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DEDICATION

This work is dedicated to:

The man of my life, my eternal example, my moral and happiness source, the one who has always sacrificed himself to see me succeed, ***my father.***

The light of my days, the source of my efforts, the flame of my heart, my life and my happiness, ***my mother****.*

May God save you and give you health and long life and give me the power to make you always proud of me.

My dear brothers and sisters who were always by my side ***"Abderahim, Souheila, Mohamed Amine, Hamza and NourElhouda"***

My sweety nephews and niece ***"Heithem and Omaima".***

My grandmothers, grandfathers and my dear uncles and aunts.

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*My dear project mate "****Khaoula"*** *and my faithful friend "****Fatima".***

To those who have always helped and encouraged me, and who accompanied me during my path of Graduate Studies, my dear and adorable friends ***"Lamia, Kawthar, Intissar, Bouthaina,Madjeda,Soumaya,Fadila,Amina,Ikram, Djouhaina,Nesrine"****,Study Colleagues* ***"Khouloud,Khaoula,Aicha,Narimene,Hakim,Ahmed…*** *" and all Industrial data processing promotion.*

God keep you, enlighten your path and help you achieve in your turn your dearest wishes.

AMIRA

DEDICATION

I dedicat this work :

TO MY MOTHER KHADIDJA

You gave me life and courage to succeed, All what I can offer you, can't express the love and gratitude that I hold for you. I offer you this modest work to thank you for your sacrifices and for the tenderness with which you have always surrounded me.

TO MY FATHER TAYEB

Solid shoulder, understanding eye, and person most worthy of my esteem and respect, No dedication could express my feelings, may God save you and give you health and long life.

***Mum and dad**, who love me unconditionally ,have taught me to work hard for the things that I aspire to achieve. Throughout my life you have always been there during all difficulties and hard times. All my love to you.*

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KHAOULA

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Abreviationslist

6LoWPAN:IPv6 Low power Wireless Personal Area Networks

AWS: Amazon Web Services

BAW: bulk acoustic wave

BLE: Bluetooth Low-Energy

CoAP: Constrained Application Protocol

DSDV: Destination-Sequenced Distance-Vector

HTTP: HyperText Transfer Protocol

IEEE: Institute of Electrical and Electronics Engineers

IIoT: The Industrial Internet of Things

IoT: Internet of Things

LTE: Long-Term Evolution

LVDT:Linear Variable Differential Transformer

MQTT: Message Queuing Telemetry Transport

NAS: National Security Agency

OSI: Open Systems Interconnection

QoS: quality of service

RESTful: Representational state transfer

SGBD: Database management system "Système de Gestion de Bases de Données"

UDP: User Datagram Protocol

WSN: Wireless sensor network

XMPP: Extensible Messaging and Presence Protocol

Abstract:

The emergence of Internet of things opens new perspectives in the domain of wireless sensor network with an objective to connect them to the Web for share measurements in real time. In this context, our project consist of a partial conception of technical platform dedicated to the Internet of things "IoT" for weather monitoring in particular place, where the sensor data are presented as graphical statistics to the system user . For the realization of this platform, we have used several hardware and software tools: the **Raspberry pi 3** as platform to connect the **BME280** sensor, **JAVA** as a developing language for the application, **MySQL** Workbench as an **SGBD**,in the cloud we have benefit of the following services **AWS RDS** for the storage and **elastic beanstalk** as the container of the web application.

Key words:wireless sensor network, Cloud, Raspberry Pi, weather monitoring, Internet of things.

Résumé:

L'émergence de l'Internet des objets ouvre de nouvelles perspectives dans le domaine desréseaux de capteurs sans fil avec comme objectif de connecter ces derniers au web pourpartager des mesures en temps réel. Dans ce contexte, notre projet consiste d'une conception partielle d'une plateforme technique dédié à l'internet des objets pour la surveillance de la météo, où les données sont présentées comme des statiques graphiques pour l'utilisateur du système. Pour la réalisation de cette plateforme , nous avons utilisé quelque matériels et des outils logiciels :la **Raspberry Pi 3** comme une plateforme pour connecter le capteur **BME280**, **JAVA** comme une langage de développement pour l'application ,**MySQL** Workbench comme un SGBD , dans le Cloud nous avons profité des services suivants: **AWS RDS** pour le stockage et **Elastic Beanstalk** et le conteneur de l'application web .

Mots clés :Réseaux de capteurs sans fil, **Cloud**,**Raspberry Pi**, surveillance de la météo, internet des objets.

ملخص:

ظهور إنترنت الأشياء يفتح آفاقا جديدة في مجال شبكة الاستشعار اللاسلكية بهدف ربط هذه الأخيرة إلى الانترنت لتبادل القياسات في الوقت الحقيقي. في هذا السياق، يتكون مشروعنا من مفهوم جزئي للمنصة التقنية المخصصة لشبكة إنترنت الأشياء "IoT" لرصد الطقس في مكان معين، حيث يتم عرض بيانات الاستشعار كإحصاءات رسومية لمستخدم النظام .من أجل تحقيق هذا المنصة، استخدمنا العديد من الأجهزة والبرمجيات: **Raspberry Pi 3** كمنصة لربط جهاز استشعار**BME280**، **JAVA** كلغة النامية للتطبيق، **MySQL** منضدة **SGBD**، **في Cloud**نستفيد من الخدمات التالية **AWSRDS**:لتخزين **Elastic Beanstalk**حاوية للتطبيق.

الكلمات المفتاحية: شبكة الاستشعار اللاسلكية، **Cloud**، **Raspberry Pi**، رصد الطقس، إنترنت الأشياء.

General introduction

With the recent technological advances in wireless technologies and the growing popularity of computing devices, information processing has become ubiquitous and part of everyday activities. Cars, electrical appliances, toys, and clothes can be fitted with microprocessors, sensors and communication devices that allow them to be interconnected and interact with each other. Present innovations in technology are increasingly emerging to reach the human needs and mainly focus on monitoring and controlling his different activities. An efficient environmental monitoring system is required to monitor and assess the conditions in case of exceeding the prescribed level of parameters (e.g., noise, CO and radiation levels). An environment becomes a self-protecting and self-monitoring environment (smart environment) when it is equipped with sensor devices, microcontroller and various software applications and those equipments form a sensor network.

A wireless sensor network (WSN) is a network formed by a large number of sensor nodes where each node is equipped with a sensor to detect physical phenomena such as light, heat, pressure, etc. WSNs are regarded as a revolutionary information gathering method to build the information and communication system which will greatly improve the reliability and efficiency of infrastructure systems. Compared with the wired solution, WSNs feature easier deployment and better flexibility of devices. With the rapid technological development of sensors, WSNs will become the key technology for IoT.

Internet of Things (IoT) is an integrated part of Internet and could be defined as a dynamic global network infrastructure with self configuring capabilities based on standard and interoperable communication protocols where physical and virtual ‘things’ are linked and being able to identify themselves to other devices and have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network.

The system proposed in our work can be a solution used in areas where the weather conditions are required to be monitored to maintain the healthy growth in crops and to ensure the safe working environment in industries...etc. this can be released by the gathering of the environmental conditions like temperature, humidity, pressure.., for controlling the changes and take the right actions.

Our objective is a Partial conception of a technical platform dedicated to the internet of things "IOT" as a weather monitoring system of particular places. For establishing a connection between the sensor network and internet, we used the Wi-Fi, the environmental parameters are informations collected and sent to the cloud database for publishing in the web application interface and then plot the sensor data as graphical statistics. The cloud offers the development of the web application for the monitoring and the storage of the collected data into a data base.

In this work we discuss the use and evolution of WSNs and the wider context of IoT.

In the first chapter we provide a review of WSN which contain firstly a section for the sensors classifications and characteristics then a second section for the wireless sensor network which focuses the attention on WSNs architecture, characteristics, applications and standards featured and finally security in WSN.

In the second chapter in the first section we mention the history of IoT then we assessed the typologies of IoT objects, technologies and standards in IoT, the architecture of IoT then describing the communication models and applications and finally the advantages and disadvantages of IoT. A second section about the cloud types and services.

In the third chapter we present the core of our work, with the different hardware and software tools that we have used in our project, also a detailed description for all the steps of the realization of the application.

Finally, we conclude with a general conclusion containing the results of our system and some prospects for future work.

CHAPITRE 1

Wireless Sensor Network

1.1.Introduction

In recent years, the need to observe, analyze and control physical world over large areas is essential for many environmental and scientific applications. The most successful solution to meet these needs is the use of wireless sensor networks (**WSN**). The WSN is consisting of a large number of nodes, where each node is connected with single or multiple sensors that communicate wirelessly. Their mission is most often to monitor an area, to take regular measurements and to raise alarms to certain nodes of the network. They are equipped with computing capacity to facilitate a lot of applications Unrealistic or expensive. This is due to the availability of cheap, low powered miniature components. WSNs can be deployed on a global scale for environmental monitoring and habitat study, over a battle field for military surveillance and reconnaissance, in emergent environments for search and rescue, in factories for condition based maintenance, in buildings for infrastructure health monitoring, in homes to realize smart homes, or even in bodies for patient monitoring [1].

WSN change the human life to the best because of its vast and rapidest development in various application domains. It can be deployed quickly in sensitive and inaccessible areas. In this chapter, we present the wireless sensor networks. We begin with a definition of a WSN, its architecture, characteristics, different hardware and software platforms, the fields of application of the WSN, routing and security in WSN and a small conclusion.

1.2.Sensors

Sensors are pervasive. They are embedded in our bodies, automobiles, airplanes, cellular telephones, radios, chemical plants, industrial plants and countless other applications.

1.2.1. Definition

A sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena. The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing. [2]

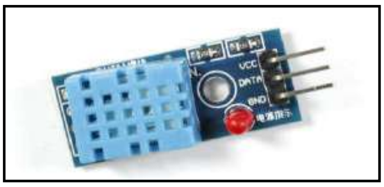

Figure 1.1: DHT11 humidity temperature sensor

1.2.2. Sensor classification

Sensors are classified based on the nature of quantity they measure. Following are the **types of sensors** with few examples:

- Based on the quantity being measured:

  Temperature: Resistance, Temperature, Detector (**RTD**), Thermistor.

  Pressure: Bourdon tube, manometer, diaphragms, pressure gauge

  Speed/ position: Tachometer, encoder, LVDT

  Light: Photo-diode, Light dependent resistor And so on.

