6COSC006W - Final Year Project Report

Contactless Voucher

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Declaration

Abstract

Acknowledgements

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1. Introduction

This chapter aims to give an overview of the context of this project, the problem is trying to resolve and the objectives.

1.1 Problem statement

Nowadays there are many ways a retailer can reward the most loyal customers. There are loyalty schemes almost for everything, from the coffee shops to flights. The more money you spend with a company more likely they are going to offer you special discounts because it is easier and more convenient for the business (Jovancic, 2019).

The current most common type of loyalty schemes available in restaurant such as Starbucks, Pizza Hut, Domino's require the customer to register online on their service and then download a mobile application (DevTeam.Space, 2020). Sometimes is the cashier that enables the digital stamp or other times is the record of the purchase in the customer account. Other smaller food restaurants usually have a classic paper card where the cashier can make a stamp on it. The cards are usually made with empty icons that can be filled with the stamp to represent the accumulation of number of purchase made.

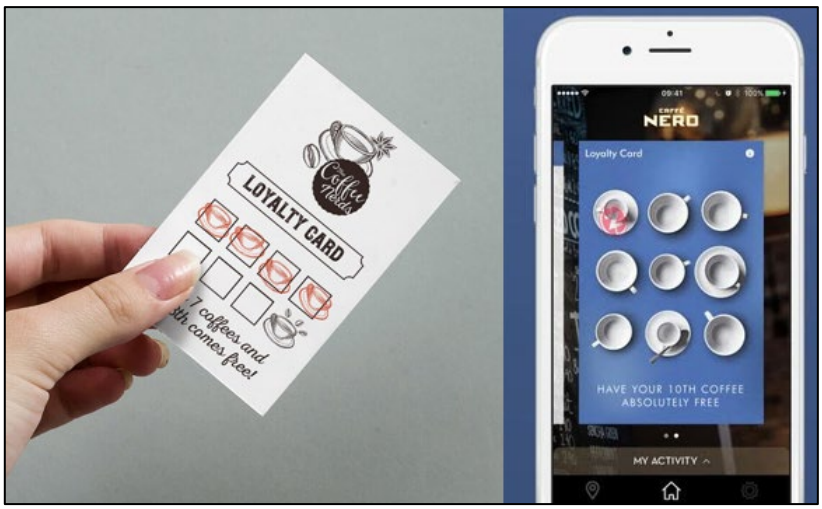

Figure 1. Paper loyalty card and loyalty Mobile App

In the example above (Figure 1.) on the left there is an example of paper loyalty card and on the right a mobile loyalty app. The concept is similar but the way it works is completely different because one is physical and other one is digital.

This project purpose is to enable something in between the two existing solutions by using the NFC (Near Field Communication) technology. Also known as contactless, this technology is now available in most of the devices in the world and it is becoming more popular.

