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Title:

An Analysis of Temperature and Humidity in student housing using a Raspberry Pi

Technical Report

Contents

Chapter 1
Introduction

1.1 Overview

This chapter outlines the structure of this research project, introducing the topic and focus of the project. Fisher, C. (2009, p317) explains that creating a structure to any document is necessary to plan the proposed topic. The introduction chapter is a summary of the chapters to come, explaining the structure of the research project.

This chapter includes;

- Title of the project
- The background of the project
- What the project intends to do
- The Literature Review Chapter
- Purpose of the system and analysis and design
- Objectives
- Conclusions and recommendations
- Summary

1.2 Title of Research Project

An Analysis of Temperature and Humidity in student housing using a Raspberry Pi

1.3 Background

The background to this project relates to the "why" of the project, as in why complete this project? This can be answered from two perspectives, the personal interest in the Raspberry Pi and its applications in everyday life and the application of complex programming in order to complete a complex project.

1.4 Personal interest

As a student, this writer believes that student housing standards are important. The project, which aims to detect mould growth conditions in student housing, may be beneficial to students and landlords who wish to maintain healthy living conditions in accommodation environments. Throughout the research conducted, there is a reoccurring issue with the presence of particular moulds, as they can be directly harmful to humans and animals but can also indirectly cause issues such as life-long respiratory diseases and illnesses. The detection of mould may also identify conditions that are unhealthy or may add to existing medical conditions.

Also as a computing student, this writer is interested in the applications of Raspberry Pi in ordinary life and how it can be developed to automate or streamline many tasks. These different tasks can be completed from one system and reduce the number of devices needed in a domestic setting or even a commercial setting. This also opens up the system for other applications which have been explained at the end of this document see section 4.3.

1.5 Summary

The next section contains he Literature Review which looks at mould and the impacts of such on a domestic or internal environment. The literature review is research conducted by looking at journals, articles and sources that explain the development and structure of the fungus.

Chapter 2
Literature Review

2.1 Overview

The purpose of this project is to develop a system that will monitor environmental conditions and report the findings to the client, in a clear and concise manner. The literature review explores the topic of mould, the types of mould and the growth conditions needed to germinate the spores and increase spread in an enclosed environment. This document will briefly look at why this project specifically looks at student housing as the prospective client, and the different products available to monitor domestic environments.

The topics covered in this literature review include an examination of the impact mould has on a residential environment as well as the costs associated with detecting and removing mould from a building. Briefly, this document outlines the differences between the existing commercial remedies and the Raspberry Pi system under development in this project, with a description of why this system might be preferable to remedial measures when mould has already developed.

2.2 What is mould and how does it develop?

We know indoor mould as that discolouration on the walls, usually in the bathroom or kitchen, and it can also be found in older houses on the external facing walls which may be less insulated than the same in new housing. The disadvantage of mould being that it is unsightly and often can be dangerous. The below text explores the structure of mould, with examples of common household moulds and the complications or damage to health and property value that the presence of mould can cause. Mould is one of the most common problems in buildings that is caused by a moisture related problem, as explained by (Moon and Augenbroe, 2004), and that recent research has identified a clear relationship between moisture, temperature and material type in relation to the presence or non-presence of mould. Often buildings have mild infestations of mould and mould spores which may never cause any problems or even be visible.

Below is an image of an affected building, which has an extensive growth of fungus or black
mould which is clearly visible on the lower portion of the walls, where a small amount of fungus can spread quickly causing huge damage to the affected area and its inhabitants.

Figure 1: Mould in a residence. Google Images. (Anon, 2017)

The physical structure of mould is interesting, mould is a fungus which differs from other types of fungus in appearance and spread. Mould is a multi-cellular fungus that may be presented as a discolouration or coating on affected surfaces, as opposed to yeasts which are single celled in nature, as expressed by the two diagrams below.

The Yeast Cell Structure.

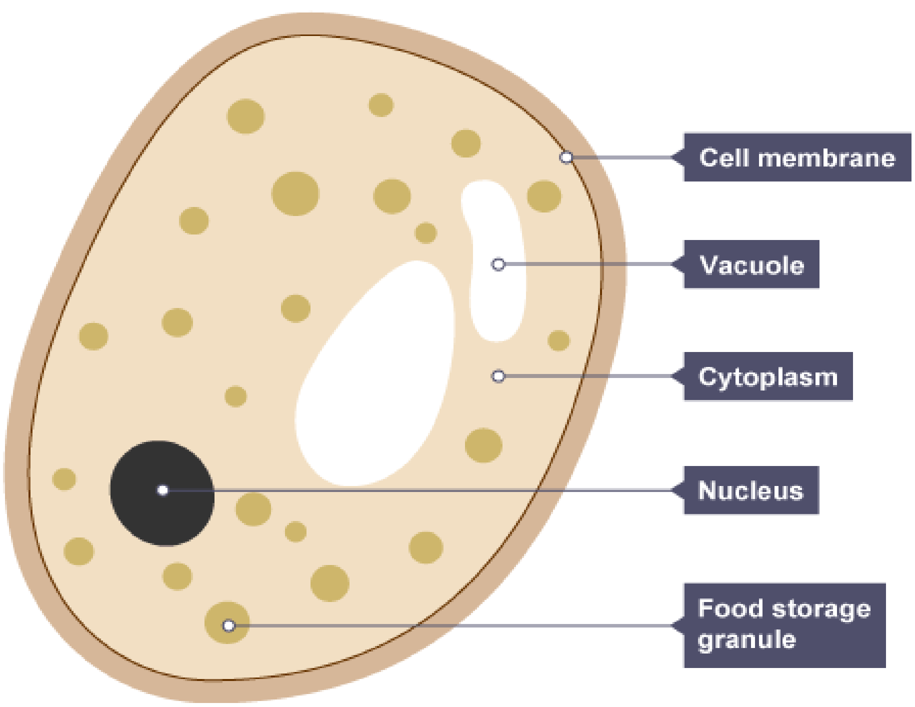


Figure 2: Structure of yeast. NA. ND. (beyondthemicroscope yeastcell, 2017)

The Fungal Cell Structure.

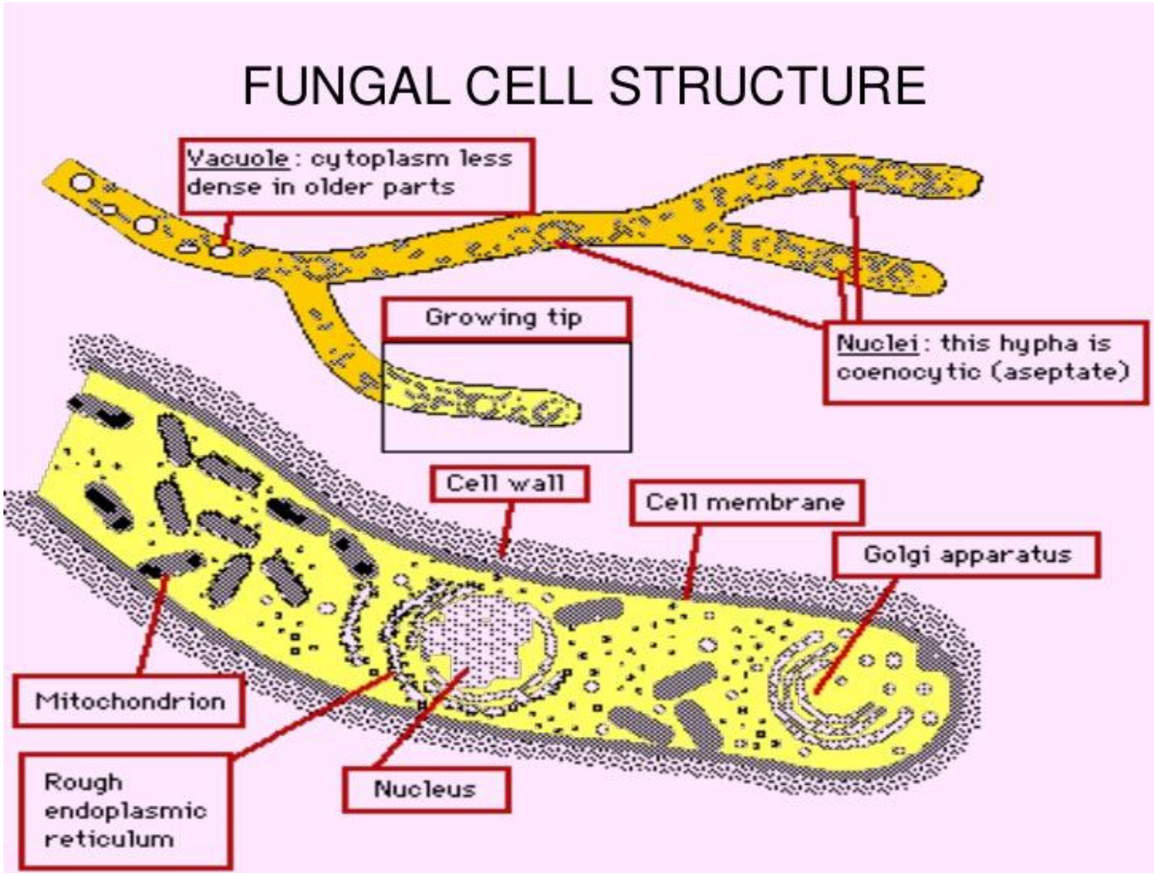
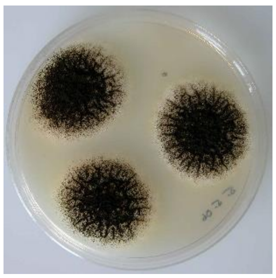


Figure 3: Structure of mould. NA. ND. (Structure of mould, 2017)

2.3 Types of mould

It is important to categorise different moulds and their effects because some can be harmless or low impact and others can be highly dangerous and high impact in the lives of the individuals who live with it in their living environments. This section deals with the common types of mould, a description and the potential impact of such a contamination in a residence.

Mould comes in many varieties and often look very different, they are also generally detrimental to health but some are more dangerous or potent than others. For example in the table below we see that the Penicillium mould, which is the mould which is medically known to be an anti-biotic can also be detrimental to one’s health depending on the situation. Sufferers with an allergy to Penicillin can have a range of reactions but it is best known for triggering anaphylactic shock in severe cases. (Mogul, 2017) states that there are many types of mould that can be found in domestic settings, such as the more common moulds found in domestic environments included in the table below:

Type	Cause	Result
Alternaria 	Usually found outdoors, this mould can be found in damp places indoors and is commonly associated with mould patches under sinks and near leaky pipes. This mould can spread very easily from home to home.	The presence of this mould can result in Asthma attacks and allergic reactions.
Aspergillus 	A common type of fungus found worldwide.	When the microscopic spores are inhaled this mould can cause serious issues such as; • High fever • Asthma attacks • Coughing up blood and mucus In rare cases where exposure to this mould is high or the individual exposed has existing lung problems the effects can be fatal, due to bleeding of the lungs, destruction of the sinus cavities/facial bones and sepsis in the entire body.
Botrytis 	Grows in areas with high humidity levels, for example in a poorly ventilated bathroom.	Can cause breathing problems and allergic reactions.
Cladosporium 	Often found growing inside homes, this mould is atypical in that is can be found in both warm humid conditions and cooler environments also. Generally found on painted surfaces or carpets.	Causes a variety of respiratory problems.
Penicillium	One of the most commonly known moulds which is characterised by being coloured blue or green, usually found	Can cause severe allergic reactions, chronic sinus infections and can inflame the lungs.

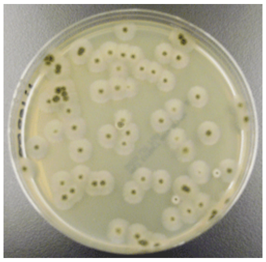
	on surfaces damaged by water and easily spread from one area to another.	
Stachybotrys Chartarum 	Referred to as "black mould" it is also known as toxic mould and has a black slimy appearance. It produces compounds, called mycotoxins that are toxic and can produce a musty odour. It present where there is a high level of condensation.	Can cause allergic reactions, respiratory problems, Asthma attacks, fatigue and depression, as well as other conditions.

Figure 4: Mould types (Mogul, 2017)

Mould develops on many surfaces and can become a problem quickly so this topic explores the development and spread of the fungus in residential buildings. Sources say that mould is caused when three conditions occur, moisture, warmth and food, flooding and leaks may provide the perfect conditions for mould to grow, as espoused by the World Health Organization. (World Health Organization, 2009). The food source mentioned is actually an organic food source and will allow the mould to develop. Things like naturally sourced surfaces such as wood, paper or fabrics are perfect breading grounds for mould.

In the next section, Section 4, the varying conditions for mould growth will be explored and discussed to ascertain whether or not there are any generalisations that can be used to detect the growth conditions of fungi within student housing. Reference

2.4 Mould growth conditions

Although mould growth conditions are difficult to quantify, the growth of moulds in a building is caused by the relative humidity and temperature conditions on the surfaces of building materials and how air flows create moisture throughout a building, as explained by (Moon and Augenbroe, 2004). High humidity in an environment and warmth can create favourable conditions for mould and surfaces can become contaminated with spores very rapidly, leading to mould growth and quickened spread of the unsightly mould. These moulds come in a variety of forms from black to blue to green. Another set of factors that affect the growth conditions of mould in a building, as espoused by (Moon and

Augenbroe, 2004), are the thermal and moisture sources, such as activity of occupants, furniture and equipment within the room for example. Various sources call the building environment the "building envelope" and explain that events which introduce moisture and humidity can cause the mould spores to germinate, which is a disruption or failure in the building envelope. (Savory et al., 2012) maintain that "without exception, the growth of mould in the built environment is always mediated by superfluous moisture" and that this moisture can be introduced in an environment through a catastrophic failure, with the example of Hurricane Katrina in 2005, or a more subtle event, such as a minor leak. Some of the possible events are listed below:

Events
Plumbing leaks
Conditions of use and lifestyle
Minor failures in the building enclosure (cracked concrete or incomplete damp proofing)
High humidity
Inadequate ventilation
Condensation

Table 1: Growth Conditions (Mogul, 2017)

In monitoring conditions in an enclosed environment, it is important to remember that conditions do fluctuate, for example doors and windows that are closed for long periods of time reduce ventilation in an area and can lead to the presence of mould and perfect humidity and temperature conditions. (Moon and Augenbroe, 2004) show that keeping track of fluctuating conditions within the environment is a more accurate method for detecting conditions that could result in favourable mould growth conditions, and monitoring the fluctuations may accrue more reliable data. Also of importance is that fluctuating humidity and temperature can have a shortening or lengthening effect on the development of mould in a closed environment. (Moon and Augenbroe, 2004) state that moulds germinate in constant or fluctuating environmental conditions, although the latter may delay the germination process somewhat. Environmental conditions have a significant effect on the type of mould growth, the speed of the growth and severity of the spread, some moulds may also be spread through brief contact with a contaminated surface and a non-contaminated surface.

2.5 Why is it important to monitor conditions and prevent mould?

There are multiple reasons as to why it is important to monitor residential conditions, not east of all the health aspects but also the structural and aesthetic issues that come along with mould growth in an environment. The following section explains the seriousness of these issues and what the impact the presence of mould in a building can have on the residents and landlords alike.

2.5.1 Health Issues

The most serious and long-term issue with indoor mould is that it can be the cause, trigger or even worsen health problems in people. Studies show that moulds can cause minor ailments and serious health issues as shown in Figure 4, in Section 3 of the literature review. (Moon and Augenbroe, 2004) state “although human health is not directly affected by high relative humidity levels, it poses severe health risks …... Microbial growth in buildings has been identified as the main moisture-related cause of indoor air quality problems”. Poor air quality and the presence of mould have been cited as being directly related to ongoing health issues and may also contribute to permanent respiratory issues. (Savory et al., 2012) clarify that the growth of mould is a significant factor in the development of atopic diseases and pose other health risks, and also that indoor mould can exacerbate allergies and Asthma and this growth is viewed as a health relevant event in residential housing. Most of the studies conclude that mould is detrimental to health and websites that deal with health issues often cover mould growth and how it can effect living conditions. (Mayo Clinic Staff, n.d.) explain that mould allergy can cause similar symptoms to upper respiratory allergies, with symptoms such as; sneezing, Runny nose, cough, irritated eyes and watery eyes, with each person suffering varied symptoms or severity of reaction. The severity of reaction is unique to each case and correlates with each individual’s own general health and sensitivities, such as allergies. Mould growth is most likely to affect people with existing health issues but as the Mayo Clinic Staff. (Mayo Clinic Staff, n.d.) state that the dangers of mould are higher for older people, young children and the individuals suffer with under developed or undermined immune systems, this being said mould can contribute to illness in even the healthiest of young adults and adults, even occasionally leading to long-term conditions such as Asthma or

Emphysema. This is particularly relevant for student housing, where young adults may be subject to a lower standard of lifestyle and subsequently become susceptible to issues mentioned above. That being established, it may be fair to note that rental properties and their conditions must be monitored regularly, lest the tenants succumb to an environment related illness, and in theory, claim liability against the owner of the property.

