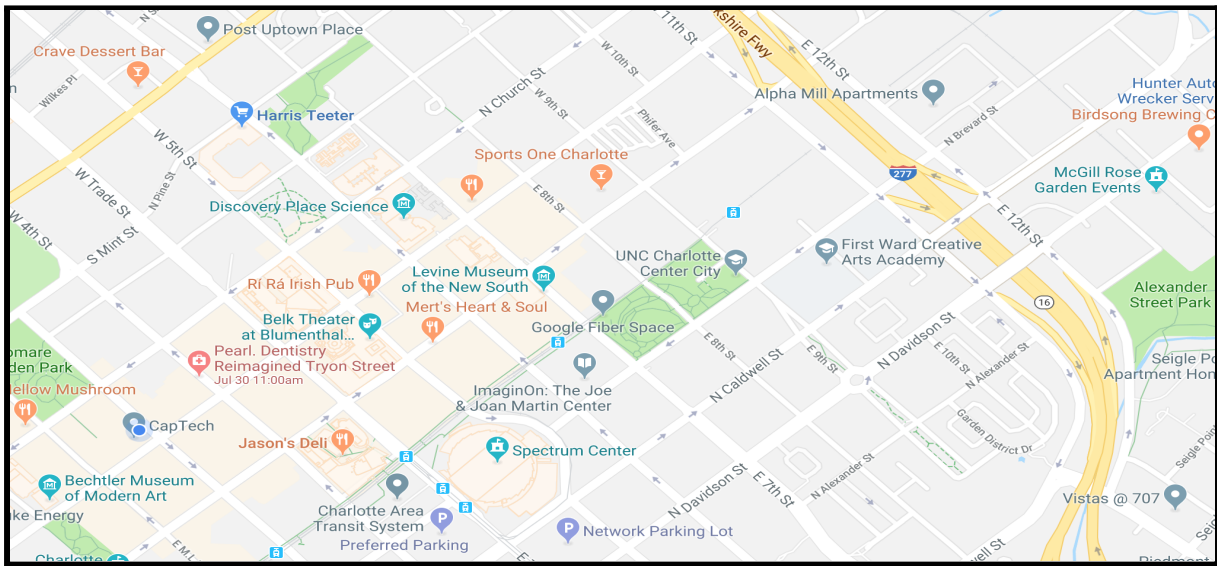


Figure 10 - Google Maps API [26]

Acquiring the Google Maps API involves the following steps

1. Going to <https://console.cloud.google.com/> and creating a free account
2. Choosing the API of your liking. E.g. Maps API.
3. Activating the API by adding a billing account.

Once the account is activated the user is given \$250 worth of API requests and then after the \$250 worth of requests is used, the billing account will be billed monthly. The monthly bill will be based on the accounts spending with no set fee [37].

The Google Maps API is a very good option as it extends its functionality by offering multiple API's under the once plan. These API's, Directions API, Places API and many more. This may be an incredibly good feature as some of these API's may be used in future versions of the application and having the connection established and accounts setup may encourage usage in the future.

6.3.2 - ESRI API

ESRI API - is an international supplier of geographical information system software [27]. ESRI offers many projects such as 3D & 2D visualisation tools, geocoding tools and also mapping tools. The tool which I am interested in is under the mapping tools and is called 'ArcGIS'. ArcGIS offers a lot of different services such as maps, data tools and live information.

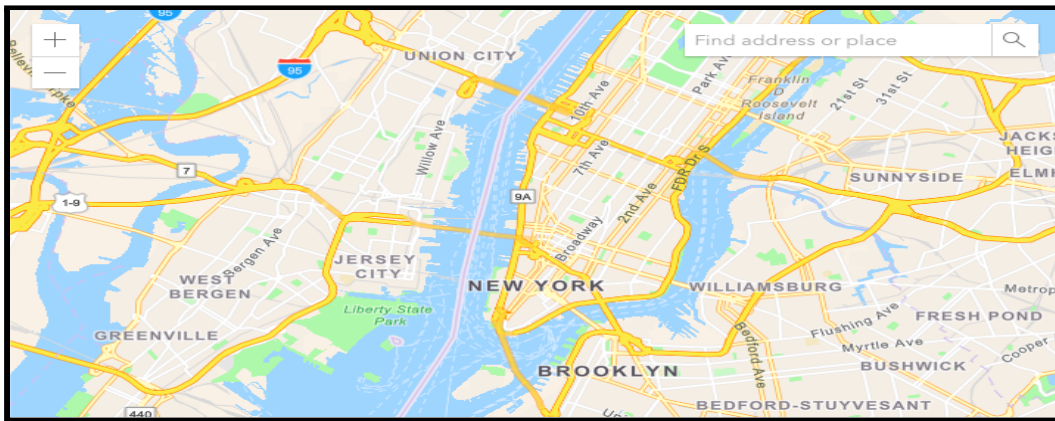


Figure 11 - ESRI Maps [27].

