

B.Sc. (Hons) in Software Development



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QR Phishing and the Security Risks of QR Codes

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Chapter 1

Introduction

In this dissertation, I will reflect on the work and research undertaken during my participation in this module. The primary objective of this module is for students to "work and learn independently under the guidance of a qualified supervisor." It aims to demonstrate the student's proficiency in "learning to learn" and ability to adapt to new technologies, programming languages, and practices within a rapidly evolving discipline. With the guidance of my academic supervisor, the following objectives will be achieved:

- Demonstrate my ability to learn, research, understand and apply new knowledge gathered.
- Explore and use programming languages and tools outside of my formal education or prior experience.
- Engage in critical analysis and showcase proficiency in researching complex computer-related issues.
- Understand current industry practices to integrate throughout my project.
- Assess the completed work and provide constructive feedback, highlighting areas for improvement or alternative approaches.

1.1 Project Description

The objective of this project is to investigate and delve deeply into the significant security vulnerabilities associated with the use of QR codes. It aims to explore how unsuspecting users can become targets of malicious attacks and how even vigilant users can fall victim to these threats. The project will demonstrate the

back-end processes involved in a QR code attack and provide an in-depth analysis supported by statistics and additional research findings.

Through this project, I intend to showcase my understanding of QR codes and highlight my ability to learn new programming languages and frameworks. By dissecting the intricacies of QR code vulnerabilities and presenting concrete examples, I aim to raise awareness about potential security risks and empower users to make informed decisions when interacting with QR codes.

1.1.1 Project Reason

I have chosen the domain of cybersecurity because it aligns with my interests and aspirations for a career path. In today's rapidly evolving technological landscape, where society is increasingly reliant on digital systems, it's crucial to address concerns about the security and privacy of personal data. The global pandemic further underscored the significance of cybersecurity, particularly with the resurgence in the widespread use of QR codes.

During the pandemic, QR codes became ever-present, serving as a convenient means for accessing various online resources, from menus at restaurants to online payment portals at shops. However, with the widespread adoption of QR codes comes an increased risk of exploitation by malicious actors seeking to compromise the security of users' personal information.

By exploring the vulnerabilities inherent in QR code technology and gaining a better understanding of cybersecurity I aim to contribute to the ongoing dialogue about cybersecurity and help raise awareness among individuals and organizations

1.1.2 Scope

After consultation with my supervisor, the scope of this application has been carefully calibrated to ensure a substantial depth suitable for a solo development project. Considering the project's requirements and deliverables, including this dissertation, the scope has been kept at a manageable size.

The planned features will pose a meaningful challenge both as a developer and as a researcher. While my expertise in cybersecurity is limited at present, this project presents an opportunity for growth. With a focus on research, my current proficiency in Python and full-stack projects may pose obstacles that I look forward to overcoming. The research aspect will catalyze expanding my understanding of cybersecurity, with the ultimate goal of helping individuals navigate the internet securely.

1.1.3 Project Objectives

The objectives of this project are to which are measurable goals I wish to achieve when partaking including the following.

- Develop a working dynamic QR Code generator using Python as the primary language.
- Deploy the web app onto an online platform using cloud services such as AWS or Heroku, ensuring accessibility.
- Implementation of MongoDB for cloud-based data storage.
- Conducting comprehensive research on QR Security and phishing.

Throughout the course of this project, I will be making sure that I meet these objectives and that they are achieved to the best of my abilities.

1.2 Chapter Breakdown

The following includes a detailed analysis of each chapter, along with a brief overview of the content contained within each section.

1.2.1 Methodology

In this chapter, I will break down the various methodologies employed to fulfil this assignment. These include the diverse research strategies implemented and the methodologies for data collection. Furthermore, I will expound upon the sampling techniques utilized and their sources. Additionally, I will explore different software methodologies and discuss their components to gain insight into structuring my workflow effectively. Alongside these discussions, this chapter will feature a comprehensive breakdown, accompanied by visual aids such as images and graphs, illustrating my project approach. Conclusively, I will offer insights into the testing procedures undertaken and the planning involved in both the project and research phases.

1.2.2 Technology Review

Within the technology review, I will conduct an examination and provide detailed explanations regarding the various technologies and languages I plan to use. Additionally, I will explore alternative options that could serve as alternatives should

the initially selected technology fail to meet expectations or pose unexpected problems.

The aim of this chapter is all about the research of the technology as it will give a much better understanding of how the project benefits from its use and the understanding of it.

1.2.3 System Design

The objective of this section is to provide a comprehensive overview of the system architecture and its constituent components. It aims to demonstrate the practical application of research insights obtained during the technology review process. This section provides a detailed explanation of how different technologies are integrated and interact with each other, displaying their collaborative implementation within the system. Visual diagrams will be utilized to provide a comprehensive understanding of the system design.

1.2.4 Evaluation

In this chapter, a thorough examination of the research findings is conducted, alongside an evaluation of the project concerning the objectives established at the start of this dissertation. The assessment encompasses an analysis of the project's strengths and weaknesses, highlighting areas of success as well as opportunities for improvement. Additionally, the discussion will revolve around potential improvements that could have been implemented to further refine the project's outcomes.

For the research, I will break down the results and the data with the use of charts and give an informed opinion on the matter. I will also discuss any shortcomings in the research I conducted concerning areas in which I can improve in the future.

The project evaluation will discuss the objectives I have reached and encounter some testing. Similarly to the research I will discuss the shortcomings and expand upon areas in which I believe could've been handled better in the future.

1.2.5 Conclusion

The conclusion of this dissertation encapsulates the key findings and insights gathered throughout the research journey. It shows off the project's accomplishments, reflecting on the extent to which the objectives were met, and the contributions made to the field. Additionally, the conclusion acknowledges any limitations encountered and outlines avenues for future research or development. Ultimately, it highlights the importance of the study's findings and their relevance for both academic and real-world discussion.

1.2.6 References

Here you will find all the research papers used and referenced during this dissertation these will be the proof of research for the dissertation and will include books, articles and other relevant forms of documentation.

1.3 Project Workspace

GitHub Repository: <https://github.com/killianosuilleabhain/QR-Security>
Within this link, you will find the following contents.

- The source code of the Dynamic QR code application.
- The source code of the Static QR code application.
- A README file, which will show the steps involved in running the code locally.
- A .txt file containing a link to the screencast, demonstrating the main features.
- The dissertation you are currently reading.
- A file containing the survey data.

Chapter 2

Methodology

Methodology is the foundation on which research and software are built. It provides the essential framework necessary for making progress and achieving successful outcomes. Without a structured methodology, finishing the project completion becomes significantly challenging. The processes undertaken within the chosen methodology pave the way for success, ensuring that the result meets the desired quality standards. Therefore, adhering to a methodology is crucial as it keeps me focused and on track throughout the project journey. In this section, a comprehensive explanation of several methodologies will be provided, along with the final ones that were chosen for implementation.

2.1 Research Methodology

Within this section, I will explore various research methodologies that I plan to use during my participation in this module. Additionally, I will delve into the significance and objectives of my research, explaining how it will contribute to my learning and deepen my understanding of the domain.

The purpose of research is to uncover answers to inquiries by employing systematic and scientific methods. According to the author Clifford Woody, “Research comprises defining and redefining problems, formulating hypothesis or suggested solutions, collecting, organizing and evaluating data, making deductions and reaching conclusions and at last careful testing the conclusions to determine whether they fit the formulated hypothesis.” [1]

Deciding on the most suitable research methodology is an important step in ensuring the effectiveness and validity of the research endeavour. The choice of research methodologies must align with the objectives set. Below is a list of the methodologies I plan to use and I will go into more depth as I explore how I carry out each methodology.

- Secondary Research
- Qualitative Research
- Quantitative Research
- Mixed Method

2.2 Research Methods

The following includes a detailed analysis of each research methodology, along with a brief overview of how I aim to use them in my research.

2.2.1 Secondary Research

While the definition of secondary research lacks precision, it is commonly understood as the utilization of pre-existing data. This form of inquiry depends on the utilization of available resources, including literature, articles, reports, and other sources, rather than initiating fresh data collection efforts. Most commonly, this data is sourced from both qualitative and quantitative methodologies.[2]

I aim to use secondary research within my literature review and my dissertation as a whole to gain a better understanding of cybersecurity and cyber threats as it is a reliable source of data which makes my task more efficient with the use of Google Scholar as it is easy to access through the use of the university.

2.2.2 Qualitative Research

Similarly to secondary research qualitative research also lacks a clear definition and is considered to be an umbrella term that covers multiple different techniques an example of these techniques are interviews, discussions, observations and content analysis as you can see this is non-numerical data to gain a more nuanced understanding of the matter.[3]

Qualitative research is particularly well-suited for exploring social contexts, which is why I intend to employ this approach in conducting a social engineering test. My plan involves placing QR codes in public locations and collecting data on the motivations behind people scanning the codes. Through qualitative methods such as interviews and observations, I aim to uncover insights into the behaviours, perceptions, and motivations of individuals interacting with the QR codes.

A useful advantage of qualitative research is its ability to stimulate discussions, particularly on topics like security. In the context of this study, qualitative research will create discussions about security, raising awareness about potential dangers

in individuals’ day-to-day online activities. By engaging participants in conversations about security risks associated with scanning QR codes in public places, this research not only gathers valuable insights but also contributes to educating and empowering people to make informed decisions regarding their online safety.

2.2.3 Quantitative Research

Quantitative research is an investigation which collects and analyses numerical data. This data can show a common similarity helping to solve the research topic. The goal of quantitative research is to “build an accurate and reliable measurement that allow for statistical analysis”. [4]

There are different types of quantitative research including surveys, experiments, and correlational studies. Surveys involve collecting data from structured questionnaires, experiments manipulate variables to determine cause-and-effect relationships, and correlational studies examine the degree of association between variables without implying causation.

