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by Richard Harrison

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50-55

- ① RESEARCH IS GENERAL WITH NO CLEAR THEME TO CONTINUE THE ARGUMENT.
- ② CITATION LIST WAS REASONABLE, BUT COULD HAVE BEEN WIDER IN SCOPE.
- ③ THE REPORT IS QUITE DESCRIPTIVE AND LACKS THE CRITICAL ANALYSIS EXPECTED AT THIS LEVEL.
- ④ THE CONCLUSIONS WERE BRIEF AND LACKED SUBSTANCE.
- ⑤ WEATHER STATION WAS IMPLEMENTED SUCCESSFULLY.

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Executive summary

Research was conducted regarding “The internet of things” as both a concept for the future and what it is currently. Research was conducted with the purpose of determining types of communications used by IoT, its enabling technologies, possible uses, enabling technologies and possible security risks and concerns that may be raised and may become a problem if the internet of things concept is not properly controlled as it grows Which it inevitably will. Furthermore, how this concept might evolve in the domestic and industrial space in the future and possibilities for technological advancement.

Research

What is IoT?

The concept of the IoT is a network of integrated/interconnected systems and devices which all share data in varying applications to improve a process/system using the internet to communicate with the user. The opportunity for using the concept of IoT can be applied to any industry/domestic space, developing the “smart home” concept. Ultimately “*merging the digital and physical universes*” (Ranger, 2020) factories, homes and other facilities would all have their own sub-nets to allow them to do their designated tasks while these sub-networks will be connected via the internet. Effectively, meaning the systems can talk to each other and the users/owners can monitor and adjust the system from anywhere quickly and easily. But this also means those same users/owners may not need to intervene as the system will be able to do the work for them.

“An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments” (Gillis, 2021)

The IoT network concept expands from simply compiling the data supplied by the multiple connected devices to intelligently using and acting upon the data being fed to it using artificial intelligence.

In a more generalised sense. The term IoT can be used to describe any device that can (but wouldn’t typically be able to) or have a use for connecting to the internet and exchanging data. However, a device which typically would connect to and communicate with the internet like a computer or smartphone would not be considered an IoT device since it could not function properly without an internet connection and was originally designed to use the internet.

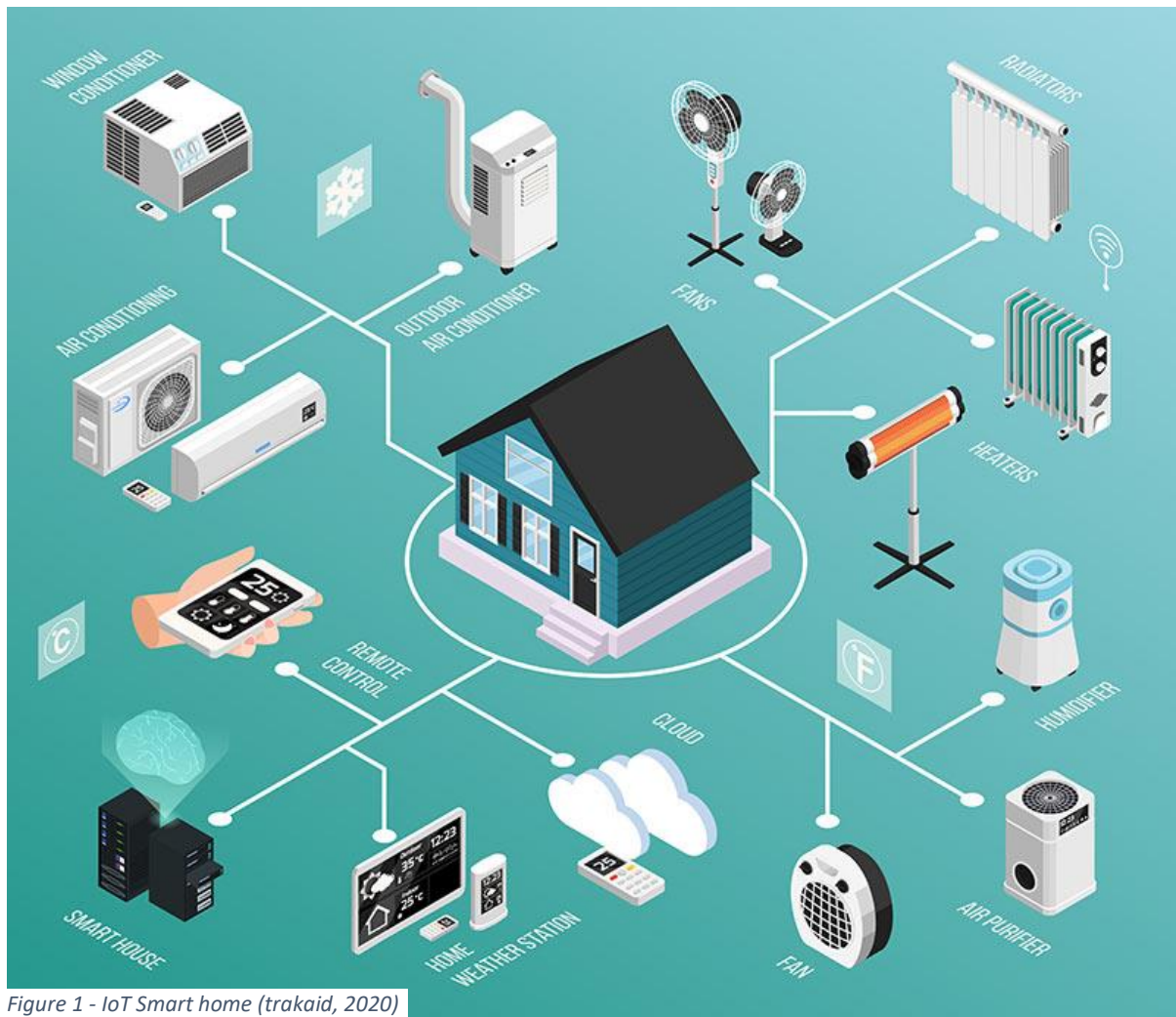


Figure 1 - IoT Smart home (trakaid, 2020)

For example, figure 1 shows a smart home with an array of possible IoT connected devices. The thermometer is reading higher than its set parameter. Instead of the system simply informing the owner, the system could intelligently turn off the heating to level out and maintain the set temperature. Another potential use within the home could be regarding emergencies. A smart home with sensors or specialised equipment for a homeowner with specialised needs could monitor the occupant and inform carers or local authorities if there was an emergency. Regarding more typical emergencies such as fires or break-ins the home could inform authorities automatically or perform special functions depending upon the emergency. For example, in case of an electrical fire caused by a heater shorting on carpet the home could detect this, shut off the heater to minimise spread of the fire, activate the sprinkler system if available and inform authorities and the owners all automatically. Another example is if there was a gas leak behind the oven and it is detected via pressure loss or detectors, the gas could be remotely shut off via a remote valve by the system and the homeowner informed. A final example could be for maximising energy production while minimising energy used for light within the home. A simple set of light sensors could provide data that allows the system to track the position of the sun accordingly and rotate a solar array on the rooftop accordingly to maximise output. While doing so, the interior sensors monitor light-intensity indoors and dim/ turn off lights to maintain light levels within the home. Industrial concepts have the promise of being far more involved and complex. Possibly having entire factories integrated and controlled by one PLC/AI.

Drivers and Future transformational potential

For businesses and partly for domestic users, the vision of IoT involves creating smart, increasingly efficient, near self-sustaining factories/homes which require a reduced amount of human interaction to remain functional and perform their functions. This vision compared to the equivalent factories/homes today would be enormously more efficient, environmentally less impactful, more cost effective, less labour intensive and would allow employees to enhance their productivity. However, other benefits include faster fault analysis and diagnosis. Resulting in less downtime for breakdowns and domestically, allow for increased quality of life at home.

