APPLICATION OF INTERNET OF THINGS ON TEMPERATURE MEASURING SYSTEM ON WAFER FURNACE SINTERING PROCESS

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DECLARATION

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ABSTRAK

‘ Internet-of-Things’ (loT) adalah sistem yang memperluaskan perkhidmatan internet dalam kehidupan hari ini. Aplikasi-aplikasinya yang semakin meluas dan dijangka akan semakin meluaskan lagi di masa hadapan kerana sektor ini telah dikenalpasti sebagai salah satu sektor kritikal yang perlu diperkasakan dan telah dikenal pasti oleh kerajaan Malaysia sendiri. Penggunaan teknologi baru dalam persekitaran IOT semakin pesat mahupun di negara kita. Pelaksanaan IoT untuk melancarkan sistem mengukur suhu telah membantu proses menggunakan relau atau pemanas menjadi lebih cekap. Ini kerana walaupun tiada sesiapa di sekeliling pemanas semasa ia beroperasi kita boleh mengawal atau mematikan relau menggunakan hanya telefon bimbit untuk menghantar arahan ke pelayan internet dan pelayan internet akan berkomunikasi dengan mini komputer Arduino untuk menyampaikan atau matikan pemanas dan sebaliknya. Ini akan membolehkan kita mengelakkan kerosakan yang tidak perlu seperti pemanasan yang melampau . Pelaksanaan IoT ke dalam sistem ini juga akan membantu kita memantau suhu pemanas dalam talian tanpa tertangguh dan oleh itu membantu untuk membuat proses pemanasan wafer elektronik menjadi lebih baik. Sistem IoT tanpa ragu-ragu akan membantu menyelamatkan kos pengunaan elektrik dan oleh itu membuat penggunaan kuasa untuk Pemanas lebih berkesan.

ABSTRACT

Internet-of-Things (loT) is a system that broadens the internet services in today life. Applications of loT are widening and are expected to widen more in the future as this sector has been identified one of the critical sector that need to be nurtured even by Malaysian government. Uses of new technologies in IoT environment are increasing rapidly even in our country. The implementation of IoT to furnace temperature measuring system has helped the process of using the furnace or heater to be more efficient. This is because even when no one is around the heater during it is operating we can control the on or off of the furnace by using only mobile phone to send instruction to the cloud server and the cloud server will communicate with the Arduino board to relay or turn off the heater and vice versa. This will enable us to avoid any unnecessary damage of overheating of the heating. Implementation of IoT to the system also will help us to monitor online temperature of the heater without delayed and hence help to make the wafer sintering process becomes much better .The IoT system without doubt will help save the electricity and therefore make the consumption of power for the heater comes more efficient.

CHAPTER 1

INTRODUCTION

1.1 Overview

In this modern world the internet has taken over a lot of important task in our daily life. The usage of internet has become a part of our daily life such as buying goods through online transaction. The usage of internet can be expand to the function of Internet of Things (IoT). IoT describes a system where items in the physical world, and sensors within or attached to these items, are connected to the Internet via wireless and wired Internet connections. These sensors can use various types of local area connections such as RFID, NFC, Wi-Fi, Bluetooth, and Zigbee. Sensors can also have wide area connectivity such as GSM, GPRS, 3G, and LTE[1].

This research purposes are mainly on using internet to monitor the reading of the temperature of a wafer furnace sintering process with the help of microcontroller as such in this project the use of Arduino board to develop an automatic measuring system for the temperature reading of the furnace. As we know, sometime during the sintering process the heat produce may exceeded certain limit so if we can monitor the temperature over time to time using internet so that we can actually avoid accident that may occur during the sintering process[2].

1.2 Project Background

The wafer furnace application is the usage of heat thermal system that involved high power input and produces large number of excessive heat. The temperature can become so high suring the etching process of the wafer so that it need to be monitored to make sure that it will have a uniform temperature transfer through all the furnace. The furnace in this project are expected to operate 24 hours per day which mean it need to be monitored all the time. The main usage of the furnace is for the etching process of sintering for the wafer circuit. The wafer circuit can take up to 100 °C and above during its operation. Since it is a small furnace there is no budget allocate to hire a person to supervise the process all the time. This project is developed to help we supervise the temperature change over time even though we are far away from the wafer furnace. It is also features a function where we can control the voltage input into the wafer furnace remotely via internet so that the furnace can be shut down in case the temperature exceed certain limit. The microcontroller use in this project will be the bridge that connect the IoT (Internet of Things) devices to the measuring system and voltage regulator that will monitor the temperature and regulate voltage to the furnace respectively. For this project the usage of Arduino will be implement to the measuring system and the board itself will the devices that send and receive data from the server of IoT to execute its function remotely.

1.3 Problem Statement

The temperature of the wafer furnace may change over time to time depend on the heat transfer activities during the sintering process. As it may operate 24 hours per day the need of a temperature measurement system is compulsory to make sure it still operate safely. The measurement of the temperature are needed to be place in several place to make sure that the wafer furnace operate in a uniform temperature so that the etching process is perfectly in order. The input voltage need to control to make sure the furnace working in a safe mode. The need of continuous monitoring process on the temperature and the voltage input into the wafer furnace is the main problem for the purpose of developing this project. This is because of the sensitivity of the uniform heat transfer throughout the sintering process is needed to make sure the wafer etching process does not occurs defect.