I intend to employ quantitative research methods by conducting public surveys and tracking the frequency of QR code usage in the social engineering experiment through a counter. By analysing the gathered data, I aim to uncover correlations between different metrics and present my findings.

2.2.4 Mixed Method

As you may have gathered, my research will encompass a combination of qualitative and quantitative research methods, constituting a mixed methodology. This approach integrates techniques from both qualitative and quantitative methods. The rationale behind this decision lies in the recognition that each method has its limitations. By adopting a mixed methodology, I aim to mitigate these limitations and construct a more robust case for my research, ensuring that no important data is overlooked or sacrificed in the process.[5]

2.3 Software Methodology

The approach we adopt in software development significantly influences the project’s development lifecycle, impacting both the quality and cost-effectiveness of the final product. Software methodologies play an important role in this regard, offering a structured framework that creates organization throughout the development cycle by establishing rules and processes to follow.

Implementing a methodology ensures consistency, thereby keeping the project on course. This consistency brings several benefits:

- A structured approach
- Enhances efficiency
- Risk management
- Visualization of upcoming tasks

2.4 Software Methods

Two software methods which I will be covering are agile and waterfall where I will give an overview and evaluate both methodologies on the needs of my project. Keep in mind that this is a solo project as this will play a pivotal role in deciding which method is best to use.

2.4.1 Agile

Agile is a methodology introduced in the Agile Manifesto which was set up in 2001 by a group of software developers. [6] It is centred around an iterative and incremental development process, placing a strong emphasis on collaboration. Its primary focus is on satisfying the customer, recognizing that requirements are prone to change or updates, particularly when working closely with clients.[7]

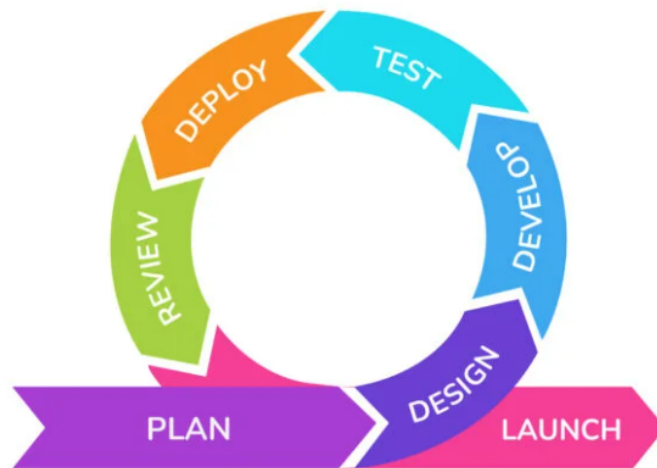


Figure 2.1: Agile Method

Within Figure 2.1 you see an iterative loop which provides context to emphasise its iterative and continuous nature it depicts the planning, designing, development,

deployment, reviewing and launch stages which occur but you may see that after the review stage, you may go back in the loop again. Agile methodologies have benefits for both the customer and developer as the methodology approach will reduce the cost of the project and unlike the waterfall methodology promote any changes to the requirements/scope.[8]

2.4.2 Waterfall

The waterfall method was originally introduced in the 1970s by Winston Royce the method consists of a linear and sequential approach to software development, where each phase of the project must be completed before the next one begins.[9]

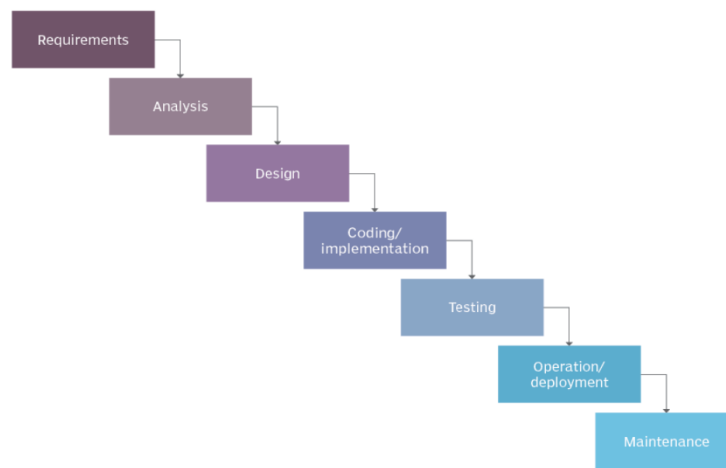


Figure 2.2: Waterfall Method

Figure 2.2 displays each phase of the waterfall method. The idea of the waterfall method is that each requirement must be defined from the beginning to make it more efficient. A drawback of this is that it makes it difficult to make any changes to the scope of the project. The list below will briefly explain each phase of Figure 2.2.[10]

1. Requirements

Define the requirements and scope of the project.

2. Analysis

Understand the Scope of the project to figure out if it is feasible and identify potential risks.

3. Design

Creating detailed technical specifications, defining data structures, and designing the user interface.

4. Implementation

Regarding the design phase create the program using the necessary languages.

5. Testing

Testing the code to see if it runs correctly and meets requirements.

6. Deployment

Deploying the project and ensuring it operates as intended.

7. Maintenance

Involves maintaining its deployment, fixing bugs and implementing updates when needed.

2.4.3 Decision

Although I believe the Agile method is of best practice when developing in general. For my project, I have clearly laid out objectives and no customers to satisfy which is why I have decided that the waterfall method is best suited for my project as it offers stability clear structure and comprehensive documentation at each stage.

2.4.4 Meetings

Throughout this module, I will be having weekly to bi-weekly meetings with my supervisor to keep track of the work completed to date and ensure I am within the scope of my project. A benefit of these meetings included getting insights and pointers which would help me throughout the project. This supervision kept me grounded as it would motivate me to have something completed each week.

Chapter 3

Literature Review

Within this chapter, I will explore the realm of Cybersecurity and QR Codes, highlighting their crucial roles in understanding my project from both a coding and research perspectives. My goal is to offer a thorough exploration of the intersection between these domains and the implications for developing and executing my project.

3.1 Introduction

In today's world, we are much more connected with one another through the use of online services prompting discussions about the extent of our reliance on technology for daily activities. Aspects ranging from online banking to personal data are securely stored on the Internet. However, the reality is that nothing remains entirely secure, as this information holds significant value in the wrong hands, potentially compromising individuals' privacy and security.

An emerging threat in Cybersecurity is Quick Response (QR) codes which gained popularity during and after the COVID-19 global pandemic with a 98% increase in uses as a convenient and safe way to access physical copies of items without having to touch contaminated items ie menus and contactless payments.[11]

This literature review aims to explore the intersection of Cybersecurity and QR code security. By exploring existing research and emerging trends. The goal is to understand the potential risks associated with QR codes and the strategies employed to mitigate them as well as the different forms of threats used.

3.2 Qr Codes

QR codes which stand for Quick response codes are two-dimensional 2D barcodes which were invented in 1994 by Denso Wave a company within the Toyota Mo-

tor Corporation with the goal being to enable quick automobile scanning during manufacturing.[12]

The QR code was created as an alternative to the long outdated 1D barcode as it is capable of storing more data and has an easier time being used. Approximately QR codes can store 100 times more data compared to the linear 1D barcode.[13]

Being machine-readable QR codes are accessible for everyone with a smart device to use. Many devices these days come with a built-in reader. Once you scan the QR code using your device it re-directs you to the information which is stored with the QR code this could include the following.[14]

- Website URLs
- Wifi Connectivity Information
- Contact Information
- Healthcare Information
- Payment
- Social Media

The two codes below include Figure 3.1 is a QR code which uses my static QR code Generator links to my GitHub Repo for this project and Figure 3.2 which is a 1D barcode.



Figure 3.1: QR Code



Figure 3.2: 1D Barcode

3.2.1 How do QR Codes Work

QR codes can be read both vertically and horizontally which is thanks to how it is constructed and read by computers.[15] Below I will attach an image breaking down the similar look of all QR codes and follow it up with the breakdown of the anatomy and inner workings of a QR code.

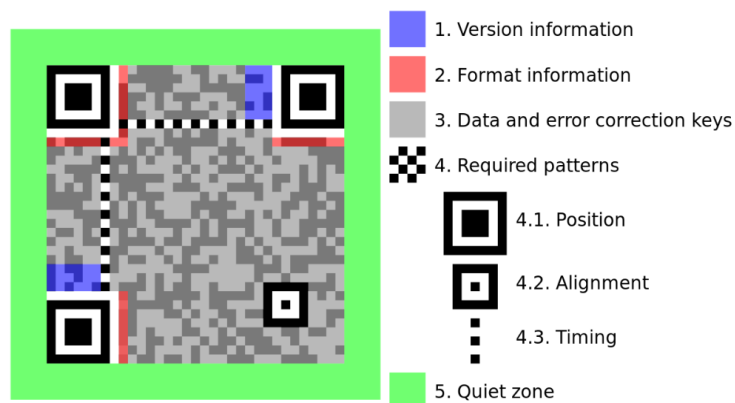


Figure 3.3: QR Code Breakdown

1. Version Information

Each version is denoted by a numeric value ranging from 1 to 40, (21x21) to (177x177). Higher versions accommodate larger amounts of data and provide greater error correction capacity.

2. Format Information

It ensures that the QR code reader can properly interpret the encoded data by specifying the error correction level.

3. Data and Error Correction

Data and error correction mechanisms ensure the integrity and reliability of information encoded in QR codes, enabling accurate scanning and decoding.

4. Required Patterns

(a) Position

Also known as the finder pattern it is used to arrange and determine the size, position and angle of the QR code and is placed in all three corners.

(b) Alignment

The alignment pattern serves a purpose in alteration restoration by aiding in the classification and verification of the QR code

(c) Timing

It enables the calculation of symbol coordinates and ensures the stability and distortion-free delivery of a symbol.

5. Quite Zone

The quiet zone is about 4 cells wide and is kept blank with no data to ensure the integrity of the data.

