Smart Irrigation System Based on Internet of Things

Project report submitted in partial fulfillment of the requirement for the degree of Bachelor of Technology

in

Computer Science and Engineering/Information Technology

By

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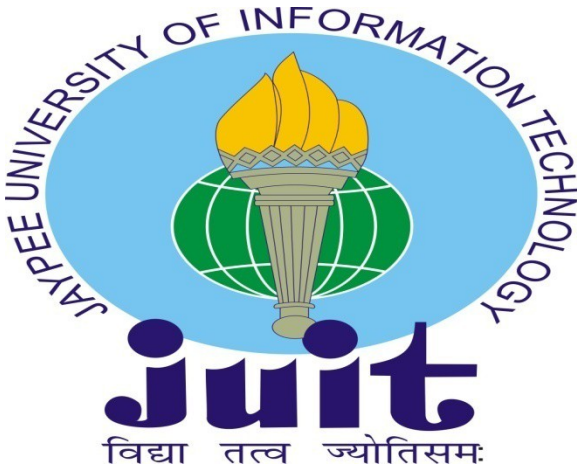
Under the supervision of

Associate Professor Dr. Hemraj Saini

To



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Candidate's Declaration

I hereby declare that the work presented in this report entitled **"Smart Irrigation System Based of Internet of Things"** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science and Engineering/Information Technology** submitted in the department of Computer Science & Engineering and Information Technology**,** Jaypee University of Information Technology Waknaghat is an authentic record of my own work carried out over a period from January 2018 to May 2018 under the supervision of **Dr. Hemraj Saini** ,Associate Professor in Computer Science & Engineering.

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

Surya Dev Singh, 141201

This is to certify that the above statement made by the candidate is true to the best of my knowledge.

Dr. Hemraj Saini

Associate Professor

Department of Computer Science

Dated:

Acknowledgement

I would like to express my special thanks of gratitude to my project guide **Dr. Hemraj Saini**, Associate Professor in Computer Science & Engineering Department who gave me the golden opportunity to do this wonderful project on the topic **Smart Irrigation System based on Internet of Things**, which also helped me in doing a lot of Research and i came to know about so many new things I am really thankful to them.

Table of content

List of graphs

Abstract

This project is for overall development of farming system in India bringing cheap technology in the hands of our farmers. For a very long time farmers have been in problem for checking proper soil conditions to keep their crops safe and check to supply water every time and staying at their fields for whole day long in strong heat conditions, checking when to supply water to crops and when to stop the supply. Also, farmers have to take recommendation from agricultural experts paying extra price to them when they need proper directions but now with the help of this smart irrigation system farmers will have the benefit of staying back at home and looking for conditions of the soil through their mobile app and start/stop the irrigation as needed. Also, the irrigation system will be automated so the farmers can relax back after cropping the crops and start/stop the irrigation as needed. This will be one time investment for farmers as they will not have to concern agricultural experts every year while cropping their crops. Also the moisture levels can be set by farmers based on the crop they are planting which they will get on their mobile app. So, economically there is one more profit in not investing in labor

to handle the irrigation process. Hence, we are giving the complete control over the crop field to the concerned farmer who can control the field after cropping their crops over growing period till harvesting. This gives a lot of relief to the farmers

Chapter 1-Introduction

1.1) **Introduction**

Internet of things is the connected embedded device. Now an embedded device is a system that performs a particular task. This task may require a large processor or a small processor based on the intensity of the task. Now take for example that we want to drive a simple motor with buttons that type of task does not require a very large processor processing Gigahertz of data at a time. A simple Atmega328 will do the work. We find this processor on an Arduino Uno board. But if we want to imply on an Car LCD interface which will require a lot computation like processing data entered by touchscreens, processing data entered and final activating the actuator either through a display or other action like sliding windows down or cleaning the windshield etc. That type of system requires a huge lot of computation for which, about a Gigahertz of clock speed is necessary. This type of applications require platforms like Rasberry Pi as Arduino Uno's processor cannot handle this type of heavy computations. Now, this embedded system works in a local area i.e. it takes input, performs computation and performs actions on actuators connected to processor by a wired connection by some means or other. Like in the above example of an LCD car interface we cannot performs the operations on some distant location from the car for which we require connectivity. The first embedded system believed to be created is an Automated Teller Machine. In that, ATM(Automated Teller Machine) which is now an IoT device was not one when it was installed in Barclays, England. The features of the device were as follows:

1) The transaction was issued by paper cheques .
2) Paper cheques were issued by the cashier.
3) Paper cheques were marked with Carbon-14 for readability and security.
4) Also a six digit Personal Identification Number (PIN) was used.

In the past ATM devices were only for debiting out money by using cheques issued by a cashier, so a person can issue cheques from cashier and withdraw money from time to time as per need. But now now ATMs are capable of accessing their account by using ATM cards which represents direct access to their accounts. With new ATMs all type of transactions like withdrawing money from account, sending money to others account by

using their account numbers, depositing money to their accounts, getting their passbook updated can done which makes life a lot easier. The ATM devices now are always connected to the server of the bank and other banks that want to share their network with the bank, so that the data related to transactions are directly uploaded with a very less degree of fault, almost zero. This has made life easy for both bank owners and customers as ATMs upload data directly on the server so no hassle of papers is required i.e. no cheques are need everytime or no need to visit the cashier so many times. Once a person receives the ATM card every type of transaction is in hands. The only limitation of new ATM is that it is too dependent on technology and whenever the server goes down all ATMs in the area do not work and also more prone to be hacked by hackers compared to old ones. The has been an issue of replication of fake ATM cards by the encoding the data on ATM cards which is also known as card skimming or card cloning, which involves installation of magnetic card readers over real ATM card card slots and use of wireless surveillance camera or a false PIN keypad to oberserve users PIN costing the privacy of customers account number and Personal Identification Number (PIN). Also, the data on centralized servers can be hacked by some hackers costing the banks privacy. This was not issue with earliers as they were only meant for withdrawing by cheques. Normal withdrawing and depositing ATM machine cost about US $7695 and the price for the old one is unavailable.

Now, from the example we see that first the Automated Teller Machine used to be just an embedded system which just took transactions based on cheques issued by the cashier to the concerned persons who used them to take out their transaction. So, first the person had to collect the cheques from the cashier in his bank and thereafter use them for transactions because there was no communications based on network between the bank the concerned ATMs but with the transition of time as the network communications improved the bank now were able to connect to their respective ATMs causing a transition of Automated Teller Machines from a simple embedded system to an Internet of Things device. This led to a lot of comfort on the both sides i.e. to the bank and the user. The bank no longer has to issue cheques for ATM transaction but simply issues an

ATM card by the user can debit money from his/her account as long as their bank balance is remaining. Moreover, things that could only be done at banks like passbook printing, crediting money to their account, checking for balance and even transfer of money from one account to another can be done via ATMs. This has all been made possible by network connectivity in embedded devices i.e. the Internet of Things.

So, basically internet of things is network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity that enables objects to connect and exchange data. Things in IoT devices can refer to wide variety of devices that are interconnected to each other performing a separate task and communicating with each other for required transmission of data between them to support each others tasks make a wide network of interconnected automated devices make life automated also referred to as ubiquitous environment.

Technological trends that have led to the incident of things, say revolution. It's a overused word, but let's try to use that right now. So there are lots of different trends that have led to this, led to the incorporation of things, technology into devices today. And so we'll talk about those things. And it sort of crept up on us over the years, but now there's this convergence where the situation is right. Everything works and you can really do a lot of the things that you see in these IoT devices today. So there are several trends. One trend is cost, is the straight cost of devices, so things have gotten a lot cheaper. Computational technology has gotten a lot cheaper than it used to be. Now, these are extremes, but take ENIAC. Early machine, 1945, very early. Not the earliest, but very early machine. At the time, it cost almost half a million dollars which in today's dollars is a lot more than that, at the time. So that was expensive, very expensive for the cheapest available machine. Now you can get a laptop for $500. You can get one cheaper than that,you can get one more expensive, but you can get a very capable laptop for $500. So things have gotten a lot cheaper over the years. And by the way, I'm saying you can get a laptop for $500, an IoT device. The computational ability of it is a lot less than laptops. So it will be a lot

cheaper than $500. But the point is that over time computational technology has gotten a lot cheaper. And so it's within the reach of what you could add on to a lot of different devices. So you wouldn't have wanted to take your standard car in 1945 and add an ENIAC to it because it would add $500,000 worth of cost, right? But now you can add on some low cost device and get the benefits of computational technology without too much cost. So this is a picture of ENIAC, the original. It is big. Big and expensive. So this is another thing that's changed. It also has a lot of wires. If you look at it, the way they programmed it was with wires. A lot of wiring going on in there. Manual wiring. So this is a picture of it and it was big. So that's another trend. Hardware size. Things have become smaller. Now that old ENIAC there was no possible way you were going be able to get that thing and fit it into a device, into a thing. So that old ENIAC was, say approximately, 1,800 square feet, 27 tons. It was a big thing. But a laptop today is small, small and light. And IoT devices are smaller and lighter than that, so think, computational technology has also shrunk and gotten lighter, to the point that it can be incorporated in lots of different devices. So this is just a size comparison. See, so we've got ENIAC over there, different lighting but basically the same machine, and then we've got a laptop. And you can see how the computational technology has just vastly shrunk to the point where you can actually incorporate it into devices. Now, another big trend that helps make IoT possible is the fact that computational ability has grown dramatically since, say, 45. So in 45, that ENIAC that you saw, that got approximately 5,000 instructions per second. Now, a standard laptop 18 billion, now this is plus or minus, right, but 18 billion easy. That's a dramatic improvement, and what that buys you, what that gives you is a fact that you can implement a lot more features. There are many things that you couldn't have dreamed of being able to do back in '45 with a computer that you can now handle because you have so many more computations to play with in a unit of time. So, for instance, speech to text, right? That's common in phones today, right? Where you talk and it interprets your speech. There's no way with 5,000 instructions