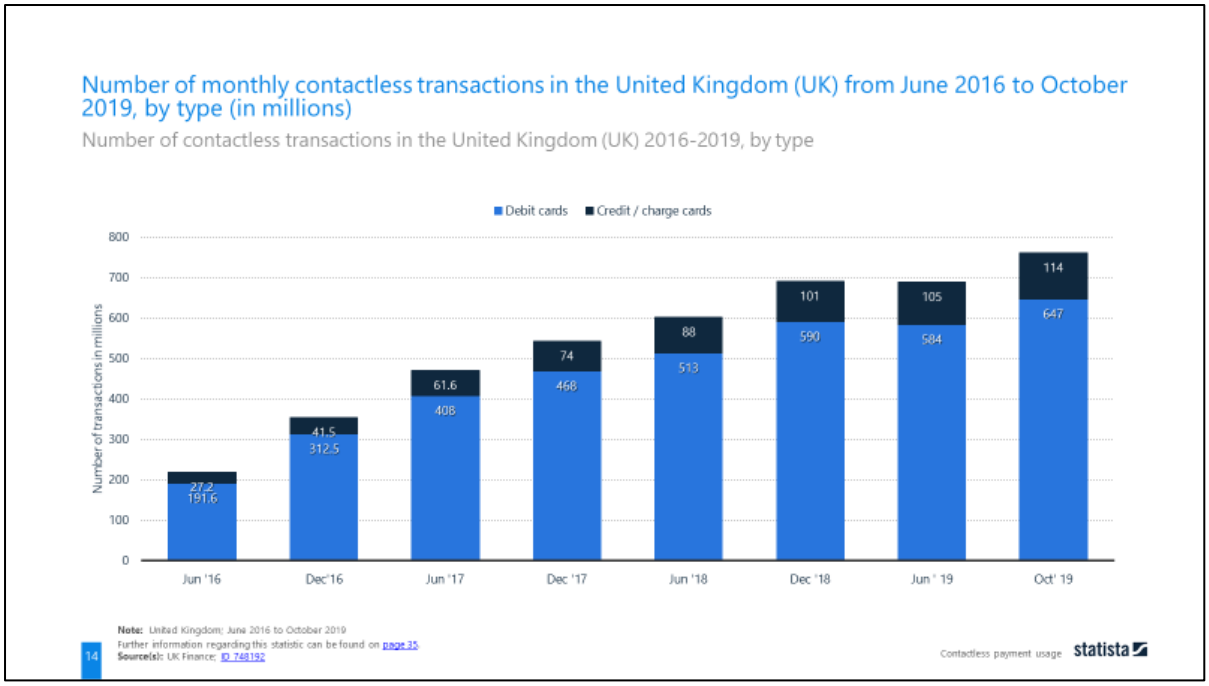

Figure 2. Monthly contactless transaction in the UK from June 2016 to October 2019

This technology is mostly used for payments with a small amount of money involved because it does not require any type of validation. The lack of validation makes the card more vulnerable to fraud (loveMoney, 2019), but that is a reasonable compromise for fast payments.

Moreover, in terms of ethic and ecologic point of view, this project has the potential to save the waste of plastic and paper by avoiding the demand of printed paper cards and plastic cards that "[...] have actually been the most requested gift in America" (Long, 2015).

1.2 Aim and Objectives

The overall purpose is to create a Web App that uses the Web-NFC experimental feature on Google Chrome browser on mobile (Bhaumik, et al., 2020) and allows both customer and retailer to manage their loyalty experience the way they want.

The main scope is to allow the customer an easy way to collect stamps or points without the need of a mobile application. For the retailer the advantage is a system where the loyalty experience is not restrict to a proof a purchase, but it could a number of visits throughout a month or maybe an interaction with a new product in the store. With the use of NFC tag the retailer is also able to reuse the same piece of technology without investing into more complex machinery.

To achieve the desired goal, I will need to complete this list of objectives:

- Gain in-depth understanding on NFC capabilities
- Research NFC security known issues and always be aware on related news
- Develop a prototype to use as demo for stakeholders
- Constantly receive feedback from different sources to gain a wider perspective of the project

- Source control to make sure there is trace of the work done in case of work lost or not working as expected
- Time tracking and documentation of the work done for the project
- Deployment of the project on a stable environment such a cloud service
- Implement an algorithm that compress the small amount of data
- Work with an external API that can send a digital voucher to the customer

Moreover, I would like to achieve some additional features (in descending order of importance):

1. Creation of own images and logos
2. Customisation of the interface per type of user
3. Gamification of the user experience

2. Background

This section introduces the literature of the project, a comparison of similar or relevant applications for the same customer reward. In addition, a discussion on the possible approaches for the intended solution is included.

2.1 Literature survey

Within the following sections the literature review will be uncovered to give an insight of the aspects of the NFC. Starting from the beginning of this technology and its original creator to the technical differentiation of the modern world. It is important to be aware of the modern enhancement and what are the future capabilities.

2.1.1 The history and physics behind

A Russian physicist and inventor called Léon Theremin (also known as Lev Sergeyevich Termen) in 1920 developed a musical instrument, later named after himself, that can produce sounds without being touched. The theremin core principles are heterodyning and capacitance. The former is the result of a combination or mixture of two frequencies (a principle used for FM radios) and the latter is the "ability of a circuit to collect and store energy in the form of an electrical charge" (Fluke Corporation, 2020).

