

Course: BSc Electrical & Electronic Engineering
Module: Electronic Design
Assignment: Micro-controllers and the Internet of Things
Name: Gareth Wilkins
University number: 1809804
Date submitted: 24 Apr 2022
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50-55

- ① CITATIONS ARE OK, BUT THE RANGE OF SOURCES COULD HAVE BEEN BROADER.
- ② THE RESEARCH COVERED THE CRITERIA, HOWEVER A LOT OF THE TEXT SEEMED FAMILIAR FROM THE COURSE NOTES AND CLASS EXAMPLES.
- ③ A SPECIFIC CONTEXT WOULD HAVE AIDED AND FOCUSED YOUR REPORT ON A SPECIFIC CONTEXT. THIS WOULD ALSO MAKE CRITICAL ANALYSIS EASIER TO ACHIEVE.
- ④ THE PRACTICAL WAS SUCCESSFULLY CARRIED OUT.
- ⑤ THE DISCUSSION ON SECURITY AND PRIVACY HAD PLENTY OF SCOPE FOR DEBATE AND CRITICAL ANALYSIS, BUT THIS SECTION WAS VERY SHORT.

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1. Executive Summary

This report was divided into two segments being a research essay evaluating developments of the Internet of Things and a practical application of an IoT system. The IOT generally refers to the capability of objects, sensors and commonplace items to generate, transfer and process data with minimal human involvement. The development of the IoT has facilitated the improvement and adaptation of existing internet technology and progression of new technologies. Four communication models were acknowledged being Device-to-Device, Cloud-to-device, Device-to-gateway, and Back-end-Sharing. The transformational potential with the advancement of the IoT was discussed; observing the concerns that passive communication from objects rather than active engagement would be the main interaction with the internet. The IoT was not created by a single entity but a spontaneous emerging of loosely allied devices. Kevin Ashton was accredited with the concept of the IoT in 1999. The security and privacy challenges were considered investigating a real-world application being vending machines with facial recognition and global positioning. This application raised security, privacy, and ethical concerns. The practical application was the design of a weather station using an Arduino IoT cloud kit. The cloud service and device were configured. The environmental variables were formatted, and the code was implemented. A dashboard was designed to monitor the weather station variables. The dashboard and the MKR IoT carrier produced comparable reading which showed functionality and IoT operation. An overall conclusion was produced detailing the IoTs benefits for improving the way humans live however security, privacy and trust concerns will have to be resolved to allow social acceptance.

2. Research

2.1 IoT Definitions

The IOT encapsulates a concept of an environment with billions of objects containing embedded intelligence, communication methods, and sensing and actuating capability with connection over IP networks (Simone Cirani, 2019). The most accepted definition was provided by the ITU which states “a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies” (ITU, 2012). The IOT encompasses an extensive array of technologies incorporating real time analytics, sensors, machine learning, information, embedded systems to deliver data and automation. (Greengard, 2021). The IOT definition is constantly evolving therefore an illustrative concept definition exists in place of a definitive tightly worded definition. The IoT interests academic and commercial organisations due to its limitless capabilities. This is illustrated by its ability of providing real world platforms for the collaboration of diverse smart object through networks. Although there is no clear definition of the IoT researchers agree that that the IoT was developed to improve the world for humans (Hany F. Atlam, 2018).

2.2 Enabling Technologies

The development of the IOT has caused improvement and adaptation of current internet technologies and advancement of new technologies. The technologies facilitate the architecture, network, and management of the IOT improving its implementation. The IOT enabling technologies are based on their application in the IOT conceptual model (IEEE, 2018). The IoT is approaching recognised reality due to the convergence of various market inclinations. The enabling technologies include Widespread adaptation of IP-based networking, advances in data analytics, computing economics, ubiquitous connectivity, miniaturization, and the advancement of cloud computing (Internet Society, 2015).