“Businesses that harness the data generated by the Internet of Things will survive and thrive in the future. They will realize a significant competitive advantage” (Aeris, 2022)

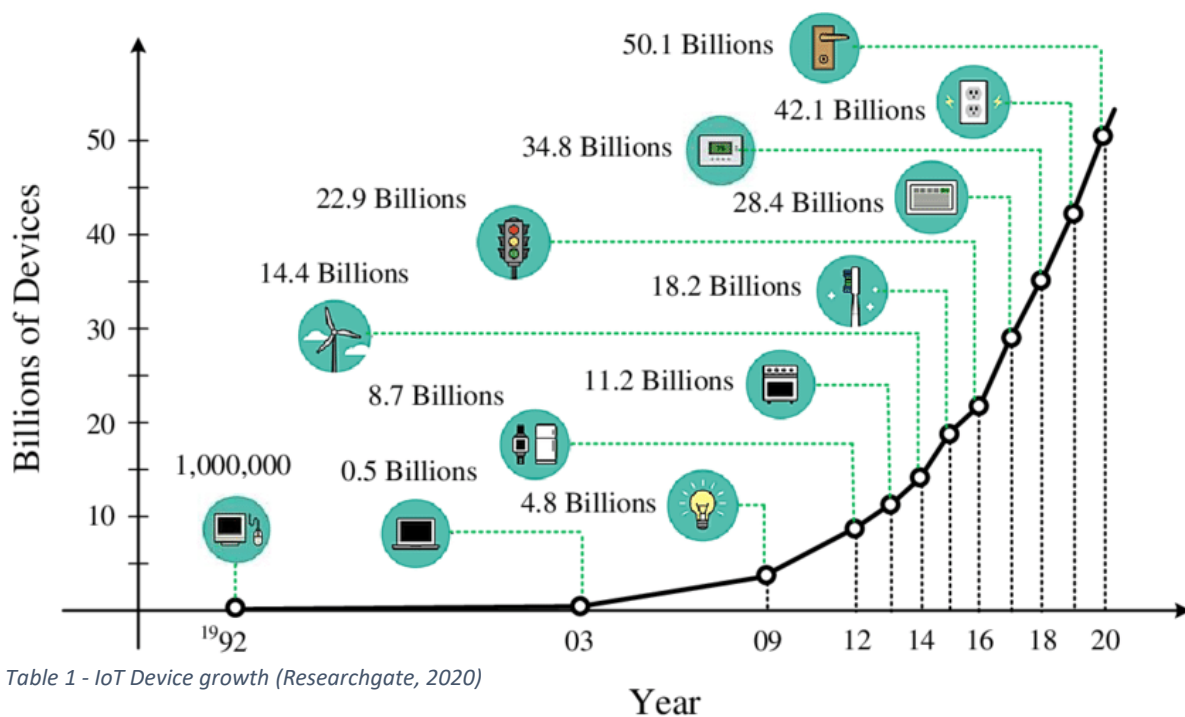


Table 1 - IoT Device growth (Researchgate, 2020)

Table 1 above shows the growth of IoT over a 28-year period of 1992 to 2020 in billions of units. Meaning over that, IoT device numbers grew by over fifty-thousand times and in 1992 the total number of IoT devices worldwide was $1.9 \times 10^{-3}\%$ of what it was in 2020.

Tech analyst company IDC predicts that in total there will be 41.6 billion connected IoT devices by 2025 (Ranger, 2020)

Table 1 is the gradual increase of IoT devices as an estimate on a worldwide scale. Results such as this can only be estimated to within a certain accuracy. Leading to the deviation between the overall results. This trend of IoT devices is set to continue far into the future.

Origins of IoT

Ideas surrounding interconnected machines and devices have been investigated and theorised since the 1970s. One of the earliest IoT devices was a vending machine used at Carnegie Mellon University, modified in the 1980s to interface with the local web so programming students could check the inventory of the machine to see if there was a drink for them to buy so they did not waste a trip walking to the machine. However, “the Internet of Things” as a term, was first used by Kevin Ashton. During a presentation he gave in 1999 about radio-frequency identification (RFID) and using tags to track equipment. Since then, the idea of thousands of interconnected devices has had various other names including “M2M”, “blogjects” and “ubicom”.

Since then, the constant development of chips and micro-controllers to be smaller while becoming more efficient coupled with the ever-growing trend of new technology being “smart” (meaning manufactured with the ability to interface with the internet and other devices wirelessly as standard) means the number of devices being incorporated into the IoT eco-system is always growing. While the constant development of enabling technologies like wireless connectivity has also contributed to the increasing speed of uptake of IoT by businesses since it is easier and easier while being more and more reliable.

Enabling technologies

The five main IoT enabling technologies are:

1. Communications protocols

Communication protocols handle the transfer of data between devices and sensors. Without these protocols IoT could not exist. The protocol specifies the addressing format at either end of the transmission, controlling the flow, routing, and sequence of data. A single communication containing several protocols (called a suite) is then called a “stack” when implemented into software.

“The IEEE handles wired and wireless networking, and the International Organization for Standardization (ISO) handles other types.” (Mishra, 2019)

2. Cloud computing

Cloud computing provides a method for users and devices to access applications, utilities, and services over the internet. The “cloud” being a host of servers, databases, software, other devices, and storage which can be accessed from anywhere in the world (possibly for a fee). There are three main types of cloud computing which are split into different levels of service. IaaS, PaaS, and SaaS.

Infrastructure as a Service (IaaS) is the most basic of the three and refers to servers, networking, virtual machines, and storage. The building blocks for creating an online network.

Platform as a Service (PaaS) supplies a service and the tools which allow users to create applications within the cloud platform such as operating systems and utility libraries.

Software as a Service (SaaS) provides full applications hosted over the internet as a service. Normally for a subscription or one-time fee the user can access the application.

3. Wireless technology

Wireless devices can be used to create a Wireless Sensor Network (WSN) for monitoring environmental conditions, creating safety buffer zones etc using the sensor devices, routers, end nodes and co-ordinators. The system works by using the end nodes to link several sensors together which interfaces wirelessly with a router. A co-ordinator will take the data packets from the router and provide a gateway to the internet so an online host can monitor the sensors. *“ZigBee protocol is a very popular WSN build to be used in the IoT industry”* (Saket, 2019)

4. Embedded systems

An embedded system can be anything with a micro-controller and embedded operating system (OS). These controllers with real-time operating systems will have dedicated functions and cannot be re-programmed or manipulated once manufactured. They are used to perform specific functions within a larger system. *“Ninety-eight percent of all microprocessors are manufactured to serve as embedded system component”* (Mishra, 2019) However, some embedded systems can function without an (RTOS)

5. Big data analysis

The term “Big Data” refers to vast quantities of collected data from multiple locations across a network of monitoring locations like sensor and social networks. This data is analysed and used to show trends, results, slow changes, patterns, and behaviours. With the spread of IoT and more devices being connected, Big Data volumes have increased vastly and so has the need for more hardware/software to manage and process this data. The main characteristics of big data are Velocity, Volume, Variety and Veracity. While the process of analysing the data involves data cleaning, munging, processing, and visualisation.

Connectivity/communication models

IoT uses four main connectivity models to connect devices to the internet. These are:

1. Device to cloud

Communicating using cellular, Wi-Fi or Ethernet, device-cloud connectivity talks directly to the cloud service and allows the user to access or update devices remotely. This model type has lots of domestic uses from monitoring the location of valuables or pets to looking at and operating security cameras fitted around the user’s property remotely. The feed from the cameras can also have cloud-based temporary storage so the user can look back on the last 24 hours of feed from their cameras via the cloud (which would be IaaS). Due to the large data packets produced by video transfer, an ethernet or Wi-Fi connection will be required for this task. When using Wi-fi, the user will also need to login to their network as well as login to their cloud service before they can access their services.

However, when linking multiple devices to one cloud service, users may have an issue where certain devices will only link with their specific manufacturers cloud service, which will complicate things for the user. Companies will do this as a way of forcing the user into a monthly or yearly subscription service where subscribing to the service “will make their lives easier” which if done badly blatantly takes advantage of the user.

2. Device to device

Device to device communication refers to direct data transmission between two devices which can be over the internet, a local IP network, Wi-fi or Bluetooth. *“This model is commonly used in home automation systems to transfer small data packets of information between devices at a relatively low data rate”* (Chris, 2016) Typical home smart devices such as door locks, appliances, heating, and lights which all communicate with each other and form a network. Which allows for the possibility of installing a controller to intelligently manage all these devices if needed.

