

SMART PLANT SOIL WATER LEVEL MONITOR

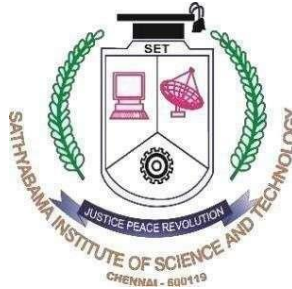
A Project Report Phase – II

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering Degree in Electronics and Communication Engineering

By

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

APRIL 2023



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **KOLA NAVEEN KUMAR (39130230)** and **KOTHAPALLI UPEDNRA (39130243)** who carried out project entitled “**Smart Plant Soil Water Level Monitor** ” under my supervision from November 2022 to April 2023.

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We, **KOLA NAVEEN KUMAR** and **KOTHAPALLI UPENDRA** hereby declare that the Project Report on “**Smart Plant Soil Water Level Monitor**” done by us under the guidance of **Dr. R. NARMADHA, M.E, Ph.D.**, at Satyabhama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

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ABSTRACT

In today's world only some devices like PC's and mobiles are connected to internet. Now-a-days world is fully overtaken by the internet and internet of things. Internet issue for basic need of all human beings. The Internet of Things (IOT) is the network of physical objects. It simply means to monitor a physical device or machine or it is inter-networking of physical devices which is embedded with electronics, sensors, software and network connectivity to enable it to achieve greater value and services by exchanging data with the manufacturer IOT permits objects to be sensed or controlled remotely across the network infrastructure. The result improves accuracy, economic benefits, efficiency and reduces intervention of human. In this paper we are going to deal with basic and important concepts of IOT and its scope in upcoming future. This paper studies the need of IOT in day to day life for different applications and gives brief information about IOT. IOT contributes significantly toward revolutionary farming methods. So we are trying to demonstrate IOT in Automatic watering system. Automatic watering system monitors and maintain the approximate moisture content in soil. STM32 is used as microcontroller to implement the control unit. The setup uses the Probe , Module , Soil Moisture Sensor Pinout , DC Motor , Water Pump, Buzzer. This monitors the soil water level of the plant and smartly transmits information over the Bluetooth Low Energy Beacon to all nearby smart phones. If smart phone featured with dedicated app, it will update the information into Cloud using Mobile Data.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Since governments throughout the world implemented lockdowns to combat the spread of COVID-19, there has been a surge in interest in home gardening. Most families nowadays begin gardening during this season since they may grow whatever veggies, fruits, or other plants they desire in their daily lives. As a result, they will be able to make it through this period without having to spend money on online grocery shopping for fruits and vegetables. Due to the epidemic in Sri Lanka, home gardening has been popular in recent months. Most of the households were attempting to grow for their purposes. However, the government is currently attempting to lift such limitations to allow people to return to regular work in Sri Lanka. People are starting to do their jobs because of this scenario, and they do not have time to continue planting in their gardens. We discussed the issue and attempted to develop a solution that would allow them to continue working while doing so. The main issue is that individuals cannot constantly watch their plants to safeguard their gardens. As a result, we decided to automate the garden labor.

The current approach is based on observation with the naked eye, which is a time-consuming process. To detect plant disease at an early stage, automatic detection of plant disease can be used. Farmers have utilized a variety of disease control techniques daily to prevent plant illnesses.

Users can manually water the plants by checking the soil moisture level at any time and from anywhere in the world, the user may also create a watering schedule so that our device will automatically water the plants based on several criteria, eliminating the need to water the plants manually every day. We also create a security mechanism that will detect movements in the environment of the plants and inform the user if they are discovered. We'll create an IoT gadget that can be installed in a garden and operated by an app or a web platform.

Our innovative device is designed to help plant owners optimize their watering practices by providing real-time monitoring of soil moisture levels. With this cutting-edge technology, you can ensure that your plants are receiving the right amount of water at the right time, leading to healthier and more vibrant plants. The Smart Plant Soil Water Level Monitor is easy to use and compatible with a wide range of indoor and outdoor plants, making it suitable for both amateur and experienced gardeners. It utilizes advanced sensors to measure the moisture content of the soil and wirelessly transmits the data to your smartphone or other devices via a user-friendly app. The app provides intuitive visualizations and notifications that allow you to track the moisture levels of your plants in real-time and set customized watering schedules based on the specific needs of each plant. This helps prevent overwatering or underwatering, which are common causes of plant stress and diseases.

The Smart Plant Soil Water Level Monitor also takes into account factors such as weather conditions and plant species to provide personalized recommendations for optimal watering. It also stores historical data, allowing you to track the moisture trends of your plants over time and make informed decisions about your watering routine. With the Smart Plant Soil Water Level Monitor, you can take the guesswork out of plant care and ensure that your plants thrive. Say goodbye to wilted or waterlogged plants, and say hello to healthy, happy plants with this revolutionary device. Get your Smart Plant Soil Water Level Monitor today and take the first step towards achieving greener thumbs!

Our smart plant soil water level monitor is easy to use and can be placed directly into the soil of your potted plants or garden beds. It uses advanced sensor technology to measure the moisture content of the soil and wirelessly transmits the data to a mobile app or a smart home system. The app provides you with up-to-date information about the soil moisture levels, allowing you to monitor and adjust your watering schedule accordingly. One of the key features of our smart plant soil water level monitor is its ability to send notifications to your phone or smart device when the soil moisture levels fall below or exceed the desired range. This helps you avoid overwatering or underwatering, which can save water, reduce plant stress, and ultimately lead to healthier and more thriving plants.

Our smart plant soil water level monitor is also compatible with weather data, allowing it to adjust watering recommendations based on local weather conditions, such as rain or humidity levels. This ensures that your plants are getting the right amount of water at the right time, taking into consideration the natural environment. In addition to its practical functionality, our smart plant soil water level monitor also promotes sustainability by helping you conserve water and reduce water waste. It also helps prevent plant diseases and pest infestations caused by improper watering, which can lead to the use of harmful pesticides or other chemicals. Say goodbye to the hassle of guesswork when it comes to watering your plants and embrace the convenience and efficiency of our smart plant soil water level monitor. Let your plants thrive with optimal watering, and enjoy the beauty and benefits of a healthy and sustainable garden.

CHAPTER 2

LITERATURE SURVEY

2.1 LITERATURE SURVEY

Solar Plant Monitoring System: A Review, Mayuri Ejgar and Bashirahamad Momin et.al., (2009). The inspection of the solar panels on a periodic basis is important to improve longevity and ensure performance of the solar system. To get the most solar potential of the photovoltaic (PV) system is possible through an intelligent monitoring controlling system. The monitoring controlling system has rapidly increased its popularity because of its user friendly graphical interface for data acquisition, monitoring, controlling and measurements. In order to monitor the performance of the system especially for renewable energy source application such as solar photovoltaic (PV), data-acquisition systems had been used to collect all the data regarding the installed system. In this paper we have given a review on solar plant monitoring system in that we have covered architecture of solar plant, Issues at solar plants, Techniques that are used for monitoring solar plants.

Predicting the Extent of Wildfires Using Remotely Sensed Soil Moisture and Temperature Trends, David Chaparro and Merce Allulose et.al., (2012). In Recent climate trends evidence a rise of temperatures and an increase in the duration and intensity of droughts which is in turn leading to the occurrence of larger wildfires, which threaten the environment as well as human lives and beings. In this context, improved wildfires prediction tools are urgently needed. In this paper, the use of remotely sensed soil moisture data as a key variable in the climate-wildfires relationship is explored. The study is centered in the fires registered in the Iberian Peninsula during the period 2010–2014. Their prior-to-occurrence surface moisture temperature conditions were analyzed using SMOS-derived soil moisture data and ERA-Interim land surface temperature reanalysis. Results showed that moisture and temperature conditions limited the extent of wildfires, and a potential maximum burned area per moisture-temperature paired values was obtained ($R^2 = 0.43$). The model relating fire extent with moisture-temperature preconditions was improved by including information on land cover, regions, and the month of the fire outbreak ($R^2 = 0.68$). Model predictions had an accuracy of 83.3% with a maximum error of 40.5 ha. Results were majorly coherent with wildfires behavior in the Iberian Peninsula

and reflected the duality between Euro-Siberian and Mediterranean regions in terms of expected burned area. The proposed model has a promising potential for the enhancement of fire prevention services.