6.3.3 - Mapbox

Mapbox - is a free open source mapping platform for custom designed maps [12]. Mapbox is a very appealing software with its nice clean user interface as well as its price. The price of mapbox is very appealing as it offers a free map to mobile applications with up to a maximum of 25,000 users, also its free web applications with 50,000 users. Mapbox is a very good option considering my low budget for this project and I'm looking to save money at every opportunity I get.

How Mapbox works - it allows you to create an application and then also to style your map down to the smallest details. This could be a useful feature for my project as it could allow me to extend my functionality in the future [13].

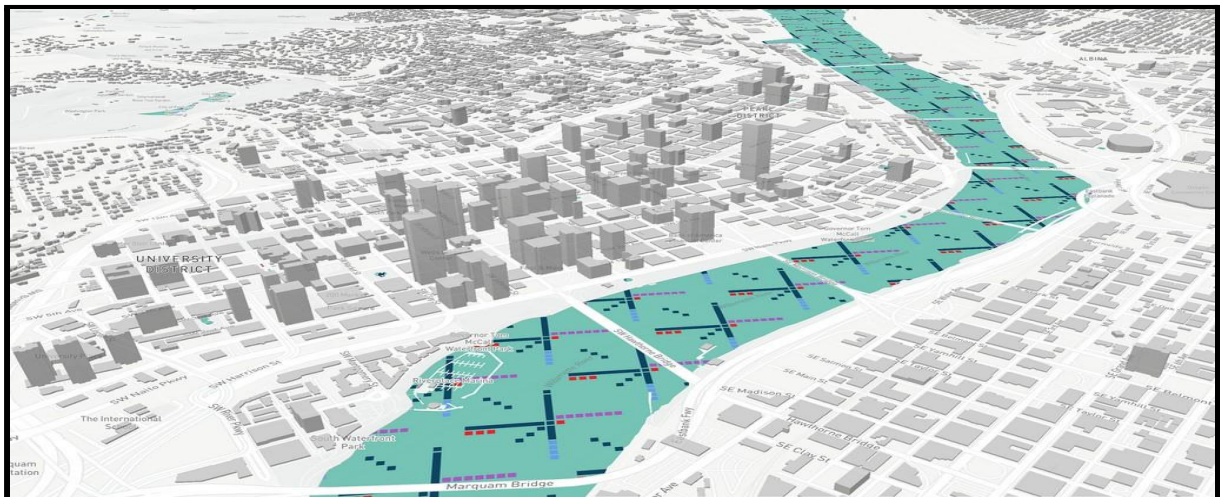


Figure 12 - Mapbox Map [28].

6.3.3 - Conclusion

In conclusion the API that I have chosen to go with is the Google Maps API, although this API does come at a price I believe paying for this product will greatly benefit the Wildfire application.

The Google Map API is the API that I believe fulfills the features of this application. The clean user interface that is loved by the world and used by the world is clean and very up to date this is important as I don't want people to have to learn how to use this application. I want them to feel that they already know how to use it.

Another additional reason for choosing the Google Maps API is the online resources. Google Maps API has multiple forums and communities dedicated to the API. This has been a deciding factor for many of the tools and technologies of this application, As I am going into this project not experienced in these fields I feel that the more help the better and online resources are the best in more instances.

7. Declaration

- I declare that all material in this submission e.g. thesis/essay/project/assignment is entirely my own work except where duly acknowledged.
- I have cited the sources of all quotations, paraphrases, summaries of information, tables, diagrams, or other material; including software and other electronic media in which intellectual property rights may reside.
- I have provided a complete bibliography of all works and sources used in the preparation of this submission.
- I understand that failure to comply with the Institute's regulations governing plagiarism constitutes a serious offense.

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Student Signature :

A handwritten signature in black ink that reads "Jack McNally". The signature is written in a cursive style with a period at the end.

Date: 30/04/21

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