



Dynamic Personal Insurance

Research Manual

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Abstract

The purpose of the project is to develop a cross-platform app and an android watch app. With their combined efforts, the project provides an ability for customers to purchase/manage dynamic personalized insurance while attached to a companion android watch. Furthermore, a client can view/manage their personal data/details that have been recorded by watch movement sensors. This document provides the research describing Dynamic personal insurance and how it can be implemented using mobile and wearable technologies.

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Introduction

The research discusses Market analysis while identifying what is dynamic insurance, the different future competitors, and data/hardware needed for deployment.

After evaluation of the current market, it proceeds to compare the different types of technologies existent that is best for the project.

Market Analysis

Insurance

Research must be done to derive an understanding of the type of insurances are there in regards to the project.

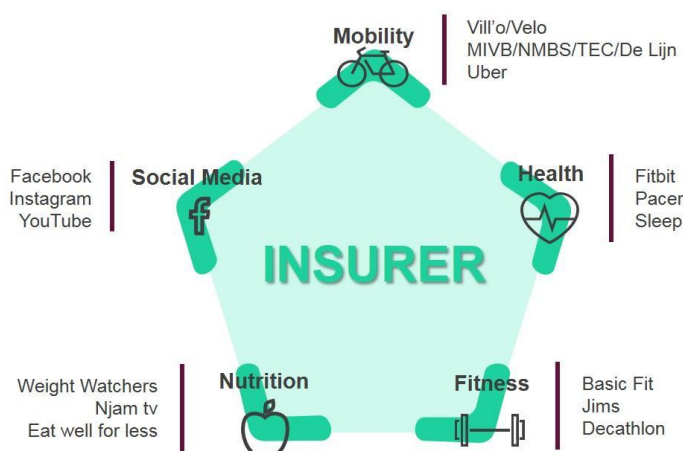
The traditional Insurance Pricing model

It is a static model on which most of the insurers are based today. example: User provides minimum data such as age, sex, address, etc... and with this data, the insurer rushes to provide the customer with a quote. After the quote is accepted the insurance generally only changes(reduces) every year if the customer does not claim the insurance but if the customer claims, the insurance increases. And that sounds like a punishment for claiming insurance.

The dynamic Insurance Pricing model

It is as the name suggests dynamic therefore the prices can be changed at different periods of time dependant on the insurer and the customer data provided. example: The policy is created the same way as a traditional insurer would but customers get discounts on their premium as a reward for using technology(wearables, internet tracking) to provide the company with data every day.

Data is collected in many different ways to improve insurance as shown in Figure 1.



1. Figure Client data sources, Source: <https://www.sia-partners.com/en/news-and-publications/from-our-experts/dynamic-personal-pricing-modeling-insurance>

Conclusion

It has been uncovered that there are limited dynamic insurance companies out there since technology is also new and it may provide barriers/issues towards the completion.

Another thing to consider before using dynamic insurance, is funds are more important than our privacy.

[DEM20]

Existing competitors

Similar applications have been taken and researched and reviewed to observe the data that clients share with companies for them to derive a suitable insurance policy, the features implemented, overall feel/look of the applications.

All the applications reviewed were based on other user reviews, images since in every application to get past the login screen the quote needed to be completed (paid) via call or online website with personal information such as A Social Security number for the USA.

Irish life-health

Irish life is an Irish insurance company that provides Health, Pensions, Investments, and other types of Insurance policies but it will be focused on Irish life that is most relevant to the project. Irish life-health is very similar to traditional insurance that has two apps, one app (*Irish Life Health Members*) is for claims and document management whereas the second one (*MyLife*) is an exercise-tracking app with rewards.

MyLife can be easily accessed/used to do challenges for gaining reward points but to receive rewards, the user must be an Irish life insurance member.

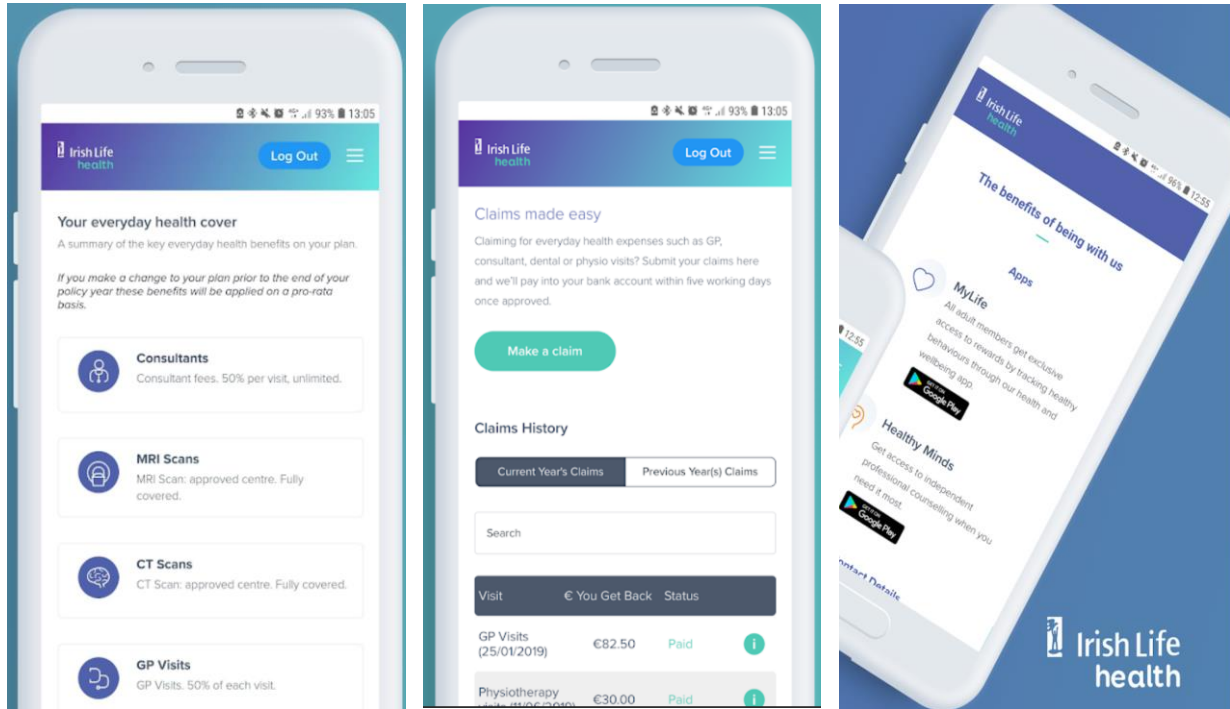
1. *Irish Life Health Members* app with a poor score of 2.2 out of 5 in the android app store and a similar score in the apple store.

App features include:

- Check your cover
- View your documentation
- Submit claims
- connect to our other services. (such as my life, healthy minds)

But to access and use the app, traditional insurance quotes needed to be processed with minimum information provided.

Irish Life Health Members app screenshots have been reviewed (taken from Google play) see figure 2.



2. Figure Irish life-health screenshot from the google play, Source: play.google.com, <https://play.google.com/store/apps/details?id=com.irishlife.myirishlifehealth>

[ILH19]

Users reviews Android store:

Author	Date	Score out of 5	Comment
Daniel Mc Inerne	July 6, 2021	1	<i>“Very buggy. Regularly complains...”</i>
BRENDA KIRBY	April 16, 2021	2	<i>“Making a claim has been a nightmare. Wont let me submit...”</i>
Una Whelan	February 5, 2020	5	<i>“Good app very easy to use. Just register your details...”</i>
Damien Middleton	December 7, 2020	1	<i>“The app is incredibly slow and unresponsive...”</i>
Sean Ryan	July 10, 2020	2	<i>“App is just a website wrapper. It's slow...”</i>

