Shape

Description automatically generated

COS7039-B SEM 1 Internet of Things (IoT)

IoT in Traffic Light Control System

Eniga Ahiante

20026427

Table of Contents

[Introduction 3](#_Toc92981395)

[Aims and Objectives. 3](#_Toc92981396)

[Literature Review 4](#_Toc92981397)

[Traditional Traffic Light Control System 4](#_Toc92981398)

[Smart Cities 4](#_Toc92981399)

[Internet of Things (IoT) 4](#_Toc92981400)

[Hardware Requirements 5](#_Toc92981401)

[Software Implementation 6](#_Toc92981402)

[Message Queue Telemetry Transport (MQTT) Message Broker 6](#_Toc92981403)

[Python Program 6](#_Toc92981404)

[Observations and Results 8](#_Toc92981405)

[Conclusion 10](#_Toc92981406)

[Appendix 10](#_Toc92981407)

[Source Codes 10](#_Toc92981408)

[Traffic Light Control 10](#_Toc92981409)

[MQTT Subscriber 10](#_Toc92981410)

[MQTT Publisher 11](#_Toc92981411)

[Main flow 12](#_Toc92981412)

[Program based on Node-Red 12](#_Toc92981413)

[References: 13](#_Toc92981414)

# Introduction

Traffic control has always been one of the basic features of an emerging city and important in road guidance across the city. As a city grows, it becomes more prone to high traffic circumstances due to high number of people moving around living their daily lives. Traffic controls today are only used by motorist but also cyclists and pedestrian’s movements as road usage must be efficiently controlled.

Traffic continues to evolve as there is an increased need to move people and goods from one location to another. Traffic flows differ fundamentally across locations and at different times of the day. This flow is determined by human behaviour and this data is important to program this traffic controls to be more efficient in navigating vehicles across these routes.

The future of motoring in the United Kingdom is destined to be electric, as British Prime Minister Boris Johnson detailed in his "Ten-point" climate plan dubbed the "Green Industrial Revolution," which is worth £12 billion, that the country will migrate to electric vehicles by 2030 (Campbell 2021). This means road transportation is gradually going to be more electrical with no petrol or diesel car on sale by 2030.

In May of 2021, “UK’s first driverless bus takes to the streets in a new trial in Cambridge” (Ruff 2021). We are gradually entering into an era where transportation is automated and there is need for infrastructure readiness such as traffic control data being made available to this self-driving vehicles. This research would be focused on building a traffic light system and sending out the traffic light timings through an MQTT Protocol, where these self-driven cars can subscribe and have access to this traffic controls as they navigate passengers across the city. A publisher and subscriber system would be built around the traffic control system. The car interfaces can subscribe to this channel and be able to tell when the lights change.

As humans, we strive for comfort and the use of autonomous systems to aide or assist us in our daily activities. Traffic in every major city has always been a continuous problem with little improvements. For smart cities to be successful, data needs to be generated, analysed, and processed for future design making to improve how this infrastructures work. This means infrastructure needs to be ready before 2030 to realize the dream of full automated cities with its citizens transported around using self-driven vehicles such as trains, buses, and taxi cars. The city infrastructure would act as a digital traffic warden allowing these vehicles know when to go or stop at traffic light junctions. While this system can be enhanced beyond this, the focus of this research is first on making the traditional traffic light system available to digital systems.

In this system we would demonstrate a traffic light system which is programmed and controlled using a python program running on a raspberry pi kit with LED light sensors connected to it via a bread board. These LED lights would represent the traffic lights at such junctions. The python program would be responsible for controlling the lights using a time-based decision and then sending the traffic time data via a publisher using MQTT which electric vehicles can subscribe and get access to this data. This is expected that the city would also provide internet infrastructures for these cars to utilize this system. Users can there for focus on enjoying other activities while being accurately driven to their various destinations.

# Aims and Objectives.

* Aim of this project is to make the current traditional traffic system available to IoT devices.
* Provide an MQTT subscription channel for companies developing systems that leverage on traffic control and IoT such as electric vehicles which would rely on these to provide self-driving and traffic navigation features.
* I will create a mini “Traffic light control” system to demonstrate the current traditional system.
* Show a roadmap of how IoT can take the current traffic control system and make it ready for a smart city.

