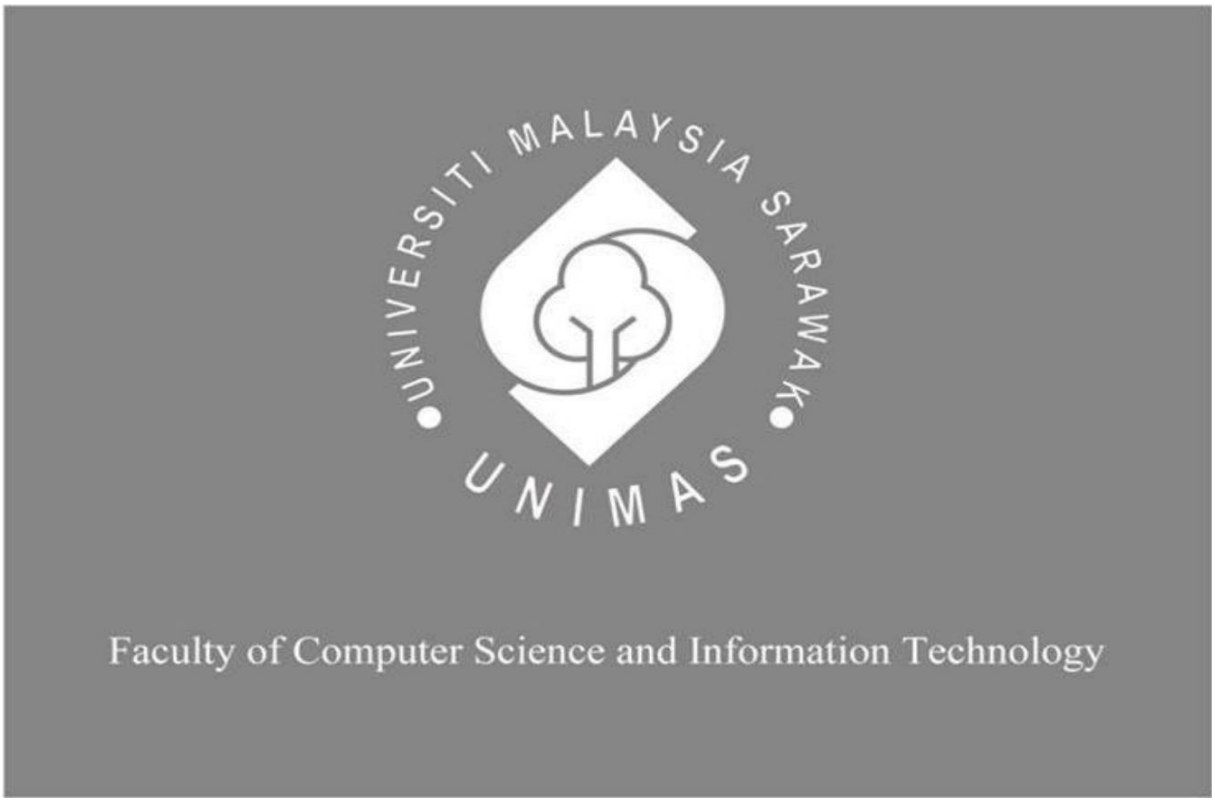

PROTOTYPE OF SMART HOME SYSTEM USING RASPBERRY PI

Ezekiel Jalin Anak Freddy Jalin

Bachelor of Computer Science with Honours

(Network Computing)

2023

UNIVERSITI MALAYSIA SARAWAK

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PROTOTYPE OF SMART HOME SYSTEM USING RASPBERRY PI

EZEKIEL JALIN ANAK FREDDY JALIN

This project is submitted in partial fulfilment of the
requirements for the degree of
Bachelor of Computer Science (Honours) (Network Computing)

Faculty of Computer Science and Information Technology
UNIVERSITI MALAYSIA SARAWAK
2023

PROTOTAIP SISTEM RUMAH PINTAR MENGGUNAKAN RASPBERRY PI

EZEKIEL JALIN ANAK FREDDY JALIN

Projek ini merupakan salah satu keperluan untuk

Ijazah Sarjana Muda Sains Komputer dengan Kepujian

(Pengkomputeran Rangkaian)

Fakulti Sains Komputer dan Teknologi Maklumat

UNIVERSITI MALAYSIA SARAWAK

2023

DECLARATION

I hereby declare that this project is my original work. I have not copied from any other student's work or from any other sources except where due reference or acknowledgement is not explicitly in the text, nor has any part had been written for me by another person.