- **Active and passive sensors:** Based on power requirement sensors can be classified as active and passive. Active sensors are those which do not require external power source for their functioning. They generate power within themselves to operate and hence called as self-generating type. The energy for functioning is derived from the quantity being measured. For example, piezoelectric crystal generates electrical output (charge) when subjected to acceleration. Passive sensors require external power source for their functioning. Most of the resistive, inductive and capacitive sensors are passive (just as resistors, inductors and capacitors are called passive devices). [3]
- **Analog and digital sensor:** An analog sensor converts the physical quantity being measured to analog form (continuous in time). Thermocouple, RTD and Strain gauge are called analog sensors. A digital sensor produces output in the form of pulse. Encoders are example of digital sensors. [3]
- **Inverse sensors:** There are some sensors which are capable of sensing a physical quantity to convert it to other form and also sense the output signal form to get back the quantity in original form. For example, a piezoelectric crystal when subjected to vibration generates voltage. At the same time when a piezocrystal is subjected to varying voltage they begin to vibrate. This property makes them suitable to use in microphone and speakers. [3]

1.2.3. Characteristics of Sensors

A good sensor should have the following characteristics:

- **High Sensitivity:** Sensitivity indicates how much the output of the device changes with unit change in input (quantity to be measured). For example, the voltage of a temperature sensor changes by 1mV for every 1^{o}C change in temperature than the sensitivity of the sensor is said to be 1mV/^{o}C. [3]

- **Linearity:** is the maximum deviation between the measured values of a sensor from ideal curve. [3]
- **High Resolution:** This specification is the smallest detectable incremental change of input parameter that can be detected in the output signal. Resolution can be expressed either as a proportion of the reading (or the full-scale reading) or in absolute terms. [4]
- **Accuracy**: is the maximum difference that will exist between the actual value (which must be measured by a primary or good secondary standard) and the indicated value at the output of the sensor. Again, the accuracy can be expressed either as a percentage of full scale or in absolute terms. [4]
- **Less Noise and Disturbance**: Noise refers to random fluctuations in the output signal when the measured is not changing. Its cause may be either internal or external to the sensor. Mechanical vibrations, electromagnetic signals such as radio waves and electromagnetic noise from power supplies, and ambient temperatures, are all examples of external noise. [5]
- **Less power consumption.**
- **Range:** The range of the sensor is the maximum and minimum values of applied parameter that can be measured. For example, a given pressure sensor may have a range of -400 to +400 mm Hg. Alternatively, the positive and negative ranges often are unequal. [4]
- **Stability**: The sensor's ability to produce the same output value when measuring a fixed input over a period of time. [5]

1.2.4. Commonly Detectable Phenomena

Sensors are generally grouped into three categories; each category has its specific measured parameters. Scalability and field-readiness are two features which are attributed to each parameter of those in the table below:

Table 1.1: Commonly Detectable Phenomena

Sensor Category	Parameter	Field-Readiness	Scalability
Physical	Temperature	High	High
	Moisture	High	High
	Pressure	High	High
	Light transmission	High	High
Chemical	pH	High	High
	Dissolved Oxygen	High	High
	Oxydation	Medium	High
	Heavy metals	Low	Low
	Organic Compounds	Low	Low
Biological	Microorganisms	Low	Low
	Biologically active contaminants	Low	Low

1.3. Wireless sensor network

1.3.1. Definition of WSNs

A Wireless sensor network can be defined as a network of devices (sensors) that can communicate the information gathered from a monitored field through wireless links. The data is forwarded through multiple nodes, and with a gateway it's connected to other networks like wireless Ethernet. These networks are used to monitor physical or environmental conditions like sound, pressure, temperature and cooperatively pass data through the network to a main location and organizing the collected data at a central location. [6]

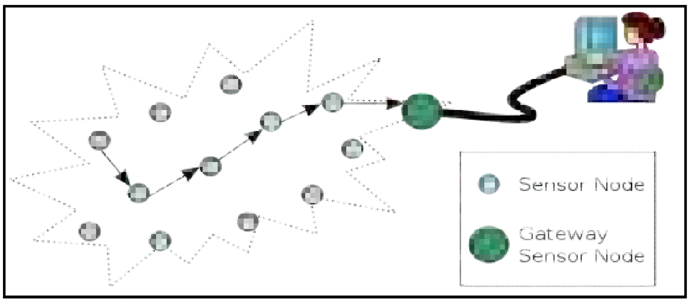

Figure 1.2: Wireless sensors network

A Wireless Sensor Network is a self-configuring network of small sensor nodes communicating among themselves using radio signals, and deployed in quantity to sense, monitor and understand the physical world [7]. The WSNs nowadays usually include sensor nodes, actuator nodes, gateways and clients. A large number of sensor nodes deployed randomly inside of or near the monitoring area (sensor field), form networks through self-organization. Sensor nodes monitor the collected data to transmit along to other sensor nodes by hopping. During the process of transmission, monitored data may be handled by multiple nodes to get to gateway node after multi hop routing, and finally reach the management node through the internet or satellite. [8]

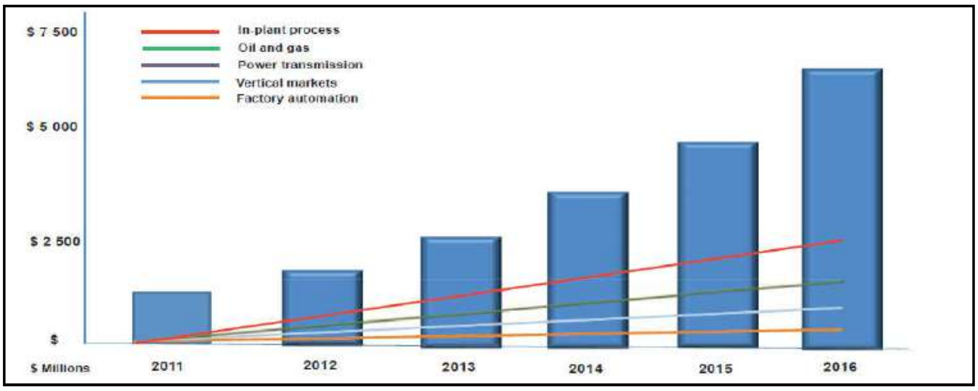

Figure 1.3: Growth in revenues generated by the sensor network

- **Sensor node component:** Wireless sensor nodes are equipped with sensing unit, a processing unit, communication unit and power unit. Each and every node is capable to perform data gathering, sensing, processing and communicating with other nodes. The sensing unit senses the environment, the processing unit computes the confined permutations of the sensed data, and the communication unit performs exchange of processed information among neighboring sensor nodes. The basic building block of a sensor node is shown in figure. [9]

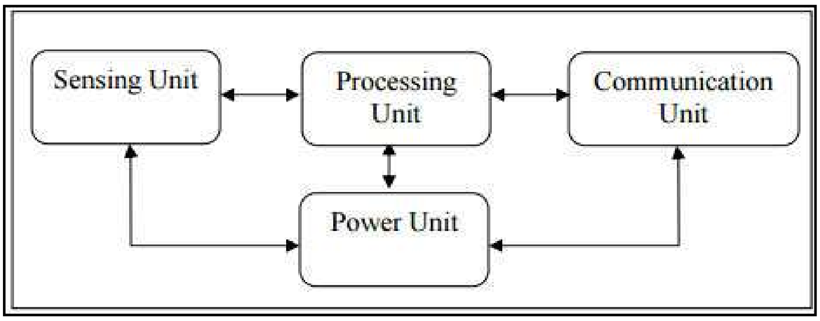

Figure 1.4: Basic Building Blocks of Sensor Node

1.3.2. Architecture of WSNs

The most common WSN architecture follows the **OSI** architecture Model. The architecture of the WSN includes five layers. These layers of the WSN are used to accomplish the network and make the sensors work together in order to raise the complete efficiency of the network. Please follows the below link for: [6]

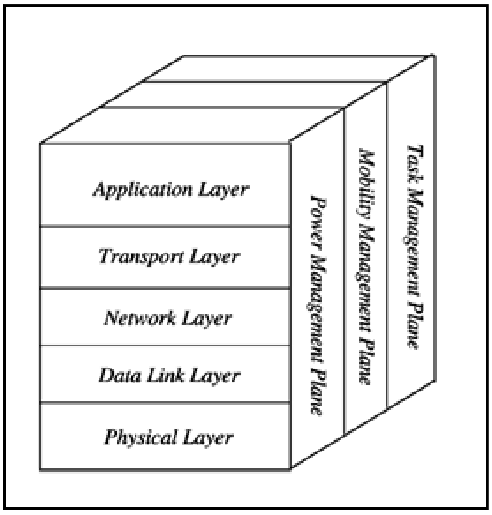

Figure 1.5: Wireless Sensor Network Architecture (stacks)

- **Physical Layer:** The objective of physical layer is to increase the reliability by reducing path loss effect and shadowing. This layer is responsible for established connection, data rate, modulation, data encryption, signal detection, frequency generation and signal detection. [10]
- **Data Link Layer:** The objective of Data link layer is to insure interoperability amongst communication between nodes to nodes. This layer is responsible for error detection, multiplexing. Prevention of Collision of packets, repeated transmission …etc. [10]
- **Network Layer:** The objective of Network layer is to find best path for efficient routing mechanism. This layer is responsible for routing the data from node to node, node to sink, node to base station, node to cluster head and vice versa. In WSN, each node in the network acts as a router (because they use broadcast mechanism), so as to create secure routing protocol. Encryption and decryption techniques are used for secure routing. [10]
- **Transport Layer:** The objective of Transport Layer is to establish communication for external networks i.e. sensor network connected to the internet. This is most challenging issue in wireless sensor networks. [10]
- **Application Layer:** The objective of Application Layer is to present final output by ensuring smooth information flow to lower layers. This layer is responsible for data collection, management and processing of the data through the application software for getting reliable results. **SPINS** (Security Protocols in sensor Networks) provides data authentication, replay protection, semantic security and low overhead. [10]

1.3.3. Topologies in WSN

There are four common sensor network topologies:

- **Point to point network topology:** In this topology, there is no central hub. A node can communicate directly to another node. This is the most common topology and it has a single data communication channel which offers a secure communication path. Each device can act as a client and a server in it. [11]

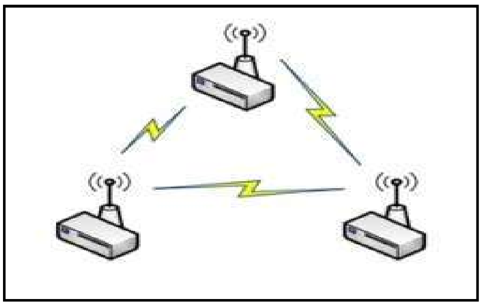

Figure 1.6: Point to point topology

- **Star network topology:** Unlike point to point networks, a centralized communication hub is present in a star network. Each communication is done through this centralized hub and no direct communications between the nodes are possible. In this case, central hub is the server and the nodes are clients. [11]

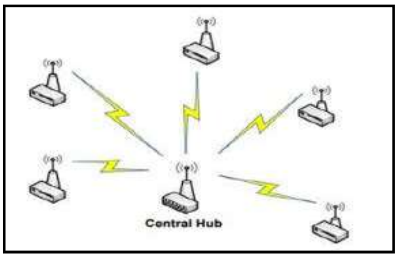

Figure 1.7: Star topology

- **Tree network topology:** This topology is said to be a hybrid of point to point and star topologies. The central hub in it is called a root node or the parent node. Data is passed on from leaf nodes to the parent node. The main advantage of this topology is less power consumption as compared to other networks. [11]

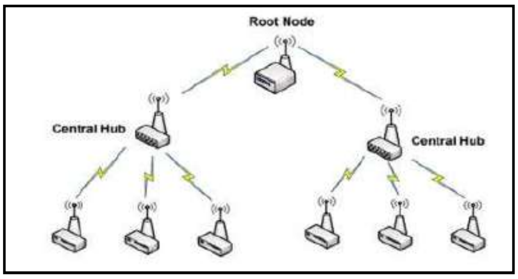

Figure 1.8: Tree topology

- **Mesh network topology:** In the mesh network, the data can 'hop' from one node to another. All the nodes can communicate with each other directly without having to depend on a central communication hub. This is the most reliable structure of network communication because there is no single point of failure in it. But this structure is very complex and requires a lot of power consumption. [11]

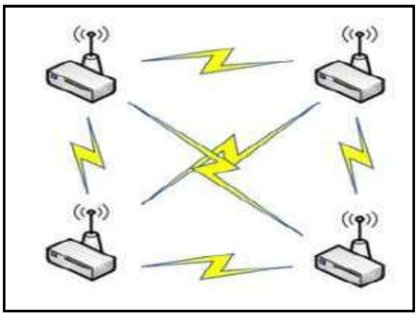

Figure 1.9: Mesh topology

1.3.4. Characteristics of WSNs

WSN is currently used for real-world unattended physicalenvironment to measure numerous parameters. So, thecharacteristics of WSN must be considered for efficientdeployment of the network. The significant characteristics ofWSN are described as follows: [12]