Potential health problems caused by mould include

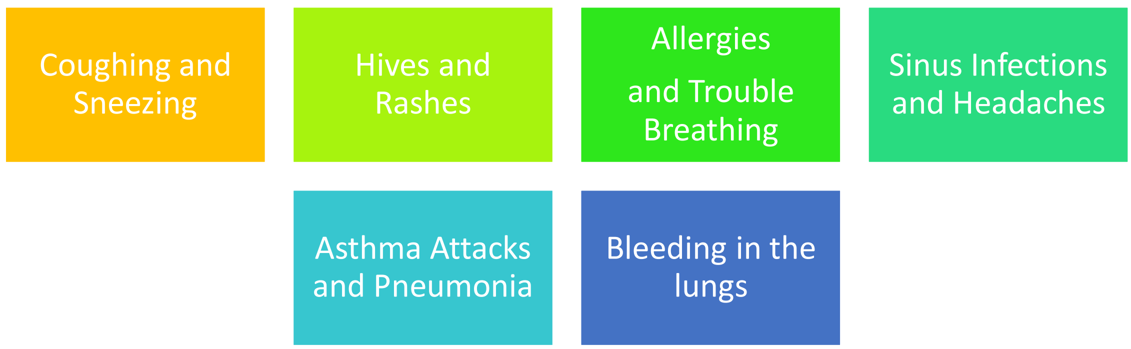


Figure 5: Mayo Clinic Staff. 2017. (Mayo Clinic Staff, n.d.)

2.5.2 Aesthetics

The most obvious issue with mould growth in particular within rented housing is its unsightly appearance. This may cause the property to be devalued as a rental option and seen as a less desirable residence to students and families. The growth of mould may be across walls and around windows, and also may exude a musty or pungent odour which can lead to a loss of income as few people would rent a place that was showing a large level of contaminated surfaces within.

Where does mould typically appear from water leaks, penetrating and rising damp?
Walls under the bottom corners of windows
Floors around toilets and under dishwashers
Walls around un-insulated cold-water pipes
Around the chimney in the attic
Near damaged or blocked downspouts

Basement - Bottom of walls, corners and floors
Bottoms of walls - bridged or earth covered damp proof courses

Table 2: LandlordZONE.co.uk. (Entwhistle, 2005)

2.5.3 Structural problems

Mould can be linked to other problems, as the United States Environmental Protection Agency (US EPA, 2017) explain, and in fact can cause structural issues such as a gradual destruction of effected materials, for example if a leak is left for too long the floor, ceiling or wall affected may be weakened or collapse. Structural damage is likely costly to remedy; therefore, it is important to monitor conditions for possible mould growth properties such as temperature and humidity. In relevance to this project, it may be necessary for the owners of student letting residences to regularly monitor the conditions within the environment in a non-invasive way.

Citizens Information. NA. (2017) states that the responsibilities that the landlord of any rental property in Ireland include the following:

> "For each apartment, flat or house being rented as a separate unit, the landlord must ensure that the rental property is in a proper state of structural repair. The Regulations require the landlord to maintain the property in a sound state, inside and out. They specify that roofs, roofing tiles, slates, windows, floors, ceilings, walls, stairs, doors, skirting boards, fascia's, tiles on any floor, ceiling and wall, gutters, down pipes, fittings, furnishings, gardens and common areas must be maintained in good condition and repair. They must not be defective due to dampness or otherwise."

Therefore, it is the responsibility of the landlords of student housing to provide a damp free environment, and mould is a symptom of damp conditions, so it may be important for these conditions to be discovered if they exist. The legal issues that could impact on landlords if perhaps their tenants become ill due to mould present in the building could be costly. The transient nature of student tenancies also mean that damp or mould may not be reported as promptly as with other types of rental accommodations, a device that helps monitor conditions could be seen as a way to reduce the risk of mould developing and fulfil some of the responsibilities of the landlord.

2.6 Expense of Detecting and Removing Mould

If there is a risk of mould present in a building it is certainly preferable to prevent an initial appearance or germination of the mould where possible, the Raspberry Pi unit is designed to monitor the environment repeatedly, as environmental conditions change rapidly from day to day and season to season for example. Humidity levels change so frequently that a one-off test may not capture the environments true conditions and therefore the possibility of mould growth may be missed. For instance, the Summer and Winter months may not be as humid as the Autumn and Spring weather therefore a test in one season may produce largely different results from another season. (Savory et al., 2012) clarifies that the detection and elimination of mould is a remedial expenditure but may involve huge effort to remove the symptoms while many of the causes lay unresolved and require an engineering perspective to fix.

A small fungal spread may be easy to deal with using domestic chemicals but this infestation may reoccur within a short period of time and will have to be treated repeatedly to remove the mould. B and Q in Ireland sell products for cleaning small areas of mould at low cost (Diy.com, 2017). Many companies and technologies can be used to detect and clean environments infested with mould or other fungal issues, for example damp testing in Ireland with the Moldbusters can cost between €180 and €250 depending on location (Moldbusters.ie, 2014) and the same company will test the samples collected to identify the type of mould for around €120.

We see above that detecting mould growth conditions and testing mould can be expensive even before the mould is removed from the building. Domestic treatments may not be effective enough to completely eliminate the mould and contributing conditions resulting in recontamination of the area. LandlordZONE.co.uk. 2005 states that years later, once conditions deteriorate again, a property which has had mould treatments, will redevelop mouldy patches and this will continue to spread. Therefor the detection of the unfavourable conditions allows for preventative action or proactive changes to be made rather than reactive treatments which are often expensive and also can be dangerous in their own right in some cases.

The aim of this project is to produce a low-cost alternative that can be used repeatedly and is easily translated to detect dangerous conditions in which mould is most likely to develop in an enclosed environment, so that preventative measures such a dehumidification or anti-fungal products can be applied to prevent an outbreak.

2.7 Comparison of commercial units to Raspberry Pi system

Moisture meters are used often to detect latent moisture in the air and on surfaces in buildings, they come in a variety of formats and have a large range of prices on online shops such as Ebay and Amazon. The devices instantly read the conditions and give a reading based on immediate readings and there are few devices that read conditions over an extended period of time, the ones that do monitor over time are expensive and the results may be difficult to interpret for a client. (Savory et al., 2012) state that a remote sensor is one of the best ways to monitor environmental conditions accurately.

The Raspberry Pi device is designed to be used over a long period of time which should be the best method for monitoring ongoing conditions and reporting more accurate information to the client. The system would monitor a range of conditions when put together create a normative representation of conditions in the space. This system has the added benefit of data processing which collate and display the data in a simple graphic which indicates the level of risk of mould growth in the normal conditions within the environment. This graphic presents the information in such a way as to help the client decide on which preventative measures need to be applied, such as high humidity would require a dehumidification measure while temperature anomalies can be addressed with wither heating or ventilation measures.

2.8 Summary

In conclusion, this literature review has examined mould and its impacts, on health, aesthetics and structural integrity. It illustrates the need to prevent and remove mould from residential environments. Where the presence of mould increases the chance of ill-health for inhabitants and where sellers or landlords may see a reduction in housing prices due to unsightly and dangerous moulds growing in their properties and therefore a drop in the potential to earn from their assets.

The document also looking at various technological solutions that are available on the market and the advantages of having the Raspberry Pi system as a viable alternative to them. The research does indicate that a preventative measure would be less costly than a remedial measure such as using a commercial company to remove the mould from the environment.

Chapter 3
Technical Requirements

3. Overview

The Technical Requirements document outlines the project background, objectives, deliverables and analysis of the testing data conducted.

The project title is “An Analysis of Temperature and Humidity in student housing using a Raspberry Pi”.

The project is a self-directed learning experience conducted by the final year student, therefore, it may be an important point to add that this learning exercise has particular utility in increasing the skill and knowledge of the student. In the case of this project the skills or knowledge, that is learned, used or further developed during this project, are a mixture of pre-existing skills and new skills learned over the duration of the project. Some of the skills or knowledge used within this project are described below.

- Hardware development
    - Raspberry Pi linked to sensors
- Software development
    - Python language
    - Adafruit Library
- Database development and Web Development
    - Initial State Dashboard
- Linking hardware to software
- Exporting data from the hardware to the database and the website
- Academic research
- Academic writing
- Technical analysis

The above skills and knowledge have been applied to create the system and link the components together into a cohesive working and useful tool.

The separate components or steps which make up the project process are;

- Research into mould and mould growth conditions.
- The hardware development – Raspberry Pi and the temperature or humidity sensors.
- The software development – the use of programming languages to link the hardware, database and website, allowing the client to use and engage with the technology.
- The use of a dashboard to create a user interface for potential clients

Within this paper there are many technical terms used so it was felt that a legend would be beneficial for the readership. The table of technical terminology is summarised below.

Acronyms, and Abbreviations	Definitions
System	Raspberry Pi 3 – a Linux based computer that is compact, cost effective and highly customisable.
Developer	the creator of the system/Niall Martin
Python	Python is a programming language that expresses concepts in fewer lines of code than is possible in languages than in C++ or Java for exception.
IoT	Internet of Things is the network of objects that feature an IP address for internet connectivity.
Moisture	In relation to this project, moisture refers to the water content in soil.
Humidity	In relation to this project, humidity refers to the water content in the air.
Use Case ID	Unique ID that represents the use case
Main flow	This is the expected way the system should run
Alternate flow	This is an alternate way the system could run
Exceptional flow	This is any exceptions and errors that could occur

Figure 1: Acronyms, and Abbreviations and Definitions

3.1 Application of complex programming

Another reason this project was chosen to be completed, is the opportunity for this writer to challenge themselves to deliver a quality product, which will showcase the programming skills and learned technical knowledge. The complexity of the project and joining each of the components, see section 3.8, will ensure that this writer has a wide range of skills and initiative.

The programming completed should remove any technical requirement on the part of the client, thus reducing training times through automation, also hopefully limiting the down time and increasing reliability and optimal operation.

3.2 To produce a cost-effective system

As with many ideas in recent times, the recession has had an impact on how projects are implemented and delivered. In this case the goal was to produce a system that was cheap, effective and could be used for multiple tasks. One of the tasks would be the detection of mould conditions and the Raspberry Pi can be programmed or modified to complete other duties.

3.3 Aims

The project aims to deliver a system that senses and records the conditions within a contained environment. It also aims to take into account moisture from the soil of indoor plants, discovering if this has any impact on the environmental conditions.

Another aim of the system is to accurately read temperature and humidity in the environment and transfer that information to a database and website.

The project's purpose is to improve student housing conditions and provide an easy way to monitor the conditions periodically.

A significant goal of this system is to allow clients to see their personalised or customised information and data securely.

Finally, one of the objectives of this project is to display the writer's skills and knowledge for the final fourth year project.

Further objectives have been outlined later on see section 4.3.

3.4 Technologies

3.4.1 Raspberry Pi

The Raspberry Pi is a small computer, which is about the size of a credit card that plugs in to any type of display device with a HDMI port on it. The Raspberry Pi runs a Linux based operating system. For the purpose of this project, the Raspberry Pi will be the main part of the system as it will be doing most of the work, it will run the Python script which will collect the data and then it will send the data to a database and server.

3.4.2 Adeept temperature and humidity sensor

The Adeept temperature and humidity sensor is called the DHT22 temperature and humidity this is a digital sensor. It uses a capacitive humidity sensor and a thermistor to read the air surrounding it. The DHT22 will be used to read the environment and gather the necessary data to analyse it to discover whether the environment is at the risk of cultivating mould.

3.4.3 Soil moisture sensor

This sensor is for detecting the moisture content of soil and is used to create an automatic plant watering system. Its purpose in this project is to help determine if having any potted plants in a room can contribute to the growth of mould in that area.

3.4.4 Adafruit Python GPIO Library

The Adafruit library provides a cross-platform GPIO interface for the Raspberry Pi it achieves this by using the RPi.GPIO and Adafruit_BBIO libraries.

3.4.5 Initial State

Initial State is Data Analytics for the Internet of Things, this site allows the client to view the data from the sensors in a well-designed user interface.

3.4.6 Google Tools

The following tool has been used within the project to provide support for the other elements of the project.

Google Drive

Google Drive is a cloud based file storage and synchronization which allows the users to store and share files across devices. This project will use google drive to store backups of files required for this project.

3.4.7 GitHub

GitHub is a web based Git repository hosting service, it provides distributed version control, source code management and collaboration features. GitHub will be used to host the source code while it is being edited and it will allow the supervisor to look at the source code to see how it is progressing.

3.4.8 Git

Git is an open source version control system, it is designed to handle projects from small to large with speed and efficiency. For this project Git will be used for the version control, this will allow for multiple versions of the project code to be created and stored in one place and accessible from multiple devices by multiple people. This will also allow for code to be taken from a previous version if a newer version runs in to any bugs. Git was chosen for this as it is part of GitHub.

3.5 System

3.5.1 Requirements

With little training, the clients should be able to use the mould detection system, as contained within the website are a full set of instructions. Also contained in the website are guidelines on how to avoid creating conditions for mould growth and how to remove it from the space. The system will be designed to be as user friendly as possible, by being simple and easy to activate.

3.5.2 Functional requirements

This section lists and explains briefly the functional requirements that are part of the end product, and will be included in the final system.

The system must accomplish the following functional requirements:

Functional requirements	How this will be achieved
Sensors	Using sensors to monitor the environment

Monitor temperature over time	Using the external sensors, it will monitor the temperatures within closed spaces over time.
Monitor humidity over time	Using the external sensors, the system will monitor the humidity levels in closed spaces over time.
Monitor moisture over time	Using the external sensors, the system will Will monitor the moisture levels in potted plants in closed spaces over time.
Export the data to a rational database	Using the systems code and programming it will export the required data to a third-party database.
Create graphs	Pulling data from the database and creating graphs which will be a more user-friendly way to display the data rather than using raw data sets.
Display the data in graphs on a website	Using an external API the website will display graphic forms of the collated information.
Allow the user to analyse the data easily and clearly	The graphic displays along with other analyses will allow the user to interpret and analyse the collated data into practical findings.
Identify possible growth conditions for mould via research	Through the research conducted the system will have a baseline of information available to help identify the growth conditions of mould. This will allow the user to compare the acquired information from the sensors to data that will definitively alert them to mould growth conditions.

Figure 2: Functional requirements

The following diagram Use Case diagram sets out the framework or processes that will culminate in detecting and monitoring environmental conditions.

3.5.2 Use Case Diagram

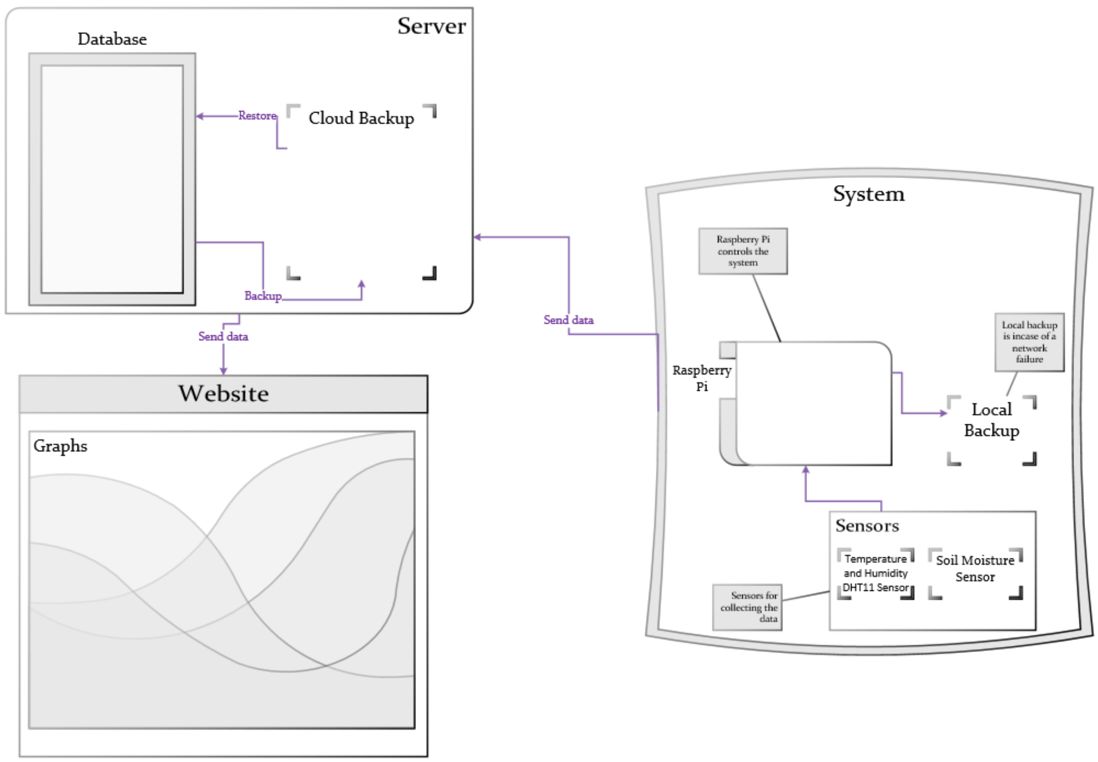


Figure 3: Use Case Diagram

The below table includes the requirements and the identification tags they have been given.