……

(EZEKIEL JALIN ANAK FREDDY JALIN)

ACKNOWLEDGEMENT

From all that has been, is created. From the great architect of the universe, my inspiration is drawn from. Of all that will continue to be, from Him, they are made. I thank you. To my parents, for their endless prayers and encouragement, I dedicate this work. With the thought of making their lives easier into their old age, I settled on this particular title. To friends and family who has been directly and indirectly supportive, your words and deeds gave me the strength and the wisdom to carry on. Finally, to my project supervisor, Mdm. Azlina binti Ahmadi Julaihi, your constant effort in guiding and mentoring my fellow mates and I will always be remembered and appreciated. To all I have named and the ones I missed, no deeds or compensation can ever repay all of your graces upon me.

ABSTRACT

Smart home systems are gaining popularity in new house development these days. It offers automation in climate control, security, and increases general home safety while simultaneously improving quality of life. Many smart home systems have been developed with some incorporating advanced technologies such as Artificial Intelligence. However, as these systems are not widely used in general households, the features that are offered in the most basic systems are lacking in many ways. The modularity of these systems induces additional costs in integrating the most basic features such as security in addition to lighting automation. The proprietary software and hardware also raise the question of how secure the current systems in the market are with the rising security breach in many areas. This prototype development aims to incorporate all the basic features of a smart home system into a single inclusive system that is open-source while being secure. The development of this prototype follows the Agile methodology, in favour of its constant improvement methodology that is highly suitable for an ever-evolving area of technology. Comparing the proposed prototype and the market offerings, it is possible to incorporate most of the existing features of a smart home system except for the Artificial Intelligence enabled features such as voice recognition. This is due to the nature of the technology that needs a lot of model training which is prohibitive at the author's capacity. This prototype incorporates elements of Internet-of-Things, wireless sensors, embedded systems, and Raspberry Pi.

ABSTRAK

Sistem rumah pintar (smart home) semakin popular di pembangunan perumahan baharu kini. Ia mempunyai fungsi untuk mengautomasi kawalan suhu, sekuriti, dan meningkatkan keselamatan rumah disamping meningkatkan kualiti hidup. Sistem ini kebanyakannya mempunyai teknologi canggih seperti *Artificial Intelligence*. Tetapi, kebanyakan sistem yang dipasaran tidak mempunyai fungsi ini dan juga kurang fungsi asas sistem *smart home*. Sifat sistem ini yang modular meningkatkan kos untuk mempunyai sistem dengan fungsi yang asas. Perisian dan peranti yang berkaitan juga adalah hak milik pembangun sistem tersebut yang menjadikan sistem itu tidak dapat dipercayai secara penuh. Prototaip ini bertujuan untuk menyelesaikan beberapa kekurangan sistem yang ada dipasaran seperti fungsi asas di dalam satu pakej. Pembangunan prototaip ini adalah berdasarkan metodologi *Agile*. Ini kerana metodologi ini adalah seiring dengan perkembangan teknologi semasa. Prototaip ini dibangunkan dengan beberapa elemen seperti *Internet-of-Things*, sensor nirwayar, sistem tertanam, dan Raspberry Pi.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Smart home system is a home that is fitted with sensors, appliances, and devices that can be controlled remotely through the home network or internet (Georgiev et al., 2018). It provides monitoring, appliance control, and media service. Smart home is a popular concept in modern homes with the most notable adopter of the technology being Bill Gates and we are starting to see its adoption into new housing developments in our country by prominent developers such as Gamuda Land (Gamuda Land, 2022).

A smart home improves the quality of life by employing various means for monitoring, control, alerts, and entertainment. The offloading of various mundane daily tasks that can be automated can be achieved through the system and more time can be spent on other activities or alleviate anxieties related to the security and safety of the home. It also promotes green living by actively helping with saving energy through the control of electrical appliances.

