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Par

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Realization of the prototype of a IoT(Internet of Things) intelligent irrigation system

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DEDICATION

Dedication to my family, my father and my mother as well as my brothers, without forgetting aunts, cousins and cousins, my partner HANIFI Ikbal and my precious friend who cares for me a lot encouraged to put in more effort. In memory of my grandparents who rest in peace, and to all who love me, and that I love, I share with you this modest work with acknowledgement

LAMRI Younes

I dedicate this modest work in the first place to my parents with all my feelings of respect, gratitude forall the sacrifices made to ensure my education in the best conditions. To all my family, and my friends, and everyone those who know me near or far. To my partner LAMRI Younes and his considerable efforts to make this possible project

HANIFI Ikbal

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General introduction

Nowadays, technology is becoming more and more important in our daily life. Who doesn't use nowadays, a connected object, such as a computer or a smartphone?
Over time, the emergence of embedded systems introduces the integration of computer systems in the real environment. It is the deployment of a new generation of interconnected objects equipped with of communication, detection and activation such as home automation, robots, wireless communication terminals, RFID... etc. is the vision of the Internet of Things In short, the physical world is gradually merging with the virtual world.
The Internet of Things (IoT) represents objects connected to the Internet that can communicate. It allows us to facilitate our lives in a more and more engaging way.

In our final year project we proposed an intelligent control and irrigation system. The main goal of our system is to help a simple farmer, with a very simple equipment, easy to handle and with an unbeatable price. The objective is to intelligently control an agricultural area and to provide monitoring and automation without a great effort.

The fundamental role of an agricultural control system is to produce a more favorable parameters to the needs of the plant. Temperature, watering frequency, humidity and light are the main parameters for a healthy farm and plants management.

In this work, we have realized a management system of real time control of some parameters, namely: temperature, humidity and automatic watering, through sensors placed inside this agricultural environment.

The thesis is structured in Four Chapters.
Chapter 1 presents a general review about the background of smart farming the relation between Internet Of Things(iot) and Agriculture.

Chapter 2 presents the state of the art and a study on the systems already realized as well as a general view on the iot and mobile applications.

Chapter 3 in which we present in detail Design of an automatic irrigation system for green areas (UML diagrams), then we defined the PID control.

At the end, we finish with chapter 4, the implementation and the regulation equipment used. Thus the presentation of the interface and the simulation.

Chapter I: Project Background

1. Background

As the human population keeps on growing and expanding the situation is becoming more dire ,for the lack of fresh water and arable land.the agriculture plays a big role in using both land and huge portions of water for this we must use new technologies in order to save water and make food production more efficient in order to satisfy the large mass of ever-expending human population.
Today farming is done manually by planting a large land and watering it with water cannons also using fertilizers and spraying plats with pesticides,this leads to a huge water waste as most of the water will not get absorbed by the soil and end up causing harm to the other surrounding forms of nature.and for that we most come with a solution to minimize water consumption.
Agriculture is very dependent on its own resources, such as land quality and texture, water availability, seeds, marketing requirements and, most especially, the climate. Up to 70% of the world's water from both rivers and groundwater sources is used for food and agricultural production, triple the consumption of 50 years ago. It is also estimated that water needs for irrigation will increase by an additional 19% by 2050. Increasing demands for irrigation threaten to dry up the ecosystem. In today's world, where we face issues such as global warming and poverty, natural sources are diminishing and seasons are becoming less reliable and unpredictable. Under such conditions, it is important to minimize water waste without affecting productivity. Water use can be mitigated by optimizing crop moisture requirements and properly scheduling watering. Sensors attached to the crop field can accurately monitor soil moisture and analysis of the data can predict the appropriate time to water the crop. Agricultural solutions are related to the day-to-day management and execution of a farm, estate, organization, or other agriculture-based production and marketing operation. Farm management research provides an awareness and description of farming systems and farm-related problems. Recognition of systems concerns and weaknesses at the farm level is addressed in a diagnostic mode. In the end, the objective of prescriptive operations is to specify action plans in the farm solutions to overcome the problems or deficiencies of the farm management system that refers to operation and control[10].
That's where agriculture technology (agritech) steps in,with the use of smarting farming and having access to Unmanned drones and sensors would solve a lot of major problems,sensors will provide information on where water and other resources are needed making agricultural productivity is higher, the use of fertilizers, water and pesticides is reduced.

2. Introduction

Smart farming is a management approach to provide the farming industry with the required framework to take advantage of modern technology. Smart farming is a new management approach to provide the agricultural field with the framework to take advantage of modern technology.
This proposal focuses on a smart farming implementation, which would provide farmers with the capability to access live information such as soil moisture, Humidity and temperature. Here are some of the technologies that are available to modern farmers.

- **Sensors**: Water, Soil, Temperature and Humidity.
- **Software**: Dedicated software solutions aimed at particular types of farms or IoT platforms that are use case agnostic.
- **Connectivity**: Lora, cellular, etc.
- **Location**: Satellite, GPS, etc.
- **Robotics**: processing facilities ,Autonomous tractors, etc.
- **Data analytics**: autonomous analytical services, pipelines of data for the downstream industry, etc.

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Figure 1.1: IOT used in agriculture

3. IoT and agriculture:

IoT is the acronym for Information and Communication Technologies that contains a strong pillar of several technologies that will help improve the increase in production and quality and reduce the cost of inputs needed for agriculture like pesticides and fertilizers.
The technologies needed are based on UAVs, UGVs and WSNs, such as Cloud Computing, Big Data, Image Processing and Computer Networks and related Protocols.
Farming is described as the Art, Science and Activity of generating crops and livestock for economic purposes. 240

As an art, it encompasses the ability to handle farm work efficiently. The competencies are classified as follows:
-Physical ability: it implies the capability and capacity to perform the operation efficiently, for instance, managing farm equipment, animals, seeds, pesticides and fertilizers, etc.
-Mental skill: The farmers are capable of taking a judgment based on evidence and experience, for example (i) the proper time and manner of land tillage, (ii) the proper selection of the soil and climate for the particular crop and cropping strategy, (iii) the use of better agricultural methods, and so on[1].
As a science: It uses all advanced techniques based on modern scientific concepts including crop improvement/ selection, agricultural management, plant protection, and economics, etc., to optimize efficiency and maximize profit. For example, new harvests and crop types being developed by hybridization, genetically engineered pest and disease tolerant crop varieties, hybridization in every crop, varieties that are sensitive to chemical fertilizers, water conservation, weed control through herbicides, the application of bio-control products to manage pesticides and diseases etc[1].
As the business: As for agriculture being the lifestyle of the farming community, the production is eventually linked to the consumption. But the purpose of farming as a business is to achieve maximum value for money through managing land, work, data, software, water and capital, applying the expertise of diverse technologies for the purpose of providing food, fiber, feed and energy. In the past few years, farming has been increasingly marketed to function as a business through the use of mechanized systems[1].

4. The IoT-Based Smart Farming Cycle:

The heart of IoT is the important information that can be retrieved from the things ("T") and transferred to the Internet ("I"). To maximize the farming operation, IoT systems on a farm must capture and analyze information in a cycle that allows producers to respond to issues and conditions as they emerge and change. Smart farming tracks a loop like this[34]:

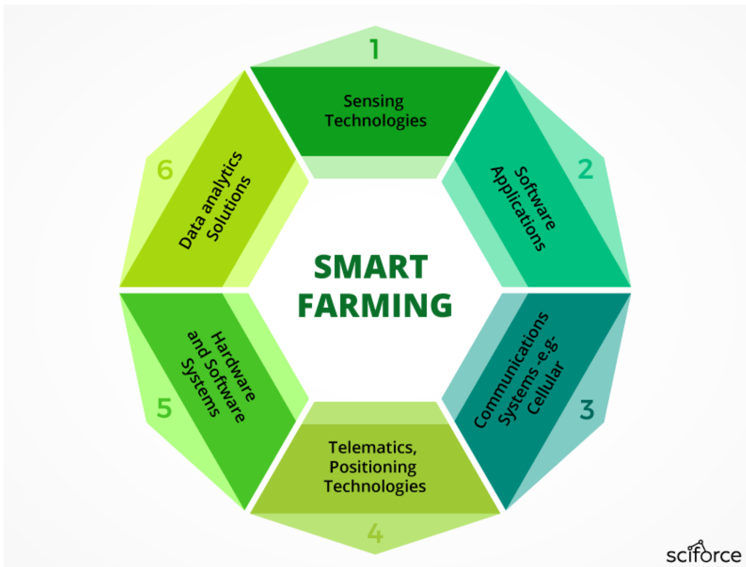

Figure 1.2: Smart Farming

5. Third Green Revolution

Smart farming and IoT-based farming are leading the path to arguably a 3rd green evolution.
After the crop selection and the genetics evolutions, the 3rd green evolution is capturing the agriculture field. This is based on the collective implementation of analytical, data-driven strategies such as accuracy agriculture devices, IoT, large database processing, unmanned aerial vehicles (UAVs), drones and robotics, among others.
In the coming future portrayed by this smart farming revolution, the use of pesticides and fertilizers will decrease as global efficiency increases. IoT technologies will provide greater traceability of goods, resulting in improved quality and safety of food. They will also provide a positive impact on the environment, for example, improved water use and optimization of processing and fertilizing.
So the possibility exists for smart farming to provide a more efficient and more durable way of farming, founded on a more accurate and efficient approach to managing resources. The new farms will eventually fulfill humanity's lifelong vision. They provide nourishment for a population that could reach 9.6 billion by 2050.

6. Future of Farming: UAV, UGV, Wireless Sensor Networks

Moysiadis et al. analyses and discussed the main technological evolutions involved with Smart farming and their characteristics and the different benefits from using them and here is some explanation about these related technologies and their main goal:

Unmanned Aerial Vehicle (UAVs) is an appealing concept that can help us monitor the growth of large crop fields. It will also support many diverse applications ranging from crop estimation, remote sensing, water monitoring, weed detection, and spraying.
The result of the research on drones, V. Moysiadis et al. concluded that UAVs are the best solution because they make it easier for farmers by giving them an overview of their fields in a short amount of time and their operating cost is so low that they allow farmers to interfere precisely when and where they need to fertilize or use pesticides, thus reducing the cost of operation and allowing for safer products for the consumers. [2]

Figure 1.3: The use of UAV in smartfarming

Unmanned Ground Vehicle (UGVs) is a technology that will have an impact in the future and has a fundamental role in smart agriculture, which will increase the efficiency of the land operations, in this regard, many problems will have to be minimized with the help of UGVs, these must be profitable and should be easy to use in an unorganized farm.
The researchers will provide a variety of equipment for the UGV robotic system, such as a camera and sensors to detect leaf moisture, potential diseases, or PH measurements, as well as vision to handle a variety of field operations, such as planting, cropping, harvesting, weeding, spraying, trimming, and crop monitoring. As a conclusion of the UGVs, V. Moysiadis et al. expect a reduction in labor effort resulting in a decrease in operational cost, as well as precise application of fertilizers and pesticides, which will prevent extensive soil compaction and decrease power usage.[2]

Figure 1.4: The use of UGV in smartfarming

Wireless Sensor Networks (WSNs) is an important technology that can be defined as self-configuring to monitor physical or environmental conditions. Various protocols have been used in wireless technologies over the course of last 10 years, such as 3G/4G, WiFi, Bluetooth Low Energy (BLE), Narrowband IoT (NB-IoT), Lora and SigFox. V. Moysiadis et al. analyzed and compared the most commonly implemented WSNs in farming in terms of Frequency range, information rate, communication range, power consumption and cost are presented in Table 1. V. Moysiadis et al. have analysed and and made a comparison of the most frequently used WSNs in the agriculture domain in Frequency band, Data rate, Transmission range, Energy consumption and Cost which is presented in table 1 [2].

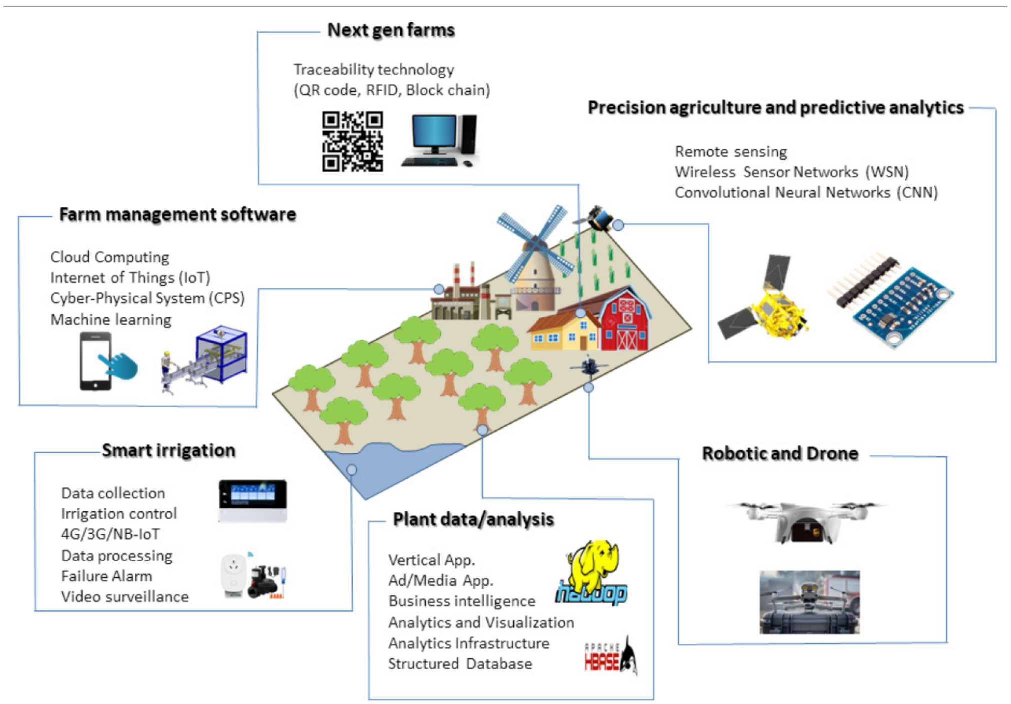

Figure 1.5: A smart farm monitored wirelessly

Table 1

Comparison of Wireless Sensor Networks.

	BLE	ZigBee	WiFi	3G/4G	SigFox	NB-IoT	LoRa
Frequency band	2.4 GHz	868/915 MHz 2.4 GHz	2.4 GHz 5 GHz	865 MHz 2.4 GHz	433 MHz 868 MHz 915 MHz	–	433 MHz 868 MHz
Data rate	2 Mbps	20–250 kbps	1.3 Gbps	1 Gbps	100 bps	250 kbps	50 kbps
Transmission range	100 m	20 m	100 m	Cellular Coverage	40 km	15 km	20 km
Energy consumption	Low	Low	High	Medium	Low	Low	Low
Cost	Low	Low	High	Medium	Low	High	Low

Figure 1.6: Comparison of wireless sensor networks

7. Conclusion

In this chapter, we have tried to define the notion of the Internet of Things and its relation with Agriculture, which is the future of several domains and the several applications of it's.

The agricultural market is particularly sensitive to the benefits of remote controlled objects. The applications are numerous and the returns on investment are now beyond dispute. The benefits become even greater when combined with internet of things (IoT), Mobile applications and Data from Sensors.

In the next chapter, we will give more details and describe precisely the term internet of things (IoT) as one of the essential components and the the different research methodologies which is part of our project and give a presentation of already made systems and our own research.

Chapter II: State of the art

1. Introduction

The United Nation's Agriculture and Food Organizations (FAO) expects the population to expand to a total of 9.2 billion by the year 2050, and projects that food availability will need to grow by up to 70% in order to maintain this pace [3]. World income is divided differently and very unevenly. In some regions of the globe, wealth prevails and there is still a significant desire for premium grade quality food. In a other part of the globe, there is famine and war and a continuous need for huge volumes of nutrition. Given the shortage of farmland and clean freshwater reserves, the only way to solve this qualitative and quantitative hunger problem is by implementing ICT in farming. The integration of ICT within the farming system can affect both larger and smaller operations, leading to improved efficiency, enhanced quality, extended functionality, and lower prices. Furthermore, ICT helps to support an approach based on information and awareness as compared to an exclusive interest in agriculture that is intensive in terms of inputs. As a consequence, farming is becoming more connected, and improved decision making and utilization of available assets can be achieved in a meaningful manner.

