

**Institut Universitaire de Technologie,
Aix-Marseille Université**

**RAPPORT DE STAGE
Diplôme Universitaire de Technologie
Spécialité Réseaux et Télécommunications**

INTERNET OF THINGS FOR SMART-HOME

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Acknowledgement

On my report about internship, it's my privilege to thank all the people who contributed to make this 10 weeks internship a great and unforgettable experience in my life.

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Also, I'm grateful to Mr. Al-Ahmed for his help with my work and allowed me to learn new skills and acquire knowledge.

I would like to thank Aix-Marseille Université and Ms. Houssain for the opportunity to do this internship abroad in a globally recognized university with its own unique culture.

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1 Introduction

As part of my course of my second year of DUT* Réseaux et Télécomuncation, I had the opportunity to do a ten weeks internship at The University,of The West of Scotland. I worked on the subject of the Internet of Things and more precicely on a smart-house project.

The Internet of Things is the network of physical devices, home appliances, cars, industry and other items that are connected to smart sensors, software, databases, electronics and network which allows all items to share collected data. The recent study shows that more than 193 million connected IoT* home devices will be online by 2020. A smart home is one in which the various electric and electronic appliances are wired up to a central computer control system so they can either be switched on and off at certain times or if certain events happen, for example when a motion sensor detect movement the light goes on.

More sensors, processors, and microcontrollers will be used to monitor as well as collect data around the house. Being able to monitor and control the house appliances using a secure phone app is crucial. The project will focus on IoT and interface on a mobile app for continuous monitoring. The project goal is to build a smart home prototype in a real-world scenario, where microcontroller board and different sensors will be used.

The aim of this project is to create a small house prototype using Raspberry PI and different sensors, where users can access and monitor data from the web-based mobile application. Different tests on the Raspberry PI and sensors will be explored to understand if the current technology is reliable and powerful enough to be used at each users' house.

Objectives of the project are as follows:

- Review the current technology and literature on IoT and Smart Home
- Evaluate the smart house performance and usuability
- Setup sensors and microcontrollerin a smart home prototype

2 Presentation of the University



University of the West of Scotland aims to have a transformational influence on the economic, social and cultural development of the west of Scotland and beyond. UWS* is ranked by Times Higher Education in their 2018 World University Rankings as being in the top 3% of universities worldwide, and feature in the top 200 of their Young University World Rankings.

The Times/The Sunday Times Good University Guide 2018 ranks us as a top 100 UK university and as the highest in Scotland for both teaching quality and student experience in the following areas :

- Aeronautical & Manufacturing Engineering, Chemical Engineering, Civil Engineering, General Engineering, Mechanical Engineering
- Education
- Hospitality, Leisure, Recreation & Tourism
- Physics & Astronomy is also ranked as highest in Scotland for teaching quality

University of the West of Scotland offers a range of career-focused undergraduate, postgraduate and research degree opportunities across six academic schools.

Six Campuses :

- Ayr
- Dumfries
- Lanarkshire
- London
- Paisley
- Hamilton

I did my internship in Paisley Campus Scotland.



Combining the town's history and heritage with modern, contemporary teaching facilities, UWS Paisley Campus provides a dynamic and inspiring learning environment. The campus is home to around 10,000 students and offers a range of courses and research opportunities in business; computing; social sciences; engineering and science; and health, nursing and midwifery.

My internship supervisor is Dr Muhammad Zeeshan Shakir he has a PhD in Electronic and Electrical Engineering he's an SMIEEE* Lecturer at the School of Engineering and Computing, Artificial Intelligence, Visual Communications and Networks Research Centre.

The School of Engineering and Computing at UWS is home to a vibrant research community carrying out high quality applied research relevant to the research community and industry which underpins and extends the quality of the student experience.

Many of the groups are multi-disciplinary and often involve collaborations with partners in industry, academia and government. Research areas within Engineering consist of the following:

- Advanced Concrete and Masonry
- Engineering and Industrial Management
- Nuclear Physics
- Thin Films, Sensors and Imaging

My internship was at the Artificial Intelligence, Visual Communications and Networks Research Centre.

