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**FINAL YEAR PROJECT DISSERTATION**

By

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**ABSTRACT**

The retail sector is a multi-trillion euro industry and yet the action of purchasing an item in-store has not evolved. With our project we looked at retail model and then set out to design an innovative alternative approach to where the consumer would no longer be required to waste time queuing up at a checkout till waiting to pay for their shopping. Together we decided to create an easy to use mobile application that could be designed for any supermarket or store and that would incorporate our objectives. Our application includes NFC (Near Field Communication) Functionality, Stripe Payments, Camera Functionality and Firebase Storage. This assignment was developed using Ionic 4, Apache Cordova and Angular Framework. Throughout the dissertation we will discuss all of the various issues that we encountered. We will illustrate the solutions that we chose to implement and then the overall conclusion as to why we chose the various methods that we did to complete our technology.

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# **Introduction**

In 2018, retail sales in Europe totalled to around 3.25 trillion euro. By the year 2023 that figure is forecast to reach a value of around 3.55 trillion euro. Since the early 2000s, online retail companies such as eBay and Amazon revolutionised the method in which consumers spend their money. These companies discovered a demand from the customer’s point-of-view to have a more convenient approach to their shopping experience. This revolutionary approach received overwhelming success. Subsequently this forced the global retail industry to embrace their online business strategy and to develop their own online presence. Netflix are another excellent example of a company that recognized - by transitioning online, the consumer would purchase their product because of the sheer convenience. In business you have to aim for growth if you wish to succeed and yet the retail in-store experience has not made that similar progression.

Conor and I brainstormed various potential ideas before we decided to develop an application that we believe will improve the customer’s overall shopping experience. According to PWC.ie [1], fifty-four percent of Irish consumers still shop in-instore weekly so if the larger portion of the population still shop in-store - we felt that we should try to incorporate what they could want as well. The concept of our application was to develop a marketplace where it would make it easier for the retailer to sell their products to potential customers in an online environment but to also add a feature that would allow the consumer to purchase any item in store by simply tapping their phone on a desired item. This feature is designed towards the in-store customers. We believe this feature could have many advantages such as time efficiency. The idea is that if a customer enters the store and is under time constraint. All they have to do is take out their phone with our application running, tap their mobile phone on any product they wish then enter their card details on the application and away they go. This eliminates the risk of waiting in a queue for ten minutes or many times even longer if you are located in a largely populated area. With the widespread outbreak of the Coronavirus disease (COVID-19) this feature also has the added benefit of reducing potential interaction with a cashier that may be feeling ill.

Our objectives for this assignment were to develop a mobile application that is compatible with the android operating system. Then to integrate a database that would store details such as a user’s login details, product details, images and order details. Our next objective was to design a marketplace that the retailer can upload their products and that is easy for the user to operate. After that we set out on adding NFC (Near Field Communication) functionality to our application. NFC allows for two-way communication between your NFC enable phone and another NFC device. When we were satisfied with the NFC addition, we then had to develop a payment method for selling the retailer’s products. Lastly, we had to complete an overall test of each component to make sure that entire application was performing in the way that we intended it to.

This dissertation will progress with the following chapters: Methodology, Technology Review, System Design, System Evaluation, Conclusion, References and Appendices. Methodology will underline how we developed our application step by step. Technology Review will describe each of the technologies that we decided to implement. System Design will present an in-depth description of the overall system architecture. System Evaluation will include an comprehensive evaluation if our project met the objectives that we initially defined and Conclusion will consist of a brief summary in reference to our dissertation.

The link to our GitHub Repository is: https://github.com/kodama96/FinalYearProject

# **Methodology**

In this chapter I will illustrate how we went about the development of our final year assignment. Methodology refers to the way in which we organize and conduct the development process of our assignment. I will discuss in greater detail our approach from the various types of methodologies which can include Agile methods, Incremental methods and Iterative methods. For our project we chose to incorporate the Agile methodology. I will review the inevitable complications involved with designing an application. I will then outline our planning and discuss our meetings throughout the academic year.

