CONTROLLING GREENHOUSE ENVIRONMENT FOR GREEN ROSE PLANTATION USING RASPBERRY PI MICROCONTROLLER AND SENSOR

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DECLARATION

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Nomenclature

Abbreviations

SoC	Broadcom system on a chip
CPU	Central Processing Unit
GPU	Graphics Processing Unit
SD	Secure Digital
HDMI	High-Definition Multimedia Interface
WiBro	Wireless Broadband
WLAN	wireless Local Area Networks
AP	Access Point

ABSTRAK

Kawalan persekitaran adalah salah satu faktor yang penting dalam meningkat pengeluaran bunga ros hijau. Sebelum menggunakan teknologi rumah hijau, perkembangan anak pokok hanya berhasil 20 daripada 100 anak pokok yang ditanam. Iaitu hanya 20% pertumbuhan anak pokok yang berjaya. Oleh itu, kajian ini memberi tumpuan kepada alat kawalan alam sekitar automatik yang merupakan sistem yang digunakan untuk mengawal faktor persekitaran seperti suhu, kelembapan udara dan kelembapan tanah dengan menggunakan pengawal mikro untuk menyediakan keadaan yang optimum kepada bunga ros hijau. Tujuan projek ini adalah untuk membangunkan rumah hijau automatik untuk meningkatkan pengeluaran bunga ros. Dalam projek ini, rumah hijau yang dibangunkan dengan menggunakan modul WiBro, DHT11penderia suhu dan kelembapan dan penderia kelembapan tanah. Dengan menggunakan peranti ini, tahap kelembapan suhu, kelembapan udara dan tanah di dalam rumah hijau boleh dikawal melalui internet. Selain itu, sistem ini juga menggunakan konsep Perkara Internet (IOT) yang membolehkan pengguna untuk memantau keadaan persekitaran di dalam rumah hijau di mana-mana dan bila-bila masa mengakses internet. Selain itu, peranti ini juga dilengkapi dengan mekanisme automatik untuk mengawal keadaan alam sekitar di dalam rumah hijau untuk mengekalkan keadaan optimum. Daripada hasil yang diperoleh menunjukkan peningkatan pertumbuhan bunga ros hijau sebanyak 63 daripada 100 pokok ditanam. Ia bermakna peningkatan sebanyak 315% pertumbuhan bunga ros hijau. Teknologi rumah hijau adalah kaedah yang terbaik untuk petani untuk meningkatkan pengeluaran mereka.

ABSTRACT

Environment control is the one of the significant factors that needs to be controlled in green rose production. Before using the greenhouse technology, there are only 20 of green rose are successful grown from 100 of green rose. There is only 20% of successful growing green rose. Therefore, this research mainly focuses on an environment control automated device which is a system that applies automated control of the environment factors such as temperature, humidity and soil moisture by using microcontroller to provide optimum condition to green rose plantation. The aim of this project is to develop an automated greenhouse for green rose plantation in order to increase the green rose production. In this project, the greenhouse are developed by using WiBro module, DHT11 temperature and humidity sensor and soil moisture sensor. By using this device, the temperature, humidity and soil moisture level inside the greenhouse can be monitored through the internet. In addition to that, this system applies the concept Internet of Things (IoT) that enables users to monitor the environment condition inside the greenhouse anywhere whenever accessing the internet. Besides that, the device is also equipped with automatic mechanism to control the environmental condition inside the greenhouse to maintain the optimum conditions. The result obtained shows the increasing the successful growth green rose to 63 from 100 green rose tree. It means increasing by 315% of green rose plantation. Greenhouse technology is the best method to the farmer to increasing their production population.

Chapter 1 : Introduction

1.1 Background

The project of the controlling greenhouse environment for green rose plantation using raspberry pi microcontroller and sensors is a project by Public-Private Research Network (PPRN) that collaborated between University Science Malaysia and Sufihealing Resources company. Sufihealing Resources company is making, supplying, distributing and saling of the herbal product aromatherapy spa treatments & traditional and health product. The company are located at Ipoh and the product based on extract of green rose. The founder of this company is Noor Asiya binti Sulaiman and the main products are Green Rose Aura oil, Green Rose soap and others. [1]

All parts of the green rose tree from a root until a leaf are used to produce a green rose product and to produce one green rose product required a lot of green rose tree. The duration of green rose growing also take a time and they main problem is there are only 20% of the replant tree are successful fully grown while another 80% of green raised die. Before this, they try a lot of different methods to replant the green rose to increasing the percentage of the full success growing of the tree but fail. So, the request a greenhouse to help them to a plantation of the green rose and hopefully can increase the percentage of the successfully growing replant green rose.

The concept of greenhouses is protected agriculture known as crop production to non-conventional means in particular facilities to protect from inappropriate weather conditions. The example are agriculture in tunnels or plastic greenhouses with controlled internal climate control and control (glass or glass Viper) to ensure heating or cooling in hot and rainy day as well as the appropriate moisture control and plant protection from hot and cold air currents, precipitation and agricultural pests, and which is a sophisticated agricultural and factor in increasing agricultural productivity and quantity of crops. [2]

Early greenhouse control used a simple concept such as pulling a chain to open or close a vent, turning a valve to control the heat and irrigation or only throwing a switch to active a pump or fan. Over the years this changed as greenhouse systems themselves became more complex and more dependable. Early automated control consisted of independent thermostats, humidistat, and timers. Even these simple devices allowed major advances in efficiency and product quality and made grower’s lives simpler. However, many of these

control devices and methods cannot deliver the level of automation and efficiency needed in today's dynamic, competitive environment. [3]

A typical greenhouse zone may require 3 or more individual thermostats to control heating and cooling functions, plus timers for irrigation and lighting control. Additional relays are often necessary to interconnect fans and louvers and other devices that must work together.

The advantages: Does not require sensors to carry out programming, these simple devices are low cost.