per second you could do that in anywhere near real time. Audio processing, network communication all these things that you can do now that require lots of computation and

it just wasn't possible with old machines. So with modern machines there is so much computational ability, their clock rates are so fast and there is parallelism. These things are multi-course, you got multiple processes in one device. There is so much computation ability you can. You can do so many more things that were thought of back then and couldn't have dreamed of back then, but now, we see there's so much you can do. So, it makes it more practical using devices today to implement the features we're interested in implementing. Another trend is Internet access. So, in '45 the Internet didn't exist.Networking wasn't there, but Internet access has improved. So, the Internet is reachable from a lot of places. First, it exists. Right? It didn't used to exist. But now it's also true that in lots of different places, almost everywhere, you can access the Internet through some mechanism. Now this depends on what country you're in and how much money your country has. Some parts of the world poor parts of the world have less access. We're in the US you havepretty good access. Wherever you wanna be you can access it directly through wi-fi, you can access it through jacks in the wall I mean we have ethernet jacks in the wall right here you can do it wirelessly you can do it everywhere. Now different parts of the world have less access, if you just look at this map, you can see the lighter parts are less access. Most of Africa, a lot of Africa has less

access is just because they're out of reach of many different, a lot of the infrastructure that's necessary. But there are some place like India, that actually lower, in fact, I question this map. I don't thing it's as bad as what's being stated on here, but it is generally true that there are parts of the country, poor parts of the world rather, where Internet access is harder to find. But generally it's greatly improved over time. Also the fact that you can do Internet access wirelessly. That actually helps a whole lot

because running cables is expensive. Where putting up a wireless router is much less expensive. Putting up a cell tower that costs a certain amount of money, but given the expanse that it covers It's much more cost efficient than having to run wires into everybody's home. So wireless access is one of those things that's ubiquitous now, and it makes IoT technology much more usable and much more possible. Data costs. So the

cost of Internet access is fairly low. Now this definitely varies depending on where you are. It's never low enough for me. I don't like how much I have to pay every month on my cell phone bill or for my cable bill, stuff like that. But it's low enough that a lot

of people can afford it. In poor countries, this is not necessarily the case, but that's changing. Bandwidth is high. So what this means is that you can transmit lots of data fast. And that actually enables a lot of different features. So streaming movies for instance, right? If you want to stream video, you need a lot of bandwidth, right? As opposed to just sending data. If you want to send email, you don't need a lot of bandwidth. Email has a certain amount of text and it doesn't take much data to transmit. But if you want to support video, you need pretty good bandwidth to support it in real time. To send the frames, lots of pixels, it takes you a lot of bandwidth. But bandwidth is available

in a lot of places. And wirelessly too. So you can, through wi-fi or some other type of wireless technology, cell phones, you can actually get enough bandwidth to be able to see

videos through that technology. So the bandwidth actually has enabled a lot of different features in IoT devices.

1.2) **Problem Statement**

This project is for overall development of farming system in India bringing cheap technology in the hands of our farmers. For a very long time farmers have been in problem for checking proper soil conditions to keep their crops safe and check to supply water every time and staying at their fields for whole day long in strong heat conditions, checking when to supply water to crops and when to stop the supply. Also, farmers have to take recommendation from agricultural experts paying extra price to them when they need proper directions but now with the help of this smart irrigation system farmers will have the benefit of staying back at home and looking for conditions of the soil through their mobile app and start/stop the irrigation as needed. Also, the irrigation system will be automated so the farmers can relax back after cropping the crops and start/stop the irrigation as needed. This will be one time investment for farmers as they will not have to concern agricultural experts every year while cropping their crops. Also the moisture levels can be set by farmers based on the crop they are planting which they will get on their mobile app. So, economically there is one more profit in not investing in labor to handle the irrigation process. Hence, we are giving the complete control over the crop field to the concerned farmer who can control the field after cropping their crops over growing period till harvesting. This gives a lot of relief to the farmers. IoT devices are a way out for the farmers to this problem. The IoT device must have a mobile application connectivity so that the farmers can handle tasks from their respective homes. Moreover, the data reguaring moisture content is uploaded on the internet for

agricultural analytics for better farming solutions based on IoT in the future i.e. upgrading the system side by side.

1.3) **Objectives**

The concise objective of this project to improve the irrigation system in such a way that it becomes very precise and easier to operate. This project incorporates the use of Internet of Things to create a communication between the user and the irrigation system and the internet and hence comprises all the types of communications in the world of IoT i.e. between two embedded systems and the internet server where is data is being uploaded for analytical purposes. Hence, this project is also meant for creating a in-depth understanding of the world of Internet of Things and displaying the power of Internet of Things and the impact it can have with the increasing number of embedded devices with connectivity creating a web of connected devices leading to an automated world.

1.4) **Methodology**

First the user interacts with the mobile app or some other connected interface to extract the data about the current soil conditions and whether or not the he should change the state of irrigation system. The sensed data is send to the embedded irrigation system. Irrigation system make change in the state of its actuators according to the received data.

Side by side, the embedded system uploads the soil data on to the servers for future analytical puposes.

Flow Chart:

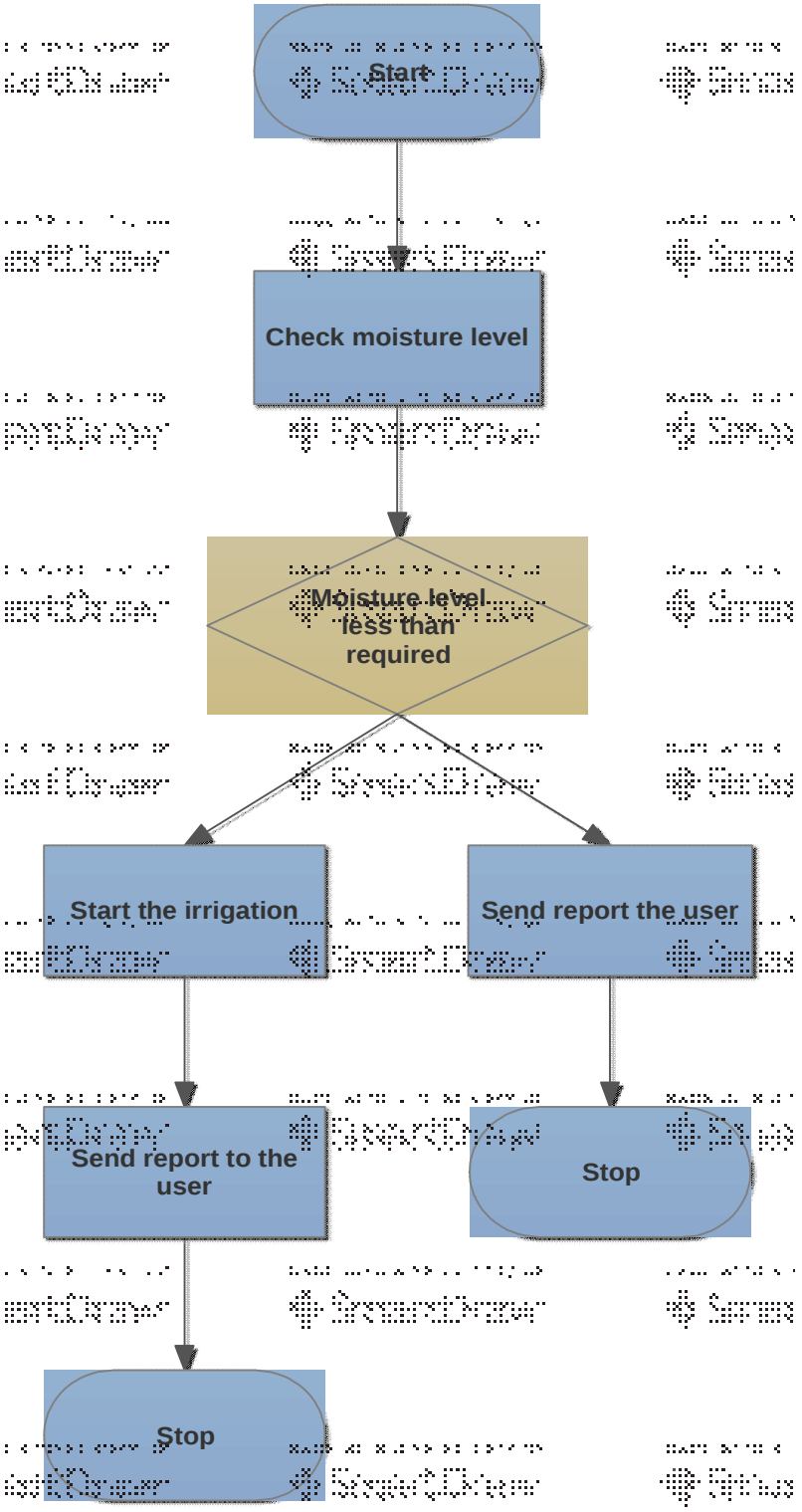

Fig. 1 Flow chart of smart irrigation system

Equipments Used:

- Arduino Uno Board
- ESP 8266
- Wifi Shield for Arduino
- Jumper Wires
- I2C Soil Moisture Sensor
- Ethernet Shield for Arduino
- Small flowerpot with a plant
- Water Pump