# Literature Review

This chapter gives a brief information on today’s traditional traffic control system, smart cities, and the use of IoT in traffic controls as well as related information to the proposed system.

## Traditional Traffic Light Control System

Traffic lights or stop lights as known in some places are signalling devices used to control traffic flow at road intersections, pedestrian crossings and other locations (McShane 1999).

International standards for traffic signals were set by the Vienna Convention on Road Signs and Signals (Tryjanowski et al. 2021). The traffic lights, according to Tryjanowski, alternate the right of way to road users using three standard colours of lighting lamps:

* Red light – A red light means all vehicles should come to a halt and it is normally safe for pedestrians to cross.
* Amber light (or orange light) – This is a warning light that indicates that the traffic light is going to change between red (stop) to green (continue) (go).
* Green light – This tells users that traffic movements are allowed and it is safe to move. (Test 2019)

## Smart Cities

A smart city is defined as the use of Smart Computing technologies to improve the intelligence, interconnection, and efficiency of a city's critical infrastructure components and services, which include city administration, education, healthcare, public safety, real estate, transportation, and utilities. (Washburn et al. 2009)

## Internet of Things (IoT)

The Internet of Things (IoT) is a term formed from two words: "Internet" and "Things."

The internet which means a global network of interconnected computer networks that provides services to billions of users using the standard Internet Protocol suite (TCP/IP).

It's a network of networks made up of millions of private, public, academic, business, and government networks that range in size from local to global and are linked by a variety of electronic, wireless, and optical networking technologies (Nunberg 2012). Things here are the objects we have in the physical or material world (Castaño Díaz 2013). IoT connects these two worlds together by making them able to interact and part of the global or local network.

# Hardware Requirements

The hardware items used for this project are as follows

* Raspberry Pi 4 Kit



This would be used as our IoT device for this project where the bread board would be connected to and would run our python program.

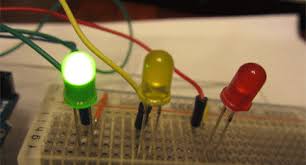
* Breadboard

A close-up of a microchip

Description automatically generated with low confidence

This is where all other components such as the lights and resistors would be connected to. The components on the bread board are connected to the Raspberry pi kit via a jumper wire.

* 3 LED lights (Red, Amber or Orange, Green)



This are the lights which would indicate the traffic control system. The changes from red, amber, and green would be seen and controlled from the Raspberry Pi.

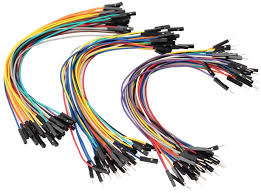
* Resistors (220 Ohms)

A close-up of a syringe

Description automatically generated with medium confidence

This is used to control the amount of current being passed from the Raspberry Pi to the LED lights to avoid damage from too much current. A 330- or 1000-Ohms resister could also be used in place of a 220 Ohms resistor.

* Jumper wires



This would be used to connect the components on the bread board to the Raspberry Pi Kit

# Software Implementation

The Raspberry Pi-Kit was connected to the school Wi-Fi to provide internet functionality so as to be able to publish and subscribe to the MQTT message broker.

### Message Queue Telemetry Transport (MQTT) Message Broker

A message broker was used namely “test.mosquitto.org”. This is a public message broker offered by Mosquitto to allow users test out their MQTT implementations. MQTT is widely used in the IoT industry for automobiles, telecommunications, etc.

### Python Program

Python programming language was used to implement the flow of controlling the lights and broadcasting the light control data using MQTT.

There are four (4) major files or modules used for this implementation

* Main.py – This is the entry point which controls the entire flow of the application. It utilizes functions from the other components to build a flow.
* Publisher.py - This implements the MQTT Publisher program to publish the traffic control data to the topic using a public broker. The broker and topic parameters are in the main.py file
* Subscribe.py - This implements the MQTT Subscription program which allows a client to receive messages broadcasted to the topic being subscribed to. The broker and topic parameters are in the main.py file
* Trafficlight.py – This implements the functions to control the lights on the Raspberry Pi Kit. It contains functions for each light

These files put together form the entire programming structure used to control the lights on the Raspberry Pi Kit and send this control data to the MQTT broker which can be subscribed to, and the client would get a real live stream of the changes in traffic light control.