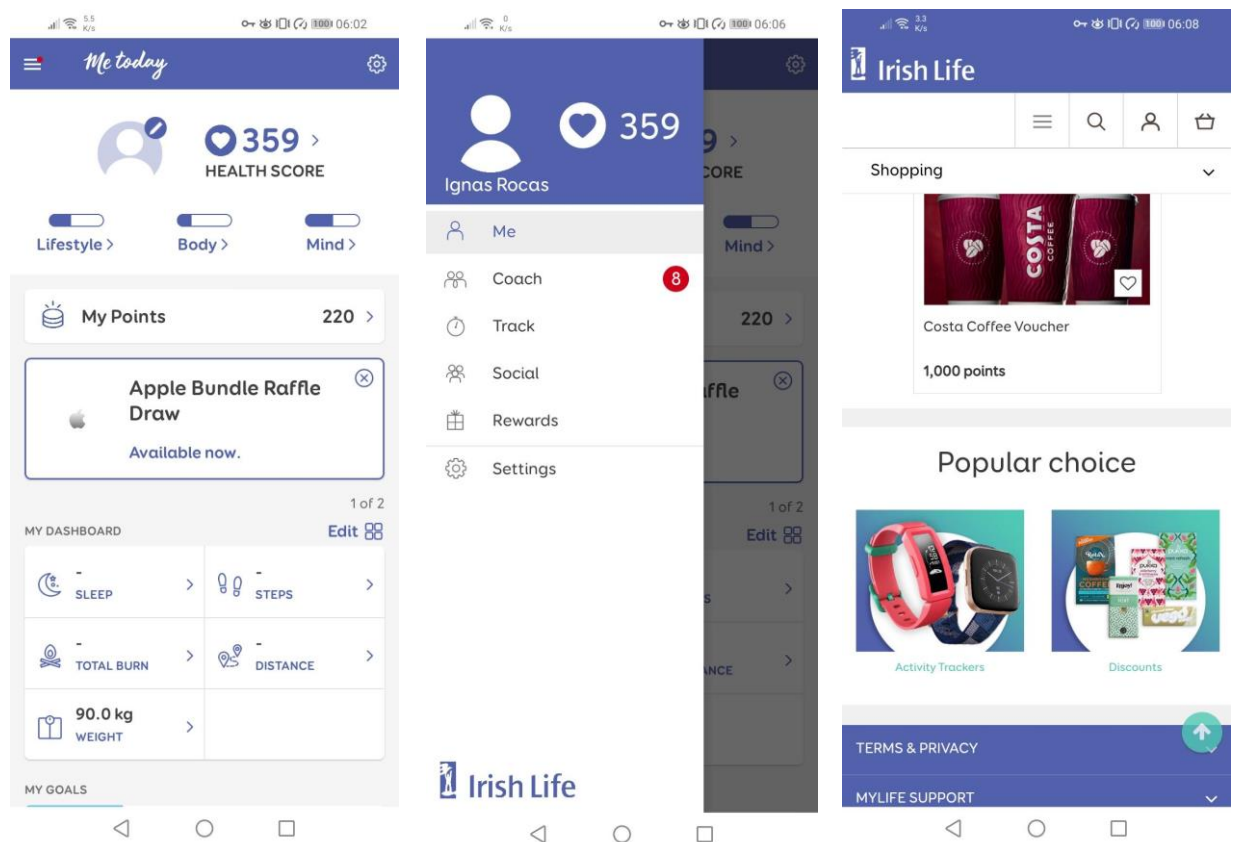
To summarize user comments, from a total of 54 comments over 50% rated it 1/2 out of 5.

2. MyLife app with an above medium score of 3.5 out of 5 in the android store and a score of 4.2 out of 5 in the apple store.

App features include:

- Real-time health score
- Personalized health coach
- Track activities and health status with Health Score.
- Use of motivational techniques such as social networks features and challenges.

MyLife app has been installed and used for a few hours to produce screenshots below screenshots have been reviewed, see figure 3.



3 Figure. MyLife app screenshots, Source: Author Photos

[MYL21]

Users reviews Apple store:

Author	Date	Score out of 5	Comment
DaveClint	March 10, 2021	1	"Data is completely inaccurate..."

kaerobe	April 15, 2020	3	<i>“An interesting approach with unclear rating system that has some major flaws...”</i>
Anto 59	September 7, 2020	5	<i>“Very detailed App...”</i>
Dublin 5	October 15, 2020	4	<i>“App updated today still not working correctly. Not updating sleep...”</i>
Pegasus 42	January 1, 2020	3	<i>“I find the App very clunky and hard to navigate. It does not correctly download data from Garmin Connect...”</i>

To summarize user comments, from a total of 2600 comments over 70% of users rated it 5/4 out of 5.

Personal opinion about Irish-life apps overall:

I think it Looks and feels great with the data that received from my Android watch seems somewhat accurate. It is engaging were trying to cough a person and with it is social and has easy registration and automatic login.

As a new user, I think there are a bit too many functionalities on it. Therefore it feels a bit clustered. The rewards page is not integrated into the app(it opens the browser) therefore it does not feel fluent. Finally, in my opinion, the two apps should be merged somehow since the *Irish Life Health Members* app seems dead and attracts negative publicity, and instead of offering rewards points for challenges, the app should offer a percentage of the premium instead.

- There are three main parameters to consider while measuring health according to MyLife by Irish Life, Body (age, height, weight, blood pressure), Lifestyle(exercise, sleep, stress, nutrition), Mind(how a person feels).

[LIF21]

Activ Health

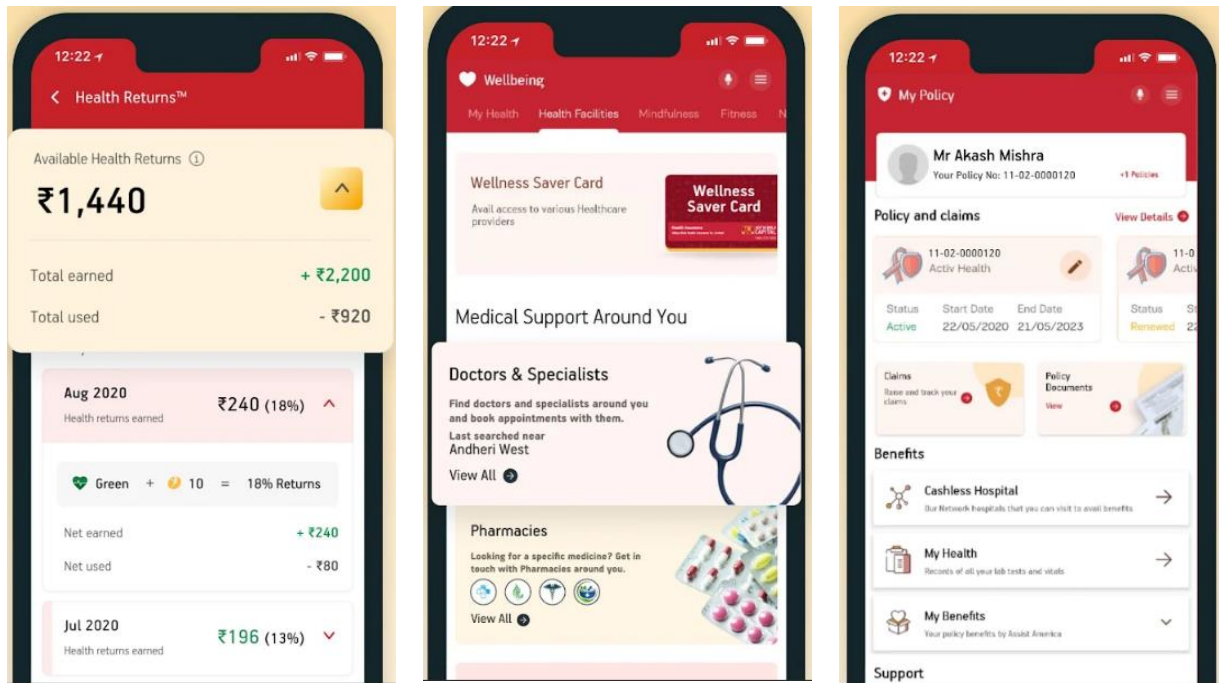
Activ Health app is owned by *Aditya Birla Capital* which is a huge Indian company that provides different types of insurance including Health, Life, Motor, Travel, and others.

The Activ Health app features include:

- Tracking and managing fitness routines with useful charts.
- Perform challenges to earn *Active Dayz™* which helps earn Health Rewards(cash-back) of the insurance policy.
- Manage the insurance details and it is claimed.
- Contact a health coach which helps with planning.
- Interact with doctors, counselors, and dieticians.
- Provide a view of the latest health blogs.
- Has health tools, such as blood glucose and cholesterol calculator.

- Connect with fitness apps such as Google fit, Samsung health, Fitbit, Garmin, and others...

The app is available on Google play store and Apple store but it seems that the app is not popular in the app store with only thirty-five ratings whereas in Google play store there are fifteen thousand reviews with an overall score of 3.9 stars. Activ Health app screenshots have been reviewed(taken from Google play) see figure 4.



4 Figure. Activ Health app screenshots, Source: play.google.com, <https://play.google.com/store/apps/details?id=com.adityabirlahealth.insurance>

[HEA19]

Users reviews Google Play store:

Author	Date	Score out of 5	Comment
Hanoosh Ravva	October 16, 2021	1	"The app always gets disconnected from Google fit, never syncs data..."
adiyaman m	June 2, 2021	3	"App working speed is very slow . It takes more loading time. Especially update profile is not working..."