The disadvantages: Requires extensive knowledge of crops and weather conditions (which are not totally predictable) to operate efficiently, and provide limited control, Lacks feedback from the crop and could damage the crop if programmed incorrectly, poor accuracy Require continuous supervision by the grower in order to maintain acceptable conditions for crop growth and health , and poor energy efficiency.

The common problems experienced with using several independent thermostats and timers to control a greenhouse led to the development of early electronic analogue controls, also known as "step" controls. These devices made a major contribution to improving the growing environment and increasing efficiency by combining the functions of several thermostats into a single unit with a single temperature sensor.

Today, computerized control systems are the standard for modern greenhouses, with continued improvements as the technology advances. Environment conditions can be maintained by these computerized control systems, where the system can be operated manually or automatically. Main components of any control system are measurement, controller, data processing, data acquisition and recording. In the environment control system, each parameter must be maintained continuously within a certain range. It needs a complex control system because there are many conditions that depend on the kind of plant and distribution of parameter values at certain times. A number of sensors, switches, actuators (e.g. fans, ventilator & sprayer) must be installed in the system. Consequently, there are many devices that must be handled in the operation. The use of a computer system will be absolutely necessary to handle control system in order to maintain temperature and humidity with high accuracy. [4]

1.2 Problem Statement

Green rose is an herb plant that used in traditional medicine. All part of green rose is used to produce a medicine so the farmer need to replant the sapling of green rose again to produce another new tree. The process of growing the plant will take a lot of time and the main problem they facing is only 20% of the replant is successful fully grown while another 80% of green rose are died. So, they need a greenhouse to help the plantation of the green rose.

1.3 Research Objective

The objective of this project are

1) To build the greenhouse for green rose which is equipped with automatic monitoring and controlling system.
2) To constantly monitor and control environmental conditions in greenhouse to ensure it remain at required temperature, light, moisture and humidity level by using Raspberry PI microcontroller and sensors.
3) To provide the user ability to see the atmospheric condition of the greenhouse plants on website/software and control the greenhouse remotely from faraway places.

1.4 Research Scope

In this thesis, the study of controlling greenhouse environment involves the sensors, relays and devices to control the greenhouse. Python programming language also have been involved to control the parameter of the controller and type of internet access and how to connected Raspberry pi and home desktop through the internet.

1.5 Overview of thesis

This thesis is comprised of five main chapters. The first chapter is about the introduction and background of greenhouse. It also presents the problem statements, objectives and scope of the research.

In chapter 2, the literature review is written by using a previous journal from the other researcher as a reference. Here, it tells more about the component and system that controlling the automated greenhouse.

In chapter 3, the methodologies in term of technical works are briefly described here. It covers from the early stage which is greenhouse system, parts or components used in automated greenhouse, python programming language and the wireless system to connect the raspberry pi remotely from faraway place.

Chapter 4 generally discusses about the result obtained from developing the greenhouse system and the data collection of temperature, humidity and soil moisture. Finally, chapter 5 will summarize the overall final year's project. The conclusion, suggestion, and recommendations for improvements that can be implemented in future are discussed within this chapter.

Chapter 2 : Literature Review

2.1 Introduction to green rose

The discovery of Green Rose or it scientific name is Rosa Veridiflora happen accidentally when founder of Sufi Healing visited Cameron Highland. According to the rose's seller, the colour of the rose is red and then founder are bought two roses from them. A few months later only one rose are red flowering but another one not bloom at all. However the tree still stored until one day the flower emit green colour roses. At the same time, the founder has a mystery illness almost a few years. One day, she had a dream of her grandfather bring those roses. She told her strange dream to her families, since from that accident she takes the roses as her medical to recover from illness. She keeps these roses almost 26 years until a Chinese man came to the house and see that flowers and suggest to dried and made into tea. [5]

After many times impregnated and learn the techniques of Syifa medical, Kundalini Reiki, Mind power and another herbal courses organized by the Department of Agriculture and private sector, she makes their own alternative treatments with the concept of aromatherapy using natural healing waves and vibrations parallel with counter-clockwise rotation method (anti clock wise). At early stages, she only focus to purchase aroma products for the treatment of patients, but one of her patients suggested her to produce her own product by using green rose as a base of the aroma. [5]

The first product released is aromatherapy Green Rose. Aromatherapy for alternative treatments. Aromatherapy received but only used for the treatment, not for business. As the product get demand, the founder of Sufi healing propose to add another aromatherapy products which are green rose massage oil. Both of the products received a good response from user. [5]

2.1.1 Green Rose

Green rose or the originally known as 'rosa chinesis viridiflora' is a kind of a rose whose uniqueness stems from its lack of true petals. Green rose consists of the sepals and a leafy middle. The flowers of the Green rose are in fact a genetic anomaly, and that is presumed to be the key to this plant's existence. Green rose presents small blooms with a rosette type form of between an inch and an inch and a half across or about the size of golf balls, and they are made up entirely of deep green sepals. These flowers begin as rose shaped buds before they unfurl into little mounds consisting of sharp, serrated leafy petals like tiny

spiky leaves. the petals are many narrowly shaped, reminiscent of little spear tips. When in full bloom, the petals open to display a three dimensional circle of narrow flat, sharply pointed spears that burst up and out, as if reaching for the sun or an unexpected touch. Figure 2.1 shows the shape of green rose.[6]

Green rose has an upright growth habit and reaches from 2 to 5 1/2 feet tall and about 3 feet wide. Green rose also shade tolerant and would do quite well in that area of garden that only receives partial sun. Another unique quality about this special rose is that it is what is known as asexual. It does not make pollen or set hips, since the blooms have no stamens or stigmas and are therefore quite sterile. As such, this rose cannot be used in hybridizing. it has, however, managed to survive for centuries without any assistance from human. [6]

Figure 2.1 : Green rose [6]