- **Energy efficient:** Energy in WSN is used for different purpose such as computation, communication and storage. Sensor node consumes more energy compare to any other for communication. If they run out of the power they often become invalid as we do not have any option to recharge. So, the protocols and algorithm development should consider the power consumption in the design phase. [12]
- **Fault tolerance:** Each node in the network is prone to unanticipated failure. Fault tolerance is the capability to maintain sensor network functionalities without any break due to sensor node failures.
- **Frequent topology change:** Network topology changes frequently due to the node failures, damage, addition, energy depletion, or channel fading. [13]
- **Security and Privacy:** Each sensor node should have sufficient security mechanisms in order to prevent unauthorized access, attacks, and unintentional damage of the information inside of the sensor node. Furthermore, additional privacy mechanisms must also be included. [12]
- **Self-organization:** The sensor nodes in the network must have the capability of organizing themselves as the sensor nodes are deployed in an unknown fashion in an

unattended and hostile environment. The sensor nodes have work in collaboration to adjust themselves to the distributed algorithm and form the network automatically. [12]

- **Heterogeneity of nodes:** The sensor nodes deployed in the WSN may be of various types and need to work in a cooperative fashion.
- **Battery-powered sensor nodes:** Sensor nodes are usually powered by battery and are deployed in a harsh environment where it is very difficult to change or recharge the batteries. [13]
- **Multi-hop communication:** a large number of sensor nodes are deployed in WSN. So, the feasible way to communicate with the sinker or base station is to take the help of an intermediate node through routing path. If one needs to communicate with the other node or base station which is beyond its radio frequency it must be through the multi-hop route by intermediate node. [12]

1.3.5. Applications of WSNs

There are numerous applications of WSNs in industrial automation, traffic monitoring and control, medical device monitoring and in many other areas. Some of applications are discussed below:

- **Military applications:** As the WSNs can be deployed rapidly and are self-organized therefore they are very useful in military operations for sensing and monitoring friendly or hostile motions. The battlefield surveillance can be done through the sensor nodes to keep a check on everything in case more equipment, forces or ammunitions are needed in the battlefield. The chemical, nuclear and biological attacks can also be detected through the sensor nodes. [9]
- **Environmental applications:** These sensor networks have a huge number of applications in the environment. They can be used to track movement of animals, birds and record them. Monitoring of earth, soil, atmosphere context, irrigation and precision agriculture can be done through these sensors. They can also be used for the detection of fire, flood, earthquakes, and chemical/biological outbreak …etc. [9]
- **Medical applications:** In health applications, the integrated monitoring of a patient can be done by using WSNs. The internal processes and movements of animals can be monitored. Diagnostics can be done. They also help in keeping a check on drug administration in hospitals and in monitoring patients as well as doctors.[9]
- **Home applications:** As the technology is advancing, it is also making its way in our household appliances for their smooth running and satisfactory performance. These

sensors can be found in refrigerators, microwave ovens, vacuum cleaners, security systems and also in water monitoring systems. The user can control devices locally as well as remotely with the help of the WSNs. [9]

- **Commercial applications:** We can cite also as commercial application of WSNs: The environmental control in industrial and office buildings, inventory control, vehicle tracking and detection, traffic flow surveillance. [9]

1.3.6. Software in WSNs (Operating Systems)

There are several operating systems used in the WSNs, TinyOS and Contiki are two of the most widespread operating systems. Other operating systems developed for WSNs include MANTIS, SOS, SensorOS and MagnetOS. Among them we describe:

- **TinyOS:** is an open source, flexible, component based, and application-specific operating system designed for sensor networks. TinyOS can support concurrent programs with very low memory requirements. The OS has a footprint that fits in 400 bytes. The TinyOS component library includes network protocols, distributed services, sensor drivers, and data acquisition tools. The following subsections survey the TinyOS design in more detail. [15] TinyOS is written in nesC, an extension to the C language**.** [5]
- **Raspbian:** Is a free operating system released in July 2012 that runs on the Raspberry Pi single-board hobbyist computer. It is derived from Debian Linux, and uses the LXDE desktop environment. [15] Raspbian is formed by the fusion of the words "Raspberry Pi" and "Debian". This is a modification of Debian Wheezy specifically adapted for ARMv6 chips with FPU. Raspbian uses software known to be lightweight, such as the LXDE window manager and the Midori web browser.
- **Contiki:** Is a lightweight open source OS written in C for WSN sensor nodes. Contiki is a highly port able OS and it is built around an event-driven kernel a typical Contiki configuration consumes 2 kilobytes of RAM and 40 kilobytes of ROM. A full Contiki installation includes features like: multitasking kernel, preemptive multithreading, proto-threads, **TCP/IP** networking, **IPv6**, a Graphical User Interface, a web browser, a personal web server, a simple telnet client, a screensaver, and virtual network. [14]

1.3.7. Communication technologies in WSNS

- **Bluetooth IEEE802.15.1:** Bluetooth wireless technology is a short-range communication system intended to replace the cables in **WPANs**. The key features of Bluetooth wireless technology are robustness, low power, and low cost [16]**.**
  Bluetooth is a personal area network (**PAN**) standard. It was originally specified to serve applications such as data transfer from personal computers to peripheral devices such as cell phones or personal digital assistants. Bluetooth uses a star network topology that supports up to seven remote nodes communicating with a single base station. [17]
- **Bluetooth low energy:** basically, it is the simplified version of Bluetooth. BLE remains in sleep mode except when a connection is initiated. This makes it ideal for wearable fitness trackers and health monitors [16]. It uses the same physical layer in 2.4 GHz ISM used by Bluetooth for interoperation with existing Bluetooth devices and allows 1 Mbit/s data rates in up to 10 meters range. Bluetooth low energy is designed to be very efficient at transmitting very small quantities of data at very low latencies to other devices. When compared to classic Bluetooth technology, it is for maximum 15 times more efficient**.** [18]
- **Zigbee:** is a standard for a suite of high level communication protocols based on the IEEE 802.15.4 standard for low power and low data rate radio communications. Zigbee is initiated and maintained by the Zigbee Alliance - a large consortium of industry players. The typical application areas of Zigbee include: Smart energy monitoring, Health care monitoring, Remote control, building automation and home automation …etc. [19] ZigBee provides self-organized, multi-hop, and reliable mesh networking with long battery lifetime. [20] A drawback of this technology is low **QoS** and message throughput. [21]
- **Wi-Fi: is** a mechanism for wirelessly connecting electronic devices. A device enabled with Wi-Fi, such as a personal computer, smart phone, or digital audio player, can connect to the Internet via a wireless network access point. “Wi-Fi” is a trademark of the Wi-Fi Alliance and the brand name for products using the IEEE 802.11 family of standards [22]**.** Recently, however, wireless networks based on 802.11 ‘Wi-Fi’ have become pervasive in enterprise and industrial environments, among others, where sensors are often deployed. 802.11 were, of course, not designed with sensor

applications in mind, but innovations in implementations have enabled the use of 802.11 while satisfying all sensor requirements and more. [23]

- **Comparison between technologies:**

Table 1.2: Comparative table between communication technologies

Technologies	*Bluetooth*	*Bluetooth low-energy*	*Wi-Fi*	*zigbee*
IEEE	*802.15.1*	*802.15.1*	*802.11a/b/g/n/ac*	*802.15.4*
Rang	*10m*	*10m*	*100m*	*100m*
Data rate	*1-3 Mb/s*	*1 Mb/s*	*11-54-108-320-1000 Mb/s*	*20 – 250 Kb/s*
Power profile	*days*	*days*	*hours*	*Months/years*
Nodes number	*255*	*Unlimited*	*256+*	*65000*
Power consumption	*Low*	*Low*	*High*	*Very low*

1.3.8. Security in WSNs

Sensor networks pretence exclusive challenges, so conventional security techniques used in traditional networks cannot be applied directly for WSN. The sensor devices are inadequate in their energy, computation, and communication capabilities. When sensor networks are deployed in a hostile environment, security becomes extremely important, as they are prone to different types of malicious attacks.[24]

- **Attacks on security in WSN:** Sensor networks are particularly vulnerable to several key types of attacks. Attacks can be performed in a variety of ways, most notably as denial of service attacks, but also through traffic analysis, privacy violation, physical attacks, and so on. Denial of service attacks on wireless sensor networks can range from simply jamming the sensor’s communication channel to more sophisticated attacks designed to violate the 802.11 MAC protocol or any other layer of the wireless sensor network. [24]

Table 1.3: Security services

Confidentiality	Keeping node information secret from others but authorized users see it.
Integrity	Possible for the receiver node of a message to confirm that it has not been customized in transit.
Device authentication	Justification of the identity of the device.
Message authentication	Justification the source of information
Validation	To provide correctness of authorization to use or manipulate resources.
Access control	Restricting access to resources.
Revocation	Renunciation of certification or authorization.
Survivability	The lifetime of the sensor node must be extended even the node is compromised.
No repudiation	Preventing the denial of a previous commitment.
Availability	High availability systems in sensor node is aim to remain available at all times preventing service disruptions due to power outages, hardware failures, and system upgrades. Ensuring availability also involves preventing denial-of-service attacks.
Data freshness	Data freshness objective ensures that messages are fresh, meaning that they are in proper order and have not been reused.

1.4.Conclusion

In this chapter, we have presented the sensor and WSNs in generally, their architecture, characteristics. We have seen that WSNs have various fields of use which remain very vast. Even we have presented the security and routing in WSNs, different operating systems and communication technologies of WSNs. In the next chapter we will present the concept of the Internet of things

CHAPITRE 2

Internet of things

2.1.Introduction

Internet of Things is a platform where every day devices become smarter, every day processing becomes intelligent, and every day communication becomes informative. While the Internet of Things is still seeking its own shape, its effects have already stared in making incredible strides as a universal solution media for the connected scenario. [25]

There have been visions of smart, communicating objects even before the global computer network was launched forty-five years ago. As the Internet has grown to link all signs of intelligence (i.e., software) around the world, a number of other terms associated with the idea and practice of connecting everything to everything have made their appearance, including machine-to-machine (M2M), Radio Frequency Identification (RFID), context-aware computing, wearables, ubiquitous computing, and the Web of Things.

2.2.IoT Definition, What does Internet of Things (IoT) mean?

In fact, there are many different groups that have defined the term, although its initial use has been attributed to Kevin Ashton, an expert on digital innovation. Each definition shares the idea that the first version of the internet was about data created by people. [26]

The internet of things (IoT) is a computing concept that describes the idea of everyday physical objects (mechanical and digital machines, objects, animals orpeople) being connected to the internet and being able to identify themselves to other devices. The term is closely identified with RFID as the method of communication, although it also may include other sensor technologies, wireless technologies or QR codes. More specifically, the Internet of Things aims at offering new applicationsand services bridging the physical and virtual worlds, in which Machine-to-Machine (M2M)communications represents the baseline communication that enables the interactions betweenThings and applications in the cloud. [27]

The IoT is significant because an object that can represent itself digitally becomes something greater than the object by itself. No longer does the object relates just to its user, but is now connected to surrounding objects and database data. [26]

2.3.IoT history

Here are a few milestones in the evolution of the mashing of the physical with the digital.

1990: the first IoT device is created by John Romkey , device is a toaster connected to the internet with TCP/IP networking at the 1990 inerop conference.

1993: the Trojan Room Coffee Pot was created at the University of Cambridge. The pot used to monitor the levels with an image being updated about 3x a stored in local server. Images were put online for viewing once browsers could display images.

1998: Google is developed by Larry page and Sergey Brin during 1996, in 1998 Google is incorporated.

1999: Kevin Ashton executive director of the Auto-ID Center coin the term “The Internet of Things”:"I could be wrong, but I'm fairly sure the phrase "Internet of Things" started life as the title of a presentation I made at Procter & Gamble (P&G) in1999”.

2000: LG announces its first Internet refrigerator .

2005: UN's International Telecommunications Union "A new dimension has been added to the world of information and communication technologies (ICTs): from anytime, any place connectivity for anyone, we will now have connectivity for anything. Connections will multiply and create an entirely new dynamic network of networks – an Internet of Things".