As a result, smart farming is used to attach crop data and analysis of the data associated with specific crop varieties. The combination of information will revolutionize the way food is produced world. To observe crop progress under different real-world conditions (soil quality, environmental conditions, etc.), typical crop studies require phenotyping to studies require phenotyping to assimilate the key factors affecting growth. These studies are performed in locations where plants grow, i.e., under natural outdoor environmental conditions, varying irrigation and irrigation and fertilizer/additive application. Using the technology of the technology (IoT), it is possible to reduce costs and increase the scope of such studies by studies by collecting related time series data from sensor networks and human sensor networks, and human observations recorded via applications. In particular, IoT devices can be used to capture temperature, humidity, and share them with interested with interested researchers and producers for further analysis.

2. Associated Technical Terminologies

We will shortly discuss some key terminology that comes up when dealing with ICT, sensors and data scanning.

Sensors is a device that transforms the state of an observed physical quantity into a usable quantity, such as an electric voltage, a height of mercury, an intensity or the deflection of a needle. The confusion between sensor and transducer is often (wrongly) made: the sensor is at least made of a transducer.

An **embedded system** is defined as an autonomous electronic and computer system, often real-time, specialized in a precise task. The term refers to both the hardware and the software used. Its resources are generally limited spatially (small size) and energetically (limited consumption)..

Image processing is a method of applying certain actions to an image to create an improved image or to retrieve valuable data from it. It is a method of treating a signal in which an image is considered the input and the output can be an image or features related to that image. Currently, image processing is one of the fastest developing sciences. It is a major research area in the fields of computer science and engineering[2].

Machine Learning is designed to provide important value in all areas of ICT. Its ability to allow machines to be trained by themselves without prior coding provides a very useful alternative across a wide range of possible applications. A standard machine learning program typically initiates a learning procedure in which the machine is given several packages of data. Afterwards, clustering and predictive techniques are extracted, that can be applied in the future along with further incoming information to generate the appropriate outcome.[2].

Cloud computing is a computing service that relies on the Internet to store, manage and retrieve information, and use assets from any location, without requiring hardware or software.

Data analysis consists of analyzing and processing large amounts of data collected in the field and providing meaningful feedback so that any interested party can use it for their future projects. These large data sets are called Big Data, and the analysis technique is called Data Mining. A separate field of study called "data science" has recently emerged. It is a combination of software and statistical algorithms for the purpose of data analysis[4].

What is smart farming and why is it the future??

Smart farming is a revolution in conventional agriculture that involves reorienting agricultural systems to effectively support food development. The main objective of smart agriculture is to increase agricultural productivity and farm income. Smart agriculture implies the use of ICT and in particular the Internet of Things (IoT) and associated big data analysis to address these challenges through electronic monitoring of crops, as well as for the environment, soil environment, soil, fertilization and irrigation conditions. This monitoring data can then be analyzed to determine crops that best meet the performance objectives of any farm in the region.

What are the key components of a farm using smart farming?

1. **Data collection**
   The sensors installed at all critical places in the farm gather and transmit data about the soil, air, etc
2. **Diagnostics**
   The collected data are evaluated by the program and a statement is made about the situation of the monitored object or process. Any potential issues are recognized.
3. **Decision making**
   According to the detected issues in the first stages, the management staff and/or the software will determine the necessary actions to be implemented in order to solve the problem.
4. **Actions**
   The steps listed in the previous section are carried out. A new survey of the environment (soil, air, humidity, etc.) is taken by the sensors and the complete process resumes.

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The outcome of this automated smart agriculture approach is – **h**igh accuracy and 24/7 monitoring, ultimately resulting in **s**ignificant financial efficiencies in all key assets used – water, power, fertilizer, time spent by skilled workers, time spent by less skilled workers[12].

3. Definition of Internet of Things:

There are several definitions of the Internet of Things concept. In the following, we will be presenting some definitions. [13]

Definition 1: Internet of Things is a network that connects and combines objects with the Internet following protocols that ensure their communication and exchange information across a variety of devices.

Definition 2: The Internet of Things can also be defined as a network of network of networks that allows, via standardized and unified electronic identification systems and unified electronic identification systems, and mobile wireless devices, to directly and unambiguously identify digital entities and physical objects and thus, to be able to retrieve, store transfer and process data seamlessly between the physical and virtual worlds.

In the context of our work, we adopt the definition proposed in which is :
"The Internet of Things (IoT) is defined as a global network of interconnected services and smart objects of all kinds designed to support humans in their daily life activities thanks to their sensing, computing and communication capabilities. Their ability to observe the physical world and to provide information for decision making, will be an integral part of the architecture of the the Internet of the future".

4. Characteristics of Internet of Things system:

The fundamental characteristics of the IoT are:

- Interconnectivity: everything can be interconnected with the global information and communication infrastructure.
- Connected object services: IoT is capable of providing object services within constraints, such as privacy protection and semantic consistency between privacy and semantic consistency between physical things and their associated virtual objects. In order to provide services related to things (i.e. objects) within the constraints on things, technologies in the physical world and the information world will change.
- Heterogeneity: IoT devices are heterogeneous across hardware platforms and networks. They can interact with other devices or service platforms via different networks.
- Dynamic changes: The state of devices changes dynamically, e.g. sleeping and waking, being connected and/or disconnected as well as the context of the devices, including location and speed. In addition, the number of devices can change dynamically.
- Huge scale: The number of devices that need to be managed and communicate with each other will be at least an order of magnitude larger than the number of devices connected to the Internet. Even more critical will be the management of the generated data and its interpretation for application purposes. This concerns the semantics of the data, as well as the effective management of the data.
- Security: As we gain benefits from the IoT, we must not forget about security. As creators and recipients of the IoT, we must design mechanisms that ensure security. This includes the security of our personal data and the security of our physical well-being. The securing endpoints, networks and the data that flows through them means creating a security paradigm that will evolve.
- Connectivity: Connectivity provides network accessibility and compatibility. Accessibility gets on a network while compatibility provides the common ability to consume and produce data.[13]

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5. Objective of internet of things:

The ambitious objective behind the Internet of Things according to the concept of object being posed, the various definitions and the literature we have studied on this subject lead us to conclude that the Internet of Things is a global of Things is a global infrastructure allowing in particular :

- active objects to exchange information or collect information about passive objects, which is in line with the definitions of a global M2M network.
- to store and make accessible the identity of the objects, the information produced by them and all the knowledge necessary for the objects to gain autonomy, through representations, structures and data formats that can be manipulated by machines.
- to offer the necessary abstractions to human beings to interact with these machines, and by extension with the physical world, as simply as possible with the physical world, as simply as with the virtual world we know today [21].

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6. Application of the Internet of Things:

We note that the concept of the Internet of Things (IoT) is exploding as we increasingly need smart objects in our daily lives that can help us achieve our goals. more and more in our daily life of intelligent objects capable of making the achievement of our goals easier. Thus, the application areas of IoT can be varied[64], some common examples are presented in Figure 1.4.

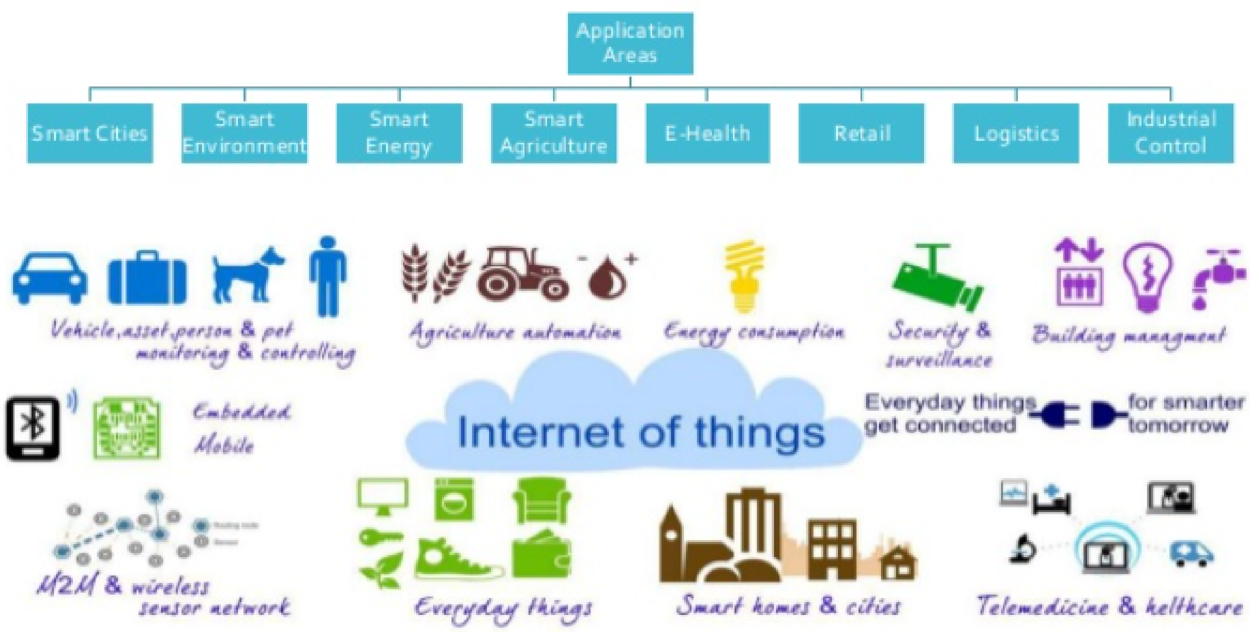

Figure 2.1: Application of the Internet of Things

- **Smart Homes**
Smart homes, being one of the greatest and most convenient IoT implementations, brings home safety and comfort to the next stage. Although there are various layers of IoT implementation for smart homes, the absolute best is when smart utility devices are linked with entertainment. For instance, your power consumption meter with an IoT feature that gives you an overview of your everyday water usage, your set top box that enables you to remotely capture broadcasts, automated home lighting systems, sophisticated security locking devices, linked monitoring devices all fit into this concept of a smart home. [22].

- **Smart City**
Internet connectivity not just for the residents of a city, but for devices located within it as well: this is how smart cities are meant to be. We can proudly say that we are in the middle of achieving this vision. Attempts are made to integrate connective infrastructure technology into certain vital fields such as transportation control, waste disposal, water distribution, power supply, etc. All of these attempts are designed to remove some of the obstacles to the growth of a smart city and to make the city a more efficient way of living and functioning in the long run, and to make it a better place to live and work. These efforts are all aimed at eliminating some of the daily challenges that people face and providing additional comfort.[22].

- **Self-driven Cars**
We've been hearing a fair amount about autonomous cars. Google has been testing it, Tesla has been testing it, as well as Uber even proposed a form of autonomous cars that it later dropped. Since we're talking about human safety on the streets, we need to make sure that the technology has everything it needs to guarantee a safer ride for the occupants and other road users. Cars use multiple embedded systems and sensors linked to the cloud and the internet to keep producing information and sends it to the cloud to make educated decisions through machine learning. While it will take a number of years for the entire evolution of the technology and for countries to change their legislation and policy, we are now witnessing one of the most successful IoT implementations.[22].

- **Farming**
One of the industries that stands to profit the most from the Internet of Things is agriculture. There are so many advancements in the range of tools that farmers can use in regards to agriculture that it certainly has a bright future. There are tools currently being developed for irrigation with drips, insight into farming patterns, distribution of water, UAVs for farm monitoring, and much more. Such tools will enable farmers to achieve higher efficiencies and better serve their needs[22].

- **Industrial Interne**
The IoT industrial internet consists of sensors, tools and other devices interlinked with computer manufacturing applications, such as fabrication, power generation, etc. Although it is still quite a bit unpopular with IoT smart wearables and other applications, research firms such as Gartner, and also Cisco, etc., consider the IoT to have the highest aggregate impact on the industrial internet of things.[22].

- **Intelligent Medicine**
Intelligent Medicine The medical field can also integrate relevant applications, such as for example, medication assistance and remote patient monitoring (heart rate, blood pressure,etc.), the identification of allergies and drugs administered to patients, the location of doctors and patients in the and patients in the hospital, etc.[21].

- **Smart Agriculture**
Smart agriculture aims to strengthen the capacity of agricultural systems to contribute to food security agricultural systems, to contribute to food security by integrating the need for adaptation and mitigation potential into sustainable agriculture development strategies. This objective requires the use of technologies, such as satellite imagery and information technology. It relies on means of It relies on the use of satellite positioning systems such as GPS, as well as on the use of sensors that will on the use of sensors that will collect useful information on the state of the soil, moisture rate, salt rate and

send this information to the farmer to take the necessary measures to guarantee the good production necessary measures to ensure proper production [21].

Figure 2.2: IOT Application Domains

7. Communication in an IoT system

While some fixed objects can be connected by wired networks, the growth of the Internet of Things is expected to be driven mainly by the use of wireless and mobile technologies. is expected to be driven primarily by the use of wireless and mobile technologies. Wireless connectivity technologies are numerous and varied, and the use of one or the other is often primarily decided by the range of the envisaged network. Some use cases also require a combination of wireless and wired technologies to connect equipment to private wide area networks or the Internet. We distinguish in the methods of data transmission between connected objects two solutions: wired and wireless [68].

- **Wired connectivity**

  The wired network is a network which as its name indicates it is a network which network that is used through a wired connection. This network uses Ethernet cables to connect computers and peripherals through a router or a switch. Wired networks provide the highest and most stable data rates. We give as examples: Ethernet, DSL12, ADSL13,SDSL14 cable, fiber Optical (FTTH, FTTB, FTTD...), PLC15 , etc.[44].

- **Wireless connectivity**

  Wireless networks make it possible to connect computers and other computing devices without the need to install cabling, which means more convenience and saving money on infrastructure. On the other hand, this kind of networks has security, because without effective protection, the introduction of intruders is probable [45]. Depending on the type of coverage, the wireless network can be classified as WPAN16, WLAN17, WMAN 18 or WAN19. WPAN20 is common for Bluetooth technology, while

WiFi 21 systems generally establish WLAN networks. WiMAX22 based technologies, in turn, allow establishing WMAN networks while WAN networks are used with GSM23, GPRS24 (2G) or UMTS25 (3G) communications [45].

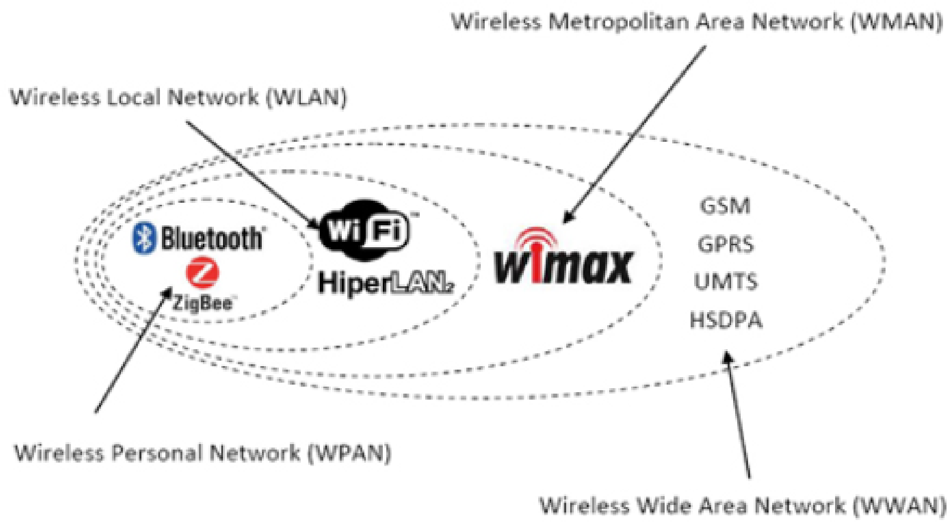

Figure 2.3: Wireless network ranking [45]

There are many options for wireless technologies used in the IoT, including: Bluetooth, Zigbee, Z-wave, 6LowPAN, Thread, Wi-Fi, in addition to cellular technology such as: NFC26, Sigfox, Neul,LoRaWAN. We present some of them [2]:

Bluetooth technology is a key player in short-range telecoms. It is expected to make a major contribution for wearables in particular, again making it easier to connect to the IoT even through a smartphone. A new BLE27 technology, now called Bluetooth Smart, is an important protocol for IoT applications. Offering a range similar to Bluetooth, it has been designed to significantly reduce power consumption[2].