2.2 Introduction to Greenhouse

A greenhouse is a system for environmental modification and management that allows plants to be grown in climates and seasons that would not otherwise be well suited for their growth. Greenhouses can be used to grow many different kinds of plants with a wide range of environmental requirements from tender rainforest plants to desert succulent. Greenhouses must optimize crop growth and energy use by allowing sunlight in during the day, absorbent as much heat as possible during cold weather, and provide sufficient ventilation to avoid extreme interior temperature and humidity. Where possible, for the greenhouse construction material should be use highest insulation value. Proper glazing material decreases energy loss while still allowing the natural spectrum of light inside to facilitate the healthy growth of the plants within. [7]

2.2.1 History

The idea of growing plants in environmentally controlled areas has been around for a long time. Doctors for the Roman emperor Tiberius prescribed a cucumber a day for him. The Roman gardeners used artificial methods (similar to the greenhouse system) of growing to have it available for his table every day of the year. Cucumbers were planted in wheeled carts which were put in the sun daily, and then taken inside to keep them warm at night. The cucumbers were stored under frames or in cucumber houses glazed with either oiled cloth known as "specularia" or with sheets of mica. [8]

The first modern greenhouses were built in Italy in the Sixteenth Century to house the exotic plants that explorers were bringing back from the tropics. They were originally called giardini botanici (botanical gardens). The concept of greenhouses soon spread to Holland and then England, along with the plants. Some of these early attempts required enormous work to close up at night, or to winterize. There were serious problems with providing adequate and balanced heat in these early greenhouses.[9]

Jules Charles, a French botanist, is often credited with building the first practical modern greenhouse in Leiden, Holland to grow medicinal tropical plants. In the Eighteenth Century the largest greenhouses were built. The conservatory at Kew Gardens in England is a prime example of the Victorian greenhouse. Although intended for both horticultural and non-horticultural exhibition these included London's Crystal Palace, the New York Crystal Palace and Munich’s Glaspalast. Joseph Paxton, who had experimented with glass and iron in the creation of large greenhouses as the head gardener at Chatsworth, in Derbyshire, working for the Duke of Devonshire, designed and built the first, London's Crystal Palace.

The success of greenhouse production depends on the efficient delivery of nutrients and water to the plants while maintaining an ideal climate within the greenhouse. Recently, research projects have been initiated to grow plants within controlled environment for purposes other than providing plant materials to meet market requirements. Plants are an important resource for sustaining and enhancing human lives and the environment. Forms of protected cultivation of plants range from growing under simple covers to production within highly integrated controlled environments. [9]

2.2.2 Structure of Greenhouse

The structure of greenhouse usually with a glass or plastic roof and side walls that is used for the production of ornamentals and food crops and may be used seasonally or year

round. The closed environment of a greenhouse has its own unique requirements, compared with outdoor production. Pests and diseases, and extremes of heat and humidity, have to be controlled, and irrigation is necessary to provide water. Significant inputs of heat and light may be required, particularly with winter production of warm-weather crops. Greenhouses for commercial production can be classified as free-standing or gutter-connected. A free-standing greenhouse can have a quonset (hoop), gothic or gable roof shape. The quonset is usually the least expensive and is available in widths up to 36 feet. Gothic designs have higher light transmission and shed snow easier. Gable designs may use trusses to span a width up to 60 feet. A gutter-connected greenhouse is a series of trusses connected together at the gutter level. Individual bays vary in width from 12 feet to 25 feet and have a clearance of 8 feet to 16 feet to the gutter. Bays can be put together to get any width of greenhouse desired.[10]

Most greenhouses are built of galvanized steel tubing and are available from many manufacturers. Steel makes a strong frame to carry snow and wind loads and still allow about 80% of the light to enter. Most greenhouses are covered with a plastic glazing. Low-cost polyethylene film or covering applied as an air inflated double cover will last 4 years. Anti-drip agents and infra-red inhibitors are added to give better service and reduced heat loss. Semi-rigid structured sheets of polycarbonate or acrylic are more permanent and have a life of at least 15 years. Tempered glass is used for crops requiring high light levels. [10]

2.3 Environmental factors and Plant Growth

Plants are dependent on many factors for growth. These factors affect the plant growth in different ways and it depends on the plant type. But the major factors include temperature, humidity and soil moisture. These factors are discussed in the following section.

2.3.1 Temperature effect

Temperature influences most of the plant development processes such as transpiration, photosynthesis, absorption, respiration and flowering.[11] Studies have shown in general that growth is promoted when temperature rises and inhibited when temperature falls noting that growth rate will not continue to increase with increase in temperature. Each plant species has a different temperature range in which they can grow.[12] Therefore, temperature range should be maintained at optimum level at whatever time possible.

2.3.2 Humidity Effect

Humidity partially controls the loss of moisture from the plant. Transpiration rates decrease proportional to the amount of humidity in the air.[11] Low and high humidity affects the development of plants. The damage can even be severe where the difference is large. Plants growing in a dry room will likely lose its moisture with time causing stress to plants and if this happens frequently it may result to shedding of flower buds or flowers may die soon after opening. Under very high humidity, fungal diseases are likely to spread.

2.3.3 Soil moisture effect

Plants take up water by their root system. Evaporation through the leaves determines the rate at which water is transferred across the plant. The rate of water loss to the environment depends on the condition of the soil, temperature, relative humidity in the air and air flow. When absorption of water by the roots does not keep up with the rate of transpiration, loss of turgor occurs and the stomata close [13]. This immediately affects the rate of transpiration and photosynthesis. If the loss of turgor extends to the rest of the leaf and stem, the plant may eventually wilt. Burns may begin at the edge of leaves and spread inwardly affecting whole leaves in more extreme cases.

When soil is water-logged, the oxygen content of the plant‘s root substrate is reduced by the higher average of water content in the pores, resulting in the damage of roots.[13] Thus, the plant will not be able to take up water and essential nutrients and will eventually wilt and die in a short period of time. Hence water needs to be supplied often enough so that there is adequate amount for the plant at all time and not so often that the air is limited in the soil.