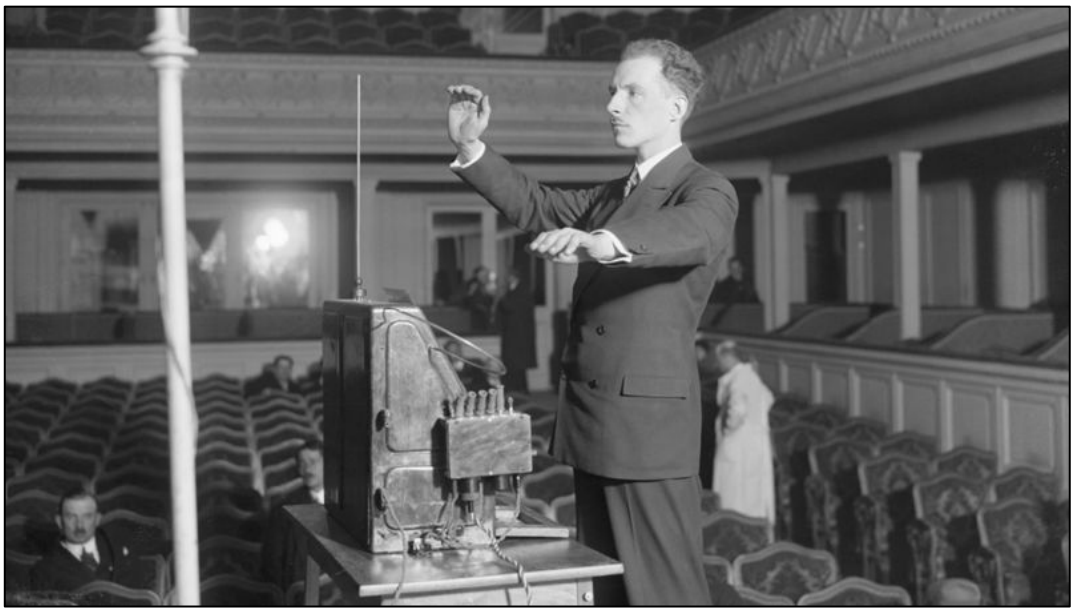

Figure 3. Léon Theremin playing his own invention

The electric instrument has two metal antennas, one to control the pitch and the other to control the volume. When a hand goes near to an antenna, a natural capacitor is generated, and its capacitance change based upon the distance to the hand. The circuit of the instrument takes the capacitance and set a frequency for the pitch and the volume. Then an inductor inside the instrument creates the frequency to be combined with the previous one so it can result with an interference that is hearable by the human hear (Huth, 2018).

Later, in 1945 the World War II finally came to an end. On the 4th August in Moscow a group of boys from the Young Pioneer Organization of the Soviet Union went to the American embassy to give a present as a symbol of friendship between the two countries. Averell Harriman, the United States ambassador at that time, took the great wooden ornament (Figure 4) as an important gesture and hung it on the wall of his office. They probably have checked every side of it to make sure it was not going to cause any harm like a Trojan horse, but nobody found anything alarming (Harford, 2019).

Figure 4. The present given to the US ambassador and the hidden device location

Eventually it was found out that the gift was an innovative creation from Theremin commissioned by his government to spy the conversation of the ambassador. It worked secretly for seven years until its discovery and gained the names "The Thing" and "The Great Seal Bug" (Harford, 2019).

The invention of Theremin consisted of a reverse concept of his musical instrument. He created a hidden circuit that had a capacitor that vibrated depending on the voice pattern. The capacitance would set the frequency representing the voice. An interference would be created when beaming a radio frequency signal to the object. This beaming would also power up and activate a response signal to broadcast out so it could be received and analysed to get the information needed (Crypto Museum, 2015).

This can be conceived as the first example of the modern RFID (radio-frequency identification) technology because of the concept and physics involved.

In fact, the underlying principle of RFID consists of electromagnetic waves and mutual inductance. The latter is a physical principle that describes how the change of current in a coil can produce an electromotive force (EMF) in an inductively coupled coil.