- **Versions:** 4.0 , 4.2 (Internet protocol support will allow Bluetooth Smart sensors to access the Internet directly via 6LoWPAN28 connectivity).
- **Standard:** the fundamental specification of Bluetooth4.2
- **Frequency:** 2.4 GHz(ISM)
- **Range:** 50-150 m(Smart/BLE)
- **Transmission speed:** 1 Mbit/s (Smart/BLE)

Zigbee Like Bluetooth, ZigBee has a large installed base, especially in industrial environments. Among the available ZigBee profiles, ZigBee PRO and ZigBee Remote Control (RF4CE) are based on the IEEE802.15.4 protocol; operating at 2.4 GHz, this industry-standard wireless networking technology is targeted at applications that require relatively infrequent data exchanges at low transmission rates over a small area and within a 100-meter range (such as a home or building)[2].

- **Standard:** ZigBee 3.0 based on IEEE802.15.4
- **Frequency:** 2.4GHz
- **Range:** 10-100m
- **Transmission speed:** 250Kbit/s

Wi-Fi connectivity is often the obvious choice for many developers. It doesn't need much explanation, except to state the obvious, namely the vast existing infrastructure, the fast data transfer and the ability to handle large amounts of data. Currently, 802.11n is emerging as the most widely used Wi-Fi standard in both the home and office environment. This standard offers high throughput, in the hundreds of megabits per second, which is ideal for file transfers, but may be too power hungry for most IoT applications.

- **Standard:** based on 802.11n (currently the most used standard for private use).
- **Frequency:** 2.4 GHz and 5GHz bands
- **Range:** about 50m
- **Transmission speed:** 600 Mbps maximum, but typical speeds are closer to 150 Mbps, depending on 150 Mbit/s, depending on the channel frequency used and the number of antennas (the latest 802.11-ac standard is expected to allow speeds of up to 500Mbps to 1Gbps)

NFC (Near Field Communication) is a technology promoting simple and secure two-way interactions between two electronic devices (smartphones in particular), to allow consumers to carry out contactless payment transactions, access digital content and connect to electronic devices. Its main action is to extend the functionalities of contactless card technology, to allow devices to share information at a distance of less than 4cm.

- **Standard:** :ISO/CEI18000-3
- **Frequency:** 13,56MHz(ISM)
- **Range:** 10cm
- **Transmission speed:** 100–420Kbit/s

The summary table below (see Figure 44) compares the four main protocols used in the Internet of Things. It shows that these typologies have different advantages and disadvantages, and their use depends on the context in which it is found.

	WiFi	ZigBee (802.15.4)	Bluetooth	NFC
Network topology	Star	Mesh	Point-to-point	Point-to-point
Range	30-100 m	10-20 m	10 m	< 0.1 m
Discovery	Broadcast	Broadcast	Broadcast	Response to field
Power	High	Low	Classic: Mid LE/Smart: Low	Tag: Zero Reader: Very low
Privacy	Low	Mid	Mid	High

Figure 2.4: Extract from a comparative table of protocols [47]

Communication protocols To address the issue of the growing number of connected objects that will appear on the web in the years to come (according to a Gartner study: nearly 26 billion connected objects will be on the Internet by 2020), and for the purpose of creating dialogue and automating their daily behavior so that they provide services or send information about their state or their environment in order to extract value [48]. the IoT has adopted the standards [49]:

- **HTTP:** :stands for Hypertext Transfer Protocol. This protocol defines the communication between a client (example: browser) and a server on the World Wide Web (WWW)
- **MQTT:** stands for Message Queuing Telemetry Transport. It uses the principle of "Publisher / Subscriber" to connect the systems between them.
- **AMQP:** stands for Advanced Message Queuing Protocol. A protocol for message-oriented messaging systems (MOM)
- **STOMP:** stands for Simple Text Oriented Messaging Protocol. Is a text-based protocol over TCP designed to allow interaction with message-oriented middleware.

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8. Internet of things platforms

With the explosion of the Internet of Things, many IoT projects have emerged and we are witnessing the emergence of many IoT developments and solutions. The Internet of Things is a set of connected objects that use the network as a medium to exchange data. These objects are diverse and can be cards (eg: Arduino), software or sensors. The existence of this vast network requires one or more platforms that serve as a support. In addition, with microprocessor boards like Arduino or Raspberry Pi becoming accessible and cheap, many wanted in the development of IoT projects. It is in this momentum that many companies have created IoT platforms for developers or just hobbyists who are interested in IoT projects.

The market for IoT platforms is huge as an ocean! Today, the IoT ecosystem owns more than 300 IoT platform companies [57], As it has become all the more necessary to correctly know the names of the best IoT platforms on the market. What is important for us is to take a comprehensive look at each of them, explore them and get our hands on the most important points and characteristics so that we can choose the right platform for our project and our modest material resources.

9. Definition of an IoT platform

An IoT platform plays a crucial role in accelerating and reducing the cost of developing IoT products and applications. It not only allows several objects to be connected and their diversity to be managed, but also to handle complex and varied communication protocols. These platforms also provide all the necessary infrastructure to allow developers to set up IoT projects easily and quickly: servers, database, object management. Finally, they ensure the data analysis part by providing libraries of algorithms, queries, dashboards and pre-built tools [58].

10. Components of a modern IoT platform

We distinguish 8 components in a modern IoT platform [58]:

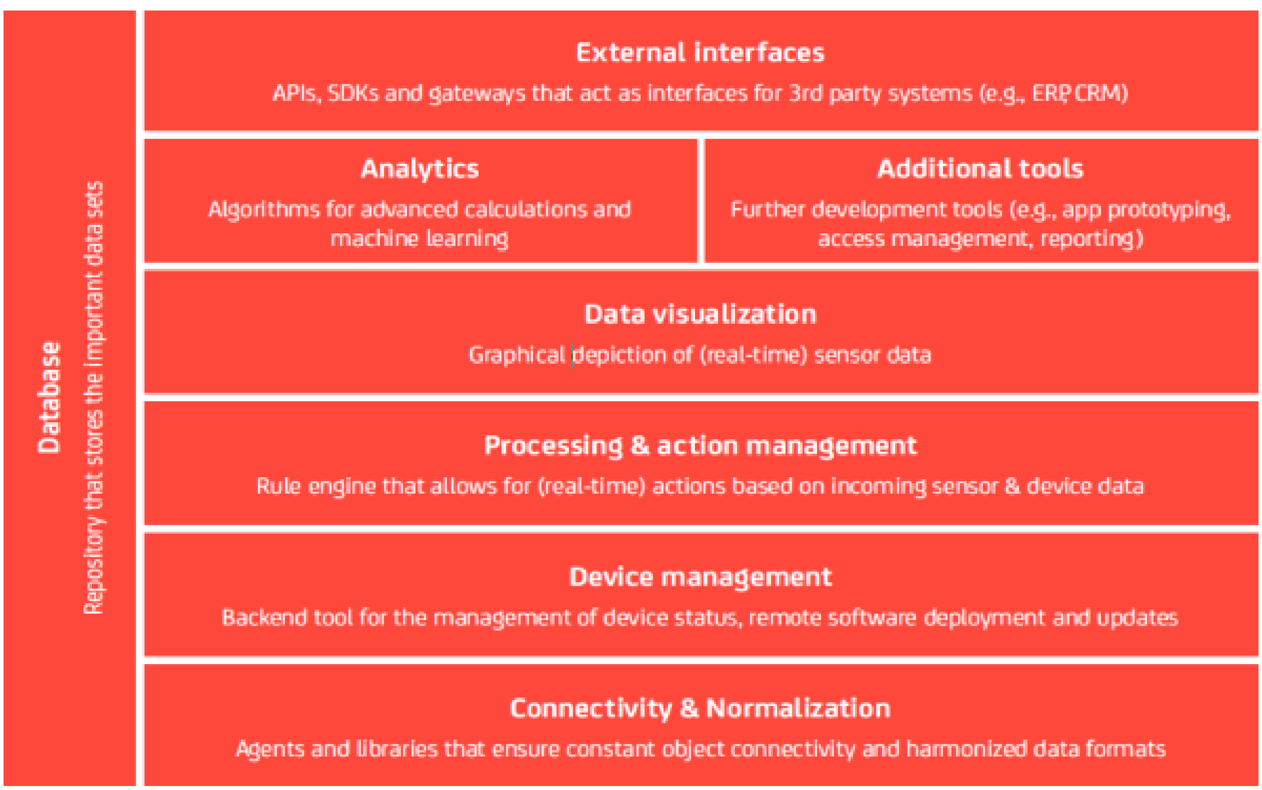

Figure 2.5: Figure 1. : Components of a modern IoT platform [58]

- **Connectivity and standardization:** brings different protocols and different data formats in a single "software" interface thus ensuring correct data transmission and interaction with all devices.
- **Hardware management:**ensures that "connected" objects run correctly by managing the updating of software and applications running on the device or on the gateways.
- **Database:** scalable storage of material data and consideration of requirements for hybrid cloud-based databases (data volume, diversity, veracity).
- **Management of actions and processes:** use of data with rules, events and actions thus allowing the execution of "smart" actions according to the data from the sensors.
- **Analytics:** data analysis ranging from data clustering to machine learning and predictive analysis to select the most relevant values from the data flow.
- **Visualization:** allow humans to see patterns and observe trends and easily interpret data through diagrams and models.
- **Additional tools:** facilitates prototyping and testing for IoT developers, also provides IoT use cases to create applications adapted to the platform.
- **External interfaces:**integration with third party systems and other IoT platforms via APIs, SDKs and gateways.

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11. Research Methodology:

The Smart Agro management system is composed of the following stages: i) the information gathering and transfer devices, ii) the linkage between all the systems (gateway), iii) the Smart Agro control network, iv) information evaluation v) reporting and actuators. The main components of the project are presented in Figure 2 [5]. The elements are detailed as follows:

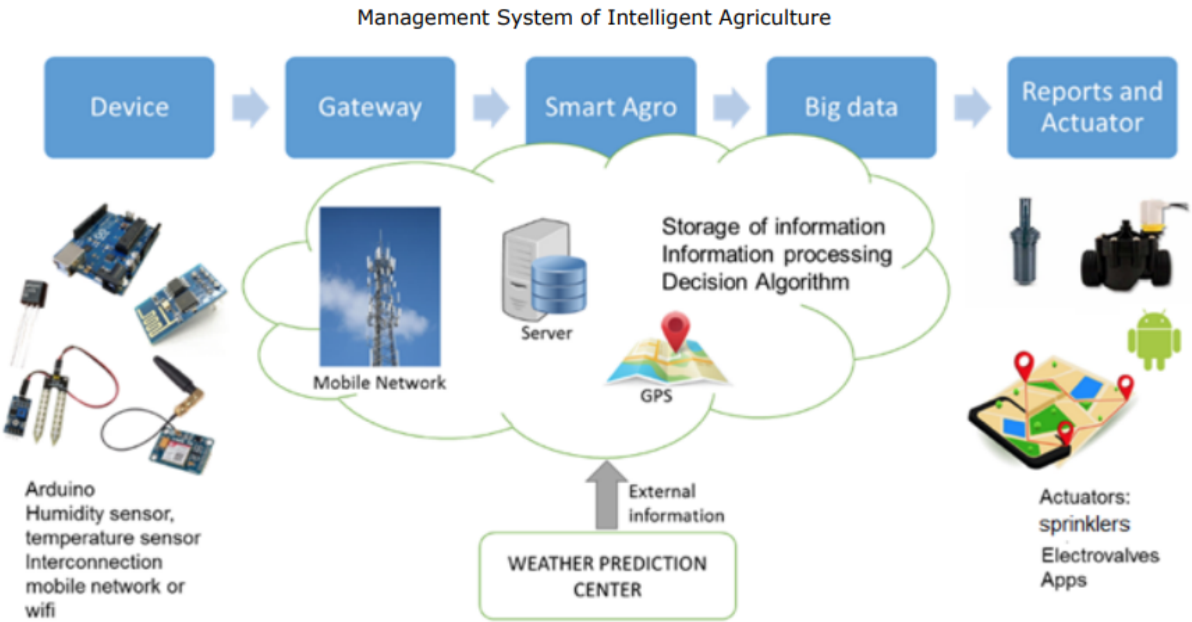

Figure 2.6: Management system of Intelligent Agriculture

. **Temperature sensor:**

The LM35 series of temperature sensors are integrated circuit accuracy technology temperature sensing units with an export voltage that is Linear proportional to the temperature centigrade. The LM35 has an edge over Kelvin calibrated universal temperature sensors in that the operator is not required to substract a significant constant current from the output to obtain a convenient scaling in degrees. The LM35 needs no additional calibration or external trimming to deliver accuracies of typical $\pm\frac{1}{4}$°C at ambient temperature and $\pm\frac{3}{4}$°C over the full temperature scale from -55°C to 150°C. A smaller cost is assured by adjustment and concentration of calibration at the chip level. The LM35's low impedance output, linear output, and inherently precise scaling make it particularly easy to Interface with reader or controller circuits. The unit is used with single supplies, or with plus and minus power supplies. Since the LM35 draws only 60 A from the power source, it has a very low self-heating of under 0.1°C in still air. The LM35 device is designed to work over a temperature window of -55°C to 150°C, while the LM35C device is rated for -40°C to 110°C (-10° with increased) accuracy. The LM35 series of devices are provided in sealed TO packages, while the LM35C, LM35CA, and LM35D devices are provided in TO-92 transistor polymer cases. The LM35D is offered in a smaller 8-pin area-mount enclosure and in a TO-220 plastic packaging.[6].

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM35	TO-CAN (3)	4.699 mm × 4.699 mm
	TO-92 (3)	4.30 mm × 4.30 mm
	SOIC (8)	4.90 mm × 3.91 mm
	TO-220 (3)	14.986 mm × 10.16 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.

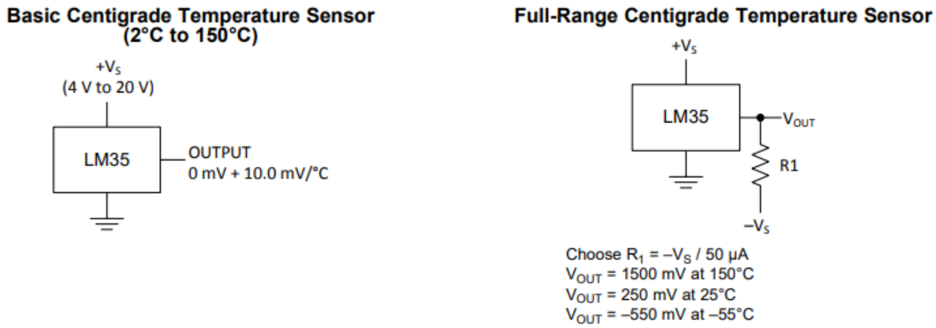

Figure 2.7: Temperature sensor

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humidity sensor:
The humidity sensor used in our experience has two parts: the first is the YL-69 sensor, which is inserted into the ground where the moisture is to be determined; the other part is the YL-38 device, which is in charge of getting the information from the sensor and then transferring it to its digital or antique signal output. The YL-38 has a precision trimmer used to control the amount of signal to be transmitted to the output. The YL-69 sensor detects the soil humidity for the conductivity variation. When these sensors are placed in the soil, they will begin to lead the electricity depending on the moisture degree of the soil. Consequently, when the ground moisture tester is inserted in wet soil, its value of electricity falls due to its lower resistance, and it is inserted in wet soil and its value rises due to its higher resistance[5].

Wi-Fi Module ESP 8266:
To transfer the information from the sensor to the web server, we have used ESP 8266 device. ESP-8266 is a low cost Wi-Fi chipset that provides support for IPv4 and TCP/UDP/HTTP/FTP and has a micro controller capability. The ESP 8266 features effective energy handling. It features a low-power consumption design that works in three manners: active state, sleep and full sleep states. Its low power usage varies from 0.5 µA when turned off to 170 mA when sending at the top of the waveform[5].

cellular networks 3G/4G:
TThe 3G/4G and soon 5G wireless networks have been used extensively in intelligent farming for data gathering from sensors in the field. The forthcoming 5G will provide low relatency, high reliability and high broadband that are significant in machine-based operations where human safety is paramount. For instance, it will handle real-time device to distance (D2D) communications and will support a huge amount of equipment [15]. Finally, the cellular grids are already offering wide area coverage in remote locations, and 5G is likely to spread it even further. The disadvantages of their usage are the high average cost of operation[2].

GSM/GPRS Module (Module SIM900):
The primary purpose of this package is to make sure that the data received by the sensors, along with the data collected from the action on the controllers, can be securely transmitted and retrieved to the web via the infrastructure of the network. In this instance, a wireless mobile communication channel is being used (GSM, TD-SCDMA) linked to wireless sensors (which use the ESP8266 module)[5].