2.4 Raspberry Pi Microcontroller

A raspberry pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation. These low power computers are mass produced at very low prices and have the feature a Broadcom system on a chip (SoC), which includes an ARM compatible central processing unit (CPU) and an on-chip graphics processing unit (GPU, a VideoCore IV). CPU operates from 700 MHz to 1.2 GHz for the Pi 3 and on board memory range from 256 MB to 1 GB RAM. Secure Digital (SD) cards are used to store the operating system and program memory in either the SDHC or MicroSDHC sizes. Most boards have between one and four USB slots, HDMI and composite video output, and a 3.5 mm phone jack for audio. Lower level output is provided by a number of GPIO pins which

support common protocols like I²C. The B-models have an 8P8C Ethernet port and the Pi 3 and Pi Zero W have on board Wi-Fi 802.11n and Bluetooth. Figure 2.2 shows the block diagram of Raspberry Pi.[14]

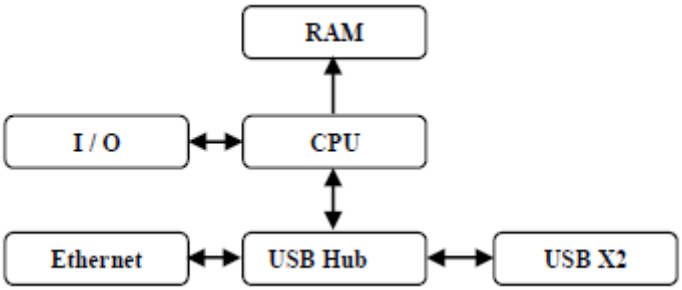

Figure 2.2 : Block Diagram of Raspberry Pi [14]

The Raspberry Pi is a small, powerful and lightweight ARM based computer which can do many of the things a desktop PC can do. The Raspberry Pi is built using ARM11 processor. The Raspberry Pi is based on a Broadcom BCM2835 chip. The Raspberry Pi is a credit card sized computer that runs the freely available Linux Operating System. It is powered by a typical mobile phone charger using a micro USB connector, which can supply at least 700 milli-amps. The Raspberry Pi can be connected to a TV using an HDMI cable although an analogue connection is also available. The powerful graphics capabilities and HDMI video output make it ideal for multimedia applications such as media centers and narrowcasting solutions. It does not feature a built-in solid-state drive or hard disk, instead relying on an SD card for long-term storage & booting [2]. The practical view of Raspberry Pi B model B as shown in Figure 2.3

Figure 2.3 : Raspberry PI model B [14]

Raspbian is optimized for the Raspberry Pi hardware which is based a Debian-based free operating system.

2.5 Output Display for ARM 11

The output of the proposed system should be seen on display which has HDMI connection facility. The HDMI connector is used to connect monitor of personel computer. Nowadays, HDMI connection facility is also available on LCD and LED Televisions. Figure 2.4 shows the HDMI connector & display. [14]

Figure 2.4 : HDMI connector and display.[14]

HDMI (High-Definition Multimedia Interface) is a compact audio/video interface for transferring uncompressed video data and compressed or uncompressed digital audio data from a HDMI-compliant source device, such as a display controller, to video projector, a compatible computer monitor, digital audio device or digital television. For existing analogue video standards, HDMI is a digital replacement. HDMI implements the standards, which define waveforms & video formats, transport of uncompressed, compressed and auxiliary data, LPCM audio and implementations of the VESA EDID. That HDMI standards are EIA/CEA-861 standards [15].

2.6 GrovePi

GrovePi is an Internet of Things device built on the Raspberry Pi. The GrovePi can be programmed using the native Scratch installed on the Raspberry Pi (Scratch 1.4 or NuScratch). This device can connect to hundreds of different Grove sensors and can be used with the Raspberry Pi Models A, A+, B, B+, 2 and 3. The GrovePi have a features such as & digital ports, 3 analoge ports, 3 12C ports, 1 serial port connect to GrovePi, 1 serial port connect to Raspberry Pi and Grove header Vcc output voltage [16] as shown on Figure 2.6. The GrovePi slides over top of the Raspberry pi as shown in Figure 2.5

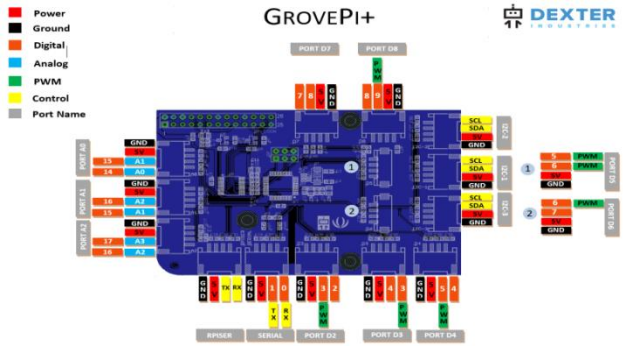

Figure 2.5 : GrovePi and Raspberry Pi [16]

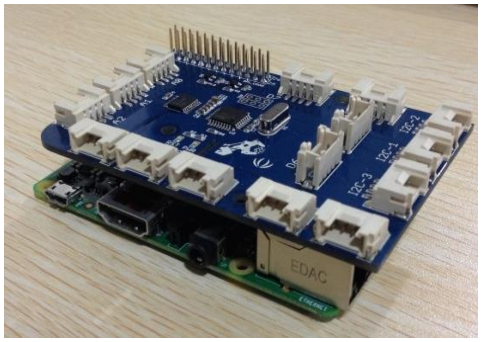

Figure 2.6 : GrovePi and Raspberry Pi [16]

2.7 Sensors and actuators

A sensor is a device to distinguish changes in the environment such as energy, heat, light, water and convert them to the electric signal. In greenhouse systems, there are many type of sensors that are used for detecting different conditions in greenhouse environment.