2008-2009: Cisco announces the Internet of Things is born. The announcement states more objects and devices are connected to the internet than people.

2011: IPV6 is launched.

2011-2014: search traffic for “internet of things” rises at an ateady peace. 171$ billion in global internet of things revenue.

2014-2020: internet of things revenue expected to top 1$ billion by 2020.in the same time scale, 50 billion devices are expected to be connected to the internet of things. [28]

2.4.Objects typologie in IoT

The hardware utilized in IoT systems inclues devices for a remote dashboard, devices for control, servers, a routing or bridge device, and sensors. These devices manage key tasks and functions such as system activation, action specifications, security, communication, and detection to support-specific goals and actions.[29]

2.4.1. IoT – Sensors

The most important hardware in IoT might be its sensors. These devices consist of energy modules, power management modules, RF modules, and sensing modules. RF modules manage communications through their signal processing, WiFi, ZigBee, Bluetooth, radio transceiver, duplexer, and BAW.[29]

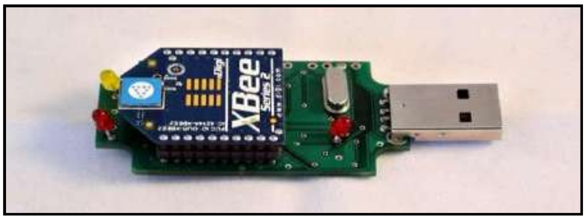

Figure 2.1: A sensing module

2.4.2. Electronic Wearable devices

Wearable electronic devices are small devices worn on the head, neck, arms, torso, and feet.

Figure 2.2: Wearable devices

Current smart wearable devices include:

- **Head:** Helmets, glasses
- **Neck:** Jewelry, collars
- **Arm:** Watches, wristbands, rings
- **Torso:** Clothing, backpacks
- **Feet :** Socks, shoes[29]

2.4.3. Standard Devices

The desktop, tablet, and cell phone remain integral parts of IoT as the command center and remotes.

- The desktop provides the user with the highest level of control over the system and its settings.

- The tablet provides access to the key features of the system in a way resembling the desktop, and also acts as a remote.

- The cell phone allows some essential settings modification and also provides remote functionality.

Other key connected devices include standard network devices like routers and switches. [29]

2.5.IoT Protocols and technologies

IoT primarily exploits standard protocols and networking technologies. However, the major enabling technologies and protocols of IoT are RFID, NFC and Bluetooth, Wi-Fi-…etc. These technologies support the specific networking functionality needed in an IoT system in contrast to a standard uniform network of common systems.

2.5.1. Radio Frequency Identification (RFID)

Is a system that transmits the identity of an object or person wirelessly using radio waves in the form of a serial number. It is more reliable, efficient, secured, inexpensive and accurate. RFID has an extensive range of wireless applications such as distribution, tracing, patient monitoring, military apps …etc. [30]

2.5.2. Near field communication (NFC)

NFC is a set of short-range wireless technologies, typically requiring a distance of 10 cm or less and at rates ranging from 106 Kbit/s to 424 Kbit/s [31]. NFC is a form of contactless communication between devices like Smartphone or tablets. Contactless communication allows a user to wave the Smartphone over a NFC incompatible device to send information without needing to touch the devices together or go through multiple steps setting up a connection.[32]

2.5.3. Wireless Sensor Networks (WSN)

Wireless sensor network is an important element in IoT paradigm. Sensor nodes may not have global ID because of the large amount of overhead and large number of sensors. WSN based on IoT has received remarkable attention in many areas, such as military, homeland security, healthcare, precision agriculture monitoring, manufacturing, habitat monitoring, forest fire and flood detection and so on medicines.[30]

2.5.4. Bluetooth

Bluetooth is a global 2.4 GHz personal area network for short-range wireless communication. Device-to-device file transfers, wireless speakers, and wireless headsets are often enabled with Bluetooth.[33]

2.5.5. Bluetooth Low-Energy (BLE)

BLE is a version of Bluetooth designed for lower-powered devices that use less data to conserve power. Its low energy can reach ten times less than the classic Bluetooth while its latency can reach 15 times.[34]

2.5.6. Wi-Fi

Wi-Fi is a technology that allows an electronic device to exchange data wirelessly (using radio waves) over a computer network, including high-speed Internet connections. The Wi-Fi

Alliance defines Wi-Fi as any "wireless local area network (WLAN) products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards".[35]

2.5.7. Wi-Fi-Direct

Eliminates the need for an access point. It allows P2P (peer-to-peer) connections with the speed of Wi-Fi, but with lower latency. Wi-Fi-Direct eliminate an element of a network that often bogs it down, and it does not compromise on speed or throughput.[36]

2.5.8. LTE-A

Long-Term Evolution Advanced (LTE-A) is a set of standards designed to fit M2M communication and IoT applications in cellular networks. LTE-A is a scalable, lower- cost protocol compared to other cellular protocols. LTE-A, delivers an important upgrade to LTE technology by increasing not only its coverage, but also reducing its latency and raising its throughput. [36]

2.5.9. Radio Protocols

ZigBee, Z-Wave, and Thread are radio protocols for creating low-rate private area networks. These technologies are low-power, but offer high throughput unlike many similar options. This increases the power of small local device networks without the typical costs. [36]

2.5.10. 6LoWPAN

6LoWPAN stands for IPv6 Low Power Personal Area Network. It is a network protocol. It is used for encapsulation of data over Network in Application layer. [37]It efficiently encapsulates IPv6 long headers in IEEE802.15.4 small packets, which cannot exceed 128 bytes. The specification supports different length addresses, low bandwidth, different topologies including star or mesh, power consumption, low cost, scalable networks, mobility, unreliability and long sleep time. [34]

2.5.11. Real-time protocols

- **CoAP:** is designed to enable low-power sensors to use RESTful services while meeting their power constrains. It is built over UDP, instead of TCP commonly used in HTTP and has a light mechanism to provide reliability. CoAP architecture (client/server model) is divided into two main sublayers: messaging and request/response. The messaging sublayer is responsible for reliability and duplication of messages while the request/response sublayer is responsible for communication.[34]
- **MQTT:**MQ Telemetry Transport is an open source protocol for constrained devices and low bandwidth, high-latency networks. It is a publish/subscribe messaging transport that is extremely lightweight and ideal for connecting small devices to constrained networks.

It follows a publish/subscribe architecture, where the system consists of three main components: publishers, subscribers, and a broker. MQTT is bandwidth efficient, data agnostic, and has continuous session awareness. It helps minimize the resource requirements for your IoT device, while also attempting to ensure reliability and some degree of assurance of delivery with grades of service. [38]

- **XMPP:**(Extensible Messaging and Presence Protocol) is a good example of an existing Web technology finding new use in the IoT space. It is a messaging protocol that was designed originally for chatting and message exchange applications. XMPP is a good example of an existing Web technology finding new use in the IoT space. [38] XMPP supports both publish/ subscribe and request/ response architecture and it is up to the application developer to choose which architecture to use. It is designed for near real-time applications and, thus, efficiently supports low-latency small messages. [34]

2.6.Architecture of IoT

There is no single consensus on architecture for IoT, which is agreed universally. Different architectures have been proposed by different researchers.

The most basic architecture is three-layer architecture as shown in the figure. It was introduced in the early stages of research in this area. It has three layers, namely, the perception, network, and application layers. [39]

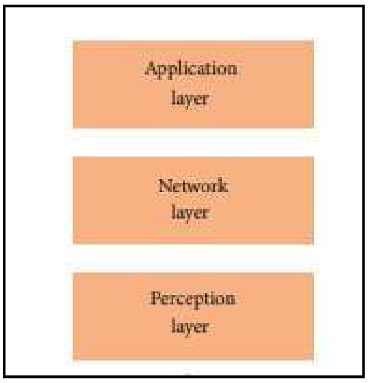

Figure 2.3: Three-layer architecture

2.6.1. The perception layer

Is the physical layer, which has sensors for sensing and gathering information about the environment. It senses some physical parameters or identifies other smart objects in the environment.[39] All the data collection and data sensing part isdone on this layer. Sensors, bar code labels, RFID tags,GPS, cameras are in this layer. Identifying object/thing andgathering data is the main purpose of this layer.[40]

2.6.2. The network layer

It's responsible for connecting to other smart things, network devices, and servers. [13] Network layer collects the data perceived by the Perceptionlayer. Network layer is like the Network and Transport layerof OSI model. It collects the data from the lower layer andsends to the Internet. Network layer may only include agateway, having one interface connected to the sensor networkand another to the Internet. [40]

2.6.3. The application layer

It's responsible for delivering application specific services to the user. It defines various applications in which the Internet of Things can be deployed. [13]Application layer presents thedata in the form of: smart city, smart home, smarttransportation, vehicle tracking, smart farming, smart healthand other many kinds of applications. [40]

The three-layer architecture defines the main idea of the Internet of Things, but it is not sufficient for research on IoT because research often focuses on finer aspects of the Internet of Things. That is why, we have many more layered architectures proposed in the literature. One is the five layer architecture, which additionally includes the processing and business layers as is shown in the figure bellow.

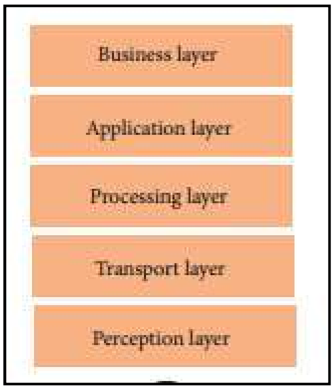

Figure 2.4: Five-layer architecture

The role of the perception and application layers is the same as the architecture with three layers. We outline the function of the remaining three layers. [13]

2.6.4. The transport layer

Transfers the sensor data from the perception layer to the processing layer and vice versa through networks such as wireless, 3G, LAN, Bluetooth, RFID, and NFC.[13]

2.6.5. The processing layer

It's also known as the middleware layer. It stores, analyzes, and processes huge amounts of data that comes from the transport layer. It can manage and provide a diverse set of services to the lower layers. It employs many technologies such as databases, cloud computing, and big data processing modules. [13] It then passes the output to thenext, Application layer.

2.6.6. The business layer

Manages the whole IoT system, including applications, business and profit models, and user's privacy. [13]Business layer is all about making money from the servicebeing provided. Data received at the application layer ismolded into a meaningful service and then further services arecreated from those existing services. [40]

2.7.IoT communication models

- **Device to Device Communications:**

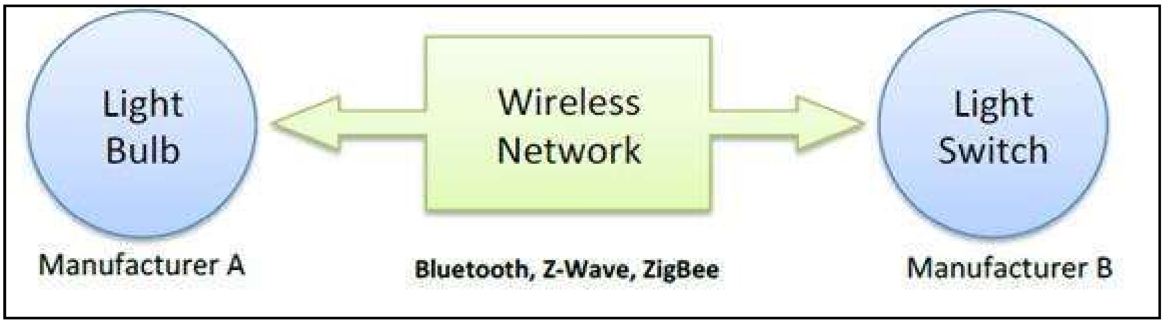

Figure2.5: Device to device communication

In this, two or more devices can directly connect andcommunicate with each other rather than throughintermediate application server. They can communicateusing different types of networks and they use protocolslike Bluetooth, Z-wave or ZigBee to establishdirect device-to-device. This communication model iscommonly used in applications like home automationsystems, which typically use small data packets ofinformation to communicate between devices withrelatively low data rate requirements.[38]