Chapter 2- Literature Survey

The “Internet of Things” field is undergoing a rapid exapansion with the decrease in price to buy components for different kinds of projects allowing people to make projects at home and coming up with great ideas to make life fantastic and easy. These ideas are also creating a buzz for future. Nowadays, “Things ” as referred to objects around us like computers, tvs, lights, fans, Air Conditioners, Refrigerators, Washing Machines have started connecting to the network of devices in the world of Internet of Things. These “things ” are a able to transmit data making a contribution to the big data world. Smart and connected devices are transforming out lifestyle and increasing the standards of life. They are creating a huge impact on the world on whichever field you may choose. This year we are going to have 4.9 billion Internet of Things devices in total but, in 2008 we already had more number of devices connected to the internet than people.Internet of Things is creating an environment in which many devices can be connected to the internet be it a home appliances like refrigerator or some smart street lamps that turn on automatically when the night falls or when it is dark enough. Talk about Smart Refrigerators which is currently in trend nowadays, it is so capacable that it can keep track of the food you store inside it through bar code or RFID scanning linked by the way of internet through various supermarkets. Basically, we know what a refrigerator does, it keeps things cold and so on. What we do is add some computational intelligence inside the Refrigerators of some kind like turing the cooling off at some point and keep the temperature constant when temperature becomes cold enough. So what we are doing is adding a small computer inside which performs some basic computation using a microprocessor because these computation do not require a load ton of calculations because what we are computing is basically thermostat inputs which is basically temperature or scanning simple RFIDs and so on. So, we are adding computational intelligence by adding a microcontroller which improves the device i.e. it does the same thing but in a improvised manner. Now, after we have added computational intelligence we add some kind of network connectivity be it through a Wi-Fi or Ethernet, which enables the IOT device to access

and make use of resources that are outside its local domain connection. So what we are doing here is basically improving the system. The refrigerator is the same, it has the same interface like open the door, close the door, pick out ice, put water in tray to become ice again, plug through alternation to digital converter outside of the system or sometimes directly inside the system invisible from our naked eyes, but, what we add on by adding computational complexity are some extra features like warning when the door is not completely shut by having a sensor at the door which senses whether the door has been completely shut or not. There is a need of filters to be changed from time to time and for it we need not need to remember the time we last installed it, the sensor automatically save the date on which the filter was installed and starts beeping when you refill it once it has gone out of date. These basic feature tell you that you refrigerator is intelligent but it does not qualify your refrigerator for an Internet of Things device. An Internet of Things refrigerator requires network connectivity over the computational intelligence. Network connectivity features can be like ordering some of your favourate items when the run low on stock in you r refrigerator. Like, papaya is feed into the system by the means of some screen inputs into your refrigerator as one of your favourate foods then what it means is that whenever you run out of papaya it will simply go order papaya from some online store to your address, or you have some issue in your refrigerator and it has been detected by the system it can report the support centre of your company to allocate a person to do a performance check over your system by visiting your home and giving them a free time allotted by you. Once you have network connectivity you can do a wide variey of tasks like making an order, debit money from your bank, send money to the merchant who is handling the payment system and final send it to the stores account. It can receive the data from world wide web like weather summary, prediction the season, what fruits are going up in prices due to some weather anamoly this year like it is going to be more hot or cold or more rain and tell the user you should stack these fruits previously before the prices go up or go on to order them directly. Hereby, it can also send a report to the makets and online store about what fruits are in trend these days and help them out to do some analytical problem solving like demand and supply in market and calculation the transportation patterns for maximum profits for the company. Finally they are able to find out which fruits are making most profit to them and increasing its supply can help the company grow. Also, they can find the best combinations of products bought together and create combo packs to optimize the sales of their company by applying some basic Linear Programming

techniques. So, the embedded system increases the functionality of the product and network connectivity not only increases the functionality but even increases the scope of functionality in the network of connected devices i.e. the “Internet of Things”.

Internet of things devices are everywhere and not only they are everywhere they are also sort of networked to each other. It is very helpful to people and provides people with a lots of abilities available on the network, and this network provides its access to us all the times.

Internet of Things is very powerful with a lot of abilities. Internet of Things can be viewed as an interface to the huge computing servers called cloud, these servers are called cloud because they are accessed via internet and can do a wide variety of things for you. As it is basically a interface to the Cloud servers we can take an example of Siri the IoS talking system which takes your query and searches for answers in its wide database saved on the server. What we derive from here is that basically not all the functionalities are performed on your IoT devices like talking about Siri here we see that when you speak something to it that computations on it like text-to-speech or other computations are performed by transferring data to the cloud server which does the computation for you. And if you are streaming movies from sources like Netflix the movies are not streaming from the storage of the device but from the cloud servers of Netflix so your device is using the functionality of some other powerful device than yours.

We all have seen commercials of home automation systems, these devices are fitted inside varies parts of your home like fans, lights, other electrical devices, doors, windows and can be controlled from remote sources like cell phones and at work too we have these motion sensors in various rooms which detect if there is some motion in the rooms then lights stay on and for some time there is no motion the light automatically turns off.

There is RFID tags at the doors of firms which lets people in after deriving out the information from the RFID tags. The RFID tags have storage memory and communicates via radio signals so that the receiving end with the same radio frequency receives the information stored which is generally personal information of the person or when fitted onto shipments then information about the products inside the shipment and so on. These RFID tags are Internet of Things device

like Barcodes which has to be interpreted according to patterns and in itself does not communicate that much.

Cell phones are Internet of Things devices as they are directly connected the network of internet and has a lot of functionality inside it which uses cloud servers to perform the full operation like many games on android which are multiplayer rely on cloud computing for all major functionalities of the game and sending and receiving data among the players. It also has apps like Youtube which streams data from servers.

Some internet of things devices are even closer to us than our cell phones. We all know about health trackers which are fitted onto your wrist and keep track of our heart rate and all other sort of stuff. These health trackers comes from companies like FitBit and many other companies. They are connected via Bluetooth™ to our smartphones and ultimately to the internet where they upload data to servers. Some internet of things devices are basically embedded inside our bodies like those Pacemakers. They are embedded with your heart if you have some heart disease and if your heart stops it gives it a shock to start it again and uploads data regarding the severity of the occurrence of heart stoppages also, when the doctors want to reset it in the office they can do it on the radio.

There are insulin pumps for people with diabetes and their pancreas is not working. When your pancreas is working just fine it senses the blood sugar level and releases insulin for you to maintain the blood sugar level but if it is not you need an external device to do the same for you. Some people take insulin injections but this is an automated better system for you as you don't need to visit doctor every week and doctor can take care of you by remotely noting down the severity of your condition and call you accordingly.

Also, we have Internet of Things surveillance devices that are used for our benefits like ATM surveillance camera which can detect the persons who robbed you at the ATM or stole your card and used it illegally. There are surveillance cameras on the traffic lights which book a ticket on you whenever you cross a red light hence, keeping the traffic in control. In London there are traffic cameras which detect the license plate numbers as you drive through the city keeping track of criminals going by the city making them unable to escape as they drive by the city, this

system is all over the city and once the license plate number is detected the person's location cannot be hidden anywhere from the police. This adds to the benefits of the society.

Internet of Things devices have a lot a benefits, one of which is that it makes you independent of people. Having interactions with people is good but relying on people for our personal tasks can a burden on the other person. Like I have a smart refrigerator for me which orders food for me which means that people no longer have to visit the market as soon as their stock replenishes. What that means is basically, people are getting to live independently as it buys from online stores or orders food for tonight as you don't want to cook. Similarly, we have these smart health trackers which keeps track of our bodily conditions and tells if everything is fine or not so I don't have to visit doctor every week to tell me that everything is fine, it helps people to live independently and be free in taking decision and not relying on others to do it for us. It also makes life a lot easier like we are not having self driven internet of things cars which can drive themselves , all we have to do is feed inside it our destination and it will drive you to that place, developed by Google[tm] . So the person with visible impairment, so very slow reaction time , or some other defects does not have to hire a third person to do this task for him. He can rely on the system and not be a burden to the other person making his life independent. With internet of things camera, i.e. a network connected camera and softwares like Skype we can have conversations or meetings online rather than having a meeting at some particular designated place and spending money there on hotels to stay overnight. Also interviews can be conducted online for aspirants from very far distance. This sort of connectivity provided by Internet of Things devices are very useful and economical and comfortable.

So, till now we have seen that internet of things devices can do a lot of stuff for you and so basically you can sit at home and every service can come to your door step. What that means is that you are getting food, medical support and even jobs online and so can just sit at home and be a hermit. It generally doesn't do to that extreme but this thing can happen as it always depends on the mindset of the person who is using the device. He can either think of not getting into potential isolation by using it to the fullest or just consider it as means of doing things and keep social interactions consistent. By social interaction, it doesn't mean connecting to the internet and chatting online which basically happens nowadays , even when people are at parties

they are consistently active on social media and completely delved into it even when they can have a lot of social interaction around them.

Along with connectivity in internet of device there also comes infrastructure along with it which has to perfect and consistently managed. Now if these devices or the cloud servers to which they are connected goes does down it can cause a lot of problem in work that has to be done like if the email server goes down and the person has to interact with other people for data regarding the work that person will get in problem and be in lag of deadline of completing his task. Likewise there can also come bugs in the software which had to befixed and are not fixed. These bugs can hang the device when you are in a critical communication or doing a work in connected interface. When these problem are is regular works then it is still acceptable but it comes to health solutions like insulin pumps it becomes a big issues like there is a bug in pacemaker software and it doesn't work at critical situations it can even cause death of the related person and hence forth these system need to designed precisely and completely bug free.

Another things about Internet of Things devices is that they are tracking your information like almost all the time. It is useful for our own benefit like turning on the location services can help you find nearby restaurants, hotels etc but all this data is being uploaded to the servers and stored somewhere which we do not want to disclose. These health monitors which are tracking your health information are completely diagnosing your health conditions over time and saving it on some cloud servers. Online streaming websites basically track your watching habits like what genres of tv shows you watch, what type of movies you watch and it flag to you whenever you visit that website what tv shows or movie you should watch or what upcoming movies you should book tickets for. There are adds popping up when you are browsing through the internet telling you should book this movie tickets in nearby theatres from our website. Which means our browsing and searching habits are being tracked and saved in some cloud servers and also shared with other servers. It maybe for our own benefit but we are being kept track of. So you were watching some product on amazon or google and when you are doing something else adds pop up reguarding the best deals from various other websites about the product. This reveals that our data is being shared also with some third party servers apart from the website's server we visited.