1.4 Objectives

i. To develop a temperature measurement system using a microcontroller for the wafer furnace.
ii. To design a system which can control the input voltage to the wafer furnace.
iii. To create a platform on a mobile phone to monitor the temperature of the wafer furnace and control the voltage input.
iv. To calculate heat transfer in the wafer furnace based on the time of its operation.

1.5 Project Scopes

i. Design an IoT system to measure temperature and monitor it online.

ii. Design a system which can control the input voltage into the wafer furnace.

iii. Create a platform on mobile phone which can control both system.

iv. Calculate the heat transfer in the wafer furnace based on temperature reading.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

To complete this project first we need to do some data collection on the existing project and theories regarding the project title to make sure that this project will obtain a good result and will give impact towards the society. Several journals that relate IoT, voltage regulator and temperature measurement system have been referred to help me conclude this literature review.

2.2 Internet of Thing

As we know the term Internet of Thing has become more popular in this modern era. The IoT is any device that can be remotely control using a device such as smart phone connected by internet. The usage of IoT itself has become quite often thing to see nowadays.

The depending on IoT onto nowadays society has become something that will reshaping the future as tomorrow as we would like to see a world where everything is cyber-connected through the internet to make our life much more easier and help to reduce the human effort in doing things whether in daily life or in industry.

2.3 Cloud Server

As in to make an IoT program first we need to have a cloud server to receive, hold and send data from the respective device and mobile phone or a computer. For an example a cloud server is need to receive the data from a mobile phone control a home automation system implement in a house[3].

There are many suitable server for the IoT application that are free, offered for this application nowadays. As in a survey on the IoT cloud server, they have compared cloud server that serve its user base on 10 criteria and included 26 existing cloud server. From the survey it can be seen that Cayenne provide the best way to be use for this project. The use of different platform will depend on the system that we are going to develop itself[4].

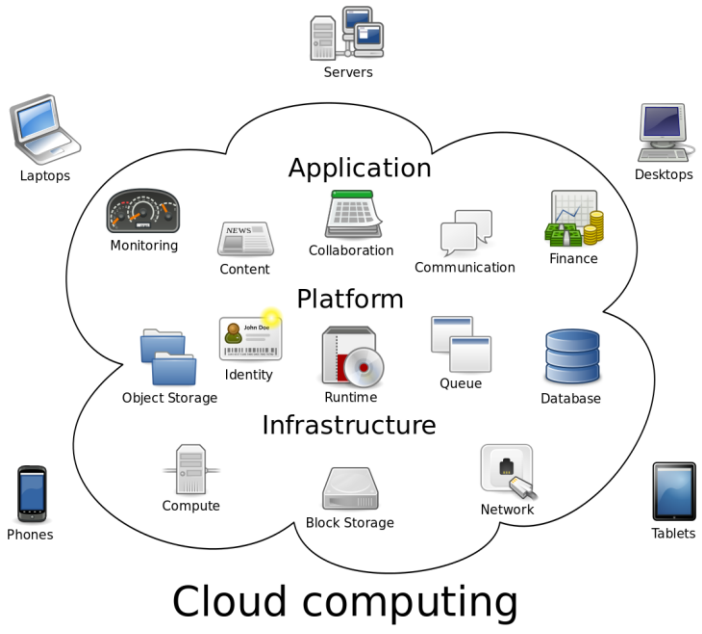

Figure 2.1 : Cloud Computing in real life application

2.4 Existing Project

In 2016 Dr. V .Ramya and G. Thirumalai Rajan have developed an automation system of energy efficient of industrial used by implementing the use of the microcontroller of Raspberry Pi. The purpose are for a secured and energy efficient wireless industrial automation system via credit card sized single board computer called Raspberry pi. In this research they are trying to manage the power utilities to avoid excessive use of power. The Raspberry pi is being controlled over a server using Wi-Fi and the server can only be access by person who only own the password to the server. This research has shown that by using an IoT devices they can monitor the working condition in industry and alert higher rank or a responsible person in case if anything happen to the working place[5].

Child missing cases has been seen quite often in television these days. In 2016 a group of researcher from University Of Kuala Lumpur (UniKL) has developed a child tracking application with the implement of raspberry pi. In this project they have design a system which can track the children anywhere, anytime and in any weather conditions. The usage of the raspberry pi is to connect the GPS module and send the data of the location through the server to the mobile phone application which they have developed so that parent can check their children whereabouts in case their children going out or missing[6].