Wireless sensor Network based automated irrigation and crop field monitoring system, G. Nisha and J Me gala et.al., (2013). Wireless sensor Network based automated irrigation system for optimize water use for agricultural purpose. The system consists of distributed wireless sensor network of soli-moisture, and temperature sensors placed in the crop field. To handle the sensor information Zigbee protocol used and control the water quantity programming using an algorithm with threshold values of the sensors to a microcontroller for irrigation system. The system has powered by solar panel and Cellular-internet interface for data inspection. A wireless camera is fixed in crop field to monitor the disease area using image processing technique. The system is low cost and energy autonomy useful in water limited geographically isolated areas.

Project Haritha” - an automated irrigation system for home gardens. In an urban setting, even the upkeep of a tiny garden may become tiresome. The need of the hour is for a completely automated system that maximizes the utilization of energy and water resources. As a consequence, a multi-mode, extremely energy efficient control for an automated irrigation system has been developed. was designed and implemented. To irrigate a targeted region, the system employs an in- situ soil moisture [4] potential sensor and programmed data. The soil moisture content is monitored using a microcontroller-based data collection and dissemination system. During a system failure, an embedded GSM module gives vital information to the user. The recommended microcontroller-based system was written and tested to see how well it performed.

P.keshavarzi et.al., (2016), Predicted the extent of wildfires using remotely sensed soil moisture and temperature trends. Weather patterns changes reveal an increase in temperatures, as well as a growth in the duration and frequency of drought, resulting in more severe wildfires, which endangers both the environment and human life. [2] Improved wildfire prediction technologies are critical in this setting. This research explored the significance of remotely sensed soil moisture

data as a crucial variable in the climatewildfires association. This research focuses on fires that occurred in the Iberian Peninsula between 2010 and 2014. When investigating their prior-to occurrence surface moisture temperature conditions, researcher utilized SMOS derived soil moisture data and ERA-Interim land surface temperature reanalysis.

The Design and Research on Intelligent Fertigation System. Crop fertilization is uneven, resulting in either too much or too little fertilization, and the concentration cannot be effectively regulated, which is a serious but typical problem. [6] Accordingly, an intelligent fertilization device has been developed that can automatically water and fertilize, as well as inject and combine fertilizer. Three control algorithms are presented in the paper: fertilizer application control algorithm; fertilizer injection and mixing; and a system priority algorithm. It also describes the system structure and the design of the piping system. This system has a good quality for EC and pH adjustment, a steady performance, and is highly practical, according to the testing findings.

Wireless sensor network based automated irrigation and crop field monitoring system. Sensors that can be used wirelessly for agricultural purposes. In order to reduce water usage, a networkbased automated watering system is utilized. [3] In the agricultural field, A wireless sensor network comprising soil moisture and temperature sensors is used in the system. To handle sensor data, the Zigbee protocol was utilized, and an algorithm using sensor threshold values was used to regulate the water amount programmed on a microcontroller for irrigation. For data examination, A solar panel powers the gadget, which also has a cellular internet interface. Using image processing techniques, to monitor the disease area, a wireless camera is installed in the agricultural field. The technology is low-cost and energy-independent, making it ideal for water-scarce and geographically isolated locations.

CHAPTER 3

SYSTEM DESIGN

3.1 EXISTING SYSTEM:

This project is designed to monitor, water, and provide security for the plants in the garden. For this project, we are selecting the Turmeric plant as our testing garden plant. In this situation, a lot of people are interested in planting Turmeric. Also, this is an Wireless network -based project. It provides you to monitor and control the system from anywhere in the world. This system consists of different sensors to get data from the plants. They are soil moisture sensor, temperature and humidity sensor, color sensor, and motion sensor. Here using a Arduino controller with Bluetooth Module.

The Turmeric plant monitoring and security system you described sounds interesting and innovative! By utilizing wireless network technology, you can remotely monitor and control the system from anywhere in the world, providing convenience and accessibility for gardeners.

The system includes various sensors to gather data from the Turmeric plants. The soil moisture sensor can measure the moisture level in the soil, helping to ensure that the plants receive the appropriate amount of water for optimal growth. The temperature and humidity sensor can provide information about the environmental conditions around the plants, which can be crucial for Turmeric plants that require specific temperature and humidity levels to thrive. The colour sensor can detect changes in the colour of the leaves, indicating potential health issues or diseases in the plants. The motion sensor can detect any movements or intrusions in the garden, providing an additional layer of security to protect the Turmeric plants from potential threats.

The Arduino controller with Bluetooth module serves as the central hub of the system, collecting data from the sensors and facilitating communication with other devices or users via Bluetooth. With this setup, you can remotely monitor and control

the watering schedule, temperature, humidity, and security of the Turmeric plants using a mobile app or a web-based interface. You can also receive notifications or alerts in real-time, allowing you to take prompt action if any issues or emergencies arise.

Furthermore, as Turmeric is a popular plant among gardeners, the data and insights collected from this project can potentially be shared with other enthusiasts or researchers to contribute to the understanding of Turmeric plant growth and health. Overall, this wireless network-based Turmeric plant monitoring and security system has the potential to greatly enhance the care and management of Turmeric plants, making it a valuable tool for both gardening enthusiasts and researchers alike.

3.1.1 LIMITATIONS OF EXISTING SYSTEM:

It requires initial evaluation of site specific conditions before selection of appropriate moisture sensor. It requires probe to be inserted in the soil. It requires labor to collect the data and maintain the measurement processes. The measured values depend on properties of various materials.

3.2 PROPOSED SYSTEM

Planting a tree in an environment where the seed or the plant would not get water adequately through natural sources like rain or ground water in its initial phases has been always a matter of concern for tree planters. This is where an autonomous moisture monitor for plants system can help. The system timely monitors the moisture level of the soil. If at the time of monitoring it comes to know that the moisture level of the soil is lower than recommended then it will raise an audio visual alert. This alert is then received by the care taker of the plant. When the care taker waters the plant the alarm goes off and the monitoring cycle continues. Here we use a water pump and dc motor. In this system we use a timer IC to time the monitoring process. A moisture level sensor is used to detect the moisture level of the soil. An LED is used to give visual alarm and a Buzzer is used to give audio alarm to the care taker of the plant. Thus in this project with the help

of a simple combinational circuit and a sensor we can help save a plant by maintaining the moisture level of the soil of the plant, thus keeping the plant healthy. The autonomous moisture monitor for plants system is a valuable tool for tree planters who are planting in environments where natural sources of water, such as rain or ground water, may not be adequate for the initial growth stages of a tree. This system is designed to monitor the moisture level of the soil and provide timely alerts to the caretaker when the moisture level is lower than recommended. The system utilizes a timer IC to control the monitoring process. The timer IC is programmed to periodically check the moisture level of the soil using a moisture level sensor. The moisture level sensor detects the moisture content of the soil and sends the information to the system for analysis. If the moisture level is found to be lower than the recommended threshold, the system raises an audio visual alert.

The alert is in the form of an LED for visual indication and a buzzer for audio indication. The LED provides a visual alarm to the caretaker, indicating that the plant needs watering. The buzzer generates an audible alarm to ensure that the caretaker is notified even if they are not in close proximity to the plant. Once the caretaker waters the plant, the alarm is turned off and the monitoring cycle continues. This ensures that the plant receives the necessary amount of water to maintain healthy moisture levels in the soil. The system can be powered by a water pump and DC motor, which are activated when the moisture level is low and deactivated once the plant is adequately watered.

Overall, the autonomous moisture monitor for plants system is a simple yet effective solution to ensure that trees and plants receive adequate water in environments where natural sources of water may be limited. By providing timely alerts to caretakers, this system can help save plants and keep them healthy by maintaining optimal moisture levels in the soil.

3.2.1 Advantages of Proposed System:

It can determine when a farm/land needs to be watered based on local weather data. It will help you to have better control on your landscape and irrigation needs. It saves money by significantly reducing water wastage.

CHAPTER 4

PROJECT DESIGN

4.1 PROJECT DESIGN

A smart plant soil water level monitor is a device or system that measures the moisture content in the soil of a plant and provides real-time data to help monitor and manage watering needs. This type of technology is typically used in indoor and outdoor gardening, agriculture, and landscaping to optimize plant health and reduce water waste. Overall, a smart plant soil water level monitor can help users optimize their plant watering practices, conserve water, and promote healthy plant growth by providing accurate and timely information about soil moisture levels.