3 Smart-Home Project

3.1 Literature and Technical Review

3.1.1 Internet Of Things

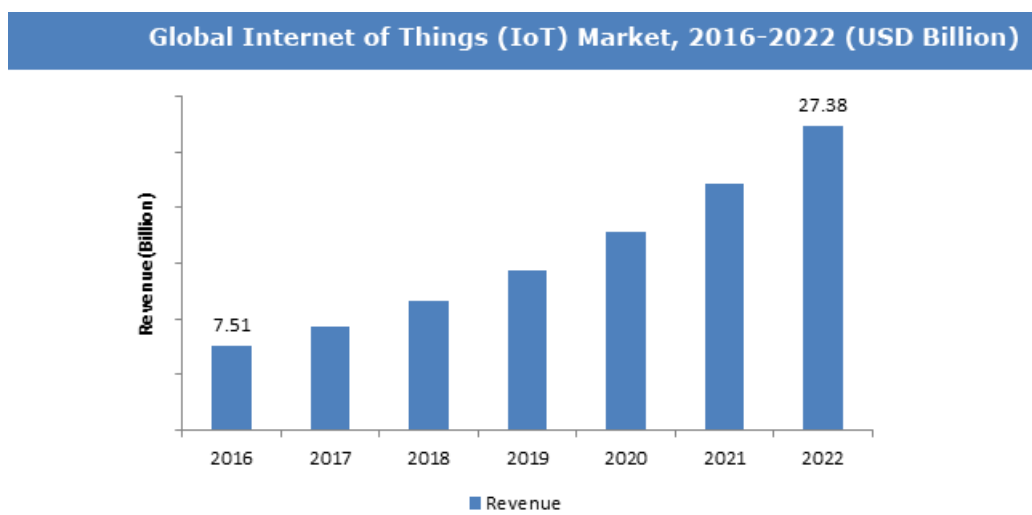
The new opportunities that IoT brings for data collection and sharing data across a network, allowing remotely controlled devices to work with a simple software or application

The physical-world is transferred into a computing world, where as much as possible human interaction is reduced.

General benefits of IoT implementations in any industry are such as :

- Reduced errors
- Ability to forecast
- Improved quality of product or service
- Improved Efficiency of the workforce

According to the vertical bar chart below, a total number of IoT devices growth is predicted to be more than 27 billion by 2022.