2.3 Transformational Potential

The development of the IOT may raise concerns about the implications and problems where the prevalent interaction with the internet comes from passive communication from connected objects instead of active engagement with content. The general-purpose characteristic of the internet structure does not hold limitations on applications or services that utilise the technology. This has the potential to produce a hyperconnected world (Internet Society, 2015).

2.4 Origins and drivers of the Internet of Things

The creation of the IOT was not created by a sole entity but a spontaneously emerging network of loosely allied devices (Wilkins, 2019). The concept of the IoT was initially founded by Kevin Ashton a British technology pioneer in 1999. His idea began whilst working as a brand manager for Oil of Olay part of the manufacturing giant Procter & Gamble. In this position he observed the dissociation of the inventory system at the retailers and the genuine inventory in the shop. Store employees and management assumed that the act of scanning sold products initiated some back-end tracking that would indicate stock levels however this was not the case. Ashton pioneered radio frequency identification technology initially on cosmetic products. Enabling the shelf and register to communicate to the product and the inventory system, Ashton closed the division between the inventory tracking system and the supply chain (Eleven Fifty Academy, 2020). An early illustration of IoT capability was from the 1980s. A Coca cola machine located in the Carnegie Mellon University was programmed via the internet to show drink availability and if it was chilled prior to making the journey to purchase one (Foote, 2022).

2.5 Communication Models

The IOT at its most basic concept is the connection of diverse devices and sensors to the internet however it is not always apparent how to connect them. The IOT requires many frameworks to allow communication between connected devices. The IOT must traverse many technologies and standards to enable functionality with an array of legacy and modern systems and protocols. The IOT is not a monolithic entity as it encapsulates an ambiguous and complicated amalgamation of vendors, technologies, systems, and platforms (Greengard, 2021).

In the IoT the communication protocols perform an imperative function in the system. The protocols stipulate the data exchange, data encoding and addressing schemes for the devices. Numerous communication protocols and standards are utilised with the most common being Zigbee, Bluetooth, ZWave, 6LOWPAN and NFC (Hany F. Atlam, 2018). The Open Systems interconnection (OSI) model enables the IoT to compile diverse entities. Four primary groupings embody the seven operational layers. The layers are the physical layer, data links, a network, a transport mechanism, a session layer, and a software application. Several IOT protocols deliver the requirements of each layer. (Greengard, 2021).

The IoT reference model was released by the IoT World Forum in October 2014. This framework intends to encourage collaboration and development of IoT deployment. The reference model establishes a common terminology for each layer. The model provides an approachable system rather than conceptual (Hany F. Atlam, 2018).

The internet architecture board in March 2015 released a guide for IoT networking. This defined the four common communication models utilised by smart objects: Device-to-device, Device-to-cloud, Device-to-Gateway and Back-End Data-Sharing (Channel Futures, 2016)

2.5.1 Device to Device

Two or more devices communicating directly to one another characterises device to device communication. They communicate over a diverse network type ranging from IP networks or the internet but generally use Bluetooth, zwave and zigbee protocols. Home automation systems generally utilise this model transferring small data packets amongst devices at a somewhat low data rate. These devices can include but not limited to lighting and thermostats which transfer insignificant information to one another. Device-to-device is prevalent in wearable IoT devices which are paired with a smart device where data does not need to be shared with several people. Device-to-device security is expressly simplified due to the short-range radio technology and an exclusive one to one pairing of the devices. Device-to-device standards are inherently being developed including Bluetooth Smart advantageous with wearable devices due to its low power demands allowing extended operational times (Channel Futures, 2016).

2.5.2 Device to Cloud

The device-to-cloud communication model utilises an internet cloud service to transfer data and regulate communications from the IoT device. This method exploits established communication systems such as a Wi-fi connections to ascertain a connection between the IoT device and the IP network.

Household devices such as learning thermostats utilise this communication model. The thermostat transfers data to the cloud database where the data can examine energy usage. The cloud connection allows users remote access to the thermostat via a supporting device and software updates.

Device-to-cloud inherently have interoperability challenges due to devices of different manufacturers. The cloud service and the device commonly share the same vendor resulting in the consumer being tied to the specific cloud service (Internet Society, 2015).