**Thought Process**

Conor and I decided to form our team at the beginning of the academic year. We were appointed Daniel Cregg as our supervisor. Initially we began to conceptualise developing a banking application. The theories that we brainstormed, we believed were adequate but Conor and I concluded that we were struggling to generate ideas to broaden the applications capabilities. We immediately returned to the drawing board and with the help of Daniel – we agreed to design a marketplace application instead. We were directly more confident in the creative aspect of the new approach. Instantly we decided exactly which languages, frameworks and platforms to use. We wanted to create a marketplace application that could be used in the day-to-day life aspect of seller and consumer. We also hoped to develop an application that would have business potential as it could mimic the real-world objectives of a software developer.

Conor and I met with Daniel on a weekly basis. During our meetings we would provide our progression with the assignment and discuss any ideas of a new form technology that we could incorporate with our application. We suggested many concepts between each other before we came across the suggestion of implementing some sort of NFC functionality. Conor and I were excited by this approach as NFC is becoming a more and more widely used technology throughout the world as most mobile phone manufacturing companies are developing their products with NFC capabilities. Conor and I immediately set out to research a variety of documents, articles and research papers to help better our understanding of NFC technology and how it is used today. Although we agreed to add NFC functionality, we still had to decide what role the NFC would play for our application. I believe this aspect took us the longest to solve. We discussed how we wanted the application to be beneficial for the user if they were situated in-store or at home. Conor had the idea that if an NFC tag is somehow attached to a store product, the customer could then open our application and by tapping their phone on the NFC tag – they could purchase the product right there and then without having to queue at a shopping checkout.

**Agile Development**

Agile Software Development derives from the concepts of the “Manifesto for Agile Software Development” [2]. The Manifesto for Agile Software Development was developed by a group of fourteen leading figures in the software industry. This Manifesto emulates their experiences in reference to which approaches work and do not work during the software development stages.

Agile development in the software industry refers to a group of software development methodologies based on gradual development, where the requirements and solution emerges through a team or group of developers [3]. In 2018, a survey answered by industry software developers found that 97% of respondents reported using Agile methods. The survey also discovered that 78% of software developers reported that within their groups, they would frequently use a mixture of Agile and plan based methods [4]. Supporters of Agile development have argued, plan-driven software processes lack the flexibility to respond to the possible changing of assignment requirements that are first presented to a group of developers.

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Conor and I took into consideration other methodologies to use such as the Waterfall technique, Feature – Driven Development and Extreme Programming but we found that Agile Development was the natural fit for us as we were already setting out to meet each other regularly and then scheduled vital meetings with Daniel Cregg on a weekly basis. Daniel played an essential role with our assignment by providing us with feedback, helping us understand the objectives of our final year assignment, scheduling meetings and so much more. Conor and I are extremely grateful for the role that he played.

**Scrum Framework**

Scrum is not a process or a technique for building products, as a matter of fact it is actually a framework that is used as a risk management mechanism to create and preserve complex products. The Scrum framework can help developers to deal with complicated issues, while also effectively and innovatively delivering output of the greatest value [5]. Scrum was developed by Ken Schwaber and Jeff Sutherland.

At the core of Scrum is a Sprint. A Sprint can be defined as a singular timeboxed iteration of a continuous development cycle. Within a Sprint, work is designated to be completed by a team of developers and to be made ready for examination in a timely manner. Depending on the overall length of an assignment, a duration of time is assigned to each sprint. For example, a Sprint could stretch between one to two weeks or it could span between two weeks to four weeks [6].

Our final year assignment consisted a sprint duration of one week but depending on the difficulty that we encountered, occasionally the duration would stretch to two weeks long. Every Monday, Conor and I would meet with Daniel Cregg where we would be assigned a task to complete. The Monday afterwards, we would discuss our progress and if we were able to accomplish our objectives. After reviewing our work, we would decide on new tasks to focus on and that we could build upon for the upcoming week.

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**Testing**

For our final year assignment, we chose to use Selenium IDE (Integrated Development Environment) to examine various features from our marketplace application. Selenium IDE is a tool that comes with the Selenium Suite. It can be downloaded as a Firefox Add-On or as a Chrome Extension. Selenium IDE allows the user to create test cases and playback tests within their browser where they can perform editing, debugging and recording tests. Selenium IDE produces an easy to use Graphical User Interface for recording user actions. We used Selenium IDE through the Google Chrome browser to examine various features such as sign up, login, add products to cart, add products to database and log out. We had to use an Apache Cordova plugin as Selenium IDE was not able to test the NFC features.