4.1.1 BLOCK DIAGRAM:

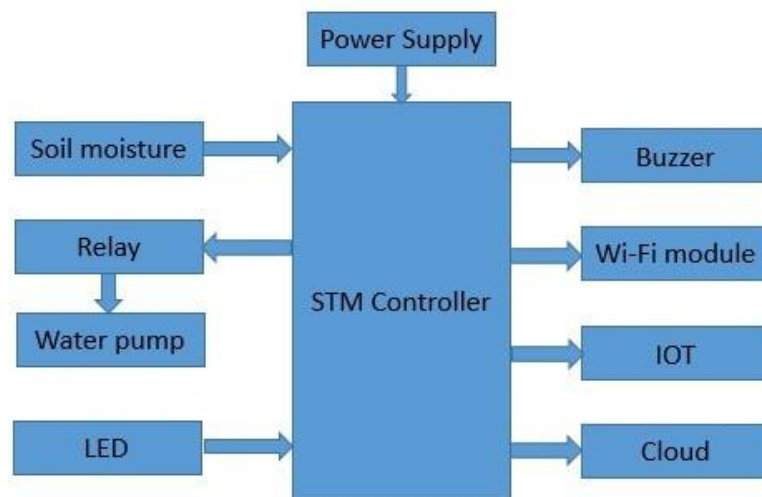


Fig 4.1: Block Diagram

4.2 HARDWARES USED:

STM32 Microcontroller

The STM32 series of microcontrollers launched by ST manufacturers. Friends in the industry know that this is a series of microcontrollers with high-cost performance, and its functions are extremely powerful. It is based on the ARM Cortex-M core specially designed for embedded applications that require high performance, low cost, and low power consumption; it also has first-class

peripherals, 1μs dual 12-bit ADC, 4Mbit/s UART, 18 Mbit/s SPI, etc.



Fig 4.2: STM32 Microcontroller

It also has a good performance in terms of power consumption and integration. Of course, it is slightly inferior to the power consumption of MSP430, but this does not affect the degree of enthusiasm for engineers. Because of its simple structure and easy-to-use tools, coupled with its powerful functions, it is well-known in the industry.

Wi-Fi Module

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community.

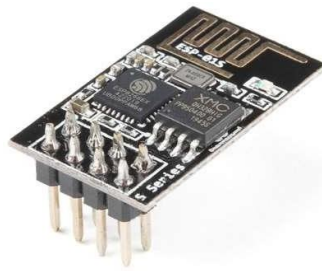


Fig 4.3: Wi-fi Module

This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area. The ESP8266 supports APSD for VoIP applications and Bluetooth co existence interfaces, it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts.

There is an almost limitless fountain of information available for the ESP8266, all of which has been provided by amazing community support. In the *Documents* section below you will find many resources to aid you in using the ESP8266, even instructions on how to transform this module into an IoT (Internet of Things) solution!

Soil Moisture Sensor

The soil moisture sensor is super easy to use and only has 4 pins to connect.

AO (Analog Output) pin gives us an analog signal between the supply value to 0V and will be connected to one of the analog inputs on your Arduino.

DO (Digital Output) pin gives Digital output of internal comparator circuit. You can connect it to any digital pin on an Arduino or directly to a 5V relay or similar device.

VCC pin supplies power for the sensor. It is recommended to power the sensor with between 3.3V – 5V. Please note that the analog output will vary depending on what voltage is provided for the sensor.

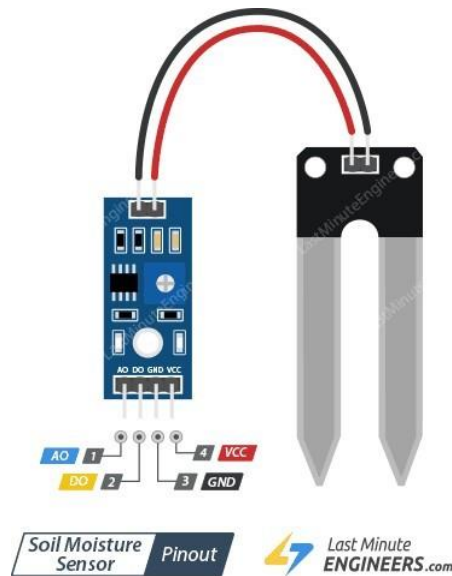


Fig 4.4: Soil Moisture Sensor

Motor

If we reside in a city or town, we almost don't think how the water is supplied to our residents every day. Small villages also frequently supply a set-up of pipes to transfer water for every home within the region. All we require to recognize is how to open the valve at the sink. Because the internal working is not visible, and the water supply is not dependent on the neighbors down the road. Every home has owned well and electromechanical system to draw the water from well and supply to the home. This article discusses an overview of the water pump and its working, types and their applications.



Fig 4.5: Motor

Water Pump

The water pump can be defined as a pump which uses the principles like mechanical as well as hydraulic throughout a piping system and to make sufficient force for its future use. They have been approximately in one structure otherwise another because of early civilization. At present these pumps are utilized within a wide range of housing, farming, municipal, and manufacturing applications.

Water Pump Working Principle:

The working principle of a water pump mainly depends upon the positive displacement principle as well as kinetic energy to push the water. These pumps use AC power otherwise DC power for energizing the motor of the water pump whereas others can be energized other kinds of drivers like gasoline engines otherwise diesel.

The water pump is a portable device and can be applied in several household applications. These pumps are used for pumping the huge amount of water from one place to another. The main purpose of a water pump is versatile. A quality pump which can be selected carefully may be perfect for draining water from a low flooded region, refilling the swimming pool, and bathtub, circulating pesticides otherwise fertilizers.

The collection of water pumps are very large, therefore, while selecting a strong and consistent one, one should think about the requirement.

Types of Water Pumps:

Water pumps are classified into two types namely positive displacement and centrifugal. These pumps are mainly designed for supplying water from one location to another constantly.

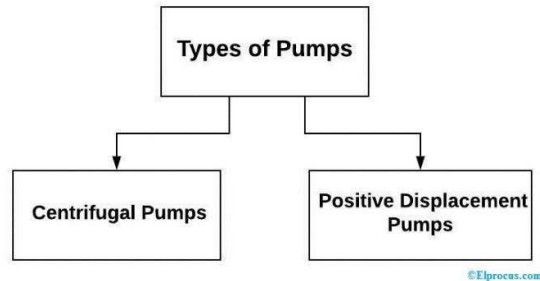


Fig 4.5: Motor

Types of Pumps:

1. Centrifugal Water Pump - Centrifugal pumps are designed with a rotating impeller which can be used for supplying the water into the pump and force the discharge flow. These pumps come in several types which includes trash, submersible, and standard models. By using these pumps, all types of liquids can be pumped with low-viscosity. And also these pumps work fine with thin fluids & gives high flow rates. These pumps are applicable in several applications like building as well as the water system. These pumps are used to provide water supplies for buildings and well-matched with pneumatic systems where the no-suction lift is necessary. The main purpose of these water pumps is to pump water from wells in homes & to increase water pressure in intake lines. Centrifugal pumps offer a nonstop pressure supply for fire guard systems, and they can supply like sump pumps in horizontal otherwise vertical configurations. Centrifugal pumps are horizontal to numerous general problems. These may require liquid circulation to stop overheating which is caused by low supplies. These types of pumps must be prepared to work properly. As a head of the positive suction system is very less while selecting the pump, it can consequence to cavitations, a situation wherever air bubbles form close to the impeller, then leads to shock signals within the water pump. At last, wear of the impeller of the pump can be degenerated by delayed solids within the fluid.

2. Positive Displacement Water Pump - Positive displacement pumps supply a set amount of flow throughout the mechanical contraction and development of a stretchy diaphragm. These pumps are applicable in several industries that control high-viscosity fluids wherever responsive solids may be there. These are suggested for the applications wherever a combination of high pressure and low flow is required. Sometimes, these pumps are also called rotary pumps, and these are very competitive

because of the fact that they remove air from the lines and therefore get rid of air leakage. These are also efficient while dealing with high-viscosity fluids. The main disadvantage of these pumps is that they need extremely little clearance among the revolving pump & the external edge of the unit. Consequently, the revolution must happen at extremely slow speeds. When the water pump is functioned at high speeds, then the fluid can ultimately decrease the efficiency of the pump.

Buzzer:

There are many ways to communicate between the user and a product. One of the best ways is audio communication using a buzzer IC. So during the design process, understanding some technologies with configurations is very helpful. So, this article discusses an overview of an audio signaling device like a beeper or a buzzer and its working with applications. An audio signaling device like a beeper or buzzer may be electromechanical or piezoelectric or mechanical type. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren. The pin configuration of the buzzer is shown below. It includes two pins namely positive and negative. The positive terminal of this is represented with the '+' symbol or a longer terminal. This terminal is powered through 6Volts whereas the negative terminal is represented with the '-' symbol or short terminal and it is connected to the GND terminal.



Fig 4.6: Buzzer

Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch

contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.