Cars have lots of sensors and also uploads data on the servers about when you hit the brake, when you accelerate i.e. it keeps tracks of all your activity and stores it on servers. These servers share your data with your insurance company keeping full track on the driving habits and what you did at time of accident. So, for example you had an accident and you were accelerating at that time so the insurance company will know you were not hitting the brakes and so you are unable to claim your insurance.

Whenever we download an app on our phone we don't read the license agreement and just click I Agree button which we first. So what we are doing is agreeing with the app servers to have access media files, location data on location services servers, and other kinds of data to be accessed by the app servers. So, they have control over our private data which have agreed to give to them freely which they can handover to some third party servers legally as we agreed to them at some point of time.

Some insurance agencies are very high on statistics and if we health trackers for ourselves that data uploaded by health trackers to the servers. These health insurance companies charge you based on the state of your health so they gather information about these state of your health from wherever possible once you are enrolled in insurance policy. So, they data uploaded by you like from health trackers like Fitbit on their servers. This data is supposed to private but there are these hackers who can steal data from any servers they want. So, what people want is that the data they upload on the cloud servers must be encrypted but it does not depend on the user whether the data they agreed to upload will be encrypted or not, it depends on the cloud servers that they have kept consistent encryption over the data upload by you on their servers. These encryption algorithm also needs to be tight so some common hacker cannot override the encryption algorithm and hack the data easily like a piece of cake.

So, when internet of things devices are designed by people the first choice that people need to make is the type of device that they need to create i.e. whether high resource requirement is needed or it is some basic internet of things device and will work well with microprocessors with limited capacity. It is basically the type of applications you require to perform by the means of internet of things device you create and after which determine the microprocessor required to fulfill your tasks or the basic function you want to perform. Until you know the type of processor you can do your operations you cannot determine the software you want to write because there

are coding and register differences among softwares for different hardwares. You can have a look at datasheets for various microcontrollers to see the specifications of your project and see if there is a match with your specifications.

For firm based projects you need to look at datasheets for various microprocessor that are in match with your project but generally home based basic projects you can choose between an Arduino Uno board or a Rasberry Pi board. These boards have microprocessor prebuild inside of them and pins to connect to the microprocessors and even change the bootloader on these devices. So, these devices are like small computers where user based programs can be run by uploaded the program onto these devices by USB interface through desktops/laptops.

Arduino Boards have small microcontrollers with limited processor speed in varients of 8Mhz / 16 Mhz which means you cannot use an Operating System on these devices. No operating system means you can run one program at a time on these devices which is being uploaded by the user. So, it means you can use these devices for tasks which are repetitive and require minimal processing computations like opening and closing a garage door in your house, sensing outside temperature and sending this data data to cloud servers like Accuweather, a simple robot which just moves left, right, front, back and moves hands . Arduino boards are very helpful to beginners in the field of internet of things. To make Arduino boards connected to the internet we require Ethernet / WiFi shield which can be directly fitted on the top of these Arduino Boards and connect them to the servers for uploading and receiving data and do some basic computations and rely for the rest of it on the cloud servers. Arduino Board has an AVR Atmega328 microcontroller along with USB interfacing microcontroller Atmeaga16U microcontroller. We can also change the bootloader using ICSP pins on the board on both of the processors like if the USB protocol which is current have to change can be done using these pins.

Rasberry Pi Boards on the other hand are high end project makers. We can call it a general purpose computer which also has an Operating System loading in its memory. The operation system is Linux OS, so we can run several processes at a time in this device which makes it more complicated to use than an Arduino Uno Board. Rasberry Pi is used when we want to drive a complicated task which requires several processes to be run at once to perform the whole basic task. For example you want a simple irrigation system which senses soil moisture content, starts irrigation and reports the data onto the cloud servers, this type of task can be easily performed by

an Arduino Board by uploading various interlinked programs on to the Arduino Board but if this task get more complicated by adding more functionalities to it then like monitoring the plants, receive notifications when the plants need water, check the data from weather forecasting servers if the weather is going to be clean today or not and what precautions must be taken for crops. For that type of system we need a Rasberry Pi because several tasks need to be performed at once which cannot be done with Arduino as it cannot support multitasking. Here at the same time we have to see the weather reports and also check for current moisture levels. This was just a basic example to differentiate between the projects for selecting appropriate device. What we saw here is Arduino is basically for beginners.

In industry grade projects you need to find appropriate microcontroller for you project and used PCB(Printed Circuit Board) Designing to optimize the selling price of the product to compete in the markets. Home Automation systems, health tracker systems are not made from Rasberry Pi or Arduino Boards. These devices are designed based on the specifications of the final product and choosing appropriate microcontroller for it. Looking at datasheets can give you good idea whether the microcontroller is fine for you or not. Datasheets are quite lengthy, but we just have to look at some basic details.

As we have these datasheets that can reveal a lot about the microcontroller we are going to use but these datasheets are very large and can contain as much as 500 pages. All this data is not needed to know about the the microcontroller all we need is some relevant information from the datasheets like configuration details, etc. So, one of the characteristics of the datasheet that we are going so see to pick out the relevant microcontroller for our project is bit width which represents the number of bit storage of the register. If the data bit width of the microcontroller is 32 bit then the mircontroller the data is represented in the the form of 32 bit number which means a 32 bit sequence of zeroes and ones. That also means that to store 32 bit number the buses that carry data are also 32 bit so there are 32 wires going around in circuit. So, more is the data bit width more is the power of the microcontroller as data is bit processed with large number of data bits at a time and carried along with a large number of data bits at a time. So, if you have a 32 bit data width you can store 32 bit of data at a time and if you have an 8 bit data width then you store 8 bit data width at a time. Moreover, we can have an operating system on 32 bit data width but it is impossible to have even the most basic operating system on a 8 bit data width.

Another factor that is to be considered is the number of input / output pins. As we know that the number of transistors on a chip are increasing according to the Moore's Law and so density of the chip transistor are increasing every year and increasing the functionality of the chip but number of input / output pins haven't been affected much. So, we can connect only limited number of devices by the chip and so not a lot of devices can be controlled with this improvised chips causing wastage of processing powers. For, choosing the number of devices to be connected via the chip we need to the microcontroller chip with appropriate number of input / output pins so that all the necessary devices are connected to the chip.

Performance of the microcontroller is another important factor as all the functionalities of the system needed to be handled. Some application do not require much performance like repetitive tasks like machine chain in a product line of a factory which just has to do a regular task all day long but intelligent systems with sensors and actuators require some performance capabities to handle the communication between devices. The performance of the device is determined by its clock speed that is the number of computation a device can perform in a second. Like 1 Mhz means a processor can do 1 million calculations in a second which is quite good enough but some applications cannot be done with this clock speed also like our desktop computer need about 3Ghz of clock speed to do tasks like gaming etc but basically these desktop computers do not utilize the clock speed to the fullest at all times but only when we run some specific high performance based applications like games, photoshop, watching movies etc and when we are running simple processes like text editors a few megahertz do the task which is why Internet of Things devices do not necessarily require that much amount of clock speed as are application specific and need processing speed according to the task being performed by the Internet of Things device.

Timers are another important components of the microcontrollers which handles the delays involved with the human interactions the chips as we have seen that these chips have clock speed in millions of instructions per second but humans are not that fast so to handle the delays involved with human interactions we need timers to handle the interactions. Moreover if we are performing some task like that of sampling where we need to sample some received data from some sensor every second then we need timers for that purpose or some actuator that has to

repeat its tasks after every few seconds and take rest in meantime then we need timers for that purpose.

Analog to Digital converts is an important feature for real world applications as the data received from the sensors in outside world is analog like sound which is received from a microphone is analog data but the microcontrollers can only handle computations on digital data which is zeroes and ones so Analog to Digital conversion is needed for that purpose.

Communication is another important feature of a microcontroller because the microcontroller has to communicate with a lot of other devices and intergrated circuits to send/ receive data or transfer of functionality to the other integrated circuit or send data to the cloud servers for high computation complex functions to be performed which cannot be done at local resources. So, these integrated circuits communicate a lot with the devices and communication is complex enough to involve a protocol with it. Some common protocols are UART, I2C, SPI. Like arduino devices communicate with the serial monitor to send/receive data from the programming desktop and communicate with it using a port number using I2C communication.

Here is an example of data sheet configurations page of ATmega328

2. Configuration Summary

Features	ATmega328/P
Pin Count	28/32
Flash (Bytes)	32K
SRAM (Bytes)	2K
EEPROM (Bytes)	1K
General Purpose I/O Lines	23
SPI	2
TWI (I^2C)	1
USART	1
ADC	10-bit 15kSPS
ADC Channels	8
8-bit Timer/Counters	2
16-bit Timer/Counters	1

Fig 2 configuration summary of ATmega328

Chapter 3- System Development

3.1) Analysis

The system which is being deveped here is an automed gardening system based on Node MCU ESP 8266 and using the Internet of Things app developed at MIT university the Blynk app. So, this project is basically going integrate the gardening process irrigation from manual gardening to a fully automated system which can handle all the gardening related tasks on its own and making the graden owner independent of gardener which is the basic motive of Internet of Things devices to make a person self dependent and independent of burdens by investing in one

time complete Internet of Things systems. This device can observe various information related to the gardening process and use it for all purposes and helping to improve the gardening process.