The security of this type of connectivity model is relatively simple because the devices are all directly connected with no need for longer range technology. The user will use the internet concept for access but will only be accessing these devices from home over a local network so the need for a cloud service is not there.

Personal, wearable and medical devices will also use this type of connectivity to communicate with the user’s phone/smartwatch.

3. Back-end data sharing

Back-end data sharing uses the same model as device to cloud with the exception that third-party companies are authorized to collect user data from any connected devices. Allowing third parties to analyse and process the compiled big data from the cloud service. This could be seen as invasive by the end user and is a subject of dispute between third parties and the end-user.

4. Device to gateway

This model integrates aspects of both the device to device and device to cloud connectivity models. The IoT enabled devices connect to a hub, router or smartphone which acts as a gateway to a cloud service. The gateway device will have its own embedded software that allows the hub to handshake with the cloud and connected devices. As well as handshaking, the hub/router can translate protocols and add an extra layer of security for the user among other things. Devices managed by a system such as this could be home appliances and heating or fitness trackers.

Gateway devices such as this that can translate protocols are good for use in applications where the devices connected use two different protocols to communicate. The gateway can translate them into a common protocol and send that to the cloud.

The five facets of IoT security



www.u-blox.com/iot-security

Figure 2 – Security (ublox, 2021)

Security is the biggest challenge for IoT given that the whole point of the IoT is to make technology more flexible, accessible, easy to use and less reliant on humans. These points mean it is relatively easy for someone to hack into any system (domestic or industrial) and either cause damage, endanger users or steal/leak sensitive data and information. This problem is made worse by the fact that IoT devices are not very well protected overall and often there is no ability to patch or update IoT devices, which means any potential flaws in software can be easily exploited and may continue to be exploited on existing devices well after the flaw has been discovered by the manufacturer. *“Too many IoT devices give little thought to the basics of security, like encrypting data in transit and at rest.”* (Ranger, 2020) If a hacker is able to exploit a vulnerability and change even a small part of big data, that can render the whole analysis process as a waste since the data is no longer accurate.

From a domestic standpoint, a hacker could easily gain access to smart speakers, webcams, door locks, smart appliances, watches etc and possibly endanger the homeowner or spy on them and other household members. Listening in on conversations, watching them around the house, tracking where they go, what they do and eat. Hacking into household security cameras and looking when nobody is home would be invaluable to criminals. Allowing them to know when they can access the home with minimal resistance. Regarding an industrial setting, sensors that monitor temperature, pressure and other things could be hacked if the company has not got an adequate firewall and the damage could be catastrophic if sensor readings are turned off so equipment like a pressure cooker goes critical and no alarms are raised.

Government security and the threat of cyberwarfare also factors in. As a result, some governments like the UK have put out certain guidelines and regulations that mean IoT device manufacturers and companies must take extra care with the security of their consumer IoT products. Figure 2 shows five parts of a key strategy a company may employ to help increase its IoT security.

Other challenges for IoT

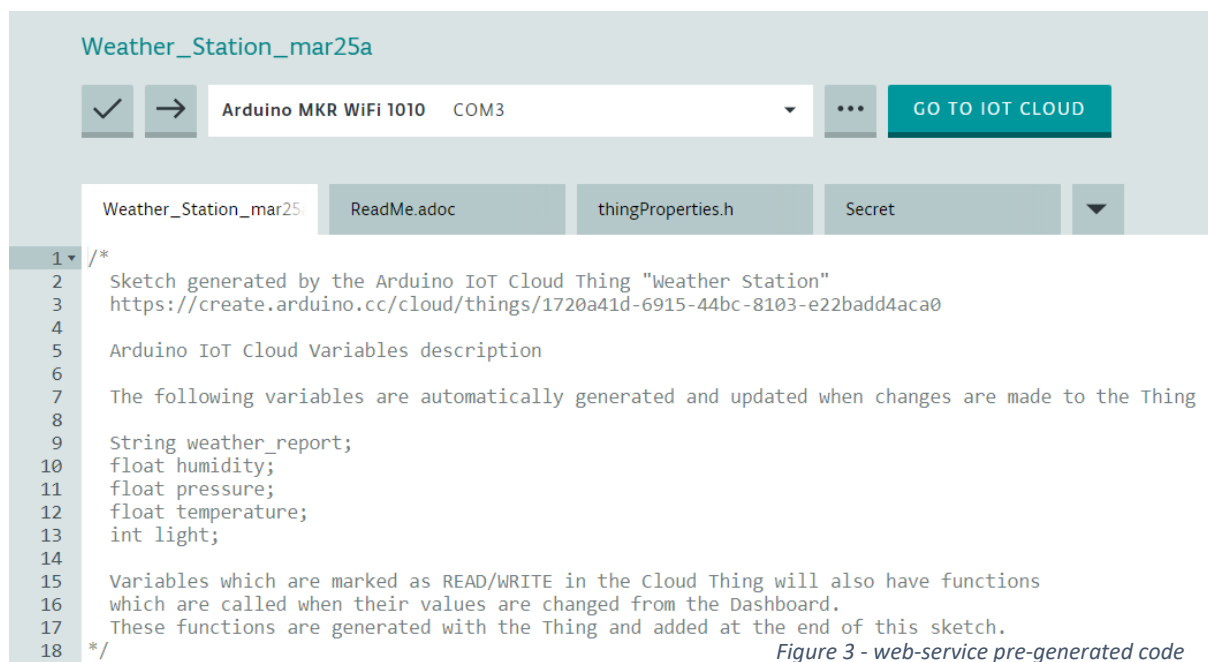
Other challenges facing IoT other than security are things like its uptake. The faster it's adopted the faster it and enabling systems need to evolve. For example, if communication methods are not further developed and constantly improved there will come a time when data cannot be transmitted in the volumes and speeds across the planet demanded by the consumer. This means as the IoT concept continues to be adopted, the need for data transmission capacity, data-centre capacity, cloud storage capacity, security and know-how will continue to rise. The need for a world-recognised set of rules and regulations specifically regarding IoT will need to be created and the need for which will continually increase as demand and uptake of IoT increases.

Methodology, testing, and results (Task 2)

Using an Arduino KIT, a weather monitoring system will be built which can be monitored using the concept of IoT. The components of the kit used here are the Arduino MKR IoT carrier (Figure 7 Page 18), Wi-Fi 1010 Board (Figure 6 Page 18).

Once “Arduino create” is installed the PC can recognise the Wi-Fi1010 board, it’s connected and set-up as a IoT cloud device which allows it to communicate with the IoT cloud service. This is a cloud computing service and is a form of SaaS (Software as a service) which allows the user to program their device with online utilities, specifically for their product. With the Wi-Fi and Carrier boards connected, they are named as one and variables are created for the required readings of temperature, pressure, and humidity (set to “float”), are read only and updated every 500ms. Finally, the Wi-Fi name/password is needed for the board to talk to the cloud service.

The initial setup is complete, the cloud is configured.



The screenshot shows the Arduino IoT Cloud web editor interface. At the top, the title is "Weather_Station_mar25a". Below the title, there is a status bar with a checkmark, a right arrow, and a dropdown menu showing "Arduino MKR WiFi 1010 COM3". To the right of the dropdown is a "GO TO IOT CLOUD" button. Below the status bar, there is a file explorer showing "Weather_Station_mar25a", "ReadMe.adoc", "thingProperties.h", and "Secret". The main editor area displays pre-generated code for a "Weather Station" sketch. The code includes comments about the sketch's origin and a list of variables: "String weather_report;", "float humidity;", "float pressure;", "float temperature;", and "int light;". It also mentions that variables marked as READ/WRITE in the Cloud Thing will have functions called when their values are changed from the Dashboard.

```
1 /*  
2 Sketch generated by the Arduino IoT Cloud Thing "Weather Station"  
3 https://create.arduino.cc/cloud/things/1720a41d-6915-44bc-8103-e22badd4aca0  
4  
5 Arduino IoT Cloud Variables description  
6  
7 The following variables are automatically generated and updated when changes are made to the Thing  
8  
9 String weather_report;  
10 float humidity;  
11 float pressure;  
12 float temperature;  
13 int light;  
14  
15 Variables which are marked as READ/WRITE in the Cloud Thing will also have functions  
16 which are called when their values are changed from the Dashboard.  
17 These functions are generated with the Thing and added at the end of this sketch.  
18 */
```

Figure 3 - web-service pre-generated code

Figure 3 shows web editor pre-generated code, acting as a base to start writing the code for the weather station. (See Figures 10 to 13 pages 20 to 23). Written so the device will continually update the cloud every set period and if certain parameters are met, a small weather report summary will be generated with the determined weather information. Providing a string of continuous data for when the dashboard is created.