# **Technology Review**

**Database**

*Firebase*

Firebase is a mobile and web application development platform owned by Google that helps developers deliver exceptional application experiences. Firebase provides developers with a collection of tools and services to help them develop high-quality apps and to grow their user base. Firebase is classed as a NoSQL cloud database that which stores data in JSON-like documents [7].

*Cloud Firestore*

Cloud Firestore is a NoSQL document cloud database that is constructed for your client- and server-side applications. By using Cloud Firestore, you can save your data on the cloud while also being able to keep your clients synchronized with the assistance of real-time listeners at the exact same time. Cloud Firestore also presents useful support for offline access, which is a great benefit for mobile and web applications regardless of network latency or internet connectivity [8].

*Cloud Storage*

Firebase Cloud Storage is a stand-alone solution that is used for uploading and sharing user generated content such as images and videos from an Android or iOS device, as well as the Web. Cloud Storage is reliable and scalable. If the user encounters a slow Internet connection problem where they are attempting to upload a document, instead of cancelling the upload process – this process will automatically restart [9].

*Firebase Authentication*

Firebase Authentication provides an arrange of APIs, easy to use SDKs, User Interface libraries and back-end services to authenticate users within a Firebase application. Firebase Authentication combines closely with other Firebase features. Firebase Authentication meets industry standards such as OpenID Connect and OAuth 2.0. It uses industry standards so it can be easily with a custom backend. Firebase Authentication works by asking the user for their personal information in order to sign into an application. This information can comprise of details such as the user’s email address and a personal password. This data is passed to the Firebase Authentication SDK. The backend services will then establish whether or not the credentials are correct before returning a response to the user [10].

*Real Time Database*

Firebase Realtime Database allows to store and synchronize data with NoSQL cloud database in real time across all clients sharing in the same database. The Firebase Real Time Database provides advantages such as if the database goes offline, data is cached in the device memory and when the database returns online then it will be synchronized.

Another excellent benefit from a Developer’s perspective in regard to the real-time database is that developers does not need the support of complex backend services. This is becauses Firebase provides Real-time database SDKs for many platforms including Android, iOS, and the Web [11].

*Firebase Cloud Functions*

Firebase Cloud Functions allows you to execute backend code as a result of events being triggered by Firebase features and HTTPS requests. The developer’s code is saved within the Google Cloud and runs in a managed environment [12].

*Firebase Hosting*

Firebase Hosting is a hosting service, owned and operated by Google. Firebase Hosting allows developers to update their contents in the Content Delivery Network (CDN) during production. Firebase provides complete hosting support with a custom domain, Global CDN, and an automatically provided Secure Sockets Layer (SSL) Certificate. SSL Certificates consist of small data files that digitally connect a cryptographic key to a company’s details. After it is installed on a web server, the padlock activates with the https protocol and provides a secure connection between a web browser and a web server. This can be beneficial for activities such as logging in, data transfers and to secure transactions [13].

**Development Tools**

*Android Studio*

Android Studio is the official Integrated Development Environment (IDE) for developing applications for Google’s Android operating system. Android Studio comes with capabilities such as a Gradle based build system, code templates, a layout editor with the ability for drag and drop theme editing and a virtual device emulator to test your application on if you’re not able to use your mobile phone. If you would like to test your application on your phone then it couldn’t be easier with Android Studio. All you need to is plug in your device via USB, allow for USB debugging and installations from unknown sources in your phone’s settings menu and then tap the green play button displayed at the top of your screen.

*Visual Studio Code*

Visual Studio Code is a powerful source code editor and is utilised for developing and debugging web and cloud applications. Visual Studio Code is available for Windows, MacOS and Linux based operating systems. It comes with support for programming languages such as GO, C++, C#, Node.js, Java and Javascript.

*Astro File Manager*

Astro File Manager is an application that is used transferring, compressing, organizing and creating a back up for your files. Astro File Manager allows to search for files on both your

device and SD Card. You can also rename files, select multiple files, copy/paste, extract zip and tar file archives. Astro File Manager was used to extract files from an APK that we would email to ourselves in order to test the application as our phones would not be recognised our laptops when connecting via a USB cable.