Although smart home system is not a new concept, it is unfortunately still far from being accessible for a common person. The current offerings in the market are prohibitively expensive, complicated, and may steal user data (Android Authority, 2022). This prototype development aims to develop an affordable, modular, and secure smart home system through the use of the popular single-board computer, the Raspberry Pi.

1.2 Problem Statement

Smart home systems are becoming more commonplace these days with the popularity of basic systems such as Google’s Home range of products. Commercially available systems

are powerful and feature-rich, but they can be costly and may collect data discreetly to push targeted advertisements (Android Authority, 2022). There are many readily available Raspberry Pi based smart home systems, but almost all of them require a subscription and complex to set up. For many people, a modular and simple smart home system is desirable**.**

1.3 Objectives

i) To build a prototype of a Raspberry Pi Smart Home System that can monitor using various sensors such as gas, fire, smoke, and intruder, and push alerts when custom parameters are triggered through the companion Android app.

ii) To integrate control of electrical appliances such as lights, fans, and power outlets through smart switches and controllers paired to the home system.

iii) To design and develop a mobile Android app for the smart home system that can receive alerts, set custom parameters, real time monitoring, and control smart appliances.

1.4 Methodology

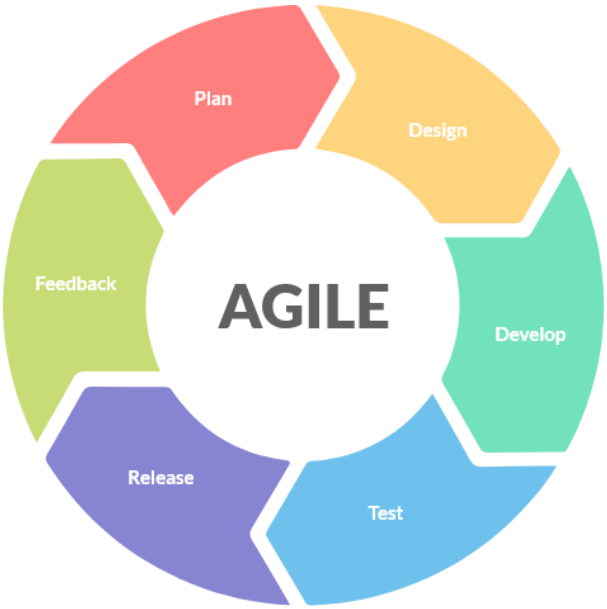

Figure 1 Agile Methodology

The development of this prototype will follow the Agile model due to the constant improvements in technology and needs of the average user. The Agile model is based on 6 phases which are requirements gathering, design, construction/iteration, testing, deployment, and feedback (Javatpoint, 2022).

In the first phase, the analysis of the average homeowner needs will be analysed to gather the basic requirements of the system. A smart home system typically consists of the central unit which is the computing and communication module and the optional controllers. It some system the controllers are optional components of the system such as the Google Home ecosystem (Google, 2022). Each controller is sold separately and, with the exception of the smart plugs, cannot be retrofitted to existing appliances. To keep the system low cost, the system must be able to work with pre-existing appliances through retrofitting compatible controllers that are commonly available.

To give an edge over pre-existing solutions in the market, the system must also be able to utilise low cost and common sensors to monitor various parameters that will concern the average homeowner. To find out what specifically are desired by homeowners, a survey will be conducted.

In the second phase, the design of the system will start with listing the requirements and using it to help build the physical prototype of the system. It will also be crucial in developing the Android companion app. At this stage, there will only be Use Case Models to facilitate the execution of the next phase.

In the third phase, the construction of the prototype will commence. This will start with the physical build of the system. This requires a Raspberry Pi and sensors for the testing stage. The Android app should be built concurrently to ensure proper functionality between the two separate modules. It is worth noting that the app can be built for cross compatibility between

Android and IOS through the use of the Flutter framework (Flutter, 2022). However, the focus at this stage would be on the Android app only due to limitation of acquiring an IOS device for testing.

In the fourth phase, the testing would be covering the proper data are collected, communication between the system and app should be stable, the app should be fully functional, and it works as intended in a real home application. Several metrics can be used to evaluate the project at this stage. For example, stress testing the sensors and collecting the data transmitted to evaluate the reliability of the data and sending multiple alerts to test the stability of the Android app.