Dharmendra Pandit	September 9, 2021	2	<i>"Most of the data is not in sync. I renew my policy using your mobile app after I called many time..."</i>
Dhaneshwari Bharatia	September 26, 2021	4	<i>"App is really good. I need to know how can I update my daily activity of gym on it. Going for the gym everyday but no idea how to update it within this app..."</i>
Vaibhav Jungari	July 21, 2021	5	<i>"From last two month I was facing active health application login issue, I couldn't login due to technical issue, but Mr Vijay Lohar resolve..."</i>

To summarise user comments, from a total of 15,091 comments 71% of users rated it at 5/4 out of 5.

Personal opinion about Activ Health app:

Since the app is inaccessible, it is difficult to judge the app. Especially the performance of it, but the look and functionalities are great judging from the *Activ Health App Unboxing* video on Youtube.[ABH20]

By reviewing a lot of the customer comments, seems like the biggest issue is synchronizing with the Google fit, and some say that data is not always updated.

But overall there is only 21% of customers have large problems with the app therefore it may be only due to their device.

Discovery

Discovery app is owned by global financial services called Discovery limited that has been founded in South Africa. It has been established in 1992 and has over 13 thousand employees with over 40 million customers across 20 countries.

Discovery provides medical care, life cover, and multiple different types of insurance.

While a person is a customer, they can participate in the Vitality program that uses the Discovery app and it rewards customers for healthy living, driving well, and banking well with vitality points.

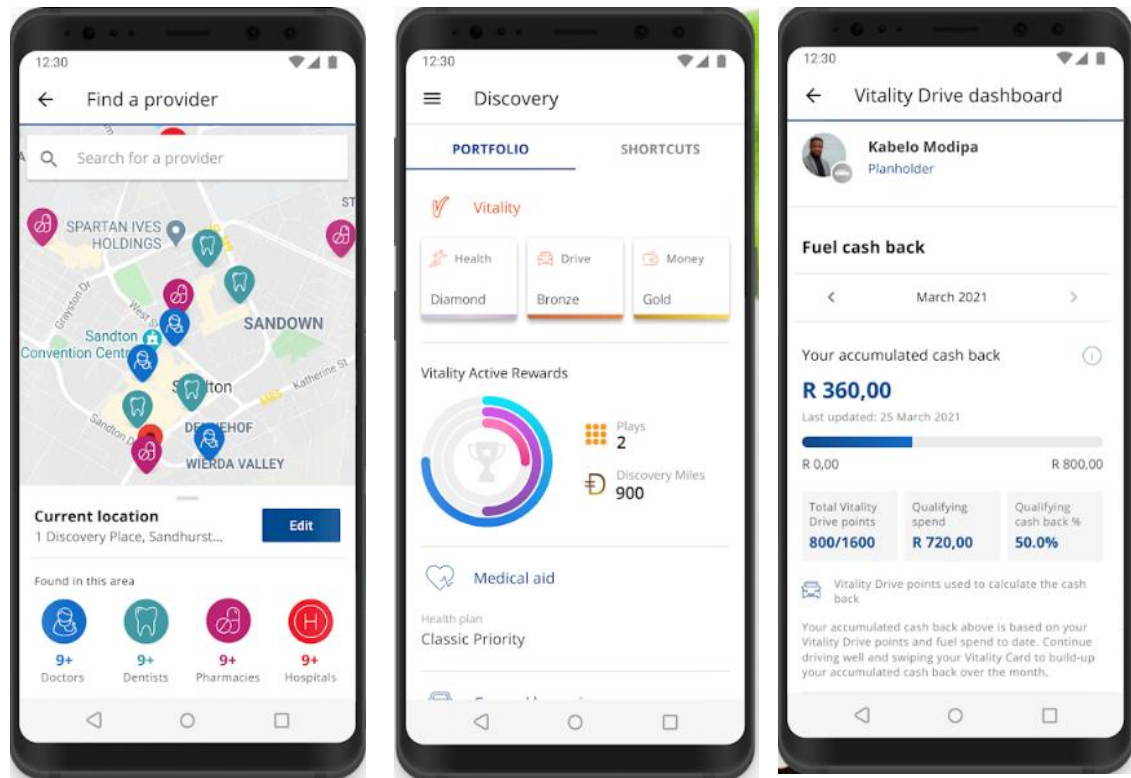
With these vitality points, customers get rewards such as travel, grocery, smart wearable, and other discounts.

The Discovery app has a huge number of features including:

- Manage Discovery health plan, detains, and claims.
- Comparing medicine prices.
- Manage Discovery card details, miles, cashback balance, etc...
- Manage Discovery Insure policy and other
- View Vitality points, active reward goals, and their rewards.
- And other...

Discovery app has an above-average score of 3.8 out of 5 with over 26 thousand scores on Google Play store whereas in Apple store it has over 77 thousand ratings with a score of 4.6 out of 5.

Screenshots of it have been taken from the Apple store for a review, see Figure 4.



5 Figure. Discovery app screenshots, Source: play.google.com, <https://play.google.com/store/apps/details?id=za.co.discovery.consumer>

[DIS21]

Users reviews Google Play store:

Author	Date	Score out of 5	Comment
Jacques-Robin Steyn	21 October 2021	1	"...Has to log in through the internet, always struggles to log in, always, scared for what might happen in an emergency..."
Phase Panther	22 October 2021	2	"Used to work well. Idk what they did in one of the more recent updates. Can't login..."

Ryan Bailey	1 September 2021	4	<i>"...There are a few bugs however for android users. Biggest issue I have is the biometric log in keeps resetting even though I enabled it in settings.."</i>
Ayva Schutte	7 October 2021	5	<i>"It is an amazing app but i hope they put more exiting rewards like typo or mr price home because there is teens using the app..."</i>
Keegan Sports	26 August 2021	3	<i>"Sluggish app. It works fine, but frustrating when things struggle to load regardless of internet speed..."</i>

To summarise user comments, from a total of 100 thousand comments around 70% of users rated it at 5/4 out of 5.

Personal opinion about Discovery app:

In my opinion, the app is packed with so many features that it becomes a performance issue discovered from viewing a lot of user comments in Google and Apple stores. Also, the app could use some more color since it is a bit plain in comparison to other apps reviewed and that's just being picky.

Summary Comparison

The three applications that have been chosen were similar in a sense but different in many other ways. All of them provide insurance with other multiple features and sometimes too many may become problematic as discussed with the Discovery app.

The Best out of three in my opinion is Activ Health since the GUI is great, has a great number of useful features, and comes closest to Dynamic personal insurance with cashback rewards. Irish life-health with MyLife is in second place since it does provide a lot of similar features in comparison to Activ Health but there are no cashback rewards and the management of Insurance policy is part of a separate app.

Discovery is not just an insurance health tracking app, it is so more. It contains such a huge following, so many features, but that becomes its downfall in regards to its performance.

The lesson here is, implement only the most valuable functionalities, synchronization with other devices is very important and rewards are extremely important.

- All applications rely on third-party applications to measure and process the raw sensor data into clear numbers.

Conclusion

In comparison to the application reviewed, the project will process the data(without access to third-party apps, such as Google fit).

As discussed before Irish Life has a good overview on how to measure a person's health(Body, Mind, Life) but the main ones to consider are Gender, Age, Height, Blood pressure(nutrition), Exercise, Sleep, and Stress levels. With these data, it can be measured the premium costs.

Communications, Hardware, and data

This section is used to document the research to discover the sensors that wearable contains, the type of data they produce, the process of sending data from wearable to handheld device, and how it can be used concerning the project.

Communications

There are a few ways to send/sync data between the handheld device and a wearable device.

- Directly with a network connection – wearable sends the data via network and mobile retrieves it. There could be possible complications such as the need for a good network connection.
- With Wearable Data Layer API – wearable sends the data via Message Client or Channel Client dependant on the size of the data with the help of Bluetooth and/or via the network. It uses Google Play services channels.

[DEV21]

- Bluetooth
 - Classic – This is normally used for constant two-way data transmission with a high as 2.1 Mbps flow. As a result, it's an ideal choice for streaming audio and video, as well as mice and other devices that require a constant, internet connection.
 - Low Energy – It has only a 0.3 Mbps data transmission rate but it uses a hundred times less power. The data is conveyed in short (20-byte) packets, although the range can be more than 100 meters, and the minimum latency between disconnected status and data transfer can be measured in a few milliseconds, in comparison to around 100 ms with Classic Bluetooth.