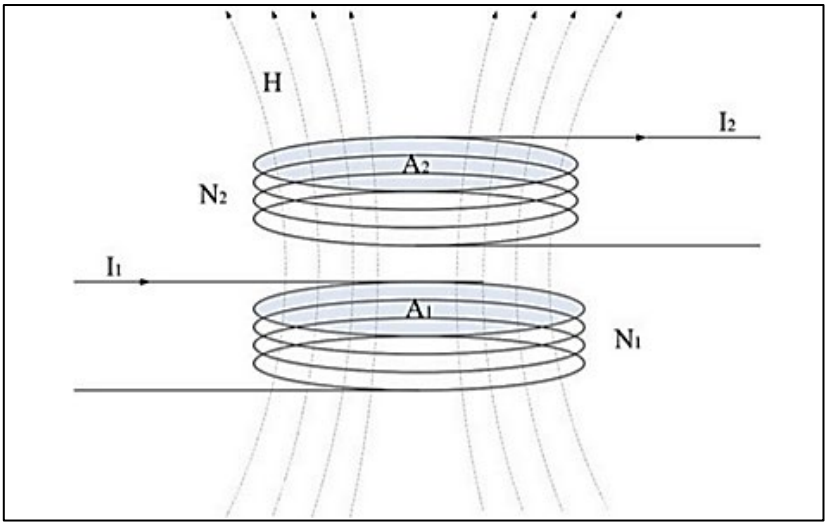

Figure 5. Inductive coupled coils

In the image above (Figure 5) we can consider N_1 to be an initiator that tries to engage to a target N_2. The mutual inductance between the two coils can be calculated by the following formula:

$$M_{12} = \frac{\mu_0 \cdot H(I_1) \cdot N_2 \cdot A_2}{I_1}$$

Being H the magnetic field strength, N the number of loops of the area A, and I the current that flows in the coil (Yang & Hancke, 2017).

2.1.2 RFID (Radio-Frequency Identification)

2.1.3 NFC (Near Field Communication)

2.1.4 Comparison between RFID and NFC

NFC can be considered as an enhanced version of RFID in the case where the initiator and target are in a short range. NFC is not designed to work the in long range so this limitation cannot be considered a real disadvantage, besides Wi-Fi and Bluetooth technologies are supposed to cover that gap.

Listed below are the common usage of the two technologies (Figure 6).