2.7.1 DHT11 Temperature and Humidity Sensor

The DHT11 sensor module is a low cost sensor and has the capability of measuring both temperature and humidity in a single module. This sensor module gives a digital output that consists of 5 bytes [14] which is used to calculate the temperature and humidity. The specification for this sensor module is show in Table 2.1 and Figure 2.7

Specification	Description
Module Name	DHT11
Measurement Range	20-90%RH 0-50 ℃
Humidity Accuracy	±5%RH
Temperature Accuracy	±2℃
Resolution	1
Package	4 Pin Single Row

Table 2.1 : Specification for DHT11 Sensor [14]

Figure 2.7 : DHT11 sensor [14]

2.7.2 Soil moisture sensor

This Moisture Sensor can be utilized to recognize the dampness of soil or judge if there is water around the sensor. They can be exceptionally to utilize, simply embed it into the dirt and after that read it. With help of this sensor, it will be feasible to make the plant remind: thirsty now, need some water. [17]. Main features of soil moisture sensor are easy to use and 2.0cm*6.0cm grove module. Figure 2.8 shows the Soil moisture sensor.

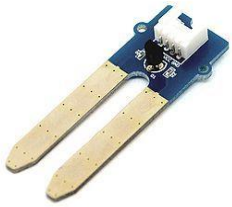

Figure 2.8 : Soil moisture sensor [17]

2.7.3 Relay

The relay driver is used to isolate both the controlling and the controlled device. The relay is an electromagnetic device, which consists of solenoid, moving contacts (switch) and restoring spring and consumes comparatively large amount of power. Hence it is possible for the interface IC to drive the relay satisfactorily. To enable this, a driver circuitry, which will act as a buffer circuit, is to be incorporated between them. The driver circuitry senses the presence of a “high” level at the input and drives the relay from another voltage source. [17] Figure 2.9 shows the component of relay.

Figure 2.9 : Relay [17]

2.7.4 Water Pump

Pumps provide the means for moving water through the system at usable working pressures. The operation and maintenance of these pumps are some of the most important duties for many water utility operators. There are two basic types of pumps used in water and wastewater systems. The most common type of pump is the centrifugal pump. The other type is the positive displacement pump. These two type of pumps are basically use irrigation system to control on the delivery of water and nutrients to the plants. The most efficient way of irrigation is an integral dripper in lateral spacing between drippers, starting from 20cm, with a flow rate starting from 1.2 l/h up to 4 l/h. [18]

2.7.5 Fan

To maintain plant health during hot day, fans should be used. Fans are available in many sizes and capacities. Typically square 120mm and this fan cool very well and there many size for example (140mm) and may we use it. Air pressure is most important for cooling. [18]

2.7.6 Humidifier

A humidifier is a mechanical device that generates a water mist or steam and release it into the greenhouse environment. A humidifier has a tank for holding water, which is eventually evaporated by a fan that distributes the moisture to the greenhouse. Humidifier can either be cool-mist or warm mist depending on the function of the humidifier itself. A humidifier will greatly improve the air quality and comfort by adding moisture to dry air in the greenhouse. [19]

2.8 Wireless Technologies

Reducing cable network complexity and operational cost is the main objective of many industrial application. Many wireless technology were developed over the last few decades to tackle this specific problem. Thanks to the rapidly increasing trend in the wireless

communication industry, many modern day applications are capable of providing a greater level of flexibility and mobility at low cost and low power consumption. Currently there are 14 existing wireless technologies available for personel industrial uses:

- Bluetooth wireless technology
- Radio frequency identification (RFID)
- Ultra-Wideband (UWB)
- Near field communication (NFC)
- Certified wireless USB
- Near Field magnetic communication
- Wi-fi (IEEE 802.11)
- HiperLan
- WiMax (Wordwide interoperability for microwave acess and IEEE 802.16)
- HIPERMAN
- WiBro (wireless broadband)
- 802.20
- Infrared (IrDa)
- ZigBee (IEEE 802.15.4)

A survey was conducted in order to determine the popularity of each wireless technology and it was discovered that the most exploited wireless technologies in modern day industries are Wi-Fi, Bluetooth and ZigBee. Each wireless technology has its own advantages and disadvantages, therefore a careful selection of suitable wireless technology for intended application is essential. [20]

2.8.1 Bluetooth

Bluetooth wireless technology is a short range wireless communication intended to replace the cable connecting portable or fixed devices while maintaining a high level of security. Bluetooth operates at 2.4 GHz ISM band and employs the frequency hopping spread spectrum (FHSS) modulation technique [21]. Bluetooth has been considered ad one possible alternative for WSN implementation [22]. A fundamental strength of Bluetooth network is the ability to simultaneously handle data and voice transmissions, which provides users with a variety of innovative solutions such as hands-free headsets for voice calls, printing and faks capabilities, and synchronization for PCs and mobile phones at low power and low cost.

The main features of Bluetooth are [21] :

- Bluetooth technology operates in the unlicensed industrial, scientific and medical (ISM) band at 2.4 to 2.485 GHz, using a spread spectrum frequency hopping full-duplex signal at a nominal rate of 1600 hops/sec.
- Bluetooth technology's adaptive hopping (AFH) capability was designed to reduce interference between wireless technology sharing at 2.4 GHz spectrum.
- Data rate
    - 1 Mbps for Bluetooth low energy technology
    - 1 Mbps for Version 1.2; Up to 3 Mbps supported for Version 2.0 EDR.
    - Up to 24 Mbps supported Version 3.0 HS.
- Range may vary depending on class of radio used in an implementation:
    - Class 3 radio – have range of up to 1 metre or 3 feet
    - Class 2 radios – most commonly found in mobile devices- have a range of 10 meters or 33 feet
    - Class 1 radios – used primarily in industry use cases – have a range of 100 metres or 300 feet.