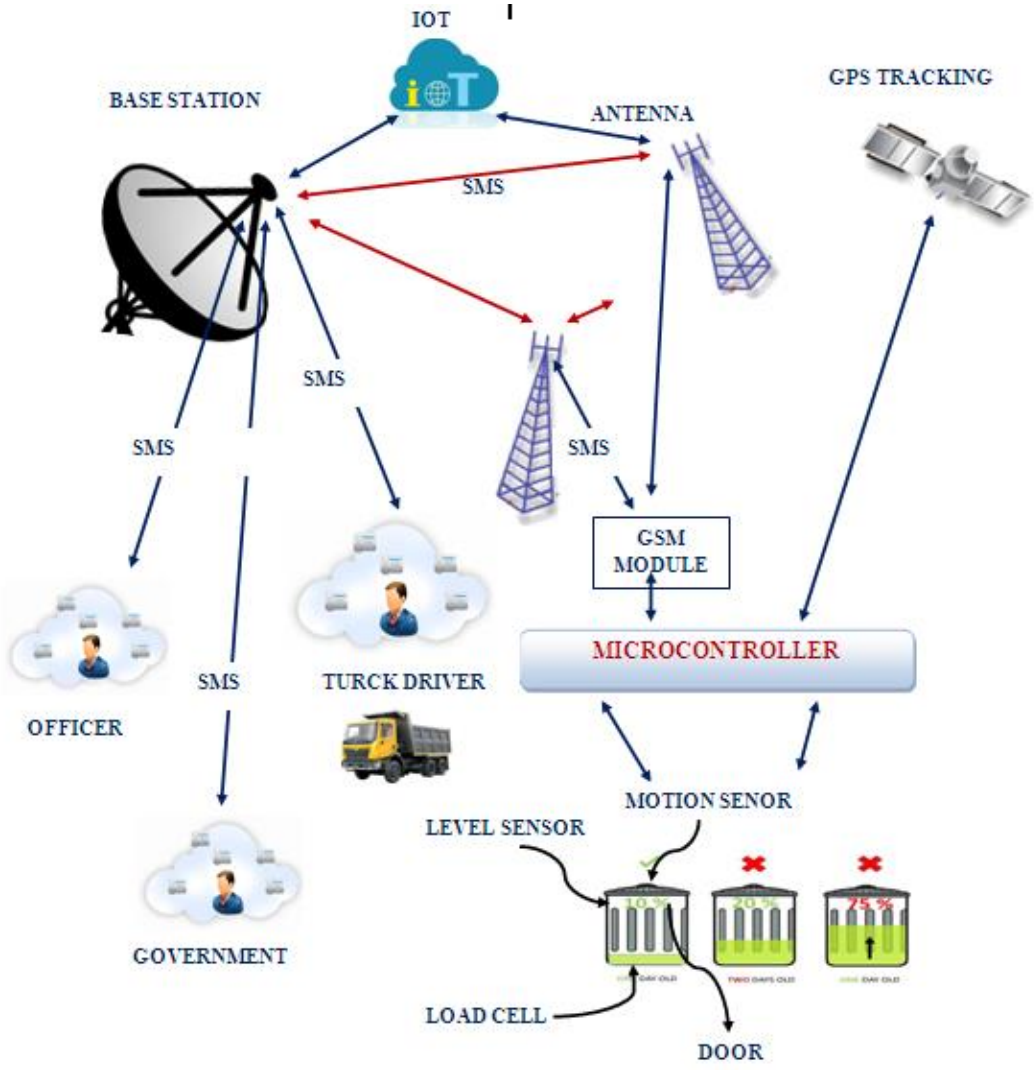

Figure 2.2 : GPS monitoring using IoT application

2.5 Temperature measurement system

The temperature and humidity sensor can be implement to the microcontroller and being monitor by a mobile phone application. As in a research, they have developed an environment monitoring system by using a Raspberry Pi to connect to sensors for

monitoring the temperature and humidity for the environment which the data collected are then being send to the IoT devices so that it can be implement for a certain use of application in real life[7]. The use of DHT11 Digital Humidity and Temperature Sensor is being implement where it uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed).It's fairly simple to use, but requires careful timing to grab data. Its small size, low power consumption and up- to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package[8].

The normal egg incubator need to be monitor regularly and in need for physical communication. In 2016 group of two researcher from UniKL has developed an egg incubator using a raspberry pi for precision farming process. They have implement the use of the microcontroller to monitor and control the temperature and humidity of the egg incubator to skip the broody process in order for a perfect egg hatching. The monitoring and control of the microcontroller are being done by accessing a web based program on a Google Chrome platform. The usage of the temperature measuring and monitoring process can be implement to the project that I am going to develop[9].

The usage or Arduino itself for this project has been wide use to perform a lot of task. For this particular project I will use the Arduino to set up a temperature measurement system that can be done using a thermocouple attach to breadboard that will connect it to Arduino an later on functioning according the given program coding. This experiment has be done and can easily be learnt from the journal[10].

2.6 Voltage Regulation

For this subtopic I will review on the existing project that include the voltage regulation of a home automation system using a microcontroller that will help me to plan and implement the design for this particular project.

As for the control of the input voltage, a project has been done to automate the electrical things in the house such as control of the on and off of lamp in 2016. The project purpose shown that the input voltage up to 240v can be controlled by a Raspberry Pi. In this project they use the relay circuit in which relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The usage of android platform has been used to control the house circuit via internet connection[11].

