DEVELOPMENT OF SMART MONITORING SYSTEM USING IOT

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Special dedication

I dedicate this work to my beloved mother, father and family.

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ABSTRACT

This research project is about the design and implementation of weather monitoring with automation control. The additional feature added in like security will help to protect the system. The general idea behind the project is to provide temperature and humidity readings, appliances control plus the security. All the systems are controlled using IoT technology. The designed system consists of microcontroller as a main component, the humidity & temperature sensor as well as the ultrasonic sensor. The humidity and temperature sensor constantly detect the humidity and temperature of surrounding. The sensor output signals are read by the microcontroller. The microcontroller process the signals and send the signal over an internet network via a WiFi module called, ESP8266. There is another sensor which is ultrasonic sensor also produce digital signal when detecting a mobile object. All the signals are send at the same time to the ESP8266 WiFi module. At the receiver, there will be a platform or Apps designed to display those signals. Typical Apps used is Blynk. By using this Apps, the information from the sensor not only can be displayed but also saved in a database.

Keywords: weather monitoring, automation control, security system, humidity & temperature sensor, ultrasonic sensor and Apps.

ABSTRAK

Projek penyelidikan ini adalah mengenai reka bentuk dan pelaksanaan pemantauan cuaca dengan kawalan automasi. Ciri tambahan yang ditambah seperti keselamatan akan membantu melindungi sistem. Idea di sebalik projek ini adalah untuk membekalkan bacaan suhu dan kelembapan, kawalan peralatan serta keselamatan. Semua sistem dikawal menggunakan teknologi IoT. Sistem yang direka terdiri daripada mikrokontroler sebagai komponen utama, kelembapan & sensor suhu serta sensor ultrasonik. Kelembapan dan sensor suhu sentiasa mengesan kelembapan dan suhu sekitarnya. Isyarat keluaran sensor dibaca oleh mikrokontroler. Proses mikrokontroler isyarat dan menghantar isyarat melalui rangkaian internet melalui modul WiFi yang dipanggil, ESP8266. Ada sensor lain yang sensor ultrasonik juga menghasilkan isyarat digital apabila mengesan objek mudah alih. Semua isyarat dihantar pada masa yang sama kepada modul WiFi ESP8266. Di penerima, akan ada platform atau Apps yang direka untuk memaparkan isyarat tersebut. Apl tipikal yang digunakan ialah Blynk. Dengan menggunakan Aplikasi ini, maklumat dari sensor bukan sahaja boleh dipaparkan tetapi juga disimpan dalam pangkalan data.

Kata kunci: pemantauan cuaca, kawalan automasi, sistem keselamatan, kelembapan & sensor suhu, sensor ultrasonik dan Aplikasi.

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CHAPTER 1

INTRODUCTION

1.1 Background study

Smart home automation system had been studied and implemented since nineteen century. The smart home automation system consists of control of electrical appliances in a building and monitor the status of the building to enhance the security.

Back to the beginning of the nineteen century, digital system had been used in the home automation. Such system performs automatic control the home appliances using sensors. Although the sensors are used in the digital system, but this cannot inform the users about the building status. For example, when the intruder break in the building, with the sensor and digital system, the system will just trigger the alarm without knowing by the user. There is no way for the user to turn OFF the alarm if user is located in far distance.

Today with the existing of internet, the information about the home status can be reported at any time and at anywhere. User can access into his or her house to monitor the condition even user does not need physically appears in the house. Internet provides much more convenient way to handle the information. Such information is come from the sensors. The information usually appears in low data size. Typical Kbit or in Mbit appears in the network.

With IoT (Internet of Things) network, the sensors' information can be transferred to the destination in a proper way and more efficient way without loss. Thus, IoT is a system of network that helps the sensor information presentable in the network without mess up with other internet data. IoT uses IPv6 which has its own

protocol stack to handle the sensors' data. Thus, this will not interferes with ordinary internet data.