[DAT20]

Conclusion

While comparing Bluetooth LE, Bluetooth Classic, Wearable API with Message Client/Channel Client, a decision has been made to use Bluetooth LE since the data transferred is not continuous but rather is broken down into x,y,z measurements (small fragments).

Also, the watch does not have a large battery in comparison to devices such as phones therefore the Bluetooth LE will be a perfect fit.

Hardware/Watch sensors

There are six-teen sensors that are described in the 2020 article that has been reviewed but it possibly could be more now. Some of these are Altimeter, Optical heart rate sensor, spO2 monitor, Proximity sensor, Magnetometer, and many more but the generally the fitness trackers use :

[TIM20]

- 3 axis accelerometer - It tracks velocity and position from the X, Y, & Z axis. It is a very powerful sensor, actions that can be identified with this sensor are steps taken and sleep length.

An accelerometer is fundamental to producing movement data, but if extra sensitivity is needed other sensors are needed such as :

- Altimeter - This sensor is not as common as the two above, it tracks height therefore it is good for mountain climbing.
- Temperature sensor - similarly to the thermometer, it measures the heat of the person to derive the difficulty of the exercise.
- Optical sensor - is in use for pulse and/or blood pumping rate data gathering with a light on the skin
- Gyroscope

[LAS19]

Data

In regards to prescribing an insurance plan, limited data has been found on the internet. Therefore, the only way to find data that is needed to develop of somewhat accurate Machine learning model is to analyze some of the health care Insurance companies(Laya Healthcare, Irish life healthcare) how the premium is calculated. These general questions were asked :

- Age – its consists of 4 groups.
 - 18-20 – with the lowest price.
 - 21 – 25 – about 5-10% increase.
 - 26 – 35 – around 10 -20% increase.
 - 36 to 64 – premium increases 2% every year.
- Hospitals(All Hospitals, Most Hospitals, Public Hospitals) - all hospitals include private and public and are most expensive with an increase to 25% of the premium price. Most hospitals are lower with a 10-15% increase and public hospitals are the cheapest.
- Cover (Low, Medium, High) – Low means the allowance on the GP visits are limited
- Hospital Excess (0,150,300 and higher) – the higher the more price person will be charged when accepted to the hospital.

- Plan – normally around 3 plans with around 10% of the premium price difference
- Smoker – being a smoker escalates the price nearly 50%

At the end of the analysis, observation has been made that most of the independent variables were categorical, with continuous dependant variables (“Price”).

Conclusion

Although the watch has a lot of sensors and it is not difficult to access them, the largest difficulty arises when needing to classify it. There is extensive research done in multiple research papers such as [MAN20], [SZL20], [SEM19] and many more but sensor data has to be classified using time series ML algorithms and it has been found too much for the project to handle. Therefore the movement data has been classified using mathematical calculations by “ANU S PILLAI”. Additionally, in the Data section is shown that a lot of ML models won't deal well with categorical/continuous data therefore the easiest solution(preventing extra pre-processing of data) is to use “Decision tree regression” to predict the premium price.

[PIL19]

Relevant Technologies

Machine learning

The project involves Machine Learning(ML) as previous sections stated therefore to clarify where models have to be trained and inference, the research has been carried out below.

Cloud vs. Local Model

Training

Training is a process of finding a data set suitable for the project, examining it, processing it, and applying ML models to it.

There are two ways to train ML model's

1. Cloud - Multiple companies provide cloud computing services for Virtual environments such as Azure Virtual Machines, Google Compute Engine, Amazon EC2, and many others. From these environments, any application can be run to train the models such as Jupyter Notebook, Keras with TensorFlow, etc...
2. Local – Manage the creation of the Model training on personal pc with application same as Cloud.

The advantage of using a cloud is scalability. If data-set changes(get larger) personal pc/s could become unable to handle the load.

Disadvantages of using a cloud:

- Cost – It cost to store data for training and cost of computing data.
- Learning curve – must learn how to set up virtual machine environment with training ide.

Inferring

Inferring is a process of taking live data that needs to be classified and checked versus the trained model. Inferring can be used in two ways, such as:

- Hosted ML in the cloud – trained model in set up in the cloud with the access of an API. There are multiple Cloud services companies providing these such as Google, Microsoft, and Amazon.
- Locally – trained model saved part of an app and processed locally.

Methods of inferring are compared below Table 1.

	Cloud	Local
Model update	No app changes	Need to change the code and users must download a new app
Security	It is more secure	Less secure as must worry of competitors getting models copy
Network access	Yes	No
Speed	Slower	Faster
Cost	Some	None

Table 1. comparing cloud and local inferring

Fully managed ML solution

Providers that create models, train them, and let infer on the cloud are called learning as-a-service. Companies that provide such services are Google Cloud Vision, Amazon Rekognition, Microsoft Azure Cognitive Services, and many others...

The app sends data via HTTPS request and within the app, we interact with to service API endpoint to get a result.

The advantage of using the service is easy to set up, less work, no training models are needed.

Disadvantages include:

- The models provided are general.
- Expensive
- Models trained with common data only

[HOL17]

Conclusion

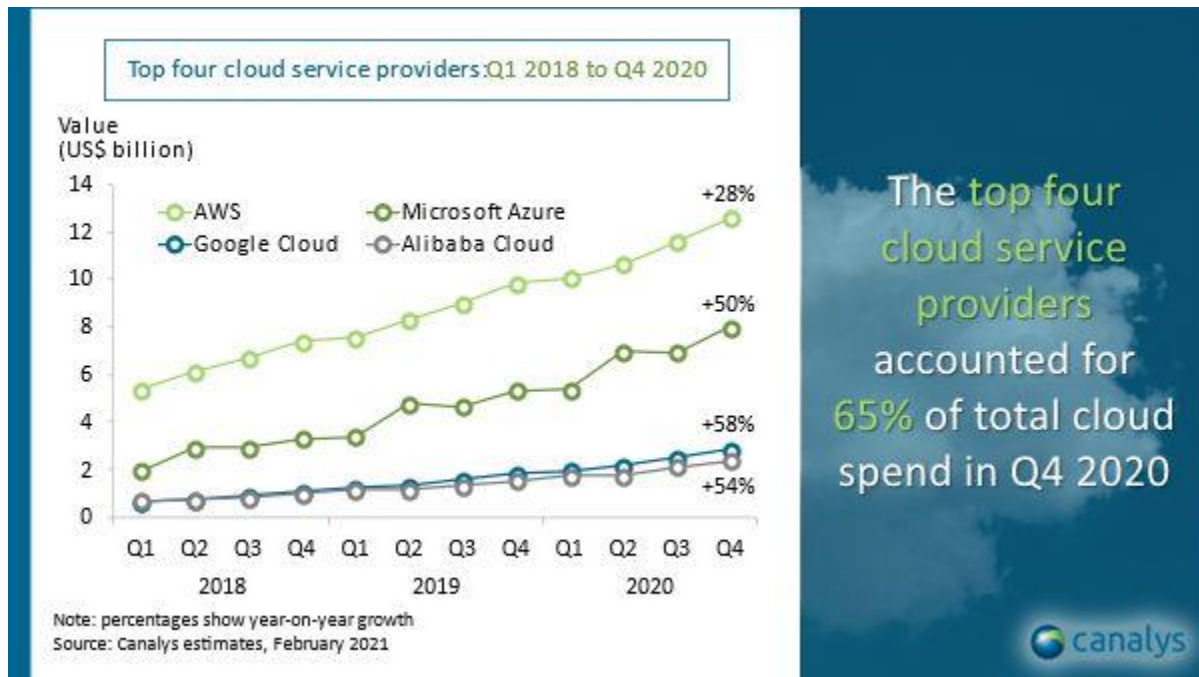
In regards to research done above section, it is decided that model training and inferring will be conducted on the cloud without fully managed ML solutions since it does provide only simple models using sk-learn.

Cloud computing technologies

Multiple companies provide cloud computing services, therefore, it is difficult to choose therefore it is researching the most popular companies, see figure 6 and compare them in the research.

Amazon Web Services (AWS)

AWS has been around since 2002 and offers hundreds of different types of services across 78 zones. Services provided include Amazon EC2, Amazon Aurora, DynamoDB, AWS Lambda, etc... As seen in Figure 6 AWS takes over thirty per cent of the market-leading in cloud computing race. The company provides over forty compliance certificates across multiple sections that are not free.



6 Figure. the top cloud provides, Source: <https://www.c-sharpcorner.com/article/top-10-cloud-service-providers/>

Microsoft Azure

Azure has been launched in 2010 and as seen in figure 6 is the second most popular service provider with over six hundred services available across 140 countries. Popular services include Virtual Machines, Azure SQL Database, Azure Cosmos DB Cognitive Services, etc...