12. Challenges and directions for future work:

The use of data sensors and analysis provides promise for the farming industry, but there are still some remaining risks and challenges. Factors related to them that still demand particular attention are noted in Sections 1 and 2.

1 Sustainable Agriculture:

While technological efforts are made in increasing the productivity of the agriculture, environmental and social factors are often not taken into account. In particular, developing countries prioritize on adopting technologies for fast development rather than a sustainable one [7]. Initiatives from the different sectors of society should be taken with a view to developing the sustainability of farming systems along with the adoption of the various technologies including sensors technology and ICT. Also, technology interventions should be designed to select appropriate and environment-friendly technologies for collecting, storing, recycling, and treating and disposing of e-waste [8].

2 Technological Constraint:

The available technology will define the progress in each area of its execution. Improvements in technology will lead to improved accuracy, precision, velocity, and dependability while lowering future expenses. Standardization of technology is key to enhancing the ability of agricultural devices to communicate with each other. In addition, research and open source initiatives must be more encouraged to raise the quality of overall solutions for technology[9].

3 Big Data:

Intelligent processing and analysis of a large quantity of unstructured and disparate legacy data is necessary. The research indicates that dimensional downscaling of big data is necessary for extraction of core content value, and that this is equally demanding [10]. Open research and publication of these datasets is very significant. But there is uncertainty about the property of these data. To farmers? To corporations? Or to the community? This issue must be approached, but then again, if addressed too strictly, it can hold up innovation. It is also critical to improve the understanding of the use of big data. The concept, its practical application, its requirement, and the worth of its use need to be promoted consistently by expanding the education and outreach on big data use[11].

4 Cost and Investment:

Investment in technology will not only facilitate, but also increase performance. Lowering costs leads to higher adoption of technology. As a result, the cost of ICT and detection devices must be minimized, and their use should be economically sustainable. The farmers need to be aware of the economical implications prior to and after using the technology[12].

13. Mobile Applications

13.1. Introduction

In the current era of ICT systems, people have become familiar with the use of IT applications. But the use and implementation of mobile applications is a new and fast developing field.
The mobile application has an impact on the overall success of the project. The application of mobile applications in advanced nations. Mobile applications operate on a compact portable mobile device that is mobile, user-friendly, and can be accessed from any location. Currently, many individuals use the mobile applications to communicate with friends, surf the web, deal with file contents, build and handle papers, get some entertainment and so on. Anywhere, the users can enjoy the advantages of the mobile application. There are many ways for people to accomplish in their day-to-day life and in their professional life. Not only does the mobile application have an effect on the person, but it also has an important function in the business. Many businesses are gaining income through mobile applications. The mobile application makes an effect on the corporation. The mobile application runs in a mobile setting where the usability is affected by many factors such as; display resolution, limitations of hardware, high cost of data usage, issues with connectivity, restricted opportunities for interaction. In the past few years, mobile carriers have been trying to build mobile devices with improved display resolution, more capacity, improved accessibility, which in turn offers a better platform for advanced mobile applications [26].

13.2. Future of Mobile Application

According to the previous study of mobile application uses we can see the mobile application uses rate increase very dramatically. Before talking about mobile application if we think about the uses of Smartphone then we can see that the uses of smartphone increase very rapidly. According to Wireless Expertise Ltd, Market Report [14], in 2008, the global smartphone sales was 140 million, and the number of smartphones sold per year will be 422.96 million. Wireless Expertise expresses that by 2013 smartphone penetration will be approaching approximately 28-30% of the total mobile market in 2013.

13.3. Mobile Application's effect in society from the Ethical Perspective

In addition to private individuals and organizations, mobile applications also have a major impact on mainstream society. The mobile application can make the entire community's life easier. Some examples of social effects are:

Quick communication:

From the previous study about mobile application use, we can realize that the rate of mobile application use has grown dramatically. Before we mention mobile application, if we consider the smartphone usages, we can find that the smartphone usages are growing extremely fast. Based on Wireless Expertise Ltd, Contract Report[14], In 2008, worldwide smartphone revenues reached 140 million, and the annual number of smartphones being sold is expected to reach 422.96 million. Wireless Expertise has calculated that by 2013, smartphone Connectivity will achieve 28-30% of the overall cell phone market in 2013[26].

Save time and increase productivity:

In the developed society or countries, people can do their everyday work such as reading their email or reaching a business associate at any moment on the public bus, rail, car or on the street. So there is no necessity to stand in a waiting room or an empty office. This means that time is conserved and people can have more time to focus on their jobs. The labor efficiency of the society or the country is increasing progressively[26].

Improve IT infrastructure in developing country:

In developing regions, the use of mobile applications increases the knowledge of people. They have access to the Internet from any location. As a consequence, the IT landscape is becoming richer in all countries in the developing world[26].

Increase Job vacancy:

Mobile app development and mobile app business are generating more number of vacant posts in the organization. Therefore, many people are able to find a position in this field. This is also good for the company and the whole country[26].

Less computer use less power consumption:

When most people use mobile applications for their daily routine and obtain easy access to the mobile application, the computer consumption will be lower and the amount of power needed will be reduced[26].

Considerable Cost Saving:

The Mobile Voice over Internet Protocol (VoIP) application can assist people to make international phone calls from their cell phones. As a consequence, the monthly expenditure is significantly reduced[26].

Entertainment:

By utilizing a mobile application, people in the community can enjoy themselves by creating opportunities for personal expression.

There are numerous other social impacts that are all ethically beneficial to the community. On the other side, there are some adverse impacts of mobile Apps that are not ethically beneficial to the community. These issues include the following ones:

- When teens have a wide variety of mobile internet-based apps they waste their time by using Facebook, Instagram, as well as YouTube, etc. The youth are at risk when they are using internet related games or other inappropriate applications.
- Besides the use of mobile applications, most people use cell phones in all locations including bus, train, school, college, office. There are some individuals who are bothered by those applications.
- Intensive use of cell phones is harmful to the reputation of the company and the health of the person.

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13.4. The mobile application is based on the concept of restriction

One of the main challenges of mobile applications is their platform capacity and limitation.Besides the usefulness of the mobile applications, they present more challenging and interesting framework related aspects. We will attempt to discuss these restrictions in the sections below.[26].

- **Small Screen Size:** On a mobile computing platform, it is very difficult, if not completely hopeless, to visualize all the relevant graphics and texts as it would be on a computer desktop or laptop monitor.
- **Lack of windows:** Missing windows: At a workstation we can see multiple screens at the exact moment. However, it is difficult on a mobile phone platform to see several windows at the same time.
- **Navigation:** Many mobile phones do not have an integrated cursor, limiting the versatility of the browsing experience.
- **Types of pages accessible:** Available pages of different formats: Not all file sizes are accessible through the mobile computing platforms, so it's important to be aware.
- **Speed:** The processing speed and connectivity rate of the platform is quite weak.
- **Size of messages or email:** Many handsets will support a certain number of messages or e-mails containing a certain amount of characters.
- **Cost:** the monthly expense of mobile application and the network capacity is considerably high.

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14. Study on already built systems

Much work has been conducted around the globe to demonstrate the available technologies for the automation of farm greenhouses. In this section of the present chapter, we present two methods for experimenting with the automation of a greenhouse[25].

First system

Principle

Among the existing greenhouse automation systems, there is also the proposed by Nianpu Li1, Yimeng Xiao, Lei Shen, Zhuoyue Xu, Botao Li and Chongxuan Yin.
Their goal is to develop a greenhouse with an IoT system to serve as a one-stop shop to meet the demand of local communities for production.

the architecture of the greenhouse system

Regarding the integrated system, they have placed different sensors in the greenhouse to collect data such as temperature, humidity, lighting intensity and so on. At the same time, there are air pumps, and other devices that will be controlled by the collected data sensor to keep the environments stable.
As for the data, it is sent via ZigBee to the local host to be updated in the cloud that stores the data. Beyond that, users could access the cloud to check the plant and get a variety of cognitive recommendations on future marketing decisions.

Evaluation

While some greenhouses have now installed a monitoring system, they still require human labor to adjust settings or equipment. On the other hand, although an automatic control system has been applied to some greenhouses, it lacks benchmarks that maximize yield and improve crop quality. Instead, their IoT-based hydroponic greenhouse integrated with both the and automated control system takes advantage of big data analytics coming from the cloud. With machine learning algorithms like ANN to process the collected data, the cloud generates decisions about temperature, humidity and light exposure adjustments and immediately sends them to the automatic control system.

Second system

Principle

The second intelligent system presented by D.O. Shirsath. This project describes the design of a greenhouse monitoring and control system based on the use of IOT.
Arduino, Automatically control the environmental conditions in the greenhouse, which allows all types of plants to be grown throughout the year. Eliminate the risk that the greenhouse is not maintained in environmental conditions specific due to human activity.

Evaluation

Some previous models used android phones to supervise the greenhouse but were unable to remotely control it with android. One was based on the GSM (global system for mobile communications) in which the notifications are being sent by SMS, but the disadvantage is that the operator had to repeatedly type in instructions, which is time and cost prohibitive.
The greatest drawback of such arrangements was that an individual needed to be in or near the greenhouse at any given instant.

15. Presentation of our project

Principle : The project is wireless plant monitoring system where can be accessed by a mobile device at any time as long as you are connected to the internet,it features a soil sensor linked to an arduino uno provided with the module ESP8266 NodeMCU to establish a WIFI connection, this project will also allow the user to allow the app the automaticly take care of the plants. How : by connecting the arduino to the WIFI through ESP8266 NodeMCU it allows the latter to connect to the firebase DataBase where data will be transmitted from the sensor through the arduino to the firebase allowing the mobile application to receive said data (Humidity,Temperature,Plant Status) and display it for the user which will have to make the decision of manually watering which will allow him to control the pump or automaticlly which make it autonomous

Solution:To simulate the environment we used Proteus 8 (Arduino Simulation Application),The most important device is the arduino UNO (a micro controller board with input/output pins) that allows control over other devices,linked to it is a soil moisture device which is the main device for retrieving data from the soil/plant , to make the simulation as real as possible we added POT-HG(active variable resistor) and LM35(temperature)to manipulate humidity and temperature in order to simulate an ordinary plant.

The second most important device is ESP8266 NodeMCU WIFI module which allows the possibility of a wireless connection, the retrieved data from the sensor is sent from the Arduino to the FireBase Database through ESP8266 NodeMCU. Since monitoring the plant can be hard a sounder is connected to the Arduino to warn the user that the plants are in need of an action either manually open the pump or set the automatic option which bring us to the next device which is the pump, a pump is simply a device that manage the flow of water,last but not least an LCD 1 LM016L to compare the data we are receiving on the application if its the correct data.

After injecting the Arduino with the code and started the simulation , the arduino device make a connection with the FireBase realtime database recieving real time data which then get sent to the application and be shown in the interface,after the user receive the data he then can turn on the pump on and off depending on the shown data or automatic making the pump only turned on when needed ,the ESP8266 receives the Commands and starts the irrigation pump.

16. Conclusions:

Sensor based technologies, particularly IoT and intelligent sensors, has led to exponential increase in sensor based implementations in agriculture. As the world of agriculture continues to grow more data demanding, these enhancements in technology have helped to advance the domain of farming. Many challenges continue to be encountered, as we discussed in the "Challenges and Direction of Future Work" segment. Overall, the positive patterns were identified, and we conclude that improvements in sensors and techniques for analyzing their data will bring new perspectives to solve a variety of farming related issues.

Chapter III: Conception

1. Introduction

To finish the process of conception-realization, we will now design and develop the model of this project by using several tools and new technologies. In this chapter we will describe the functioning of this model with the application that is being implemented, we will specify the software environment supporting our application and we will explain the utility of each tool. Thus, we will describe the stages of the project realization.

What is a model?

- To represent a subject of study
- Applying to several cases of this study topic
- Embodying a point of view on these cases Example of a point of view : U = RI

Modeling languages :

Languages used to express a model :

- Natural languages : which evolve outside the control of a theory Ex : French, English, ...
- Artificial languages: designed for specific uses
- Formal languages : syntax defined by a grammar Ex : Logic, computer languages (C, Java, SQL, ...), ...

. History of UML

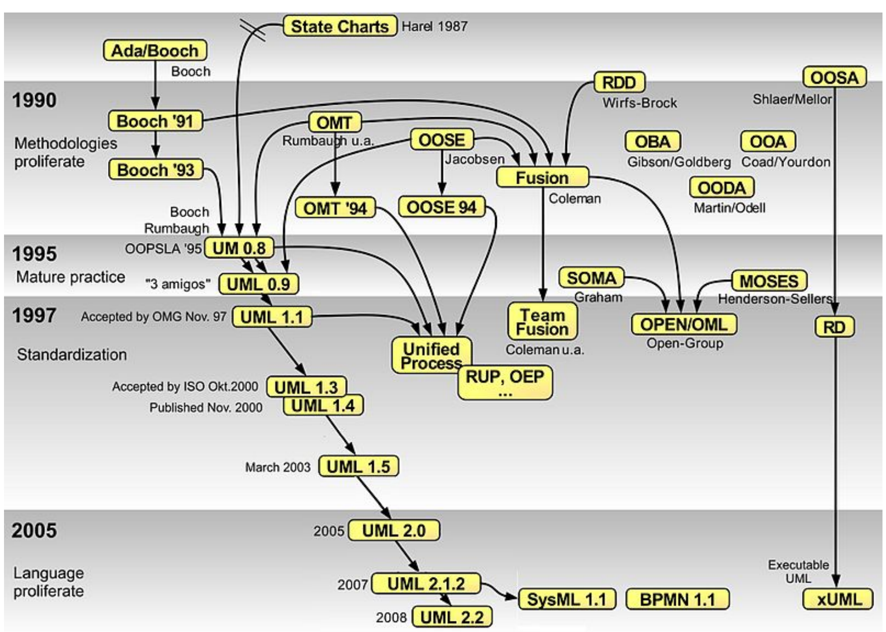

Figure 3.1: UML history

2. System modeling

For the modeling of the system we use UML (Unified Modeling Language) which is a modeling language for systems engineering. It allows to model the stages of specification, analysis and design. It also allows some verification steps. As far as we are concerned, we will essentially use only three diagrams.

3. Different UML models

3.1. Use case diagram

The use cases allow to express the way to use the system from a user point of view. Use cases allow to define the limits of the system, its functions (its cases), as well as its relations with its environment. They model the activities (functionalities) and communications (interactions). They are a means of determining the needs of a system. They allow to express the users expectations from the first phase (needs analysis).
Quite simply, a use case allows to represent the functions of the system from the users point of view as shown in figure 1[15].

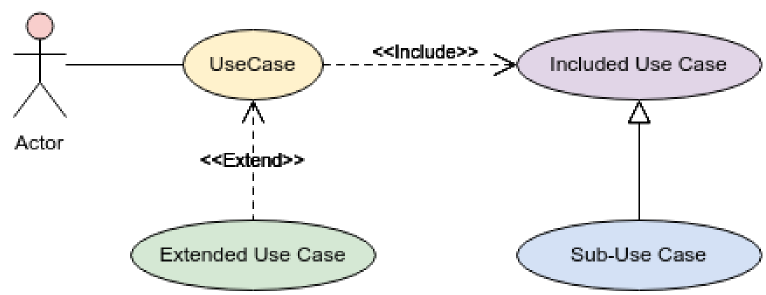

Figure 3.2: Use Case Diagram

The elements of the use case diagram are :

- **Actor:** a role played by a person, a service, etc. that interacts with the system studied.

Figure 3.3: Actor

- **Use case:** specific way of using a system. Image of an expected functionality, triggered in response to an actors stimulation.

Figure 3.4: Use case

- **Relationships:** there is three type of relationships between use cases and actors which are Include / Extend / Generalisation.