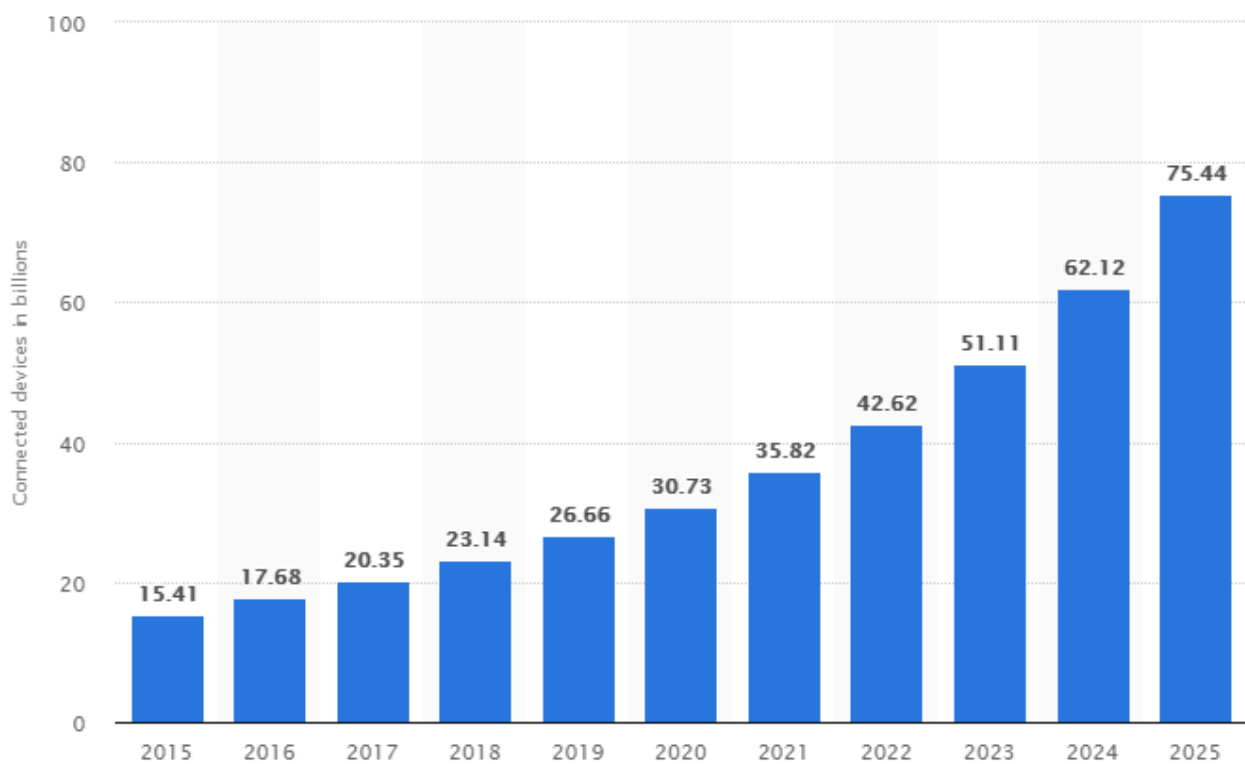


IoT Global Market (Source: statista.com, 2017)

3.1.1 Smart Home Solution

A smart home is a convenient home setup where appliances and devices can be automatically controlled remotely from any internet-connected place in the world using a mobile or other networked device. A smart home has its devices interconnected through the internet, and the user can control functions such as security access to the home, temperature, lighting and home theater

In other words, a smart device would provide consumers with the feedback based on collected information from the sensors. Using internal network, the smart home shares data. The most important part of the smart home concept is to have at least one smart control system .



Global smart home market (Source: statista.com, 2016)

The bar chart explains a significant global market growth in the next five years. With this we can assume that the demand for smart home solutions will grow, and more devices will be manufactured. A lot of companies are becoming specialised in smart home solutions (e.g. Samsung, Panasonic Philips, and others).

3.1.2 Samsung

For this project, we will use a company smart home product to analyze it.

The reason for choosing Samsung as an example is because it has the largest number of apps and devices available for the smart home concept. Samsung company offers a starter kit called 'Smart Things'. The kit contains the following devices:

- Hub
- Presence Sensor
- Motion Sensor
- Multi Sensor



The consumer can monitor his system using the SmartThings App on his smartphone, it is compatible with the following mobile operating systems: iOS, Android and Windows Phone 8.1.

The smart kit concept is still brand new to customers, and they find many flaws.

Based on customer and personal reviews the biggest issues are related to the app and sensors. Both options have limitations, for example the consumer can only use SmartThings kit for assigned tasks by Samsung. A mobile application has its imperfection (only one consumer can use mobile application per kit) whereas sensors give false alarms and results. To integrate third-party devices, it can be difficult for non-technical consumers.

According to a report made by 'PlumChoice' and the 'Z-Wave Alliance' in 2015, only 67% of consumers showed that they knew what a smart home and smart device is. However, one year later in 2016, 97% consumers said that they recognise the smart home concept. It is understandable that every year consumers become more knowledgeable and interested in smart home and its devices.

About third of people would prefer a hub that would connect all smart devices and control all of them using a single application. Interoperability is an essential factor in the smart home as consumers are adding more interconnected smart devices. For instance, in the year 2015 and 2016 half of all interviewed consumers said that the smart home devices are not necessary, and the value is not known.