So, the information is captured about the soil about humidity, temperature, light content and the information is also captured about the air about humidity, temperature using I2C Soil Moisture sensor and some other sensor for the soil to completely receive the data based on the sensors receiving the data so that this data can be stored and used. Now, this stored data is used to determine various things like amount water and heat the plant should receive based on the type of crop we are planting and activate the actuators accordingly. This makes the irrigation through water pump completely automated and makes it easy for person to take care of the crops as the system is completely automated which whenever the plantation need water supply it automatically start supplying water to the system. Moreover, the system must have connection the app so that user has a manual control over the data being send and the control over turning the pump on/off. This type of manual intervention must be through connected buttons and remotely by the use of the mobile app so that the person can see if there is a problem with the automated system he can override the manual system and control the irrigation system from the far remote mobile application.

3.2) Design

So the design of the system is as follows. Here we are going to see what are system requirements and what is design configurations of the system. This system used very high intensive hardware like Rasberry Pi. We are using Arduino here to do do our basic computations.The irrigation system will have the system of remotely controllable water pump using buttons from BLYNK app, automatic irrigation if the soil moisture content sensed form I2C communication based soil moisture sensor is if the soil moisture content is sensed low, supporting both the automatic and manual controls which allows transition between the modes of

automatic or maual, soil moisture and water content display on the thingspeak.com channel by the means of communicating with the channet immediately by the means of WiFi connection, for doing the analytical jobs saving the logs of the data uploaded on the thingspeak website. We can set the threshold soil moisture levels in the WEB interface and control the water pump accordingly to detect the soil moisture content and use the water pump system accordingly. The water pump will be turned on 10 seconds and start pumping water for 10 seconds and stop and again check the soil moisture content level and turn the water pump on if the moisture content needed for the plan t if not sufficient as the pump was turned off for 10 seconds to check the soil moisture content level.

So, what the system receives as input is form the sensors like data about soil moisture content, the air moisture content which the air relative humidity, the temperature of air and soil. The buttons on the BLYNK app for remotely turning the buttons on/of and the lamp on/off for manual control of the system from distant locatins.The output of the system are through actuators which are relay for water pump and relayfor the lamp which is controlled both automatically and manual. Messages are alos sent about the main event to the owner of the device to let him know about the system that the system is online or not, the pump is online or not and the lamp is online or not. All the analog and digital data must be uploaded on thingspeak.com for evaluation on the data and derive results and decision by the means of this data which all the above data we have seen which are sensed from the sensors. The historical data must stored remotely in databases for future concerns and analytical purposes for the overall system improvement is system development life cycle.

3.2.1) Complete list of materials

- Node MCU Wireless Fidelity Internet ESP8266
- Temperature and Humidity Sensor
- Soil Moisture Sensor (Optional, can be Dit Ii Youself)
- Waterproof Digital Temperature Temp Sensor Thermal Probe

- 0.96 inch I2C protocol IIC SPI Serial 128X64 Yellow & Blue OLED Liquid Crystal Display
- Buttons (3 in number)
- LEDs (2 in number)
- 2 Channel DC 5V Relay Module with Optocoupler Low Level Trigger
- Jump wires
- Big Breadboard with connected columns and rows
- 4.7 Kilo Ohms resistor
- 10 Kilo Ohms resistor
- 220 Ohms resistor
- 5V / 2A External Power Supply
- Mini Direct Current Water Pump

3.2.2) The NodeMCU

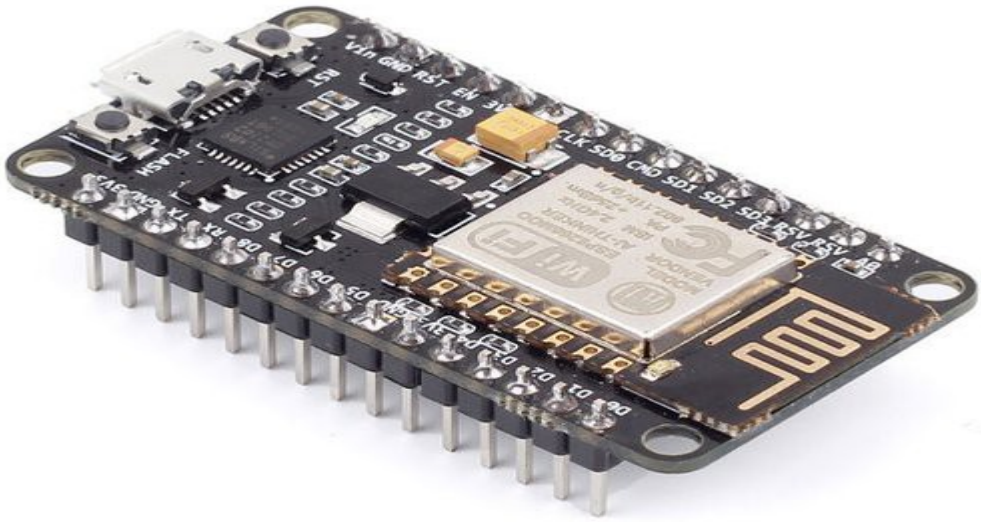

Fig 3) The Node MCU ESP8266

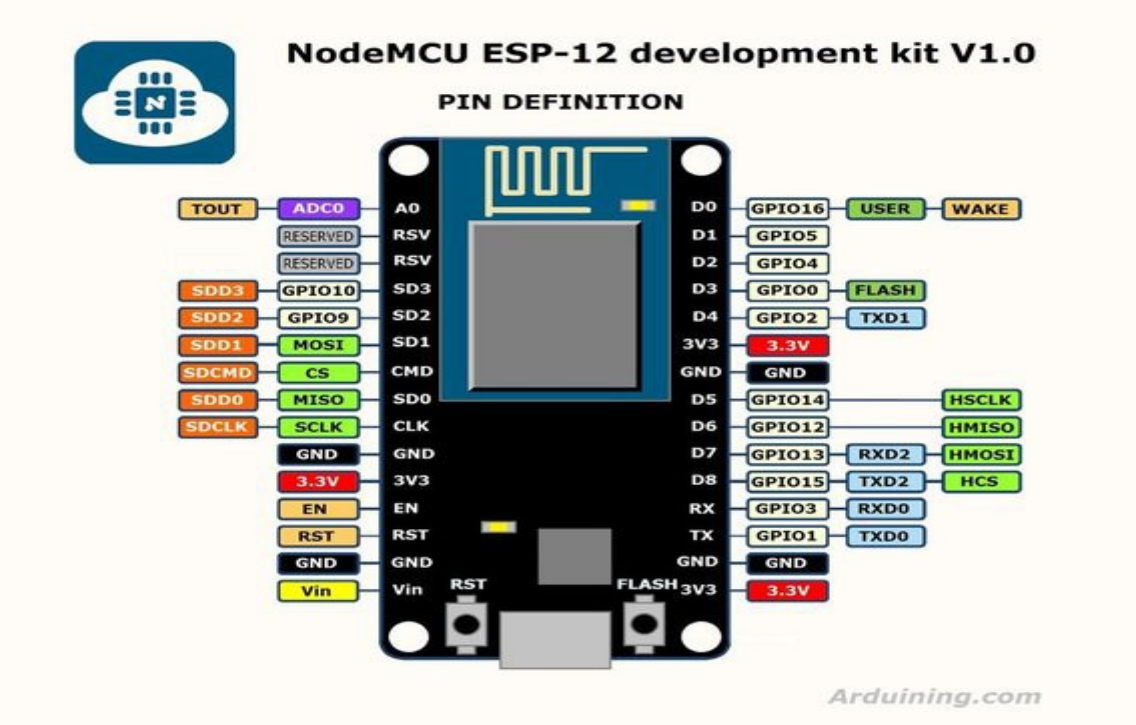

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Figure 4) Pin definition of Node MCU ESP 8266

The NodeMCU ESP-12E is the integration of the version of the popular ESP8266, a Serial to Wi-Fi System On a Chip (SoC) that appeared after for the first time in history in 2014, been released on following year 2015. The ESP8266 was developed by the Shanghai - based company Espressifier Systems, an Integrated Circuit manufacturer focusing on the development of Real time finance chips, particularly Wireless-Fidelity.

There are several modules in the world that use the ESP 8266 microcontroller chip, they are named ESP-NN, where NN is a number 1, 2,3,4,5... 12, which is sometimes followed by a small or capital letter. These modules typically carry the ESP8266 so C, flash memory which is a crystal, and in most cases, an Antenna. In the marke you can find the full set of ESP8266 based devices found in the market: NODE MCU ESP 8266 module family. The 2 more important models are these which work with the same functionality and more enhanced features are the ESP-01 and the ESP-12E.

We will use the ESP-8266 Development Board (Node MCU ESP 8266 Kit 2.0). This development board for the ESP8266 inside the ESP-12E module is off the shelf in the market and easily available to you all a person has to do is the install the Arduino IDE and connect with the USB cable to the arduino after installing the NODE MCU libraries onto the Arduino Integrated Development Environment, install Universal Serial Bus drivers required for the device to understand the protocol associated with the ESP 8266 board to communicate using the serial port and the protocol on the ESP 8266 for programming purposes, and get started with writing programs that is able to connect your device to the WiFi network and do your tasks associated with the applications you want to process.

3.2.3) Technical Specifications

- Supports STA / AP / STA along with AP 3 working with the respective modes which are different available modes in the device.

- Built-in TCP/IP protocol stack, support multiple-channel Transmission Control Protocol client connection (maximum 6 in number).
- PINS are 0 through D8, SD1throigh SD3: used for General Purpose Input/ Output, Pulse Width Modulation (Pins D1 through D8), IIC, etc and the driven ability can be arrived at 15milli Amps.
- AD0: one-way 10 bits Analog to Digital Converter .
- Power input: From 4.5V to 9V (10V is the maximum limit above which the device can be harmed), supporting for the USB powered and USB debugging mode.
- Working current: almost 70milli Amps (200milliAmps is the maximum theshold, continuation from last mode), standby 200microAmperes for standby mode where you do not use the device and save energy because these devices are battery driven and we need to save energy for not replacing batteries on daily basis.
- Transmission data rate: 110-460800 bits per second very high as compared to simple Arduino Boards.
- Support Universal Asynchoronous Receive and Transfer/ General Purpose Input Output data communication interface with the programming device generally desktops / laptops
- Support update firmware remotely.
- Support Smart Link from the thingspeak.com
- Working temperature: temperatures as low as-40 to as high125 so supporting crop plantation in extreme temperatures in modified green houses for artificial environment generation.
- Driven mode: double large-power High bridge driven.
- Weight: 7grams.