The electrical circuit can also be monitor as in for its current, voltage and temperature. A study in 2016 has shown that by using a Raspberry pi they can monitor the input voltage and in any case the if the load increases beyond the specific location rated capacity, the microcontroller will automatically shut down the specific location and intimates the same to the operator by sending a message through a GSM modem from the raspberry pi ARM vortex that has been set up for the system[12].

2.7 Microcontroller

The usage of the microcontroller has become a major thing in today world. As such the Arduino board has widely used in the IoT system itself because of its durability and cheap price for such complicated project. Surprisingly, the flexibility of a microcontroller can be improved by introducing Arduino Service Interface Programming (ASIP) model which function to add new service and support for network boards that can be run on several programming language which is more user friendly[13].

CHAPTER 3

PROJECT METHODOLOGY

3.1 Introduction

This chapter will describe about the method use to complete this project. This project mainly focusing on the Internet of Things application which has been implemented as a vision for our country in the Industry 4.0 budget plan. The process of finding the right method for this project is mainly based on the System Development Life Cycle (SLDC), which has 3 main components that are planning, implementing and analysis.

For this final year project the following chart will show the load distribution based on the three main components.

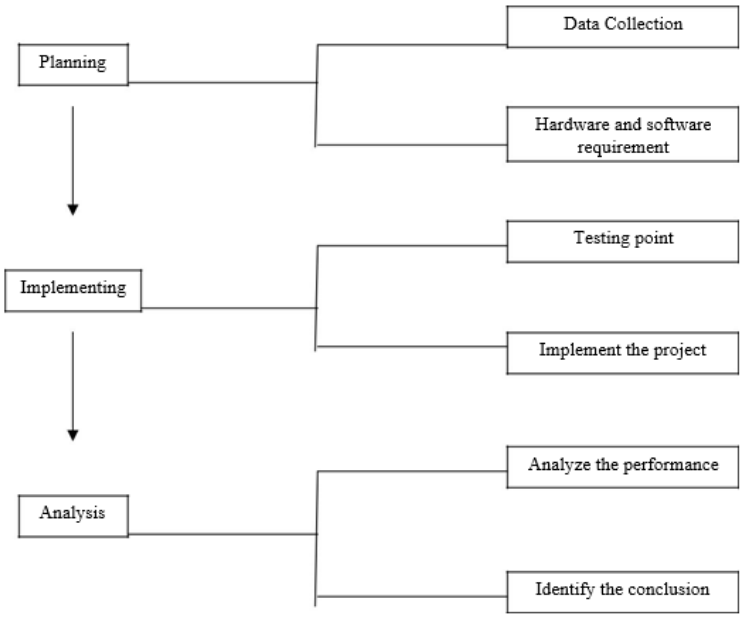

Figure 3.1:Steps of Methodology

3.2 Planning

To find all the required knowledge and requirement such as hardware and software, a good planning must be done in a proper manner. In the phase of planning, there will be two main components which are the data collection and the requirement of hardware and software.

3.2.1 Data Collection

As we know data collection is the main thing to be done in any kind of research. We first need to find the information regarding the title of the project. All the required information for this project has been found out from journals, text books and research paper which can be accessed through internet and library.

Within this process I have found out the study on the application of Internet of Things and I have did some research and study on related existed project. Once I found the suitable project to refer to I have tried to do some simple project which eventually became a prototype of my project.

In meantime while I was doing the research I have found the best hardware to be used for this project which is reliable and are easy to gain access for all the hardware that are needed. Figure 3.2 below show the basic connection of IoT application.

Figure 3.2: Connection of IoT application

3.2.2 Hardware and Software Requirement

3.2.2.1 Hardware requirement

Below is the list of the hardware that are needed to complete this project for it to be working efficiently.

- **Microcontroller**

  i. Arduino Uno R3

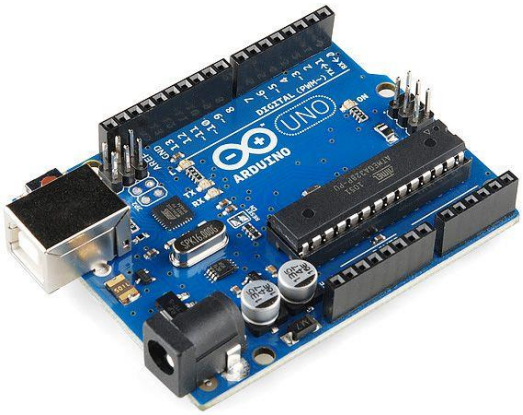

Figure 3.3 : One unit of Arduino Uno

The reason on why I choose Arduino Uno for this project is because of it's simplicity and the high level of task that this microcontroller capable of. This board provide broad range of usage and are very easy to program and connect to any other electrical appliances for the project.