3.2 Hardware Involved

3.2.1 Raspberry Pi

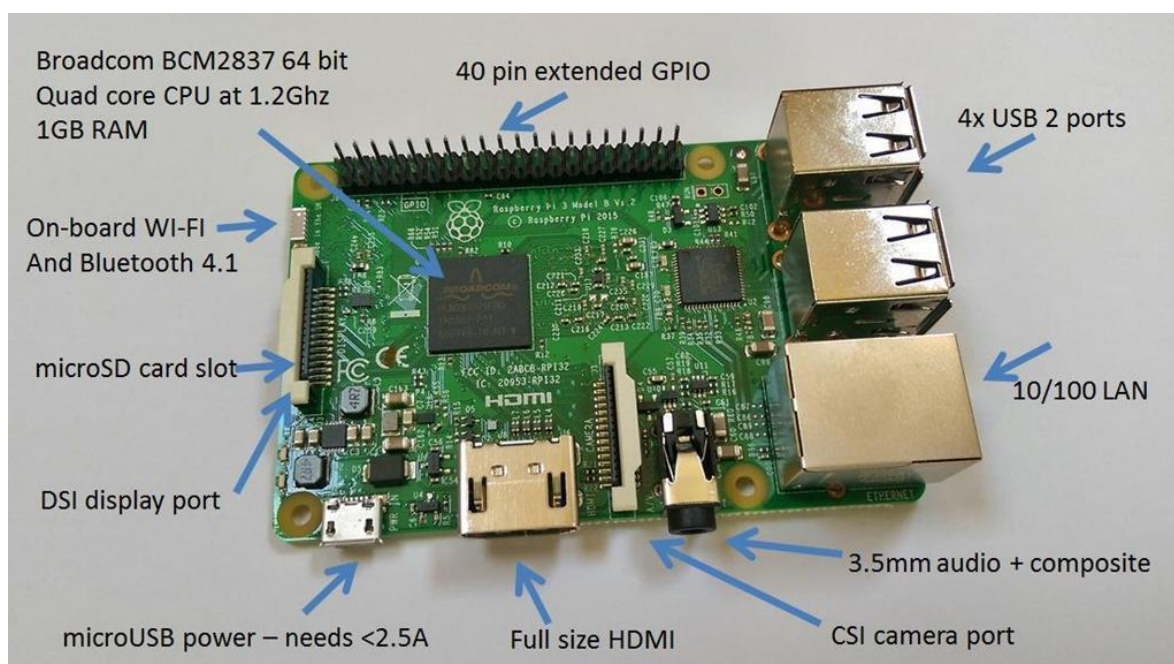
The study showed that consumers need an integration between sensors and one single application for controls. Raspberry PI allows sensors to be connected between the microcontroller and application. For this reason, the project was based on the Raspberry PI 3 microcontroller.

Raspberry PI is a low-cost computer that runs on the specially designed operating system – Linux (Raspbian). Raspbian is a Debian-based operating system. Due to the small hardware size and low energy consumption, the device has been used by users in a variety of projects, (robotics, smart homes, multimedia and so on). For a small device, it contains powerful internal hardware as stated below.

Raspberry PI 3 was released in February 2016, and it is the most powerful microcontroller version to date. It uses Broadcom BCM2837 system on chip (SoC) running at 1.2 GHz ARM-Cortex-A53 central processing unit (CPU) and 1GB of SDRAM

Following features are available:

- 4 x USB2.0 Ports with up to 1.2A output
- 10/100 Mbit/s Ethernet (RJ45)
- 802.11n Wi-Fi
- Bluetooth 4.1
- Video/Audio Out via 4-pole 3.5mm connector
- Storage: microSD
- 5V at 2.4A power source,



Raspberry PI 3 structure

3.2.1 Other Hardwares

Due to their mobility restriction and lack of movement options, disabled people are often dependent on someone.

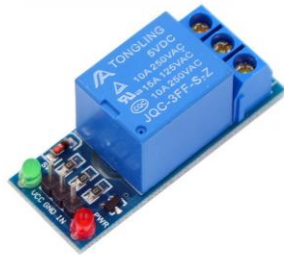
Setting up the smart device is crucial to the user experience. IoT for the smart home would help consumers in their daily life, especially people with disabilities and could bring them some independence. But companies appear to have a lack of awareness about this.

In this project those hardware were chosen because of their ability to help disabled people.

The smart house is equipped with 5 LEDs* that can be toogled on and off from a phone.

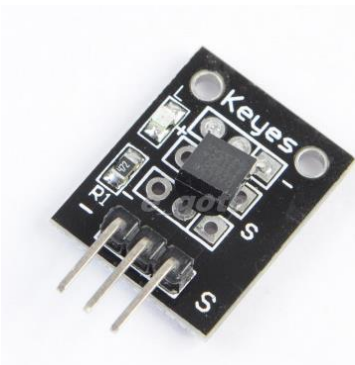


The Relays module is an electrically operated switch that simulate a boiler.