With the information provided, it's clear why QR codes are widely adopted world-wide and have become a commonly used technology.[16]

3.2.2 Two Types of QR Codes

There are two types of QR codes Dynamic and Static both of which have their advantages and disadvantages below is a table comparing the two and the key differences.

3.3 Cybersecurity

According to Cisco "Cybersecurity is the practice of protecting systems, networks, and programs from digital attacks." [17] Cybersecurity covers many if not all kinds of possible attacks from data on your personal computer to, Internet of Things (IoT). Each day, various cybersecurity measures are employed to protect us online. An example of this is secure websites using HTTPS protocol which offers encryption when establishing a connection in comparison to its counterpart HTTP which does not.

Table 3.1: Dynamic VS Static QR Codes

Feature	Dynamic	Static
Content	Can be modified after creation allowing updates	Data is fixed after creation not allowing updates
Capacity	Higher data capacity	Limited data capacity best used for fixed information ie, Contact details, Wifi details.
Tracking	Tracking user engagement is useful for advertisers.	Limited tracking
Complexity	Requires a back-end system making it more expensive	Is easy to create at no added cost.

The objective of Cybersecurity is to mitigate security risks and uphold the CIA triad, which comprises Confidentiality, Integrity, and Availability.[18]

- **Confidentiality**

Keep data confidential by ensuring only the people with access to the data can access the data

- **Integrity**

Maintain integrity by preventing any unauthorized user from altering the data.

- **Availability**

Ensuring the information is always available to access through the system which stores and maintains the data.

Within this section, I will be researching and exploring the different forms of security threats and the different approaches taken to prevent them.

3.3.1 Possible Threats

The goal of an attacker is to compromise the CIA triad as being able to disrupt any of the 3 values can be of significant value to the attacker and a huge cost to the owner of the data. Below is an exploration of the different forms of attacks used with and without QR codes which may be used to gain unauthorized access to the data and the approach which was used.

- **DOS & DDOS Attacks**

Dos also known as Denial of Service is an attack on the availability of a network/device which targets the bandwidth and connectivity. The attack achieves this by overwhelming the server with requests and making it impossible for the system to work as intended. [19]

- **Man in the Middle Attacks**

A Man in the Middle Attack is when an attacker gets between the communication of two parties. By doing this the attacker can intercept and manipulate data without either party knowing about it. [20]

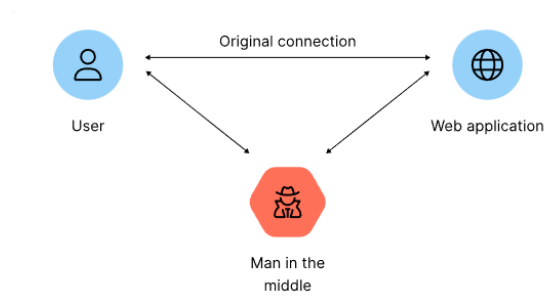


Figure 3.4: Man in the Middle Attack Demonstrated

- **SQL Injection Attacks**

SQL (Structured Query Language) Injection Attacks occur when an attacker inserts a malicious SQL statement into an interaction between the client and a database, The statement then proceeds to query the database and if successful can modify or extract the data. [21]

- **Phishing**

Phishing is an attack which most people have had exposure to. Phishing is seen as a social engineering attack in which the attacker sends fraudulent emails, SMS and websites which impersonate banks, companies people and other forms of organizations to trick people into sending over personal and confidential information including passwords and money. As recently as 2019 90% of organisations also faced phishing attacks with this number expected to rise.[22]

- **Social Engineering**

Social engineering is a form of an attack which requires a target to take a series of steps which in general would not be seen as security aware. The issue

in regards to protecting one's devices from these attacks is to be informed and alert as many of these techniques can bypass the robustness of a security system and go undetected. These attacks may be performed by leaving a USB stick around and getting people to scan QR codes. With the other forms of attacks in this chapter, all can be considered a social engineering attack.[23]

- **Malware**

Malware short for malicious software is a form of technology which is harmful to the user and device by either stealing data or gaining control of the user's device without the user knowing.[24] Malware is such a big domain in its own right that the two following attacks which I will be covering fall under the title of malware.

- **Ransomware**

Ransomware is a form of malware which stops users & organizations from accessing their own devices or encrypting data which becomes inaccessible. Following up with the attack the attacker using ransomware will demand payment usually in the form of crypto as it is untraceable.[25] It is best not to pay this ransom as it encourages the attacker to continue their attack on others and also there is no guarantee that the attacker will return the device or data.

- **Trojan Horse**

Trojan horse attacks involve malware disguised as legitimate software. When executed, the malware operates without any detection, allowing the attacker to remotely access the device and steal personal information, presenting a significant opportunity for unauthorized access.[26]

3.3.2 Protection

Cyber attacks do not look good for business as they can cost a lot of money while also damaging relationships with clients and potential clients. In Figure 3.5 we can see that these attacks are rising and costing more and more as organisations do not want to damage said relationships. According to Grant Thornton between 2020 and 2021, the cost of a data breach rose from 3.38 million to 3.72 million.[27]

To protect against cyber attacks there must be an increase in spending which has been announced by the Irish government.[28] There must also be an emphasis on teaching others how to approach cyber attacks and how to lower the risk of being a victim of attacks.

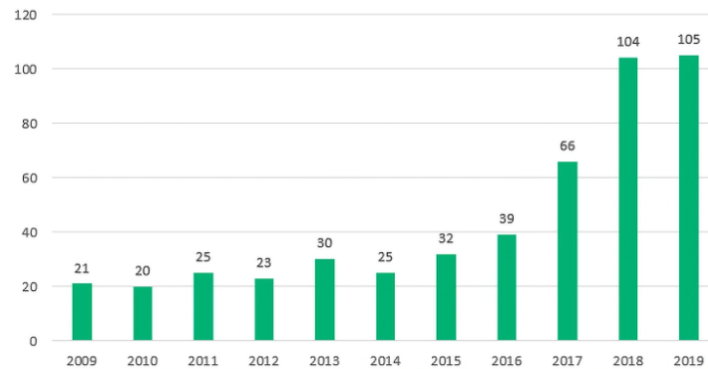


Figure 3.5: Cyber Attacks with +1m in losses

3.4 QR Code Security

In terms of security Dynamic QR codes are a better fit as they can update out-of-date data which may be stored on an easily recognisable QR code which can be expensive to replace ie on advertisement boards company portals etc. Dynamic QR codes are also used in multi-factor authentication with the help of shortened URLs that can link the user to their account if scanned within a certain window which makes it harder for attackers to infiltrate.[29]

QR code readers are a cause for concern when scanning QR codes as many third-party readers often do not scan the information within the QR code leading to Qishing which is a form of phishing that hides within a QR code. When scanning malicious QR codes with a third-party app the user may find their device data or both compromised by an attacker. [30] To counteract this it is recommended you use certified scanners which all modern phones come pre-installed with, these may be hidden in your Google bar or your camera depending on the operating system.

3.4.1 Attacks

QR phishing attacks also referred to as "Quishing", are attacks with the focus of someone scanning a malicious QR code which could host multiple different threats including DDOS, Malware, Ransomware and of course Phishing itself. The Hoxhunt challenge is a project that quantifies human risk in cybersecurity where in this project it was discovered that at the beginning of October 22% of all phishing attacks used QR codes to deceive users from this only 36% of users recognised the risk. This research was conducted in 125 countries by 38 unique organizations.[31]

3.4.2 Possible Solutions

With the use of QR code generators, Organisations can create unique QR codes to make them distinguishable and also add a layer of security to their codes. To replicate the unique QR code an attacker will need to invest time and money which for the convenience of QR attacks goes against its fundamental simplicity. A benefit to the user is it makes it easier to distinguish between malicious and legit QR codes. below is a figure of a unique QR code created by Instagram which links to a photographer's page.



Figure 3.6: Unique Instagram QR Code

3.5 Conclusion

In conclusion, after exploring and discussing cybersecurity and QR code security there is a need for greater education concerning online security and how to stay safe with an increase also needed in government spending to keep the public and government organisations safe from any data breaches.

The convenience of QR codes can not be overlooked as it is a brilliant piece of technology which many people and businesses use today for beneficial reasons ie climate and health. As technology continues to evolve, we must all remain vigilant as even the least suspicious technologies may cause the biggest harm.