- **Electrical Component**

i. Thermocouple Amplifier MAX 6675

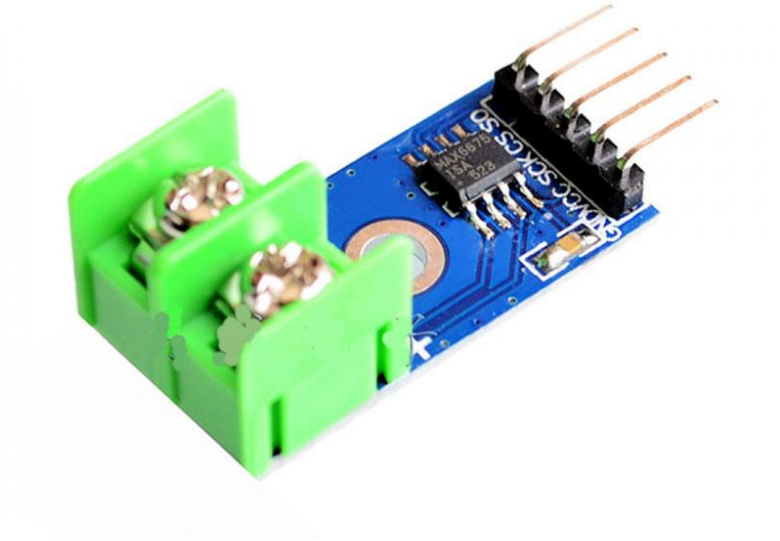

Figure 3.4 : MAX 6675 Thermocouple Amplifier Chip

This chip MAX6675 performs cold-junction compensation and digitizes the signal from a type-K thermocouple. The data is output in a 12-bit resolution, SPI™-compatible, read-only format. This allow the thermocouple-K to be able to read up to 1024°C compared to it's normal operation which only allow reading only up to 300°C.

ii. Jumper wire

iii. Project Board

iv. USB power cable

v. Solid State Relay

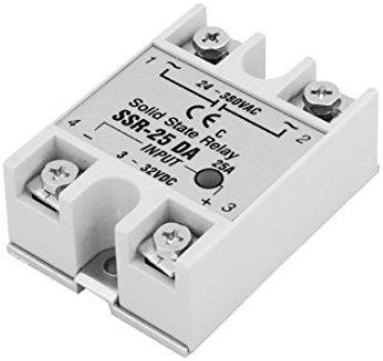

Figure 3.5 : Solid State Relay (25Amp)

Solid state relay are used to change the channel of input voltage in so that the circuit and easily be manipulated to open or closed circuit.

- **Thermocouple**

i. K-type thermocouple

Figure 3.6 : Glass Braid Thermocouple Type K

K-type thermocouple is one of the cheapest thermocouple that has high durability and are easy to get compared to other type of thermocouple.

- **Internet Connection**

i. Ethernet Cable

ii. W5100 Ethernet Shield v2.0

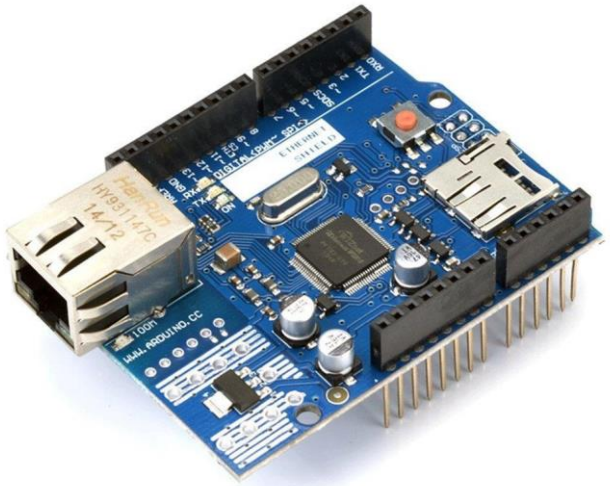

Figure 3.7 : W5100 Ethernet Shield for Arduino Uno

This shield provide extension slot for Arduino Uno for internet cable connection. It will connect the Arduino board to be able to connect to internet to send and receive data from cloud server as in this project it will communicate with Cayenne server to send temperature data and received instruction for the relay. Ethernet connection are chosen for this project since Wi-Fi connection in the lab is quite poor and could delayed the data transmission between microcontroller and cloud sever.