**Tools**

*Stripe*

Stripe is a global online payment transaction platform. Stripe provides a service to transfer money from a customer’s bank account into a business’s account by means of a credit or debit card transaction. Stripe payments provide the customer with a method to pay for a product or service with all major cards around the world on web or mobile applications. Stripe incorporates gateway functionality and payment processing which makes it an easy and convenient way to handle eCommerce [14].

*Ionic Framework*

Ionic Framework is an open source UI toolkit with a considerable set of Angular components and Cordova plugins. Ionic Framework is used for developing cross-platform powerful, high-quality mobile and desktop applications using technologies such as CSS, HTML and JavaScript. Ionic Framework is capable of providing the developer with pre built Angular components that can give a native appearance to an application [15].

*Angular*

Angular is an open-source front-end framework that is built on Typescript. Angular is developed by Google and is used for developing modern, compelling client-side web applications. Since the revamp of Angular in 2014, Angular has become a cornerstone for many developers. Angular allows the developer to build interactive and dynamic Single Page Applications (SPAs) with its compelling features which consist of RESTful API handling, templating, code splitting, modularization, AJAX handling and dependency injection. A lot of developers consider Google support to be another benefit of Angular as it makes the platform trustworthy. [16]

*Node Package Manager*

Node Package Manager is the standard package manager for Node.js. Node Package Manager comes with two key functionality traits. These traits include an online repository for node.js packages and modules while also providing a command line utility to install packages, complete version management and dependency management of Node.js packages [17].

*Typescript*

Typescript is an open-source programming language that builds on Javascript. Typescript was developed and maintained by Microsoft. Typescript provides optional static typing, interfaces and classes. Typescript simplifies Javascript code which in turn makes it easier for a developer to read and resolve any complications. Typescript code can be compiled as per the ES5 and ES6 standards to support the latest browser [18].

*Apache Cordova*

Cordova is an open-source mobile development framework. Cordova allows the developer to incorporate standard web technologies such as JavaScript, HTML5 and CSS3 for cross-platform development. Cordova can be used for developing an application across multiple platforms without needing to re-implement it with each specific platform’s tool set and language [19].

# **System Design**

A system design is the action of defining the components, modules, interfaces, and data for a system to satisfy specified requirements. [20] Throughout this chapter, I will discuss the overall design of our application and try to give a better understanding of the system architecture. I will attempt to achieve this by explaining different snippets of code from our assignment while also providing imagery.

Our application involves a three layer process: a Data Layer, an Application Layer and a Presentation Layer. The Data Layer consists of a database or data storage system and accessing data. [21] The Application Layer transfers information between the Data Layer and Presentation Layer. The Application Layer directs the application while also performing functions such as decision making and calculations. [21] The Presentation Layer is the user interface of the application. This layer translates the functions and then comprises it all to execute a visual display for the end user. [21]

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*Data Layer*

**Firebase**

During the planning process of our Fourth Year Assignment, Conor and I chose to use Firebase as our database for our mobile application. We debated over several application development platforms but we both came to the conclusion that Firebase was the correct solution for us. As we researched, we learned many advantages in relation to Firebase. Firebase offers to the developer many great integration services and tools such as Authentication, Database, Functions and an ML Kit. Firebase is also capable of supporting all of the major devices such as Android and iOS [7].

**Firebase Authentication**

When we determined that we would develop an E-Business Application, Conor and I agreed to add the authentication feature provided by Firebase as we wanted to implement a sign up and log in system for our user base. Firebase Authentication comes with simple SDKs and easy to use libraries to allow the developer to integrate the authentication component. This feature works by asking the user to input their credentials as they attempt to complete the sign-up form. The user is the returned to the log-in page where they are asked to re-enter details such as their e-mail address and password. That information is sent to the Firebase Authentication SDK. The Firebase backend services will then verify the data and then return a response to the user. This response can take only a matter seconds [10]. Conor and I have also deigned a specific page for the client to use depending on which category they selected during the sign-up process. This category includes a buyer or seller option for the user’s profile. If the user enters their correct details then the Authentication service will display their specialised page.

**Firebase: Cloud Firestore**

**Firebase Realtime Database**

**Thought Process**

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# **System Evaluation**

# **Conclusion**

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# Appendices

GitHub Repository

The link to our GitHub Repository is: https://github.com/kodama96/FinalYearProject