Once the board is connected and recognised, the web editor uses the plugin to upload the code to the board. Once uploaded successfully the “Monitor” function in the web editor is used to start the board which generate figure 4s results.

The setup can now be tested. The board has touch-sensitive pads which change the info readout on the screen. Figures 14 to 16 (Pages 24 to 26) show the readouts. Each readout is correct. The board is working, the dashboard can now be created.

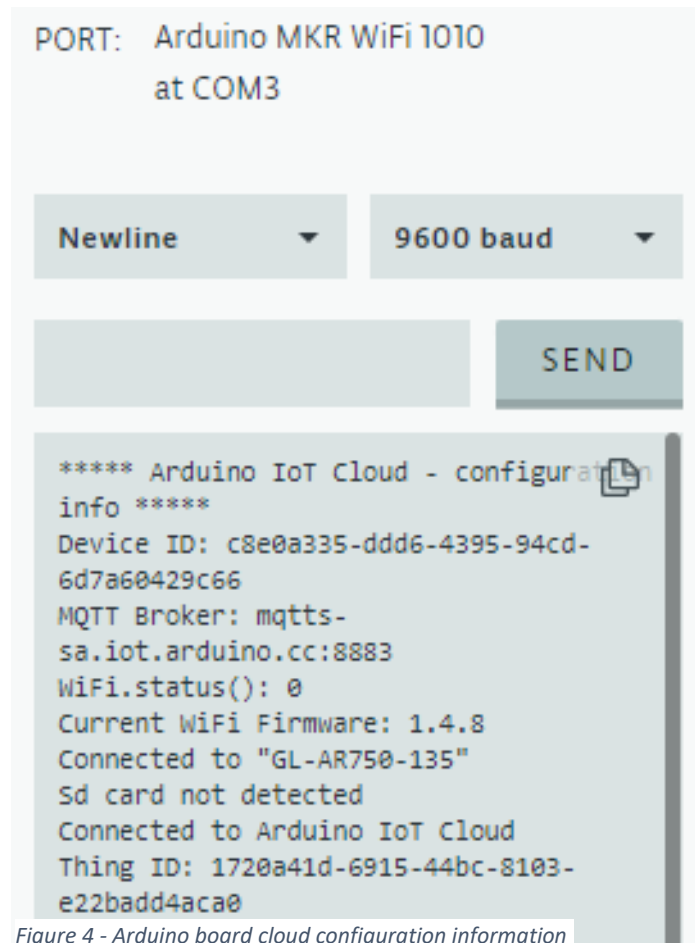


Figure 4 - Arduino board cloud configuration information

To view the data the board sends to the IoT cloud service, a dashboard is created. The dashboard (figure 5) will show the results of the readings and summarise the results over a period. Accessible from anywhere through the portal on the service website or their mobile app. For each of the readings, humidity (percentage), temperature (gauge) and pressure (value). Readouts have history charts showing 15 days prior or live.

Figures 18-19, pages 28-29 show readouts from the IoT remote app, receiving data from the carrier board, through the cloud service.

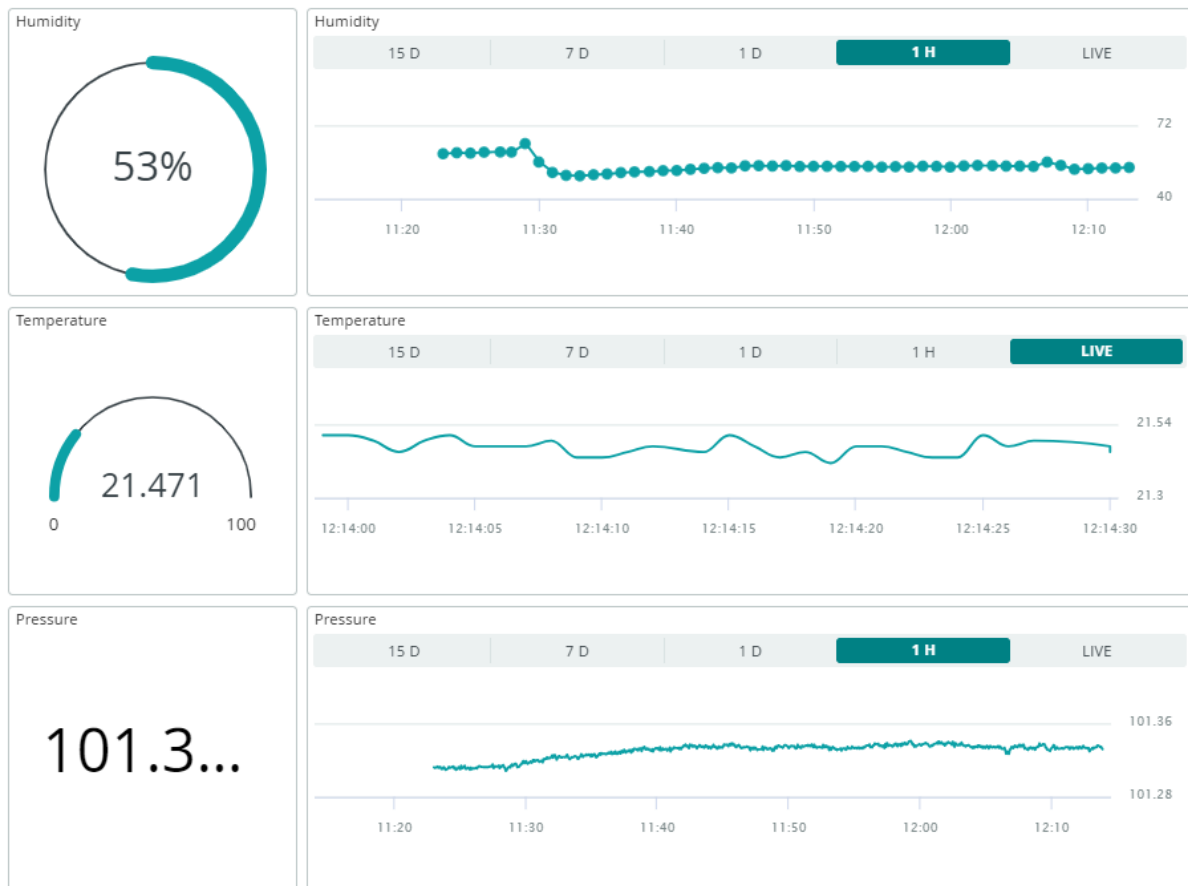


Figure 5 - Computer IoT weather station dashboard

Figure 20 page 29 shows the dashboard with Light (value) added in with its accompanying graph. Figure 17 page 27 shows the initial board testing of the light function.

Conclusions

IoT as a concept will continue to evolve at a greater and greater rate as its supporting technologies continue to develop. However, the uptake of IoT as a universally accredited concept and the widespread use of it in the industrial and domestic space will depend mostly on its capabilities, security, and relevant regulations. This concept shows an interesting and massive change in how industrial and domestic systems are thought about and gives a glimpse into a potential future for both spaces that if implemented correctly, could be extremely practical and revolutionary. To conclude, IoT could be a jump forward like the industrial revolution except the internet revolution with everything interconnected. However, there is also room for severe issues regarding security and reliability but either way, the IoT makes for an exciting concept for the future of both Industrial and domestic life.