Use Case ID	Use Case Name	Complexity	Priority
UC1	Sensors for reading the environment	Low	1
UC2	Reading Temperature	Low	2
UC3	Reading Humidity	Low	3
UC4	Reading Moisture	High	4
UC5	Database	Medium	5

UC6	Graphs	High	6
UC7	Website	Medium	7

Figure 4: Table of Use Case Identification Tags

3.5.3 Requirement 1: Sensors for Reading Environment

Description & Priority

The sensors are part of the system, they read the environment for the temperature, humidity and moisture. They are hardware that is added in order to allow the system to measure these conditions and relay them to the Raspberry Pi, as shown in the Use Case diagram above. The Raspberry Pi cannot detect temperature or humidity without the sensors, therefore, this component is critical and necessary to the project's successful delivery and why it has been given high priority as a requirement for this system.

Use Case

The Use Case for the sensors will be identified as UC 1, because without the sensors the system would not be able to collect the readings needed. UC 1 will be the sensors which will read the environment.

Scope

The scope or purpose of UC1, the sensors, is to read the environment for the temperature, humidity and moisture, and convey the readings to the Actor, the Raspberry Pi, so that the Actor can export the collated data to a website and record, over time, conditions which can be compared to the known conditions for mould growth.

Description

This Use Case, UC1, describes how the Actor or Raspberry Pi and the sensors interact with each other.

3.5.4 Flow Description

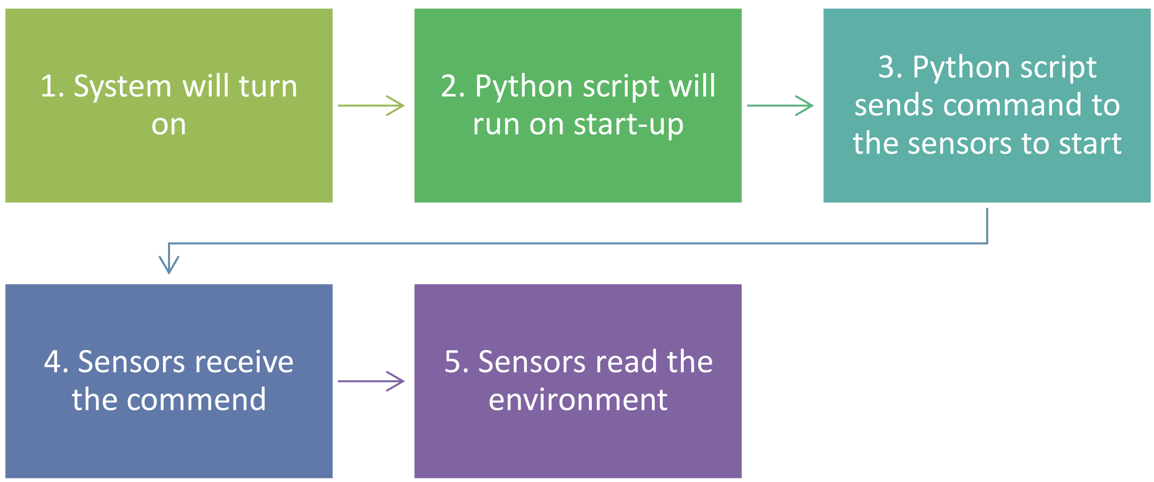
Precondition

The system, the Actor, gives the sensors, UC1, the command to read the environment. This is a key part of the system and relies on reliable hardware and customised software to logically monitor, relay and order the data collected.

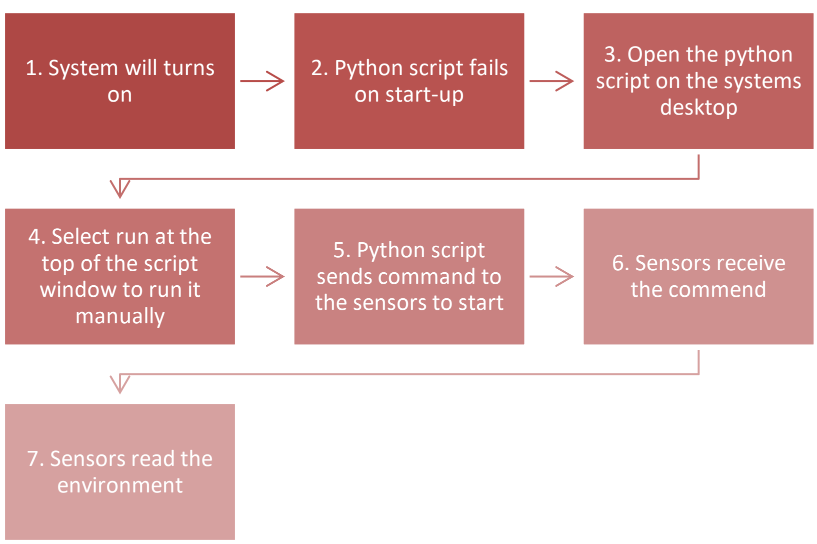
Activation

This use case starts when the Python script has been run on the Raspberry Pi. The Python Script allows the sensors to detect temperature and humidity in the environment and records the information on the Raspberry Pi hard drive. Without the Python script the Raspberry Pi could not communicate with the sensors and monitor the environment.

Main flow



Alternate flow



Termination

Once the system and the sensors have established a connection it will proceed to the next stage.

Post condition

The system will go in to a wait state, in which it waits for the next event, in this case requirement, to initiate the next task. The next task in the requirements is recording the temperature.

3.5.5 Requirement 2: Recording Temperature

Description & Priority

The requirement that the system records the environments temperature is a significant part of the system, as it is one part of the data collected which will indicate the conditions for example that lead to the growth of mould. It has been given high priority because it is an essential factor in mould growth, as the research shows that mould may be more likely to grow in colder spots or on the inside of external walls. The correlation between temperature and humidity are key to detecting possible mould growth conditions and UC2 is a critical part of gathering the necessary information to create the data sets that identify such conditions.

Use Case

The Use Case for temperature will be identified as UC2, because without monitoring temperature levels, in the environment, the system would not be able to accurately collect the readings needed.

Scope

The scope of UC2, Recording Temperature, is to collect the readings from the environment using the sensor to monitor the temperature of a confined space. When the Raspberry Pi has received the readings, it will store the readings in the database. Then the database will export the collated data to a website and record over time the conditions of the spaces chosen for testing and operation.

Description

This use case describes how the temperature and the sensors interact with each other and how the Actor receives, records and stores the information.

3.5.6 Flow Description

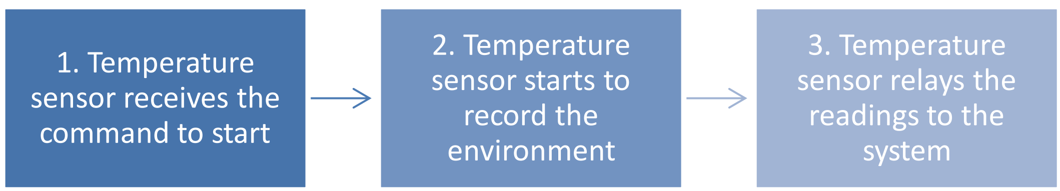
Precondition

The sensors, UC1, will read the environment to determine the temperature and then relay the temperature of the environment to the Raspberry Pi, which is the Actor.

Activation

This use case starts when the sensors have established a connection with the Raspberry Pi. The sensors will begin to read the environment to detect temperature in the environment and records the information on the Raspberry Pi hard drive.

Main flow



Termination

Once the sensors have read the environment temperature and stored the readings locally, it will proceed to the next stage.

Post condition

The system will go in to a wait state, in which it waits for the next event, in this case requirement, to initiate the next task. The next task in the requirements is recording the humidity.

3.5.7 Requirement 3: Recording Humidity

Description & Priority

Humidity is another important part of the system, as it is the other portion of the data collected which will be used to create a complete set of data so that the user can detect mould growth conditions.

Use Case

The Use Case for humidity will be identified as UC3, because without the humidity, the system would not be able to collect the readings needed.

Scope

The scope of UC3, Recording Humidity, is to collect readings from the environment which are humidity levels within student housing. As the Raspberry Pi receives the readings, it will store the readings in the database. Then the database will export the collated data to a website and record over time the conditions for or against mould growth.

Description

This use case describes how the humidity and the sensors interact with each other.

3.5.8 Flow Description

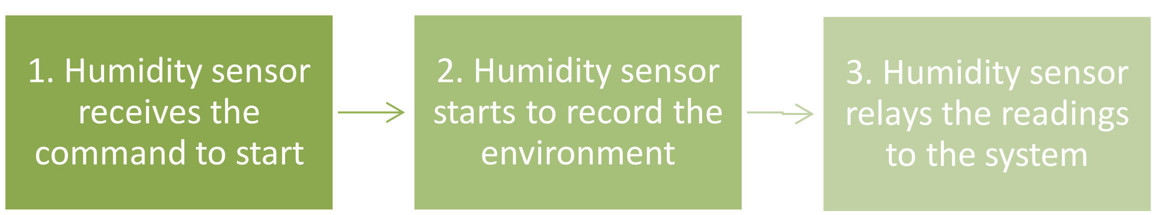
Precondition

The sensors read the environment to determine the humidity and then relay this information to the Raspberry Pi, which is the Actor.

Activation

This use case starts when the sensors have established a connection with the Raspberry Pi. The sensors will begin to read the environment to detect humidity in the environment and records the information on the Raspberry Pi hard drive.

Main flow



Termination

Once the sensors have read the environment humidity and stored the readings locally, it will proceed to the next stage.

Post condition

The system will go in to a wait state, in which it waits for the next event, in this case requirement, to initiate the next task. The next task in the requirements is recording the environment for moisture.

3.5.9 Requirement 4: Recording Moisture

Description & Priority

Moisture is vital to the system, as it is part of the data collected to be able to detect mould growth. Moisture is an important factor in mould growth, and the research suggests that temperature and moisture together allow for the growth of mould.

Use Case

The use case for moisture will be identified as UC4, because without the moisture the system would not be able to collect the readings needed.

Scope

The scope of this use case, moisture, is to collect readings of moisture levels from the environment. When the Raspberry Pi has received the readings, it will store the readings in the database. Then the database will export the collated data to a website and record over time the conditions for or against mould growth.

Description

UC4 describes how the moisture and the sensors interact with each other.

3.5.10 Flow Description

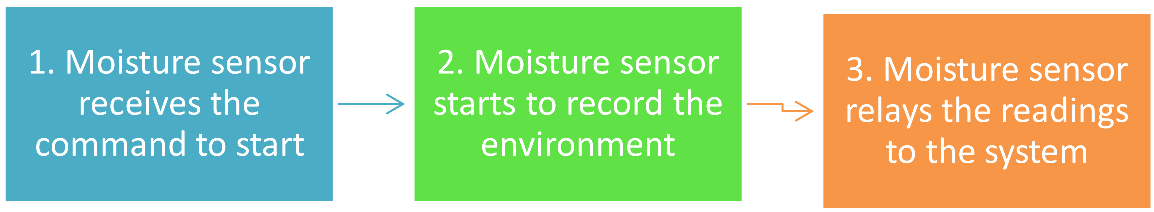
Precondition

The sensors will read the environment to determine the moisture and then relay the collected data to the Raspberry Pi, which is the Actor.

Activation

This use case starts when the sensors have established a connection with the Raspberry Pi. The sensors will begin to read the environment to detect moisture in the environment and records the information on the Raspberry Pi hard drive.

Main flow



Termination

Once the sensors have read the environment moisture and stored the readings locally, it will proceed to the next stage.

Post condition

The system will go in to a wait state, in which it waits for the next event, in this case requirement, to initiate the next task. The next task in the requirements is storing the environment readings in the database.

3.5.11 Requirement 5: Database

Description & Priority

The database is a key component to the system, as it is the part of the system that stores the collected data so it can be analysed at a later date. This is an important part of the process, as the information gathered by the sensors and Raspberry Pi is sent to the database and must be interpreted properly in order for the information to display correctly on the website.

Use Case

The use case for database will be identified as UC 5, because without the database the system would not be able to store the collected readings needed.

Scope

The scope of this use case, database, is to store the readings form the environment. The Raspberry Pi has sent it after collecting the readings from the sensors. The information collected when transferred to the database will be ordered correctly and displayed on the website in graphical form.

Description

This use case describes how the sensors and the database interact with each other.

3.5.12 Flow Description

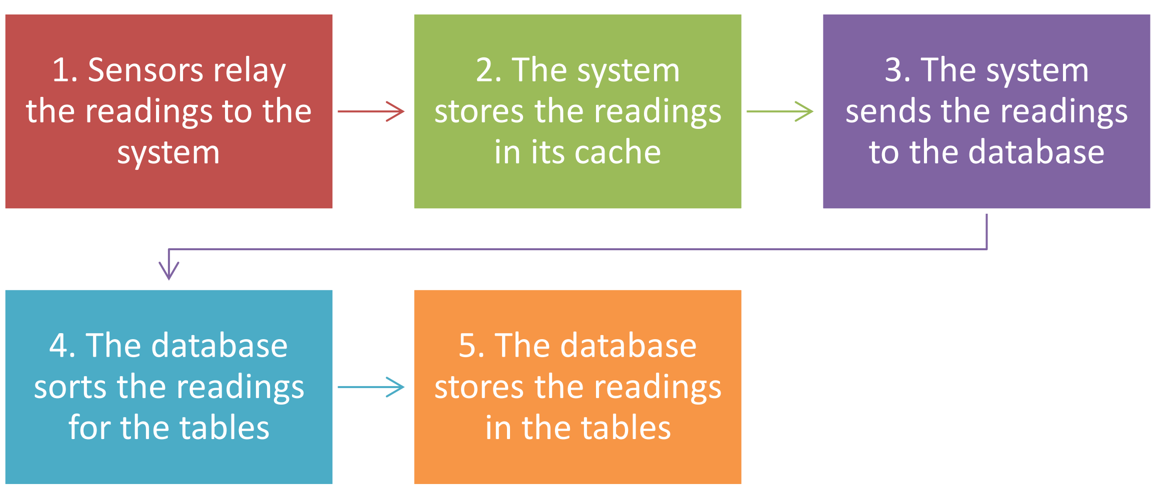
Precondition

Once the sensors have collected the readings, they will then send the readings to the database

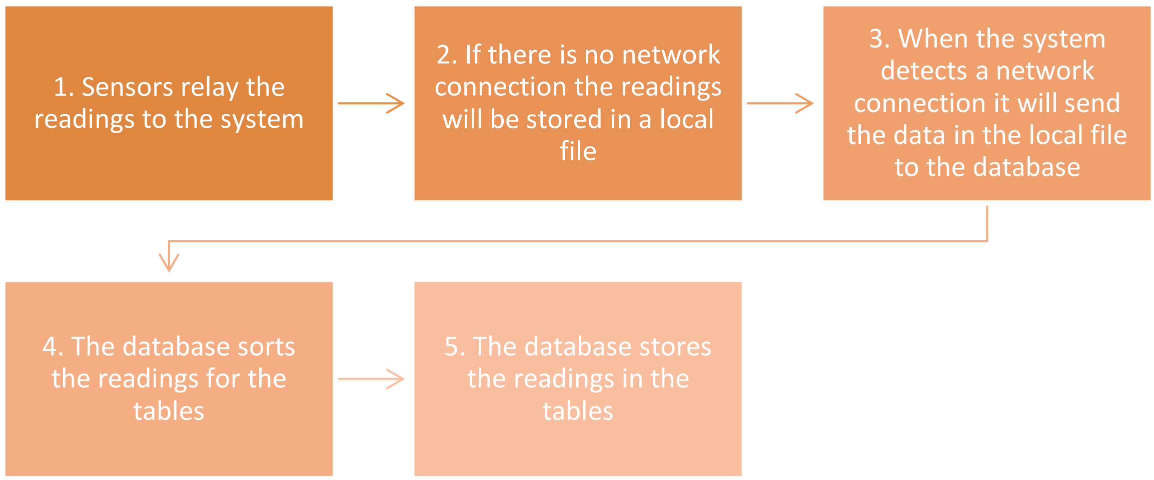
Activation

This use case starts when the sensors have collected the environmental readings they store them in a database to be reviewed.

Main flow



Alternate flow



Termination

Once the database has received and stored the readings of the environment, it will proceed to the next stage.

Post condition

The system will go in to a wait state, in which it waits for the next event, in this case requirement, to initiate the next task. The next task in the requirements is storing the database information in graphs.

3.5.13 Requirement 6: Graphs

Description & Priority

The graphs are a key component of the system, as the will display the data in a user friendly interface for the client. The graphs supply the information to the clients in a clear and easy to understand manner, therefore it is important to transfer the information into the graphs correctly for the information to be reliable and accurate.