- **Device to Cloud Communications:**

Figure 2.6: Device to Cloud Communications

In this communication model, the IoT device connectsdirectly to an Internet cloud service like an applicationservice provider to exchange data and control messagetraffic. This approach uses existing communicationsmechanisms like traditional wired Ethernet or Wi-Ficonnections to establish a connection between the deviceand the IP network, which connects it to the cloud service.This communication model is employed by some popularconsumer IoT devices like Samsung *SmartTV*. [38]

- **Device to Gateway Model:**

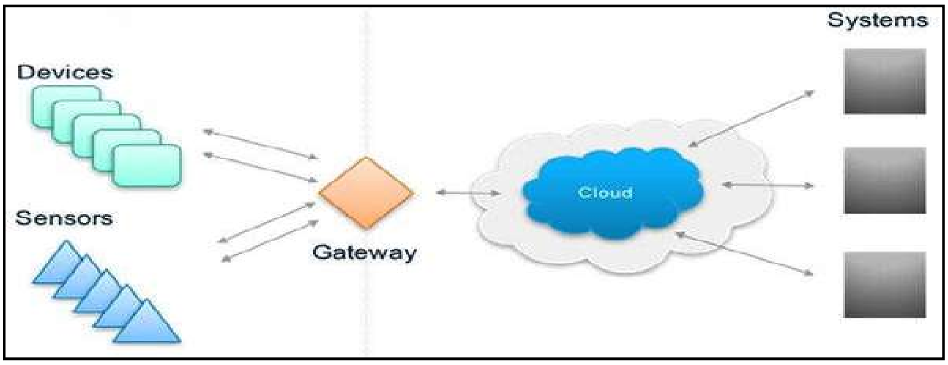

Figure 2.7: Device to Gateway Model

In the Device-to-Gateway model, IoT devices basically connect to an intermediary device to access a cloud service. This model often involves application software operating on a local gateway device (like a Smartphone or a “hub”) that acts as an intermediary between an IoT device and a cloud service. This gateway could provide security and other functionality such as data or protocol translation. If the application-layer gateway is a Smartphone, this application software might take the form of an app that pairs with the IoT device and communicates with a cloud service. [41]

- **Back End Data Sharing Model:**

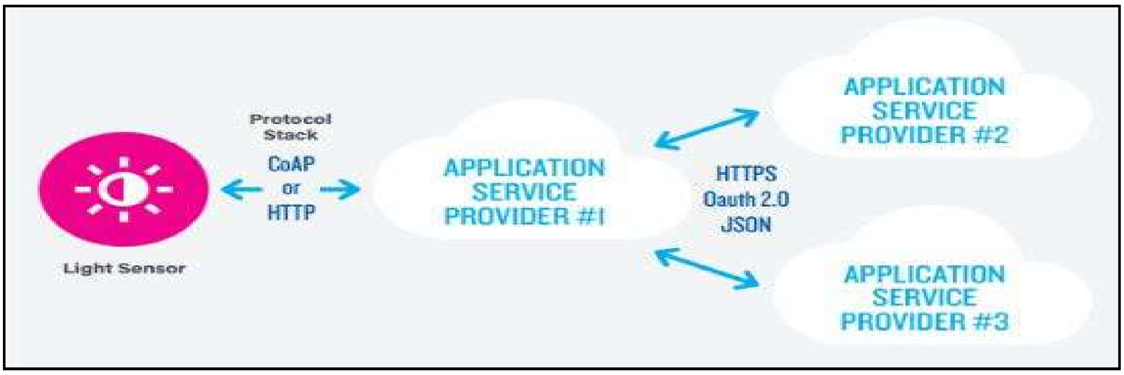

Figure 2.8: Back End Data Sharing Model

Back-End Data-Sharing essentially extends the single device-to-cloud communication model so that IoT devices and sensor data can be accessed by authorized third parties. Under this model, users can export and analyze smart object data from a cloud service in combination with data from other sources, and send it to other services for aggregation and analysis. [41]

2.8. Iotapplications

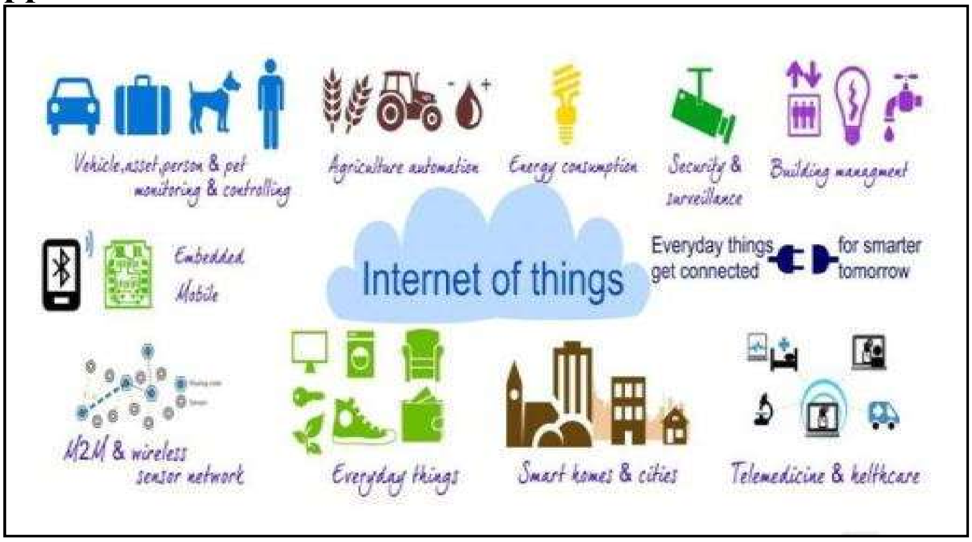

Figure 2.9: IoT applications

This technology has a lot of applications in various fields. Following are some possible areas where we can leverage the power of the Internet of Things (IoT) to solve day-to-day problems.[42]

- **IoT in Healthcare:** Healthcare is one sector which is supposed to be highly boosted with advent of internet of things applications. [43] IoT in healthcare is aimed at empowering people to live healthier life by wearing connected devices. [44] We can use this technology to identify health problems. The patterns of heart rate, pulse, digestive system, and blood pressure can be monitored and diagnosed for anomalies. The information can be sent to the doctor for analysis. The hospital can also be contacted in times of emergencies. This system will be very useful to senior citizens and disabled people who live independently. [42]
- **Smart Cities:** Smart surveillance, automated transportation, smarter energy management systems, water distribution, urban security and environmental monitoring (Forest Fire Detection, Air Pollution, Earthquake Early Detection, and River Floods) all are examples of internet of things applications for smart cities. IoT will solve major problems faced by the people living in cities like pollution, traffic congestion and shortage of energy supplies …etc.[44]The IoT can be used to monitor the vibrations of buildings, bridges, and monuments in case the building material is threatened or overloaded. Noise pollution can be controlled around hospitals and schools. It can be used to manage traffic especially during traffic jams, peak hours, accidents, and rains. It can be used to manage street

lights—automatically switch them off in the presence of sunlight and switch them on at the onset of darkness.[42]

- **Industrial internet:** The Industrial Internet of Things (IIoT) is the use of Internet of Things (IoT) technologies in manufacturing. Also known as the Industrial Internet, IIoT incorporates machine learning and big data technology, harnessing the sensor data, machine-to-machine (M2M) communication and automation technologies that have existed in industrial settings for years. The driving philosophy behind the IIoT is that smart machines are better than humans at accurately, consistently capturing and communicating data. This data can enable companies to pick up on inefficiencies and problems sooner, saving time and money and supporting business intelligence efforts. In manufacturing specifically, IIoT holds great potential for quality control, sustainable and green practices, supply chain traceability and overall supply chain efficiency. [31]
- **IoT in agriculture/farming:** With the continuous increase in world's population, demand for food supply is extremely raised. Governments are helping farmers to use advanced techniques and research to increase food production. Smart farming is one of the fastest growing fields in IoT. Farmers are using meaningful insights from the data to yield better return on investment. Sensing for soil moisture and nutrients, controlling water usage for plant growth and determining custom fertilizer are some simple uses of IoT. Smart farming will become the important application field in the predominantly agricultural-product exporting countries. Livestock monitoring is about animal husbandry and cost saving. Using IoT applications to gather data about the health and well-being of the cattle, ranchers knowing early about the sick animal can pull out and help prevent large number of sick cattle.[44]

There are other applications of internet of things: Smart home, Electronic Wearable devices, Connected Cars, Smart retail, Energy Management (smart grids).

2.9.Advantages and the Disadvantages of IoT

Before we understand the impact IoT can have on our way of living, it's important to go through its advantages and disadvantages:

2.9.1. The Advantages of IoT

Some of the most important advantages of IoT are as follows:

- **Transportation:** IoT eases and simplifies the entire process by introducing a monitory sensor that helps to track distance and time locations and other contributing factors. [45]

- **Inventory Management:**IoT is used to tag radio frequency sensors to track the location of products in real time. It has been instrumental in tracking the level of inventory and to stock it in advance, making alerts for unforeseen stoppages, automatically placing orders …etc. [45]
- **Assessing web user intelligence:** IoT is used by third party web data aggregators to have a better understanding of their key customer by tracking them on social media networks to know their preferences. [45]
- **Integration into Health Care Systems:** This could prove to be incredibly beneficial for both an individual and a society. A chip could be implemented into each individual, allowing for hospitals to monitor the vital signs of the patient.[45]

2.9.2. The Disadvantages of IoT:

Considering that IoT is still an emerging technology, it has its unfulfilled drawbacks:

- **Compatibility:** Currently, there is no international standard of compatibility for the tagging and monitoring equipment. The manufacturing companies of this equipment need to agree to a standard, such as Bluetooth, USB …etc. [45]
- **Privacy:** In light of the NSA spying revelations, having more information accessible on the web to government agencies, data aggregators, and hackers may not be a comforting thought for members of the public [45].
- **Potential of widespread malware:** The interconnection of devices could make it much easier for malware to spread throughout a home's integrated system, with results ranging from complete corruption to minor inconveniences. [45]
- **Complexity:** As with all complex systems, there are more opportunities of failure. With the Internet of Things, failures could sky rocket. Infrastructure is still being developed and it will still take quite some time to overcome these disadvantages. [45]

2.10. IoT platforms

The IoT platforms are suites of components that enable deployment of applications that monitor and control connected devices. They remotely collect data from connected devices to manage all of them in one system. There are dozens of IoT platforms on the market. Building an IoT solution requires a platform to host and support it. [46] There are many **IoT platforms** available now that provide option to deploy internet of things applications on the go. Here we will mention the IoT platforms which are way ahead of others in the competition:

- **Amazon Web Services (AWS):**AWS internet of things platform is a managed cloud platform which facilitates easy, smooth, secured communication & interaction between the connected devices, Cloud Application & other external devices. [33] Main features of AWS IoT platform are:
  - Registry for recognizing devices
  - Software Development Kit for devices
  - Device Shadows
  - Secure Device Gateway
  - Rules engine for inbound message evaluation.[43]
- **Microsoft Azure:** Azure IoT Suite is a collection of services and it supports a vast array of devices and operating systems, and enables analysis and visualization of large quantities of data.[46]

Azure IoT Platform offer:

- Device connectivity
- Remote monitoring
- Predictive maintenance
- Back Up & Achieve
- Big Data & Analytics
- Data Warehouse
- Development & testing of IoT App
- Disaster Recovery.[33]

- **IBM Watson:** IBM Watson is an IoT platform which is pretty much taken among developers already. Backed by IBM's hybrid cloud PaaS (platform as a service) development platform, the Bluemix, Watson IoT enables developers to easily deploy **IoT applications**.