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3.2. General use case diagram for smart irrigation system

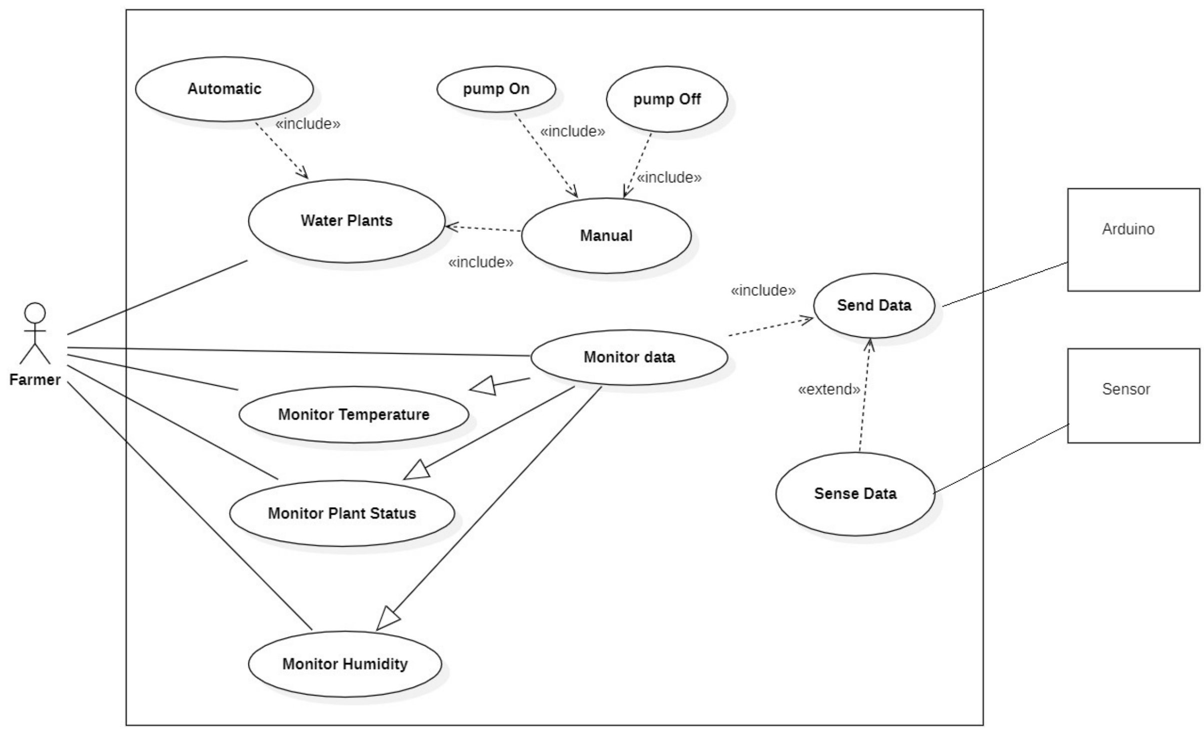

Figure 3.5: Use case diagram

4. Sequence diagram

The primary use of the sequence diagram is to display the pattern of interactions between items in the sequential manner in which they occur. Like the class diagram, designers typically believe that sequence diagrams are intended to be used exclusively for themselves. But an organization's business staff may consider sequence diagrams to be a helpful tool for communicating the current functioning of the organization by demonstrating how the different types of objects in the business structure relate to each other[24].Below, the different sequence diagrams of our system:

4.1. Sequence diagram : Log in

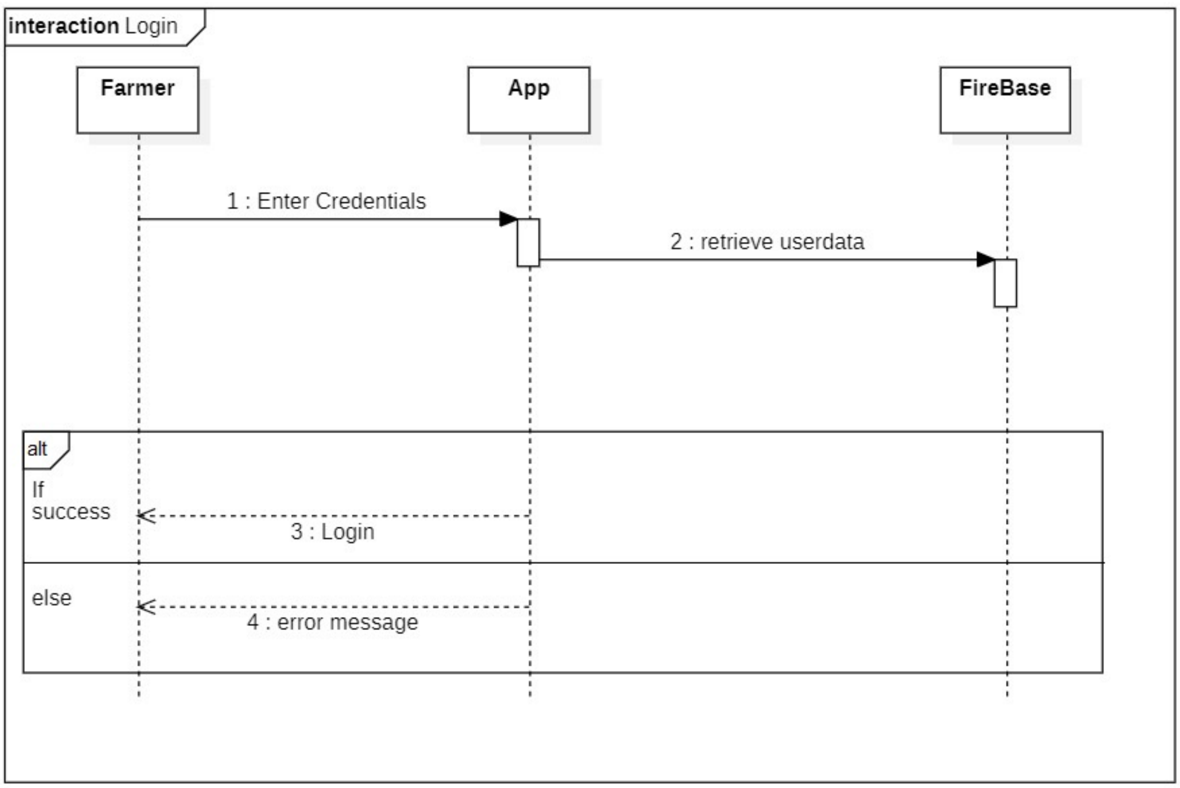

Figure 3.6: Sequence diagram :Log in

4.2. Sequence diagram : General Interaction

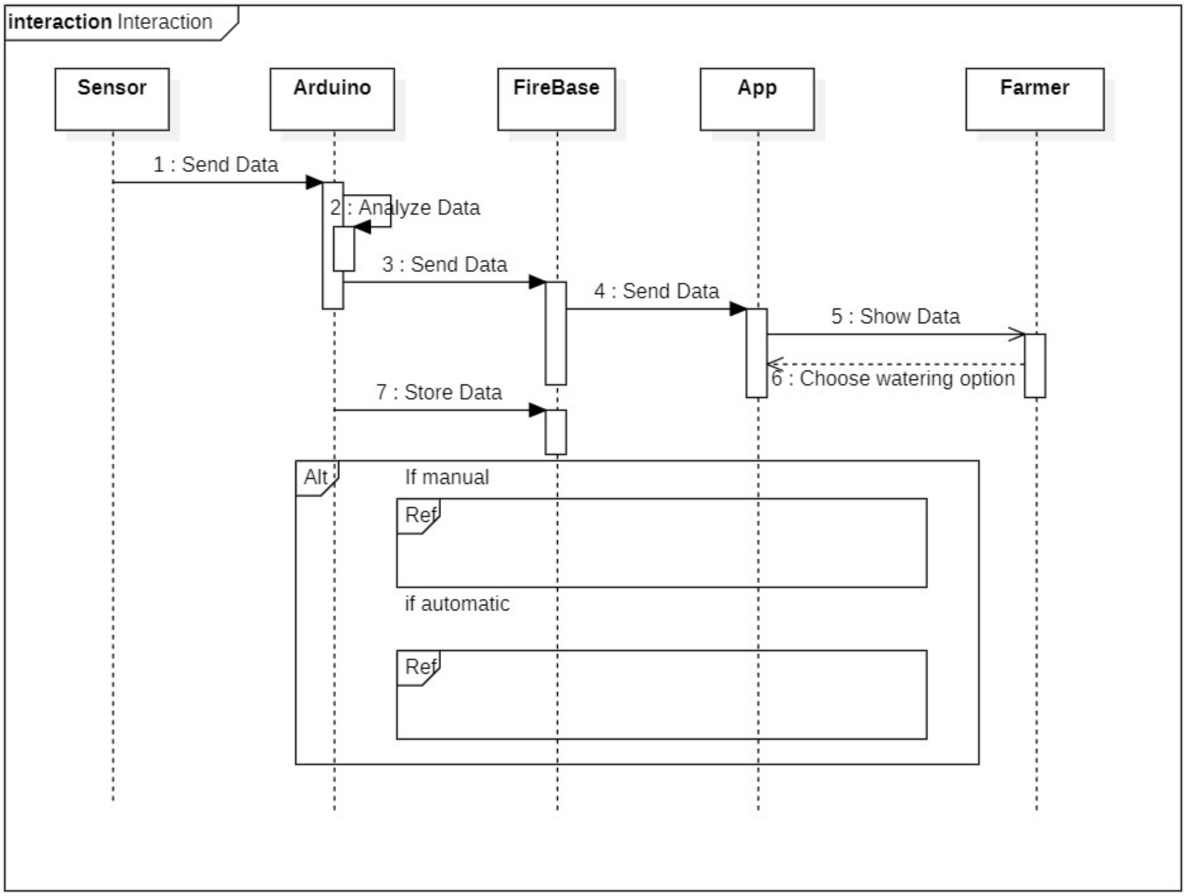

Figure 3.7: Sequence diagram :General Interaction

4.3. Sequence diagram : Automatic watering

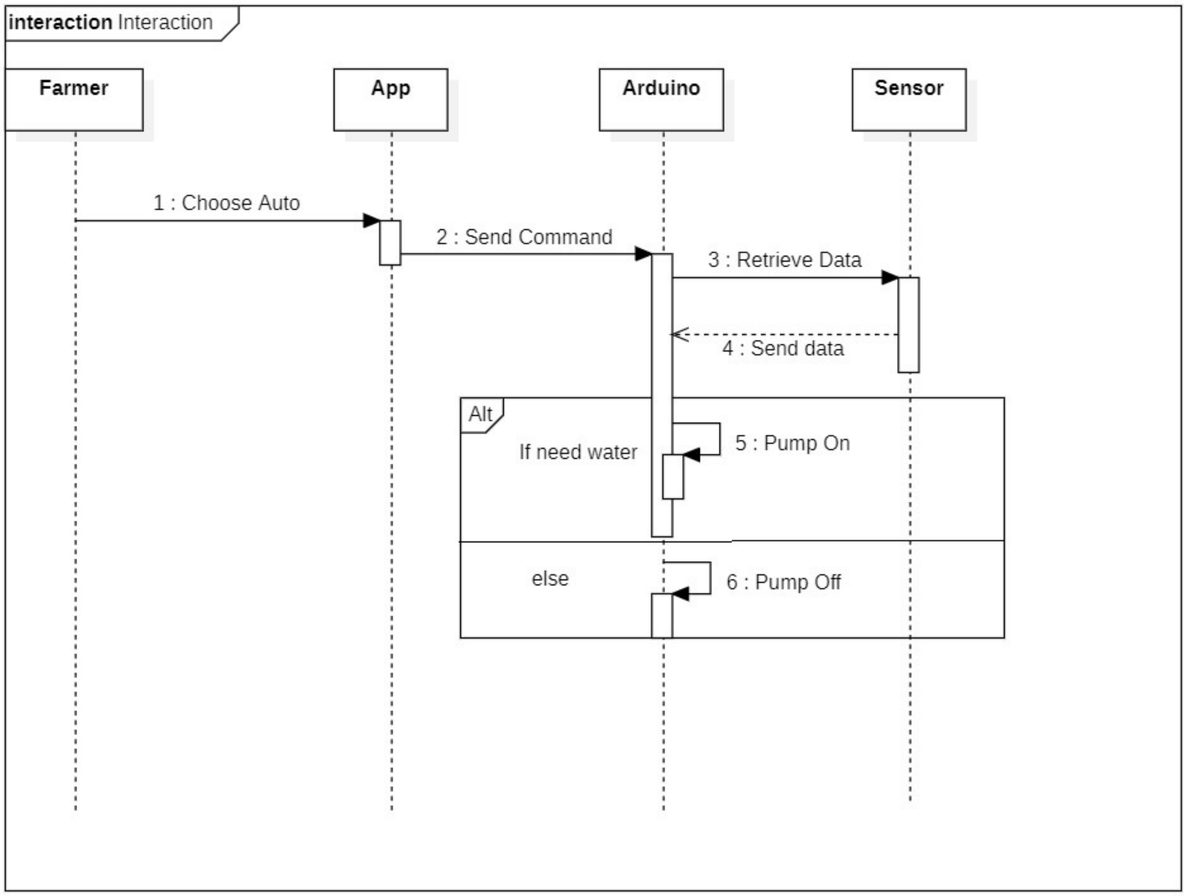

Figure 3.8: Sequence diagram :Automatic watering

4.4. Sequence diagram : Manual watering

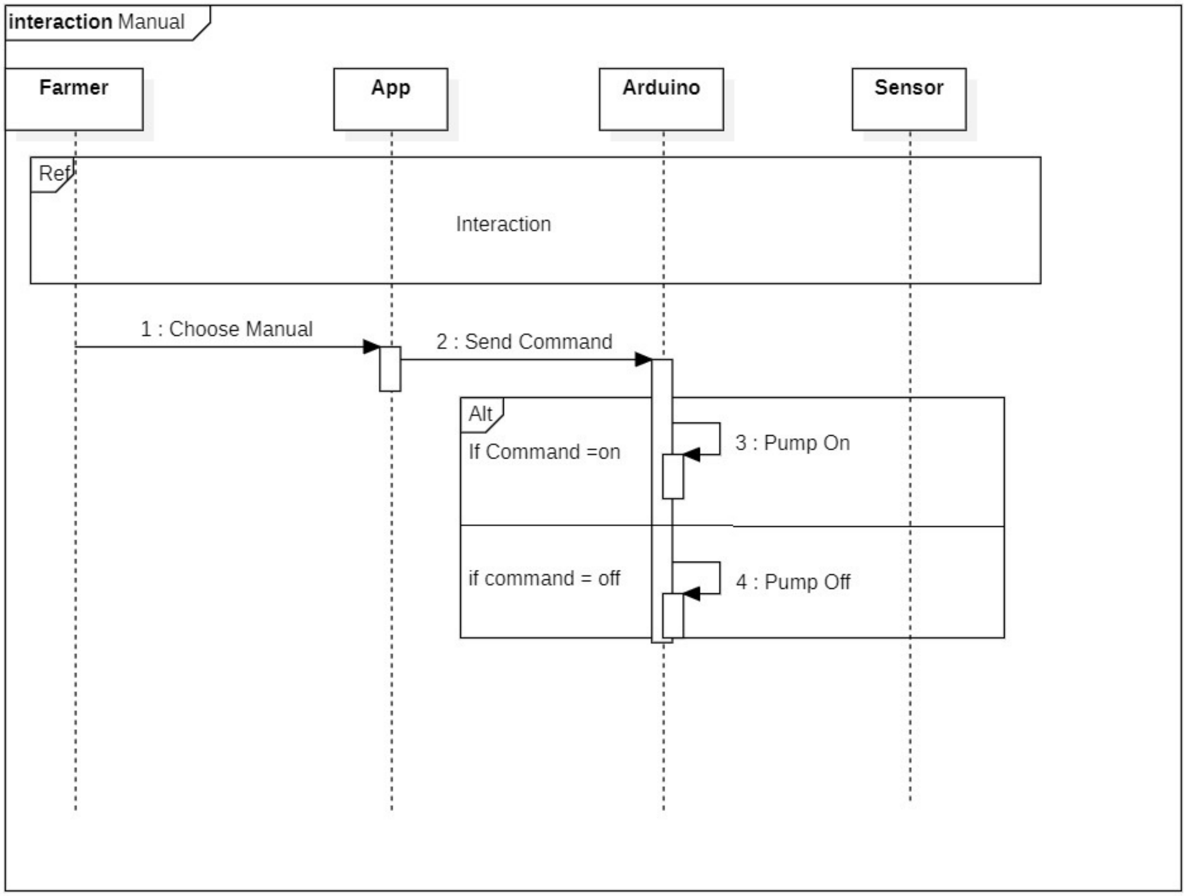

Figure 3.9: Manual watering

5. Activity diagram

Activity diagrams allow you to focus on processing. They are therefore particularly well suited to modeling the flow of control and data flows.
They allow the behavior of a method or the progress of a use case to be represented graphically [68].
We represent below the activity diagrams corresponding to each use case of our system.