Use Case

The use case for graphs will be identified as UC 6, because without the graphs the client would not be able to view the readings in a logical and utilisable way.

Scope

The scope of this use case, graphs, is to display the data which is stored in the database. This is the chosen method with which to display the collated data as the graphs may allow the client to make sense of and interpret the information more easily.

Description

This use case describes how the database and the graphs interact with each other.

3.5.14 Flow Description

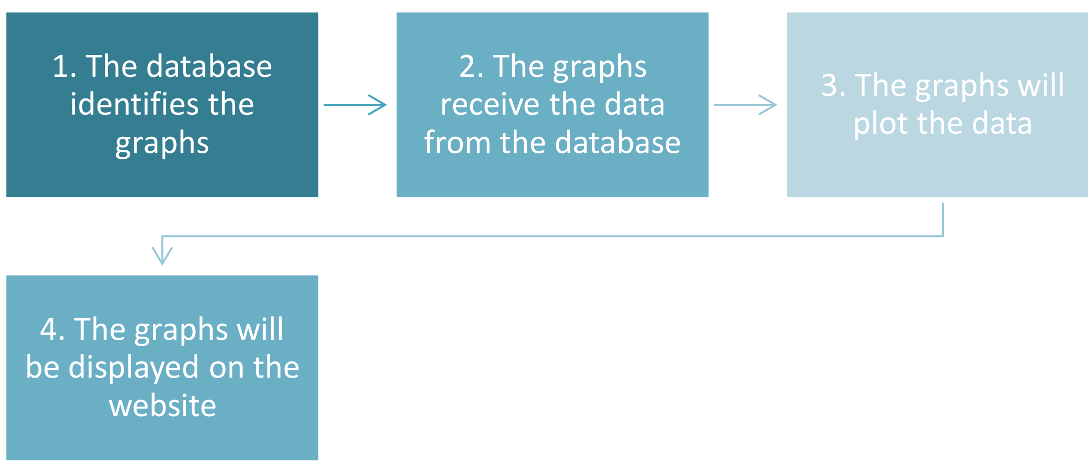
Precondition

Once the data has been stored in the database, it will then be pulled from the database and will be displayed in the graphs.

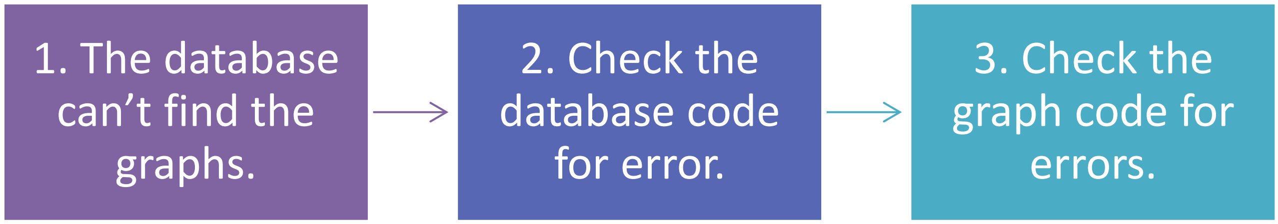
Activation

This use case starts when the database has stored the readings from the sensors. The database will then proceed to send the data to the graphs.

Main flow



Alternate flow



Termination

Once the graphs have received the data from the database the graphs will display the data, it will proceed to the next stage.

Post condition

The system will go in to a wait state, in which it waits for the next event, in this case requirement, to initiate the next task. The next task in the requirements is displaying the on the website.

3.5.16 Requirement 7: Website

Description & Priority

The website is the final part of the system, the website will allow the client to view the graphs form any device. The graphs will be transferred from the database to the website where the client can view them. The website is important as it is client facing, must be easy to use and be reliable and bug free.

Use Case

The use case for website will be identified as UC 7, because the website gives the user the opportunity to view the collected data in a meaningful and clear way through the graphs.

Scope

The scope of this use case, website, is to display the graphs in a user friendly interface. The user friendly interface gives the clients the best opportunity of interpreting the information the system has collected over time.

Description

This use case describes how the graphs, sensors and the user interact with each other.

3.5.17 Flow Description

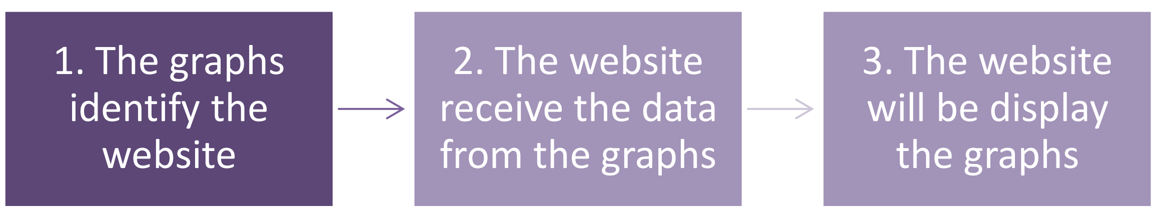
Precondition

Once the graphs have had the data inputted into them, they will then be displayed on a website.

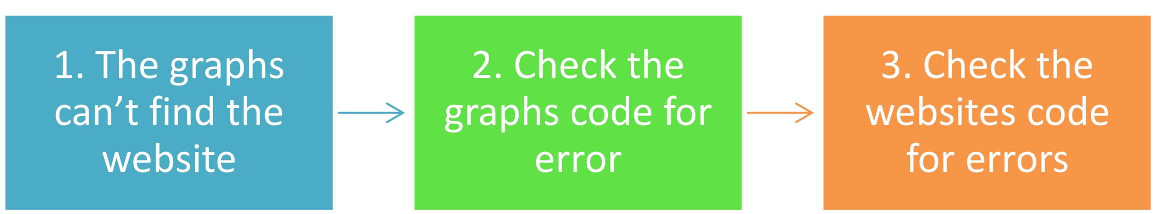
Activation

This use case starts when the graphs received the data from the database. The graphs will be displayed on the website.

Main flow



Alternate flow



Termination

Once the graphs have mapped the data from the database they will be accessible on the website, this is the final stage.

Post condition

The system will go in to a final state, in this case requirement, to initiate the next task. The next task in the requirements is displaying the graphs on the website.

3.6 User requirements

The user or client for this system is the landlord of student accommodation, the students living in the accommodation or the authorities that monitor student housing. Therefore, the system must be user friendly, taking into account the possibility that the client may not be capable of running a highly technical piece of software. Below the user requirements are defined;

- To be able to detect conditions that have the potential to breed mould or make it worse.
- To collect and analyse the data that is monitored by the sensors.
- To identify mould growth conditions.
- To be able to view the collected data.

3.6.1 Usability requirements/ Non-Functional Requirements

Accuracy

The system uses sensors that are specifically made to gauge temperature and humidity. These sensors can be used to measure the temperature or humidity in air or in soil. The specified accuracy for the sensors is outlined below.

- Good for 20-80% humidity readings with 5% accuracy
- Good for 0-50°C temperature readings ±2°C accuracy

Recovery requirement

The system will need to store data, so the data will need to be backed up this will be achieved by using phpMyAdmin as it will be the provider for the database and it has a backup built in. PhpMyAdmin will back up the database to a SQL file and store the file on google drive, the system will also use Google tools to log the data to Googles spread sheet to store the data as well. The system will be housed in a custom-made box and placed on the wall to avoid physical damage.

Security requirement

The security requirement for this system is a login system so the sensor data is protected for each individual client. The custom case for the system will be fitted with a lock and only certain personal will have a key so it can’t be physically tampered with.

Reliability requirement

The programming and design will provide the necessary reliability for the user, ensuring that the lowest risk of technical issues is attained.

Maintainability requirement

The system needs to be low maintenance to keep the cost down, that is why the Raspberry Pi was chosen as it is low cost and easy to maintain. The sensor that will be used are very low cost as well and requires little input from the client as the process is highly automated. The client need only switch on the Raspberry Pi system and allow the software to run. The Python script will be set up to run the moment the system is fully booted up, this will reduce the training needed for the client to run it.

Portability requirement

The system will be small and light, while being protected by a casing, making it portable for use in different environments.

Reusability requirement

The system will be reusable, and when a client no longer needs or wants the system it can be set up for a different client.

User friendly

The system will be user friendly due to the simplicity and functionality of the product. The website and database will also help to achieve a high level of user responsiveness through the user interface.

3.7 Design and Architecture

The following system architecture was chosen as it is the most effective and efficient way to find the conditions for mould, while also being created at an affordable price. The framework used is shown below in the diagram and outlines the project processes.

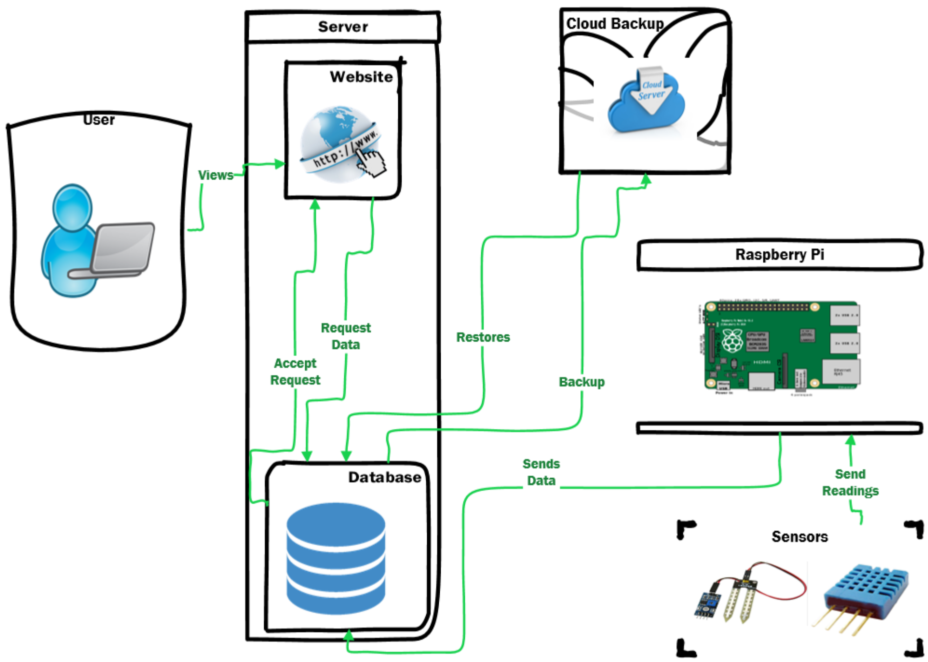


Figure 2: System Architecture

3.8 General overview and approach

System design

This section will describe in detail how to set up the hardware and how to run the python script to collect the data from the sensors. To install the Raspbian operating system on the Micro SD card visit the following website.

https://www.raspberrypi.org/documentation/installation/installing-images/

Hardware setup

Step 1

The first step is to gather the components required shown in figure below, which are as follows Raspberry pi, Micro SD card 8GB or larger, non-solder breadboard, DHT22 sensor, three male to female jumper wires and a 10k ohm resistor.

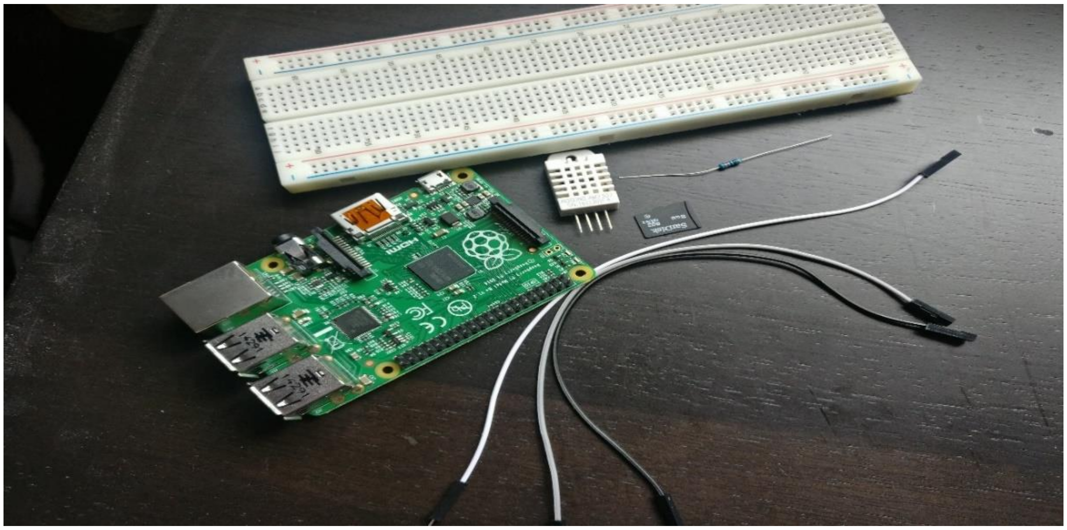


Figure 6: Raspberry Pi Components

Step 2

In this step place the DHT22 sensor in the non-solder breadboard see figure below.

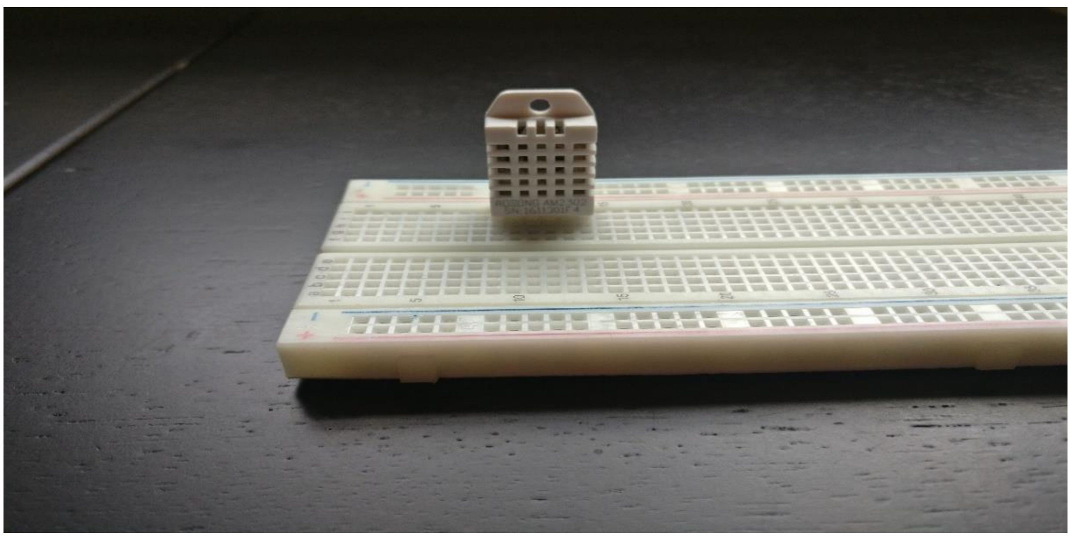


Figure 7: Sensor on Breadboard

Step 3

Now we need to connect the DHT22 sensor to the raspberry pi. First place the male end of the jumper wire into the non-solder breadboard at the first pin of the DHT22 sensor this is the power pin *see* figure below. Next take the female end of the jumper wire and place on the 3.3V pin on the Raspberry Pi see figure below white wire is the power line for this assembly.

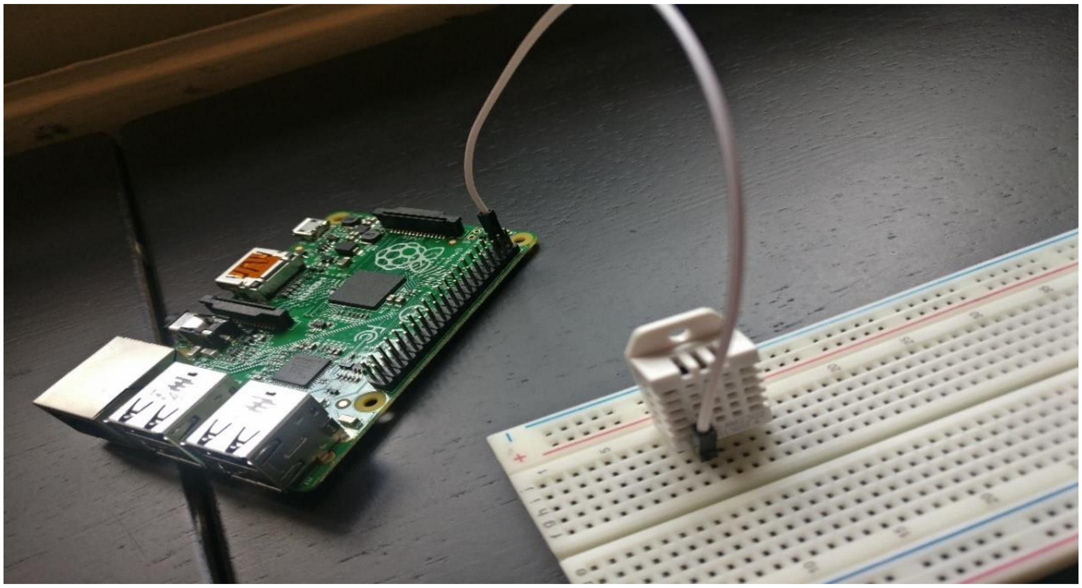


Figure 8: Pin to 3.3V Pin

Now place the male end of the jumper wire into the non-solder breadboard at the second pin of the DHT22 sensor this is the data pin see figure bellow. Next take the female end of the jumper wire and place on a GPIO pin on the Raspberry Pi, pin 22 was chosen for this assembly. See figure below grey wire is the data line for this assembly.