3.3) Development

3.3.1) Installing the Arduino IDE with library files of NODEMCU ESP 8266 version 1.0

In this step we are going to install the libraries associated with the NODE MCU ESP 8266. We are doing basic setup for the Wireless device and it done after the Arduino Integrated Development Environment is installed on the desktop / laptop. This integrated development environment is meant for a lot of devices which can be programmed with the help of it and by verifying and uploading the software application the environment itself. There are also these simulation environment software where we can make the circuits offline or online and check our code if it working properly on the simulation environment and then upload the code on the respective device so we are getting an idea if our device is working properly or not. There are also these time delays where the simulation environment is sometimes faster that the hardware but we want the human interaction to be proper and understand the delays previously to deal with the human interaction properly because finally our project has to do some real time application in the world and deal with the human interactions. One of the websites is circuits.io where we can write our code, make the circuits and verify our code if it is working properly or not.

The programming of the Node MCU is similar to the programming of the Arduino and when we install a new program on the device's flash memory the flash memory is reset and the new program with new functionalities is uploaded on to the flash memory. Original firmware which is uploaded by the company contains the protocols for USB interfacing and the protocols for communication between the parts of the hardware and using the AT protocol for communication. There is also the original Integrated Development environment for the ESP8266 but we can use the Arduino universal Integrated Development Environment for the board because it is commonly familiar to most of the people.

So, let us now start the process,

First, of all open the preferences from the file dropdown menu and there you have preferences. It will open a dialog box where you have to enter the URL of the library file of the board to download the board association in Arduino IDE in Additional Boards Manager box.

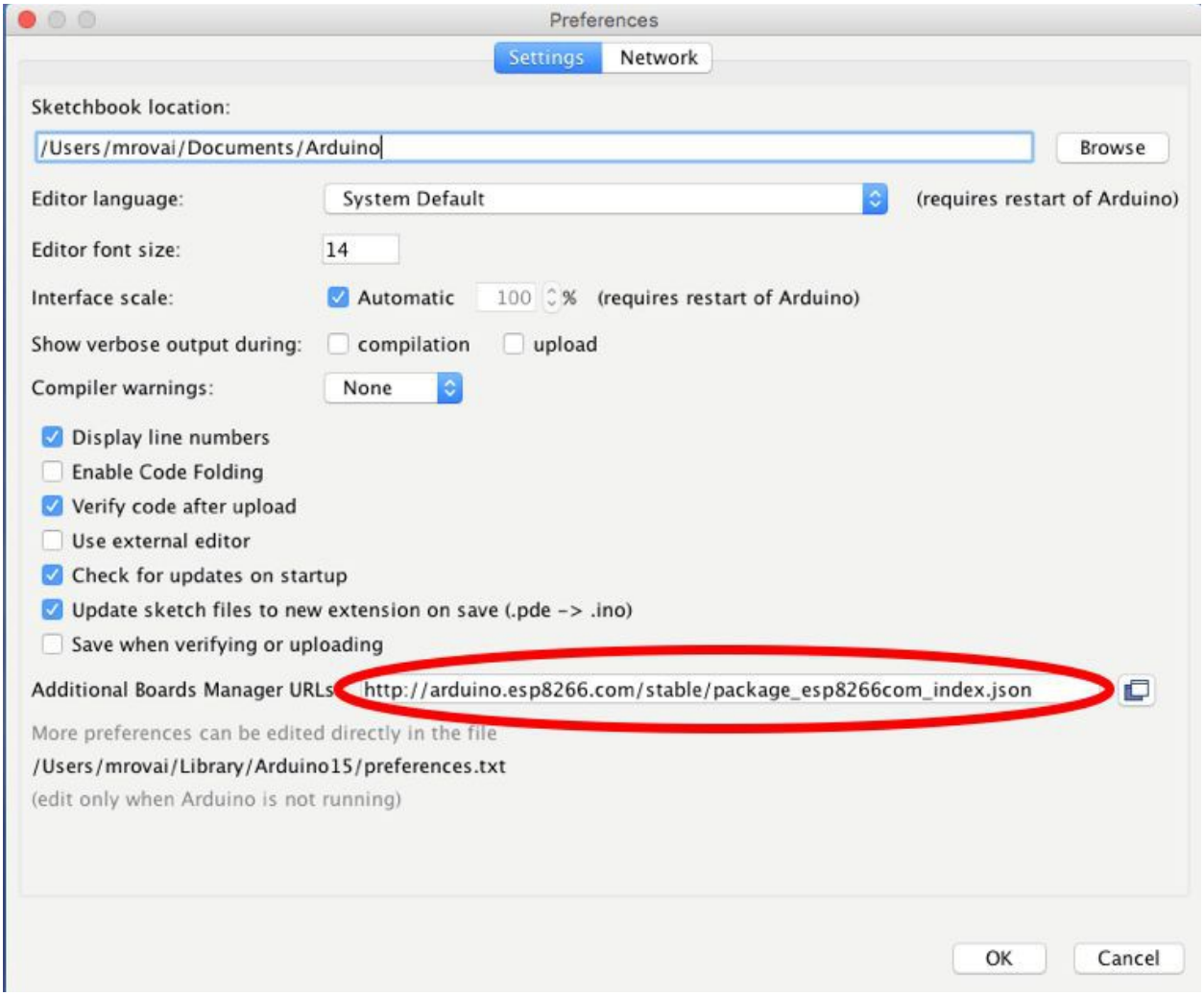

Fig 5) the preferences dialog box

Secondly, in the menu bar you will se a tools dropdown menu where you have to select Board and then Boards Manager where you can search for ESP8266, there will appear a link to install the association with the arduino IDE which was received from the URL you entered in the Additional Boards Manager. Click on install to install the supported association. Now, your IDE is ready to support your code based on ESP866 and compile but you can not upload it until you have drivers installed.

So, the third step is to install the drivers for the board, go the website of GitHub and search for ESP 8266 drivers and select the respective driver for windows which is basically available is 64-bit version. Unzip the downloaded file and install the drivers. After installing the drivers you can see it appear in the device manager in the section of PORTS.

After that you come to the fouth step, where you have to restart the Arduino IDE and there go the tools drop down menu and select the board to NODE MCU ESP 8266 version 1.0 or 0.9 based on the hardware you have. Also, specify the CPU clock frequency to 80 MHz, the upload speed to 115200 and the serial monitor to baud rate of 9600 which is the general baud rate for basically all the I2C serial port communication devices until and unless the device's firmware is changed the boot loader pins. Select the port which you saw in the device manager where the PORT number was corresponding that of the ESP 8266.

3.3.2) Installing the OLED

OLED has the characteristics of 128 pixels in horizontal and 64 pixels in vertical so it has a very good display interface for displaying the data so when we use 8 X 8 characters then we are going to have a total of 16 X 8 characters. It is an I2C display so are going to connect the device the device using pins SCL to D1 (pin number 5) and SDA to D2 (pin number 6) to the NODE MCU ESP 8266. We can power it directly through external power source using supply of 5Volts through adaptor or using NODE MCU using the supply of 3.3 Volts. It will be used to display the current sensor and actuator status. Also we need to download the library for OLED to connect it support the OLED when the specific code is being written for the OLED. We need to write code to display the sensor and actuator data for the OLED display and display it accordingly. We have a lot of concerns for this and need to learn the programming for it. Although it is quite easy to handle. Here is the basic hello world example for sake of it and understanding the basic working of the code.