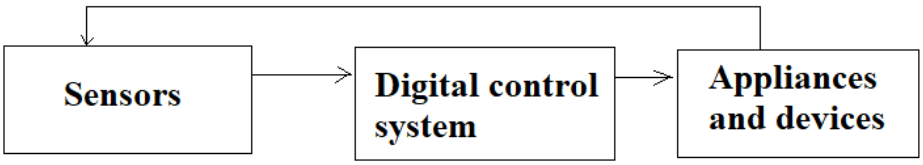
In this project, a simple real time home automation and weather monitoring system based on IoT is proposed. The project uses Arduino UNO as a main component interface with sensors and ESP8266 (Wi-Fi). To monitor the weather, humidity sensor and temperature sensor are used. To control the home appliances like turn ON the fan and the lights, an Apps is developed in the smart phone. The Apps consists of few buttons that give convenient for the user to control the lights and the fans. The control signal is using Wi-Fi signal.

For security enhancement, additional sensor like ultrasonic sensor is used in the project to detect an intruder break into a house. The sensor constantly detects any mobile object. The sensor signals are send over the internet network and displayed by a html platform. The html platform proposed is Thingspeak.com. With this platform or page, all the sensors signals (not only the ultrasonic sensor) can be viewed in the form of graphs. User can access into this Thingspeak.com at any time and at anywhere.

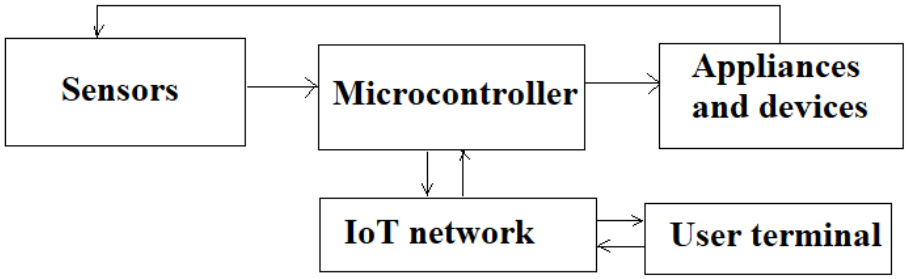
1.2 Problem statement

The traditional home automation system does not allow user to know the home condition. The traditional home automation perform automatic control the home appliances based on the sensor signals. This is not enough because user is not reported on the status of the control. With IoT system, the home appliances and conditions not only being controlled but also monitored by the user from far distance. Figure 1.1 illustrates the comparison of traditional home automation and monitoring system versus IoT home automation and monitoring system.

From Figure 1.1, it is notice that the traditional home automation and monitoring system is using one way communication and it form a loop system. Whereas for modern home automation and monitoring system, it uses two way communication system where the home appliances not only being monitored, but also can controlled via an internet network.



(a) Traditional home automation and monitoring system



(b) Modern home automation and monitoring system

Figure 1.1: Comparison between traditional and modern home automation and monitoring system

The advantages of using IoT are:

- Allow user to control the home appliances from far distance if it is needed
- Allow user to know the house conditions especially the electrical energy consumption

Allow user to record the intruder break into the house and presents the record as eviden

1.3 Objectives of the Study

The objectives of the project are:

(i) To design and develop a real time home automation and weather monitoring system using IoT technology.

(ii) To develop an Apps and pages that can control appliances and monitor the weather.

(iii) To analyses the sensor signals displayed on the platform.

1.4 Scope of the project

The scope of the project will cover the circuit design, programming design, Apps and page design.

The circuit design involve microcontroller circuit design that interface with sensors and ESP8266 Wi-Fi module. The Apps and the page design are using Blynk and html. The Blynk is an open source Apps that allow user to develop GUI (Graphical User Interface). This Apps can link to the Arduino UNO with specific commands.

The page on the other hand is supported by Thingspeak.com. The Thingspeak,com is a customize page for IoT database. The Thingspeak.com allows user to design his or her own page that can display the sensor signals and other control function. Thingspeak.com also allow user to store his data into the cloud system. To do that, user must program the page so that it can record the data whenever it is needed. The data can be protected by password. This is an additional feature for security of sensor data[t] paragraph.

1.5 Thesis arrangement

Title This report consists of five chapters. The chapters are introduction, literature reviews, methodology, results & discussions, conclusion & recommendations.
Chapter one introduces overall idea about the home automation and monitoring of weather system using IoT technology. The chapter also presents the objectives, problem statements and scope of the project.