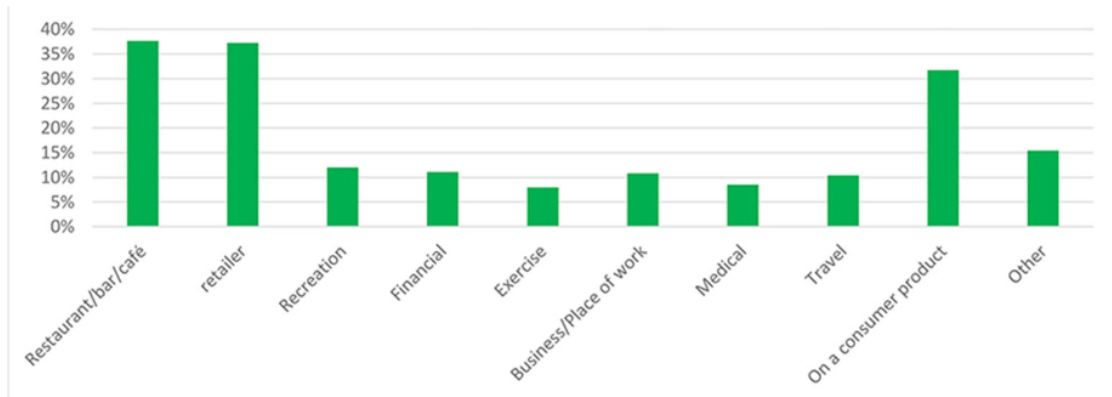


Figure 3.7: Most Common Reasons to Scan QR Codes

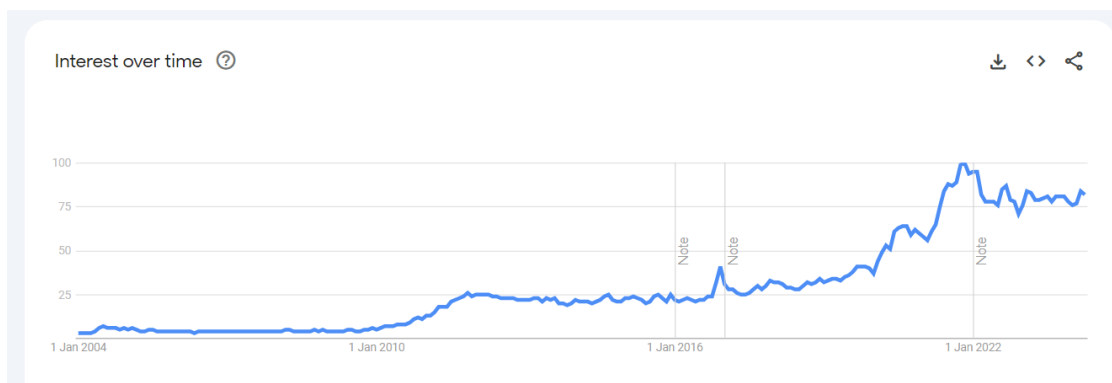


Figure 3.8: Google Trends: Search Frequency of QR codes Last 20 Years

Chapter 4

Technology Review

In this chapter, I will explore the various technologies and programming languages employed during the development of this project. Additionally, I will discuss the technologies that were considered or experimented with for potential implementation. Below I have listed the technologies I used and the possible alternatives.

- Languages (Python, HTML, CSS)
- Other Technologies (Flask, MongoDB, AWS)
- Alternative options (Angular, Django, Heroku)

4.1 Languages

Below are the languages I used to bring the project to life including a description and reason as to why I chose them.

4.1.1 Python

Python stands out as a high-level programming language which is celebrated for its simplicity, readability, and adaptability. Introduced by Guido van Rossum and initially launched in 1991, Python has emerged as a leading programming language globally. Known for its versatility, Python is used throughout web development, data analysis, artificial intelligence, scientific computing, automation, and more.[32]

The reason why I opted for Python as my primary language is due to its reputation for simplicity and accessibility, making it an ideal choice for both beginners and experienced developers alike. Additionally, Python's extensive collection of diverse libraries offers a wealth of resources that will prove important for my

project. Its seamless integration with other technologies further solidifies this decision, particularly as I'll need to work with databases and web servers throughout the development cycle.

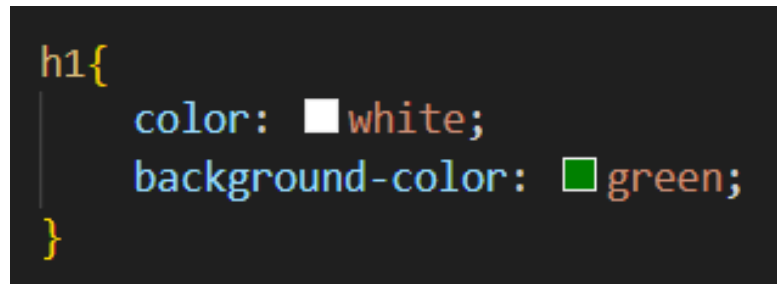
4.1.2 HTML

HTML, an acronym for Hypertext Markup Language, serves as a foundational markup language essential for crafting and formatting web pages. Operating through a system of tags and attributes, HTML creates structure and organization in web content. These tags define elements such as headings, paragraphs, links, images, and more, facilitating the creation of cohesive and navigable web pages.

With the aforementioned Python, and in collaboration with CSS which I will discuss next, HTML achieves enhanced functionality and aesthetic appeal. While Python contributes to dynamic content generation and server-side processing, CSS complements HTML by providing style and presentation elements, such as layout, typography, colours, and visual effects. This collaborative integration of HTML, Python, and CSS empowers developers to construct web experiences that are both visually captivating and functionally robust.

4.1.3 CSS

CSS, short for Cascading Style Sheets, serves as a pivotal style sheet language employed to dictate the presentation and layout of HTML documents. Within my project, CSS collaborates seamlessly with HTML and Python to elevate the appearance and functionality of web pages.



```
h1{  
  color: ■ white;  
  background-color: ■ green;  
}
```

Figure 4.1: CSS Selectors

Within Figure 4.1 above the use of selectors in CSS creates styling for all H1s (Heading 1) to have a green background with white text. This creates consistency in design which becomes useful for the overall design and look of the project.

Integrating CSS into the project enhances the user experience, making web pages more intuitive and visually appealing. Through CSS, the project's web pages acquire a sense of simplicity and user-friendliness, facilitating seamless navigation and exploration for users. The project aims to create an inviting and engaging online environment conducive to effortless interaction and exploration by leveraging CSS alongside HTML and Python.

4.2 Other Technologies

Within this section, we see the other technologies I used during the development of my project with the benefits and uses of each.

4.2.1 Flask

Flask is a lightweight and flexible web framework for Python, designed to make building web applications simple and scalable. Known for its simplicity and minimalist design, Flask has become a popular option for constructing web applications, APIs, and microservices in the Python ecosystem. It's user-friendly interface and flexible architecture render it an ideal choice for developers seeking efficiency and agility in their projects.[33]

I will be using Flask for the following:

- **Routing**

Flask provides me with a mechanism for defining routes that map URLs to Python functions. In my project, I define routes to handle different HTTP requests, such as generating QR codes, tracking usage, and redirecting users based on shortened URLs.

- **Template Rendering**

With the use of the Jinja2 templating engine which is integrated into Flask, I can render HTML pages into the project and pass data to it to display.

- **Request Handling**

Flask provides me with tools for handling HTTP requests and accessing request data.

- **Response Handling**

Flask allows me to generate and send HTTP responses to clients. I use it to send QR code images as file attachments in the HTTP response and perform URL redirections for shortened URLs.

- **Configuration**

I use Flask's configurations to connect to my MongoDB database which I will do in deeper detail on in within this chapter.

- **Error Handling**

Flask provides mechanisms for handling errors and exceptions that occur during request processing.

Overall, Flask serves as the cornerstone of the project, providing me with the necessary tools and functionality for building a dynamic web application.

4.2.2 MongoDB

MongoDB is a popular open-source NoSQL database management system, known for its versatility and scalability. Unlike traditional relational databases, MongoDB adopts a flexible, document-based format known as BSON (Binary JSON), which allows for the storage of structured data in a highly adaptable manner. A key strength of MongoDB lies in its ability to scale horizontally, making it ideal for handling large volumes of data and supporting high-performance applications. Its distributed architecture enables effortless scaling across multiple nodes, ensuring optimal performance and reliability.[34]

Below is a list of reasons as to why I have chosen MongoDB and how I plan to implement it.

- **Price**

One of the main reasons as to why I chose MongoDB was due to its cost for the use of my project it is free which is of huge benefit to me.

- **Scalability**

The scalability of MongoDB makes it well-suited for the amount of data I anticipate to create. As my application expands and the quantity of QR codes and usage data grows, MongoDB can effectively handle the storage and retrieval operations with efficiency.

- **Data Storage**

The storage of data such as the original URL, the shortened URL, and the number of times each QR code has been scanned (usage) greatly benefit my research and the overall project.

- **Data Retrieval and Manipulation**

Manipulating and retrieving data includes operations such as inserting new records (QR code data) and updating existing records (incrementing usage counters). As part of the data storage, this is once again a key benefit.

- **Integration with Flask**

PyMongo seamlessly integrates with Flask, allowing me to perform database operations directly within my Flask application. This was a key finding of mine during the research phase of the project as it gave me a clear indication as to what technologies to use and the added benefits.

4.2.3 Heroku

Heroku is a cloud platform as a service (PaaS) that provides me with a seamless environment for building, deploying, and managing applications. With Heroku's user-friendly interface and robust set of tools, I can speed up the development process and focus on the code without having to host the infrastructure. Additionally, Heroku offers scalability and reliability, ensuring that the application can seamlessly handle high traffic and maintain high availability.[35]

Over alternatives, Heroku is easier to use and cheaper to run as it has a simplistic approach to the deployment process by providing a platform where developers can deploy applications with minimal configuration. Heroku also offers automatic scaling and load balancing, allowing applications to scale dynamically based on demand.

As I am running my project as a solo developer Heroku proves to be a great platform for hosting and overseeing applications, harmonizing works well with MongoDB's proficiency in storing and managing data. Heroku also works seamlessly with Flask/Python which is of huge benefit to the project.

4.2.4 GitHub

GitHub serves as a cloud-based platform designed for storing projects and tracking changes over time, ensuring consistency and reliability throughout the project's life cycle. [36]

Throughout this project, I have committed each change I made to my code to GitHub as proof of continuous work and as a safe and reliable location to store a backup of my code. You may find the link to my GitHub in Chapter One under the section Project Workspace.