2.5.3 Device to Gateway

The device to gateway communication model fundamentally connects to an intermediary device to enable access to a cloud service. Habitually application software operates on a local gateway device that behaves as an intermediary connecting the device with the cloud service. These devices may be fitness devices or home automation applications and connect to the cloud via a hub service. Gateway devices have the capability of bridging the interoperability issues discussed earlier caused by different communication standards (Channel Futures, 2016).

2.5.4 Back-end Data Sharing

The back-end sharing model facilitates the export and analysis of smart objects via a cloud service and in conjunction with information from different sources. This model enables the sharing of data to third parties. This is an expansion to the device to cloud communication model which can lead to data silos where uploaded data from a device only reaches one application service provider. The data obtained from an IoT device using back-end sharing can be aggregated and analysed (Internet Society, 2015).

2.6 Security and privacy challenges faced by IoT

Security in the IOT context applies to diverse levels extending from technological problems to philosophical concerns including privacy and trust (Simone Cirani, 2019). The IoT system depends on sensing objects installed in the environment. The sensors not only retrieve environmental information but personal information such as habits and other sensitive information. Hence it is of great importance that a secure IoT system exist. To facilitate social approval of the IoT applications and services depends on protection of personal information (Hany F. Atlam, 2018). An application that emphasises these concerns are vending machines in Japan with facial recognition and global positioning systems. These vending machines are so advanced that simply walking past generates advertisements on social media applications on the individual's smart phone. The facial recognition technology allows the identification of customers by age and gender and computes recommendations accordingly. Five beverage companies own a combination of 80% of the vending machine market with over 1.96 million machines nationwide. These companies are seeking expansion and a larger market share and have resorted to installing vending machines outside private properties. These machines are obtaining new features to improve customer experience but at what cost to personal privacy (Mpelembe, 2017).

2.7 Proprietary ecosystems detrimental to the IoT and limit consumer choice

Producing proprietary ecosystems of compactible IoT devices can produce marketing benefits for device manufacturers. This limits consumers choice as interoperability would only be achievable within supporting product lines. The manufacturers lock in consumers to the device ecosystem by implementing switching costs to swap brand or replace devices with rival vendors. This is an impediment to consumers as it discourages them to change to alternative devices. This is also detrimental to innovation and developers to produce new devices on the ecosystem's foundational infrastructure. Device manufacturers argue that closed ecosystems provide a protocol that can be modified simpler when market or technical requirements arise. Data collection and processing is another aspect of interoperability consideration. Data exchange to the services in the cloud provides valuable data to users. This is an advantageous aspect to the IoT however challenges may arise when a consumer intend to move to an alternative service. Albeit the data produced by the device is provided it may be futile as the data would be presented in the proprietary format. Consumers would only freely be able to transfer their data if the source data was provided in an open standard format (Internet Society, 2015).

3. Methodology, testing and results for Task 2

A personal weather station utilising an Arduino IoT cloud kit was implemented. This project enabled the collection of basic data that can inform the user of local weather conditions. The data can be obtainable from anywhere as it was done through the cloud. The capacitive touch buttons and RGB display was developed on the MKR IoT carrier. The embedded sensors provide data on local weather conditions that enable real time monitoring. The components used in this project were:

Arduino MKR Wifi 1010

MKR IoT Carrier

Micro USB Cable

(Söderby, 2022)

An Arduino account was created. The device was configured in the thing overview as shown in figure 1.