Chapter two will show the reviews of IoT network and other components that related to the project. This chapter mainly presents the theories that are needed in the design of IoT system. Apart from that, the chapter also reviews some research papers that related to the IoT system.

Chapter three shows the methodology of implementing the weather monitoring and home automation system. This chapter will show the circuit design, programming design and software tools.

Chapter four presents the experimental results for the circuit testing. Part by part of the circuit testing and sensor testing will be presented in the chapter. The final testing will show the prototype performance.

Chapter five concludes the project works and state the recommendations to improve the project. The chapter highlight the important points which summarize the whole works of the project. The recommendations are given for further improvement of the project. This might be helpful for further study.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

Internet of Thing (IoT) becomes well known in sending receiving the sensors' signals in an internet network. The IoT has its own protocol and usually it does not affect the real data performance in the internet network. IoT data rate typically very low, which is less than 1 MB. Because of this, there is a need of separate hardware and internet protocol to support this data rate.

This chapter reviews the theories about the IoT and some of the current IoT development. The chapter also demonstrates the basic components require in the IoT network to support the sensors' data communication. At the end of the chapter, there are papers presented to show the latest research about the IoT system and development.

2.2 The IoT system and control

1st The IoT first introduced by Kevin Ashton in year 1999. The system became very popular in year 2010 until today.

IoT basically is an internet connection of devices that share information. The devices connected into internet not limited to computers, but also the mobile communication devices like cell phone, home appliances, sensors and other electronic devices like printers in office.

Today IoT widely applied into the smart house. It is used to enhance the security system, monitor the building conditions and send the report to the owner of the building. All these require the following devices to support [1]:

1. The internet network

2. The IP address
3. The router or the gateway
4. The sensors
5. The microcontroller
6. The mobile devices
7. The page
8. The server or the cloud system

The basic working principle of the IoT is two ways (duplex) communications. The two ways communication means the sensors will send the signals to the receiver. The receiver processes the signals and wait for the user commands to control the devices in the building. If the control function is not available, then the system is purely monitor the compound of the building. The monitoring is via a webpage or the Apps in the cell phone. The monitoring is continuous and hence the signals are continuous sending to the receiver. If any things sensed by the sensor, the signals will be updated. The information about the signals can be stored in the cloud for future references [2]. In a nutshell, the IoT basically comprises of three important components. These are sensor nodes, gateway and the platform (Apps or webpage).

The sensor nodes consist of sensor and a microcontroller. The nodes are wireless. They pick up the information from the environment and convert those information into electrical varying signals. With the microcontroller in the nodes, the information will be processed and send to the Wi-Fi module. Once the Wi-Fi module received the signals, it then route the signals to the gateway and hence log into the internet. The connection between the gateway and the sensor nodes are important. The gateway is a hotspot that gives the radio coverage for the nodes access into the internet. The number of sensor nodes that can be supported by the gateway are depends on the following [3]:

1. The types of gateway used.
2. The bandwidth.
3. The data rate of the gateway.
4. The coverage of the gateway.

The information signals once reaching the internet network, they will be propagated toward the destination. Depending on the program written in the microcontroller. Some programmer program the signals stored in a cloud and some of

them program the signals display immediately in the Apps and in the page. All these are controlled by the microcontroller.

Today with the existing of Named Data Network (NDN), the IPv6 is no longer support the IoT signals. It is using NDN protocol to support the IoT signals. The NDN protocol is faster and isolate the use of IP address and the named network address. The NDN also has less bandwidth and less data rate. Hence it is very suitable to support the IoT signalling.