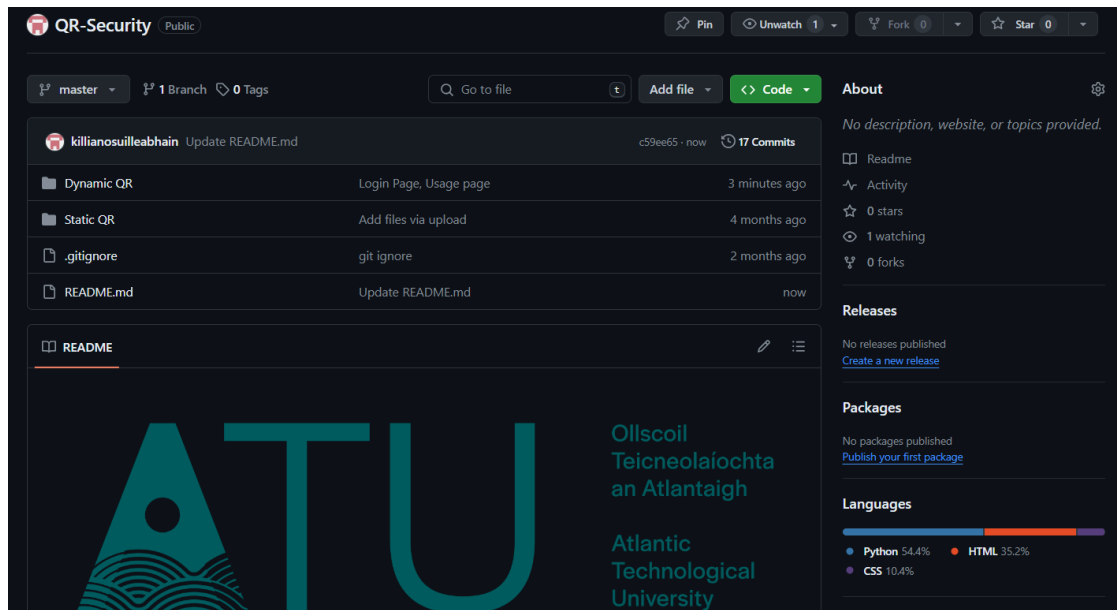


Figure 4.2: My GitHub Repository

4.3 Alternative Technologies

Here are a few technologies that I considered during the development of this project, along with a concise overview of each and a comparison explaining why they weren't ultimately selected.

4.3.1 Angular

Angular is a popular open-source front-end web application framework maintained by Google and a community of developers. It is widely used for building dynamic single-page applications and progressive web apps. Angular is based on TypeScript, a superset of JavaScript that adds static typing and other features to the language. [37]

Although Angular and Python/Flask are fundamentally different both sets of technology could offer the same outcome for the scope of my project in which they could create a QR code generator which can be connected to a database to gain an insight into the research.

During the research phase of this project, I explored the possibility of using Angular instead of Python and Flask. However, based on my experience, I concluded that Angular was not the preferred direction for this project. One of the reasons was the quality of the QR code library in comparison to the Python library

in which the Python Library had the edge. Additionally, I decided to proceed with Python and Flask over Angular because part of this module emphasized learning new technologies. While I have more experience with Angular from my studies in Software Development, I saw the project as an opportunity to expand my knowledge and skills in Python and Flask, which are relatively new to me.

4.3.2 Django

As an alternative to Flask, Django emerges as a high-level Python web framework celebrated for its simplicity, versatility, and scalability. Known for its robust features and comprehensive ecosystem, Django is well-suited for a diverse array of projects, spanning from straightforward websites to intricate web applications. Trusted by companies and organizations of all scales globally.[38]

Table 4.1: Flask VS Django

Features	Flask	Django
Framework	Flask has a Lightweight Framework with a micro web framework philosophy	Django has a Full-stack framework with a "batteries-included approach"
Learning	Flask has an easier learning curve thanks to its minimalist design and flexible architecture.	Django has a steeper learning curve due to its comprehensive feature set and built-in conventions.
Flexibility	Provides more flexibility like other databases and APIs	Provides less flexibility as it is a full stack system
Uses	Best used for smaller applications or prototypes	Used by big global companies for large scale applications

The reason why I opted for Flask over Django is that I am doing a solo project focused on research. While Django offers numerous advantages for full-stack applications, I determined that its extensive features might not align with the scope of my project. Instead, I concluded that the lightweight Flask framework would best suit the needs of my project.

4.3.3 AWS

AWS (Amazon Web Services) is a cloud computing platform offered by Amazon. It provides a wide range of cloud services and solutions that enable businesses to

build, deploy, and manage applications and infrastructure in the cloud.[39]

Originally, the plan was to host the project on AWS, considering its capabilities as an alternative to Heroku. However, following discussions with both peers and supervisor, the consensus strongly favoured leveraging Heroku for hosting the project. It was emphasized that Heroku offers a user-friendly interface and proves to be a more cost-effective option overall.

Table 4.2: Heroku VS AWS

Features	Heroku	AWS
Ease of use	Heroku offers a streamlined deployment and is known for its simplicity	AWS is a lot more complex in comparison to Heroku as it has more manual configuration setups
Pricing	Heroku offer a simple pricing option and for my small project this would work out cheaper	AWS offers a pay-as-you-go pricing model with a wide range of services and pricing options.
Service	Heroku offers (SaaS) Software as a service which is simple to use	AWS provides (IaaS) infrastructure-as-a-service which although comes with more is not useful in my project
Scalability	Heroku offers automatic scaling based on load and traffic patterns,	AWS offer multiple scaling options including EC2 Auto Scaling, Elastic Load Balancing, and Amazon RDS.

Chapter 5

System Design

Within this chapter, I will explain the system design for my project, supplemented with visual aids for clarity. The objective is to discuss the interactions and synergy between various technologies employed. I wish to point out that the technology review chapter has previously discussed all the technologies displayed.

For my project, I created both a static and dynamic QR code generator. During this project, the emphasis has always been on the dynamic QR code generator as that is what follows the aim of the scope. That being said I will briefly explain the architecture behind the Static QR code as it is work which has been completed.

5.1 System Architecture

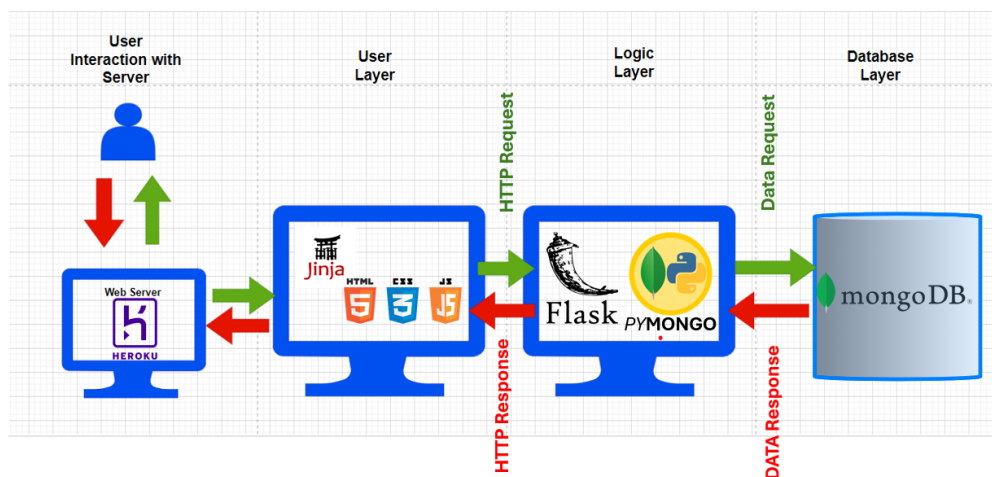


Figure 5.1: System Architecture

The Figure above visualizes the system architecture and the various steps that happen within. Below is the list of steps from start to finish.

1. **User Interaction**

The user interaction takes place thanks to Heroku which is a product as a service (PaaS) on which the site is hosted.

2. **User Layer**

The user layer serves as the graphical user interface (GUI) of the project, representing the initial interaction point between users and the site. Jinja2, a templating language for Python, facilitates the creation of HTML pages. These pages are then delivered to users through an HTTP request.

3. **Logic layer**

The logic layer processes and validates the user input while they are using the site in this instance Flask is the application framework and with the help of PyMongo it can connect to the database layer.

4. **Database Layer**

The database layer is where the data is stored in this instance the data is stored on the cloud using MongoDB between the logic layer and the database layer they are connected to retrieve any needed data to be displayed on the users layer.

5.2 Front-End

Front-end is an area in which I am most familiar and comfortable while programming. I have plenty of experience in designing and implementing front-end solutions from the multiple modules I have studied during my time in college. HTML was the first coding language I learned, laying the grounds for my understanding of web development.

With the knowledge of what I just said it is important to remember that a key goal of this module was to work and learn independently. Although I have experience in HTML the use of Jinja2 which as mentioned before is a templating language for Python which incorporates HTML, CSS and JavaScript into Python. A key shakeup in this language is the use of variables enclosed in double curly braces (`{{ ... }}`) which I found useful during my time programming.

The below Figure displays the use of templates and a static folder with a similar job of containing the CSS which connects by using the aforementioned double curly braces.

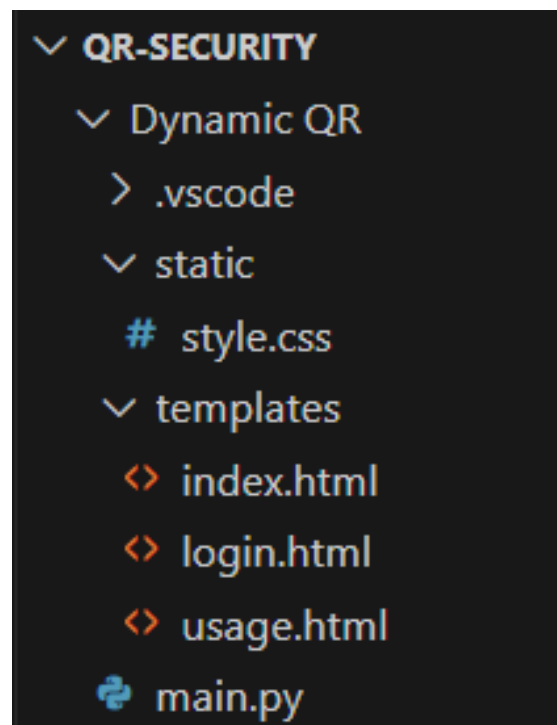


Figure 5.2: Jinja Templates

5.2.1 User Interface

The graphic user interface (GUI) is of significant importance to all websites as the first impressions matter to the customer. The GUI should be readable understandable and attractive this includes picking pleasing colour pallets which create cohesion throughout the GUI.