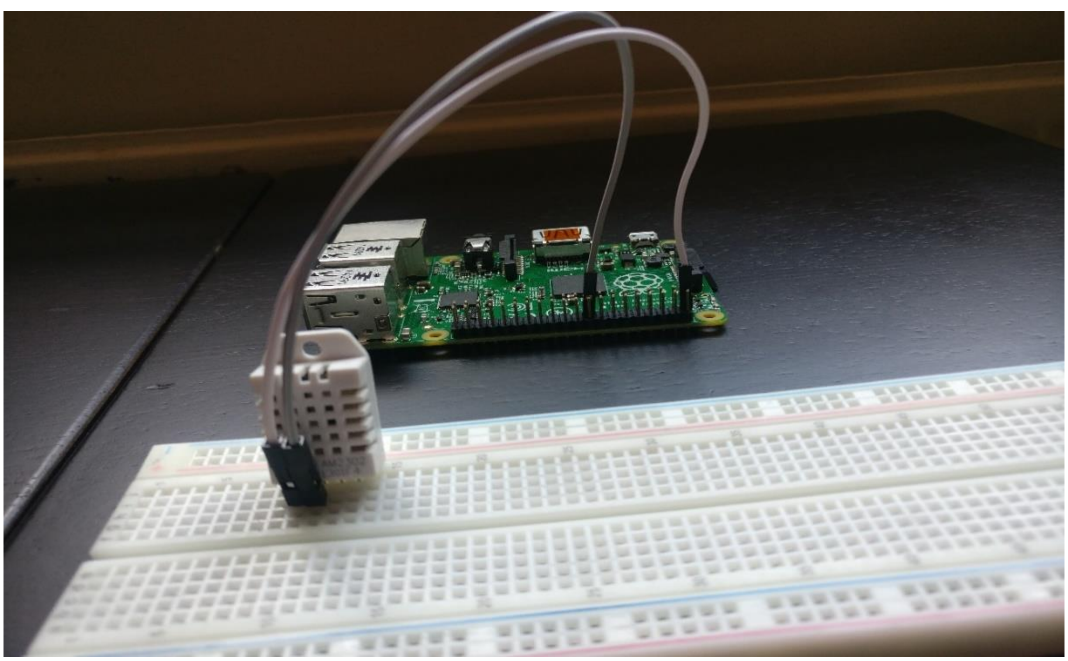


Figure 9: Pin 2 to GPIO Pin 22

We skip pin 3 of the sensor as it is not needed for this assembly. Place the male end of the jumper wire into the non-solder breadboard at the forth pin of the DHT22 sensor this is the ground pin see figure bellow. Next take the female end of the jumper wire and place on one of the ground pins on the Raspberry Pi see figure below black wire is the ground line for this assembly.

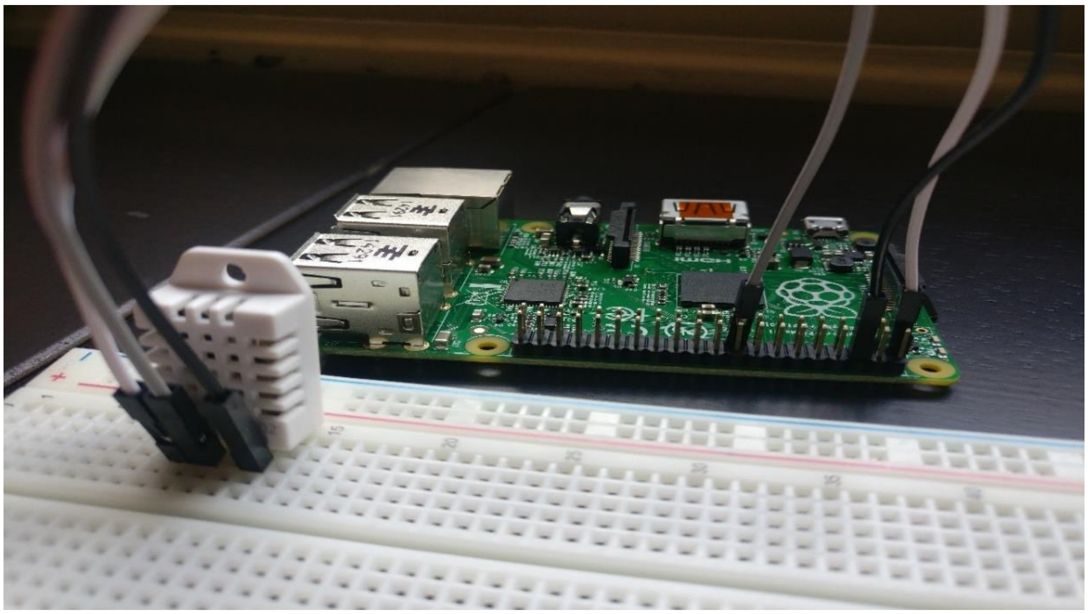


Figure 10: Pin 4 to Ground Pin

The final step is to add a 10K ohm resistor between the pin 1(power line) and pin 2(data line). See figure below.

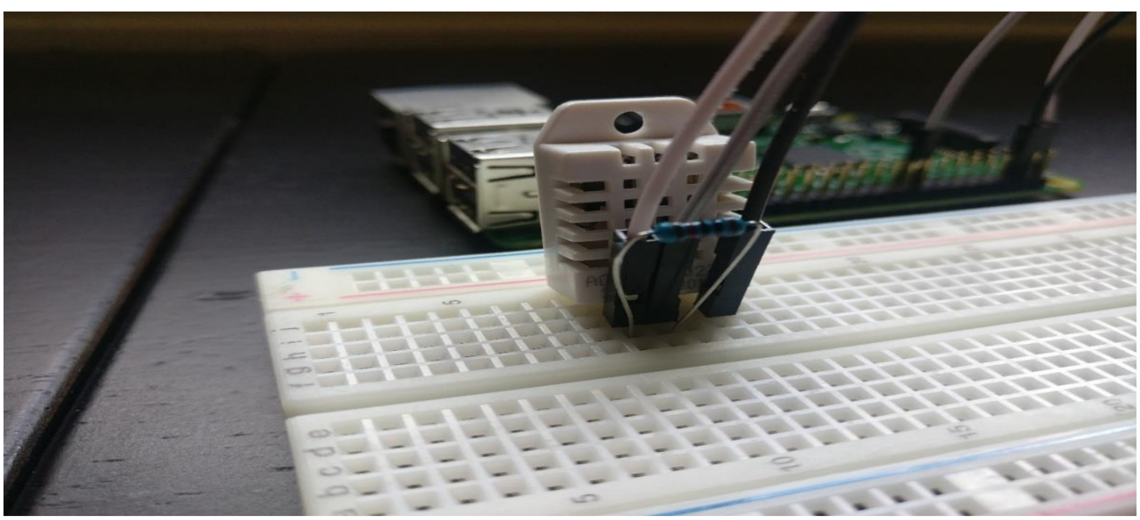


Figure 11: 10K ohm Resistor Between Pin 1 and 2

3.9 Software setup

Step 1

The first step is to open the terminal and make sure you are in the root folder to achieve this type the following command

“cd /home/pi”

Now install the Initial State drivers so the code can be sent to the dashboard type the following command.

“sudo apt-get install gcc python-dev”

Step 2

In this step, we will install the Adafruit library for the DHT22 sensor, first type the following command to clone the Adafruit library.

“git clone https://github.com/adafruit/Adafruit_Python_DHT.git”

next we need to be in the Adafruit_Python_DHT folder to install the Python library type the following command to achieve this

“cd /Adafruit_Python_DHT”

Now we need a few dependencies to be able to use the Adafruit library, type the following command to install these dependencies.

“sudo apt-get update”

“sudo apt-get install build-essential python-dev python-openssl”

Now we can install the Adafruit library by typing the following command.

“sudo python setup.py install”

Step 3

Now we need to test that the everything is working, to do this we need to be in the examples folder of the Adafruit library type the following command to enter the examples folder.

“cd examples”

Now run the example Python script. 2302 is the name on the DHT22 sensor and 22 is the pin chosen. Type the following command

“sudo ./AdafruitDHT.py 2302 22”

If everything worked you should see a reading of the temperature and humidity.

Step 4

In this final step, we run the Python script once it has been fully finished. To see the full script, see the appendix section 6.2. To run the script, type the following command.

“sudo python /home/pi/mould-catcher-house-1.py”

3.10 Auto running Python script

To set up the Python script to run when the Raspberry Pi boots up, open the terminal and type the following command to open the profile file.

“sudo nano /etc/profile”

Once the profile has opened scroll all the to the bottom and type the following command, this will tell the Raspberry Pi where to look for the Python script where to locate the file.

“sudo python /home/pi/ mould-cathher-house-1.py”

Now type” Ctrl+x” to exit the file then type “Y” to save then hit “Enter” to exit and finally reboot the system and the Python script will run automatically.

3.11 Application program interfaces

Concept Graphical User Interface (GUI) Layout

The GUI is the frontend, or client facing, part of the software or project, where the client can view the information in various forms, such as graphs or tables. For this project, the concept GUI is a website that will display graphical information relating to the humidity, temperature and moisture conditions in the clients space.

The five pages of the concept GUI or in other words the website are listed below;

- Home Page
- Registration Page
- Temperature Page
- Humidity Page
- Moisture Page
- Mould Information Page
- Contact us Page

The data collected by the sensors will be exported from the database to graphs which will be displayed on these pages. The data will pulled from the database using SQL, HTML5, CSS, JSON and JavaScript. The JSON and SQL will pull the data from the database, then using HTML5 and CSS the data will be displayed in charts on the site.

The above pages will be linked using navigation bar with five buttons that when clicked will display the appropriate page and information. The navigation bar will be coded with a combination of HTML5 Hyperlinks and CSS.

Home Page

The home page will be the main page of the website, and will be the first page the client encounters. On the page there will be seven buttons in a navigation bar with links behind them that link the buttons to the other pages, thus allowing the client or user to navigate easily through the website. A simple mock-up version of the page can be seen below.

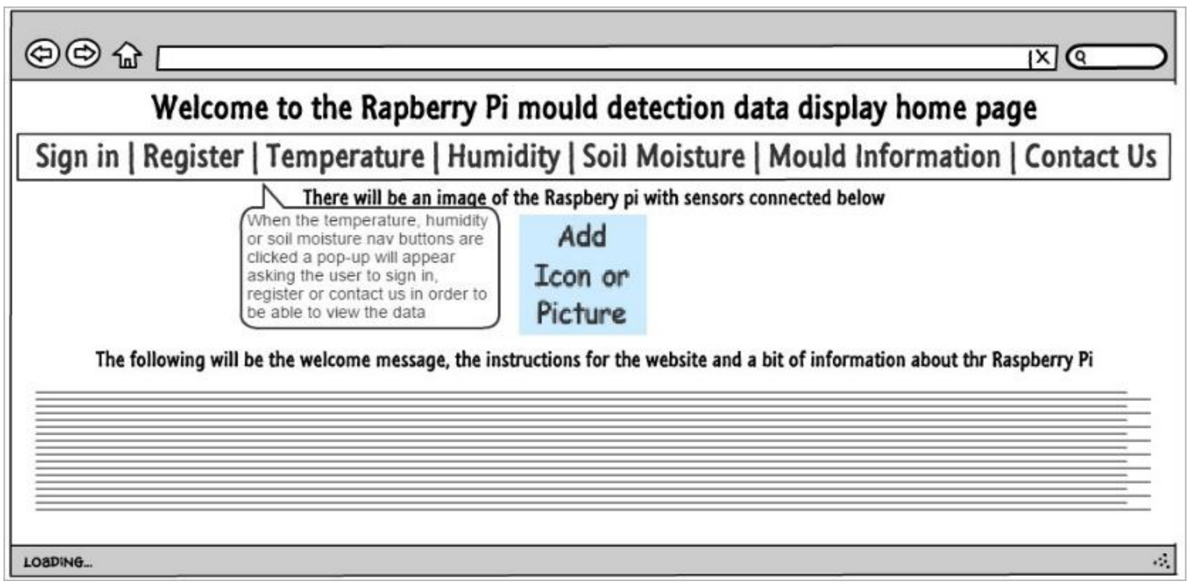


Figure 12: Home page

Sign-in page

The sign in page is the same layout as in figure 3 the only difference is when the sign in button is clicked a pop up menu displaying the username and password input fields, see figure 4. It allows the client to sign-in and view their personal information and the data collected from their target environment.

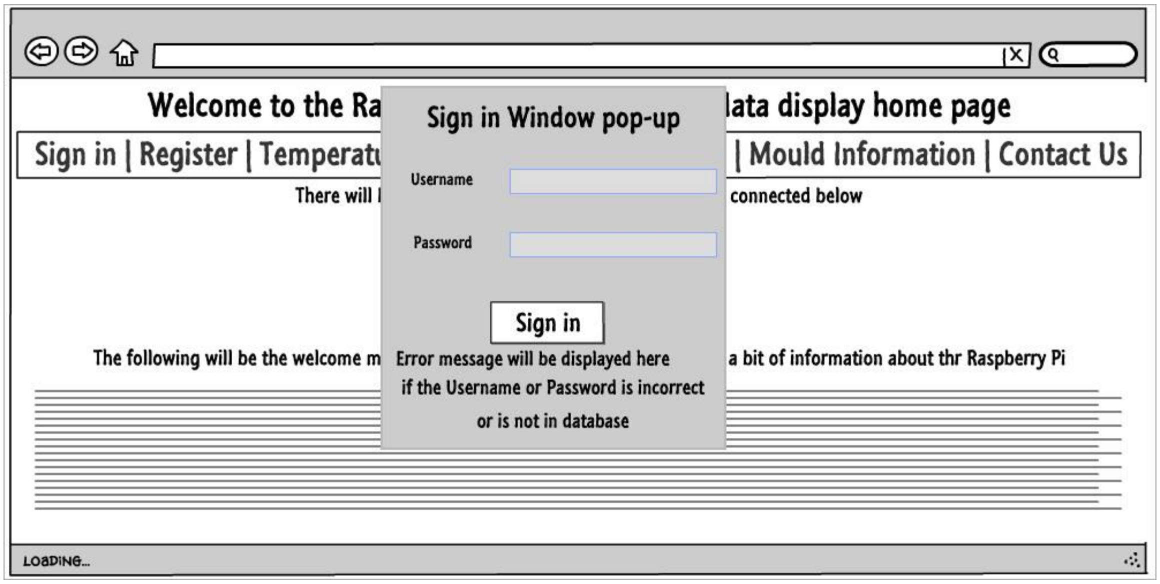


Figure 13: Sign-in page

Registration Page

The registration page will have seven buttons on the navigation bar to link all the pages of the site. This page is where the client will input their information to create an account, see figure 5. The information will be stored in the database and protected according to data protection legislation.

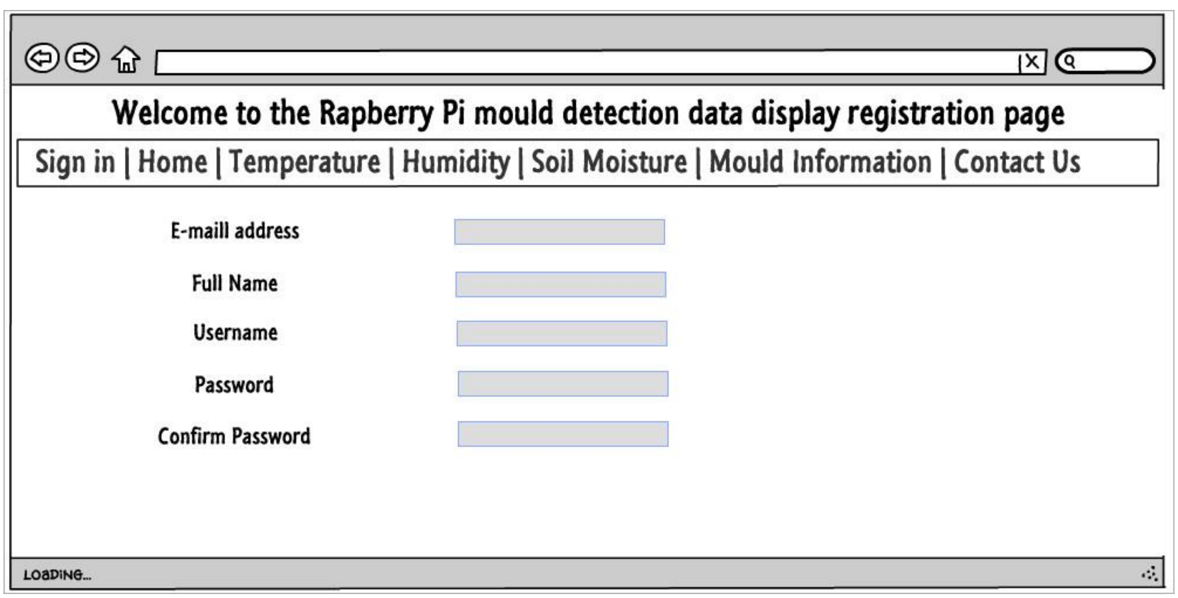


Figure 14: Registration page

Temperature Page

The temperature page will have seven buttons in the navigation bar, in order to allow the client to navigate the website without having to revert to the home page. It will also feature the graphical data relating to the temperature ranges of the clients spaces. The temperature page can only be accessed with an account and login details.