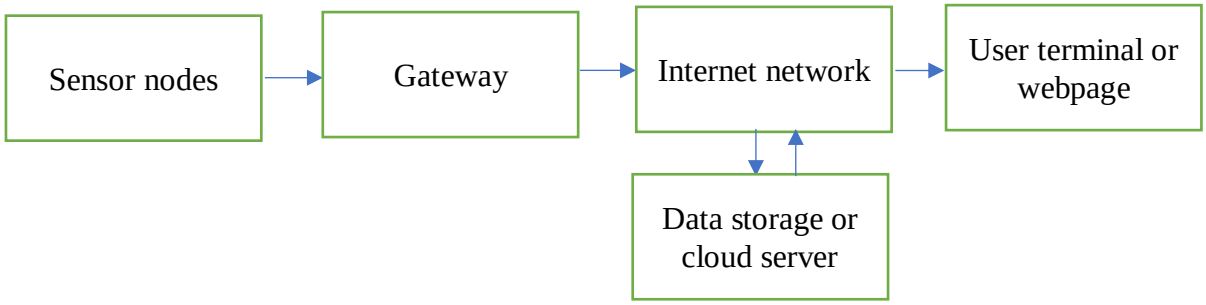
Another things popular in IoT are the power consumption control of the devices and introducing the 6LoWPAN system to manage the IoT device. The power consumption is about the total energy or power used by all the sensor nodes in the network. It is assumed that all these nodes are sharing the power using RF harvesting technology. Therefore, to save the energy or power usage by the nodes, the ON and OFF mechanism had been introduced to save the energy. The ON and OFF is about the 'awake' and 'sleep' nodes. The awake is an active sensor nodes where they are sending and receiving the information signals. The 'sleep' nodes means those nodes are not active in the network. They are in sleep mode to save the energy.

To save overall power consumption, many researchers had proposed that after the nodes have sending the information or receive the information signal and they are no more used in the network, then they can automatically turned into sleep mode. The nodes will start become active when they are called to send or receive the information signals [4].

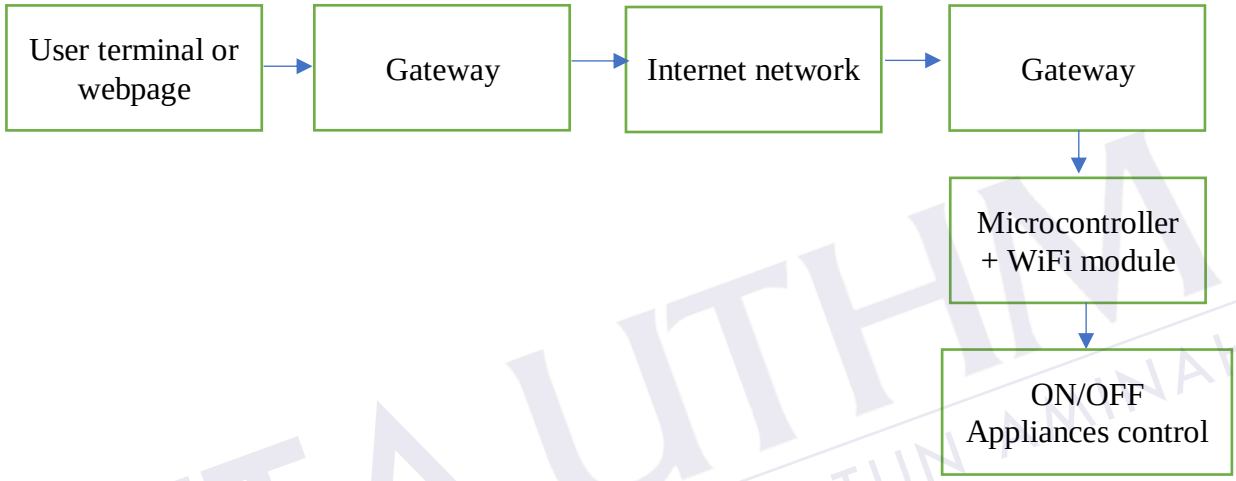
Another things need to be considered in the IoT system design is the nodes topology. This topology is important because it determines how the signals propagate in the network. The 'star' topology which is the most commonly used by many people allow all the nodes send the information signals into one gateway. Although this is a very simple topology, but the designer should consider the traffic flows as data collision could happen due to multiple access into the network.

There are other types of network topology like mesh, tree and distributed network. All these topology can be applied in the wireless sensor networks to control the signals access into the network.[5]

Figure 2.1 shows the IoT applications divided into two parts. One is monitoring and second one is control of appliances.