In the fifth and sixth phase, it should be run concurrently to ensure feedback are used to resolve or improve issues immediately. This will also ensure that the system keeps up to date with technological improvements in algorithms, sensor quality, and upgradability, to name a few.

Through using the Agile methodology, the system can be consistently improved. This reduces the risk of obsolescence, and the project can be a strong competitor to the existing smart home solutions in the market.

1.5 Scope

The scope of this project covers internet of things (IoT), network, mobile app development, and embedded systems. The project will consist of sensors and the central processing module that processes and automate processes through simple algorithms and sends any user configured alerts to their smartphone. The primary mode of connection between modules will be on WiFi through the use of existing access points. Its intended user would be a homeowner who are interested in improving their quality of life by using a smart home system.

1.6 Significance of Project

This project requires the application of the knowledge the student has gained in their studies, primarily the application of IoT technology and embedded systems. The Android app development will also expose the student to app development, which is not taught in the student's programme. It also adds value to the ongoing evolution of the smart home system by introducing a low cost, simple to setup, and fully functional system using Raspberry Pi and microcontrollers such as the ESP8266 nodeMCU. Through these constraints, it will make future smart home systems be more accessible to everyone. It may even be as commonplace as the smartphone in the future.

The project has the potential to be integrated with emergency response services by collaborating and integrating with them and their current system. A close example of such integration is the Apple Watch ability of alerting emergency contacts and emergency services. Through the use of the various sensors and algorithms that can determine the need for emergency services, it can be automated in such a way that can potentially save lives and increase quality of life.

This system will be able to allow its user to remotely control appliances such as lights, fans, and power sockets remotely through the app which allows the user to be able to save energy, increase safety by turning off malfunctioning appliances, and schedule lighting for when the user returns when it is dark.

1.7 Project Schedule

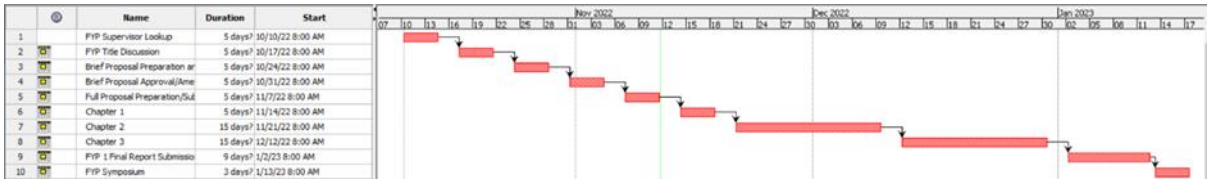

Figure 2 Project Gantt Chart

By referencing the progress monitoring dates briefed during the weekly meetings, a project schedule is generated through the major tasks that are due on certain weeks or days. It starts in the first week of the semester where a student should have already had an FYP supervisor of their choice. Arguably, a student should have already had a supervisor before the start of the semester but due to the Online Delivery Learning (ODL) mode that was on for 2 years prior including the 6-months internship in the previous semester, it was difficult for a student to identify a suitable supervisor through the faculty directory alone.

The second task is the FYP title discussion between the student and their supervisor. Through this discussion, the proposed title chosen by the student was scrutinised to determine the suitability of the proposed project with their field and level of study. This task should be completed before the due date for the submission of the brief proposal.

The third task is the preparation and submission of the brief proposal. A week was sufficient to prepare a brief proposal based on the outcome of the previous discussion. The student sent a draft of the proposal to their supervisor for approval and amendment recommendation.

The fourth task is the formal approval and recommendation for improvement. As the student had obtained the supervisor's approval prior to submission, there were no further comments. The evaluator also did not recommend any amendments.

The fifth task is the preparation and submission of this full proposal. It expands on the brief proposal and goes into greater detail concerning the project.

The sixth task is the first chapter which is the introduction to the project. The seventh task is the second chapter which details the background study consisting of literature study, surveys, and concludes with a statement of requirements. Finally, the third chapter is the

requirement analysis and design which details the approach in the development of the prototype, design, description, and justification.

The ninth task will be the compilation of the previous parts into the final FYP report and submission. Finally, the tenth task is the FYP symposium that will be held in January 2023.