Fig 4.7: Relay Module

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay. The animated picture shows a working relay with its coil and switch contacts. You can see a lever on the left being attracted by magnetism when the coil is switched on. This lever moves the switch contacts. There is one set of contacts (SPDT) in the foreground and another behind them, making the relay DPDT.

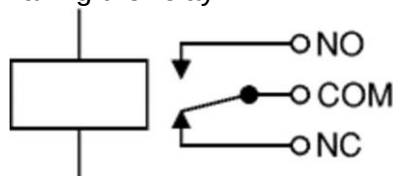


Fig 4.7: Relay Switch Connections

The relay's switch connections are usually labeled COM, NC and NO:

- **COM** = Common, always connect to this, it is the moving part of the switch.
- **NC** = Normally Closed, COM is connected to this when the relay coil is **off**.
- **NO** = Normally Open, COM is connected to this when the relay coil is **on**.

4.3 SOFTWARES USED:

Arduino IDE

Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Arduino projects can be stand-alone, or they can be communicate with software running on your computer. The boards can be assembled by hand or purchased preassembled; the open-source IDE can be downloaded for free. The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment.

The Arduino microcontroller is an easy to use yet powerful single board computer that has gained considerable traction in the hobby and professional market. The Arduino is open-source, which means hardware is reasonably priced and development software is free. This guide is for students in ME 2011, or students anywhere who are confronting the Arduino for the first time. For advanced Arduino users, prowl the web; there are lots of resources. This guide covers the Arduino Uno board (Spark fun DEV-09950, \$29.95), a good choice for students and educators. With the Arduino board, you can write programs and create interface circuits to read switches and other sensors, and to control motors and lights with very little effort. This is what the Arduino ide looks like.



Fig 4.8: Arduino IDE

The Duemilanove board features an Atmel ATmega328 microcontroller operating at 5 V with 2 Kb of RAM, 32 Kb of flash memory for storing programs and 1 Kb of EEPROM for storing parameters. The clock speed is 16 MHz, which translates to about executing about 300,000 lines of C source code per second. The board has 14 digital I/O pins and 6 analog input pins. There is a USB connector for talking to the host computer and a DC power jack for connecting an external 6-20 V power source, for example a 9 V battery, when running a program while not connected to the host computer. Headers are provided for interfacing to the I/O pins using 22 g solid wire or header connectors.

The Arduino programming language is a simplified version of C/C++. If you know C, programming the Arduino will be familiar. If you do not know C, no need to worry as only a few commands are needed to perform useful functions. An important feature of the Arduino is that you can create a control program on the host PC, download it to the Arduino and it will run automatically. Remove the USB cable connection to the PC, and the program will still run from the top each time you push the reset button. Remove the battery and put the Arduino board in a closet for six months. When you reconnect the battery, the last program you stored will run. This means that you connect the board to the host PC to develop and debug your program, but once that is done, you no longer need the PC to run the program.

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog

inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Arduino Software (IDE)

- Writing Sketches
 - File
 - Edit
 - Sketch
 - Tools
 - Help
- Sketchbook
- Tabs, Multiple Files, and Compilation
- Uploading
- Libraries
- Third-Party Hardware
- Serial Monitor
- Preferences
- Language Support
- Boards

The Arduino Integrated Development Environment - or Arduino Software(IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

CHAPTER 5

IMPLEMENTATION DETAILS

5.1 IOT (INTERNET OF THINGS):

IoT stands for Internet of Things, which means accessing and controlling daily usable equipments and devices using Internet. Our IoT tutorial includes all topics of IoT such as introduction, features, advantage and disadvantage, ecosystem, decision framework, architecture and domains, biometric, security camera and door unlock system, devices, etc. Let's us look closely at our mobile device which contains GPS Tracking, Mobile Gyroscope, Adaptive brightness, Voice detection, Face detection etc. These components have their own individual features, but what about if these all communicate with each other to provide a better environment? For example, the phone brightness is adjusted based on my GPS location or my direction.

Connecting everyday things embedded with electronics, software, and sensors to internet enabling to collect and exchange data without human interaction calledas the Internet of Things (IoT). The term "Things" in the Internet of Things refers to anything and everything in day to day life which is accessed or connected through the internet.

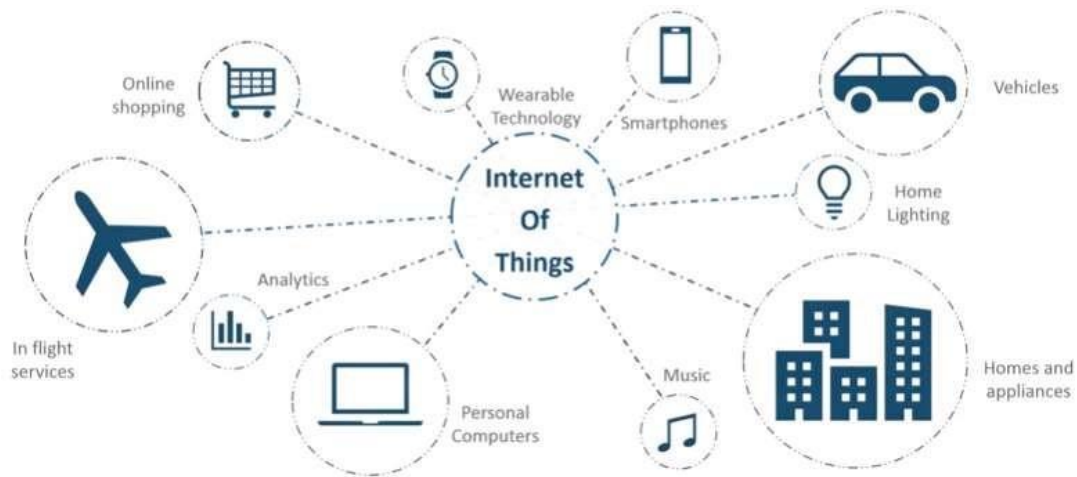


Fig 5.1: Internet of Things

IoT is an advanced automation and analytics system which deals with artificial intelligence, sensor, networking, electronic, cloud messaging etc. to deliver complete systems for the product or services. The system created by IoT has greater transparency, control, and performance. As we have a platform such as a cloud that contains all the data through which we connect all the things around us. For example, a house, where we can connect our home appliances such as air conditioner, light, etc. through each other and all these things are managed at the same platform. Since we have a platform, we can connect our car, track its fuel meter, speed level, and also track the location of the car.



Fig 5.2: IoT Cloud Architecture

If there is a common platform where all these things can connect to each other would be great because based on my preference, I can set the room temperature. For example, if I love the room temperature to be set at 25 or 26- degree Celsius when I reach back home from my office, then according to my car location, my AC would start before 10 minutes I arrive at home. This can be done through the Internet of Things (IoT).

The working of IoT is different for different IoT ecosystem (architecture). However, the key concept of their working are similar. The entire working process of IoT starts with the device themselves, such as smartphones, digital watches, electronic appliances, which securely communicate with the IoT platform. The platforms collect and analyze the data from all multiple devices and platforms and transfer the most valuable data with applications to devices.

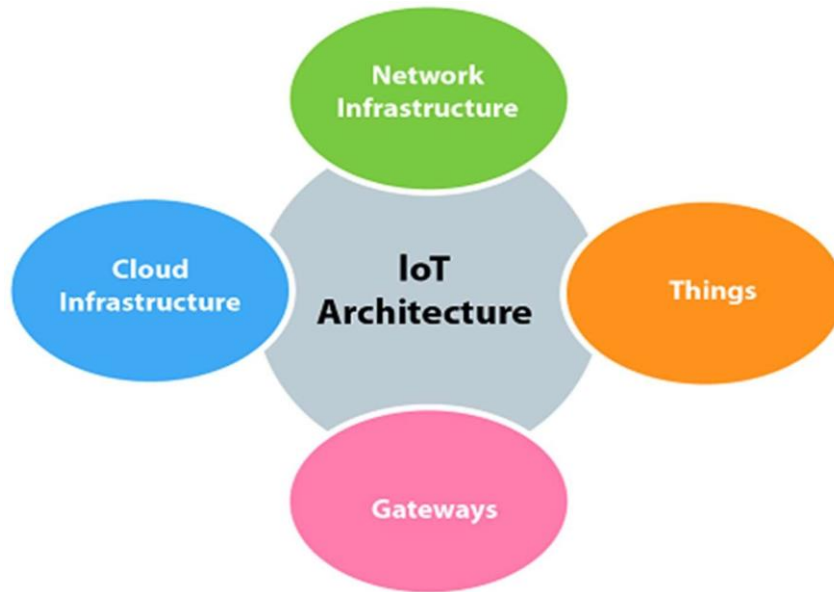


Fig 5.3: IoT Architecture

Features of IoT

The most important features of IoT on which it works are connectivity, analyzing, integrating, active engagement, and many more. Some of them are listed below:

- 1. Connectivity:** Connectivity refers to establish a proper connection between all the things of IoT to IoT platform it may be server or cloud. After connecting the IoT devices, it needs a high speed messaging between the devices and cloud to enable reliable, secure and bi-directional communication.
- 2. Analyzing:** After connecting all the relevant things, it comes to real-time analyzing the data collected and use them to build effective business intelligence. If we have a good insight into data gathered from all these things, then we call our system has a smart system.
- 3. Integrating:** IoT integrating the various models to improve the user experience as well.
- 4. Artificial Intelligence:** IoT makes things smart and enhances life through the use of data. For example, if we have a coffee machine whose beans have going to end, then the coffee machine itself order the coffee beans of your choice from the retailer.
- 5. Sensing:** The sensor devices used in IoT technologies detect and measure any change in the environment and report on their status. IoT technology brings passive networks to active networks. Without sensors, there could not hold an effective or

true IoT environment.