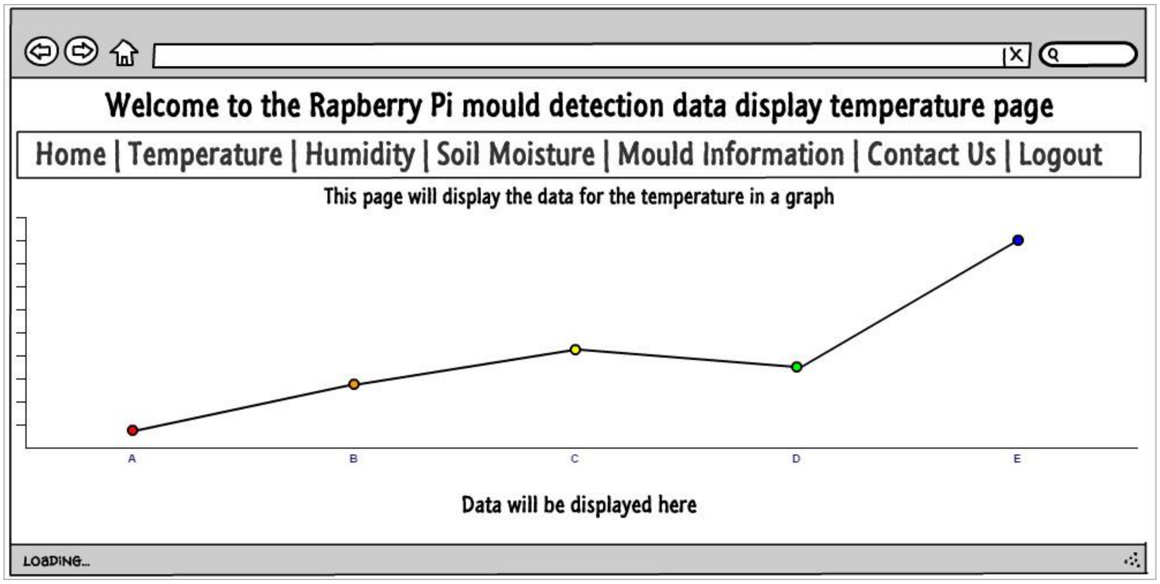


Figure 15: Temperature page

Humidity Page

The humidity page will have seven buttons in the navigation bar, in order to allow the client to navigate the website without having to revert to the home page. It will also feature the graphical data relating to the humidity ranges of the clients spaces. The humidity page can only be accessed with an account and login details.

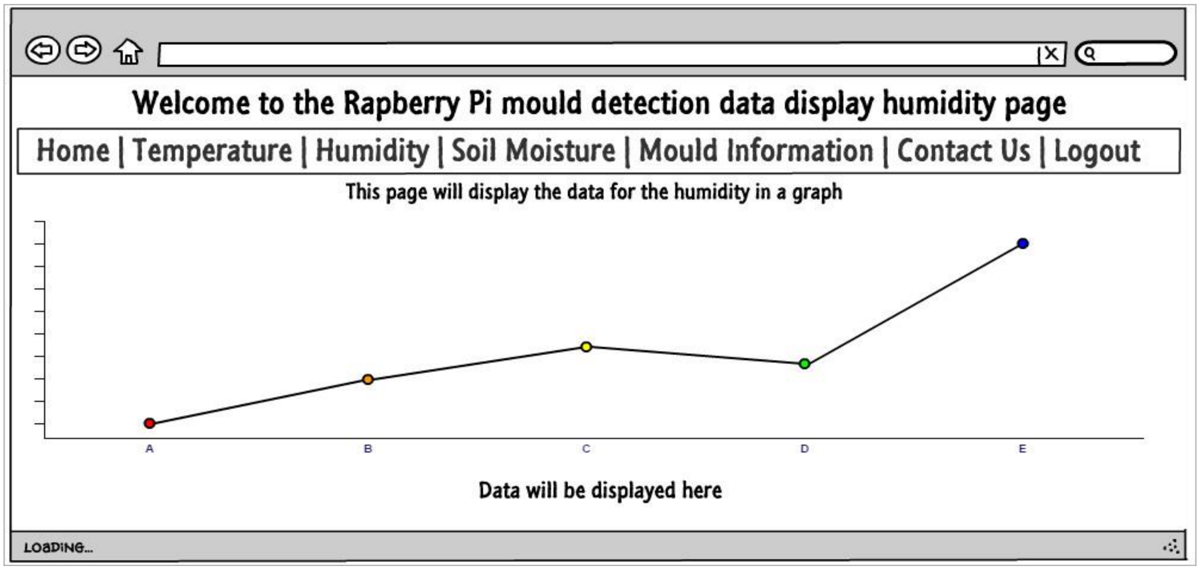


Figure 16: Humidity page

Moisture Page

The moisture page will have seven buttons in the navigation bar, in order to allow the client to navigate the website without having to revert to the home page. It will also feature the graphical data relating to the moisture ranges of the clients spaces. The moisture page can only be accessed with an account and login details.

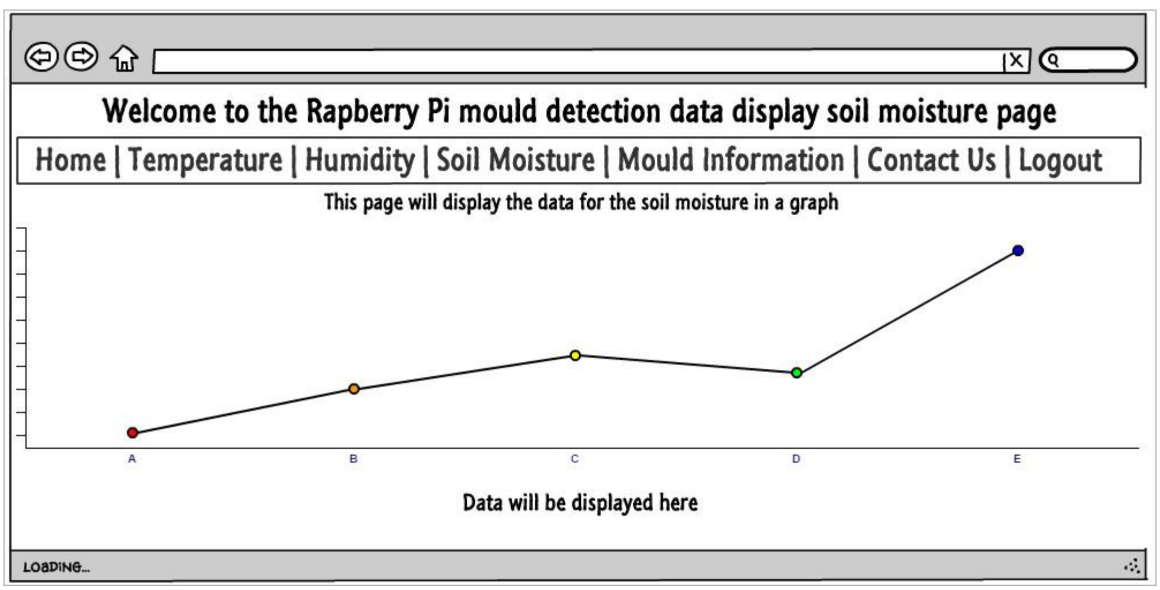


Figure 17: Soil moisture page

Mould Information Page

The moisture page will have seven buttons in the navigation bar, in order to allow the client to navigate the website without having to revert to the home page. This page will have detailed information on mould and mould prevention.

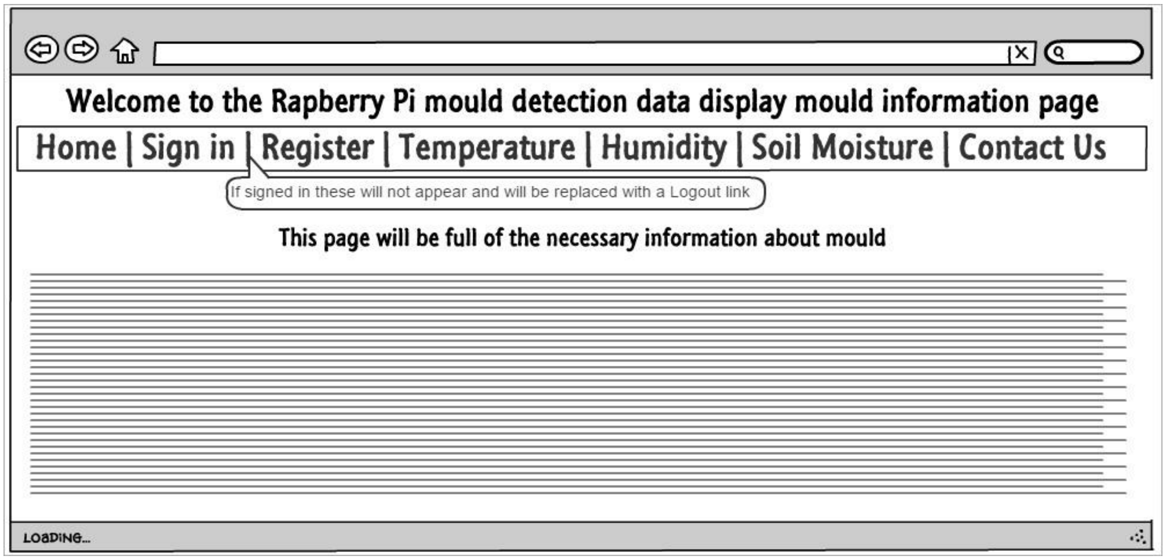


Figure 18: Mould Information page

Contact us Page

The contact us page will have seven buttons in the navigation bar, in order to allow the client to navigate the website without having to revert to the home page. This page will allow the user to send the administrator a message.

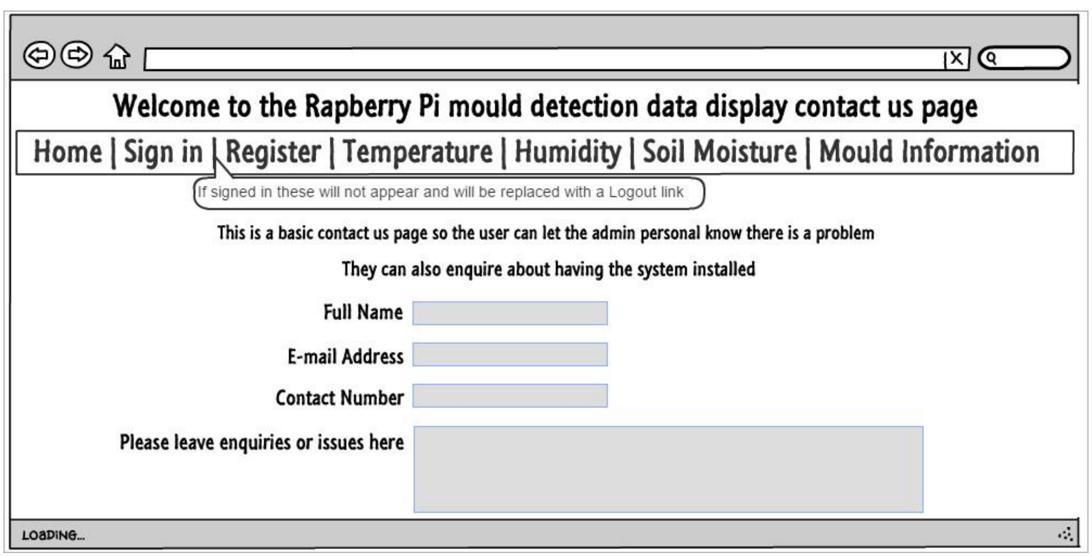


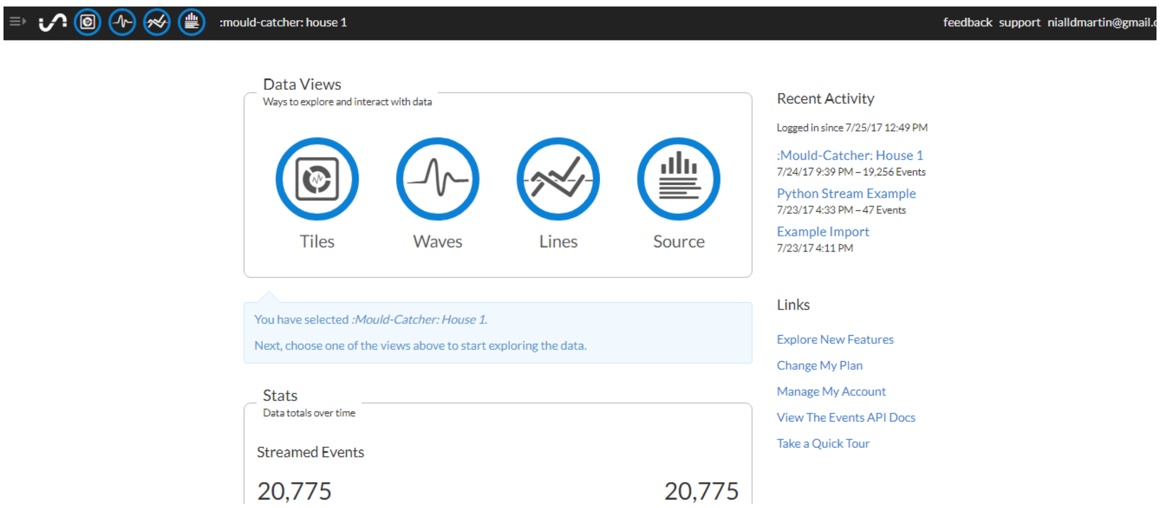
Figure 19: Contact us page

3.12 Final GUI

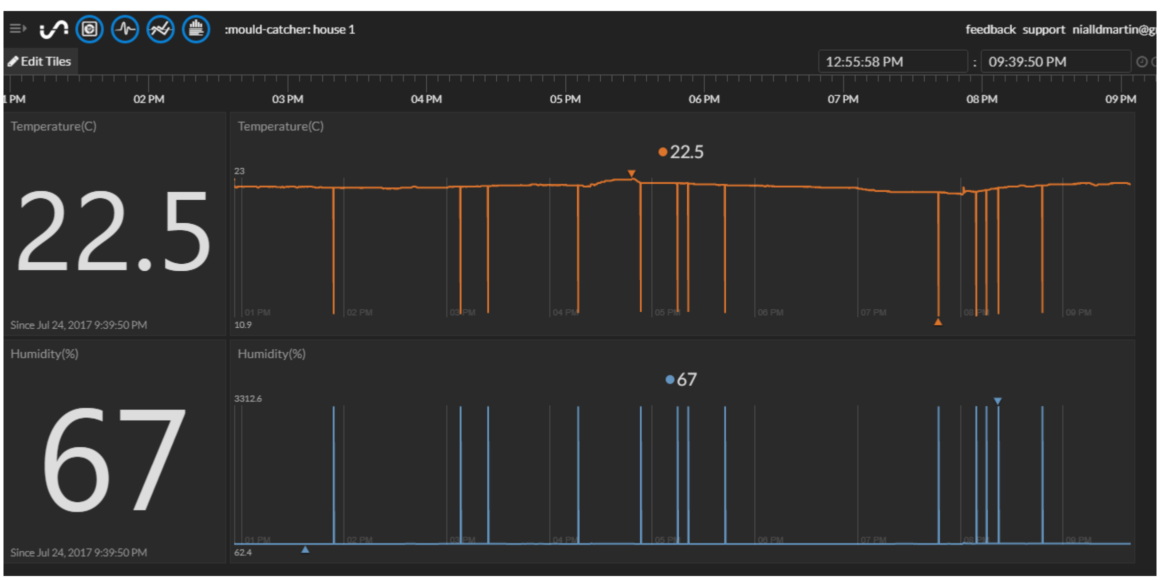
The final GUI is somewhat different from the original concept seen above, it is a simplified version that is easier for the client to use. This consists of a Home page, Tile page, Waves page and Line page, which display the Raspberry Pi's collated information from the environment in which it will be running.

This page will give you four display options Tiles, Waves, Lines and source. When any of the options are chosen it will display the readings in different visual ways as shown in the figures below.