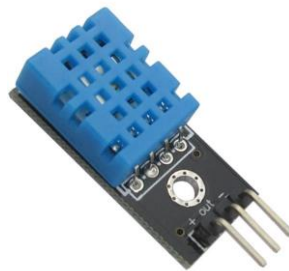


The sensors all came from the KOOKYE Smart Home Sensor Kit for Arduino Raspberry Pi.
The sensors used were :

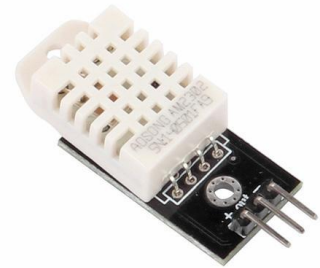
- Temperature and humidity sensor DS18B20, DHT11 and DHT22, it can protect consumers and valuables from the damage that temperature change can do or just be a source of information of the different temperature inside and outside the house.



DS18B20



DHT11

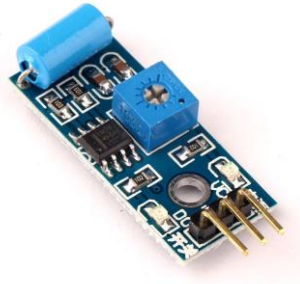


DHT22

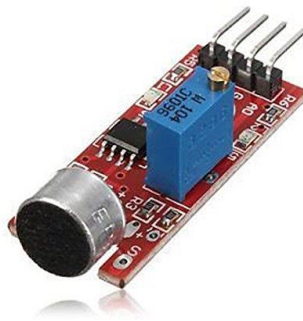
- A flame detection sensor to alert the user if a fire is starting in the house.



- Vibration sensor module, to detect when the glass gets broken or pushed forcefully.



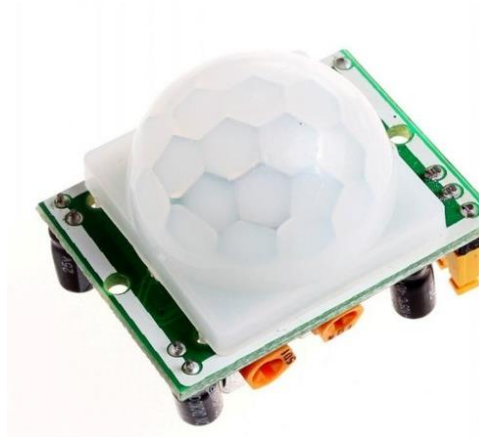
- Sound sensor module, The Sound Sensor can detect the sound strength of the environment.



- Photosensitive sensor module, detects when it's night and switch on the lights inside.



- I mostly worked on the HC-SR501 infrared sensor module, who has two functions, first When an intruder enters through the detection area, it sends alarm signal to control panel. Second when movement is detected the light in the room goes on and if no more movement is detected after 60 secondes the light then switch off.



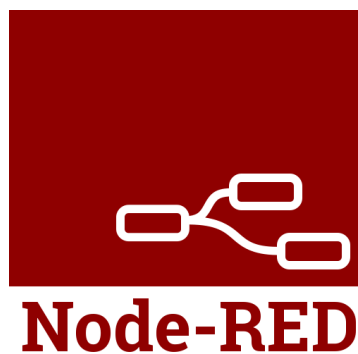
3.3 User Interface Plateform

In the project, one of the initial objectives were to build a user interface platform based on Java programming language. The plan was to connect Raspberry PI sensors and display on the mobile application which was meant to be made in the Android Studio.