Users of IBM Watson get:

  - Device Management
  - Secure Communications
  - Real Time Data Exchange
  - Data Storage
  - Recently added data sensor and weather data service. [43]

- **ThingWorx:** PTC ThingWorx is an application development platform for the Internet of Things (IoT). It has large number of devices connected to it. ThingWorx is the only enterprise-ready technology platform that enables innovators to rapidly develop and deploy smart, connected solutions for the Internet of Things.[47]

It offers features like:

- Easy connectivity of devices to the platform.
- Remove complexity from IoT application development.
- Sharing platform among developers for rapid development.
- Integrated machine learning for automating complex big data analytics.
- Deploy cloud, embedded or on-premise IoT solutions on the go.[36]

2.11. IoT hardware platforms

Choosing a hardware platform to prototype and build an IoT appliance is not too difficult it depends on skills, goals, and budget. Here is a table which contains examples of IoT hardware platforms and their features:

Table 2.1: IoT hardware platforms

Features IOT Hardware	Dimension (mm)	RAM	CPU	Connectivity	programming langage
Raspberry Pi 3 	96x71	1gb	A 1.2GHZ 64-bit quad-core armv8	Wi-Fi Bluetooth BLE zigbee Ethernet	Python/c/java
Arduino UNO 	68.6x53.4	2kb	Atmega328p 16 MHZ	Bluetooth Wi-Fi Zigbee Ethernet	C++
BeagleBone Black 	87x53	512mb	AM335x1GHZ arm® cortex-a8	Bluetooth Wi-Fi Zigbee NFC Ethernet	C,c++python, perl,ruby, java
Intel Edison 	35.5x25	1gb	Dual-core intel®atom™ processor at 500 MHZ	Bluetooth Wi-Fi BLE Zigbee Ethernet	C/C++, python, node.js, html5, javascript

2.12. The Cloud definition

Figure 2.10: Cloud computing

Simply put, the cloud is the Internetmore specifically; it's all of the things you can access remotely over the Internet. When something is **in the cloud**, it means it's stored on Internet servers instead of your computer's hard drive. [48] The term originated as a metaphor for the Internet which is, in essence, a network of networks providing remote access to a set of decentralized IT resources.[49]

Prior to cloud computing becoming its own formalized IT industry segment, the symbol of a cloud was commonly used to represent the Internet. [49] Simply put, cloud computing is the delivery of computing services, servers, storage, databases, networking, software, analytics and more over the Internet.[50]One way to think of cloud computing is to consider your experience withemail. Your email client, if it is Yahoo, Gmail, Hotmail, and so on, takes care of housing all ofthe hardware and software necessary to support your personal email account. When you want toaccess your email you open your web browser, go to the email client, and log in. The mostimportant part of the equation is having internet access. Your email is not housed on yourphysical computer; you access it through an internet connection, and you can access it anywhere. [51]

2.13. Types of cloud deployment:

Not all clouds are the same. There are different ways to deploy cloud computing resources:

- **Public Cloud:** This is where computing resources (servers, storage) provided by a cloud providers are used by different organizations through public Internet. [52] Microsoft Azure is an example of a public cloud. With a public cloud, all hardware, software and other supporting infrastructure is owned and managed by the cloud provider. You access these services and manage your account using a web browser.[50]
- **Private Cloud:** A private cloud refers to cloud computing resources used exclusively by a single business or organization. A private cloud can be physically located on the

company's on-site datacenter. A private cloud is one in which the services and infrastructure are maintained on a private network.[50]

- **Community Cloud:** A community cloud is shared among two or more organizations that have similar cloud requirements.[51]
- **Hybrid Cloud:** It is the combination of any type of cloud model mentioned above connected by standardized or proprietary technology. [52] Hybrid cloud gives businesses greater flexibility and more deployment options. [50]

2.14. Cloud services:

Most cloud computing services fall into three broad categories: infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (Saas). These are sometimes called the cloud computing stack, because they build on top of one another. [50]

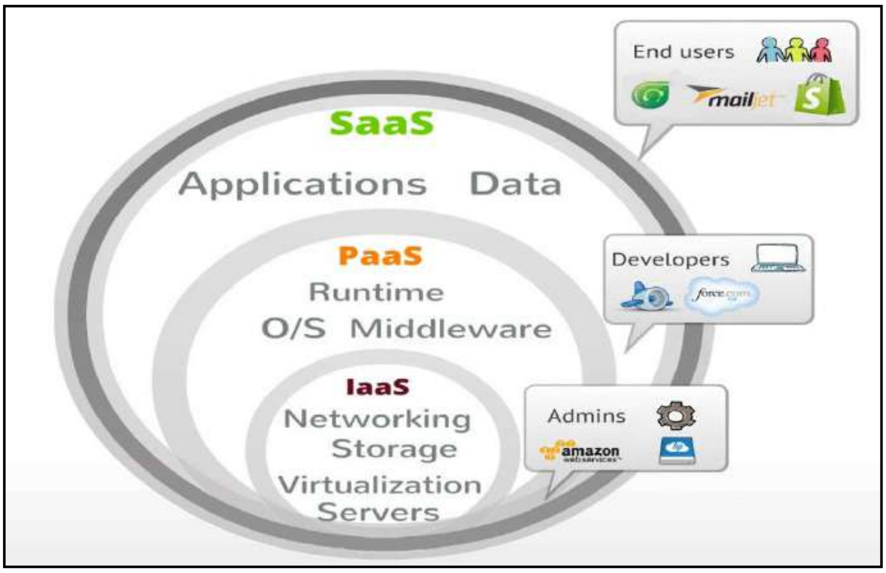

Figure 2.11: Cloud services

- **Infrastructure as a service (IaaS):** Is the most basic category of cloud computing services. With IaaS, you rent IT infrastructure servers and virtual machines (VMs), storage, networks, operating systems from a cloud provider on a pay-as-you-go basis.[50] IBM Smart Cloud Enterprise+, Soft Layer cloud and Amazon EC2 are some examples of IaaS. [52]
- **Platform as a service (PaaS):** An integrated platform (environment) for the development, deployment, testing and support of web-applications. Presented as a service on the basis of the concept of cloud hosting. IBM Smart Cloud Application Services and Google App Engine are two examples of PaaS. [52]

- **Software as a service (SaaS) :** Is a method for delivering software applications over the Internet, on demand and typically on a subscription basis. With SaaS, cloud providers host and manage the software application and underlying infrastructure and handle any maintenance, like software upgrades and security patching. Users connect to the application over the Internet, usually with a web browser on their phone, tablet or PC.[50] Examples are Google Docs, IBM Smart Cloud Docs…etc.

2.15. Conclusion:

This chapter was dedicated to the enlightenment of the Internet of Things; in first part We have presented the basic elements in IoT: architecture, protocols, communication models and applications, in the second part we have talking about the cloud that is the important in the IoT, internet of thing change our world to the best and solve lot of problems .in the next chapter we will present how we use IoT in environment monitoring system.

CHAPITRE 3

Conception and realization

3.1.Introduction

This chapter is dedicated to the practical realization of our solution as a platform of weather monitoring using internet of things technology where the collection of environmental data is cyclical; the equipment records the captured data in a database on the cloud. The information can then be presented to the user for exploitation. In this chapter, we describe the Hardware and software used in our work then we will detail in the installation, configuration and implementation realized. Finally, we discuss the obtained result of our system.

3.2.Hardware and software

3.2.1. Hardware:

- **Raspberry pi 3 model B:** The Raspberry Pi is a cheap computer that exposes pins for physical computing. This means that you can attach a wide variety of electronic components to it and drive them from software, The Pi primarily runs a version of the Linux operating system called Raspbian but other operating systems can also be used to host software applications that you write. Designed and distributed as a cheap device for the purpose of educating folks in the skills of computer programming. [53] Raspberry pi has a several versions: A+, B+, pi 2 and Pi 3, it is the latest version of the Pi and beats version 2 in performance and features. This version offers a few extras that make using a Pi so much easier. It is featured by:

  •Broadcom BCM2837 chipset running at 1.2 GHz,64-bit quad-core ARM Cortex-A53, Dual core Videocore IV® Multimedia co-processor.

  •802.11 b/g/n Wireless LAN, Bluetooth 4.1 (Classic & Low Energy).

  •1 GB LPDDR2 memory.

  •microUSB connector for 2.5 A power supply.

  •1 x HDMI, 1 x RCA video/audio connector,1 x CSI camera connector.

  •4 x USB 2.0 ports,1 x 10/100 Ethernet port.

  •40 GPIO pins.

  •Chip antennas display connector.

  •microSD card slot.

  •Dimensions: 85 x 56 x 17 mm.[54]

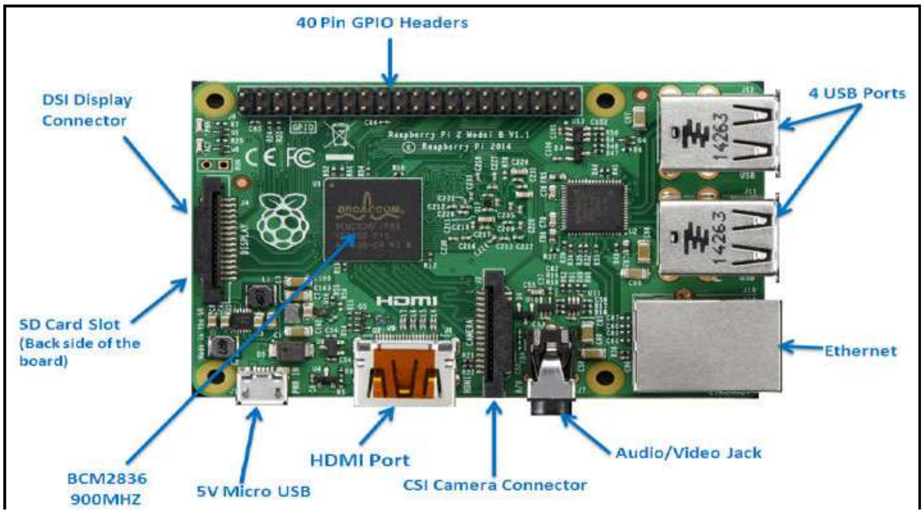

Figure 3.1: RPI 3 B Components

- **Sensor BME280:**DIGITAL HUMIDITY, PRESSURE AND TEMPERATURE SENSOR

The BME280 is a combined humidity, pressure and temperature sensor. The humidity sensor in the BME280 provides an extremely fast response time and high overall accuracy with ±3%RH. The pressure sensor in this device is an absolute barometric pressure sensor with extremely high accuracy and resolution and low noise output. The temperature sensor has been optimized for the lowest noise and highest resolution. Measurements with the BME280 can be performed by the user or performed in regular intervals. It is featured by:

- ±3% Relative Humidity Sensor.
- Pressure Sensing 300 to 1100 mbar.
- -40 - +85 °C Temperature Sensor.
- Up to 3.4 MHz Communication Speed.
- 2 Devices per I2C Port.
- 0x76 I2C Start Address. [55]

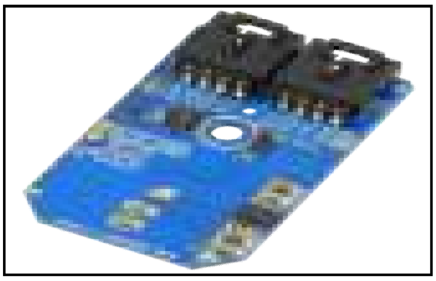

Figure 3.2: BME280 sensor

- **Compatible shield:** Raspberry 2 & 3 compatible shield with outward facing I2C terminating over HDMI.
  - Provides a Level-Shifted 5V I2C Port.