2.8.2 Wi-Fi

Wi-Fi is commonly called wireless Local Area Networks (WLAN). It is one of the networks in which high frequency radio waves (usually at 2.4 GHz or 5 GHz) bands are required for transmission of data from one place to another. Wi-Fi operates on several hundred metres between two places of data transmission and they support 2 modes of operation [20]:

- Ad-Hoc mode – allows stations to spontaneously from a wireless LAN, in which all station communicate with each other in a peer-to-peer manner
- Infrastructure – the network has an access point (AP), through which each client station communicates, a typical Wi-Fi AP may have range of 45 m indoors and 90 m outdoors

Wi-Fi was intended to be used for mobile computing devices, such as laptop, in LANs, but is now often used for increasingly more applications, including Internet, gaming and basic connectivity of consumer electronics such as television and DVD players. There are four generation of Wi-Fi product available [22]. Each generation is defined by a set of features that relate to performance, frequency and bandwidth.

2.8.3 WiBro (Wireless Broadband)

WiBro is a system of data transmission founded by radio waves developed from Korea telecom industry and the Korea government to be able to provide a variety of information, multimedia content and services through high-speed wireless Internet access via various user terminals such as notebook PCs, PDAs, and handheld PCs. [23] The communication technique used are radio waves (frequency of 2.3 GHz) and the maximum theoretical speed allowed are 30 megabits per second over a range 1 to 5 kilometer.[24] .

There are three type of WiBro services;

- Internet access, emailing, data searching, etc.
- Entertainment type services: picture transmission, VoD, gaming, etc.
- Business type services: remote approval, telemetering, e-commerce, etc.

The main features of WiBro are ;

- Spectrum: 2.3-2.4 GHz
- Channel bandwidth: 10 MHz
- Wireless access/duplexing: OFDMA/TDD
- Maximum data rate: 50 Mb/s (with SA/MIMO) and 30 Mb/s (without SA/MIMO)
- Cell configuration: up to 1 km (radius) of cell coverage, up to 60 km/h of mobility, and multicell shape
- QoS: PER<10−2 handover latency of <100 ms (between APs) and <10 s (between PARs)

2.9 Remot3.it

Remot3.it is a port forwarding for the Raspberry PI to manage the large number of Pi. and access a single Pi for the user from anywhere over the internet. The user can use web such as SSH, VNC, HTTP(S), RDP, and custom TCP services to access any TCP port on the Pi. [25].

Figure 2.10 below shown the working system of Remot3.it.

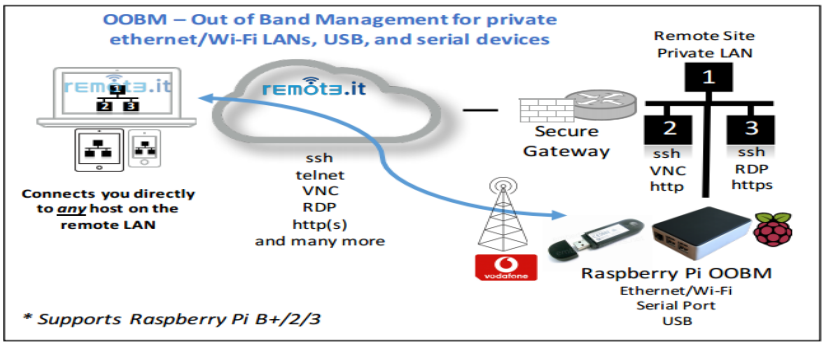

Figure 2.10 : System of Remot3.it [25]

2.10 PuTTY

PuTTY is a Telnet and SSH terminal software for Unix and Windows platforms that enables any users to remotely access computers over the internet. PuTTY is a free and open source and network file transfer Application which supports several network protocol. The working system of PuTTY is by sending typed commands and receiving text responses over a tcp/ip socket like a traditional terminal (TTY), but it uses secure socket (SSH) with public key encryption wrapping the packet payloads. Figure 2.11 shows the PuTTY software.

The main features of PuTTY are; [26]

- The storing of hosts and preferences for later use.
- Control over the SSH encryption key and protocol version.
- Command-line SCP and SFTP clients, called "pscp" and "psftp" respectively.
- Control over port forwarding with SSH (local, remote or dynamic port forwarding), including built-in handling of X11 forwarding.
- Emulates most xterm, VT102 control sequences, as well as much of ECMA-48 terminal emulation.
- IPv6 support.
- Supports 3DES, AES, Arcfour, Blowfish, DES.
- Public-key authentication support (no certificate support).
- Support for local serial port connections.
- Self-contained executable requires no installation.

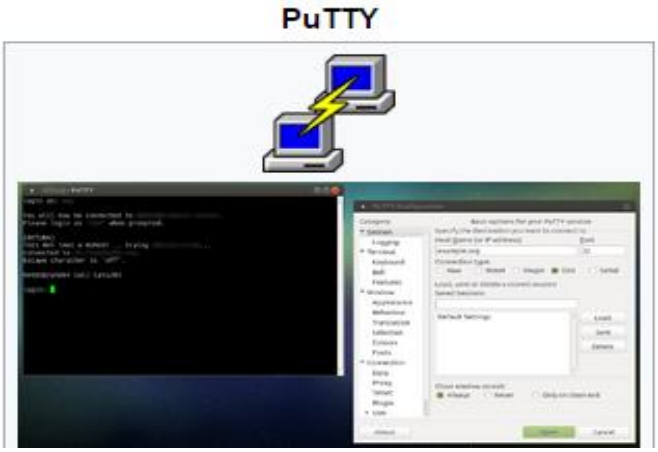

Figure 2.11 : PuTTY software [26]

2.11 WinSCP

WinSCP is an open source free SFTP client, FTP client, WebDAV client and SCP client for Windows. Its main function is file transfer between a local and a remote computer. Beyond this, WinSCP offers scripting and basic file manager functionality. Figure 2.12 shows the WinSCP software. [27]