iii. Cloud Server : Cayenne

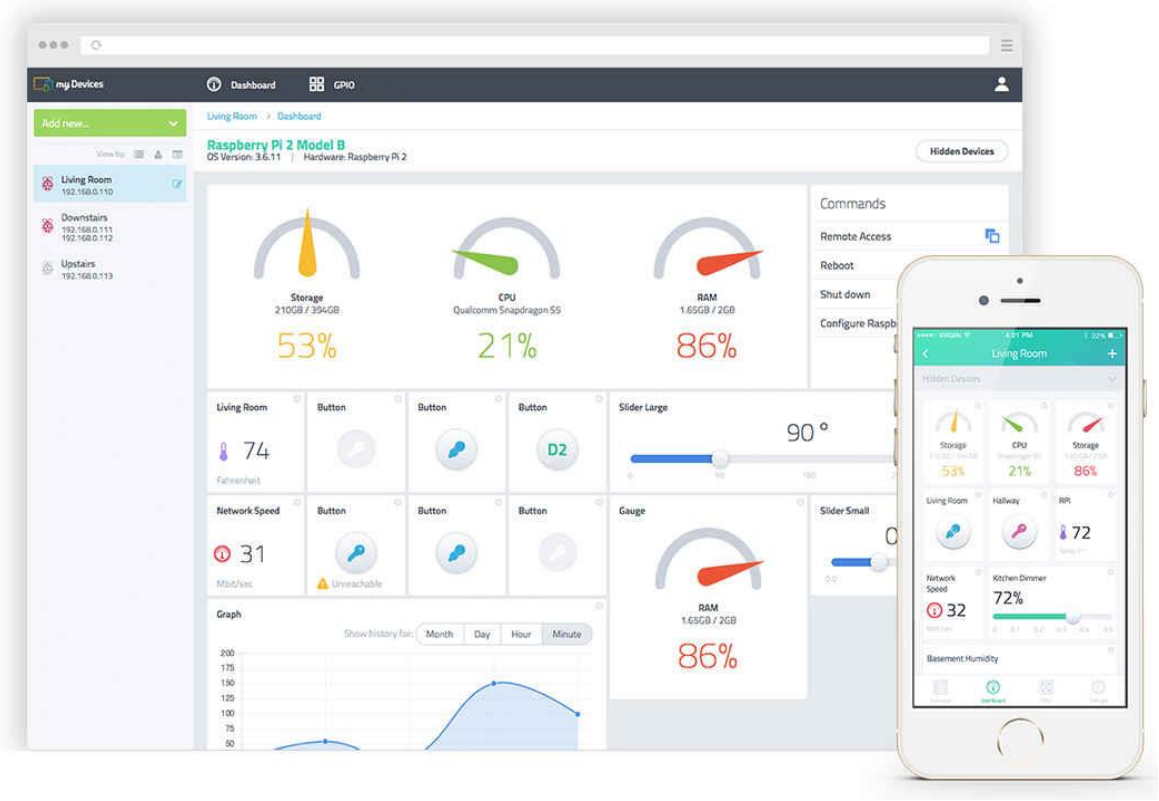

Figure 3.8 : Interface of Cayenne dashboard on devices

Cayenne server provide an easy interface for a user that is a beginner for an IoT application and they also provide application to be used in mobile phone or tablet.

- **Other Hardware needed**

i. A computer with windows 8 as it operating system

3.2.2.2 Software Requirement

For the software needed to complete this project I have choose Arduino IDE which is a software develop to help programmer write their coding into the Arduino board. The software mainly used to connect the computer with the Arduino board.

It is an easy software to use and are widely uses on most application or projects that involve Arduino board. Once the coding has been finished sketch or write the software will help we to install the program into the board using the function of upload as in we uploading the coding to the board for it to execute it according to the programmable application that we have set before.

After the data collection phase, I implement the coding for the purpose of this final year project in this software. The coding for temperature measurement using the hardware of thermocouple connected to the Arduino board has been wrote and have successfully show some result on reading the real time temperature which will be applied to the wafer furnace.

For the software which will connect the Arduino board I have choose the Cayenne software which is an open source platform to perform IoT application that is easy to use and user friendly. The software can also be download into smartphone which will make it easier to monitor the temperature wherever we are. The interface are very friendly as we can select the type of device we use and it will show us a value that very easy to understand and for this project it will show the value of the real time temperature of the wafer furnace and can be monitored using a mobile phone. The software itself help us to create a trigger which will help us to control the situation of the hardware that we use.

This software is the most applicable and favorite IoT open source platform by the developers all around the world for it has a lot of advantages to be explored.

3.3 MQTT Protocol

MQTT (Message Queuing Telemetry Transport which is a protocol designed to connect physical devices with applications used in web development making it the best option as connectivity protocol for IoT. By using this protocol it make the transition of the instruction and data received between the microcontroller and the cloud server become easier and avoid delay in data transition[14].