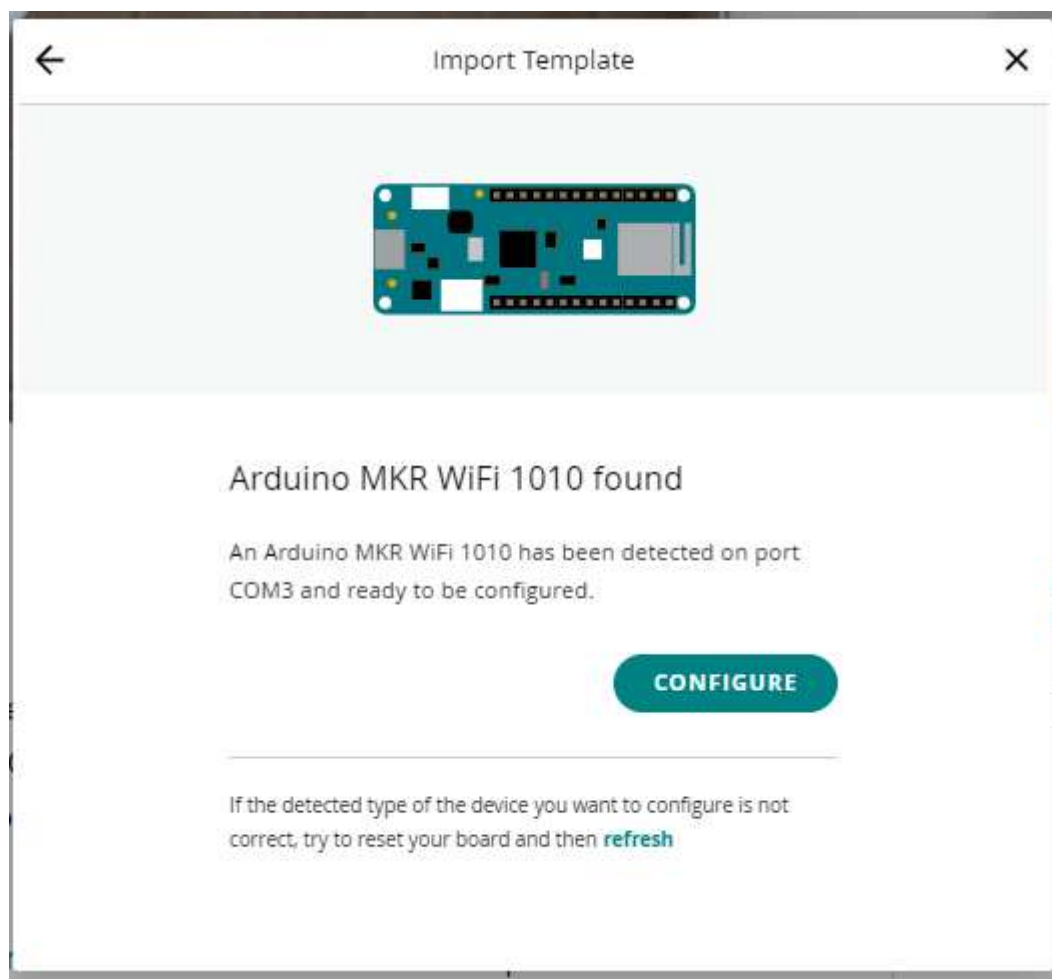


Figure 1: Arduino MKR WiFi 1010 configuration

An overview of the devices was obtained from the devices tab of the Arduino IoT cloud interface which is shown in figure 2.