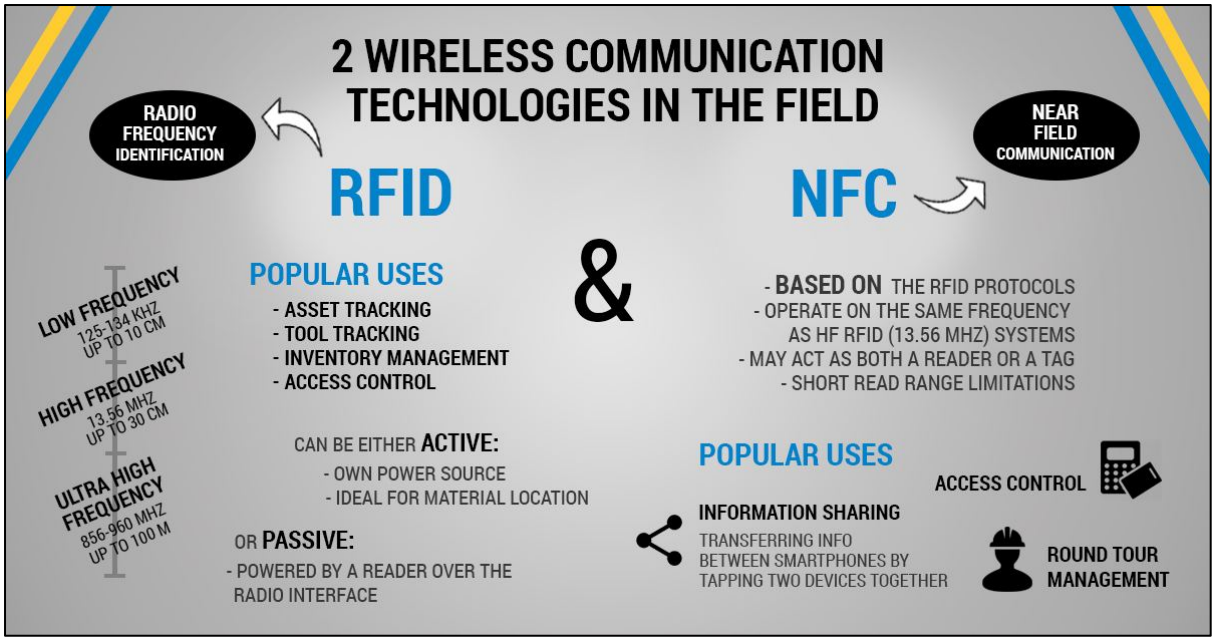

Figure 6. RFID & NFC comparison

A big advantage of NFC is that it has a very low cost in comparison to the RFID, an NFC tag usually cost less than a pound (e.g. NTAG213, NTAG215, NTAG216). The long range advantage of RFID requires the target to be an active tag, and that is where the cost rise. Currently, every single RFID active tag can cost from £25 to £100 depending on the range required. The RFID reader is also very expensive costing from £150 to £1800 also depending on the range required (NextPoints, 2020). On the other hand, NFC readers can cost something around £40 but given that the number of smartphones with the NFC enabled are constantly increasing in numbers, maybe there is not even the need of an additional purchase.

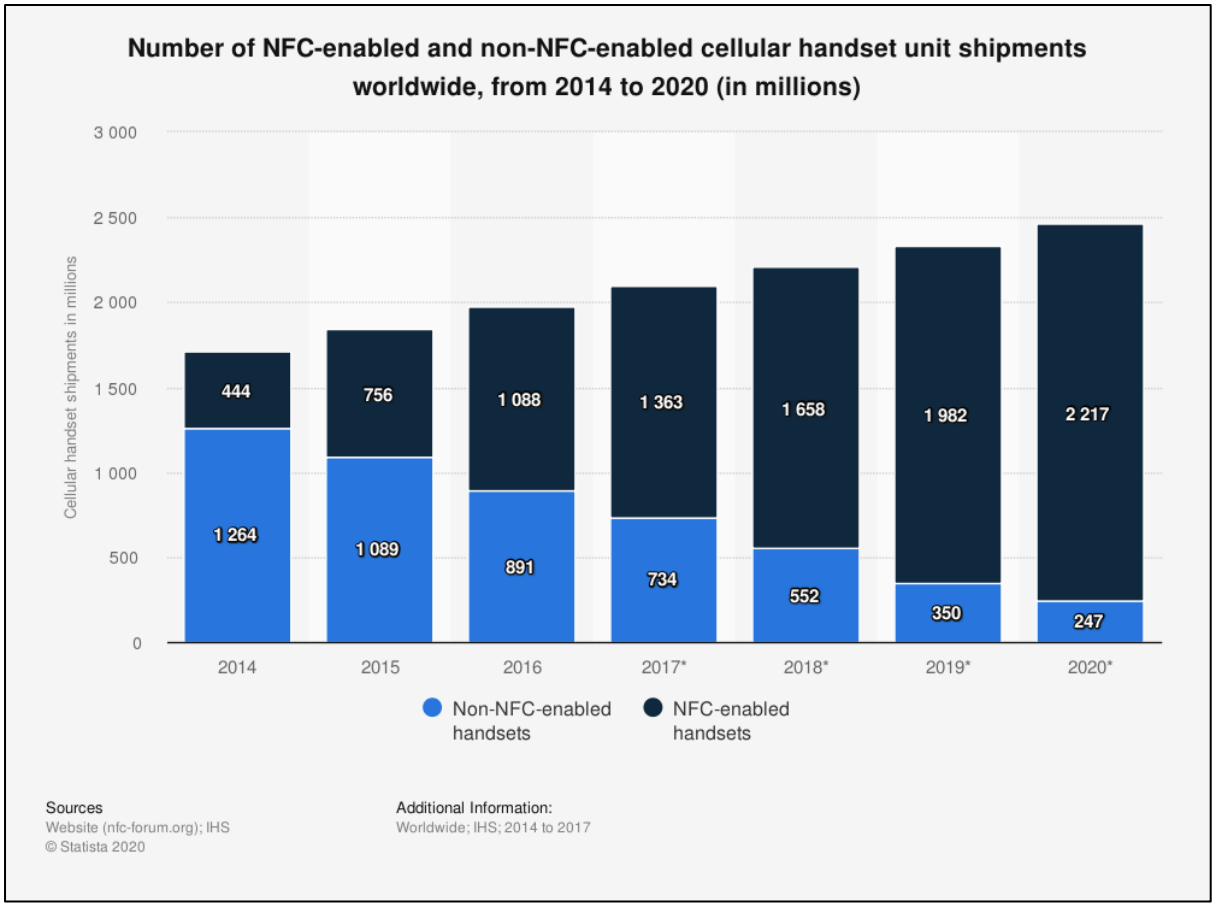

Figure 7. NFC enabled handsets from 2014 to 2020

In the figure shown above (Figure 7) it is possible to see the change over time of NFC enabled smartphones shipped in the world. Although this graph does not represent fully the numbers of all the smartphones in the market, it is fair to assume there is a similar trend because what changes is only the device delivery system.