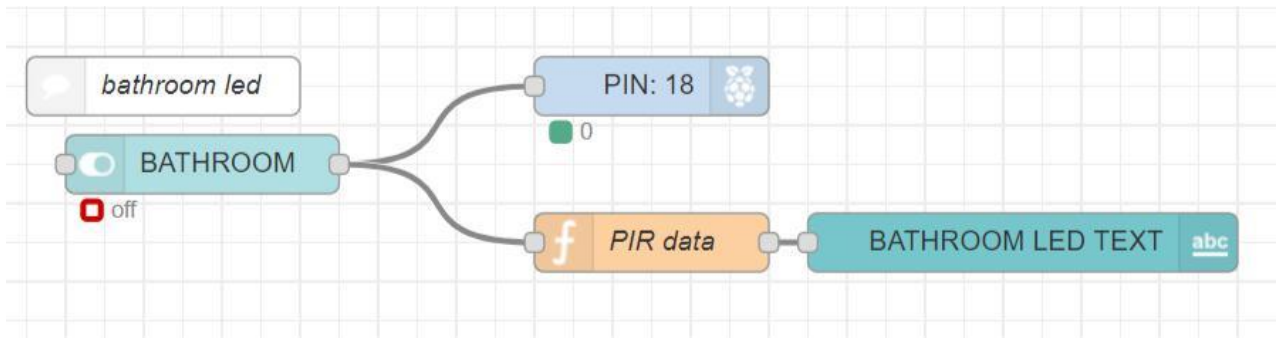
However, during the project development process, it was discovered that the latency from the sensors to the user interface platform was with high delays. The time is important, and it is crucial to receive correct measurements on time, as for some specific functions to suit user needs time can be critical.

The Node-Red programming tool was discovered which is available by default in the Raspberry PI operating system Raspbian. To access Node-Red the Raspberry PI and a smart device must be connected to the same network.

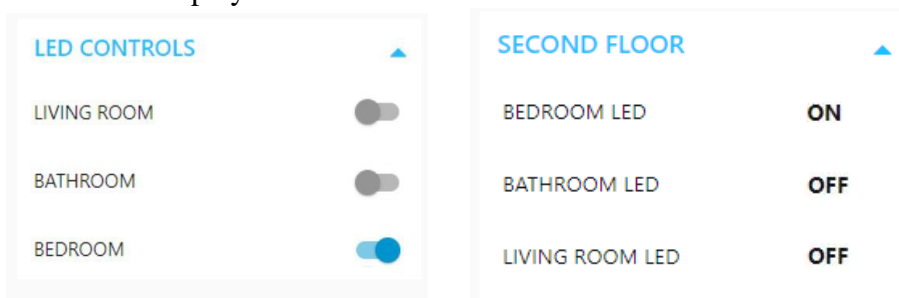
Node-Red is a visual development tool to wire together different type of Internet of Things devices, including Raspberry PI and its sensors.



To clarify, the tool allowed to build flows using different nodes. Example for a single flow that triggers ‘ON & OFF’ function to turn LED on and off in the bathroom.



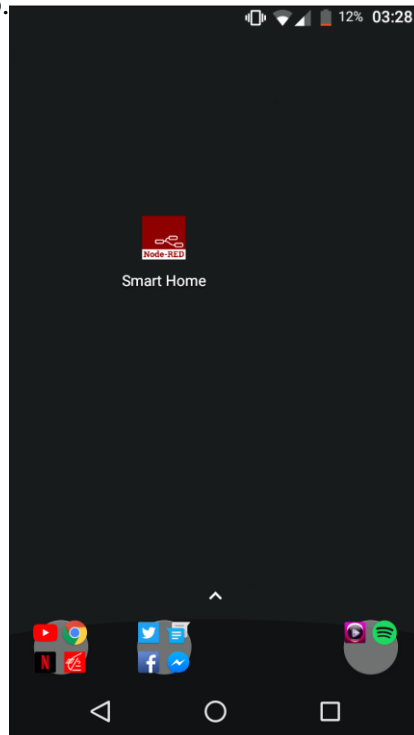
A node such as ‘BATHROOM’ which is responsible for a button as seen in Figure 12 and ‘PIN’ is the GPIO (General Purpose Input Output) on Raspberry PI that is responsible to turn led on or off. Where further ‘PIR data’ using simple JavaScript, code turns the input/output (1/0) function into the text format and shows on the display if the led status is active or inactive.



User Interface Dashboard

Nevertheless, of above-mentioned benefits, the Node-Red also offers powerful user interface interactive dashboard. The data or functions can be displayed on any device that has a network access, including a personal computer, smartphones and tablets.

To simply access the dashboard, the user types the address on the browser that usually ends with the *port: 1880/ui* and to make access easier for mobile device users the website can be added to the home screen, which functions as an app.



Those examples shows the flexibility that the tool can offer to the user. Depending on their needs the necessary function or process can be created.

In this case, linking nodes and programming language together, Node-Red makes the best solution for the users who would need the full control over its devices and sensors. Node-Red allows connecting any device (e.g. Apple, Android), as long as the device is connected to the wireless network.