6. Active Engagement: IoT makes the connected technology, product, or services to active engagement between each other.

7. Endpoint Management: It is important to be the endpoint management of all the IoT system otherwise, it makes the complete failure of the system. For example, if a coffee machine itself order the coffee beans when it goes to end but what happens when it orders the beans from a retailer and we are not present at home for a few days, it leads to the failure of the IoT system. So, there must be a need for endpoint management.

Advantages and Limitations of (IoT)

Any technology available today has not reached to its 100 % capability. It always has a gap to go. So, we can say that **Internet of Things** has a significant technology in a world that can help other technologies to reach its accurate and complete 100 % capability as well. Let's take a look over the major, advantages, and disadvantages of the Internet of Things.

Advantages of IoT

Internet of things facilitates the several advantages in day-to-day life in the business sector. Some of its benefits are given below:

- **Efficient resource utilization:** If we know the functionality and the way that how each device work we definitely increase the efficient resource utilization as well as monitor natural resources.
- **Minimize human effort:** As the devices of IoT interact and communicate with each other and do lot of task for us, then they minimize the human effort.
- **Save time:** As it reduces the human effort then it definitely saves out time. Time is the primary factor which can save through IoT platform.
- **Enhance Data Collection:**
- **Improve security:** Now, if we have a system that all these things are interconnected then we can make the system more secure and efficient.

Limitations of IoT

As the Internet of things facilitates a set of benefits, it also creates a significant set of challenges. Some of the IoT challenges are given below:

5.2 EMBEDDED DEVICES (SYSTEM) IN (IOT)

It is essential to know about the embedded devices while learning the IoT or building the projects on IoT. The embedded devices are the objects that build the unique An embedded device system generally runs as a single application. However, these devices can connect through the internet connection, and able communicate through other network devices.

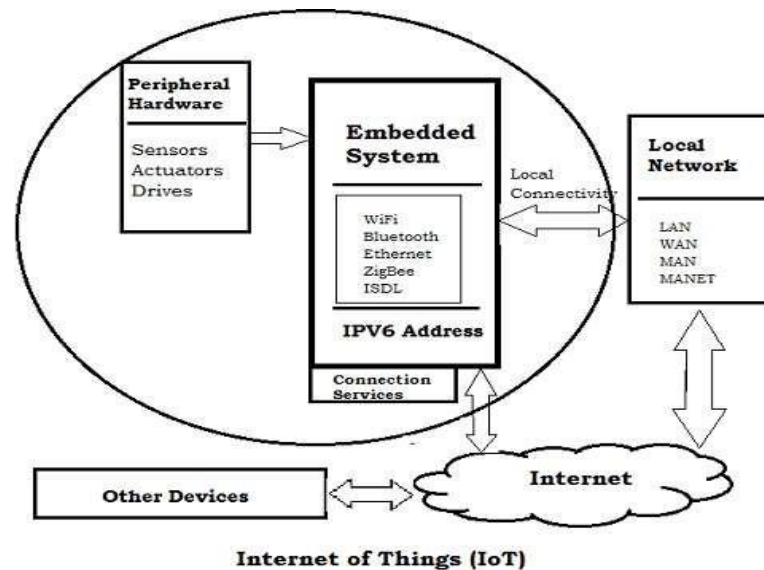


Fig 5.4: Embedded Devices

Embedded System Hardware

Embedded system can be of type microcontroller or type microprocessor. Both of these types contain an integrated circuit (IC). The essential component of the embedded system is a RISC family microcontroller like Motorola 68HC11, PIC 16F84, Atmel 8051 and many more. The most important factor that differentiates these microcontrollers with the microprocessor like 8085 is their internal read and writable memory. The essential embedded device components and system architecture are specified below.

Embedded System Software

The embedded system that uses the devices for the operating system is based on the language platform, mainly where the real-time operation would be performed. Manufacturers build embedded software in electronics, e.g., cars, telephones, modems, appliances, etc. The embedded system software can be as

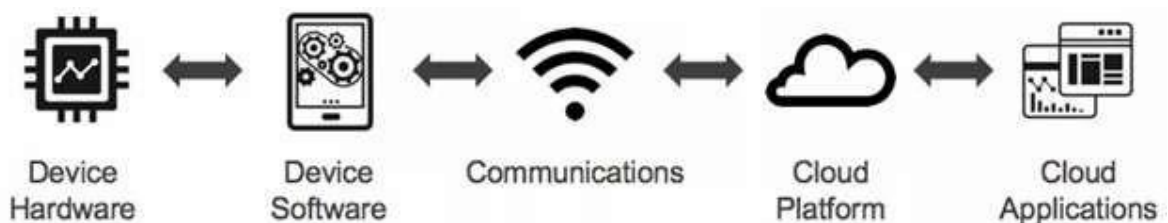
embedded processing using devices. These devices are connected through any type of devices such as GPS, Wi-Fi, RFID, etc. over the networks.

- **Smart devices and environment, Cloud Computing, Big Data:** The data transfer or receive through smart devices and environments are communicated through Cloud Computing or others Servers and stored as Big Data.
- **Technology, Software, Application:** The IoT ecosystem uses any of different technologies, software and application to communicate and connect with smart devices and environment.
- **Users or groups of community:** The product or services generated by the IoT ecosystem are consumed by the users or the group of communities to serve the smart life.

IoT Decision Framework

The IoT decision framework provides a structured approach to create a powerful IoT product strategy. The IoT decision framework is all about the strategic decision making. The IoT Decision Framework helps us to understand the areas where we need to make decisions and ensures consistency across all of our strategic business decision, technical and more. The IoT decision framework is much more important as the product or services communicates over networks goes through five different layers of complexity of technology.

1. Device Hardware
2. Device Software
3. Communications
4. Cloud Platform
5. Cloud Application



The IoT Technology Stack

Fig 5.6: IoT Decision Framework

Decision Area

The IoT decision framework pays attention to six key decision areas in any IoT product. These decision areas are:

1. User Experience (UX)
2. Data
3. Business
4. Technology
5. Security
6. Standards & Regulations

Each of these decision areas is evaluated at each of the IoT Technology Stack. The User Experience will be evaluated at Device Hardware, Device Software and so to provide the better user experience. Then at the next step Data Decision Area, we have to explore data considerations for all the stages of IoT Technology Stack.