Maintaining a similar style throughout the process is important as it brings all the pages together and makes the website recognisable from a distance. Using the same font for the same buttons has the same effect. It is also appropriate not to over-saturate the pages with content as it makes it less accessible for some with poor eyesight and also looks messy and clunky.[40]

Throughout this project, I have used CSS styling to create a coherent style on all 3 pages as will be displayed in the following sections and as can be seen with a code snippet below which displays the use of forms and the all-important body tag.

```
1  /* Set the background color of the entire page */
2  body {
3      background-color: #6b36dd;
4      margin: 0;
5      padding: 0;
6      display: flex;
7      flex-direction: row;
8      justify-content: center;
9      align-items: center;
10     height: 100vh;
11     gap: 20px;
12 }
13
14 /* Styling for each form */
15 form {
16     background-color: #ffffff;
17     padding: 20px;
18     border-radius: 8px;
19     box-shadow: 0 0 10px rgba(0,0,0,0.1);
20     width: 300px;
21     display: flex;
22     flex-direction: column;
23     gap: 10px;
24     margin: 10px;
25 }
26
```

Figure 5.3: CSS

5.2.2 Login Page

The login page is usually the first page you see when entering a new website for the first time it is a method of security and authentication for the user.

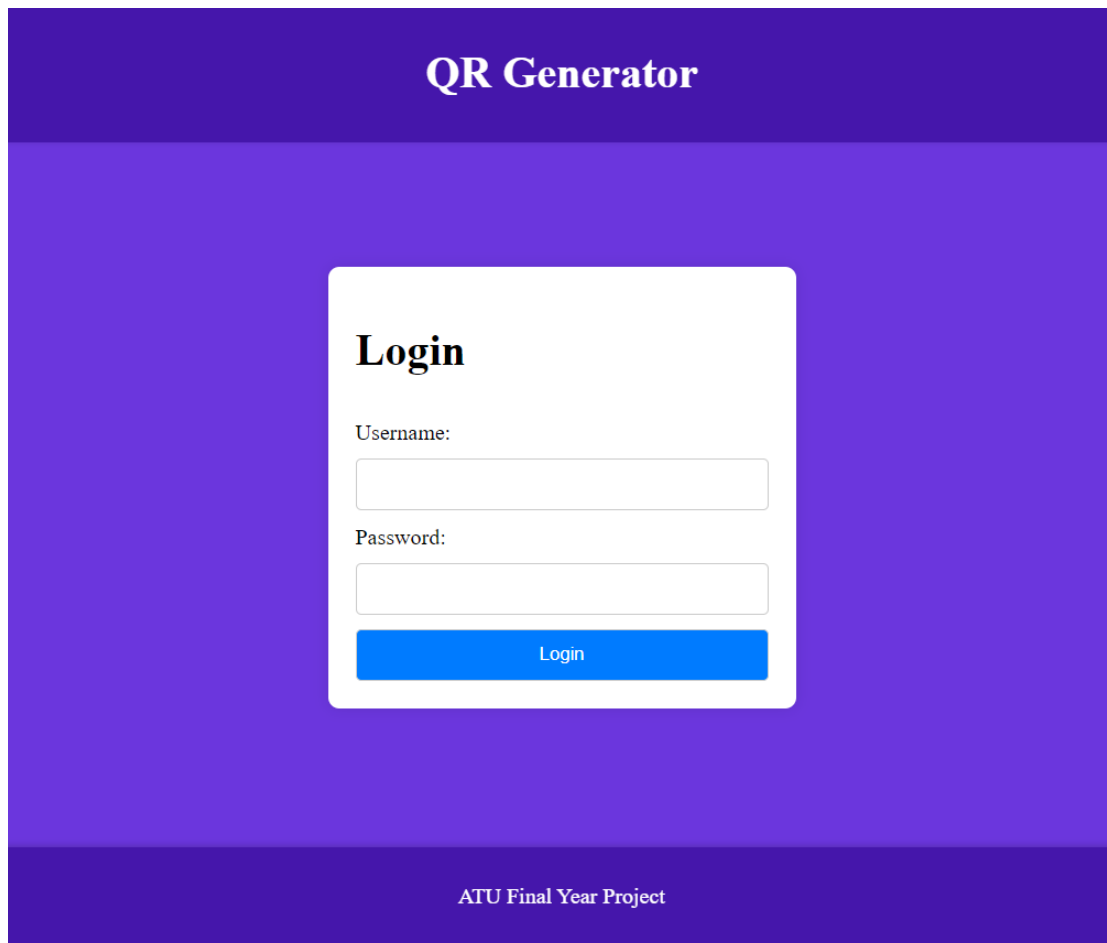
During the planning stage, I had overlooked the need for a login page as it was something I hadn't considered but as I realized I would be hosting this website and that I could be easily under attack as up to this point attackers would've had free access to my QR code generator and database which could have been of huge cost.

The design philosophy behind the login page was to keep it simple while maintaining similarities between itself and the other two pages to welcome and bring the user in.

As the login page wasn't planned out I went for a simple approach when programming. The approach I took was not very secure but cost me little time to implement. The approach taken was to hard code the username and a unique

password into the Python script which I hope with a private GitHub repository will keep it safe.

Below is an Image of the login page GUI and the login route.



The image shows a web application interface for a 'QR Generator'. The background is a solid purple color. At the top, there is a dark purple header bar with the text 'QR Generator' in white, bold, serif font. In the center of the page, there is a white rectangular box with rounded corners. Inside this box, the word 'Login' is written in a bold, black, serif font. Below 'Login', there are two labels: 'Username:' and 'Password:', both in a black, serif font. Each label is followed by a white rectangular input field with a thin grey border. Below the input fields, there is a blue rectangular button with the word 'Login' in white, sans-serif font. At the bottom of the page, there is a dark purple footer bar with the text 'ATU Final Year Project' in white, sans-serif font.

Figure 5.4: Login GUI

```
30 # Login Route
31 @app.route('/login', methods=['GET', 'POST'])
32 def login():
33     error = None
34     if request.method == 'POST':
35         if request.form['username'] == 'StudentATU' and request.form['password'] == '':
36             session['logged_in'] = True
37             return redirect(url_for('index'))
38         else:
39             error = 'Invalid credentials. Please try again.'
40     return render_template('login.html', error=error)
41
42 # Logout Route
43 @app.route('/logout')
44 def logout():
45     session.pop('logged_in', None)
46     return redirect(url_for('login'))
47
```

Figure 5.5: Login Code

5.2.3 Home Page

Initially, the design of the home page was to include only a dynamic QR code generator but after a couple of tests, it was discovered a URL shortener was needed which would help with the tracking of QR statistics. By adding a previous test file to the main file I quickly got to work on ways in which I could design and incorporate the two files together. The use of the `<form>` element provided a way to structure and organize input fields on the web page as well as bringing a recognisable theme to the page.

The home page consists of 3 forms which consist of the URL shortener, The QR code generator and the Statistics form which contains a quick tip and a button which leads to the statistics page. All together the forms look tidy as the 3 are well framed and all follow a consistent style.

The use of Python libraries made it possible to create both the dynamic QR codes and the shortened URL with the help of a route decorator.

Below are two images of the Home GUI and code from the project which uses these important libraries.

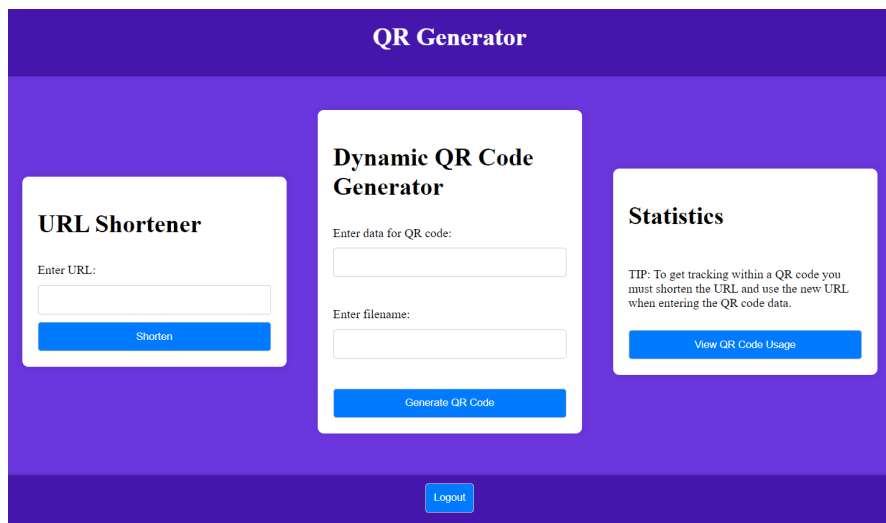


Figure 5.6: Home GUI

```
74 # QR code Generator
75 @app.route('/generate_qr', methods=['GET'])
76 def generate_qr():
77     original_url = request.args.get('data')
78     filename = request.args.get('filename', default='qrcode')
79
80     short_url = generate_short_url(original_url)
81     qr = qrcode.QRCode(
82         version=1,
83         error_correction=qrcode.constants.ERROR_CORRECT_L,
84         box_size=10,
85         border=4
86     )
87     qr.add_data(request.host_url + short_url)
88     qr.make(fit=True)
89     img = qr.make_image(fill_color="black", back_color="white")
```

Figure 5.7: QR Code Generator Code

5.2.4 Statistic Page

The goal of the statistics page was to retrieve and display the live data from MongoDB to the web application with the help of PyMongo which enabled my web application to interact with MongoDB databases.

Within the statistics page, there is information about current QR codes and shortened URLs which contain a counter for the QR code scans. This is important for gathering data for the research of the project.

Similar to the home page the common theme of the purple background and a white form continues finishing off the theme within this the QR code which was originally encoded for the database is decoded to show on display.