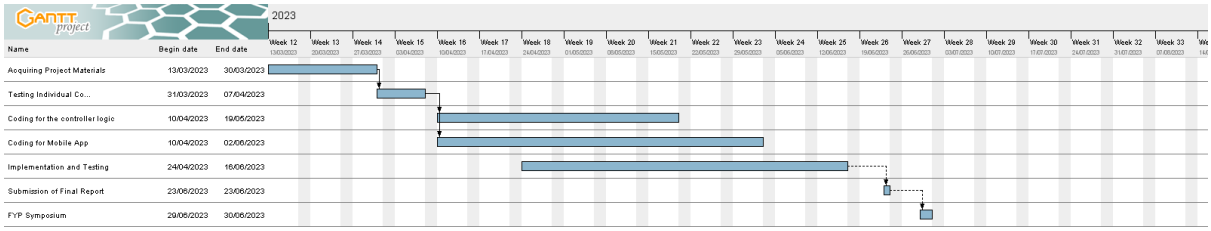

Figure 3 FYP 2 Gantt Chart

For FYP 2 in semester 2 2022/2023, a continuation from FYP 1 is expected and the Gantt chart was drafted based on the upcoming requirements and continuation of the project. It starts with acquisition of the project materials such as controllers and sensors. As these components are hard to come by in physical stores, they had to be ordered online. To account for possible shipping delays and quality issues, almost 3 weeks was allocated for this stage.

Next, testing each component. At this stage, all components have arrived and be tested for functionality as they are all purchased sight unseen through the internet. This is crucial for the continuity of the project as a non-functional component will jeopardise the success of this project.

Next, coding for both the system and android app. At this stage, the coding would be done simultaneously, and implementation and testing would follow. It is imperative that the system should work as planned in the testing process before deploying for public testing.

Finally, the submission of this final report and symposium will be held in June 2023 for the presentation and evaluation of this project.

1.8 Expected Outcome

i) Build a fully functioning smart home system with monitoring and alert features through integration of various sensors such as gas, temperature, smoke, and IR sensors.

ii) Build feature rich, professional looking Android app for the system where a user would be able to receive alerts, control appliances, and actively monitor their home.

1.9 Summary

To sum up, this chapter discusses the smart home concept and the problems with the current market offerings. This project aims to solve the various issues that makes a smart home system inaccessible to the common person such as security and cost. The objective of this project is to develop a prototype of a Raspberry Pi based Smart Home System that employs an array of sensors that will be able to push alerts to its user based on the custom parameters through the companion Android app. It will also be able to integrate control of various electrical appliances and switches connected to the system. A companion Android app will also be developed where a user will be able to receive alerts, set parameters, monitor, and control the system. This development will follow the Agile methodology in favour of its principle of continuous improvement so that the system will be able to keep abreast with the technological improvement. This project encompasses an array of concepts such as internet of things (IoT), networks, mobile app development, and embedded systems. The intended user would be a homeowner that wants to automate and monitor their home for various reasons. This project will result in a fully functional prototype of a Raspberry Pi based Smart Home system utilising common sensors to keep costs low and a companion Android app.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this chapter, three popular smart home systems are reviewed and compared. The two most popular commercial offering, Google Home and Amazon Alexa, and an open-source system are chosen. Due to the three systems' widespread use in its basic form, they would be the best reference point to expand and improve upon what the current offerings have. Google Home and Amazon Alexa has its own proprietary central controller that enables voice commands that puts it as the leaders in smart home solutions. However, the concern lays in how it collects and uses the data to push features or advertisements. In terms of privacy, commercially popular options are convenient but not trustworthy. This chapter will delve deep into the features offered by commercial smart home systems and comparison with the proposed solution.

2.2 Review of Google Home

Google Home central controller runs from the mobile app aptly named Google Home. Through another app named Google Assistant, it allows voice commands to control Google certified smart devices and other Google features such as the Hey Google feature that is highly versatile. Alternatively, Google offers a standalone device named Nest which functions as a speaker and a receiver for voice commands. This allows the smart home system to be a little independent of the mobile app. However, both methods require an active connection to the internet. For Malaysians, getting a Google Home system would require a little effort as Google, regionally, only sells these devices officially in Singapore.