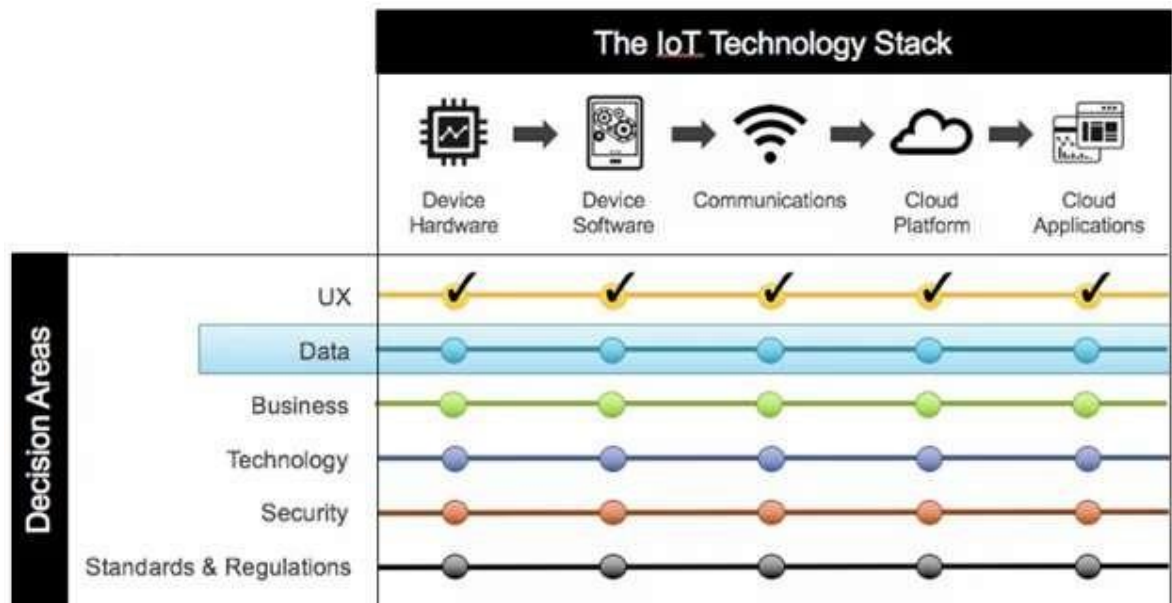


Fig 5.7: IoT Technology Stack

Decision Area of the IoT Decision Framework

Let's see each of the Decision Area of IoT Decision Framework in detail:

1. **User Experience Decision Area:** This is the area where we concentrate about who are the users, what are their requirements and how to provide a great experience at each step of IoT stack without worrying about the technical details.

2. **Data Decision Area:** In this area, we make the overall data strategy such as the data flow over the entire IoT stack to fulfill the user's requirements.
3. **Business Decision Area:** Based on the previous decisions area, we make the decision how product or services will become financial potential. At each of the IoT Stack level are monetized about the costs of providing services.
4. **Technology Decision Area:** In this area, we work with the technology for each layer to facilitate the final solution.
5. **Security Decision Area:** After going through the implementation of technology it is important to decide and provide the security at each stage of the IoT Stack.
6. **Standards & Regulations Decision Area:** At the last stage of IoT Decision Area, we identify the standards and regulations of product or services that will affect your product at each layer of the IoT Stack.

IoT Architecture

There is not such a unique or standard consensus on the Internet of Things (IoT) architecture which is universally defined. The IoT architecture differs from their functional area and their solutions. However, the IoT architecture technology mainly consists of four major components:

- Sensors/Devices
- Gateways and Networks
- Cloud/Management Service Layer
- Application Layer

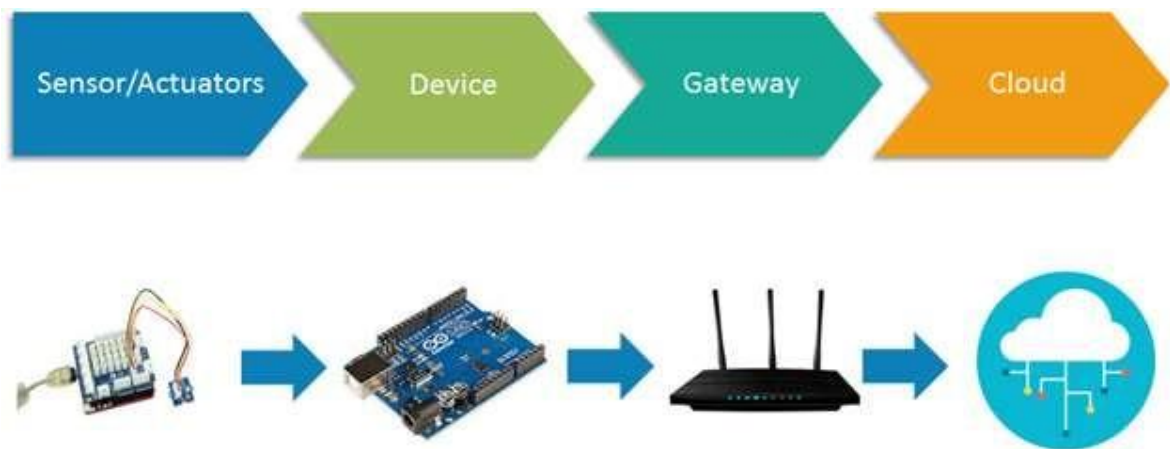


Fig 5.8: IoT Architecture

Stages of IoT Solutions Architecture

There are several layers of IoT built upon the capability and performance of IoT elements that provides the optimal solution to the business enterprises and end-users. The IoT architecture is a fundamental way to design the various elements of IoT, so that it can deliver services over the networks and serve the needs for the future.

Following are the primary stages (layers) of IoT that provides the solution for IoT architecture.

1. **Sensors/Actuators:** Sensors or Actuators are the devices that are able to emit, accept and process data over the network. These sensors or actuators may be connected either through wired or wireless. This contains GPS, Electrochemical, Gyroscope, RFID, etc. Most of the sensors need connectivity through sensors gateways. The connection of sensors or actuators can be through a Local Area Network (LAN) or Personal Area Network.
2. **Gateways and Data Acquisition:** As the large numbers of data are produced by this sensors and actuators need the high-speed Gateways and Networks to transfer the data. This network can be of type Local Area Network (LAN such as Wi-Fi, Ethernet, etc.), Wide Area Network (WAN such as GSM, 5G, etc.).
3. **Edge IT:** Edge in the IoT Architecture is the hardware and software gateways that analyze and pre-process the data before transferring it to the cloud. If the data read from the sensors and gateways are not changed from its previous reading value then it does not transfer over the cloud, this saves the data used.
4. **Data center/ Cloud:** The Data Center or Cloud comes under the Management Services which process the information through analytics, management of device and security controls. Beside this security controls and device management the cloud transfer the data to the end users application such as Retail, Healthcare, Emergency, Environment, and Energy, etc.

The 4 Stage IoT Solutions Architecture

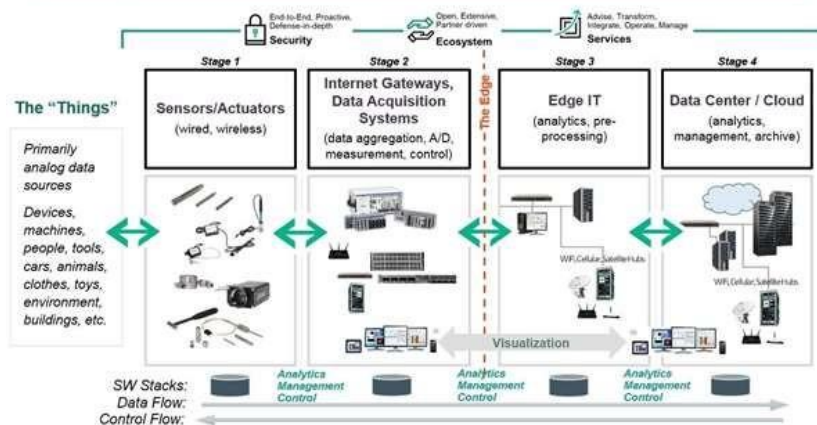


Fig 5.9: IoT Solutions Architecture

Smarts Objects in IoT

The concept of smart in IoT is used for physical objects that are active, digital, networked, can operate to some extent autonomously, reconfigurable and has local control of the resources. The smart objects need energy, data storage, etc.

A smart object is an object that enhances the interaction with other smart objects as well as with people also. The world of IoT is the network of interconnected heterogeneous objects (such as smart devices, smart objects, sensors, actuators, RFID, embedded computers, etc.) uniquely addressable and based on standard communication protocols. In a day to day life, people have a lot of object with internet or wireless or wired connection. Such as:

- Smartphone
- Tablets
- TV computer

These objects can be interconnected among them and facilitate our daily life (smart home, smart cities) no matter the situation, localization, accessibility to a sensor, size, scenario or the risk of danger.



Fig 5.10: Smart objects in IoT

Smart objects are utilized widely to transform the physical environment around us to a digital world using the Internet of things (IoT) technologies. A smart object carries blocks of application logic that make sense for their local situation and interact with human users. A smart object sense, log, and interpret the occurrence within themselves and the environment, and intercommunicate with each other and exchange information with people.

The work of smart object has focused on technical aspects (such as software infrastructure, hardware platforms, etc.) and application scenarios. Application areas range from supply-chain management and enterprise applications (home and hospital) to healthcare and industrial workplace support. As for human interface aspects of smart-object technologies are just beginning to receive attention from the environment.