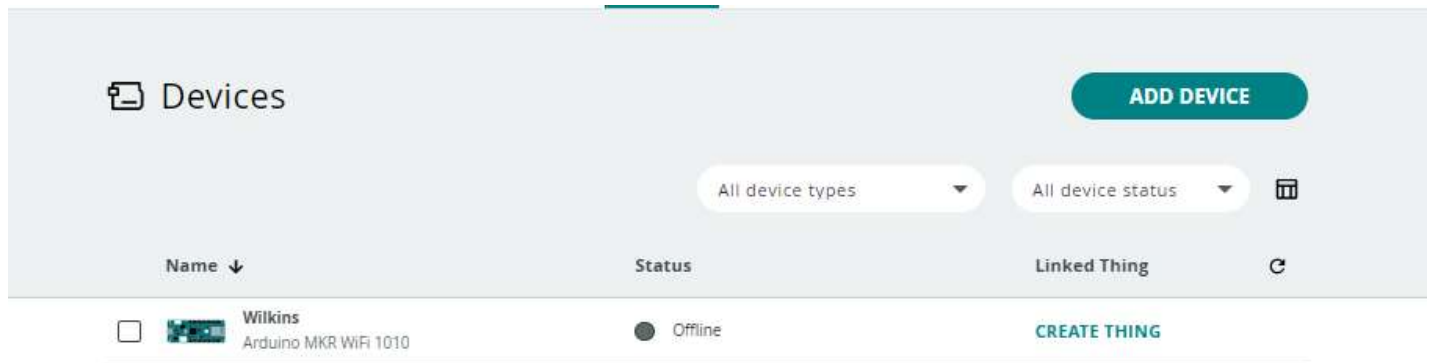


Figure 2: Arduino IoT project device overview

The project was configured as shown in figure 3.



Figure 3: Weather station added to project

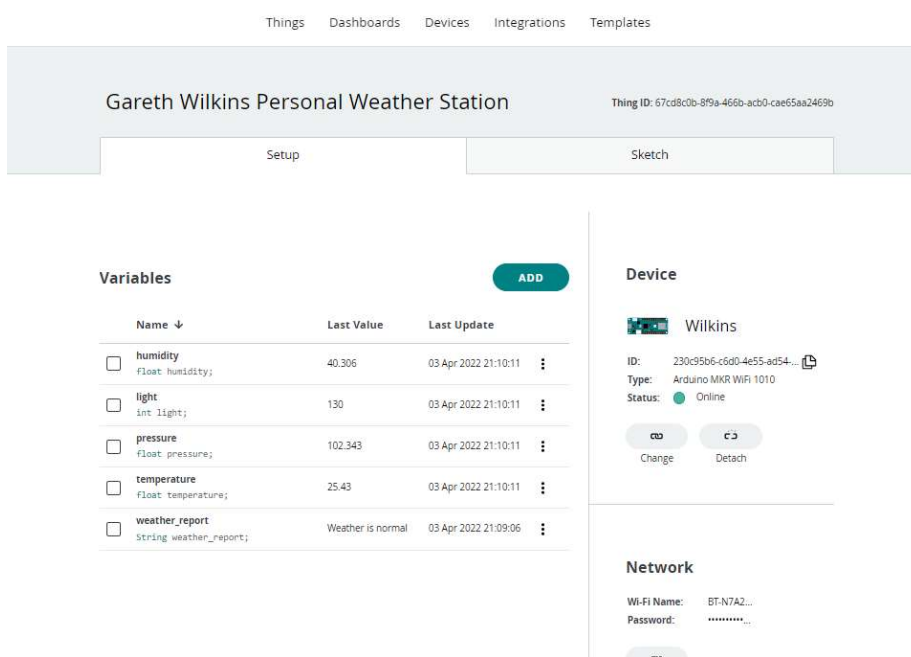


Figure 4: Configuring variables for weather station

The WiFi credentials were entered, and the device was configured to the network.

With the variables, device and network settings configured the device was programmed. In the sketch tab the code was generated as shown in figures 5 and 6. The program was uploaded to the board.

```

1 #include "thingProperties.h"
2 #include <Arduino_MKRIoTCarrier.h>
3 MKRIoTCarrier carrier;
4
5 void setup() {
6   // Initialize serial and wait for port to open:
7   Serial.begin(9600);
8   // This delay gives the chance to wait for a Serial Monitor without blocking if none is found
9   delay(1500);
10
11   // Defined in thingProperties.h
12   initProperties();
13
14   // Connect to Arduino IoT Cloud
15   ArduinoCloud.begin(ArduinoIoTPreferredConnection);
16   //Get Cloud Info/errors , 0 (only errors) up to 4
17   setDebugMessageLevel(2);
18   ArduinoCloud.printDebugInfo();
19
20   //Wait to get cloud connection to init the carrier
21   while (ArduinoCloud.connected() != 1) {
22     ArduinoCloud.update();
23     delay(500);
24   }
25   delay(500);
26   CARRIER_CASE = false;
27   carrier.begin();
28   carrier.display.setRotation(0);
29   delay(1500);
30 }
31
32 void loop() {
33   ArduinoCloud.update();
34   carrier.Buttons.update();
35
36   while(!carrier.Light.colorAvailable()) {
37     delay(5);
38   }
39   int none;
40   carrier.Light.readColor(none, none, none, light);
41
42   temperature = carrier.Env.readTemperature();
43   humidity = carrier.Env.readHumidity();
44   pressure = carrier.Pressure.readPressure();
45
46
47   if (carrier.Buttons.onTouchDown(TOUCH0)) {
48     carrier.display.fillScreen(ST77XX_WHITE);
49     carrier.display.setTextColor(ST77XX_RED);
50     carrier.display.setTextSize(2);
51
52     carrier.display.setCursor(30, 110);
53     carrier.display.print("Temp: ");
54     carrier.display.print(temperature);
55     carrier.display.print(" C");
56   }