The Arduino is a very capable and adaptable device which is very useful for a wide array of applications. In this use case, it is accurate and easy to use. Helping the user to build upon their knowledge of coding with DIY scale kits. The weather monitoring station created is a first step in the direction of fully IoT integrated homes. A device that supplies the user with data regarding their device's surroundings (possibly in the home) and has the optional functionality for the user to send or program commands for the unit to act on depending on the situation and what modules it is connected to. In short, it could be a simpler form of a vastly superior system created in the future to control a domestic home.

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[Accessed 11 04 2022].

Annex

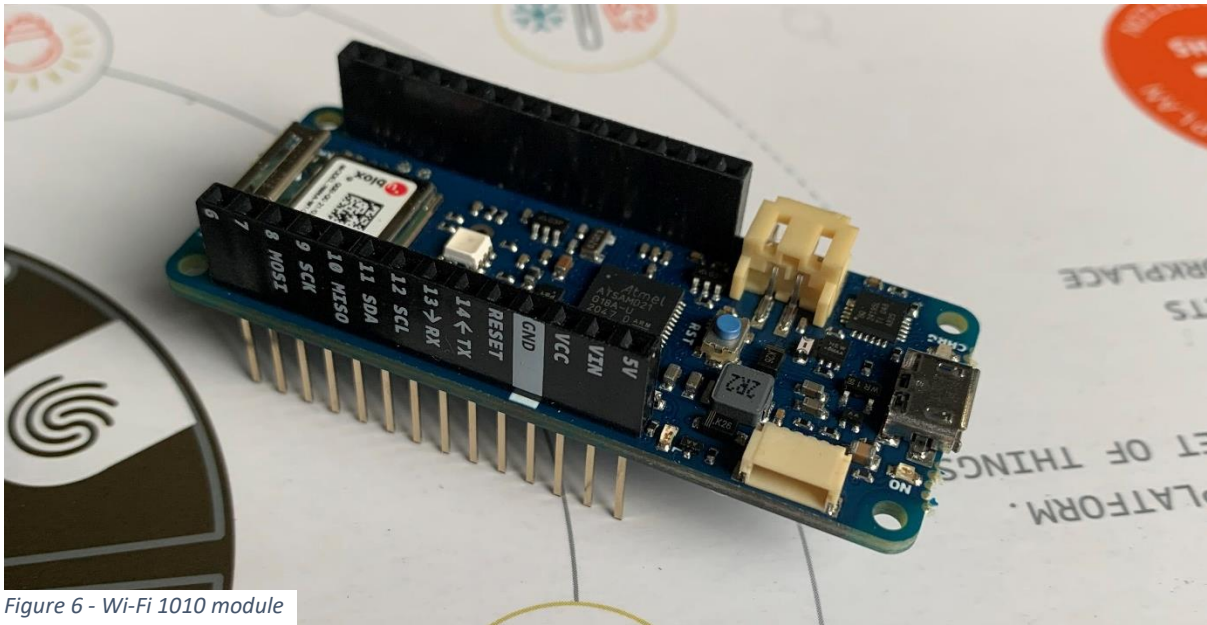


Figure 6 - Wi-Fi 1010 module

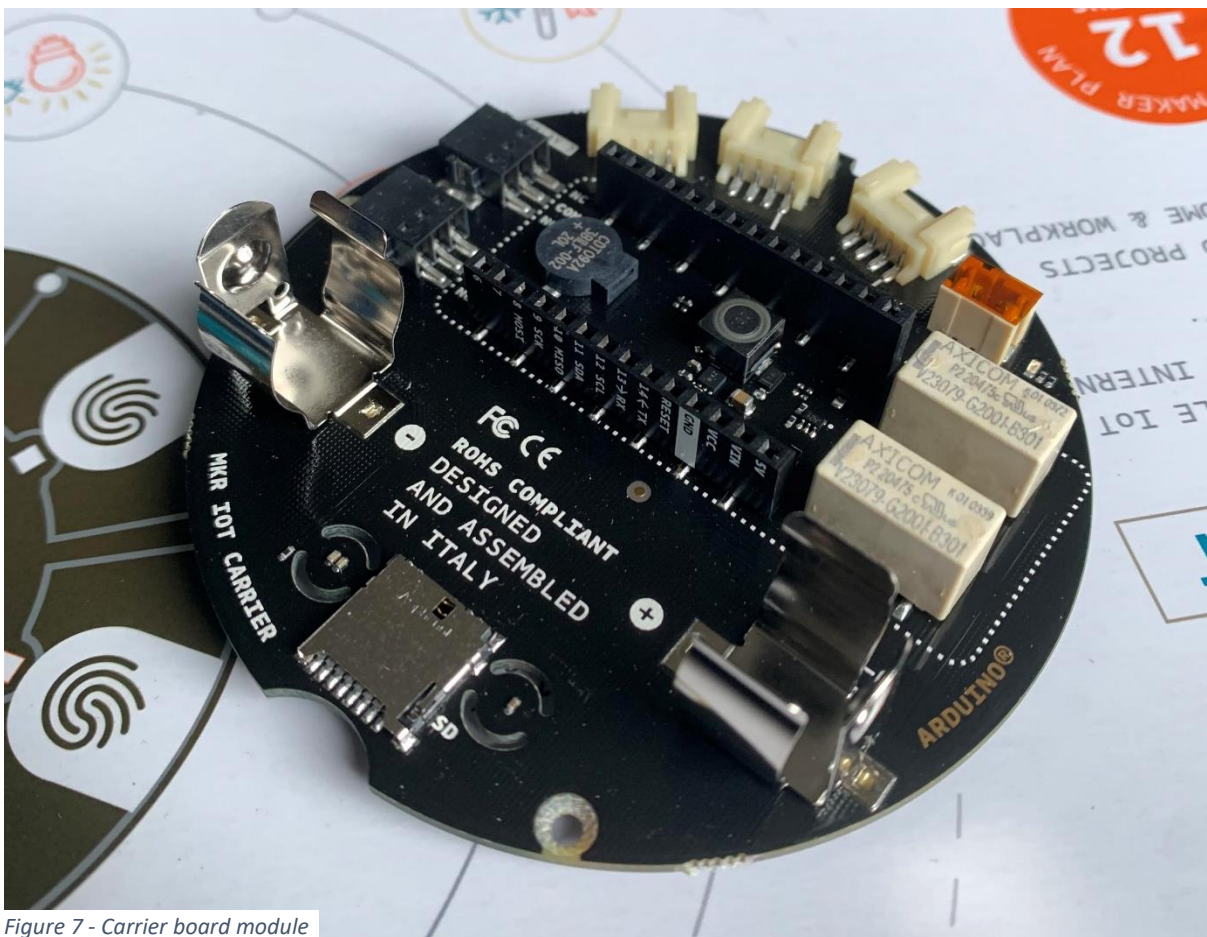


Figure 7 - Carrier board module

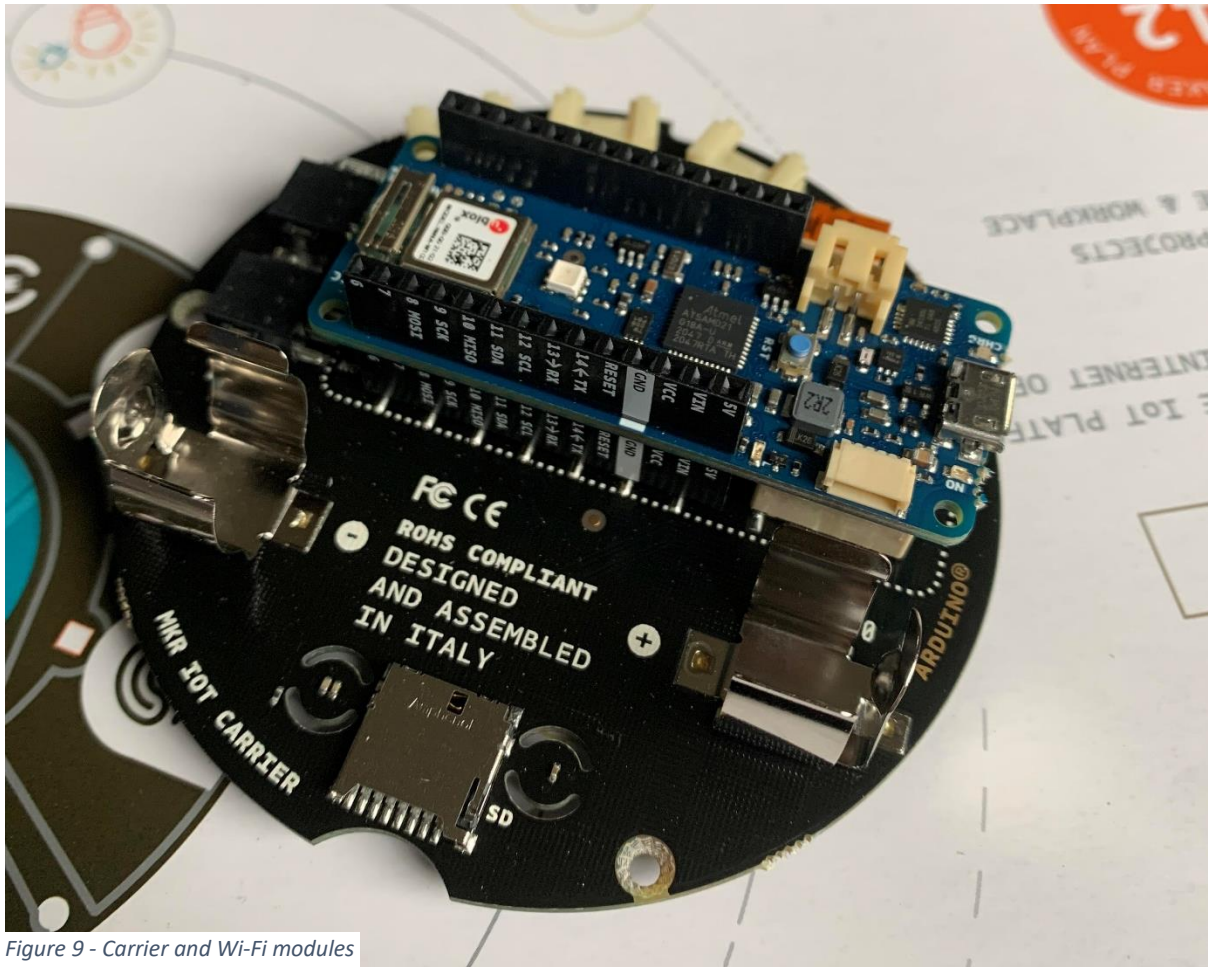


Figure 9 - Carrier and Wi-Fi modules

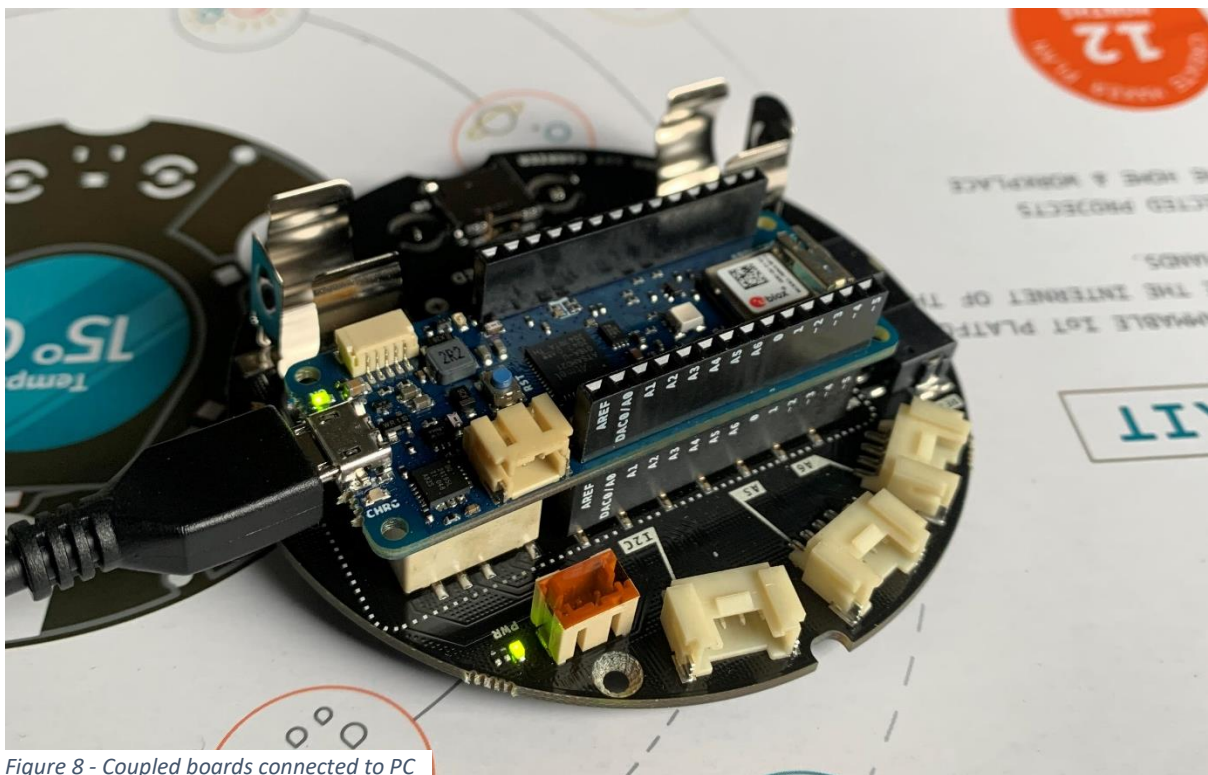


Figure 8 - Coupled boards connected to PC

	Weather_Station_mar25	ReadMe.adoc	thingProperties.h
19			
20	<code>#include "thingProperties.h"</code>		
21	<code>#include <Arduino_MKRIoTCarrier.h></code>		
22	<code>MKRIoTCarrier carrier;</code>		
23			
24	<code>void setup() {</code>		