The company provides over ninety compliance certificates across multiple sections that are not free.

Google Cloud

Google cloud has been around since 2008 is the third most popular cloud computing service provider according to *Canalys* in figure 6 and It is available across over sixty zones with over a hundred services across multiple sections.

[CHA21]

AWS vs Microsoft Azure vs Google Cloud

Figure 7 clearly shows the cons and pros of these cloud provides.

Vendor	Strengths	Weaknesses
AWS	<ul style="list-style-type: none">• Dominant market position• Extensive, mature offerings• Support for large organizations• Extensive training• Global reach	<ul style="list-style-type: none">• Difficult to use• Cost management• Overwhelming options
Microsoft Azure	<ul style="list-style-type: none">• Second largest provider• Integration with Microsoft tools and software• Broad feature set• Hybrid cloud• Support for open source	<ul style="list-style-type: none">• Issues with documentation• Incomplete management tooling
Google	<ul style="list-style-type: none">• Designed for cloud-native businesses• Commitment to open source and portability• Deep discounts and flexible contracts• DevOps expertise	<ul style="list-style-type: none">• Late entrant to IaaS market• Fewer features and services• Historically not as enterprise focused

7 Figure. Cons & Pos of Vendors, Source: <https://www.datamation.com/cloud/aws-vs-azure-vs-google-cloud/>

[HAR21]

Conclusion

According to research done, the AWS service provider(EC2) is the best fit for the ML part of the project since it is:

- It is most popular in comparison to others.
- A lot of documentation online with a huge number of tutorials found on Youtube etc...
- Even doo it has been said that it is difficult to use, Containers such as Docker may help that weakness.

Choosing Operating System(O.S)

The project consists of dealing with three types of OSs. Client-side, Server-side, and smart-watch side, to decide which operating to choose, research has been conducted and described below.

Client-side

Similar applications clearly show that to receive quality personal biometric/ movement data, the app must have a mobile OS for the client-side of the application.

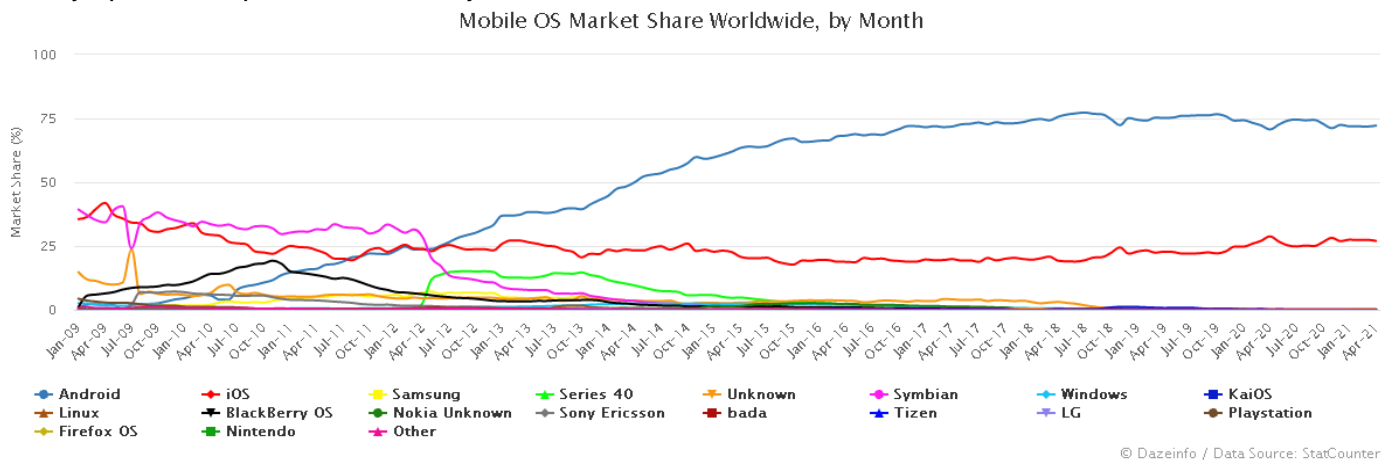
There are a lot of mobile operating systems out there that most would have not heard of such as KaiOS, bada, Series 40 but most society would know that Android and iOS mobile O.S are the most popular, as is shown in figure 8.

It is shown that since 2011/2012 Android begin to take over the mobile OS market, society has begun to realize that OS's can be "Free-Open-Source"(F.O.S) and soon after in 2014 it has been introduced to TVs that making android even more popular.[WIK21]

Since Android is F.O.S, it is less secure in comparison to iOS therefore iOS is still taking place in the market. It still takes over 26.75% of the worldwide O.S. market at this time(09/2021) according to GlobalStats.[GS20]

Apple does not share O.S. sources with the public therefore it is harder for it to be exploited.[MAR21]

In general, the number of low-income citizens overtakes the higher paid society therefore always prefer the price over security.



8 Figure. Market share by month for different types of OS comparison, Source: Dazeinfo.com, <https://dazeinfo.com/2019/08/23/mobile-os-market-share-worldwide-by-month-graphfarm/>

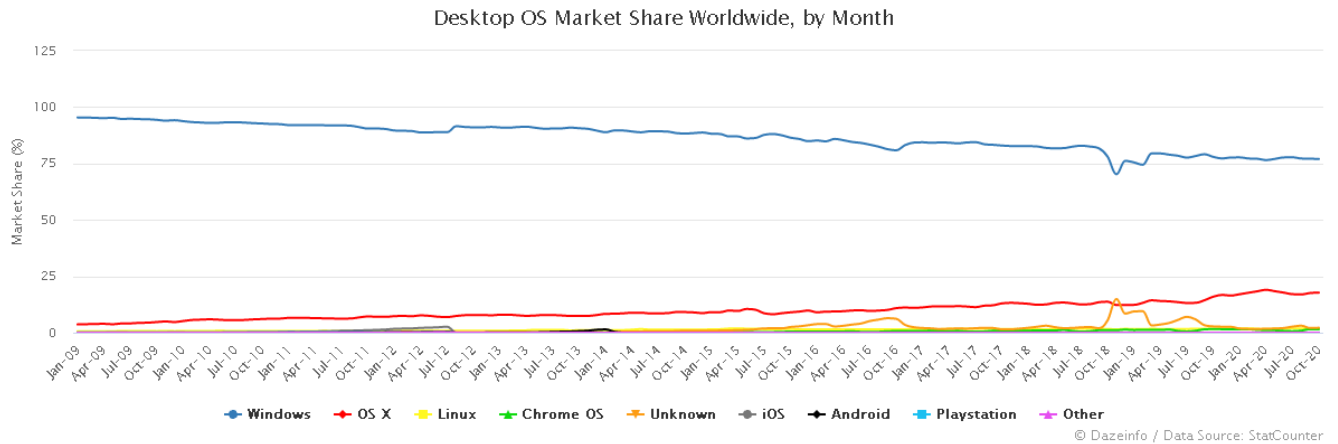
Server-side

For the server-side application, the most popular O.S. is Windows according to figure 9 by "Dazeinfo" as there is no surprise.

Windows O.S. was introduced by Microsoft in 1985 with closed-source but with Shared Source Initiative. It dominated the market since then focusing on encapsulating the operating system with a friendly user interface and limited settings, not as Linux(with the opened source model).[WI212]

In 2001 Microsoft released Xbox that runs type Windows O.S. increasing its popularity even more.[WI321]

With the success of game consoles, Microsoft gain the confidence to move on to the mobile market in 2010 but it did not last long as it was discontinued seven years later in 2017.[WI421]