(a) IoT based monitoring system [6]



(b) IoT control system [7]

Figure2.1: Applications of IoT system

In the control of appliances, the user terminal consists of Apps or a platform. This platform will link to the microcontroller that located at far distance. The linkage is through the internet connection.

The platform consists of many buttons that allow user to turn ON and OFF the appliances. Once the button is pressed, the signal will send to the gateway and then to the internet.

At the receiver, the microcontroller detects the incoming signal with the help from the Wi-Fi module. The signal is then interpreted to determine which appliances need to be controlled.[8]

By looking into the diagram shown in Figure 2.1, we can see that the IoT brings many benefits to the user and improve the living style in human life. The benefits of the IoT are[9]:

1. Remotely control the home appliances without physically reach to the home.
2. It has an energy saving capability if the microcontroller is programmed to do that.
3. Efficiency in monitoring the house condition and hence enhance the security.
4. Using cell phone to control allows user 2 in 1 operation without using extra remote control.

2.3 The basic components of IoT system

The working principle of the IoT has been discussed in section 2.2. This section presents more detail about the components used in the IoT system. Although there are many types of components can be found in the IoT system, but the basic components are microcontroller, Wi-Fi module, sensor, user mobile terminal and webpage.

2.3.1 Microcontroller

This is the core of the device in the IoT system. The microcontroller usually connect with sensor and Wi-Fi module. Hence this form a sensor node.

The microcontroller is a programmable devices. They are programmed to read the sensor signals, interpret the signals and make decision to send the signals whether to the webpage or to the Apps.

Today all microcontrollers can perform the basic operation on interfacing with sensors, reads the sensor signals and send the signals to the WiFi module. Some microcontrollers are hard to use and some are very easy. For example, PIC microcontroller will be the difficult one to use and require addition MAX 232 IC module interfaces with Wi-Fi module. On the other hand, the Arduino microcontroller and the Raspberry Pi are easy use because they have the functions to interface with Wi-Fi module. Thus no additional circuit or module requires to support the WiFi connection [10]. Compare with Raspberry Pi, Arduino microcontroller is the easiest microcontroller that can be used to support the IoT. Arduino microcontroller until today is chosen by many IoT designer because it has an analogue port. The analogue port is used to interface those analogue sensors like temperature sensor, LDR sensor, ultrasonic sensor, water level sensor and so on. Unlike Raspberry Pi, this

microcontroller does not has analogue port and face the problem on analogue sensor connection.