The main features of WinSCP are

- Graphical user interface
- Translated into many languages
- Integration with Windows (drag&drop, URL, shortcut icons, jump list)
- All common operations with files
- Support for SFTP and SCP protocols over SSH and FTP and WebDAV protocols
- Batch file scripting and command-line interface and .NET assembly for advanced programming tasks
- Directory synchronization in several semi or fully automatic ways
- Integrated text editor
- Shares site settings with PuTTY
- Support for password, keyboard-interactive, public key and Kerberos (GSS) authentication
- Integrates with Pageant (PuTTY authentication agent) for full support of public key authentication with SSH
- Explorer and Commander interfaces

- Optionally protects stored site information with master password
- Optionally supports portable operation using a configuration file in place of registry entries, suitable for operation from removable media

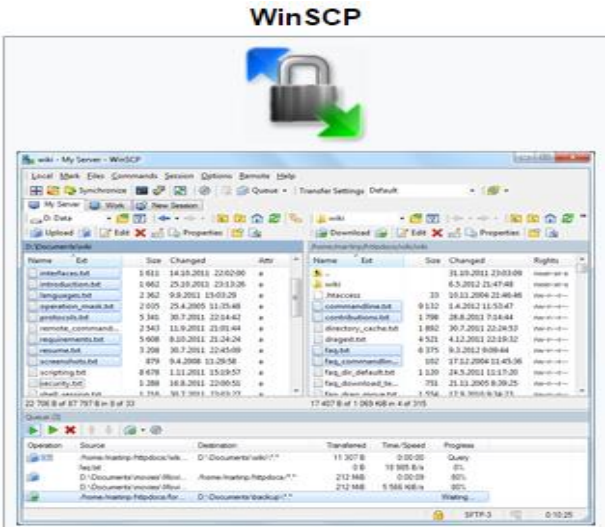

Figure 2.12 : WinSCP software [27]

2.12 Existing work

2.12.1 Automated environment monitoring and control system for agro-based industries using wireless sensor networks [28]

The research is to develop an automation system agro-based industries using wireless sensor network and also analyses and compare data using fuzzy logic. To design automated Monitoring and Controlling system which will monitor the analog parameters and transmit these values to the other side where they can be read and control with the set points. The Raspberry-Pi receives the value from the analog parameters like PH, Temperature and Humidity are read by the respective sensors and these values are transmitted by the transmitter node and the communicate uses ZigBee.[28] The concept are shown in Figure 2.13

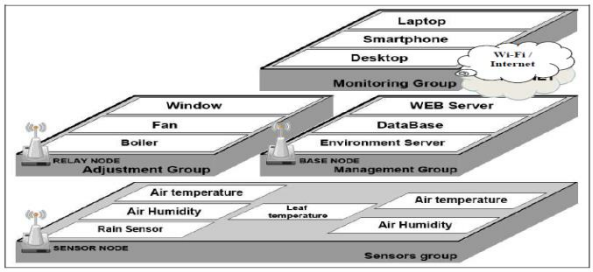

Figure 2.13 : The concept of automated monitoring and controlling system [28]

2.12.2 IoT based smart agriculture [29]

This paper contain about the features of the smart agriculture smart using automation and IoT technologies. Table 2.2 shows the hardware and software that are used in this research.

Hardware	Software
AVR Microcontroller Atmega 16/32	AVR Studio Version 4
ZigBee module	Proteus 8 Simulator
Raspberry pi	Dip Trace
Temperature Sensor LM35, Moisture sensor, Humidity sensor, Obstacle sensor (Ultra-Sonic),	SinaProg
	Raspbian Operating System

Table 2.2 : Hardware and Software [29]

Smart agriculture are consist of four main section in this paper such as node1, node2, node3 and PC or mobile app to control system. The Smart agriculture are shown in Figure 2.14

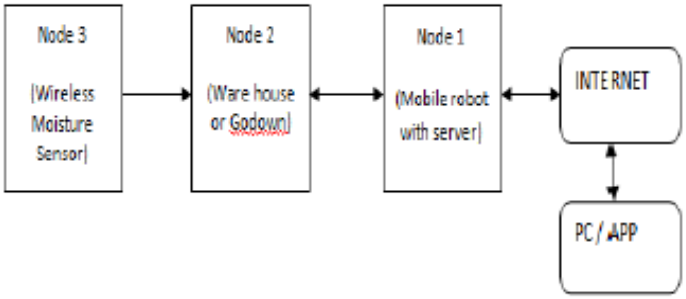

Figure 2.14 : System of Smart agriculture [29]

Node1 is GPS based mobile robot have various sensors and devices to perform tasks like weeding, spraying, moisture sensing, bird and animal scaring, keeping vigilance and others. The GPS based mobile robot can be controlled remotely using computer. The concept of system node1 shown in Figure 2.15 and Figure 2. 16 show the experimental setup of mobile robot with central server, GPS module, camera and other sensors that interfaced with microcontroller and the microcontroller interfaced with the raspberry pi.

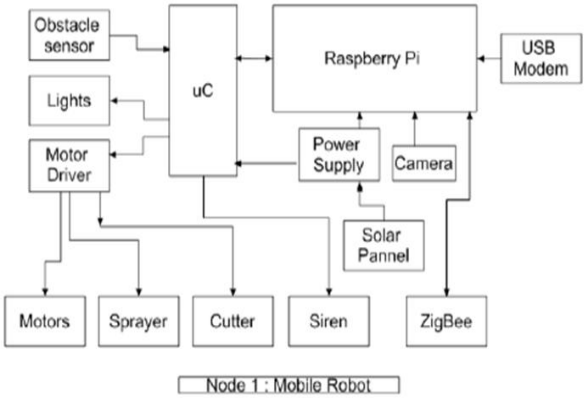

Figure 2.16 : Concept of system Node 1[29]

Figure 2.15 : Experiment setup [29]

Node2 is warehouse that consist of variety of sensors and devices like motion detector, light sensor, room heater and others altogether interfaced with AVR microcontroller. The concept of system node2 are show in Figure 2.17 and the experimental setup of node2 are shown in Figure 2.18.