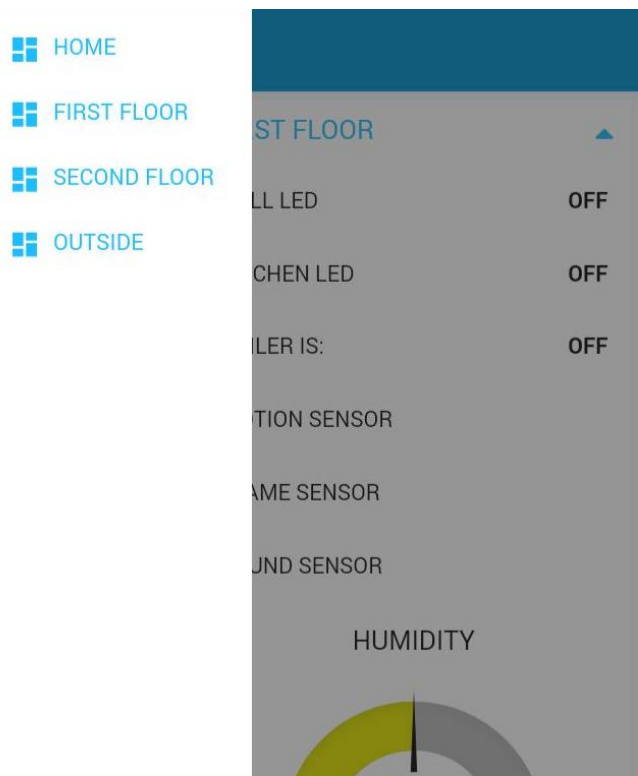
The Node-Red offers a variety of examples that can be achieved with the tool. Different options such as adding the smart voice assistants up to making different triggers such as when the outside temperature is above the average, the cooling indoors will increase.

With the 21st-century technology making an automation and monitoring with an open source development tool such as Node-Red would be the most suitable for people with needs due its flexibility and efficiency.

3.4 Prototype

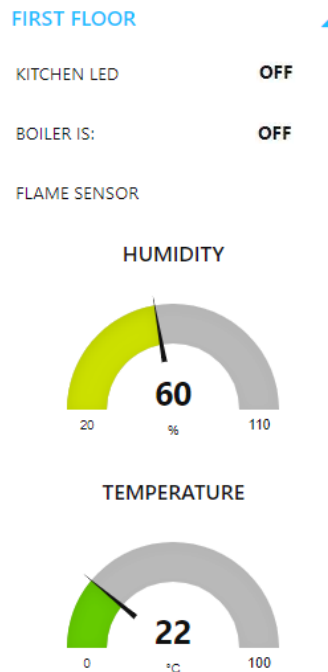
One of the project aim was to build a prototype into a small house, in this case, a dollhouse. The dollhouse scale is small compared to the actual size of the real house, despite this, same sensors and microcontroller can be used to make a smart house on a bigger scale.

Users can monitor data using node red user interface dashboard. With different tabs that were specifically made for this project, the user can choose a floor and monitor data or trigger functions. In total there were 5 different rooms, as well as outside the house.



The display of the First floor in shows temperature and humidity gauges. The kitchen was based on the first floor, thus the user could turn the boiler on or off using ‘5V DC single channel relay’.

The relay response is instant if compared to the Samsung SmartThings which had delay around 1 to 2 sec. As well as lights, in this case, LED’s can be controlled in the control panel with simple touch function..



3.5 Testing

3.5.1 Raspberry Pi3

In general Raspberry Pi3 was capable to run multiple functions and sensors at the same time. But the Raspberry Pi occasionally worked unstably and many reboots for the device was done to allow the device work again with sensors.

The Raspberry Pi also had some problem to make the temperatures sensors work. Even when a successful SSH connection between the laptop and Raspberry Pi was established, the temperature sensors DS18B20, DHT22 and DHT11 weren't working properly.

I tried to troubleshoot the problem with the help of Mr Al-Ahmed, a PHD student, but sadly the internship ended before we could resolve this issue.

We realized that the Raspberry Pi3 had some security vulnerability.

To be assured that non-authorized users are not accessing Raspberry pi security measures must be applied.