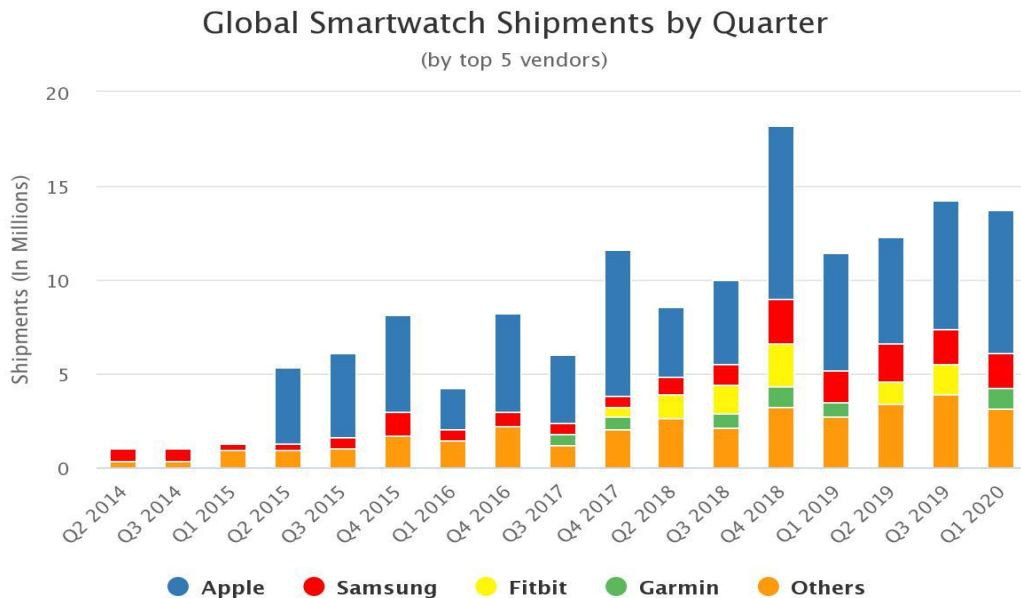


9 Figure. Market Share between different types of OS over years comparison, Source: Dazeinfo.com, <https://dazeinfo.com/2019/08/23/desktop-os-market-share-worldwide-by-month-graphfarm/>

Smartwatch-side

For the smartwatch side of the application, there are multiple choices when it comes to choosing O.S as shown in figure 10 but the biggest giant is Apple. Since 2015 apple has completely dominated the market.

Each year since 2015 Apple has taken over fifty percent of global smartwatch shipments as indicated in figure 10, according to Dazeingo Strategy Analytics.



10 Figure Smartwatch shipments compared by years, Source: Dazeinfo.com, <https://dazeinfo.com/2020/07/22/global-smartwatch-shipments-by-top-vendors-by-quarter-graphfarm/>

Apple uses OS named watchOS. It is modified iOS which is apples main OS through other products. WatchOS provides an API for developers called *WatchKit*. [WI521]

The rival (Samsung) release their watch two years earlier. The OS has been experimented on since the OS changed a few times from Android OS to Tizen to Android Wear and back to Tizen OS. [WI621]

Tizen OS is a type of Linux OS that has been created as an HTML5 platform by the Linux foundation but it was not successful.

Samsung has taken it and combined it with Bada(discontinued Korean OS for mobile devices) into Tizen.

The newest smartwatches use an operating system called *WearOS* which is made by Google.

Conclusion

As seen in the covered section above, it has been discovered that the most used OS for the client-side of the application is Android and iOS, for the server-side is the undefeated champion Windows and for the watch side is watchOS.

Therefore, to create a good chance in creating the largest customer base these platforms need to be covered, except for iOS.

The watchOS has to be chosen for the project since I do not possess an apple watch and I do not possess the knowledge of swift while trying to minimize the learning curve.

Type of development choice

To cover OS's that have been picked in the section above, extensive research has been done below to guide the app towards a development framework.

Native app development

Native development is apps that are developed with Java/Kotlin and installed with the help of the Google play store. They can access and use most of the device features such as a camera, clock, GPS, notification/calendar system, and many more.

The reasons that Native developing a native application won't work here:

- Time constraint. The project is less than a year long.
- Manpower. There is only one developer.
- Multiple OS's covered. This is the biggest reason why it won't work is that to access App for each OS, it would have to be coded with a different programming language (for example apple: swift, Android: Java), not all the languages uses the same coding tool, therefore it would increase the learning curve.

Hybrid app development(HAD)

Hybrid app development consists of applications built similarly to how the website is built, with programming languages such as Html, CSS, and Javascript, and could be run on a web view component available in a Native app. Most of the app is built with Javascript code but the look and feel of the app are extremely similar/unrecognizable to a native app because most of the components are provided by HAD frameworks such as Apache Cordova and Ionic.

Reasons to pick HAD are

1. One codebase while saving time.
2. Simpler to maintain since the app is created similar to a web.
3. Quicker time to the market.
4. There are more customization options therefore the UI/UX is improved.

Reasons not to pick HAD are:

1. There is no offline support
2. Some of the features do not work on different OSs.

Cross app development(CAD)

CAD is extremely similar to HAD since it provides features that allow creating one code base apps for multiple OSs.

The difference between HAD and CAD is that Hybrid needs an internet connection while running javascript thread on web view component on OS selected, whereas in Cross-platform the code is created with a specific framework programming language that is available and the framework automatically adjusts the code towards different OSs.

The way components are distributed is also specific to a framework that is chosen. (For example, Flutter components are created as widgets whereas mobile components are rendered with React Native APIs)

[SHA20]

Reasons to pick CAD:

1. Cost reduction. Less manpower with less expertise is needed to produce the code since the selected framework uses one programming language.

2. Code Reusability. Code created for each OS from one main code.
3. Similar Pros to CAD

Reason not to pick CAD:

1. Slower than a Native app, especially when the app is extremely complex/demanding.
2. More difficult to code.
3. UI/UX is not as exceptional as Native app counterpart.

[SIN21]

Conclusion

In consideration of the research done above, Cross app development has been picked to receive minimize the learning curve since Hybrid app frameworks are coded in Javascript. Also, it's been discovered that Hybrid does not provide offline support and the project has to be functional offline.

Front-end technologies

There are a lot of frameworks out there somewhat different from each other, but the research below has been done on the three most popular ones to explore which suits the project the most. Each of these frameworks is a high contender to be chosen as a developing framework.

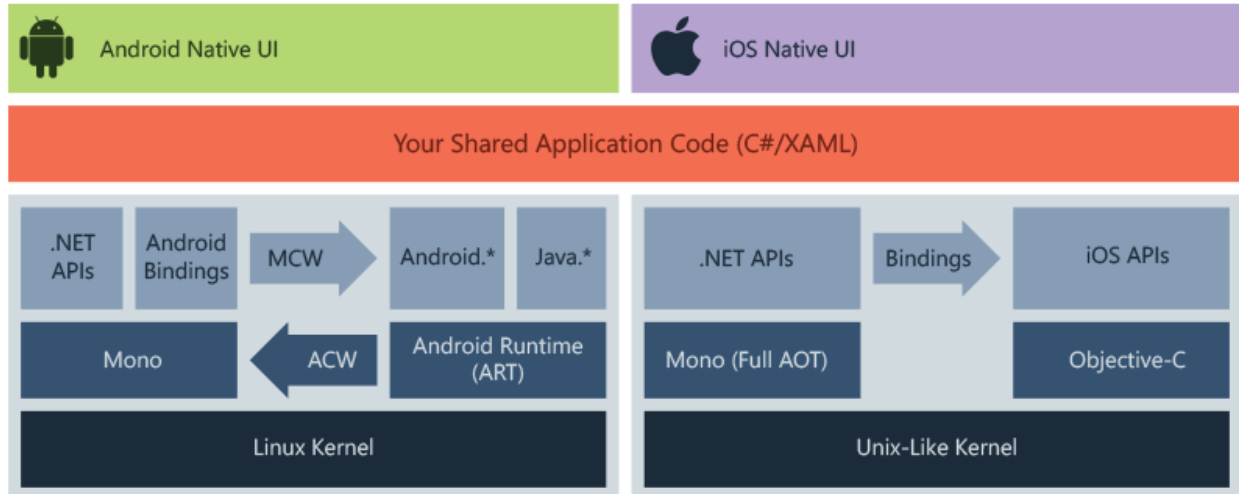
Xamarin

Xamarin is an open-source platform that was founded in 2011 as a standalone cross-app framework however it was subsequently purchased via Microsoft 2016 and improving it greatly. It is used for developing stylish and performant.NET apps for iOS, Android, and Windows Operating Systems with a single code base.

Xamarin allowed programmers to replicate 90 percent of their programs across OSs. This approach makes it easy to build all of their core functionality in a single language while maintaining standard android speed, design, and experience.

Xamarin uses C# language to create the base app logic and XAML language to create the GUI which is translated to other platforms.

As seen in figure 11 below, Xamarin compiles with a *Mono* environment and communicates with Android Runtime via MCW and ACW calls, whereas in iOS Mono compiled fully before communicating with *Objective-C* via *Bindings*.



11 Figure. Xamarin basic architecture diagram, Source: docs.microsoft.com, <https://docs.microsoft.com/en-us/xamarin/get-started/what-is-xamarin>

[XAM21]

Xamarin pros include:

1. It is very popular. Over three thousand organizations with sixty thousand contributors use Xamarin.
2. Xamarin shares over seventy-five percent of the code through the different platforms.
3. Easy to understand/learn since it runs C# and XAML. (If completed Android projects, makes it even less complicated)

Xamarin cons include:

1. The cost for a company license of a Visual studio could be expensive but it does not concern me as an individual.
2. The base/abstract app's UI does not allow drag & drop elements as Android studio would therefore it takes longer to design the UI, especially if the person using it has no previous experience in android development.
3. Application with heavy graphics will not perform very well.