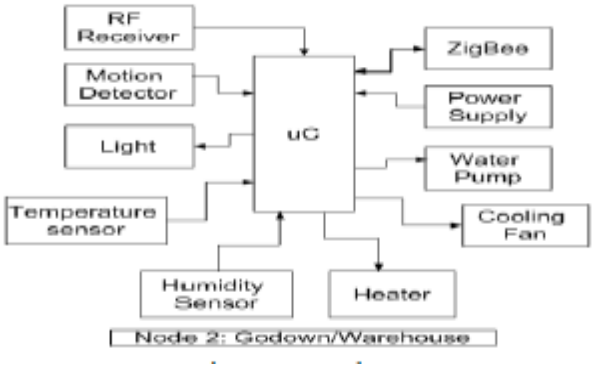

Figure 2.17 : Concept of system Node 2 [29]

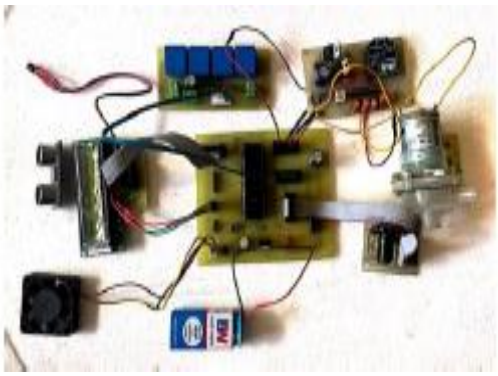

Figure 2.18 : Experiment setup [29]

While node3 is smart irrigation with smart control and intelligent decision making based on accurate real time field data. It can be set into two mode such as auto mode and manual mode. When in auto mode, the pump can automatically turning on/off after attaining the required soil moisture level and when in manual mode, the water pump can switch on/off remotely via mobile or computer. [29] Figure 2.19 and 2.20 show the concept and experiment setup.

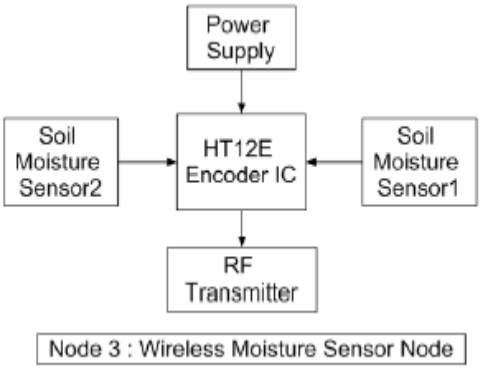

Figure 2.19 : Concept of Node3 [29]

Figure 2.20 : Experiment Setup [29]

2.12.3 Smart agriculture monitoring through IOT [30]

This paper presented the smart greenhouse monitoring system using internet of thing (IOT) using two microcontrollers working in parallel which are Arduino and ARM11 based on Raspberry Pi. There are three parameter that will be control such as temperature, humidity and soil moisture and used three type of sensor, temperature sensor, humidity sensor and soil moisture sensor for controlling the environment of the greenhouse. The Arduino microcontroller is responsible for communicating with the sensors and sending the data to the

Raspberry Pi over its serial port. Raspberry Pi accepts the data and displays it in the form of GUI (graphical user interface) on the monitor screen attached to it and further pushes that data over the internet to a real-time database service Firebase. The concept of system are shown in Figure 2.21 and 2.22

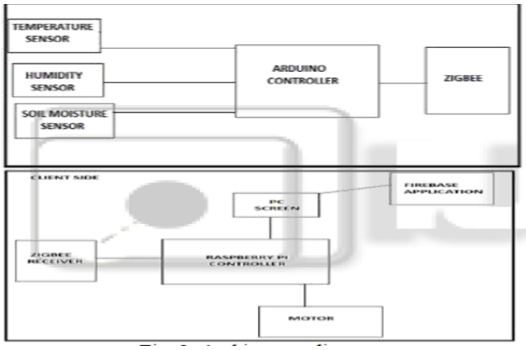

Figure 2.22 : Concept of Smart Greenhouse [30]

Figure 2.21 : Experiment setup [30]

2.12.4 Survey on android based live monitoring system of greenhouse parameter [31]

The research are focus on automatic monitoring of greenhouse parameters using wireless sensor network using embedded system. The Raspberry Pi is used in this project as an embedded Linux board who's designed is based on the arm 9 microcontroller architecture. Embedded Linux board makes the communication between all distributed sensor nodes placed in the farm through ZigBee protocol and itself act as a coordinated node in the wireless sensor network. The main work of coordinator node is to collect the parameters like soil moisture and soil temperature wirelessly. Each sensor node consists of soil moisture and soil temperature sensor and ZigBee RF antenna device for communication with the coordinator node. Raspberry Pi stores collected data in the database and analyses the stored data. [31] The system are shown in Figure 2.23

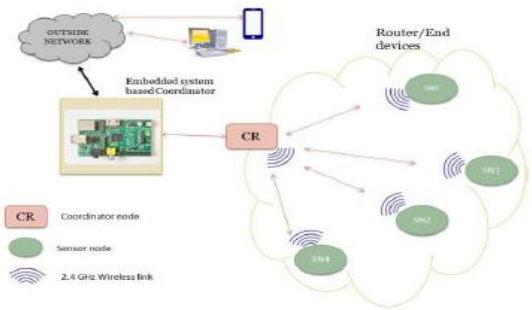

Figure 2.23 : Concept of Automatic Greenhouse [31]