25	<code> // Initialize serial and wait for port to open:</code>		
26	<code> Serial.begin(9600);</code>		
27	<code> while (!Serial);</code>		
28			
29	<code> // Defined in thingProperties.h</code>		
30	<code> initProperties();</code>		
31			
32	<code> // Connect to Arduino IoT Cloud</code>		
33	<code> ArduinoCloud.begin(ArduinoIoTPreferredConnection);</code>		
34	<code> //Get Cloud Info/errors , 0 (only errors) up to 4</code>		
35	<code> setDebugMessageLevel(2);</code>		
36	<code> ArduinoCloud.printDebugInfo();</code>		
37			
38	<code> //Wait to get cloud connection to init the carrier</code>		
39	<code> while (ArduinoCloud.connected() != 1) {</code>		
40	<code> ArduinoCloud.update();</code>		
41	<code> delay(500);</code>		
42	<code> }</code>		
43	<code> delay(500);</code>		
44	<code> CARRIER_CASE = false;</code>		
45	<code> carrier.begin();</code>		
46	<code> carrier.display.setRotation(0);</code>		
47	<code> delay(1500);</code>		
48	<code>}</code>		
49			
50	<code>void loop() {</code>		
51	<code> ArduinoCloud.update();</code>		
52	<code> carrier.Buttons.update();</code>		
53			
54	<code> while (!carrier.Light.colorAvailable()) {</code>		
55	<code> delay(5);</code>		
56	<code> }</code>		
57	<code> int none;</code>		
58	<code> carrier.Light.readColor(none, none, none, light);</code>		
59			

Figure 10 - Weather station code (1)