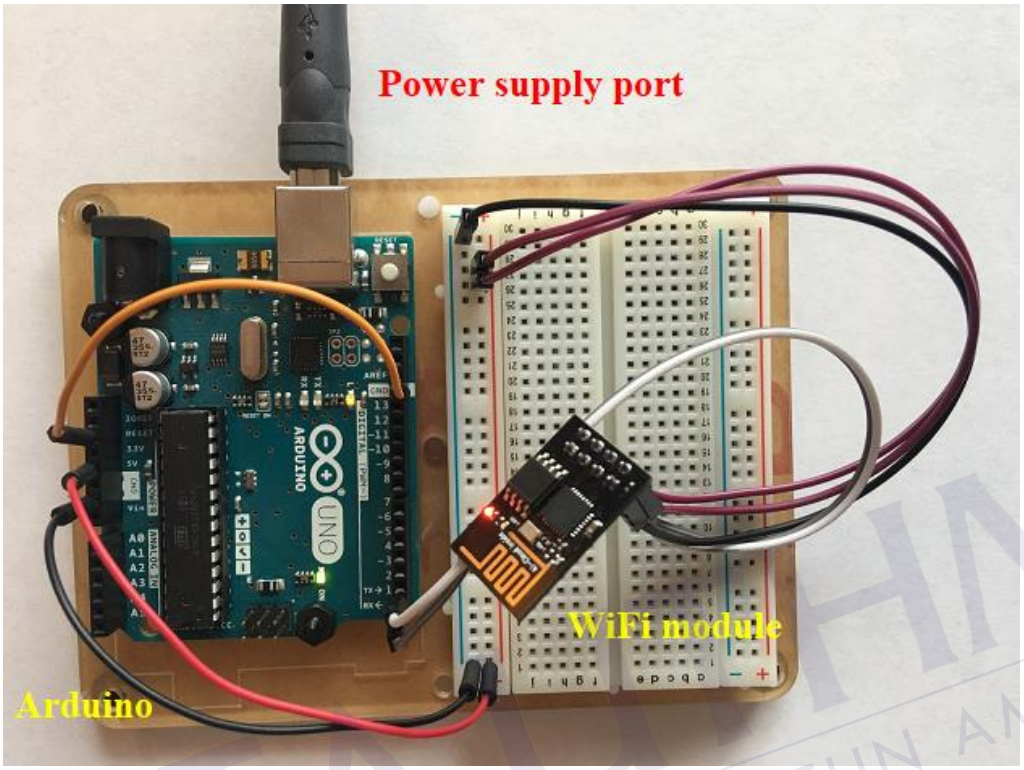


Figure2.2: Basic Arduino microcontroller connect to Esp8266 WiFi module [11]

The detail of the Arduino microcontroller pin configurations can be seen in Figure 2.3 and 2.4. Note that there are two types of Arduino microcontroller which are useful to support the IoT. One is Arduino UNO and the other one is Arduino Mega. The different between these two are the number of I/O pins. From the diagram, one can see that Arduino Mega is having high number of I/O pins compare with Arduino UNO. The cost of Arduino Mega is also high.

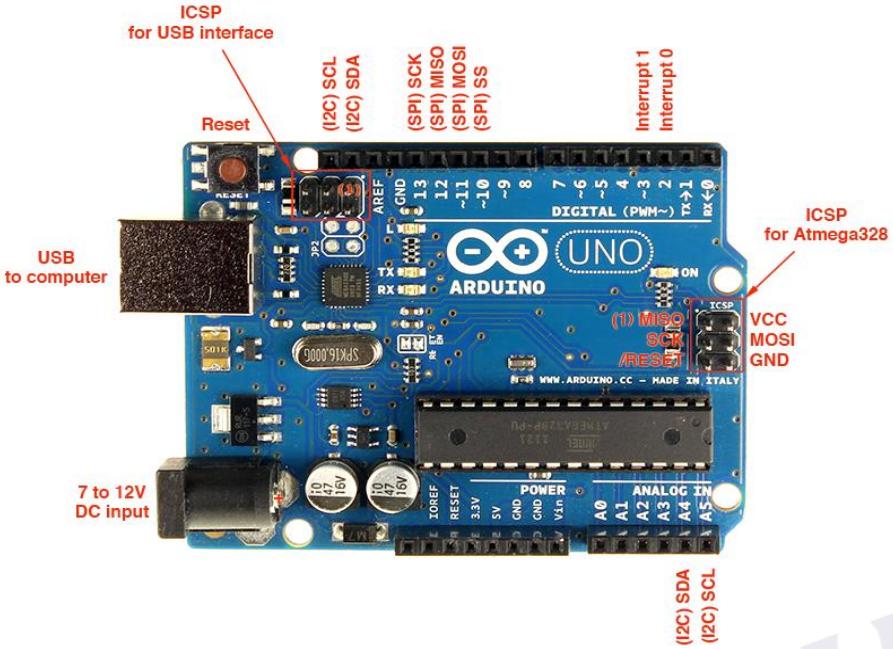


Figure 2.3: Pin configuration for Arduino UNO [12]