```

Figure 5: Generated code

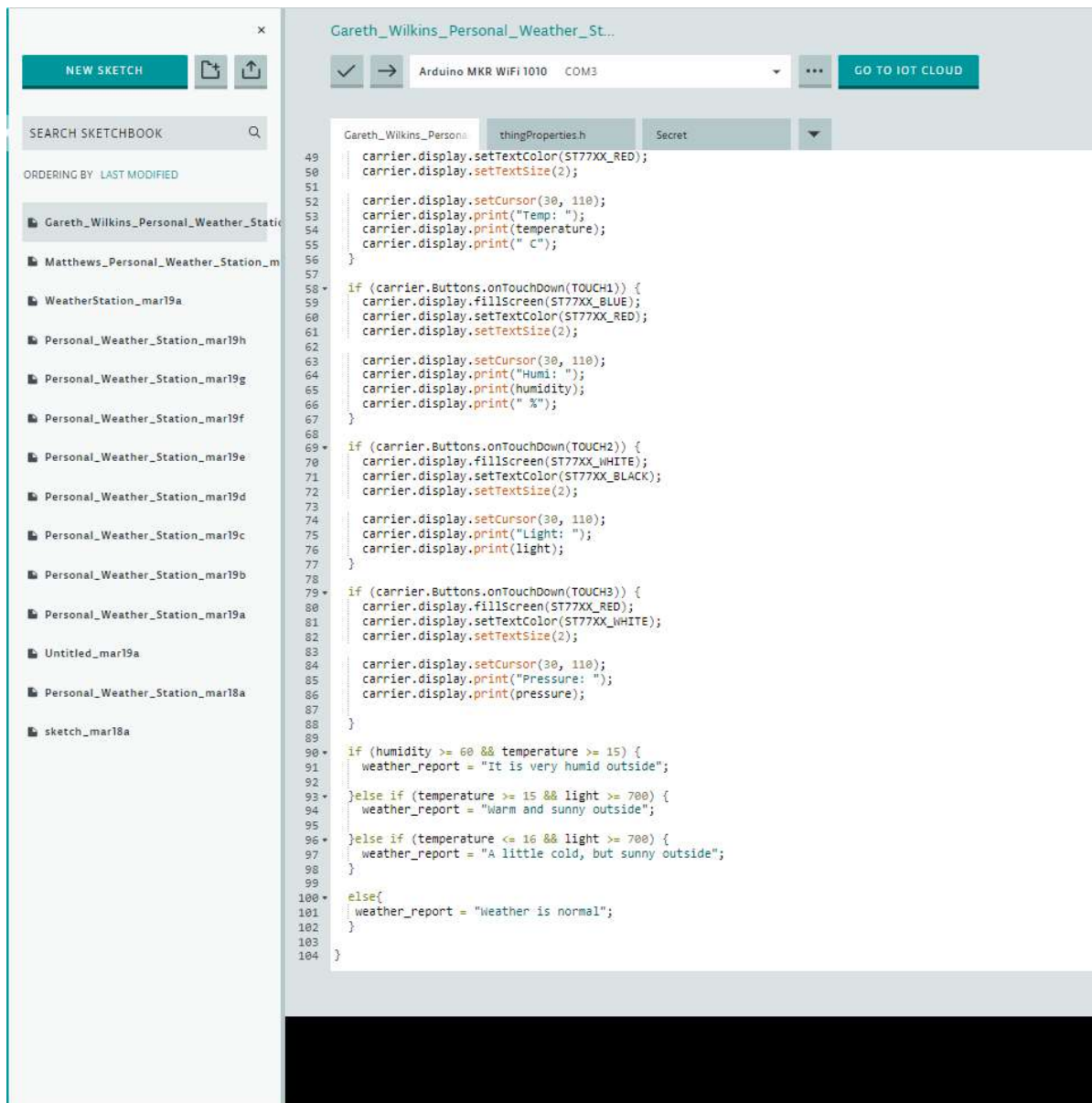


Figure 6: Generated code

The dashboard was designed to provide a visual user interface to interact with the board over the cloud. Widgets being the visual representation of the variables that were designed. These widgets were linked to the variables. The configured dashboard is shown in figure 7. The dashboard contains the humidity, light, pressure, temperature, weather report and temperature trend display.