5.1. Activity diagram: Log in

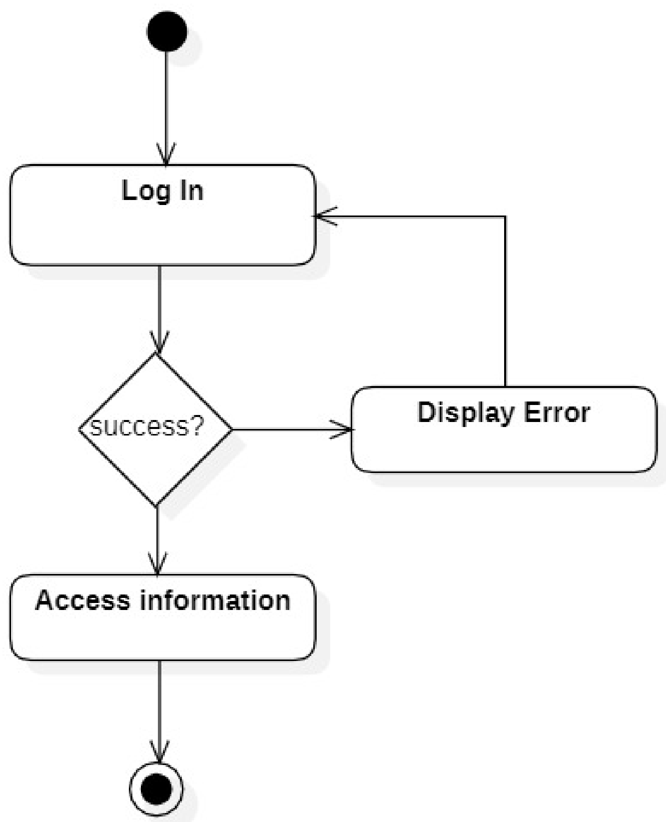

Figure 3.10: Activity diagram: Log in

5.2. Activity diagram: General Interaction

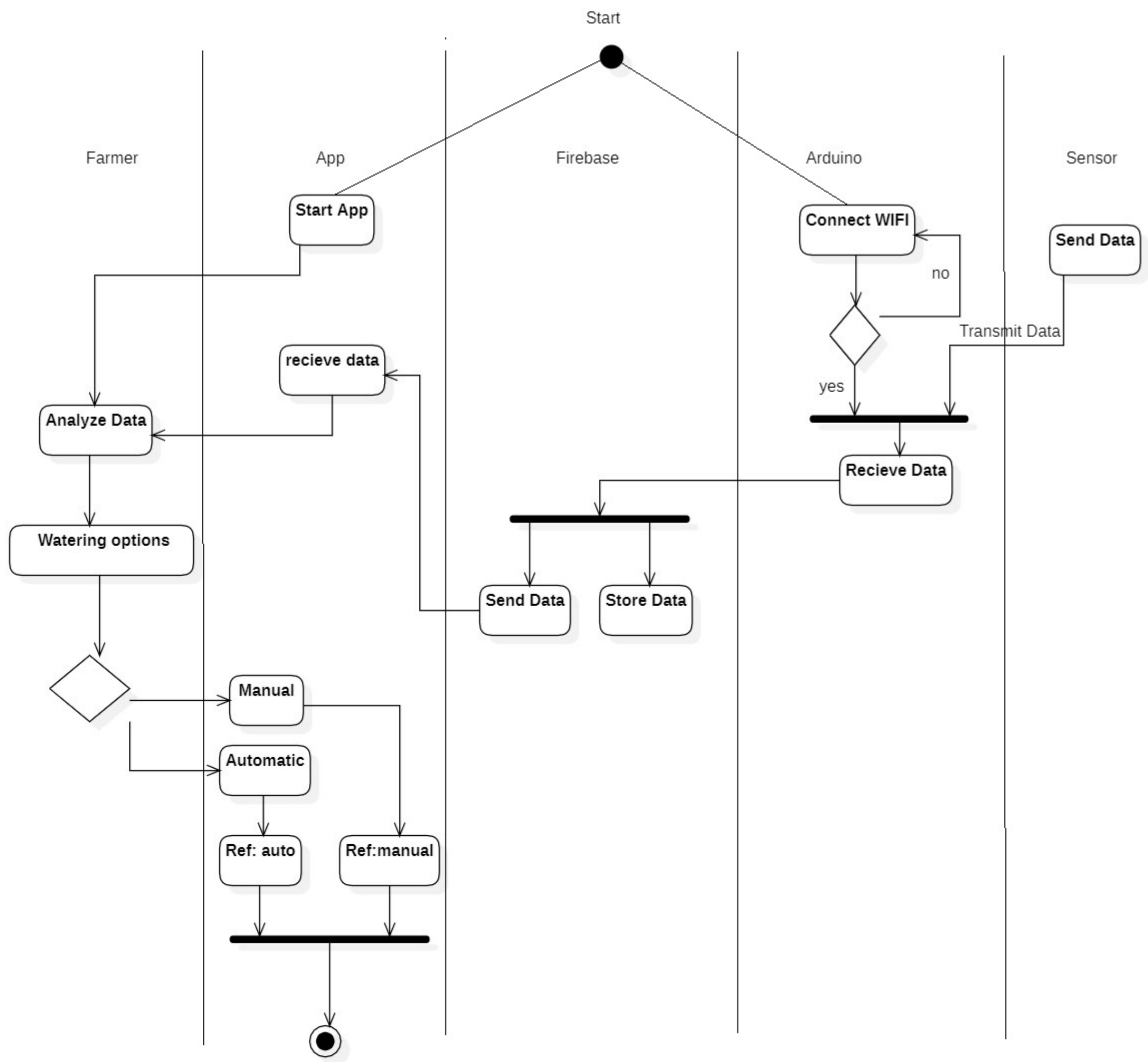

Figure 3.11: Activity diagram: General Interaction

5.3. Activity diagram: Automatic watering

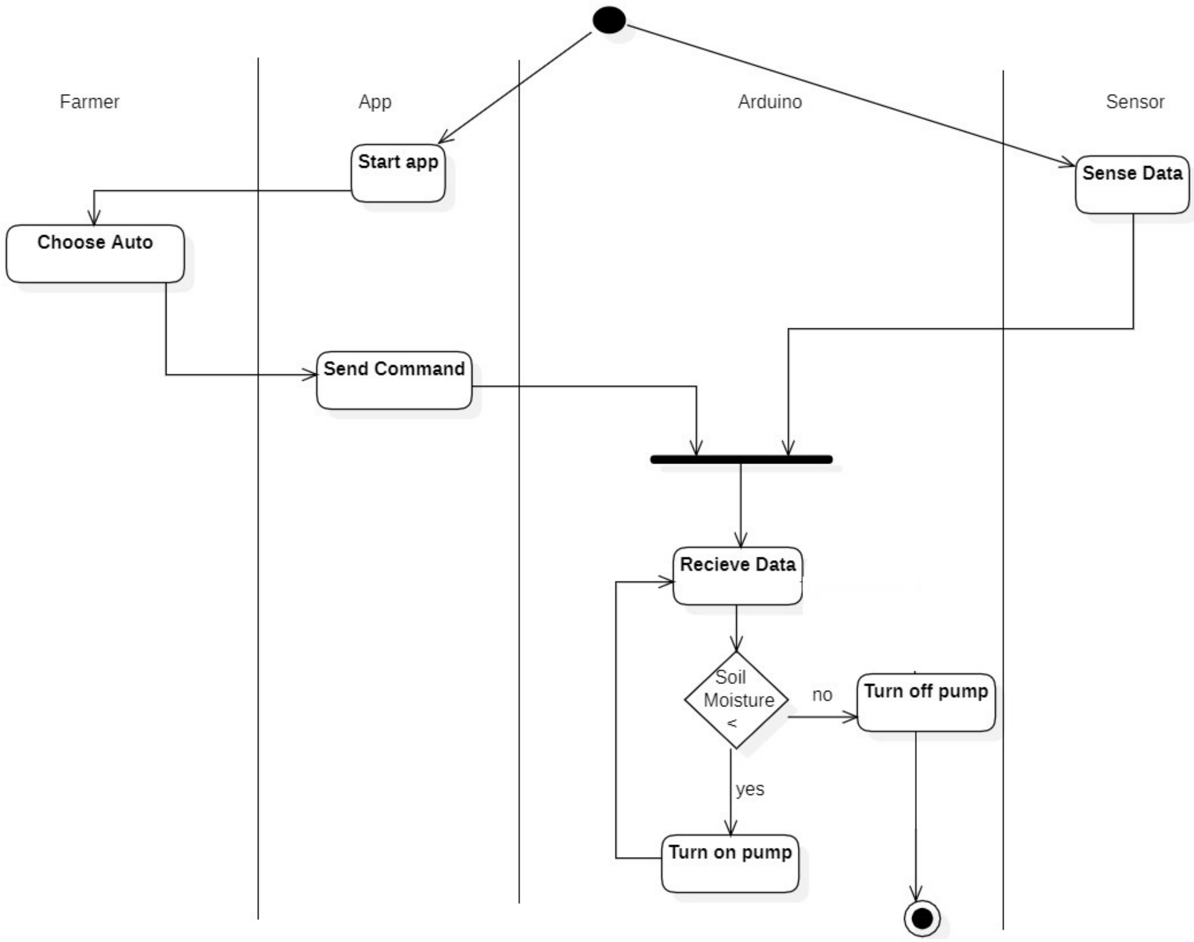

Figure 3.12: Activity diagram: Automatic watering

5.4. Activity diagram: Manual Watering

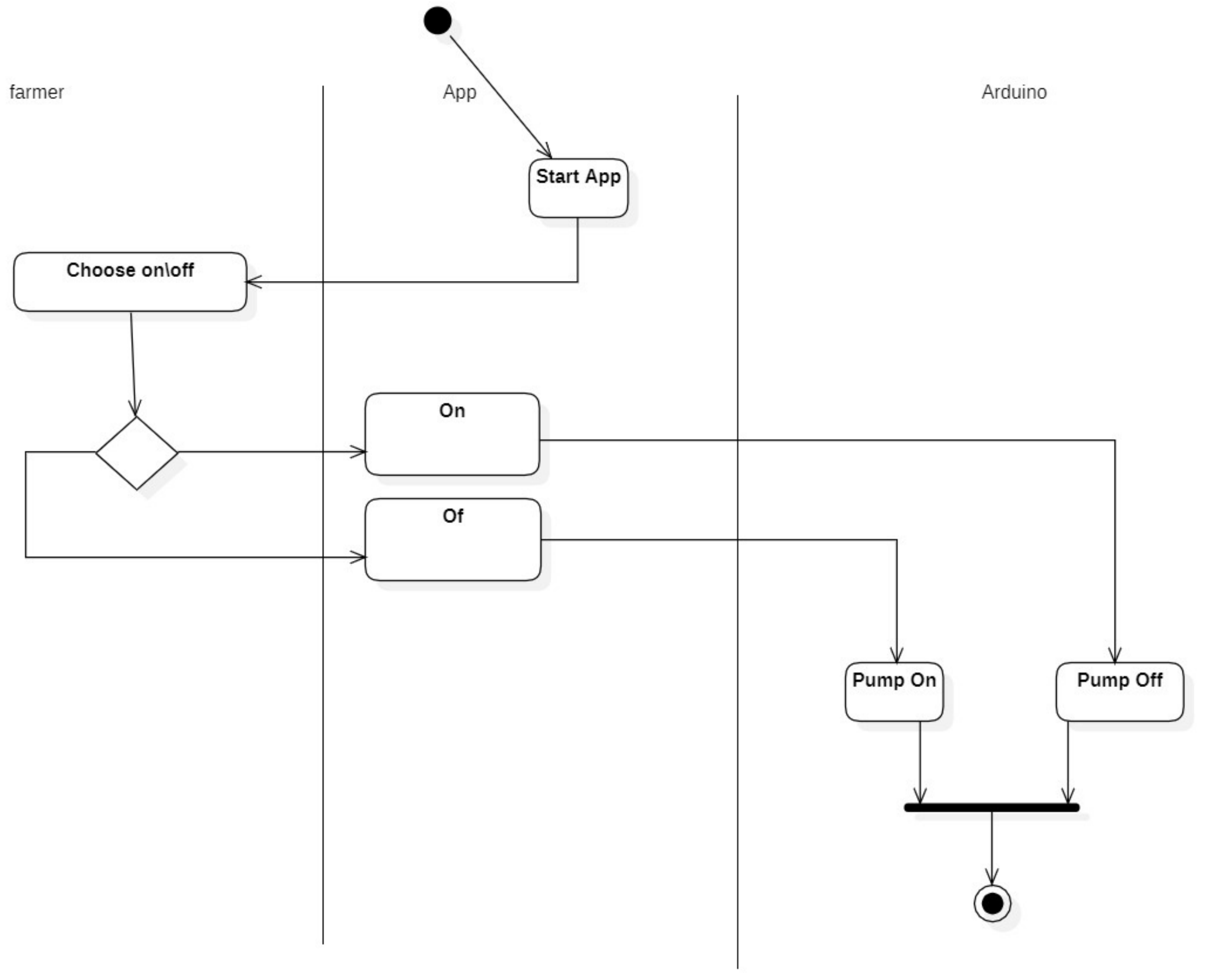

Figure 3.13: Activity diagram: Manual watering

6. Class diagram

6.1. Class diagram

We have built the class diagram for our SQL database to allow us to represent a static view of our information system and to show the fixed structure of our software solution. a static view of our information system and to show the fixed structure of our software solution. The figure below represents the class diagram of our system [68] :

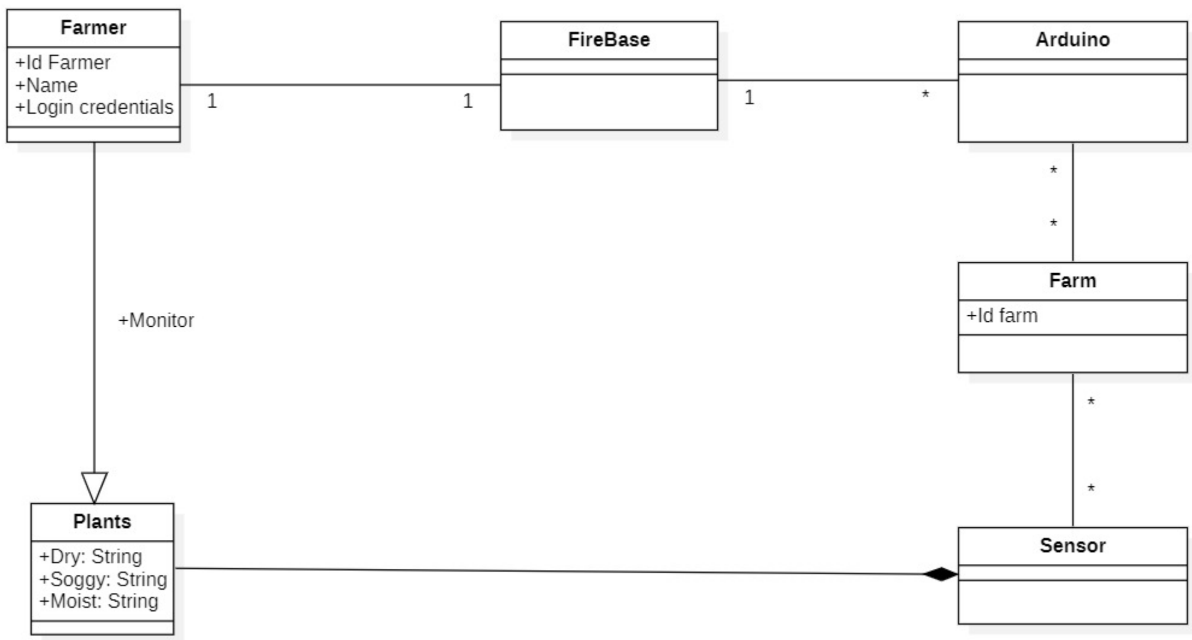

Figure 3.14: Class diagram

7. System Regulations

The regulation in the field of industrial processes concerns the implementation of all the theoretical, material and technical means to maintain each essential physical quantity equal to a desired value, called set point, by action on a regulating value, called set point, by acting on a regulating variable, in spite of the influence of disturbing variables of the system[13].

7.1. The overall objective of the regulation

They can be summed up by these 3 key words: measure, compare, correct. But each process has its specific demands, each equipment has its own operating requirements. It is essential, consequently, that the regulation is designed to meet the particular needs of security, production and physical necessities. Regulation is the automatic setting of a value so that it constantly remains at or near the required setting, irrespective of any perturbations which may occur[26]. Types of loops

7.2. Open loop

Figure (3.19) represents an open loop. The magnitude of the correction is independent of the magnitude of the measurement. The controller is in manual mode, which means that the user can choose the value of the control signal applied to the actuator [26].