- Compatible with Raspberry Pi 3.
- Compatible with Raspberry Pi2.
- Outward Facing I2C Port.
- 40-Pin Pass-Through Connector.
- Terminates Directly Above HDMI Port. [55]

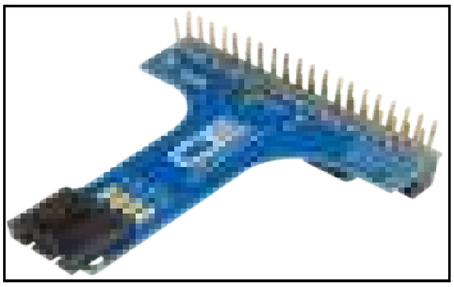

Figure 3.3: Compatible shield

3.2.2. Software

- **Operating system "Raspbian":**is a free operating system based on Debian optimized for the Raspberry Pi hardware. An operating system is the set of basic programs and utilities that make your Raspberry Pi run. However, Raspbian provides more than a pure OS: it comes with over 35,000 packages; pre-compiled software bundled in a nice format for easy installation on your Raspberry Pi. [56]
- **SDFormatter:** This software formats all SD memory cards.
- **Win32DiskImager**: A Windows tool for writing images to USB sticks or SD/CF cards
- **Java:** Java is a programming language and computing platform first released by Sun Microsystems in 1995. There are lots of applications and websites that will not work unless you have Java installed, and more are created every day. Java is fast, secure, and reliable. From laptops to datacenters, game consoles to scientific super computers, cell phones to the Internet, Java is everywhere. [57]
- **Eclipse IDE:** (Eclipse Java EE IDE for Web Developers. Version: Neon.3) Eclipse is a Java- based open source platform that allows a software developer to create a customized development environment (IDE) from plug-in components built by Eclipse members. Eclipse is managed and directed by the Eclipse.org Consortium. [58]
- **Apache tomcat:** Tomcat is an application server from the Apache Software Foundation that executes Java Servlets and renders Web pages that include Java Server Page coding. Described as a reference implementation" of the Java Servlet and the Java Server Page specifications, Tomcat is the result of an open collaboration of developers and is available from the Apache Web site in both binary and source versions. Tomcat requires a Java Runtime Enterprise Environment that conforms to JRE 1.1 or later. [59]

- **Apache maven:** Maven is a project management tool which encompasses a project object model, a set of standards, a project lifecycle, a dependency management system and logic for executing plug-in goals at defined phases in a lifecycle. [60] Maven's primary goal is to allow a developer to comprehend the complete state of a development effort in the shortest period of time. [61]
- **MySQL workbench:** MySQL Workbench is a unified visual tool for database architects, developers, and DBAs. MySQL Workbench provides data modeling, SQL development, and comprehensive administration tools for server configuration, user administration, backup, and much more. MySQL Workbench is available on Windows, Linux and Mac OS X. [62]
- **Amazon Web Service (AWS):** From the several Amazon web services we have used:
  - **Amazon elastic beanstalk:** AWS Elastic Beanstalk is an easy-to-use service for deploying and scaling web applications and services developed with Java, .NET, PHP, Node.js, Python, Ruby, Go, and Docker on familiar servers such as Apache, Nginx, Passenger, and IIS. You can simply upload your code and Elastic Beanstalk automatically handles the deployment, from capacity provisioning, load balancing, auto-scaling to application health monitoring. At the same time, you retain full control over the AWS resources powering your application and can access the underlying resources at any time. [63]
  - **Amazon RDS:** Amazon Relational Database Service (Amazon RDS) is a web service that makes it easier to set up, operate, and scale a relational database in the cloud. It provides cost-efficient, resizable capacity for an industry-standard relational database and manages common database administration tasks. [63]

3.3.Installation &configuration :

3.3.1. Installation de Raspbian on Raspberry pi :

After Downloading OS image of Raspbian from: https://www.raspberrypi.org/downloads/raspbian/

- Format SD card with **SDFormatter:**

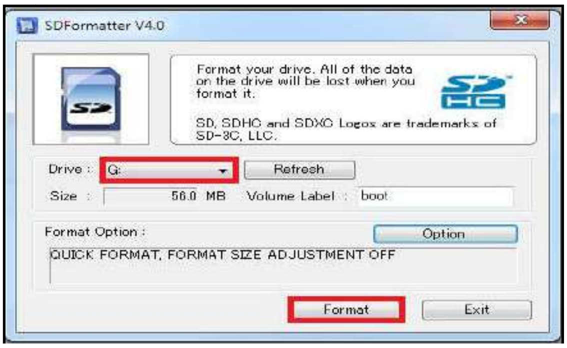

Figure 3.4: SDFormatter software

- Write the OS image in SD card using Win32DiskImager:

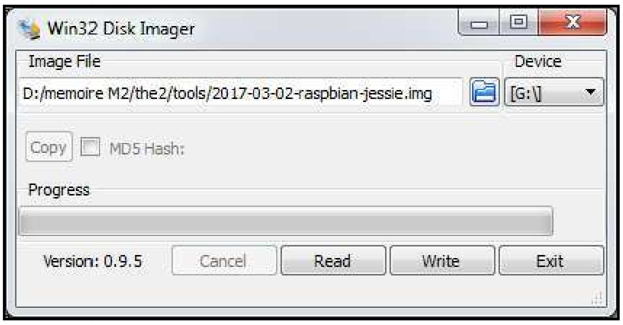

Figure 3.5: Win32DiskImager

- **Give an IP address to the RPI:** in SD card path, we open the file cmdline.txt and add the IP address "**IP= address of RPI: address of the machine ".**

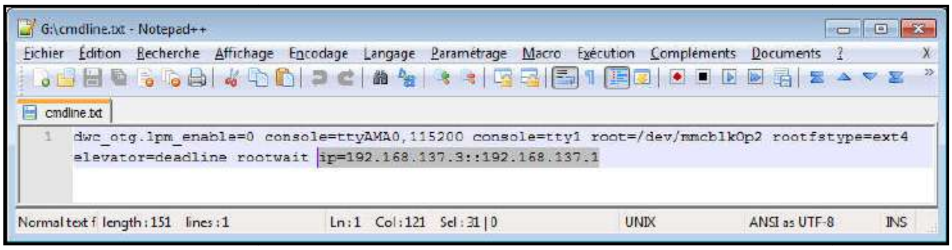

Figure 3.6: Giving an IP address to the RPI

On PC: give an IP address to the local machine.

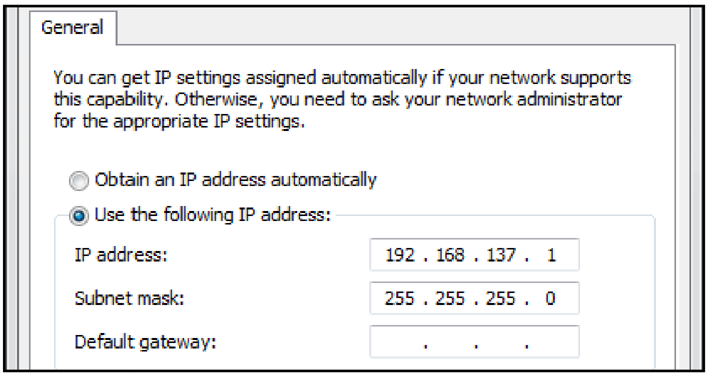

Figure 3.7: Giving an IP address to the local machine

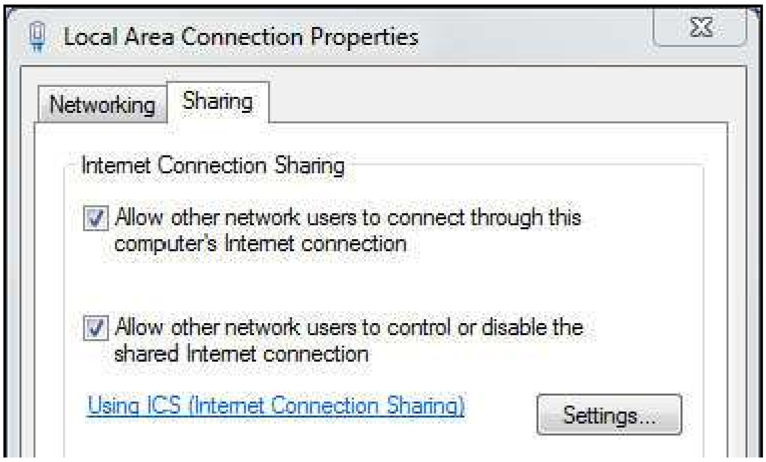

Figure 3.8: Sharing network

- **Booting Raspbian for the first time:** Put SD card in RPI and power it with USB cable and connect it to the PC in RJ45 port.
- **Using putty connect to the RPI with SSH:**

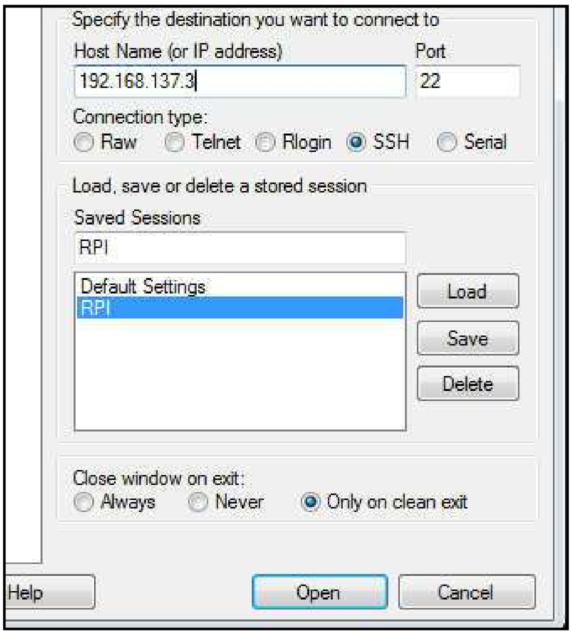

Figure 3.9: Connection to RPI using SSH

- **The RPI is connected now:** Login as: pi // Password: raspberry

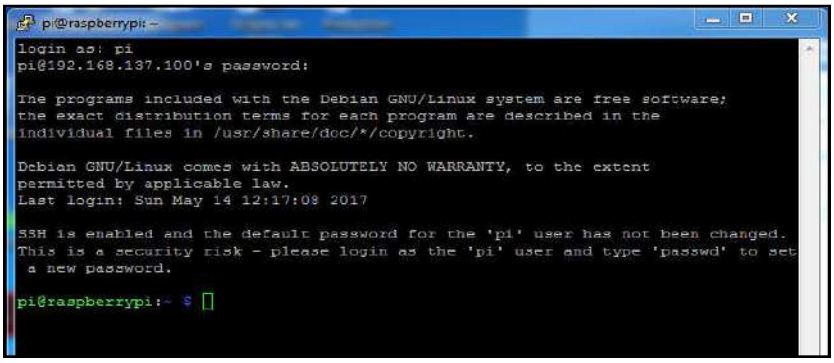

Figure 3.10: SSH command line of RPI

After installation of Eclipse IDE and its requirement of programming (JDK: java development kit) we need to install:

Configure the Windows environment variables: Right click on “Computer” icon and select properties, select “Advanced System Settings”, then reach “System Properties” window, select “Environment Variables” and create new Environment.

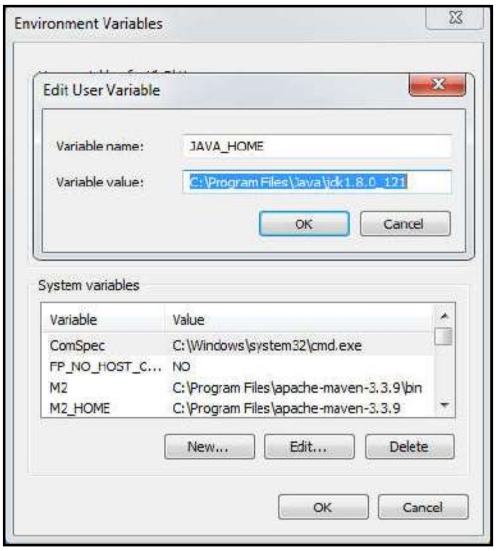

Figure 3.11: Adding java variable

3.3.2. Apache Tomcat Installation (apache-tomcat-8.0.43) :

To install Apache tomcat on Windows, download the Apache tomcat’s zip file from http://tomcat.apache.org/download-80.cgi , and unzip it to the directory to install.