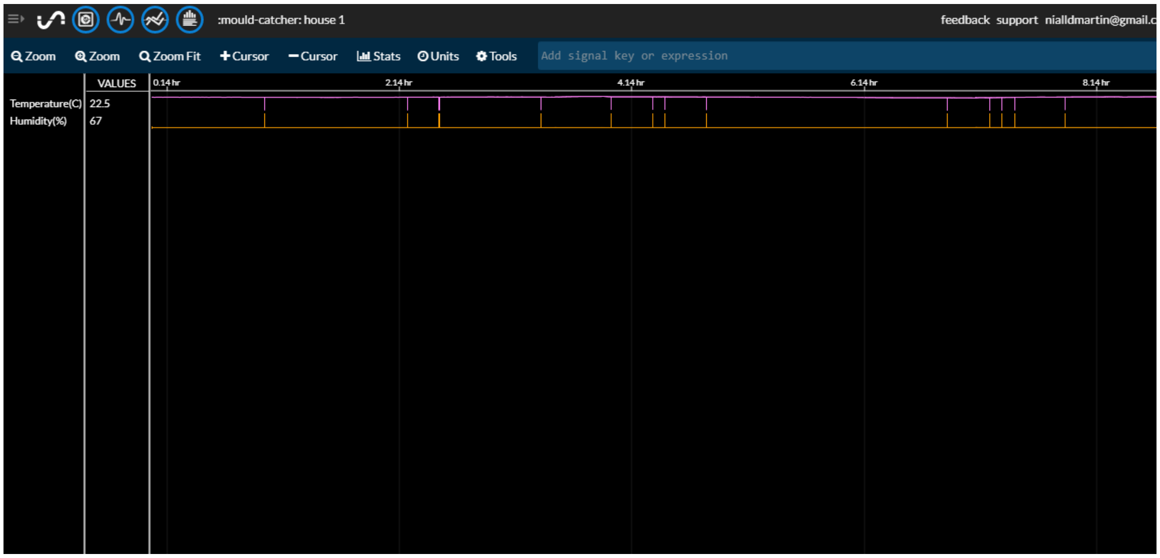
Homepage



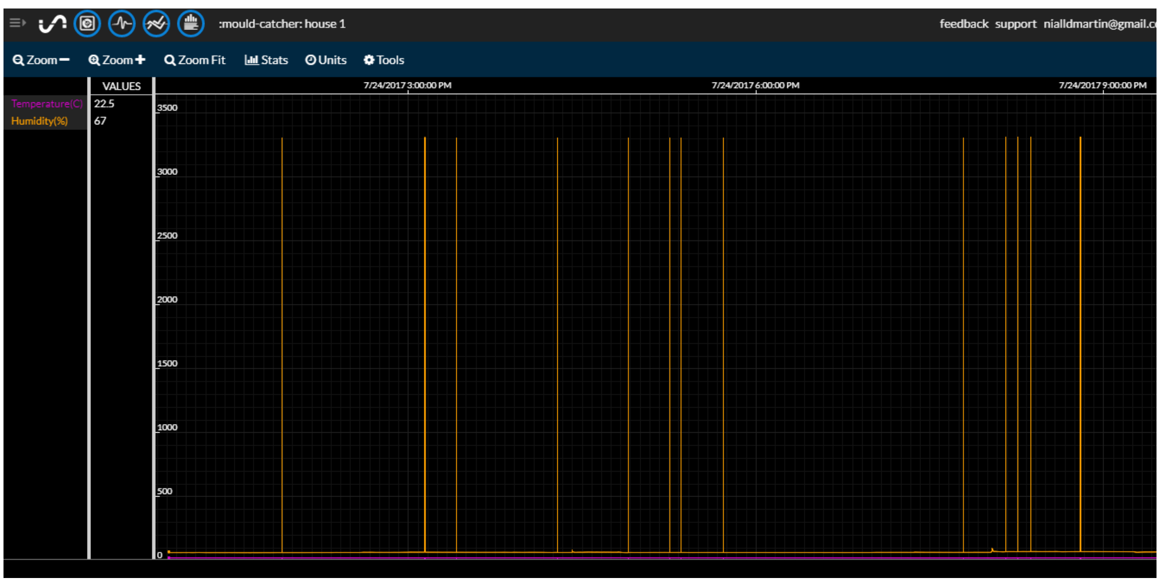
Tiles Page



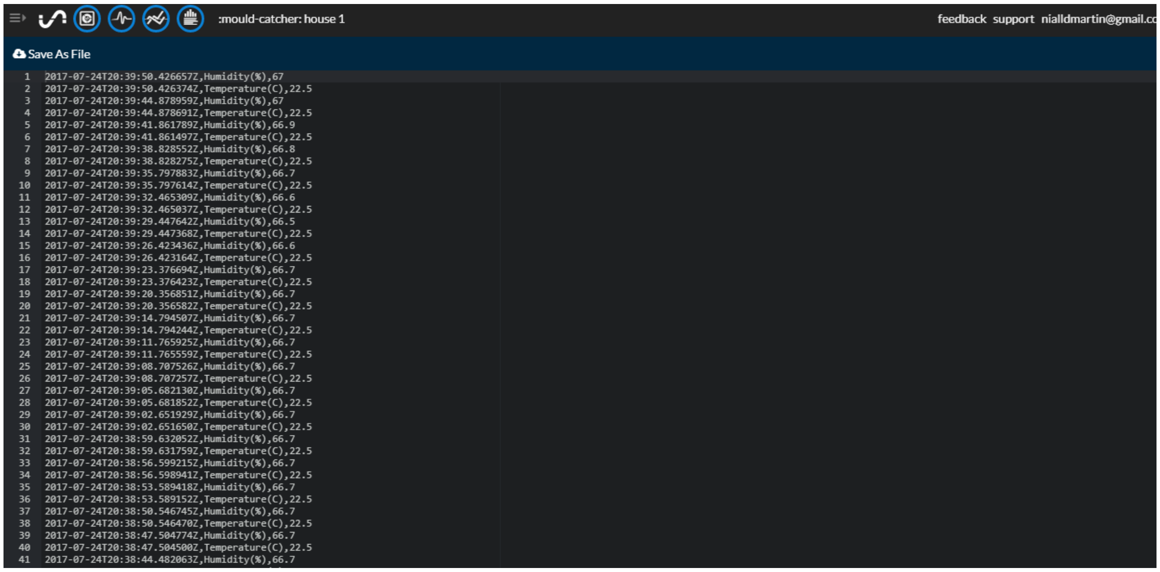
Waves Page



Lines Page



Source Page



3.13 Testing

The first testing stage was to see how accurate the DHT22 sensor was at reading the temperature and humidity of the environment. This was achieved by placing a Hygro-Thermometer in the room where the DHT22 sensor was reading and comparing the results with each other. The findings were the DHT22 sensor was never more than .2 of a reading of difference.

The second testing stage was to see how users could interact with the Raspberry Pi interface, this include how to turn it on, how to find the terminal, how to type, run the command if the auto run failed, stop the script from running and shut down the Raspberry Pi. candidates of low, moderate and high computer skills were chosen to teach and see how long training would take. The recommendation for training is two days as the candidates chosen all picked it up very quickly and by the end of the first day were able to run the Python script without any help.

Chapter 4

Conclusions and Recommendations

4.1 Conclusion

In conclusion, the Raspberry Pi performs well as a device which monitors environmental conditions, it can also be repurposed if needed to complete other tasks and be used possibly for other unrelated projects, therefore it is cost effective to a company who possesses them. The task the Raspberry Pi had to complete during this current project was to monitor the environment, temperature and humidity, and report this information to the next stage. It does this task efficiently; the sensors and hardware are easily installed to modify it to perform as such. The software was certainly more difficult as the programming language was unfamiliar to this student and was a lesson in coding with new technologies. The Raspberry Pi's performance as a sensor device was flawless, any problems that were encountered were down to other factors such as internet or human error with the coding and database. The Raspberry Pi is an affordable device that can do so much from a weather station to a home security device, there are so many different sensors out there and with IoT gaining more popularity who knows where the Raspberry Pi and its sensors will evolve. The detection accuracy from the DHT22 sensors is very reliably. it will read 0-100% humidity with an accuracy within 2-5% and it will read from -40-125 degrees Celsius. This aloud the user to monitor the environment for the conditions the allows mould to grow and take early actions to prevent it.

Advantages

- Low cost
- Size and portability
- Low power consumption.
- Most of the software is free or open source this allows for learning expansion
- It allows direct accessible processor pins through GPIOs.
- Has a simple server for light internet traffic.
- Great for prototyping

Disadvantages

- Demands knowledge of Linux.
- Coding can be difficult.

4.2 Recommendations

This author would make the following recommendations if this project were to be attempted again in the future. These recommendations are explained as to improve the system and its design for future projects and to try to avoid the same pitfalls experience in this attempt.

One of the recommendations that would improve the time management and efficiency of the project might be to try the development in a different language than Python, such as ruby on rails as it offers a more dynamic database and web development structure.

One of the biggest pitfalls of this project is time management, as the errors and difficulties in programming in Python for the first time has delayed the development of the project significantly. The recommendation in this case may be to give a longer project timeline or change the programming language.

4.3 Further development or research

This system could eventually evolve in to a full weather system, by adding more sensors and placing it outside, by taking the outside weather into account and measure how much it affects the temperature and humidity inside the building.

It could be permanently installed in a building as a temperature and humidity measure, with sensors in each room. This system could be applied in the health care sector, schools or domestic settings where temperature and humidity measurements are required. It could also be developed further to provide an alarm or notification that unhealthy or unwanted conditions are detected.

Chapter 5

References

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Chapter 6:

Appendices

6.1 Project Proposal

Proposal Introduction

This project proposal is a document which outlines the proposed objectives, background, solutions for the chosen project. Firstly, it is useful to identify and define what the project proposal is in its entirety. The project proposal is not a business plan but may contain many of the same elements, such as the planned project tasks, resources and pricing information for example. It outlines the problem, issue or task and provides solutions that are in theory more cost effective or efficient than the alternatives available to the client.

This document looks at the problem, proposed objectives, while also outlining the reason for choosing to deliver this particular project. It also includes the recommended solutions with a description of the technical approach and resources needed to complete the project as far as can be predicted at this time.

The project chosen is entitled:

An Analysis of Temperature and Humidity in student housing using a Raspberry Pi.

Statement of Problem

The statement of the problem, which will be resolved on deliverance of this project, is to research and identify the humidity or dampness conditions that are optimal for the growth of mould within a confined area. The confined area, for the purpose of this project, can be defined as any room that may be subject to damp or developing patches of mould such as a kitchen, bedroom, or bathroom.

Below, the objectives and anticipated risks have been outlined in order to further define the problem and its distinct components or issues.

Objectives

This writer has identified five distinct objectives which relate to this project and will guide the direction of tasks and actions taken over the course of the project duration.

Objective 1: To research mould types, previous studies and empirical information.

Objective 2: To build the Raspberry Pi system and integrate the temperature/humidity sensors and test the system using controlled experiments.

Objectives 3: To use the information gained in the first two objectives to test the areas in which mould is present to measure the temperature and dampness levels at different times of the day and in different conditions.

Objective 4: To identify an improvement to the application of this system and also real-life applications for the technology.

Anticipated challenges

1. Building the Raspberry Pi.
2. Testing conditions for mould accurately over a short period of time (where a longer period of time encompassing all seasons would give a better baseline result).
3. Analysing the results in such a way as to discover a correlation between humidity, temperature and mould growth.
4. Researching and identifying related articles or texts.

Background

This writer chose the above project as the concept of measuring temperature and humidity using a small independent device such as a Raspberry Pi seemed interesting, and would have further applications in areas such as; healthcare, public housing, personal use and general healthy living. The development of this device for this purpose would in this writer's opinion be cost effective and could identify, after creating a baseline of empirical research, possible areas where the conditions could cultivate mould before the mould becomes visibly present or dangerous. Therefore, it could be used to measure conditions in an effort to reduce the likelihood that mould could interfere with for example an asthmatic's health. The other interesting feature of this project is that the system can test multiple conditions at once such as to measure temperature, humidity and soil moisture, giving the results a better set of results for analysis.

Benefits to completing this project along with future applications

There are some identified benefits to completing this project as it gives the writer additional experience in creating hardware systems, coding in Python, and analysing independent research. Further developments to the idea could bring the system into the realm of being applied to public service, for example for monitoring conditions in public housing, private or domestic use and for the healthcare sector.

Proposed Solution

The prosed solution is to build and develop the Raspberry Pi system to measure multiple conditions at once, which in this project may be temperature, humidity and soil moisture. The following points are the steps that this project requires, which is detailed in depth with a Gant Chart later within this document.

The proposed solution to the previously discussed problem contain a description of the technical approach used the resources needed to implement the above solution.

Literature Review

Research is to be conducted into the area of mould growth conditions as studied by authors of salient and peer reviewed materials.

The literature used will be a mixture of texts on the subject and peer reviewed articles or journals. The purpose of researching and identifying other empirical studies is to be able to compare the results gathered in this project with academic research already conducted to validate the information received. Also, examples of the types of analysis conducted may give some indication of how this project's analysis should be ordered and collated.

Independent Research

The project requires independent research to be conducted in the form of creating, developing and testing the chosen project. This is outlined in more detail in the project plan section of this document. The technical approach chosen is to utilise the Raspberry Pi to indicate temperature levels and humidity in the air.

Conclusions

After the independent research is completed and the research conducted, this writer will draw up conclusions based on the results gathered from the real-time use of the Raspberry Pi system. It will also include the challenges faced during this project as every project faces obstacles and it is important to record any difficulties.

Recommendations

In the final document, some minor recommendations based on the writers experiences during the project will be posed, so that future development of the same or similar projects may learn from and avoid these risks.

Special Resources Required

At this time the special resources needed to complete the project are as follows;

Item	Cost
Raspberry Pi	€40
16gb Micro SD Card	€6
Case	€6
Adeept RFID Starter Kit. **http://www.adeept.com/index.php?con=index&act=product&id=36**	€49
Total	€101

Figure: 20

Technical Details

Implementation language and principal libraries

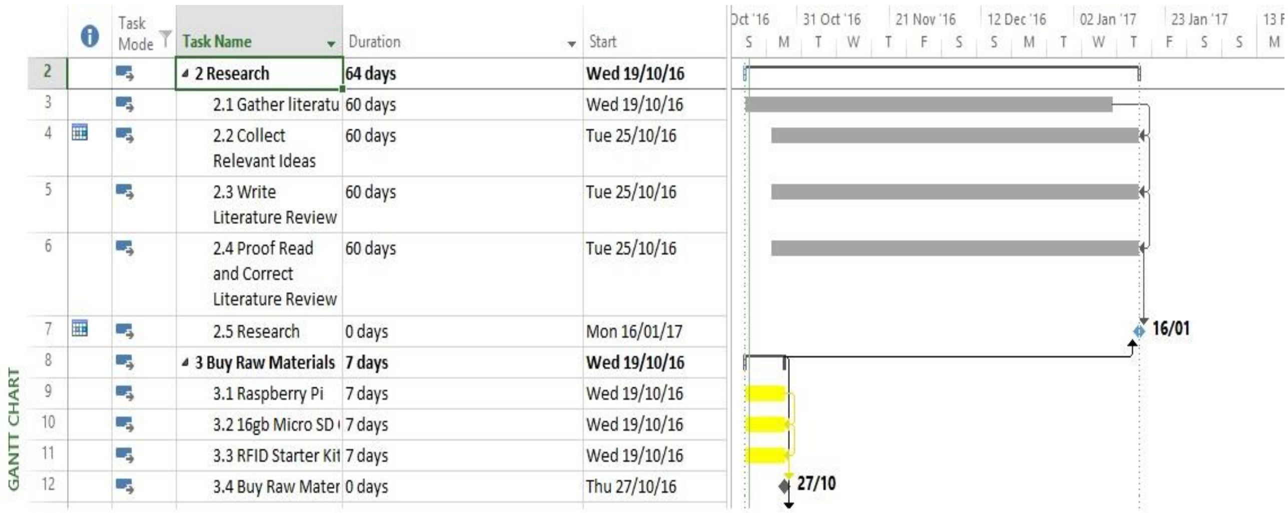
Python GPIO code for DHT11 temperature/humidity sensor

Cloud 9 – this may change as the project progresses because there are several alternative storage options available. Further research should identify the most compatible, effective and user-friendly.