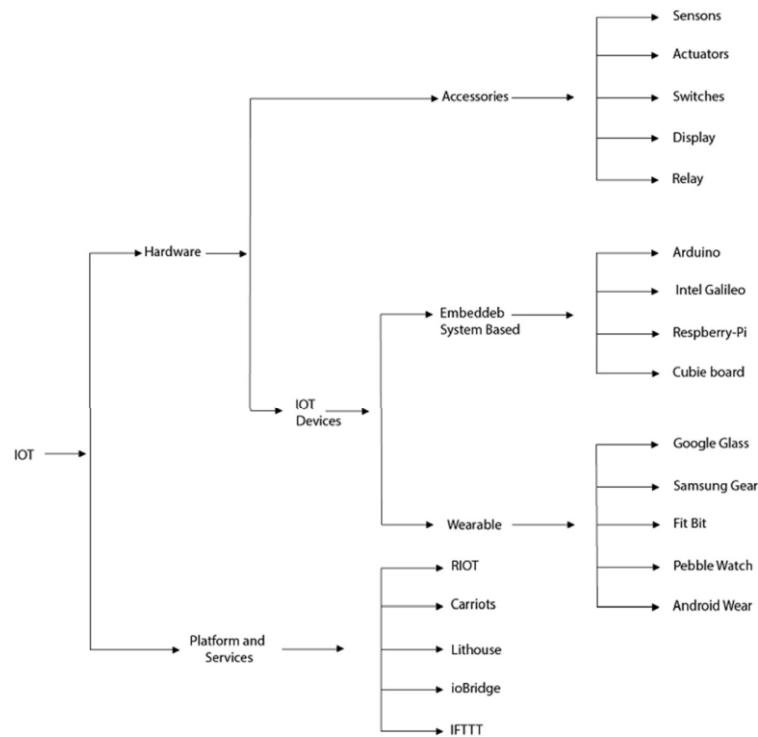
IoT Devices

Internet of Things Devices is non-standard devices that connect wirelessly to a network with each other and able to transfer the data. IoT devices are enlarging the internet connectivity beyond standard devices such as smartphones, laptops, tablets, and desktops. Embedding these devices with technology enable us to communicate and interact over the networks and they can be remotely monitored and controlled.



Fig 5.11: IoT Devices

There are large varieties of IoT devices available based on IEEE 802.15.4 standard. These devices range from wireless motes, attachable sensor-boards to interface-board which are useful for researchers and developers. IoT devices include computer devices, software, wireless sensors, and actuators. These IoT devices are connected over the internet and enabling the data transfer among objects or people automatically without human intervention. Some of the common and popular IoT devices are given below:



IoT Devices and Technologies

Fig 5.12: IoT Devices and Technologies

Water level monitoring

This resistance is inversely proportional to the soil moisture:

- The more water in the soil means better conductivity and will result in a lower resistance.
- The less water in the soil means poor conductivity and will result in a higher resistance.

The sensor produces an output voltage according to the resistance, which by measuring we can determine the moisture level.

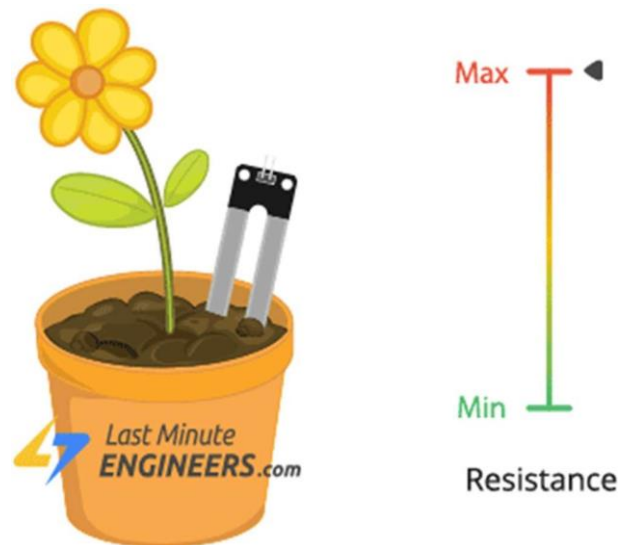


Fig 5.13: Soil water level monitoring

5.3 IEEE STANDARDS

The board selection has two effects: it sets the parameters (e.g. CPU speed and baud rate) used when compiling and uploading sketches; and sets and the file and fuse settings used by the burn bootloader command. Some of the board definitions differ only in the latter, so even if you've been uploading successfully with a particular selection you'll want to check it before burning the bootloader. You can find a comparison table between the various boards [here](#).

Arduino Software (IDE) includes the built in support for the boards in the following list, all based on the AVR Core. The Boards Manager included in the

standard installation allows to add support for the growing number of new boards based on different cores like Arduino Due, Arduino Zero, Edison, Galileo and so on.

- *Arduino Yùn* An ATmega32u4 running at 16 MHz with auto-reset, 12 Analog In, 20 Digital I/O and 7 PWM.
- *Arduino/Genuino Uno* An ATmega328P running at 16 MHz with auto-reset, 6 Analog In, 14 Digital I/O and 6 PWM.
- *Arduino Diecimila or Duemilanove* w/ ATmega168 An ATmega168 running at 16 MHz with auto-reset.
- *Arduino Nano* w/ ATmega328P An ATmega328P running at 16 MHz with auto-reset. Has eight analog inputs.
- *Arduino/Genuino Mega 2560* An ATmega2560 running at 16 MHz with auto-reset, 16 Analog In, 54 Digital I/O and 15 PWM.
- *Arduino Mega* An ATmega1280 running at 16 MHz with auto-reset, 16 Analog In, 54 Digital I/O and 15 PWM.
- *Arduino Mega ADK* An ATmega2560 running at 16 MHz with auto-reset, 16 Analog In, 54 Digital I/O and 15 PWM.
- *Arduino Leonardo* An ATmega32u4 running at 16 MHz with auto-reset, 12 Analog In, 20 Digital I/O and 7 PWM.
- *Arduino/Genuino Micro* An ATmega32u4 running at 16 MHz with auto-reset, 12 Analog In, 20 Digital I/O and 7 PWM.
- *Arduino Esplora* An ATmega32u4 running at 16 MHz with auto-reset.
- *Arduino Mini* w/ ATmega328P An ATmega328P running at 16 MHz with auto-reset, 8 Analog In, 14 Digital I/O and 6 PWM.
- *Arduino Ethernet* Equivalent to Arduino UNO with an Ethernet shield: An ATmega328P running at 16 MHz with auto-reset, 6 Analog In, 14 Digital I/O and 6 PWM.
- *Arduino Fio* An ATmega328P running at 8 MHz with auto-reset. Equivalent to Arduino Pro or Pro Mini (3.3V, 8 MHz) w/ ATmega328P, 6 Analog In, 14 Digital I/O and 6 PWM.
- *Arduino BT* w/ ATmega328P ATmega328P running at 16 MHz. The bootloader burned (4 KB) includes codes to initialize the on-board bluetooth module, 6 Analog In, 14 Digital I/O and 6 PWM..
- *LilyPad Arduino USB* An ATmega32u4 running at 8 MHz with auto-reset, 4 Analog In, 9 Digital I/O and 4 PWM.

- LilyPad *Arduino* An ATmega168 or ATmega132 running at 8 MHz with auto- reset, 6 Analog In, 14 Digital I/O and 6 PWM.
- *Arduino Pro or Pro Mini* (5V, 16 MHz) w/ ATmega328P An ATmega328P running at 16 MHz with auto-reset. Equivalent to *Arduino Duemilanove* or *Nano* w/ ATmega328P; 6 Analog In, 14 Digital I/O and 6 PWM.
- *Arduino NG or older* w/ ATmega168 An ATmega168 running at 16 MHz *without* auto-reset. Compilation and upload is equivalent to *Arduino Diecimila* or *Duemilanove* w/ ATmega168, but the bootloader burned has a slower timeout (and blinks the pin 13 LED three times on reset); 6 Analog In, 14 Digital I/O and 6 PWM.
- *Arduino Robot Control* An ATmega328P running at 16 MHz with auto-reset.
- *Arduino Robot Motor* An ATmega328P running at 16 MHz with auto-reset.
- *Arduino Gemma* An ATtiny85 running at 8 MHz with auto-reset, 1 Analog In, 3 Digital I/O and 2 PWM.

CHAPTER 6

RESULTS AND DISCUSSIONS

A smart plant soil water level monitor is a device that measures the moisture level in the soil of a plant and provides information on when and how much to water the plant. It usually consists of a sensor that is inserted into the soil near the plant's root zone, and a connected system that collects and analyses the data from the sensor. When the sensor measures the moisture level in the soil, it may provide data such as the current moisture level, historical moisture levels over time, and possibly even temperature and humidity data. This information can be transmitted to a connected device, such as a smartphone or a computer, where it can be analysed by an accompanying mobile app or software.