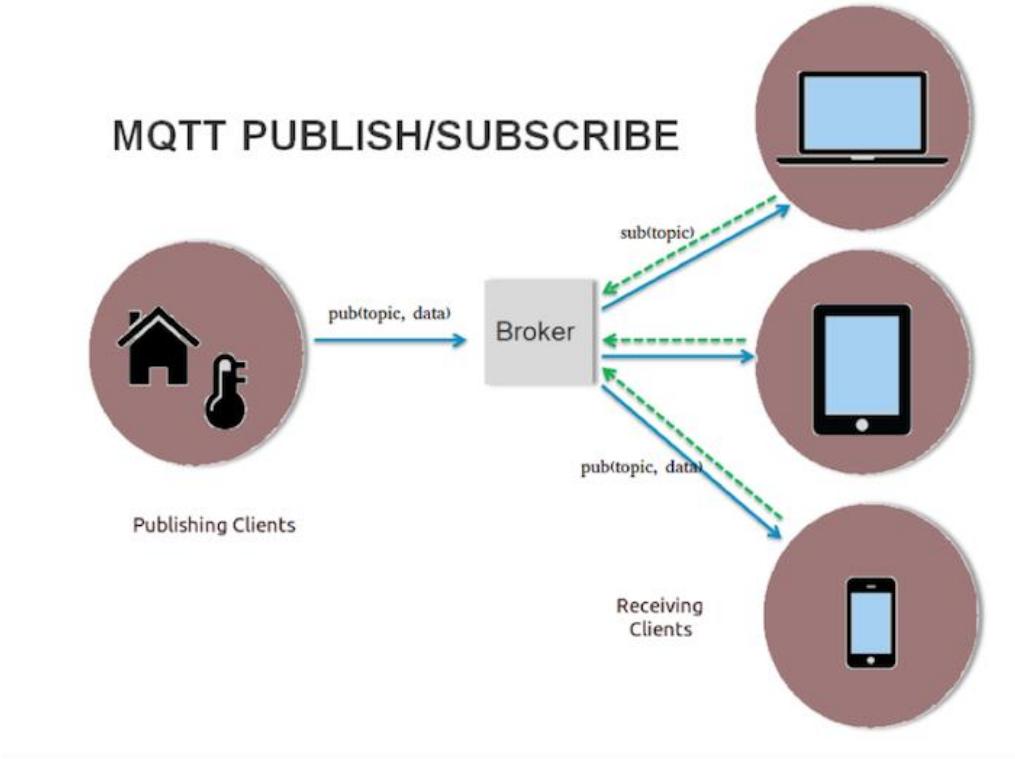

Figure 3.9: Example of MQTT protocol in real life

HTTP protocol is quite slow compared to MQTT and this make MQTT is more preferable to use in IoT application as connection of machine to machine such as sensor to the phone is much faster and reliable transmitted using MQTT protocol rather than old way of using HTTP protocol that can generate a slight delay for the transmission of data for the temperature measurement system using the Arduino board[15].

3.4 Programming

The programming for the IoT system have been developed several times to get the correct and functioning program that will work according to the project that I need to do. Using Arduino Uno is easy as it only use basic C language that are capable to be done by a beginner. The programming has been done fully in then Arduino IDE software as it easier to direct verified and upload the coding to the Arduino UNO board.