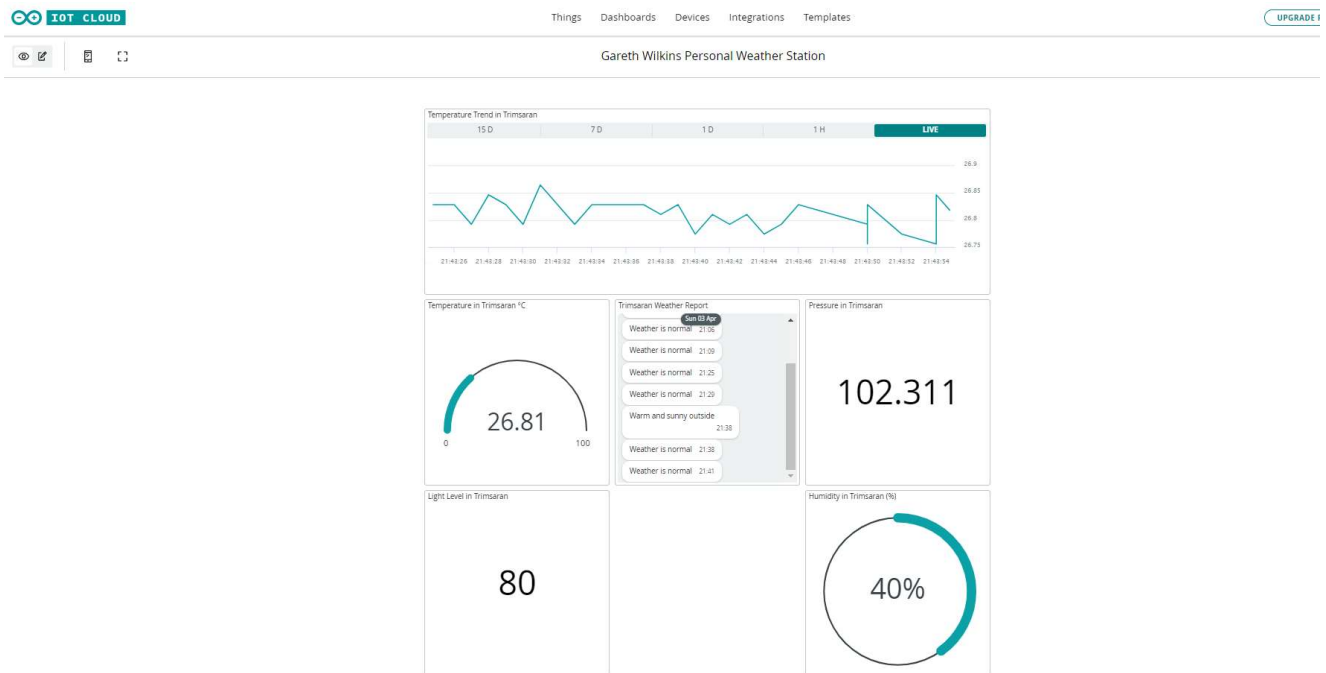


Figure 7: Weather station dashboard

As the variables were configured in the cloud, the program was coded, and a dashboard was designed the MKR IoT carrier functionality as a weather station could be tested. The transducer values were displayed on the dashboard as the device was connected to the cloud. Cycling through the MKR IoT display showed the variables as shown in figure 8. The dashboard showed similar readings to the MKR IoT carrier showing functionality of the cloud IoT.



Figure 8: MKR IoT carrier display values

4. Conclusion

The IoT incorporates a broad range of technologies containing real time analytics, sensors, machine learning, information embedded systems, communication systems and automation. The IoT definition is continually developing and as such only an illustrative concept definition exists. Due to its limitless capabilities the IoT has attention from academic and commercial organisation. The advancement in the IoT has initiated upgrading of current internet technologies and development of new technologies. Transformational potential of the IoT could have implications on the way the internet is utilised as connected objects generate passive communication instead of active engagement. This has the potential of producing a hyperconnected world. The IoT has produced reference models to encourage collaboration and implementation of IoT services. Four common communication models are employed in the IoT. Security and privacy are the most significant challenges the IoT encounters. Proprietary ecosystems are detrimental to the IoT as it limits innovation and development of new products. Proprietary ecosystems also limit consumer choice by locking in consumers to specific product lines. The Arduino IoT kit enabled a practical application of an IoT system. The Arduino has an abundance of online resource that enables the configuration of numerous IoT projects. The cloud software was user friendly and developed programming knowledge. The weather station was configured and enabled the obtainment of real time data from the cloud dashboard. Further development of the Arduino kit utilising different sensors would enable further understanding and greater functionality. The IoT will play a large part in everyday life in the future.

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Assignment 2

by Gareth Wilkins

Submission date: 24-Apr-2022 08:28PM (UTC+0100)

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Assignment 2