[MAN20]

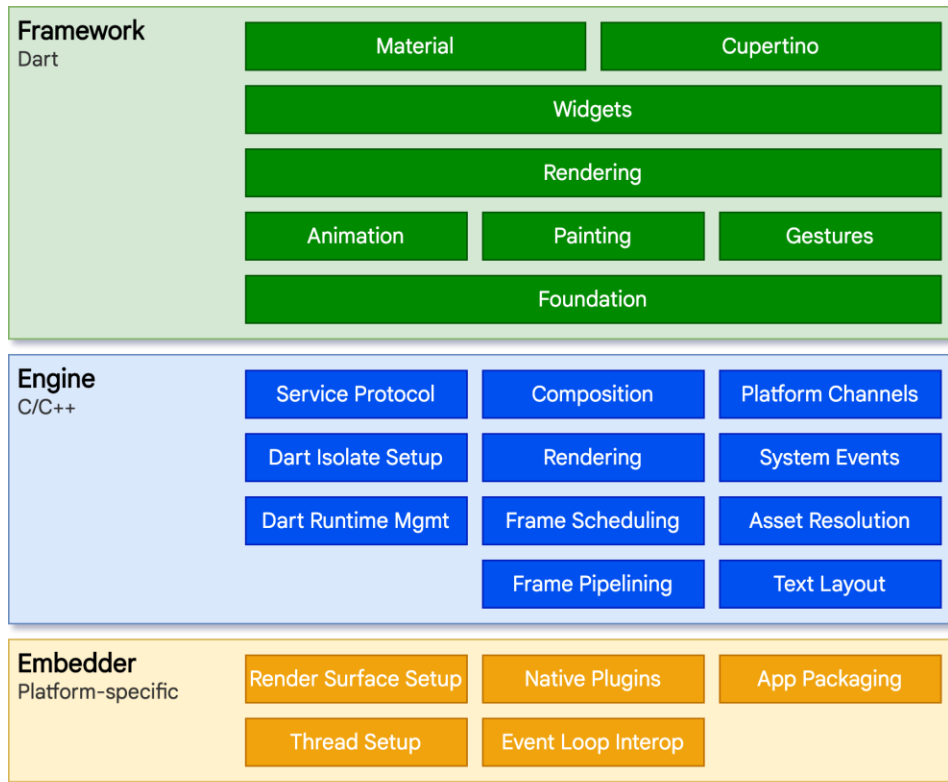
Flutter

Flutter is an open-source mobile cross-platform framework that was released in 2017 by Google.

It's a new, exciting thing that everyone is raving at since it is released by Google. Flutter uses Dart as the core language. Dart is quite similar to most object-oriented languages (C#/Java) but the flutter is created with multiple widgets inside other widgets. In these widgets, the logical and interface code is mixed in a sense.

Flutter compiles code in C/C++ with *Dart Isolate Setup* and *Dart Runtime Mgmt* as shown in the architecture, Figure 12.

12 Figure. Flutter's architecture overview, Source: flutter.dev, <https://flutter.dev/docs/resources/architectural-overview>



Flutter pros consist of:

1. Compiling is not necessary after each change in code since there is *Hot reloading* feature available.
2. Increasing popularity. Since 2020 flutter community has increased.
3. The flutter does not allow a drag and drop interface but there are platforms such as *flutterflow* where elements can be dragged and drop and it automatically creates code behind that could be copied.

Flutter cons consist of:

1. Support for smart TV is not existent.
2. Since Flutter is a new framework, it is not complete in comparison to native app development.
3. Flutter mixes user interface code and logic code in the same file as part of different types of widgets therefore we could end up with multiple threes and it is difficult to follow as a new flutter user.

[MAN20]

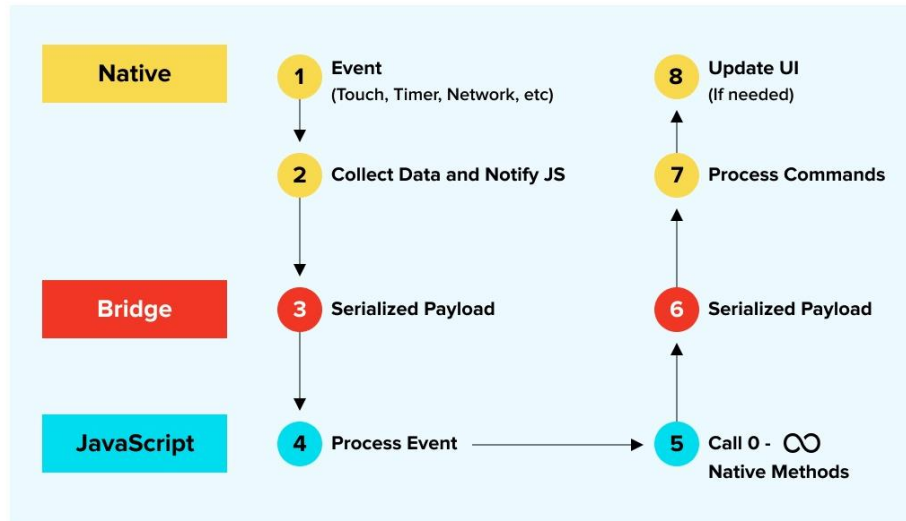
React Native

React Native is a mobile cross-platform framework, it is released in 2015 by Facebook. Apps that are created in React Native use JavaScript and JSX. JSX is a language that implements HTML and JavaScript.

The code that is written in JavaScript is connected by a *bridge* to rendering APIs such as Java and Objective-C, as shown in figure 13.

Its architecture is made of three threads JavaScript, Native, and Bridge that exchange data between them.

Basic Overview of React Native Architecture



13 Figure. React Native architecture overview, Source: netsolutions.com, <https://www.netsolutions.com/insights/flutter-vs-react-native-vs-xamarin-which-framework-is-right-for-you/>

React Native pros include:

1. A high percentage of code reusability. Code that is shared between all the platforms up to eighty percent, which helps to develop the app quicker.
2. *Hot Reload* feature available, therefore the application is not needed rebuilding when making changes
3. Performance. The similarity between Native and React Native is quite similar since it renders elements for a specific platform.

React Native cons include:

1. There are limited native features available.
2. Debugging/testing is quite difficult since React Native works between threads.
3. The framework is still new and updated frequently, therefore it is difficult to keep up.

[SHA21],[ALS21]

React Native vs Flutter vs Xamarin Summary

To Summarize the research done above, see table 1 was created below to personalize the Choice for the project.

Framework	Xamarin	React Native	Flutter
Popularity/Maturity	Least popular but established	Most popular but relatively new	Close to the most Popular but newest
Learning Curve Difficulties	Low	Medium	High
Debugging/Testing Difficulties	Low	High	Medium

Table 2, React Native vs Flutter vs Xamarin Summary

Conclusion

By reviewing research that has been done in previous sections above, the cross-platform that will be chosen is Xamarin. The main reason for the choice is that Xamarin has a familiar language, it is still very popular and does not seem to provide with Testing difficulties. Overall it has been discovered that other frameworks had a higher probability of risk to the project, unlike Xamarin.

Type of Databases

There are a lot of different types of databases out there such as Centralized, Hierarchical, Network, and many more, but to research and review them abstractly, it has been categorized into two groups.

SQL(Relational database)

A relational database is one of the most popular databases out there and the biggest reason is that it has been released since the 1970s, it is hard to get rid of. It is based on the relational model which is logical data structures, which is a simple and obvious manner of expressing data in tables. Each table contains rows and columns, and each row must have a unique ID called Primary key. Its responsibility is to be an access point to its row content.

Tables can contain multiple keys(Primary, secondary, etc...) and they are used to connect data from different tables. Popular databases include The Oracle, MySQL, Microsoft SQL Server

[ORA21]

Advantages include:

- Transaction security and correctness with the ACID property which is:
 - Atomicity - every process either completes or is scaled back.
 - Data written to a database must be consistent and adhere to all set standards.
 - Isolation - Concurrent transactions do not clash.
 - Durability - Transaction deemed permanent when it has been recorded to the database.
- Well established since it has been it has created for a long time.

- Great for handling horizontal multiple user queries.

[MA20]

Disadvantages include:

- Vertically scalable, which means the database can function on one server.
- Difficult to store objects on tables.
- It Rigid database and data migration are difficult. Deleting/Adding columns to the database is a big deal.