3.5 Layout Design

3.5.1 Connection of Max 6675 and K-type Thermocouple

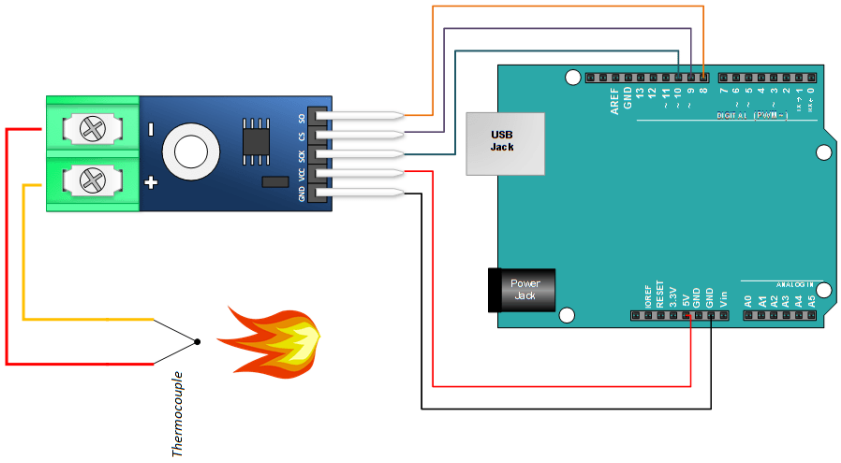

Figure 3.10 : Layout design for the connection of the thermocouple

3.5.2 Connection of Solid State Relay

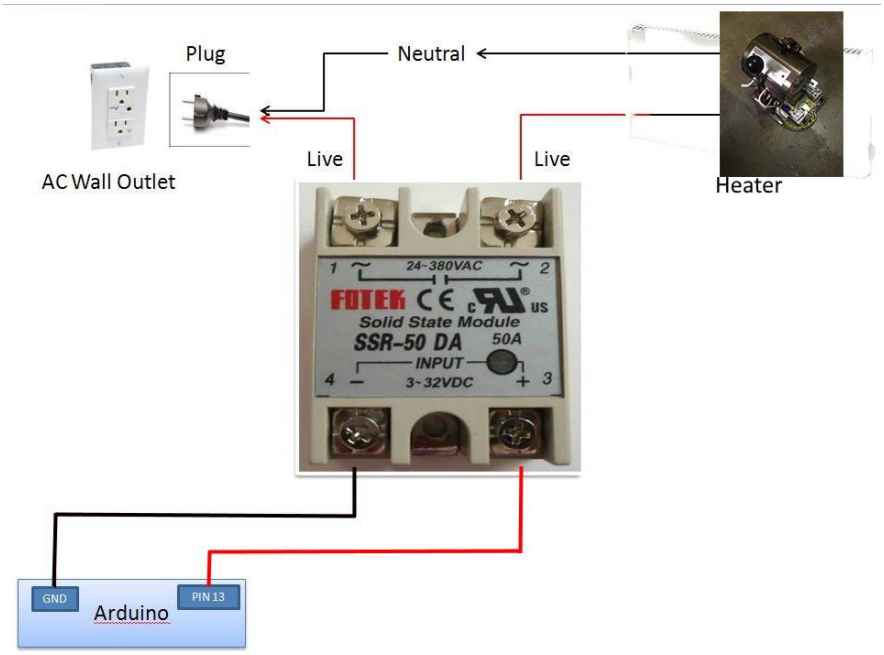

Figure 3.11 : Layout design for the connection of the solid state relay

3.5.3 Entire connection of the IoT system

Figure 3.12 : Full Setup for the system

3.5.4 Schematic diagram for the circuit of the system

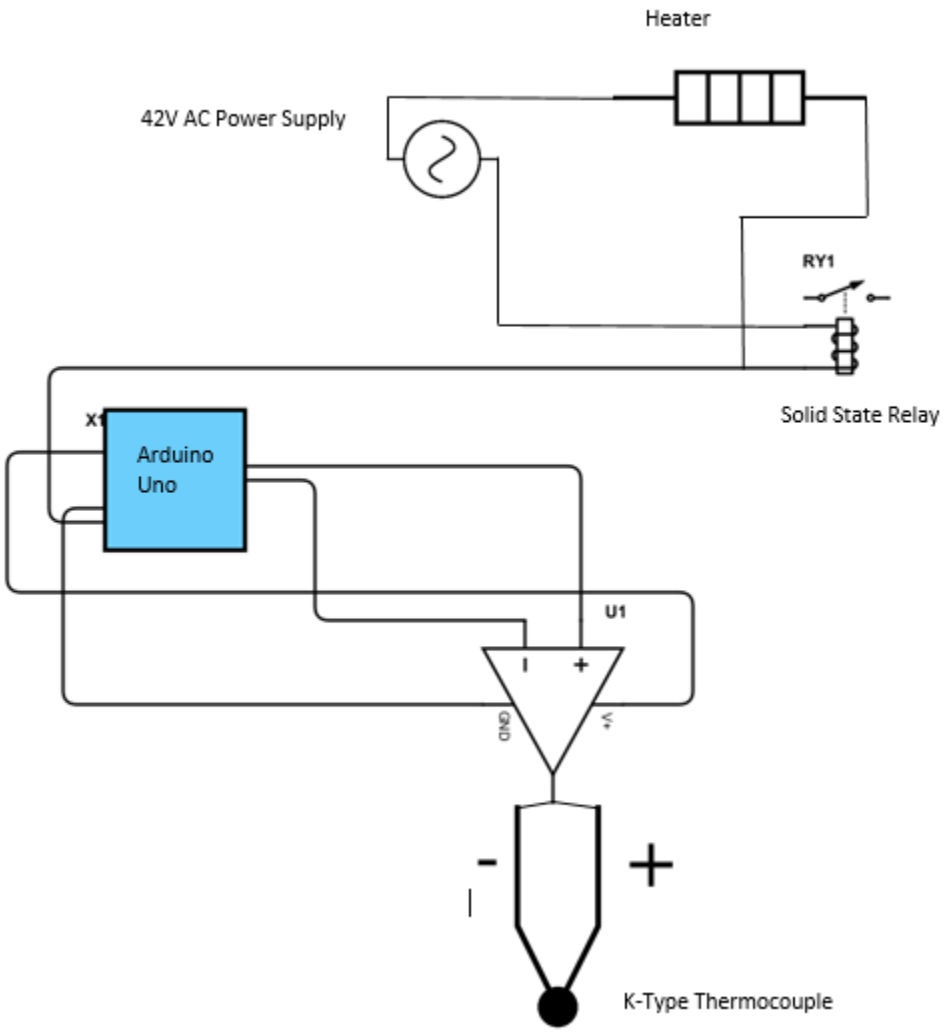

Figure 3.13 : Full Schematic Diagram for the system

CHAPTER 4

RESULT AND DISCUSSION

4.1 Application of IoT on Mobile Phone

For this project the purpose of controlling the heater and monitor the temperature in real time using mobile phone has been achieved. The application call Cayenne can be download to connect both the Arduino board and cloud server for the temperature monitoring process and the control for the on or off of the heater.

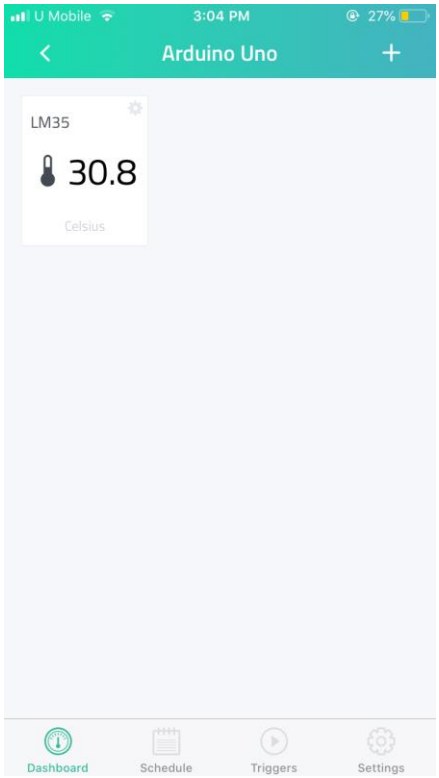

Figure 4.1 : Monitoring of temperature in mobile phone application