In 2014 only the 25.99% handsets had NFC. Two years later, this feature increased in availability reaching 54.98%. Now in 2020, that percentage had rose to 89.98% and it is most likely to grow over time (Kenneth Research, 2020).

2.1.5 NDEF (NFC Data Exchange Format)

NDEF is a data format operating across all NFC devices. A common NDEF message contains one or more NDEF records. Each of this record has its own UID, record type, length and payload of data (Igoe, et al., 2014).

A generic record is represented in the figure below (Figure 8).

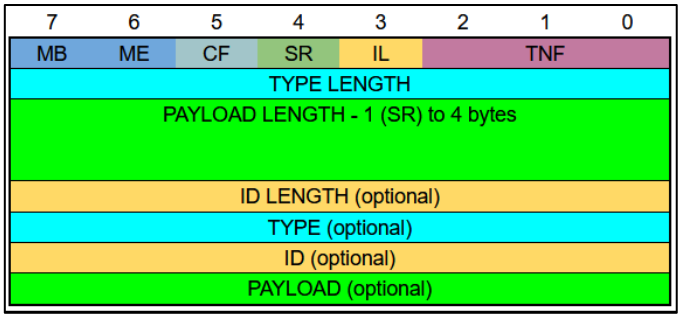

Figure 8. NDEF record structure

- Bit 0-2 indicates the format of the type name.
- Bit 3 indicates the presence of an ID length field.
- Bit 4 indicates a short record.
- Bit 5 indicates whether the payload is chunked across multiple records.
- Bit 6 indicates whether this record is the last in the NDEF message.
- Bit 7 indicates whether this record is the first of the NDEF message.

This is the list of the NDEF record types:

1. **Empty NDEF** (TNF 0) as the name suggest it represent a record with no data and therefore Type Length field, ID Length field and Payload Length field must be 0 and the last three optional fields (Figure 8) must not be present.

2. **Well-known** (TNF 1) which is a set of sub record types standardised by the NFC forum such as text, URL, media and smart posters and handover options.

3. **MIME** (TNF 2) stores binary data with the associated MIME (Multipurpose Internet Mail Extensions) type.

4. **Absolute-URL** (TNF 3) contains the string of the full address that includes protocol and domain name.

5. **External** (TNF 4) is a URN with the application data type (e.g. *urn:nfc:ext:domain.org:atype*).

6. **Unknown** (TNF 5) is for storing data that have incomprehensible data and are not associated with a MIME type. The application may assume the latter.

7. **Unchanged** (TNF 6) is a section of a chunked data set, so the payload is spread across multiple NDEF records.

8. **Reserved** (TNF 7) which means reserved by the NFC Forum for future use.

TNF value	Description
0	Empty record
1	NFC Forum well-known type record
2	MIME type record
3	Absolute-URL record
4	NFC Forum external type record
5	Unknown record
6	Unchanged record
7	Reserved for future use

Figure 9. Summary of possible Type Name Format (TNF)

2.1.6 Web NFC

2.2 Review of project / applications

3. Requirements

4. Methodology

5. Design

How the project design is implemented and the tool used

UI interface

Landing page for registration

Customer scheme

Retailer settings

6. Tools and implementation

6.1 Tools

Programming languages, libraries, framework with choice justification. Razor pages

6.1.1 Visual Studio MVC
6.1.2 Git
6.1.3 StyleCop
6.1.4 Chrome Developer Tools
6.1.5 Entity Framework Core

https://docs.microsoft.com/en-us/ef/core/miscellaneous/cli/powershell

6.1.6 6.1.6 Adobe Illustrator

6.2 Loyalty Scheme system

6.2.1 Digital card visualisation

6.2.2 Web API

6.2.3 Collecting the stamp

6.2.4 Creating the stamp

6.3 Deployment

6.3.1 Web Application setup

6.3.2 Database setup

6.3.3 Visual Studio

7. References

8. Bibliography