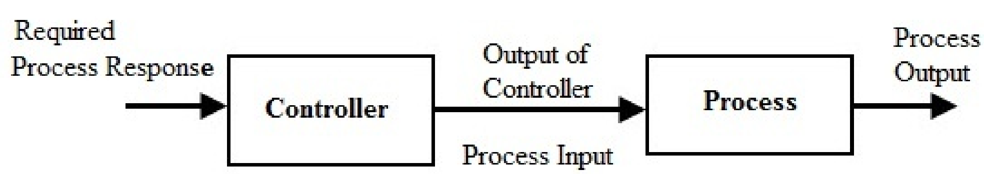

Figure 3.15: Open loop diagram[30]

7.3. Closed loop

A loop is said to be closed (Figure 3.20) if the measured quantity affects the corrected quantity (manipulated quantity), i.e. it compares its output to a desired value that it sets to regulate its function; this sign is called the shrinkage sign (automatic mode) [30].

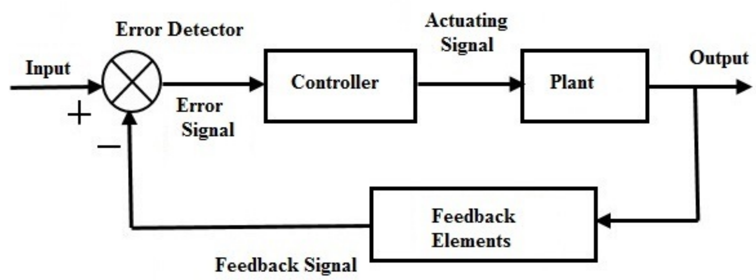

Figure 3.16: Closed loop diagram[30]

8. Types of regulation

Several types of industrial regulation can be distinguished. We mainly mention :

8.1. PID Control

The PID controller (proportional, integrating, derivative or proportional, integral, derivative) is a control system The PID controller (proportional, integrating, derivative or proportional, integral, derivative) is a control system, which allows a closed-loop control of an industrial or "process" system (Figure 3.21). It is the most widely used controller in industry, and allows a large number of physical quantities to be regulated. physical quantities. The controller provides a proportional term (Kp), an integral term (Ki) and a derivative term (Kd)[49]. derivative term (Kd)[49].

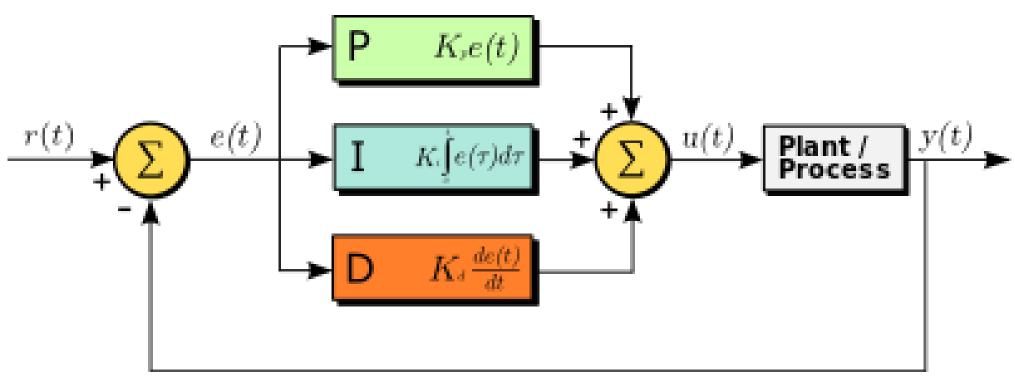

Figure 3.17: Diagram of the PID controller

The advantages

- The best known among the staff
- Best precision
- Robustness

.

The disadvantages

- Difficulty of an optimal adjustment of the coefficients
- Fragile with respect to the noises of measurements

.
We also provide Figure (34) that summarizes the pros and cons of each term of the PID controller.

Controller	Pros	Cons
P	• Easy to Implement	• Long settling time • Steady state error
PD	• Easy to stabilize • Faster response than just P controller	• Can amplify high frequency noise
PI	• No steady state error	• Narrower range of stability

Figure 3.18: summary of the affect of changing PID functions

8.2. Digital control

The simplest of the control techniques is the On/Off (TOR) control. It is used when the dynamics of the dynamics of the process is very slow (large time constant). This control technique is considered as a discontinuous control as a discontinuous control because the command sent to the actuators varies instantaneously. Its realization requires to set a lower and an upper limit of the controlled variable. When the measurement reaches the limit, the actuator controlled by the digital regulator or simply a relay, takes a particular position (stop or on for a heating system). (off or on for a heater, fan, . . .). Figure 3.22 illustrates the operation of the the digital algorithm[49].

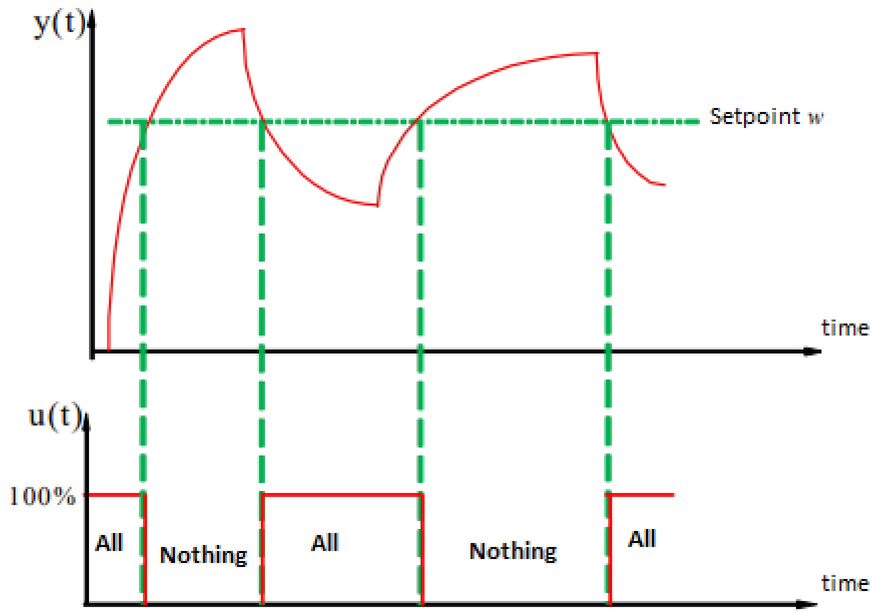

Figure 3.19: Response of a system with a digital controller

The advantages

- Easy to implement
- Inexpensive

.

The disadvantages

- Imprecision
- Energy consumption
- Faster use of actuators can be damaged

.

8.3. Fuzzy logic control

Fuzzy logic is a branch of mathematics and as such a whole series of fundamental notions are developed. These notions allow to justify and demonstrate some basic principles. In the following, we will retain only the elements essential to the comprehension of the principle of the adjustment by the fuzzy logic, These elements are [49] :

- The fuzzy variables
- The rules of inference

.

8.4. Predictive control

Predictive control is mainly used for the control of complex industrial processes. Its principle is intuitive and simple, the objective is to anticipate the future behavior of a process by using a dynamic model inside a controller[54]

8.5. The benefits of predictive control

When one is confronted with the control of systems where classical controllers are insufficient, predictive control becomes a good recourse to remedy this problem.predictive control becomes a good recourse to remedy this problem, because these systems can have important delays, inverse responses and numerous disturbances. The use of predictive control is advantageous, among them we can mention :

- The control concept is easy to understand because it is intuitive.
- Offers the possibility to take into consideration the constraints on the controlled variables.
- The ability to adapt the system to the measured disturbances.
- The smoothness of the control, by a not excessive variation on the manipulated variables.
- A real financial gain by a better use of the actuators, which leads to the extension of their their life span[54].

.

Method	Accuracy	Speed	Stability
TOR	Good	Medium	Poor
PID	Good	Medium	Good
Fuzzy logic	Medium	Good	Medium
Predictive	Poor	Medium	Medium

Figure 3.20: Comparative study between controllers

9. Automatic watering system

9.1. Introduction

This part concerns the automation of the irrigation system to avoid the need for human intervention. The goal is to save water by giving to the plants just the amount they need. Reducing water waste saves money. This automatic watering system will provide an opportunity to study the use of an analog signal from a sensor to activate a powerful actuator (in this case an electric pump).

9.2. Functional principle

Installed near the plant(s) to be monitored, the assembly monitors the dryness state of the earth using a dedicated sensor, by characterizing the resistance of the earth between two electrodes. This information is then used to activate a 12 V pump if necessary to supply the plants with water.

9.3. Notions

The concepts covered in this part are: reading a humidity sensor, using an analog input sensor, use an analog input, use a transistor to switch high powers, drive a motor. to switch high powers, drive a motor.

9.4. Equipment and tools

The necessary equipment is the bare minimum:

- An Arduino UNO.
- An analog soil moisture sensor.
- An electric pump and hoses.
- electric valve.
- A water tank.
- An auxiliary water tank.
- A power supply.

.

9.5. Installation

As shown in the fig below, the soil moisture sensor is rinsed in the soil of the plant and is connected to the analog input of the Arduino board in order to acquire the information and decide whether to activate the watering system or not. The inlet of the pump is connected to the outlet of the reservoir by a channel and the outlet of the pump to the plant. The pump is controlled through the application, by the digital outputs of the Arduino as shown in the figure.

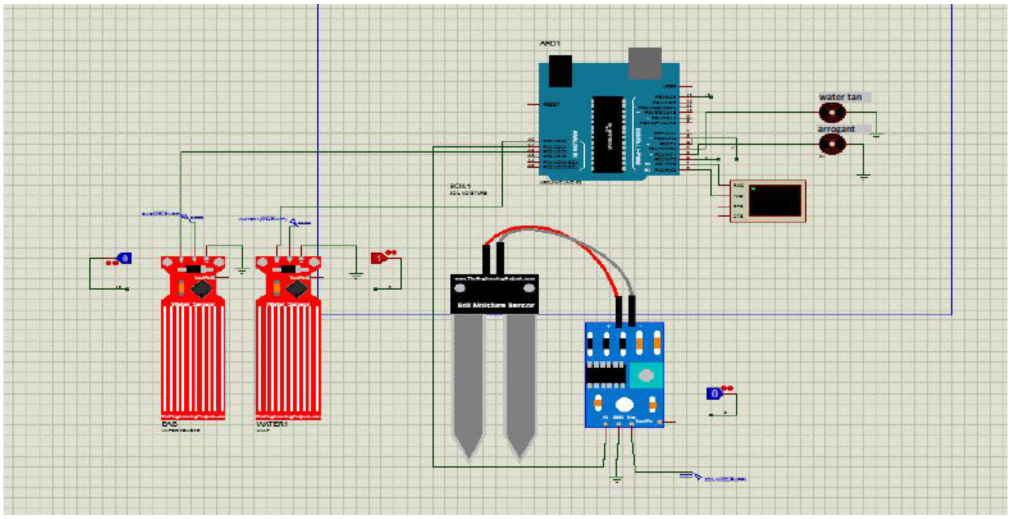

Figure 3.21: Water level detection subsystem schematic

9.6. How soil moisture control works

This is the C language diagram of the Arduino irrigation subsystem operating in an infinite loop. If the captured value is lower than the minimum set point the system runs until the set point is reached and then it stops.

- X : the digital value measured by the sensor
- C : the setpoint variable
- If $X < C$: X is lower than the setpoint,
  then
  the watering pump is triggered.
- If $X > C$: X is greater than the setpoint,
  then
  The irrigation pump is not activated.
- If Y = C : X is within the setpoint range, then there is no reaction.
  Therefore:
- If $Y \approx C$: X is within the setpoint interval there is no reaction.

.

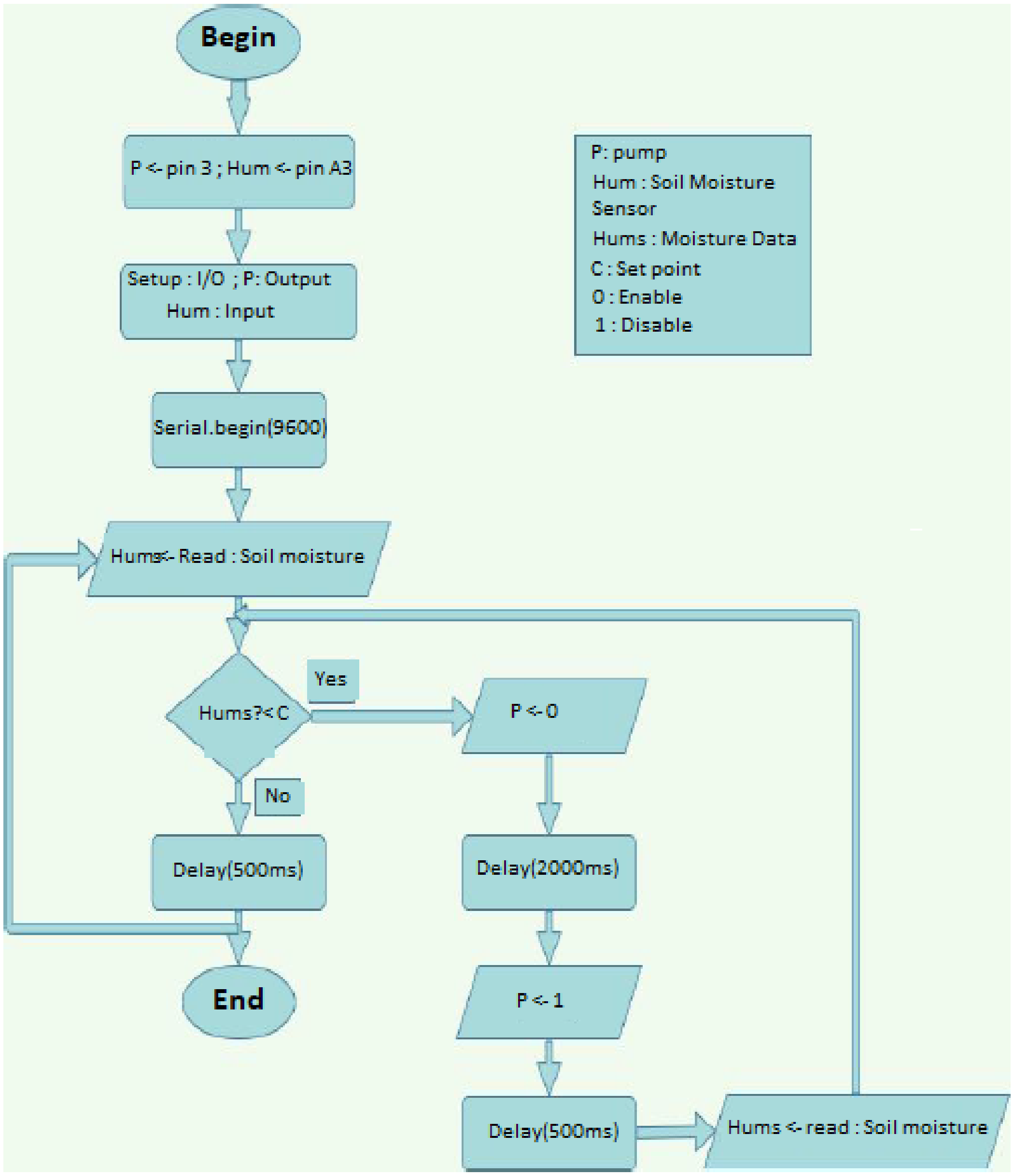

Figure 3.22: Irrigation Subsystem Program Diagram

10. Internet connection system

Connecting the Arduino to an internet network will allow to store the data in real time in the cloud.

10.1. System components and installation.

An ESP 8266 : It is a WIFI shield that allows the Arduino to access a WEB server which will store data in order to make forecasts or to download these data.
Steps to connect the shield with the server :

- Add support for the ESP8266
- Then select the Boards Manager
- Select the esp8266 package
- Choose the target Generic ESP8266 Module

Once the ESP is connected to your computer, select the appropriate COM port.
If the original firmware is still present in the ESP8266, you can communicate with it through the Serial Monitor.

- create a FIREBASE database that will allow us to store data in real time for further use.

.

Chapter VI: Implementation

1. Introduction

To finish the process of conception-realization, we will now design and develop the model of this project by using several tools and new technologies. In this chapter we will describe the functioning of this model with the application that is being implemented, we will specify the software environment supporting our application and we will explain the utility of each tool. Thus, we will describe the stages of the project realization.