The structure of the data being published contains the light being change, the state which the light is being changed to (“ON” or “OFF”) and the duration this change would be held for before the next change is published. This is published as a json string which any device can serialized into a json object and read each of the values. A sample of the JSON string is as below.

"{light: green, signal: ON, duration: 10}"

Find below the flow of the entire python program.

A picture containing text, screenshot, businesscard

Description automatically generated

# Observations and Results

The system successfully created the traffic light control data, published it for each light and also controlled the lights on the bread board as programmed.

Analysing the data from the message broker to relate the time message is received and when the lights changed, it is noticed that the message times are accurate for the “Red” and “Amber” light while there is a delay in receiving the message for a change in the “Green” light. So buffers have to be created for this lag in message delivery to ensure the clients connecting to this broker can make up for the delays. Recommended addition to the message object is a timestamp from the system which shows when the time was sent and allow the client to be able to accurately calculate the message lag and adjust where needed.

Text

Description automatically generated with low confidence

The message times are circled above, and it is noticed that it takes about 14 seconds change in time for the green light compared to the others which are accurate for 5 and 2 seconds respectively for the Red and Amber light

# Conclusion

This project showed that traffic control data can be made available to IoT systems. This is important if we are going to be ready for a smart city life. Vision of self-driving vehicles coming to life and people never having to bother about taking driving classes or purchasing any vehicle if the public transportation system could also offer self-driven vehicles at the disposal of any user on request.

While lots of improvements could be brought to this system this was just a first step towards introducing IoT into traffic control system by making the data available and possible to analyse.

# Appendix

## Source Codes

All source codes and report can be found on GitHub via the repository

<https://github.com/eniga/mqtt_trafficlight>

## Traffic Light Control

Text

Description automatically generated

## MQTT Subscriber

Text

Description automatically generated

## MQTT Publisher

Graphical user interface, text

Description automatically generated

## Main flow

Graphical user interface, text

Description automatically generated

## Program based on Node-Red

Graphical user interface, application

Description automatically generated

# References:

Campbell, M. (2021) *UK has no 'roadmap' towards electric car usage by 2030.* Euronews: Euronews [*https://www.euronews.com/green/2021/02/12/uk-has-no-roadmap-towards-electric-car-usage-by-2030*](https://www.euronews.com/green/2021/02/12/uk-has-no-roadmap-towards-electric-car-usage-by-2030)

Castaño Díaz, C. M. (2013) Defining and characterizing the concept of Internet Meme. *Ces Psicología* 6 (2), 82-104.

McShane, C. (1999) The origins and globalization of traffic control signals. *Journal of Urban History* 25 (3), 379-404.

Nunberg, G. (2012) *The Advent of the Internet*. Open Journal of Applied Sciences.

Ruff, M. (2021) *UK’s first self-driving bus takes to Cambridge roads.* Garagewire. [*https://garagewire.co.uk/news/videos/uks-first-self-driving-bus-takes-to-cambridge-roads/*](https://garagewire.co.uk/news/videos/uks-first-self-driving-bus-takes-to-cambridge-roads/) Accessed June 1, 2021.

Test, T. (2019) *Traffic Lights in the UK - Meanings,Sequence & Rules for Learner Drivers.* Theory Test. [*https://theorytest.org.uk/traffic-lights/*](https://theorytest.org.uk/traffic-lights/)

Tryjanowski, P., Beim, M., Kubicka, A. M., Morelli, F., Sparks, T. H. and Sklenicka, P. (2021) On the origin of species on road warning signs. *Global Ecology and Conservation*, e01600.

Washburn, D., Sindhu, U., Balaouras, S., Dines, R. A., Hayes, N. and Nelson, L. E. (2009) Helping CIOs understand “smart city” initiatives. *Growth* 17 (2), 1-17.