Weather_Station_mar25ReadMe.adocthingPro

```
59
60 temperature = carrier.Env.readTemperature();
61 humidity = carrier.Env.readHumidity();
62 pressure = carrier.Pressure.readPressure();
63
64
65 ▼ if (carrier.Button0.onTouchDown()) {
66     carrier.display.fillScreen(ST77XX_WHITE);
67     carrier.display.setTextColor(ST77XX_RED);
68     carrier.display.setTextSize(2);
69
70     carrier.display.setCursor(30, 110);
71     carrier.display.print("Temp: ");
72     carrier.display.print(temperature);
73     carrier.display.print(" C");
74 }
75
76 ▼ if (carrier.Button1.onTouchDown()) {
77     carrier.display.fillScreen(ST77XX_WHITE);
78     carrier.display.setTextColor(ST77XX_RED);
79     carrier.display.setTextSize(2);
80
81     carrier.display.setCursor(30, 110);
82     carrier.display.print("Humi: ");
83     carrier.display.print(humidity);
84     carrier.display.print(" %");
85 }
86
87 ▼ if (carrier.Button2.onTouchDown()) {
88     carrier.display.fillScreen(ST77XX_WHITE);
89     carrier.display.setTextColor(ST77XX_RED);
90     carrier.display.setTextSize(2);
91
92     carrier.display.setCursor(30, 110);
93     carrier.display.print("Light: ");
94     carrier.display.print(light);
95 }
96
97 ▼ if (carrier.Button3.onTouchDown()) {
98     carrier.display.fillScreen(ST77XX_WHITE);
99     carrier.display.setTextColor(ST77XX_RED);
100     carrier.display.setTextSize(2);
101
```

Figure 11 - Weather station code (2)

```

101
102     carrier.display.setCursor(30, 110);
103     carrier.display.print("Pressure: ");
104     carrier.display.print(pressure);
105
106 }
107
108 ▾ if (humidity >= 60 && temperature >= 15) {
109     weather_report = "It is very humid outside";
110
111 ▾ } else if (temperature >= 15 && light >= 700) {
112     weather_report = "Warm and sunny outside";
113
114 ▾ } else if (temperature <= 16 && light >= 700) {
115     weather_report = "A little cold, but sunny outside";
116 }
117
118 }
119
120
121
122
123
124
125 ▾ /*
126     Since Humidity is READ_WRITE variable, onHumidityChange() is
127     executed every time a new value is received from IoT Cloud.
128     */
129 ▾ void onHumidityChange() {
130     // Add your code here to act upon Humidity change
131 }

```

Figure 12 - Weather station code (3)

Weather_Station_mar25ReadMe.adocthingProperties.hSecret▼

```
1 // Code generated by Arduino IoT Cloud, DO NOT EDIT.
2
3 #include <ArduinoIoTCloud.h>
4 #include <Arduino_ConnectionHandler.h>
5
6 const char SSID[]      = SECRET_SSID;    // Network SSID (name)
7 const char PASS[]      = SECRET_PASS;    // Network password (use for WPA, or use as key for WEP)
8
9 void onWeatherReportChange();
10 void onHumidityChange();
11
12 String weather_report;
13 float humidity;
14 float pressure;
15 float temperature;
16 int light;
17
18 void initProperties(){
19
20     ArduinoCloud.addProperty(weather_report, READ, 60 * SECONDS, NULL);
21     ArduinoCloud.addProperty(humidity, READ, 60 * SECONDS, NULL);
22     ArduinoCloud.addProperty(pressure, READ, 1 * SECONDS, NULL);
23     ArduinoCloud.addProperty(temperature, READ, 1 * SECONDS, NULL);
24     ArduinoCloud.addProperty(light, READ, 1 * SECONDS, NULL);
25
26 }
27
28 WiFiConnectionHandler ArduinoIoTPreferredConnection(SSID, PASS);
29
```

Figure 13 - Weather station properties



Figure 14 - Board temperature readout

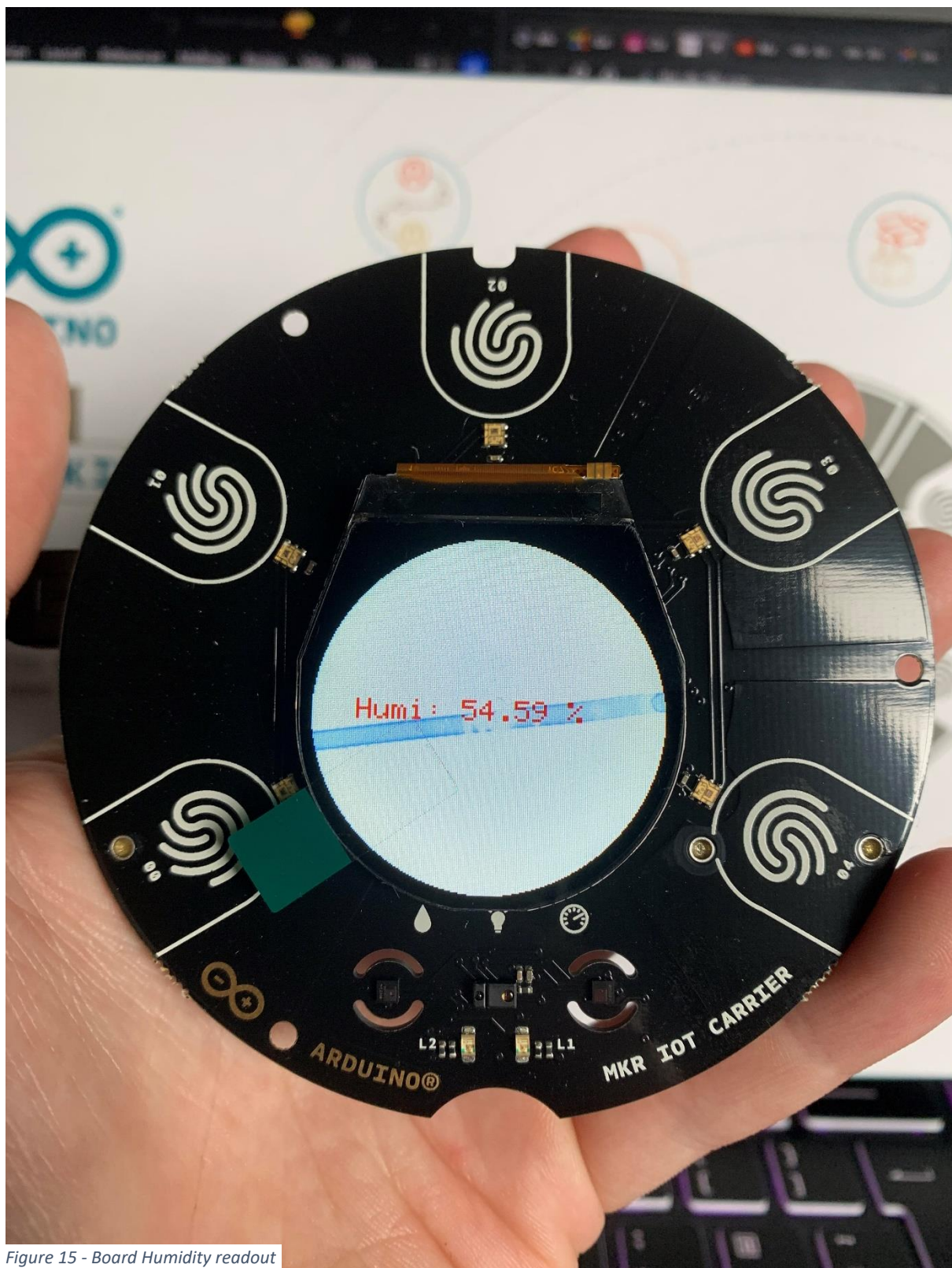


Figure 15 - Board Humidity readout



Figure 16 - Board Pressure readout

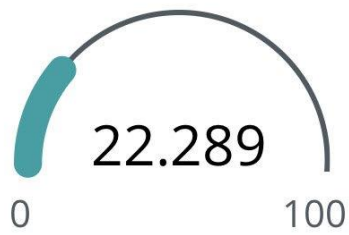


Figure 17 - Board light readout addition

12:24



Temperature



Temperature



15D

7D

1D

1H

LIVE



Figure 18 – Temperature readout (phone app)