[MON17]

NoSQL(Non-relational database)

NoSQL stands for “*Not Only SQL*”, it has firstly called a lightweight database that did not use SQL in 1998 but later in 2009 become more popular with descriptions as non-relational databases.

The main reason it has been developed is that it could handle big, unstructured, web data, big data.

NoSQL database has multiple categories such as:

- Key-Value Stores. Data is stored as the name suggests in key-value pairs. Popular databases include Amazon ElastiCache, Redis, Azure Table Storage, and many more.
- Document storage. Data is stored as “key: value” pairs as XML/ JSON documents. Popular databases include MongoDB, Apache CouchDB, IBM Cloudant.
- Wide Column storage. Data is stored as rows and columns however they are more flexible with the functionality of each column having families that are stored separately. Popular databases are HBase, Cassandra, Hypertable.
- Graph database. Data is stored as so-called *Nodes* that are connected with so-called *edges* that relate the data together. Each edge is defined by its ID and has a starting and ending place node. Popular databases include Infinite Graph, OrientDB, FlockDB.

[KDF18]

Benefits include:

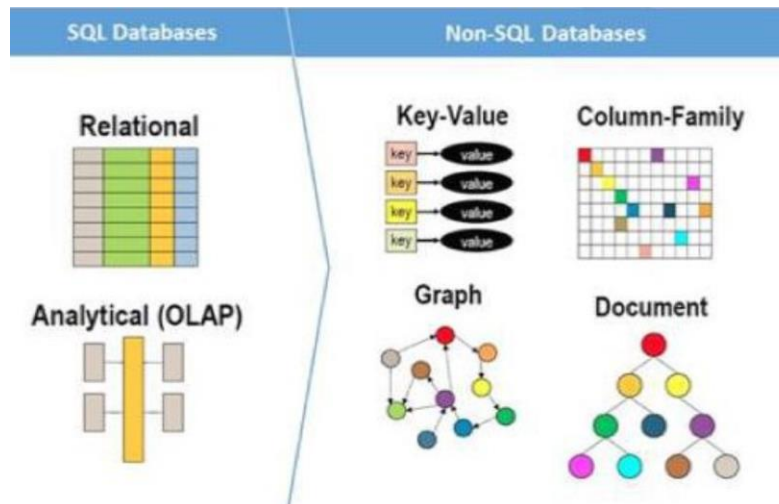
- Distributed processing. Big Data can be processed across several clusters while it increases the speed.
- NoSQL is horizontally scalable with adding CPU components to the server such as CPU, RAM, and/or SSD.
- Flexible schema with simple migrations.

Limitations include:

- Some of NoSQL do not comply with ACID.
- Maintenance can be difficult if using a key-value pair type database.
- Limited query capability.

[AGR21]

NoSQL and SQL comparison



14 Figure, SQL and Non-SQL data storage, Source: thornotech.com, <https://www.thornotech.com/sql-vs-nosql/>

The way NoSQL and SQL store data is shown in figure 14.

In table 3 below has to be compared two major categories of the section in regards to the project.

	SQL	NoSQL
Query/update speed	Faster	Slower
Read and Write speed	Slower	Faster
Quantity can be stored	Less	More
ACID (Thread-safe)	Yes	Not All
Flexible schema	No	Yes
Scaffolding code	More	Less

Table 3, Categories Compared

Conclusion

It has been uncovered with the research done in the above section, that the NoSQL category is a better fit for the project since it will store watch sensor data.

Now that we know what category we going to use, back-end technologies will be researched and discussed in the section below.

Back-end technologies

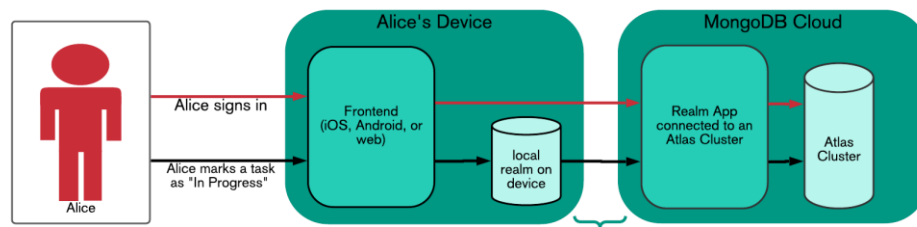
There are a lot of No-SQL databases out there somewhat different from each other, but the research below has been done on the two most popular ones to explore which suits the project the most. Each of these databases is a high contender to be chosen as a storage facility.

MongoDB

It is a database platform created in 2007 by employees of “*DoubleClick*”, in order to improve the scalability and agility of the existing database in place. Right now MongoDB has over twenty-six thousand customers in over 100 countries with over two thousand employees.

The products that it provides include *Atlas*, *Enterprise advanced*, *Community Edition*, *Realm*, and some of the tools to complement these products.

Atlas and Realm will be focused in regards to the project. Realm is light a data storage for mobile and web that has a function called *sync* that synchronizes with Atlas which is a *Multi-cloud database platform*. As mentioned in “NoSQL” the data is stored in documents in BSON format. Figure 15 below simplifies the connection.



15 Figure, MongoDB connection, Source : [mongodb.com,https://docs.mongodb.com/realm/tutorial/preview/](https://docs.mongodb.com/realm/tutorial/preview/)

Firebase

It is a mobile development platform created by Envolv in 2011 and acquired by Google in 2014.

Firebase provides seventeen different types of products such as Cloud Functions, ML Kit, Cloud Firestore, Cloud Store, Realtime Database, and so on...

How Firebase stores data depends on its product. The two most relevant products are:

- Real-time Database:
 - stores data as JSON documents which are key-value pairs.
 - Multiple databases allowed
- Cloud Firestore :
 - stores data as a group of documents.
 - Faster with advanced querying and sorting.

The most relevant out of the two is Cloud Firestore.

[STE18]

MangoDB vs Firebase-Firestore

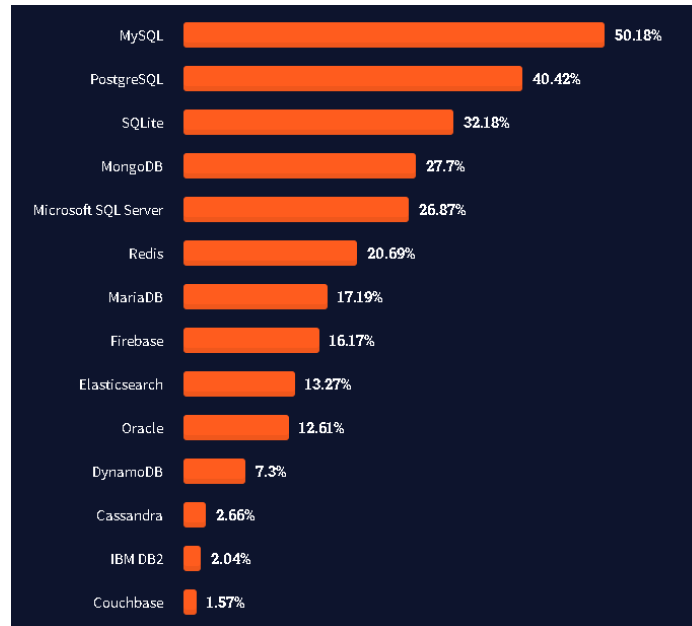
In regards to the project, these two giants have been compared in table 3.

	MongoDB	Firebase Firestore DB
Security	More secure	Less Secure
Offline	fully	Not fully.
Extra features	Not internally	Many are available
Respond speed to requests	Faster	Not as Fast
Scalability	Very high	High
Learning Curve	Less	More

Table 4. Comparison of databases

[TOB21]

According to the StackOverflow insights developer's survey 2021 which over eighty thousand developers participated, shown in figure 16, MongoDB is the highest NoSQL database on the list.



16 Figure, Developers survey 2021, Source: stackoverflow.com, <https://insights.stackoverflow.com/survey/2021>

[STA21]

Conclusion

By reviewing research that has been done in previous sections above, the database that will be chosen is MangoDB.

It clearly shows that its major downside is that it does not contain prebuilt futures (as Machine Learning is needed) but it has many other things to offer instead (for example, saves time on the learning curve and it is more popular).

Summary and overall conclusion

The author personally thinks that the major details of the project have been cleared up as the document describes that the author developing a Dynamic Cross-platform Insurance app using Xamarin forms that provides insurance management capabilities while connecting and receiving data from the android smartwatch which collect raw data from its sensors.

Finally, the raw data is identified and separated as movement data which is stored as in MongoDB.

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