Figure 5.8: Statistics GUI

5.3 Back-End

Within this section, I will be discussing the back-end development cycle which includes the database and the hosting service.

Back-end development has never been an area which I enjoyed during my time in Software Development. Tackling the back end was my biggest challenge in this project as I had to learn new technologies with little prior knowledge

5.3.1 Database

MongoDB is the primary database within this project which I use to store QR codes, shortened URLs and the usage statistics associated with one another.

The original goal when designing the database was to keep all the statistics within one database and one collection which would make it easier to retrieve and display within the statistics page. Unfortunately due to consistent errors at the later stages of the project, the final result ended up being 1 database but two collections which were separated as storage for the URL shortener and the QR code in which only the URL shortener had working usage statistics.

A noteworthy experience was when saving data to MongoDB I was having a difficult time saving and retrieving images of the QR codes through some research I discovered it is best to encode the image when sending it to the database. I used the Base64 scheme which turns binary data into printable ASCII characters.

Below is a code snippet which displays the Base64 encoder as well as an image of the MongoDB database.

```
91     # Save QR by encoding it
92     buf = io.BytesIO()
93     img.save(buf)
94     buf.seek(0)
95     img_data = buf.read()
96     data_url = base64.b64encode(img_data).decode('utf-8')
```

Figure 5.9: Base64 Encoder

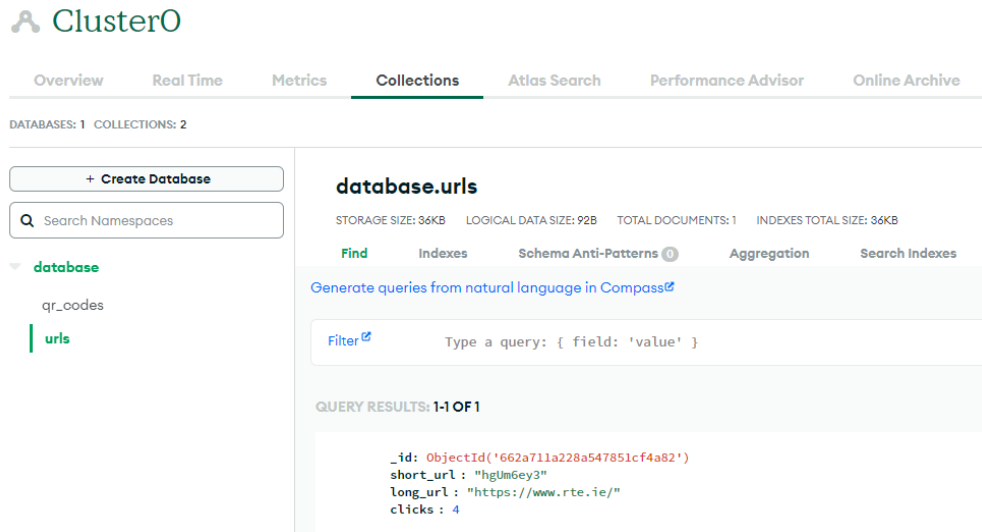


Figure 5.10: MongoDB Database

5.3.2 Hosting

As discussed in previous chapters I will be hosting my Web application using Heroku the goal of this is to learn how to host a web app as well as be able to run a more distinct set of research as I will be able to use a custom URL.

The importance of a custom URL is that when users hover over a QR code before accessing it the URL of the site shows. This is important information as when I shorten the URL using my web application it will shorten it to "MyWebApplication/00000000" which will deceive users in the Phishing/Quishing experiment.

Below is a figure which displays the purchase of a domain related to the university which displays the simplicity of running a Quishing and Phishing and how attackers may attack more users. The second figure displays a phone displaying a URL before the user enters the site.

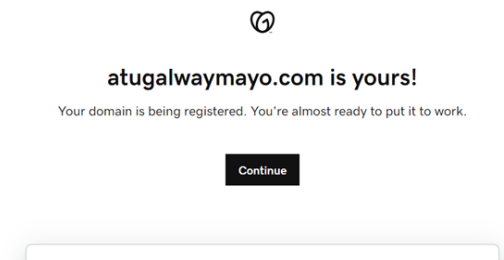


Figure 5.11: Domain Purchase

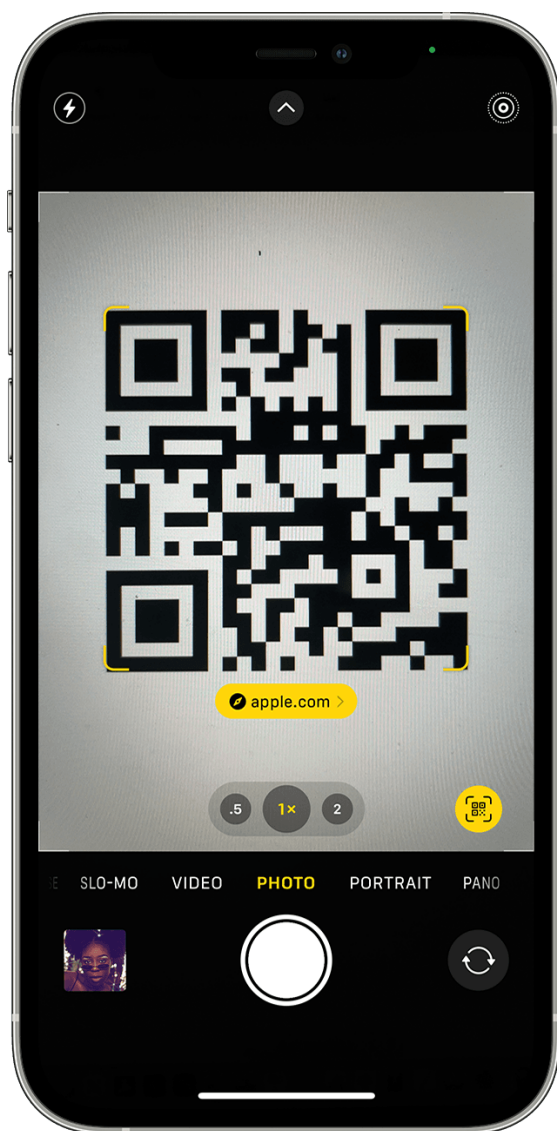


Figure 5.12: QR Code Reader Displaying Content of URL

5.4 Research

As mentioned in a previous chapter I will be conducting a mixed approach to research during this project. The research includes both an experiment and a survey in which I test the public on their knowledge of QR codes.

The survey will be a public survey in which I plan to gain more information on people's opinions on QR codes and their day-to-day use in society within this survey there may also be an opportunity to find a correlation between statistics which may be important.

The experiment I plan to run is a social engineering experiment where I place publically accessible QR codes throughout my local area including shops libraries, gyms etc for a set period of time. The QR code will direct scanners to a Microsoft Forms survey in which I will gather qualitative research. As well as that I will be using my QR generator so I can collect data on the number of scans I have received.

A second experiment which I plan to run is a direct Phishing/Quishing experiment with help from the university security team. This experiment will give me hands-on experience regarding how security training is enforced and taught in an organisation while also collecting the necessary data for the project.

Below are images of the QR codes I placed publically and within the next chapter you will see the results.



Figure 5.13: QR Code on Bathroom Stall Door

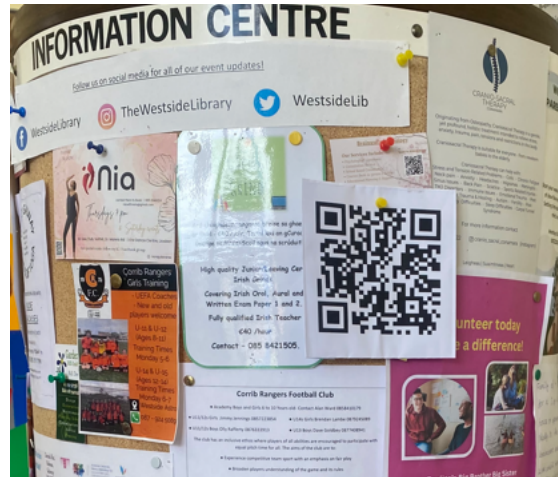


Figure 5.14: QR Code On Notice Board



Figure 5.15: QR Code on public Library desk

Chapter 6

Evaluation

Within this chapter, I am going to reflect on and evaluate the research and programming I achieved during the last couple of months of studying this module.

6.1 Research Results

With the help of visual-aid within this section, I am going to discuss the results of my experiments and surveys in which I where successful. With the use of this data, I hope to display correlations between data and make a well-informed opinion on said results.

For reasons out of my control, I was unable to run the Phishing/Quishing experiment which I will discuss in greater detail within the shortcomings section.

6.1.1 Survey Results

The survey I ran was sampled from family and friends using forms of sharing the survey online from this I received 56 unique responses which I will break down now.

Of the 56 responses, 20 were female and 36 were male with the most common age range between 18-24 below I will discuss each question asked along with the results to demonstrate the knowledge of security. Below is a list of the questions asked and a rundown of the results

- **Do you use the same password for more than one account?**

An estimated 71% of people surveyed said yes to the above question with 20% saying no and the other 9% not saying.

This data shows how vulnerable one can become if they lose access to just one of their accounts as the attackers know this data and can test other

accounts using the same password

- **Do you use two-factor authentication for online accounts?**

77% of people claim to use two-factor authentication with 14% saying they don't and 5% claiming they are unaware of it

For the 77% this is beneficial as it adds an extra layer of security between their account and attackers.