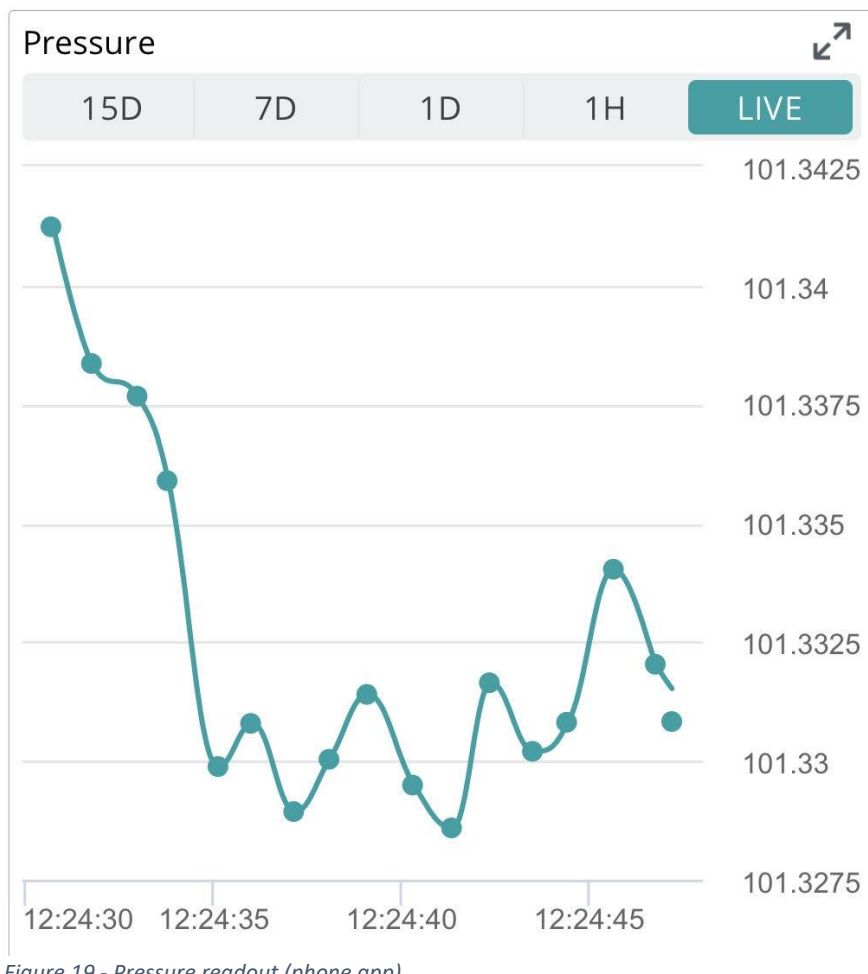
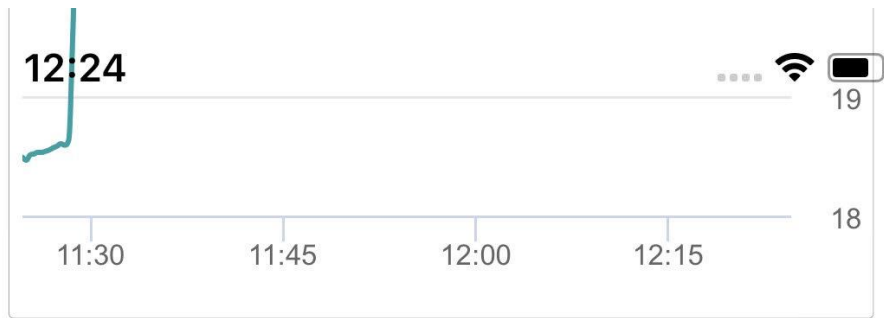


Figure 19 - Pressure readout (phone app)

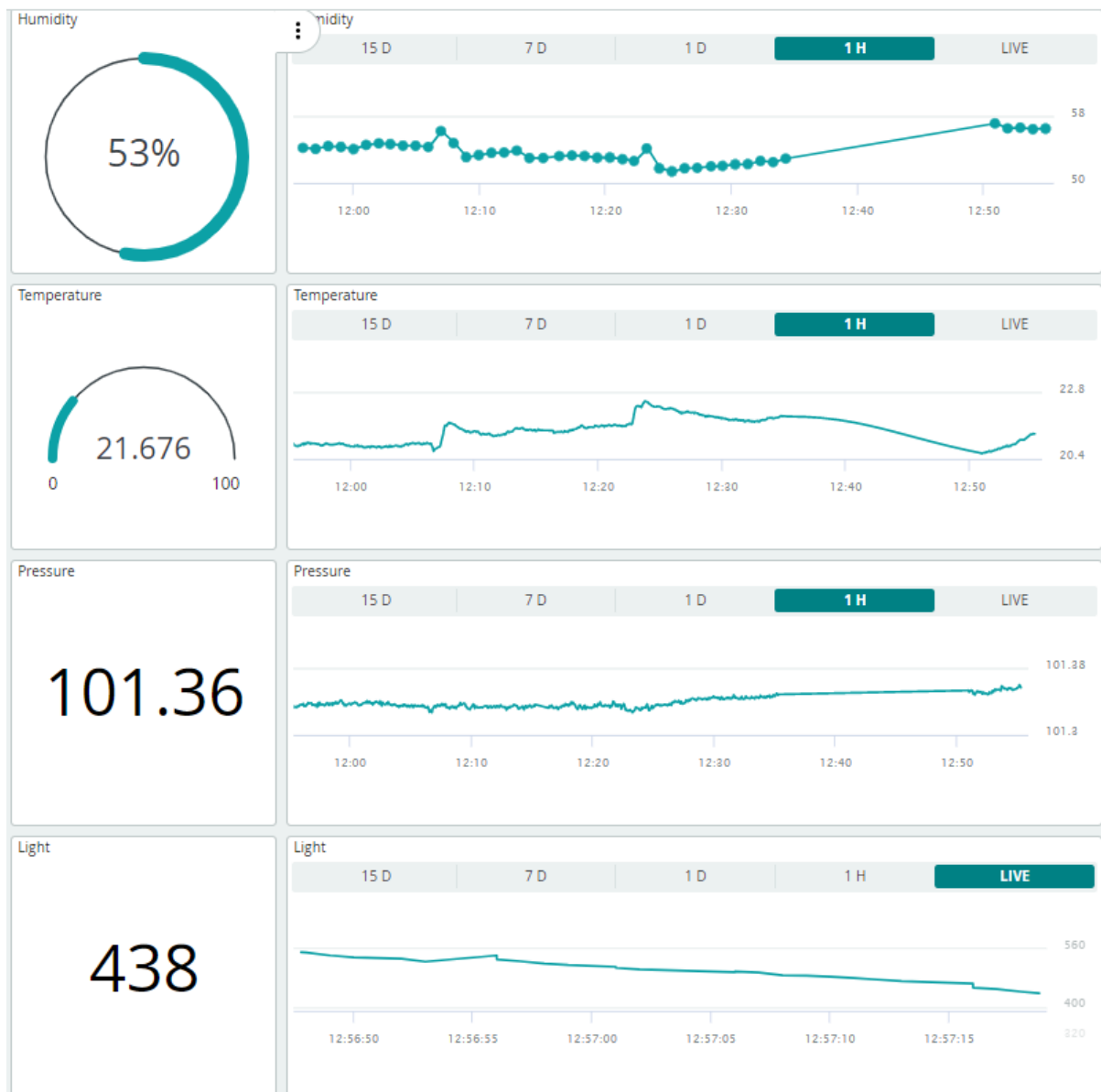


Figure 20 - Light readouts added to dashboard

FINAL GRADE

GENERAL COMMENTS

Instructor

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GRADING FORM: CSG-RUBIC

RICHARD HARRISON

0

RESEARCH-INFORMED LITERATURE



There was evidence of further reading and research with the inclusion of a reference list and appropriate in text referencing. Your interpretation and understanding of the additional research was good. Your references were appropriate to the task and your reference list was of an appropriate

12/20

length for this assignment. You should consider widening your range of sources for future assignments.

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, both in class and as shown in this assignment, 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 reasonable conclusion that demonstrated some skills in analysing quantitative and qualitative data, however this was generally basic in nature.

13/30

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.



In this assignment you have demonstrated skills in working individually and also collaboratively. Your written report was generally good and contained most of the required detail, it was also written in a coherent and logical way. The available word count was in the main effectively used.

7/10