Fig 6.1: Wet soil water level Monitoring

Based on the data collected, the smart plant soil water level monitor may generate results or recommendations, such as:

1. Soil moisture level: The monitor may provide information on the current moisture level in the soil, indicating whether the soil is too dry, too wet, or at an optimal moisture level for the plant's needs.
2. Watering schedule: The monitor may provide recommendations on when and how much to water the plant based on the soil moisture data. For example, it may send

notifications to your smartphone indicating that it's time to water the plant or adjust the watering schedule based on the plant's water requirements.

3. Historical data: The monitor may provide historical data on the moisture levels in the soil over time, allowing you to track trends and patterns in the plant's water usage and adjust your watering practices accordingly.

4. Alerts: The monitor may send alerts or notifications to your connected device if the soil moisture level falls outside of a preset threshold, indicating that the plant needs immediate attention.

5. Graphs or charts: The monitor may provide visual representations of the soil moisture data, such as graphs or charts, which can help you better understand the plant's water needs and make informed decisions about watering.

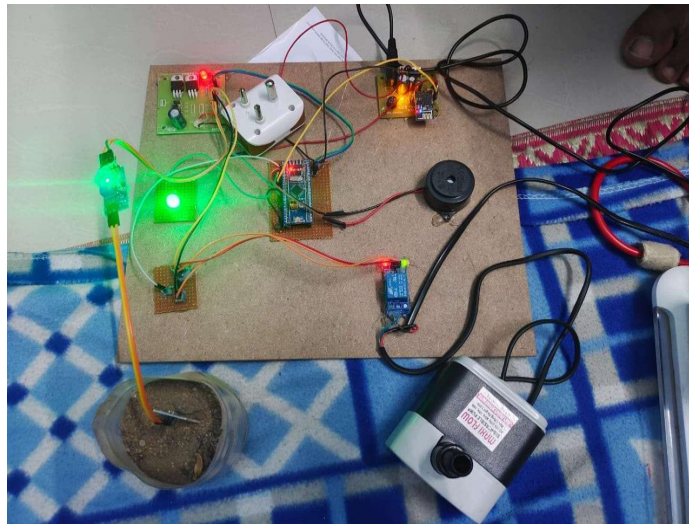


Fig 6.1: Dry soil water level Monitoring

It's important to note that the accuracy and effectiveness of a smart plant soil water level monitor may vary depending on the quality of the sensor, the type of plant being monitored, and other environmental factors. It's always a good practice to use the results from the monitor as a guideline and take into consideration other factors such as weather conditions, plant species, and personal observation to ensure optimal care for your plants.

CHAPTER 7

CONCLUSION

A system to monitor moisture levels in the soil was designed and the project provides an opportunity to study the existing systems, along with their features and drawbacks. Agriculture is one of the most water-consuming activities. The proposed system can be used to switch the motor (on/off) depending on favorable condition of plants i.e sensor values, thereby automating the process of irrigation. which is one of the most time efficient activities in farming, which helps to prevent over irrigation or under irrigation of soil thereby avoiding crop damage. The farm owner can monitor the process online through android App. Though this project can be concluded that there can be considerable development in farming with the use of IOT and automation.

In conclusion, the proposed system for monitoring soil moisture levels and automating irrigation in agriculture has the potential to significantly improve farming practices by reducing water waste, saving time and effort, and allowing for remote monitoring. However, careful consideration of sensor accuracy, initial costs, and maintenance requirements should be taken into account during implementation to ensure its effectiveness and sustainability in real-world farming scenarios. With proper planning, implementation, and management, this system can contribute to the development of more efficient and sustainable farming practices using IoT and automation technologies.

CONSTRAINS

There are several constraints to consider when designing a smart plant soil water level monitoring system:

1. **Power Constraints:** The system should be designed to operate on low power and should be able to work on batteries for extended periods of time without needing frequent replacements.
2. **Wireless Connectivity Constraints:** The system should have a reliable and robust wireless connectivity system to transmit data from the sensors to the base station or cloud servers. The system should also work in environments where wireless connectivity is limited or disrupted.
3. **Accuracy Constraints:** The sensors used in the system should be accurate and precise in measuring the soil moisture level. Any error in measurement can lead to incorrect irrigation decisions and can negatively affect the plant growth.
4. **Calibration Constraints:** The system should be easy to calibrate and should provide accurate readings under different soil conditions.
5. **Environmental Constraints:** The sensors used in the system should be designed to withstand harsh environmental conditions such as high temperature, humidity, and moisture.
6. **Cost Constraints:** The system should be cost-effective and affordable to encourage widespread adoption among farmers and gardeners.
7. **Maintenance Constraints:** The system should be easy to install and maintain, with minimal maintenance required to ensure continuous and accurate monitoring of soil moisture levels.

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APPENDIX SCREENSHOTS

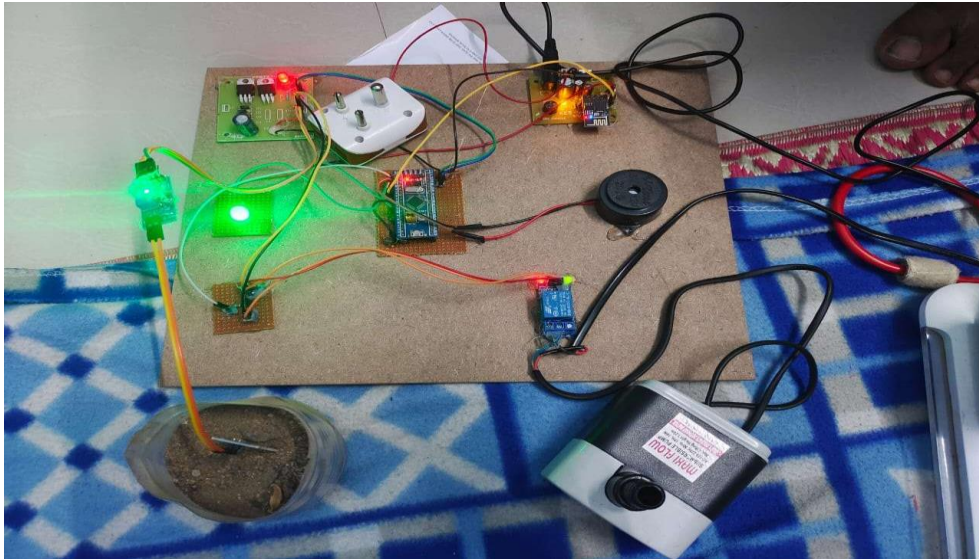


FIG 7.1 DRY SOIL

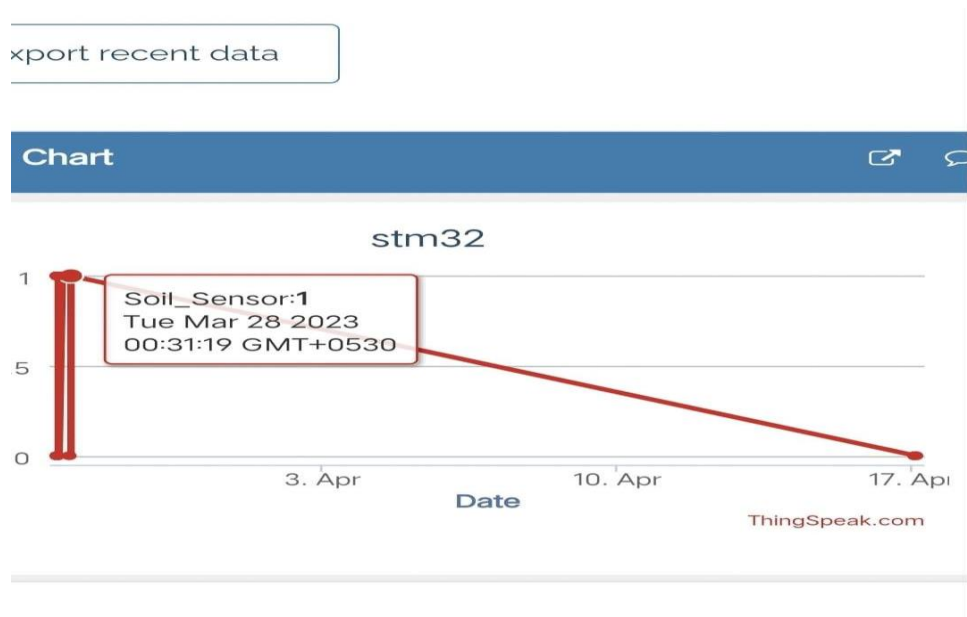




FIG 7.2 WET SOIL

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