- **How often do you get phishing emails, texts, calls (Scam Messages)**

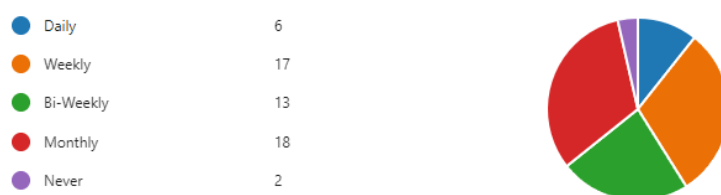


Figure 6.1: Phishing messages duration

From the figure above we see that phishing scams are a popular occurrence among people with only 4% of people claiming to have never gotten one. It can be seen that most 64% of people are receiving at least 2 phishing scams a month.

- **Have you ever been hacked or breached of personal information before?**

From my sample size, 25% of people have claimed to have been hacked or breached previously. From the follow-up question of how they became a victim, many results were unclear but 3 people claimed to have been caught in a phishing sting.

- **How often do you use QR codes?**

When exploring research for technology it is important to look at the frequency in which the technology is used the below figure displays just that. The figure shows that 67% use QR codes monthly or more.

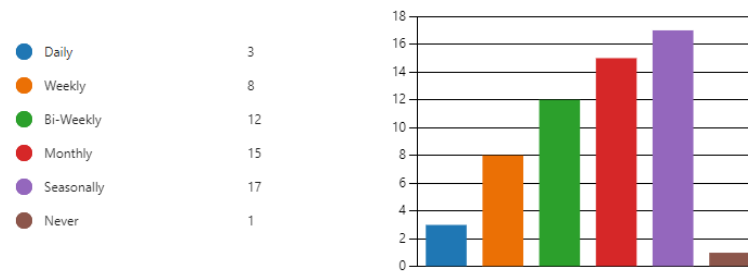


Figure 6.2: How Frequently do you Scan

- Are you aware that QR codes have the potential to be harmful?

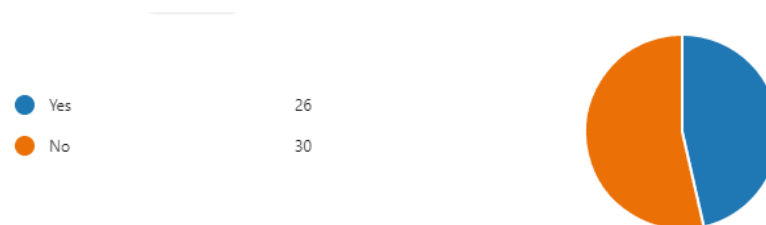


Figure 6.3: Knowledge on QR Code threats

The above figure displays a worrying factor in terms of potential threats with 54% of those surveyed unaware of the threats associated with QR Codes.

- On a scale of 1-10, How confident are you in your ability to identify and respond to online security threats?

When asked about the confidence that the surveyors had the response was worrying with 41% not confident in their ability with a further 37% unsure about their ability to identify or respond to an attack. The below figure gives a Net Promoter Score (NPS) of the general average.

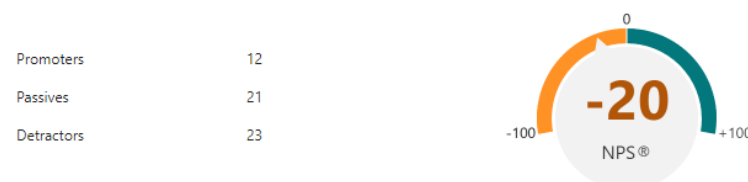


Figure 6.4: Confidence in Response

6.1.2 Social Engineering Results

The social engineering experiment I ran came back to be a success as my QR codes were scanned 27 times and from those 27 scans, I received 21 responses of which 57% were men 38% were women and 5% (1) preferred not to say.

As mentioned previously the goal was to collect qualitative data which meant the use of answer boxes and not just yes or no questions. Below are the common reasons why people scan the QR code and the number of people who can fit into each category.

- Boredom/Curiosity 7
- Advertisement 5
- Advertisement 5
- Competition 3
- Unsure 1

Below are the most common places in which my QR code was scanned. Miscellaneous stands for the people who left a vague answer

- Library 6
- Miscellaneous 5
- Gym 4
- Toilet 3
- traffic light pole 3

Unlike the previous experiment, a whopping 86% of people were unaware that QR codes could be harmful which is up from 54%.

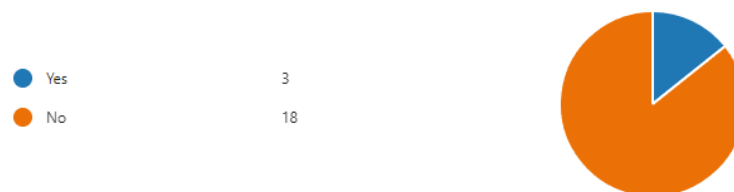


Figure 6.5: Knowledge on QR Code threats

6.1.3 Correlation

Within this section, I am going to explore correlations between the surveyed data. A Correlation which stands out to me originally is the ability of those who use multi-factor authentication and the respondents' confidence in their ability to identify and respond to online security threats is high which is most likely a trend which shows that they are aware of the possible threats.

There is an age correlation between the use of QR codes is also a noticeable correlation but as a larger majority of 18-24 year-olds answering my survey I can't say if a product of sample size.

Users who get daily phishing scams answered the "Detractor answer" for the question "On a scale of 1-10, How confident are you in your ability to identify and respond to online security threats?" This to me is a sign that possibly attackers know these users are more susceptible to falling for attacks.

6.2 Testing

During the project lifecycle, I continuously tested my project throughout development with an emphasis on unit testing, integration testing and end-to-end testing.

- **Unit Testing** Unit testing is an approach in which I test each component in isolation in my case the the QR code generator and the URL shortener were both tested on their own before incorporating the two together. These tests were done to ensure each one was able to connect to MongoDB and function as designed.
- **Integration Testing** Integration testing is the second form of testing which I completed this was to ensure that both the URL shortener and QR code generator worked seamlessly together during this I discovered the issue of the two collections within MongoDB but with the little time I had remaining in my project I worked around it.
- **End-to-End Testing** End-to-end testing was the final test I completed after having no luck with the web hosting I decided to cut my losses and ensure that the application was still deployable and held value. During this time I ran through the page from start to finish ensuring that the application completed all tasks and did what it said on the tin.

6.3 Limitations

With any project or research, there are limitations. My project is no exception to this as a lack of motivation and time is a factor. The project lacks in both areas of programming and research which I will delve into.

6.3.1 Research Limitations

Limitations within research involved the bad timing of my request to run a Phishing/Quishing experiment in college. The idea for this experiment came about at the presentation before the Christmas holidays where I was recommended by a member of the programme board to do so. When I returned after Christmas I spoke to my supervisor about this who gave me information on who to contact which I did at the time but didn't get a response from until 2 weeks later in which he mentioned I'd have to go through the ethics board and that my application simply won't be done in time. This was a blow to the research as If I were to approach the ethics board sooner I may have gotten my Request.

A second limitation of my research involved the social engineering experiment where I only placed the QR codes locally and for only a week when they were active. This was a limitation of my software as originally I planned to create the QR codes myself and track them that way but when it became apparent that I was nearly out of time I needed to use a third-party QR generator to display the QR code and get tracking information. The questions asked within the social engineering experiment were also too broad as I received a handful of vague answers.

The research survey sample size may have also been off-balanced with the lack of older generations taking part in the survey as it was shared online.

6.3.2 Programming Limitations

Limitations within my code include a messy database and a web application which failed to host. Due to time limitations, I didn't want to risk fixing too much of my database in case I were to lose all of my progress an alternative to this would have been merging the two collections on the Flask/Python side but this was also a late suggestion I received which caused me to maintain my 1 database and 2 collections. The main limitation I faced had to be the failure to host the web application on Heroku for similar reasons as the database it was down to time as I know Heroku from a separate module in this course.

Improvements that could've been implemented in my code include a more secure login system. This became a limitation as I discovered towards the end of my project that I had a wide-open database which could've been easily manipulated and cost me money and time.

With this knowledge in mind, there can be improvements made throughout this project and different approaches can be taken that will suit the project more for example a more Agile approach would've taken the need for a login page into consideration sooner and left enough time for it to be implemented correctly.

Chapter 7

Conclusion

Within this dissertation, I have achieved the goal of exploring the domain of cybersecurity with a focus on the vulnerabilities involved with QR codes and the threats which they may carry. I have successfully gathered data which may prove to be valuable as well as give an insight into the need for better education in regards to personal security online or by an organisation. With the use of programming, I have discovered the back-end processes which create and maintain QR codes while also discovering how attackers may use this knowledge to their advantage.

The core objective of this dissertation was to "work and learn independently under the guidance of a qualified supervisor." and demonstrate the student's proficiency in "learning to learn" and ability to adapt to new technologies, programming languages, and practices within a rapidly evolving discipline. Below is a list of the following objectives that will be achieved that are also listed at the start of the dissertation.

- Demonstrate my ability to learn, research, understand and apply new knowledge gathered.
- Explore and use programming languages and tools outside of my formal education or prior experience.
- Engage in critical analysis and showcase proficiency in researching complex computer-related issues.
- Understand current industry practices to integrate throughout my project.
- Assess the completed work and provide constructive feedback, highlighting areas for improvement or alternative approaches.

During the project, I followed the scope to the best of my abilities whereas other than web hosting I believe my project demonstrates the core values of my scope. Below is a refresher as to what the scope of the project was.

- Develop a working dynamic QR Code generator using Python as the primary language.
- Deploy the web app onto an online platform using cloud services such as AWS or Heroku, ensuring accessibility.
- Implementation of MongoDB for cloud-based data storage.
- Conducting comprehensive research on QR Security and phishing.

I enjoyed taking part in this module as it is a sign of the end of a chapter in my life but the start of a new one I am delighted that I got to research the domain which is cybersecurity as it is an area in which I hold great interest for and with this project, it has allowed me to explore something which otherwise wouldn't have been done during my university studies.

Overall, I found this module immensely rewarding, enhancing my learning and driving me towards achieving my objectives. The module provided valuable hands-on experience, serving as a stepping stone towards real-world application and expertise development.

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