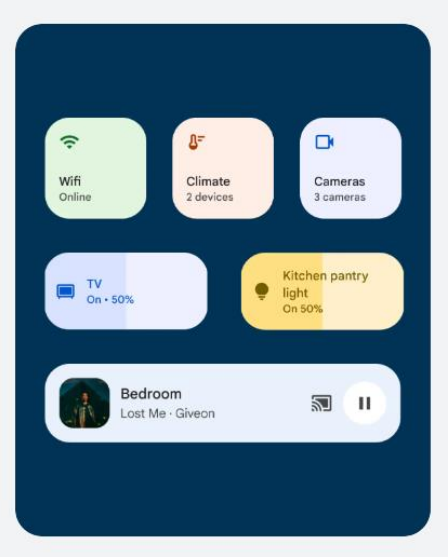

Figure 4 Google Home App Interface

Although local online shopping platforms and some computer stores sell Google products, they are not officially supported by Google. This means that if it were to break down or even hacked, the end customer is left with no support. There are also risks of getting a counterfeit Google product or a questionably compatible product that is not from Google. As Google does not directly manufacture these products, a lot of products of questionable quality are sold on marketplaces that would work with the system, but its quality may be suspect, or it may even be spying its user without them knowing. There are many reports on smart monitoring cameras being hacked and its footage are sold on criminal sites.

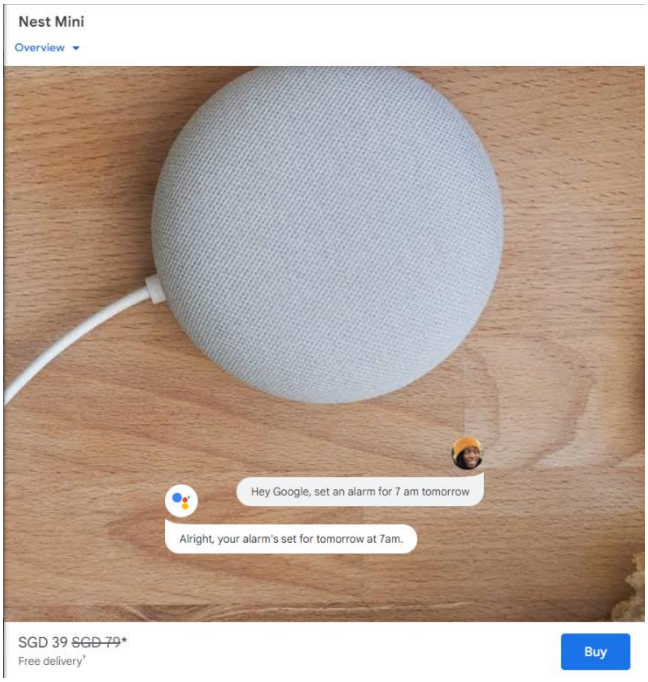

Figure 5 Google Nest

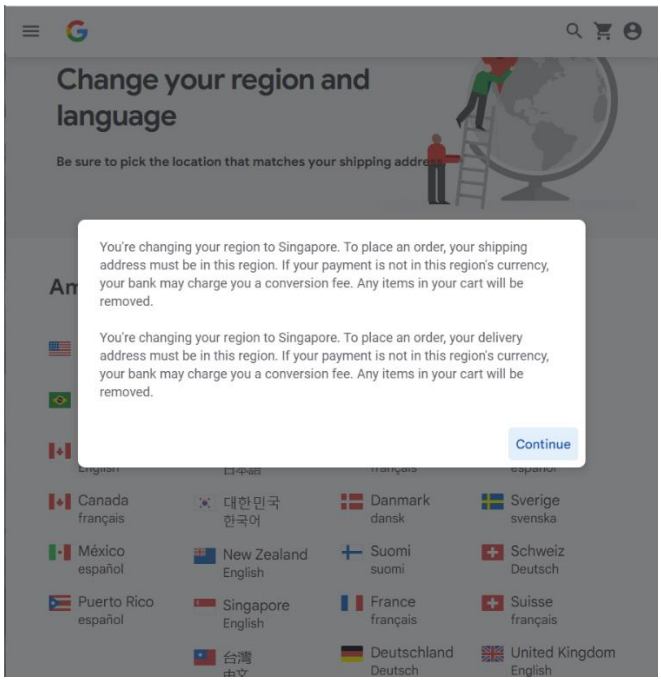

Figure 6 Google Region