To limit possible breach the owner of the Raspberry Pi must apply simple countermeasures such as, changing the default password, username, improving SSH security and have the latest update with security fixes.

Some of the previously predicted results failed and the conclusion is that the Raspberry PI works great as a simple computer rather than a microcontroller. I think it would be beneficial to this project to exchange the Raspberry Pi3 for a lighter and cheaper model like the Raspberry Pi Zero.

Similarly, I think that using a microcontroller such as Arduino would suit the best for the future of this project or for other project like this.

3.5.2 Sensors

Sensors were one of the most important parts of the project. Every sensor contains a datasheet which is a document with available technical information such as, the performance and technical specifications. The datasheet was used to choose correct voltage and reading examples. In the real-world scenario if the sensor would fail it would affect expected results and cause possible side effects.

One of the first conclusion to those tests is that cheap sensors (below 5£) are unreliable and unprecise.

During pre-tests, before installing sensors into the dollhouse some of the sensors failed showing incorrect measurements.

Sensors such as the Light sensor started showing incorrect measurement working after 24 hours of running constantly.

It again shows how important is to have sensors that would work under pressure, especially if the person with needs would need precise measurement otherwise it could affect its life and in other cases, the outcome can be lethal.

It can be concluded that separate in-depth research must be done for the sensors, to find the best solution where less chance for the failure that might occur. Similarly, to suit specific user needs e.g. a user with needs or elderly the distinct sensor should be developed, as above-mentioned sensors are for general use only.

4 Presentations

I had the pleasure to introduced the project to teachers, students and parents for the Posgraduate Open Day on the 22nd of May.

It was a good way for the students who are considering an undergraduate, postgraduate or postgraduate research degree.at UWS to learn about what it's like to live and study in this university. It was also a great way to hear from staff and students about the differents course and a chance to visit the different facilities (lecture halls, labs, sports and students unions, student accommodation). UWS holds open days and information sessions throughout the year.

A lot of students's project were presented.

I had to explain and present the project to student and parents. I had to learn how to appeal to different types of people, depending on their level of knowledge of the technological world (student, parents, teachers...).

I also had to deal with the unwillingness of some highschool students.

A lot of people were interested in my background as a french student from the IUT d'Aix-Marseille doing an internship at UWS.

5 Conclusion

This internship has helped me grow on a personal and professional level.

Those ten weeks allowed me to learn a lot about the Internet of Things. During those ten weeks I put my adaptability one of the most important skills the IUT R&T has taught me to good use.

I have learned how to use the programming tool Node-Red and learned a lot more about how to setup and manage different types of programs. I had never used a Raspberry Pi at this level of depth. I always had preset Raspberry Pi that would accomplish simple task. This allowed me to understand in more depth the different ways of managing a Raspberry Pi.

I also had to troubleshoot a problem with the temperature sensors (DHT22 and DHT11) that wouldn't work.

Me and my coworker, Shahriar Al-Ahmed, spent a lot of time trying to work around this issue but even though we weren't successful in resolving this problem I still learned a lot in terms of how to troubleshoot a problem in a Raspberry Pi and in systems in general.

This internship was interesting because working on a real project that would evolve and improve through time is really interesting and especially if this project can help people in need.

This internship has helped me overcome my fear of moving away. I was unsure of myself at first, but I quickly became used to meeting new peoples.

My strengths in this internship, where most of my work was made from my house since I was close to Doctor Shakir's office, was my ability to set goals and be disciplined enough to reach those goals. This internship forced me to become organized. Being able to organize will help me in everything I do in college and at work.

One of my weaknesses is my shyness. I have partially overcome this weakness because of the niceness of the people that I've met during my stay in Scotland. This internship has helped me become more confident. I will be able to use this newfound confidence to do better in college and in my future job.

Since this was an abroad internship my english level has also improved.

In closing, I would like to add that I have really enjoyed the experience of this internship. And that I'm thankful that this opportunity was given to me.

6 Glossary

DUT - Diplôme Universitaire de Technologie

UWS - University of the West of Scotland

IOT - Internet Of Things

SMIEEE - Senior Members of the Institute of Electrical and Electronics Engineers

SOC - System on a chip

LED - light-emitting diode

GPIO - General Purpose Input Output

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