2. Presentation of our solution

Our goal is to implement an application that supports smart irrigation through the use of sensors to minimize water consumption. Our system must offer a set of services capable of ensuring the collection of environmental data, such as (temperature, humidity, . . .) from sensors[35]

Figure 4.1: Environment materials and software

3. Physical environment

This part is dedicated to the representation of the list of materials necessary for the realization of our WoT "Smart Green" system.

3.1. Arduino Board

The microcontroller can be programmed to analyze and produce electrical signals, in order to perform a wide variety of tasks such as home automation (control of domestic appliances - lighting, heating, etc.), robot control, embedded computing, etc.

It is simply based on output/input interface. It was originally intended mainly but not exclusively for interactive multimedia programming for shows or artistic animations, which partly explains the descent of its development environment from Processing, itself inspired by the Wiring programming environment (one thought for the production of applications involving graphics and the other for the control of theaters).[68].

Technical characteristics of the Arduino UNO board

- Power supply: via USB port or 7 to 12 V on connector (Min. and max. 6-20V)
- Microprocessor: ATMega328.
- 14 I/O pins including 6 PWM
- 10 bits analog inputs.
- Current per I/O : 40 mA
- Clock speed : 16 MHz
- Serial bus, I2C and SPI
- Interrupt management
- USB B plug
- Dimensions: 74 x 53 x 15 mm
- Original version made in Italy

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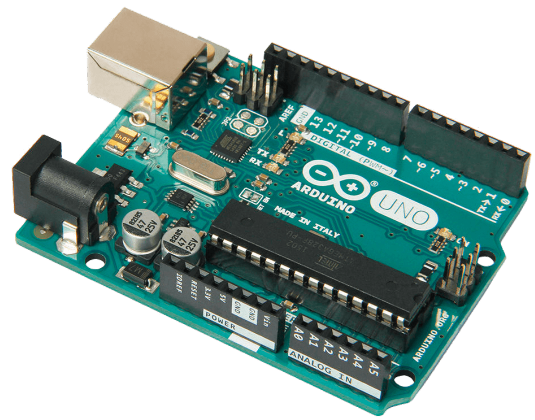

Figure 4.2 - The Arduino UNO card

3.2. The ESP8266-12E module (NodeMCU V3)

The ESP8266 is an integrated circuit with a microcontroller allowing WiFi connection. The modules integrating this circuit are widely used to control peripherals via Internet. The ESP8266 comes with a pre-installed firmware that allows you to take control of it using standard "AT commands" that can come from an Arduino board with which it can communicate by serial link. But all the flexibility and power of this module lies in the fact that you can also develop and flash your own code, making the module completely autonomous.For the Internet of Things (IoT), this small module (25x14 mm) will be very useful. [68]

Features and Electrical Characteristics

- Integrated low power 32-bit CPU could be used as application processor
- Wake up and transmit packets in ¡ 2ms
- Access Point and Station Modes
- Integrated PLLs, regulators, DCXO and power management units
- Integrated TR switch, balun, LNA, power amplifier and matching network
- Integrated TR switch, balun, LNA, power amplifier and matching network
- +19.5dBm output power in 802.11b mode
- Power down leakage current of ¡10uA
- Integrated TCP/IP protocol stack
- SDIO 1.1 / 2.0, SPI, UART
- STBC, 1×1 MIMO, 2×1 MIMO
- A-MPDU A-MSDU aggregation 0.4ms guard interval
- Wake up and transmit packets in ¡ 2ms
- Standby power consumption of ¡ 1.0mW (DTIM3)
- Wi-Fi Direct (P2P), soft-AP
- 802.11 b/g/n

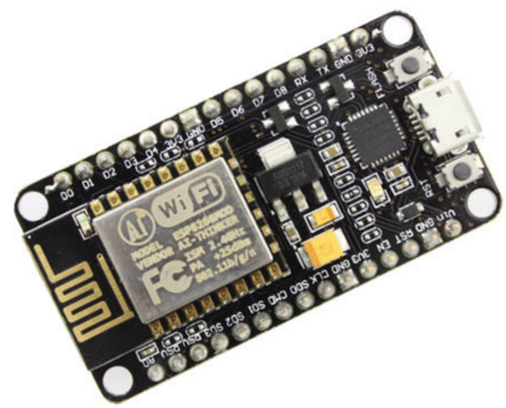

Figure 4.3 – ESP8266 NodeMCU V3

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Programming of the microcontroller

For the programming of the microcontroller, we will use the Arduino development environment because this IDE has many advantages such as:

- Open source and free.
- numerous-platform(windows,mac,Linux).
- Easy to install and clear and intuitive programming.
- Availability of many examples of programs and courses.
- Availability of a large number of libraries that make programming easier.[49]

.

The following figure shows the interface of the Arduino IDE with the program of our microcontroller and actuators.

```
ESP8266WebServer server(80);

void handleRoot() {
  server.send(200, "text/html", "<form action=\"/LED_BUILTIN_on\"
}
void handleSave() {
  if (server.arg("pass") != "") {
    Serial.println(server.arg("pass"));
  }
}
void setup() {
  pinMode(LED_BUILTIN, OUTPUT);
  delay(3000);
  Serial.begin(115200);
  Serial.println();
  Serial.print("Configuring access point...");
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
```

Figure 4.2: Arduino Program

Soil moisture sensor

Soil moisture sensors sense the amount of water in the soil. The sensors are stationed or moved like probes. Stationary sensors can be placed at the locations in the field where the portable sensor probes can sense soil moisture at several locations.
There are two categories of soil sensors depends on which category used :
1) Sensors to sense volume of water content
2) Sensors that sense soil moisture when placed in the soil.

Characteristics

- Interface: PH2.0-3P
- Size: 99x16mm / 3.9x0.63 ”
- Output voltage: DC 0-3.0V
- Version: V 1.2
- Interface: PH2.0-3P
- Analog output
- Size: 99x16mm / 3.9x0.63 ”
- Output voltage: DC 0-3.0V

.

Figure 4.6 – Soil Moisture Sensor

Water Pump

The irrigation pump used in our project is a mini submerged water pump. The pump is a device that allows to suck in and to discharge a fluid, the choice of a pump is always made according to its use and the determination of the performance parameters for our irrigation system, we need a watering pump, that is to say a pump is the organ that provides the soil with the water that the plants need to keep the soil moisture at the set level. For our prototype, we used a pump (Figure 4.20), powered by a 220v voltage source and controlled by a power circuit L293D[49].

Figure 4.7 – Mini Water Pump 220v

4. Software environment

To realize our application and to make our system work we used several programming languages, so we used the development tools with these languages.

4.1. Programming languages

Arduino

The Arduino language is based on C/C++ . The programming language of Arduino programming language is in fact an wiring implementation (a similar open source computing platform for physical computing which itself proposed a library called Wiring that simplifies input/output operations). It is composed of the two mandatory functions:

- The setup() initialization function which is executed only once at startup.
- The "loop without fifin" function loop() which is executed in a loop once the the setup() function has been executed once.

.

Android Studio

Android Studio may be a new surroundings for totally integrated development and programming that was recently launched by Google for android systems. it had been designed to produce a development surroundings and another to Eclipse that is that the most generally used IDE:

- A unified environment where you can develop for all Android device
- A fast and feature-rich emulator
- Built-in support for Google Cloud Platform, making it easy to integrate Google Cloud Messaging and App Engine
- Lint tools to catch performance, usability, version compatibility, and other problems
- A flexible Gradle-based build system
- Apply Changes to push code and resource changes to your running app without restarting your app
- Code templates and GitHub integration to help you build common app features and import sample code
- Extensive testing tools and frameworks

.

Fire Base

Firebase is the name of a mobile platform from Google that facilitates the creation of scalable and high-performance back-end. In other words, it's a platform that allows you to quickly develop applications for mobile and for the web.
The goal of creating Firebase.google.com in 2011 by James Tamplin and Andrew Lee is to save professionals and individuals from engaging in the complex process of creating and maintaining a server architecture.
Moreover, the platform can be operated by several users at the same time without experiencing any bugs. Practicality is also at the rendezvous thanks to its intuitive functionalities. Since the platform was acquired by Google in 2014, Firebase sdks has undergone numerous improvements and never ceases to satisfy its users.

4.2. Development platform and software tools

Arduino IDE

The creators of Arduino have developed a software to make the programming of arduino boards visual, simple and complete at the same time. This is called an IDE, which stands for Integrated Development Environment.
The Arduino IDE is the software that allows you to program the Arduino boards.
The IDE displays a graphical window that contains a text editor and all the tools necessary for the programming activity. You can enter your program, save it, compile it, check it, transfer it to an Arduino board...

- To modify a program: sketch.
- Compile a program in the language that arduino machine uses.
- To upload the program to the Arduino's memory.
- With the terminal that allows the communicate with arduino board[68].

.

Proteus

Proteus is an electronic CAD software, published by Labcenter Electronics and resold in France exclusively by Multipower. Proteus is currently (2020) the only electronic CAD that allows the design of a complete electronic system and its simulation, including microcontroller code. To this end, it includes a schematic editor (ISIS), a placement-routing tool (ARES), an analog-digital simulator, an integrated development environment for microcontrollers, an algorithmic programming module and an interface editor for smartphones to control Arduino or Raspberry boards remotely.
Proteus is composed of different packages which are: Proteus PCB for the printed circuit board, Proteus VSM for simulation, Proteus Visual Designer/IoT Builder for Arduino/Raspberry to develop projects comparable to those designed with tools such as Scratch and App inventor

- Pack containing software that is quick and easy to understand and use.
- The technical support is efficient.
- The virtual prototype creation tool helps reduce hardware and software costs during the design of a project

.

The Mobile Applications

A mobile application is a software application developed for a mobile electronic device, such as a PDA, a cell phone, a smartphone, a digital music player, a touch-sensitive tablet, or even certain computers running the Windows Phone or Chrome OS operating system.

They are mostly distributed from download platforms (sometimes themselves controlled by smartphone manufacturers) such as the App Store (Apple's platform), the Google Play (Google / Android platform), or the Microsoft Store (Microsoft's platform for Windows 10 Mobile). But applications can also be installed on a computer, for example through the iTunes software distributed by Apple for its devices. The applications distributed from the application stores are either paid or free, but usually with advertisements.[15].

Mobile Application Qualities

- Greater functionality as they have access to system resources
- Easier to build due to the availability of developer tools, interface elements and SDK
- downloaded and installed via google play or android store and can have access to GPS and camera.
- improved networking capabilities

.

5. Realization of the connected object

5.1. Connection of all components of the connected object

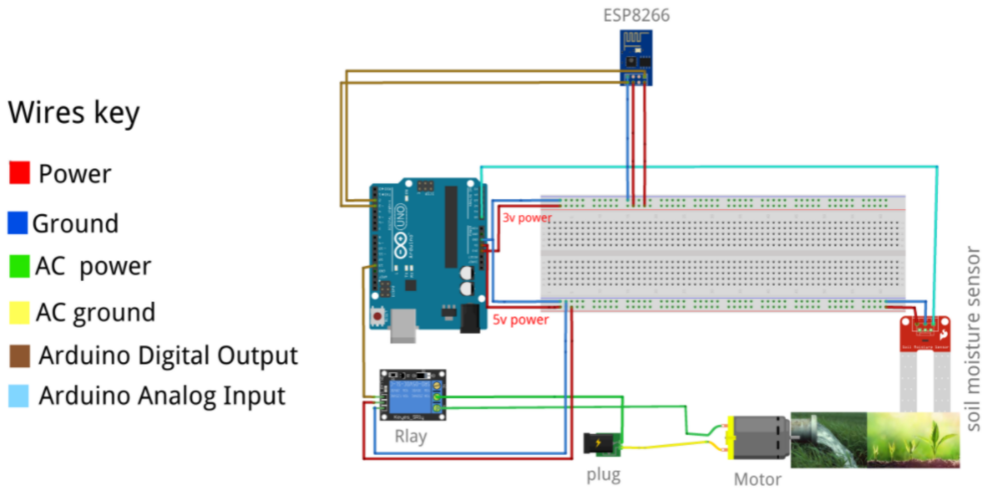


Figure 4.3: Connection of all the components of the connected object

5.2. Proteus simulation

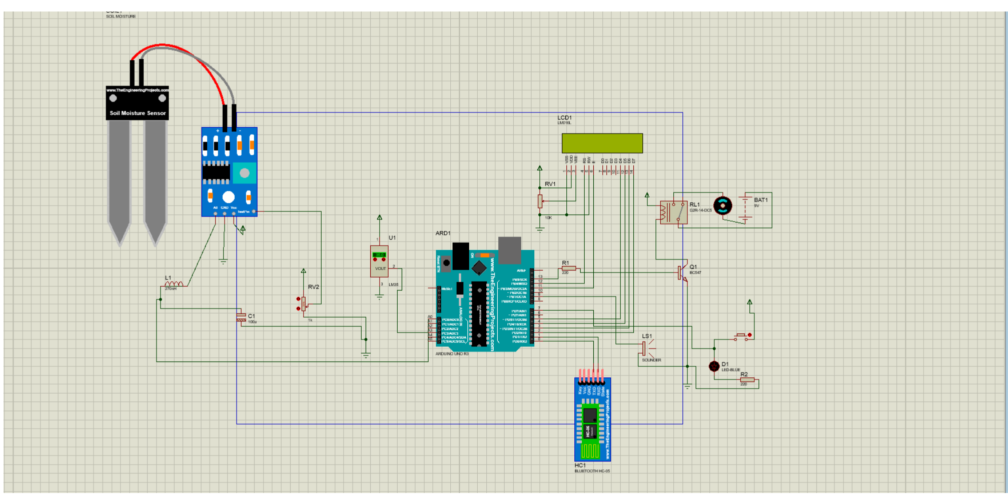


Figure 4.4: Your caption

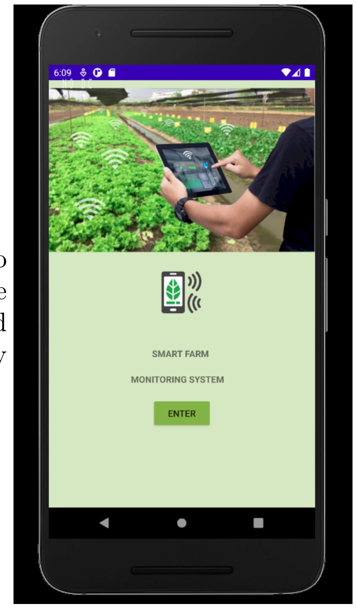
In this simulation we linked a moisture sensor to an arduino UNO device providing other devices to manipulate temperature and humidity to make this simulation as real as possible,also providing a visual display screen to show data retrieved from the sensor. The pump linked need to be turned on by a button ,if they plants are in need of water the pump is not powered up a sounder will alert the farmer. Lastly providing a wireless to make the connection between the mobile application and the arduino possible thus allowing data to be transferred from the mobile application to the arduino and the other way around.

5.3. App presentation

We developed this interface in a form of a mobile application to monitor and water our plants remotely wirelessly and in real time and that is just by a simple connection from the application to the arduino monitoring system.

Part 1

This is the homepage of the application,We chose a simple layout to be easily used and understood by the user,the light colors specially the light green color was used to reduce eye strain and be more friendly and joyful,also the green color represent nature and plants making it easily recognized as an application involving plants



Part 2

In this window we can see the data retrieved from the sensor in real time as it shown in the figure,The user can check on temperature and humidity of the soil and if the numbers ought to be a little bit confusing there is a status tab where it show the status of the plant (soggy,moist,dry) and its up to him to choose the right action.
so his action vary from manually watering his plants or setting up the automatic mode leaving it a fully automated farm ,if his action was taking over manual control then he will assume control over the pump turning it on and off as he please therefore disabling automatic control.
if the farmer then chooses the automatic control manual control will be disabled and the pump will be turned on and off depending the data retrieved from the sensor leaving the application take care of the plants.

General conclusion

We have designed and produced a system to obtain a optimized watering system with the regulation of the parameters most influencing plant development. In this work we have tried to get to know the different parts better. constitutive of our system and throughout our research we have tried to use our knowledge in the electronic and IT field of a a simple, direct and comprehensive way, Several theoretical and practical notions have been presented, Using in the practical part several software programming such as Proteus, which allowed us to simulate our job. The main function of the card carried out is automatic control and watering control. And for the future we have thought about integrating a renewable energy source consisting of a solar panel and a battery to make the project more reliable.

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