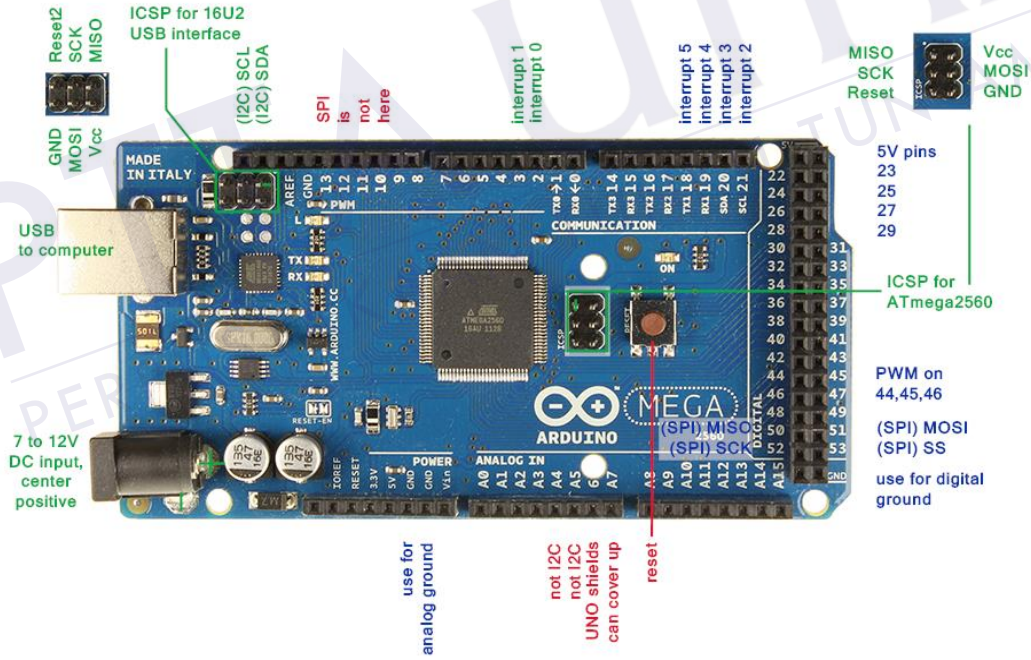


Figure 2.4: Pin configuration layout for Arduino Mega [13]

Table 2.1: Summary of dataset attributes for classification problems

Arduino UNO	Arduino Mega
Operate in 5 V	Operate in 5 V
Maximum current support is 100 mA	Maximum current support is 200 mA
One analogue port	two analogue
13 digital I/O pins	21 digital I/O pins
Power required is 500 mW max	Power required is 800 mW
Support WiFi	Support WiFi
Support Bluetooth	Support Bluetooth
Not support voice processing	Support voice processing
Not support video signals	Support video camera signals
Support analogue and digital sensors	Support analogue and digital sensors
Build in Vcc 5 and 3.3 V power supply	Build in Vcc 5 and 3.3 V power supply

There are also other types of Arduino microcontroller like Tiny and Pro. All these will not use in IoT as the device cannot support high current of loads.

All the Arduino microcontrollers are programmed using Arduino C compiler. This compiler is an open source programming and can be downloaded free from internet. Figure 2.5 shows the Arduino C compiler window.

Figure 2.5: Arduino C compiler

The Arduino C compiler allows user program the Arduino microcontroller. This compiler has three important functions. One is library function, second is compiler and third is compile with download the program into physical Arduino microcontroller board. Other function like converting the C code into Hex file also provided by the compiler.

When the compiler wants to interface with microcontroller, it has to ensure the microcontroller types are in the library. If the microcontroller type is not in the library, user is asked to download one. The compiler only works if the library of that microcontroller is available. Thus, each time the compiler compiles the program, it will call the library function and add the library into the program.

When user wants to check his or her program content bugs or not, he or she can run the compile function. Once this compile function is running, the compiler will check the syntax of the program.

To download the program into physical Arduino microcontroller board, user can choose compile and download. This will compile and download the program directly into the microcontroller board.

To download the program into the virtual Arduino microcontroller board, user can choose export the program. Once the program is exported, it will converted into Hex code or Hex file. The virtual Arduino microcontroller requires this file to run in the simulation environment.

2.3.2 ESP 8266 Wi-Fi module chip

ESP8266 is a tiny Wi-Fi module chip specifically designed for Arduino microcontroller usage. This module comes with two types: blue colour and black colour. The pin configurations of these two types are the same. The only different is the data rate. The blue Wi-Fi module is 0.5 Mbps whereas the black colour WiFi module is 1 Mbps of data rate. Figure 2.6 illustrates the the ESP 8266 WiFi module.[14]

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