Project Plan

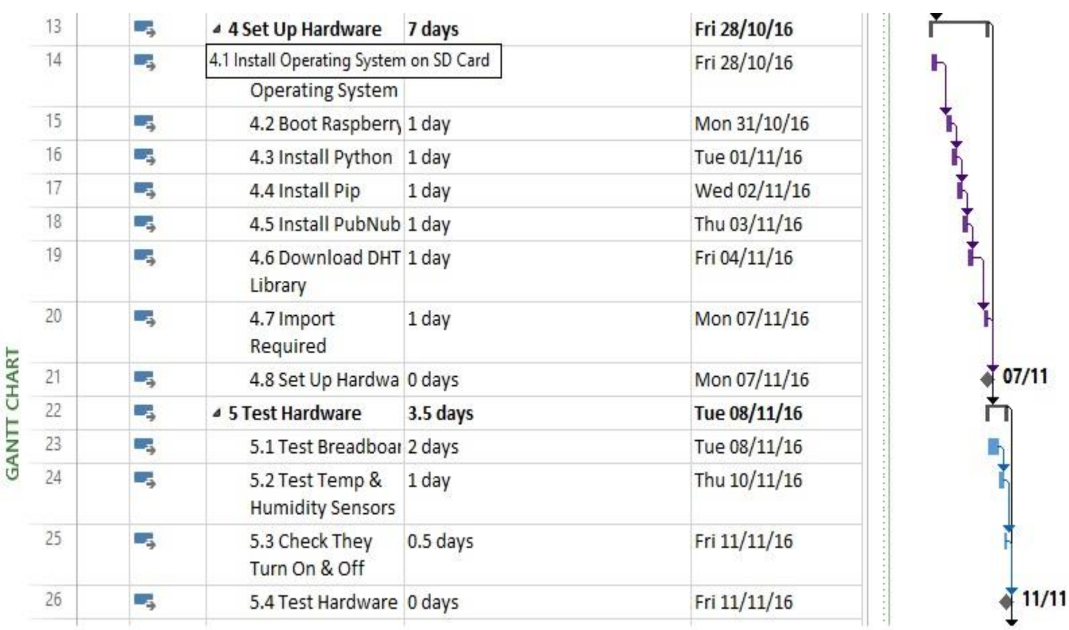
It is important to provide a project plan, as risks, challenges and opportunities may be identified earlier, than without a detailed plan. A Gant Chart is a visual representation of the project progress and can be modified to include lag time or slippage. Its purpose is to ensure that the project owner meets each of the deadlines or milestones and classify each set of tasks in groupings to allow for better project organisation. This Gant Chart includes the purchase of raw materials, the source hardware and the steps that should lead to project success. Also, it is a notable advantage to have the project progress automatically logged as it will show tasks when tasks begin and end which reduces the possibility of risk to the project. #

Gant Chart and Recorded Tasks



	Task Name	Duration	Start
2	2 Research	64 days	Wed 19/10/16
3	2.1 Gather literatu	60 days	Wed 19/10/16
4	2.2 Collect Relevant Ideas	60 days	Tue 25/10/16
5	2.3 Write Literature Review	60 days	Tue 25/10/16
6	2.4 Proof Read and Correct Literature Review	60 days	Tue 25/10/16
7	2.5 Research	0 days	Mon 16/01/17
8	3 Buy Raw Materials	7 days	Wed 19/10/16
9	3.1 Raspberry Pi	7 days	Wed 19/10/16
10	3.2 16gb Micro SD	7 days	Wed 19/10/16
11	3.3 RFID Starter Kit	7 days	Wed 19/10/16
12	3.4 Buy Raw Mater	0 days	Thu 27/10/16

Figure:21



	Task Name	Duration	Start
13	4 Set Up Hardware	7 days	Fri 28/10/16
14	4.1 Install Operating System on SD Card		Fri 28/10/16
15	4.2 Boot Raspberry	1 day	Mon 31/10/16
16	4.3 Install Python	1 day	Tue 01/11/16
17	4.4 Install Pip	1 day	Wed 02/11/16
18	4.5 Install PubNub	1 day	Thu 03/11/16
19	4.6 Download DHT Library	1 day	Fri 04/11/16
20	4.7 Import Required	1 day	Mon 07/11/16
21	4.8 Set Up Hardwa	0 days	Mon 07/11/16
22	5 Test Hardware	3.5 days	Tue 08/11/16
23	5.1 Test Breadboar	2 days	Tue 08/11/16
24	5.2 Test Temp & Humidity Sensors	1 day	Thu 10/11/16
25	5.3 Check They Turn On & Off	0.5 days	Fri 11/11/16
26	5.4 Test Hardware	0 days	Fri 11/11/16

Figure:22

27	6 Coding	15.5 days	Fri 11/11/16
28	6.1 Set Up GIT HUB	0.5 days	Fri 11/11/16
29	6.2 Practice Code	5 days	Mon 14/11/16
30	6.3 Tutorials for Python Code	5 days	Mon 21/11/16
31	6.4 Store Data with Cloud 9 for	5 days	Mon 28/11/16
32	6.5 Coding	0 days	Fri 02/12/16
33	7 Prepare Prototype	26 days	Mon 05/12/16
34	7.1 Have Working Pi - Fix Bugs	3 days	Mon 05/12/16
35	7.2 Have Working Code - Fix Bugs	3 days	Thu 08/12/16
36	7.3 Collect Test Da	20 days	Tue 13/12/16
37	7.4 Collect Temp & Humidity Data	20 days	Tue 13/12/16
38	7.5 Prepare Protot	0 days	Mon 09/01/17
39	8 Final Working Devi	5 days	Tue 10/01/17
40	8.1 Present Final Project and	5 days	Tue 10/01/17
41	8.2 Final Working I	0 days	Mon 16/01/17

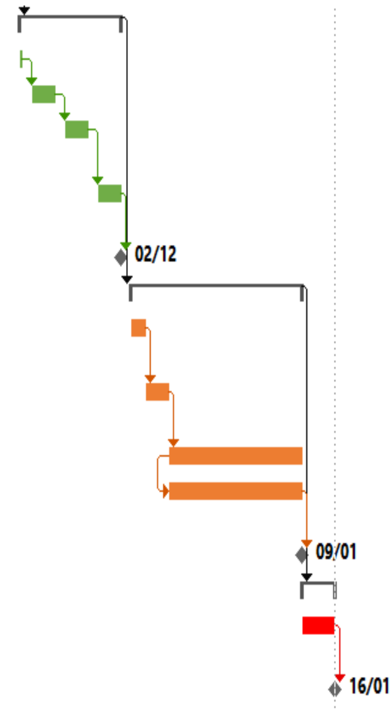


Figure:23

6.1 Monthly Journals

Reflective Journal 1

Student Name	Niall Martin
Student Number	x00110321
Programme	BSc Honours in Computing (Stream: Internet of Things)
Date Submitted	08/10/2016
Journal Month	September

My Achievements

This month, I spent my time trying to decide on what my final project would be, so I could present it to the lecturers on the 5th of October. I came up with an App for students that would allow them to plan their college, work and social life in the one application from their mobile device such as phone or tablet. The aim of this application is to schedule the major and minor events in their lives, so that they don't conflict with their college life. If, for example, they have a continuous assessment and a society event occurring at the same time, the app will let them know that they conflict and allow the student to prioritise or reschedule one or more of the events. The App will also be able to take notes, plan study time or project progress, record project ideas and create project groups to share ideas and notes.

My Reflection

It was difficult to try come up with my idea, as most of ideas I produced, were already available online and possessed similar qualities to the idea that I had come up with. My college App idea does already exist with several applications of a similar nature available but during my research I realised they didn't cover the social or work activities of students, therefore allowing me to improve and expand upon the idea in a significant way.

Intended Changes

I will make any required changes once I have pitched my idea, and the judges have given me feedback. I will be adding a timetable section to the App and small calendar area for visual purposes, making it easier for the student to view their upcoming events.

Supervisor Meetings

Supervisor meeting to be organized when I have been assigned a supervisor.

Reflective Journal 2

Student Name	Niall Martin
Student Number	x00110321
Programme	BSc Honours in Computing (Stream: Internet of Things)
Date Submitted	04/11/2016
Journal Month	October

My Achievements

This month, I choose project 27 An Analysis of Temperature and Humidity in student housing using a Raspberry Pi, this was Lisa murphy's project so I emailed her to arrange a meeting with her, so we could discuss the project and my ideas to expand on it in the hope Lisa would choose me for the project. I was delighted to hear from Lisa telling me I got the project. I then proceeded to complete the project proposal.

My Reflection

At the start of this month, I had the project pitch. It went well, my project idea was denied because the idea was an app for students to plan all aspects their college and social life's, and it was not suitable to my stream which is Internet of Things. After all the project pitches were done, the list of projects were put up for students to view and choose which one they would like to do.

Intended Changes

After completing the project proposal, I proceeded to do even more research, into the growth of mould, and discovered that having potted plants in a room could contribute to the growth of mould. I then proceed to research if I could use the raspberry pi to analyse this, I found a sensor that can be placed into the soil of the plant, and check the moisture level of the soil. So I will discuss this with my supervisor Dominic to get his thoughts on the idea, before I update the proposal for the final submission in May.

Supervisor Meetings

My supervisor is Dominic Carr and will schedule a meeting in November after reading week.

Reflective Journal 3

Student Name	Niall Martin
Student Number	x00110321
Programme	BSc Honours in Computing (Stream: Internet of Things)
Date Submitted	09/12/2016

Journal Month	November

My Achievements

This month, I was able to complete the requirements document. Dominic, my supervisor, reviewed the material and gave me some advice and changes to make, which I will complete in December.

I further developed the idea for what I want my prototype to be. The prototype will be a sensor that reads data and stores it locally on the Raspberry Pi.

My Reflection

I felt the requirements document was tough to write. I struggled with the functional requirements, the use case diagram, the use cases and the class diagram for the system architecture, as I have never been strong at creating them. Adding a hardware requirement has made it more difficult for me, because it had never been covered in lectures before, but I attempted to complete it in any case.

It was difficult, this month, to focus on the requirements document, as there was a lot to do for the other modules. I found myself using the time I had allotted, for the requirement documents, on other projects and exams, which created some scheduling issues which required extra effort and time put in to complete all necessary areas.

I finally got the requirements document completed, by putting in extra hours, and I was happy with it for the most part, the only part that I was worried about was the use case. I was not confident that it was close to being right and after my supervisor read it, he said that there were problems with the use case diagram. Thankfully, there were minor issues that needed fixing in the rest of the document, in which I did not give enough detail about what I was writing about.

Intended Changes

Next month I will have the technical report to complete along with the midpoint presentation and the prototype. I will also need to fix my use case diagram, the individual use cases and the class diagram.

Supervisor Meetings

Date of Meeting: 10/11/2016

Items discussed:

- To get a feel for how the meetings should go.
- What will be expected of me between each meeting.
- Requirements document
- Prototype
- Use Case Diagram
- Writing

Action Items:

- Complete the requirements document
- Send the document to supervisor
- Think about evaluation of the project
- Look in to version control
- Assess the requirements for the sensors in terms of accuracy
- Assess need for multiple raspberry PI for simultaneous testing

Reflective Journal 4

Student Name	Niall Martin

Student Number	x00110321
Programme	BSc Honours in Computing (Stream: Internet of Things)
Date Submitted	06/01/2017
Journal Month	December

My Achievements

This month, I was able to complete my technical report fully, also completing the mid-point presentation and prototype. I have now started to do the research on mould growth for my literature review, this will allow me to compare my findings with other findings to check if the conditions match.

My Reflection

This month has been a busy month due to projects for all the other modules that are due before Christmas and this has taken some time away from my final year software project. My mid-point presentation was moved till January due to personal circumstances.

Intended Changes

Next month, I will try and make the python script run as soon as the raspberry pi boots up.

Supervisor Meetings

Date of Meeting: 15/12/2016

Items discussed:

- Technical report
- Prototype
- Use Case Diagram
- System architecture
- Mid-point presentation

Action Items:

- Complete the Technical report
- Send the report to the supervisor
- Think about evaluation of the project
- Look in to version control

Reflective Journal 5

Student Name	Niall Martin
Student Number	x00110321
Programme	BSc Honours in Computing (Stream: Internet of Things)
Date Submitted	10-02-2017
Journal Month	January

My Achievements

Throughout the past month, I was able to look over the analysis and design document, I also completed the mid-point presentation and prototype. I have almost entirely completed my research on mould growth for my literary review.

My Reflection

I felt my mid-point presentation and prototype showcase went well, I got great feedback from the two markers. They also had some great ideas on what I can add to the completed project. It was hard to get much done on the project this month as I was studying for my exams.

Intended Changes

Next month, I will try to complete my python script and database fully so I can gather data while I start my literary review. I will also try have half of the analysis and design document done. I will also look in to adding a temperature and humidity warning system to the website.

Supervisor Meetings

No supervisor meeting this month as I spent most of my time studying for exams.

Reflective Journal 6

Student Name	Niall Martin
Student Number	x00110321
Programme	BSc Honours in Computing (Stream: Internet of Things)
Date Submitted	10-03-2017
Journal Month	February

My Achievements

This Month I was able to start the analysis and design document. This month I began to write my Python script for the Raspberry Pi monitoring software, which should allow me to customise the Raspberry Pi to complete the tasks needed.

My Reflection

I have encountered many problems in getting the python script to work, it is not registering the sensors, when it does read the sensor it won't store it in the database. One problem I had was when I ran the Python script my sensor melted, I must have wired it wrong so now I have ordered a few new ones in case it happens again

Intended Changes

I intend to look into an alternative way to read and store the sensor data.

Reflective Journal 7

Student Name	Niall Martin
Student Number	x00110321
Programme	BSc Honours in Computing (Stream: Internet of Things)
Date Submitted	07-04-2017
Journal Month	March

My Achievements

This month I was able to find another way to get the Python script to work, I achieved this by discovering Adafruit libraries and a dashboard called Initial State. I have also completed half of the analyse and design document, so that I will have less to do at the end of the project.

My Reflection

I felt working with the Adafruit libraries and Initial State dashboard is going really well. It is a more efficient way to transfer and display the data needed for the client end of the system.

Intended Changes

Next month I will try get all my testing done as well as finish my analysis and design document. Once they are completed I will prepare my presentation and demonstration.

6.2 Code/Programming Language

---- Code reference ----

---- Created by WeMustBeGeeks RichP ----

---- Edited by Niall Martin x00110321 ----

---- https://www.wemustbegeeks.com/iot-temperature-humidity-to-initial-state-using-a-raspberry-pi-dht22/ ----

import sys

import Adafruit_DHT

import os

import time

from ISStreamer.Streamer import Streamer

--------- User Settings ---------

The DHT_SENSOR_TYPE below may need to be changed depending on which DHT sensor you have:

0 - DHT11 - blue one - comes with the GrovePi+ Starter Kit

1 - DHT22 - white one, aka DHT Pro or AM2302

2 - DHT21 - black one, aka AM2301

DHT_SENSOR_TYPE = 22

Connect the DHT sensor to one of the digital pins (i.e. 2, 3, 4, 7, or 8)

DHT_SENSOR_PIN = 22

Initial State settings

BUCKET_NAME = ":Mould-Catcher: House 1"

BUCKET_KEY = "dht22-rpi-sensor"

ACCESS_KEY = "r97NFVUXqztCdIo5YB55hR4ziHmc7WnD"

Set the time between sensor reads

MINUTES_BETWEEN_READS = 1

CONVERT_TO_FAHRENHEIT = False

setting up main method

```
def main():
        # Using streamer to send the data to Initial State
 streamer = Streamer(bucket_name=BUCKET_NAME, bucket_key=BUCKET_KEY, access_key=ACCESS_KEY)
 while True:
        # Using the Adafruit library to tell the sensor to collect readings
  [hum1,temp_c1] = Adafruit_DHT.read_retry(DHT_SENSOR_TYPE,DHT_SENSOR_PIN)
  #if isFloat(temp_c1):
  temp_c = float(round(temp_c1,2))
  if (CONVERT_TO_FAHRENHEIT):
   temp_f = temp_c * 9.0 / 5.0 + 32.0
   # print("Temperature(F) = ", temp_f)
   streamer.log("Temperature(F)",temp_f)
  else:
   # print("Temperature(C) = ", temp_c)
        # sending the temperature to the streamer log
   streamer.log("Temperature(C)",temp_c)
  #if ((isFloat(hum1)) and (hum1 >= 0)):
  hum = float(round(hum1,1))
  # print("Humidity(%) = ", hum)
        # sending the humidity to the streamer log
  streamer.log("Humidity(%)",hum)
  streamer.flush()
  #except IOError:
   #   print ("Error")
  time.sleep(2*MINUTES_BETWEEN_READS)
# calling main method
if __name__ == '__main__':
```

```
main()
```

Declaration Cover Sheet for Project Submission

SECTION 1 *Student to complete*

Name: Niall Martin
Student ID: X00110321
Supervisor: Dr. Dominic Carr

SECTION 2 Confirmation of Authorship

The acceptance of your work is subject to your signature on the following declaration:

I confirm that I have read the College statement on plagiarism (summarised overleaf and printed in full in the Student Handbook) and that the work I have submitted for assessment is entirely my own work.

Signature:____ Date:_____________

NB. If it is suspected that your assignment contains the work of others falsely represented as your own, it will be referred to the College's Disciplinary Committee. Should the Committee be satisfied that plagiarism has occurred this is likely to lead to your failing the module and possibly to your being suspended or expelled from college.

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