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

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GARETH WILKINS**0****RESEARCH-INFORMED LITERATURE**

There was evidence of further reading and research and some in text referencing. Your references were mainly appropriate to the task, however the reference list was short and you should increase the breadth of your research for future assignments. There was a heavy reliance on information gained from the course notes.

10/20**KNOWLEDGE AND UNDERSTANDING**

The knowledge and understanding of the subject demonstrated by this assignment was reasonably extensive. There were very few gaps in your knowledge of the basic principles and your understanding of the higher level concepts was demonstrated to a limited degree. You have demonstrated some critical understanding of the main concepts and expanded your knowledge beyond that contained in the course notes, however your explanations need to be more detailed and written with a greater emphasis on critical evaluation rather than description.

17/30**ANALYSIS**



Your analysis of the task was generally satisfactory, however it did tend more towards descriptive rather than analytical. You have demonstrated some analytical skills and your approach to the task was logical. You wrote a short conclusion that demonstrated some skills in analysing quantitative and qualitative data, however this was generally basic in nature. Further work – in your conclusion, you should relate the results to the original specification and to accepted theory and provide a detailed critical analysis of this.

15/30

PRACTICAL APPLICATION AND DEP.



Your application of practical skills for this task was generally very good. You used the resources appropriately when designing the dashboard and you used appropriate options for testing and evaluating the performance. You managed to design an effective dashboard that functioned within the specification and achieved this by only asking for assistance when appropriate thus demonstrating some advanced problem solving skills.

7/10

SKILLS FOR PROFESSIONAL PRAC.



Your written report was reasonably well presented in terms of content and layout and was mostly structured in a coherent way, however you should endeavour to use the available word count more effectively in future. You need to be much more

6/10

selective with where you put diagrams and graphs, only put those essential for the explanation in the report, the rest can be referred to in the appendix.