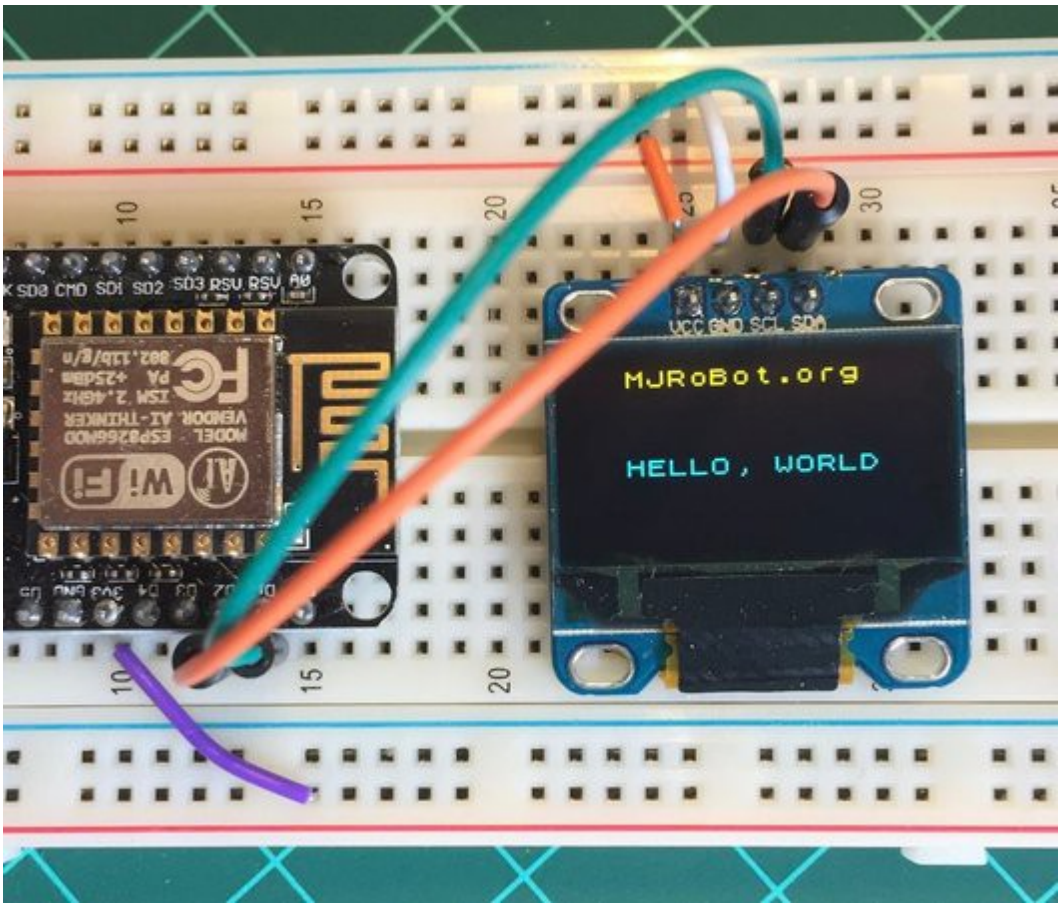

Figure 6) OLED interfacing with the NODE MCU 8266

The default size of the text character is set to 8 X 8 but we can change this but using the function OLED.setFont(font 6 X 8) which set the character size to 6 X 8 pixels if we are going to need to fit more characters into the display. This is necessary for fitting more number of characters in the OLED display and depends on the size of the number of characters we need to display.

```
/*************************************************************************
*  NodeMCU and OLED display "Hello World" test
*
*  MJRoBot 15march17
*************************************************************************/

#include <Wire.h>
#include <ACROBOTIC_SSD1306.h>

void setup()
{
  Wire.begin();
  oled.init();                      // Initialize SSD1306 OLED display
  oled.clearDisplay();              // Clear screen
  oled.setTextXY(0,0);              // Set cursor position, start of line 0
  oled.putString("  MJRoBot.org");
  oled.setTextXY(4,0);              // Set cursor position, start of line 4
  oled.putString("  HELLO, WORLD");
}

void loop()
{
}
```

Figure 7) Basic hello world example for OLED

3.3.3) Capturing Soil Moisture Humidity

Now, we need to capture the soil moisture humidity for the purpose of getting information about the soil moisture content from the Soil Moisture Sensor and displaying the data accordingly and activating the actuators that are water pumps and other reporting mechanisms like OLED, BLYNK app in the hands of user which also controls the actuators and receives data from it but we will talk about that later on. We need this data and write a program to act accordingly with the changing values coming from the sensors to activate the actuators so that the irrigation system works properly.

The soil moisture sensor has an hygrometer to sense the soil moisture content which is the water content in the soil to find the correct levels of the soil moisture content. The soil moisture sensor has two inputs one of which is digital (Digital pin D0) which can be managed with the help of a

potentiometer which does perform the function of having digital inputs to the soil humidity sensor and an analog input (Pin A0). This power input to the device can be given by the NODE MCU ESP 8266 with 3.3 Voltage supply. The pins of the Soil Moisture sensor to the NODE MCU is connected as follows :-

- NODE MCU analog input pin A0 to A0 onput of pin Soil Moisture Sensor
- VCC of NODE MCU to the Soil Moisture Sensor D3
- NODE MCU GND to GND of Soil Moisture Sensor as the ground connection needs to be common
- Soil Moisture Sensor D0 is kept open.

We have to save energy in these type of applications to save battery energy connected to the NODE MCU so we connect the VCC of the sensor to the digital pin output of the So NODE MCU so the power is given to the Soil Moisture Sensor only when we need to sense the data from the sensor and otherwise the device is kept idle making the power saving possible as generally the soil moisture content has be checked after 10 of 15 minutes in these type of applications.

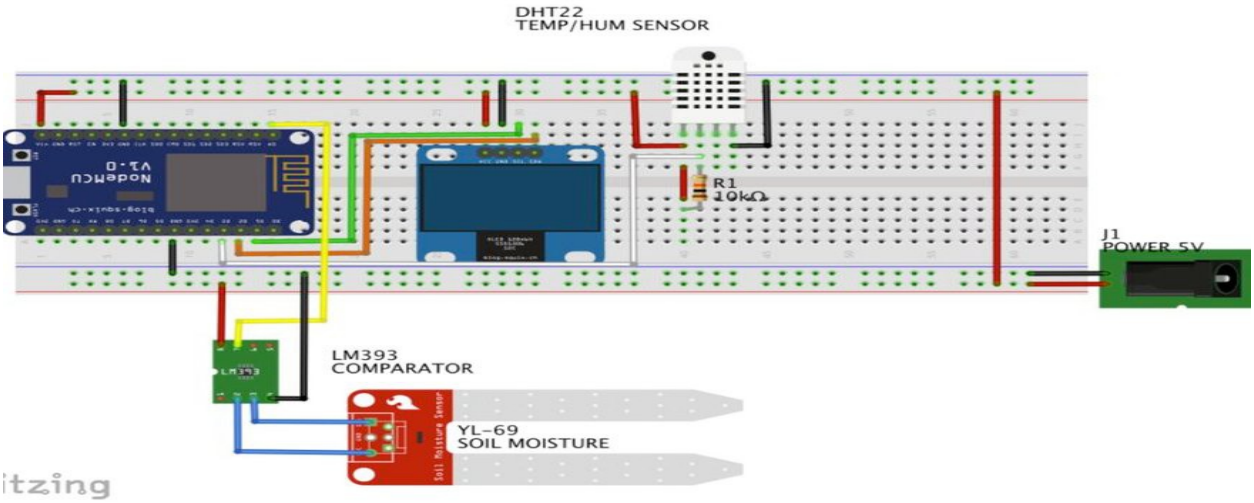

Figure 8) Connection setup of the Soil Moisture Sensor

When we sense the data about the soil moisture content we try to make it as precise as possible and make time delays between the data sensing periods because sensing data every second is not necessary as soil moisture content cannot have reasonable changes every second and we will also send data to the actuators every second which will increase the power consumption and reduce the economic value of the system. So, we need to make the system economically feasible and generate sustainability in the project. Talking about the precision of the data recorded we take sensor value 3 times and find the average of the accumulated data to increase the preciseness of the data recorded. If we by mistake make a short circuit at sensor probes then we get he output of 100 % humidity represented by 0 at sensor output and leaving the sensor in open air will give the output of 600 at ADC output.

```
/**************************************************
 * Get Soil Moister Sensor data
 *************************************************/
void getSoilMoisterData(void)
{
  soilMoister = 0;
  digitalWrite (soilMoisterVcc, HIGH);
  delay (500);
  int N = 3;
  for(int i = 0; i < N; i++) // read sensor "N" times and get the average
  {
    soilMoister += analogRead(soilMoisterPin);
    delay(150);
  }
  digitalWrite (soilMoisterVcc, LOW);
  soilMoister = soilMoister/N;
  Serial.println(soilMoister);
  soilMoister = map(soilMoister, 600, 0, 0, 100);
}
```

Figure 9) Basic routine code of receive the data from soil moisture sensor

3.3.4) Completing the hardware

As we know that the soil moisture sensor and the OLED can be powered using ESP 8266 module but driving these things by the means of NODE MCU can result in current making the system unstable the sensor and the OLED can together make a lot of power consumption so we need to make the system stable and give the supply of 5Volts as both the sensor and LED can run on 3.3Volts and 5Volts so it better not to give the supply to system by the means of NODE MCU, the sensor does not make the system so much unstable but the OLED is quite a power consuming system compared to the electronic system of the microcontroller chip NODE MCU.

First we will use the LEDs for simulation purposes to see if the system is working just fine or not. We will use red colored LED for pump action simulation and green colored LED for the simulation of the lamp if it is working according to the sensed output from the Board.

We are also incorporating a manual control over the system to control the irrigation system on the project itself for on the site control over the system so that we can manually use the system when we are on the site for control purposes and see the sensor data when we at the site. For that purpose we are going to use push buttons. We are going to use a red colored push button for the manual control of the pump, a green push button for the manual control over the lamp and yellow push button to activate the sensor and print out the sensor value to the OLED. The buttons will be used in the toggle mode which means when we press the button the values will be change from low to high and vice versa on again pressing the button so that we do not have to keep the button pressed to read data or control the lamps and pumps.

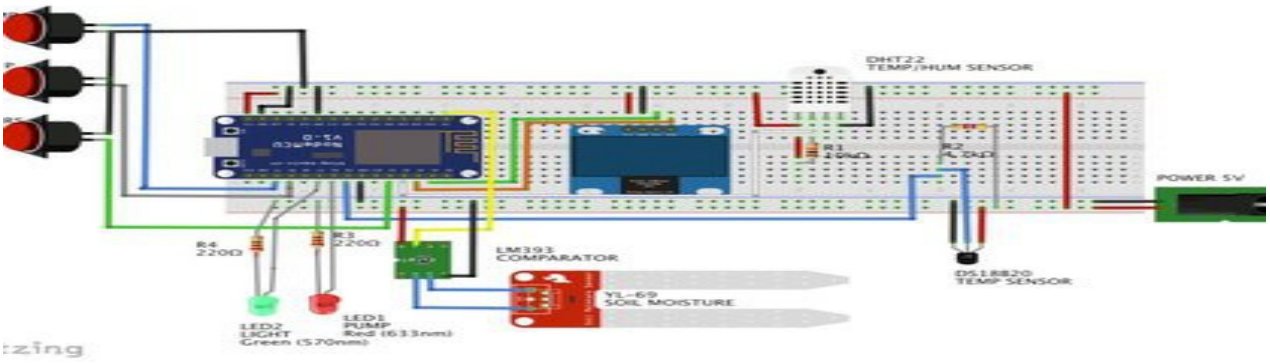

Figure 10) The complete hardware connection made after doing all the required connections

For the programming of the coordination between complete hardware structure first we need to read sensor data, then read data from the input from buttons, thereafter act on pumps and lamps and finally display the data.

Reading data from each button has be done and is done by using the command readLocalStatus() which reads the data from all the buttons for the purpose of analysis and using it to activate the actuators. For reading the pins we use debounce (pin number) to read the data from the pins instead of analogRead(pin number) or digitalRead(pin number) because these commands can read misleading and false data which is prevented by debounce command. To activate the actuators we use use thesec ommands after getting the data stored using the above commands to the actuator variables pumpStatus and lampStatus. In the code below we are not actually activating the actuators but we are just making changes in the actuator variables.

```
void readLocalCmd()
{
  boolean digiValue = debounce(PUMP_ON_BUTTON);
  if (!digiValue)
  {
    pumpStatus = !pumpStatus;
    aplyCmd();
  }

  digiValue = debounce(LAMP_ON_BUTTON);
  if (!digiValue)
  {
    lampStatus = !lampStatus;
    aplyCmd();
  }
}
```

Figure 11) Code to affect the actuator variables after the data is sensed from buttons and sensors

Previously we had just changed the variables for actuators according to the sensed data from the sensors and button. After that we also need to apply those changes to the actuators by activating the actuators according to the data received from the buttons if we are manually using the system on the site and by the output of sensors if we are remotely using the system. For, turning the actuators ON/OFF we need to use the command called aplyCmd(), which will turn the actuators

ON/OFF based on the status of the input given to command received from the push button or the sensors.

```
void aplyCmd()
{
  if (pumpStatus == 1)
  {
    digitalWrite(PUMP_PIN, HIGH);
    displayData();
  }
  else
      {
        digitalWrite(PUMP_PIN, LOW);
        displayData();
      }

  if (lampStatus == 1)
  {
    digitalWrite(LAMP_PIN, HIGH);
    displayData();
  }
  else
      {
        digitalWrite(LAMP_PIN, LOW);
        displayData();
      }
}
```

Figure 12) Function for turning the actuators ON/OFF based the data received from sensors/actuators

As, we already talked about the soil moisture sensors that whenever we sense data we do not have to sense the data every second because the soil moisture and the sunlight does not vary every moment so we need to create a coordination between tasks as we are also using a manual system through buttons to activate the actuators and even the sensors and it can happen that remote control of the system and manual control over the system override the system and hang each other or create other types of instability in the system. For, the proper coordination between the systems both manual and remote we need to add timers in the program. We can use millis() and send the number of milliseconds to agreement for delay or waiting time between action of

remote and manual control and sensor or actuator control, but there a better library to implement the same purpose. This library is included at the top of your code and is very handly to use, we just have to specify two arguments in it, the first one is the number of milliseconds and second argument is the name of the function which has to delayed for the time being and executed again. Here is an example code for the same,

```
timer.setInterval(1000L, readLocalCmd);       // Read buttons at every 1 second
timer.setInterval(2000L, getSoilTempData);    // Read Soil Temp at every 2 seconds
timer.setInterval(2000L, getDhtData);         // Read DHT Sensor at every 2 seconds
timer.setInterval(10000, getSoilMoisterData); // Read Soil Humidity at every 10 seconds
timer.setInterval(10000, displayData);        // Display Data at OLED at every 10 seconds
```

Figure 13) Setting the time delays for the functions to be executed after a specified period of time

What we see in the above image is that we are displaying on OLED every 10 seconds which saves us a lot of energy and also if we see the real world implementation it is not real world thing to keep OLED on all the time. We sensing soil moisture content every 10 seconds which is also quite much but it increases the precision of irrigation system for good planting practices. Also we are reading commands from the buttons every second which is also according to real world situation because we are not doing any kind of response time testing on the system and the user will not press the button every second. Finally we add the yellow button which activates the actuator which is the water pump for starting the supply. And hence we add the code to the readLocalCmd() function to introduce the functionality of the yellow button input to activate the actuator. Figure below shows the added code for yellow button.

```
  digiValue = debounce(SENSORS_READ_BUTTON);
  if (!digiValue)
  {
    turnOffOLED = !turnOffOLED;
    if (!turnOffOLED)
    {
      oled.setTextXY(0,0); oled.putString("UPDATING SENSORS");
      getDhtData();
      getSoilMoisterData();
      getSoilTempData();
      oledStart();
      displayData();
    }else oled.clearDisplay(); //turn off OLED
  }
}
```

Fig 14) Added code to the readLocalCmd() function to add the functionality of yellow button

3.3.5) Automation of the gardening process

Till now we have made our gardening system manual which it can only be controlled manually on the site, we have created button s to read input data soil moisture sensor and control the actuators which are pump and lamp. So, currently we just have control over the system manually. Now we are going to fully automate the system which is the feature of embedded systems. This feature of embedded system makes the device to work without any attention being paid to system and system controls itself based on the program being booted onto the board. So, this means that we are adding the brain to system which means it can sense when the pump and lamp (actuators) need to turned on/off.

In the project demonstration we will use sample ranges of sensor values for the determination the activation of actuators but if we want a real time application we need include functionalities in the code where we just need to enter the type of seed and system will be fed with information regarding the soil moisture and temperature values at various points of time. For example if feed into the system that we are germinating the potato seeds so the germination process, first six days temperature requirement is between 20^{o} to 25^{o} C. Thereafter we require temperature below 10^{o} C and after that for nine days we need temperature around 35^{o} C. So, this type of data will be defined and stored and processed according to the conditions of which we set up in the program

like if we enter the crop to be potato then this data regarding the processing will be used using if conditions.

But, for now we will use demonstration using some sample values like for soil moisture it will be considered wet for humidity above 88% and the water pump will be turned off, and humidity to be achieved is in between 66% and 88%, and finally if the humidity is below 66 % then the water pump is turned on until the target humidity is completely achieved by constantly sensing the data from the sensors.

So, here we are defining the sample parameters which we are going to use in our program,

```
#define DRY_SOIL      66
#define WET_SOIL      85
#define COLD_TEMP     12
#define HOT_TEMP      22
#define TIME_PUMP_ON  15
#define TIME_LAMP_ON  15
```

Figure 15) Automatically controllable parameter definition

So now we can do the basic assumption that if its dry then the pump has to be turned on and if it wet then the pump has to turned off.

Here is the code associated with it

```
void autoControlPlantation(void)
{
  if (soilMoister < DRY_SOIL)
  {
    turnPumpOn();
  }

  if (airTemp < COLD_TEMP)
  {
    turnLampOn();
  }
}
```

Figure 3.9) code for the condition of dry and wet and turning the pump on/off accordingly

The function for the program above are as follows:-

```
void turnPumpOn()
{
  pumpStatus = 1;
  aplyCmd();
  delay (TIME_PUMP_ON*1000);
  pumpStatus = 0;
  aplyCmd();
}

/************************************************
* Turn Lamp On for a certain amount of time
************************************************/
void turnLampOn()
{
  lampStatus = 1;
  aplyCmd();
  delay (TIME_LAMP_ON*1000);
  lampStatus = 0;
  aplyCmd();
}
```

Figure 16) functions for turning pump on/off

Chapter 4- Conclusion

4.1) Basic Conclusion

To conclude this topic we say that the internet of things is making the revolution in the world and creating opportunities to make that world and creating difference. It is creating opportunities to make the world a smart and better place and making things easy by making people self

dependent and free from the burdening others for their tasks. It is making the tasks that used to take a lot of manual effort to a task that is easily handled by remote control over the tasks and making people smart and focus on their tasks. Everything we see around us is becoming smart nowadays due to internet of things. It is very pervasive and spreading in alsmost all the possible field even in the tasks outside the field of computer science. Where we see around us the Internet of Things is making a revolution. We can see now cashless transfer of money through TEZ, PAYTM etc are creating peace for people around the world as they don't need to carry cash always, they just have carry their smart phones which can transfer money from one's account to another's in a very easy manner. If this task was to performed without internet of things, the person would have first go his bank withdraw money and then go to other person's bank and deposit by filling a form. Even though withdrawing money from the account through ATMs is giving of Internet of Things as Automated Teller Machines are considered to be the first internet of things device as ATMs are capable of accessing their account by using ATM cards which represents direct access to their accounts. With new ATMs all type of transactions like withdrawing money from account, sending money to others account by using their account numbers, depositing money to their accounts, getting their passbook updated can done which makes life a lot easier. The ATM devices now are always connected to the server of the bank and other banks that want to share their network with the bank, so that the data related to transactions are directly uploaded with a very less degree of fault, almost zero. This has made life easy for both bank owners and customers as ATMs upload data directly on the server so no hassle of papers is required i.e. no cheques are need everytime or no need to visit the cashier so many times. Once a person receives the ATM card every type of transaction is in hands. The only limitation of new ATM is that it is too dependent on technology and whenever the server goes down all ATMs in the area do not work and also more prone to be hacked by hackers compared to old ones. So, basically Internet of Things is new generation top class technology which will one day create a ubiquitous environment all over which is now only tested in Labs.

4.2) Future Scope

This future scope of this project is leading to fully automated farming system where the farmer can sit back at home and do the farming process by using his mobile app. Also, the data uploaded onto the servers can be used for analytical purposes of the farming procedures and improve the farming practices all around the world. Each and every crops data will be saved on the cloud

server and what farming practices led to the best production in various regions will tell about the best irrigation practices of each crop and by using the system update of the software in our project the productivity will be increased year by year as more analytics will be done on the data.

Moreover, farmers will be at high profits as they be saved from the cost of labour used in irrigation process as the irrigation process is a very long process for various types of crops and labour costs reduce the profits earned by the farmers. So, it is a one time investment for future year long profits. Also, farmers had to take a look at labors all the crop growing season that if the irrigation is done properly or not in the scorching heat but now this task will be automated and checking upon the irrigation can be done by sitting back at home and checking the app.

Chapter 5- References

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