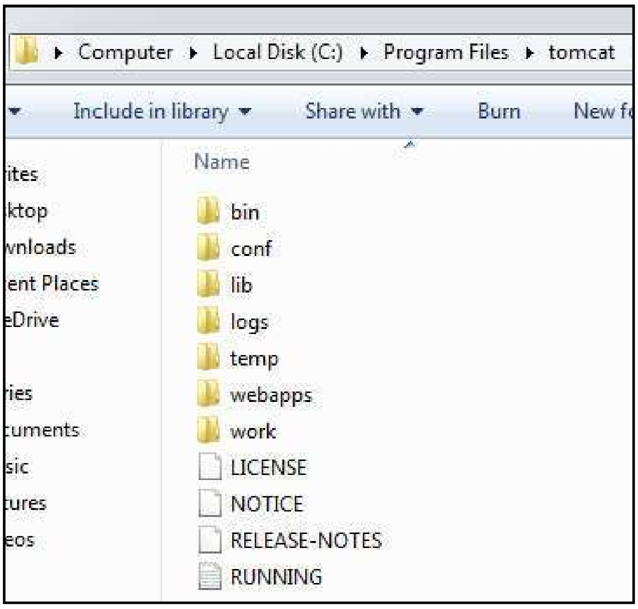

Figure 3.12: Addition of apache tomcat server

3.3.3. Apache maven Installation (apache-maven-3.3.9-bin):

Make sure JDK is installed, and "**JAVA_HOME**" variable is added as Windows environment variable.

Download the Maven zip file from Maven official websiteand Unzip it to the folder.

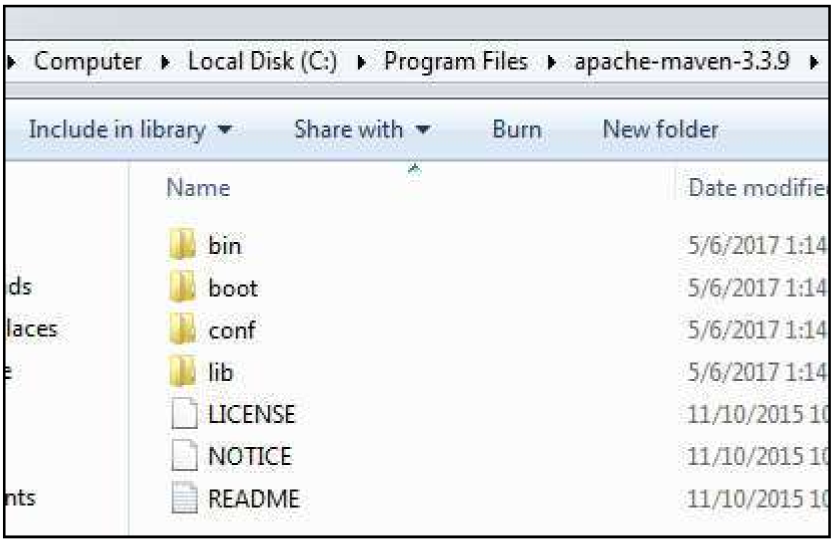

Figure 3.13: Addition of apache-maven

Add both **M2_HOME** and **M2** variables in the Windows environment, and point it to your Maven folder.

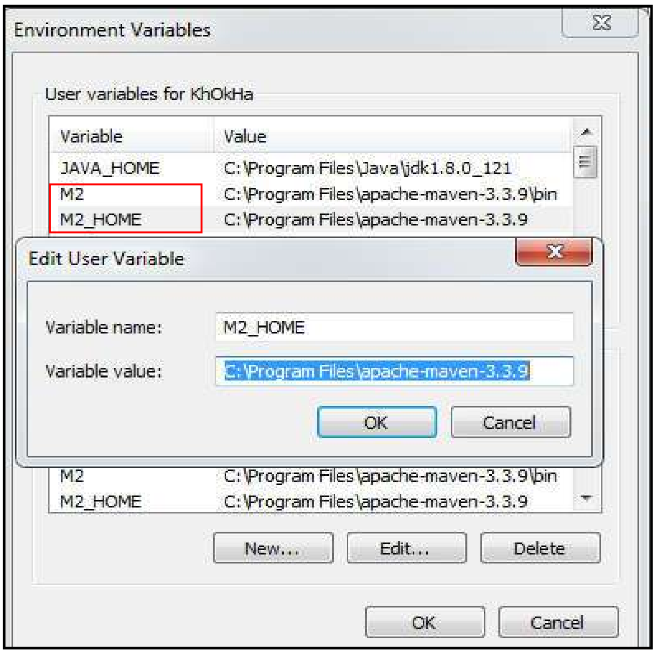

Figure 3.14: Addition of maven variable

Update **PATH** variable, append Maven bin folder – **C:\Program Files\apache-maven-3.3.9\bin**, so that you can run the Maven's command everywhere.

Done, to verify it, run mvn –version in the command prompt.

Figure 3.15: Maven version

3.4.Diagrams :

3.4.1. Database illustration:

Our database contains five principal entities as shown in conceptual model below:

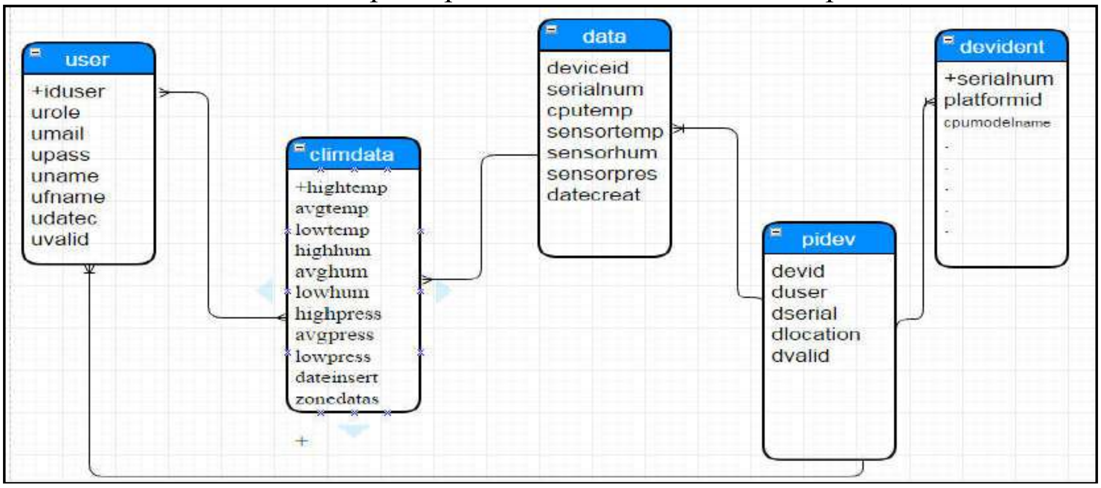

Figure 3.16: Database illustration

3.4.2. Use case diagram:

This diagram represents the different interactions between the different actors in the system and shows the different uses of the system.

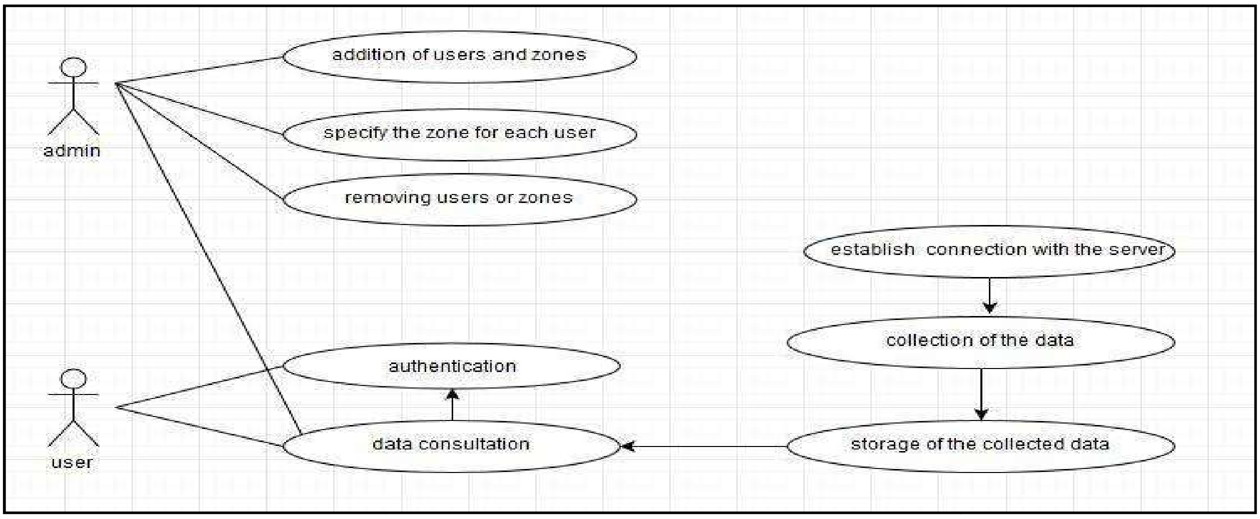

Figure 3.17: Use case diagram

3.4.3. Diagram of data:

The Scenario of data routing from a specific area to the cloud:

- The sensor captures the environmental data
- send the collected data to the gateway (Raspberry Pi)
- the gateway send data to the cloud for manipulation and storing

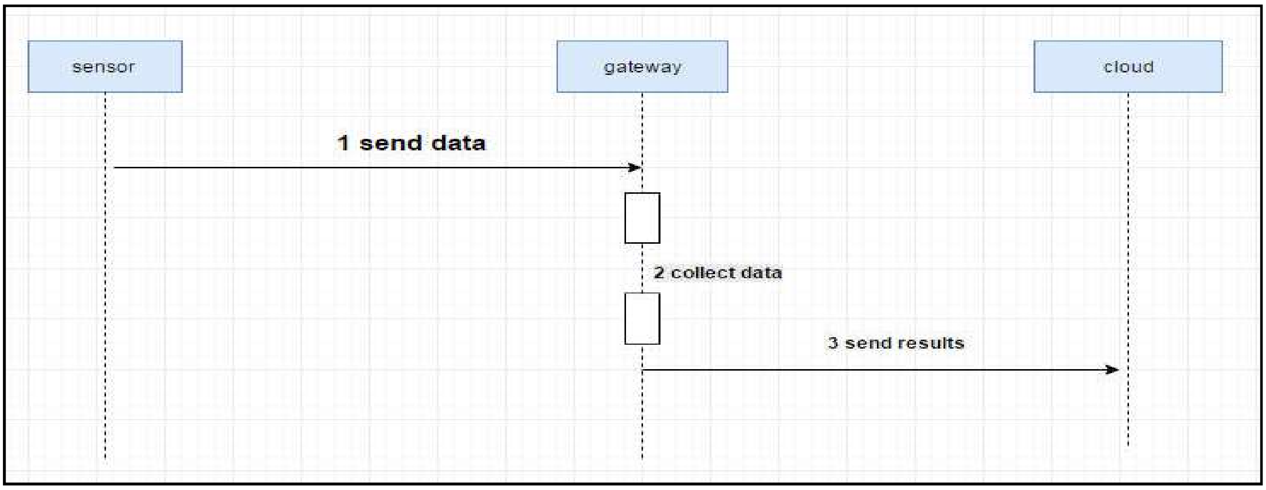

Figure 3.18: Data routing from a specific area to the cloud

3.4.4. Diagram of inscription:

it is authorized only for the admin of system who can add specific users, the scenario of the inscription is:

- the admin access to the web application
- chose add user then fill the fields
- The system must check the constraints for each field
- If the constraint verification succeeds, the system sends data to the SGBD
- The SGBD records the received data

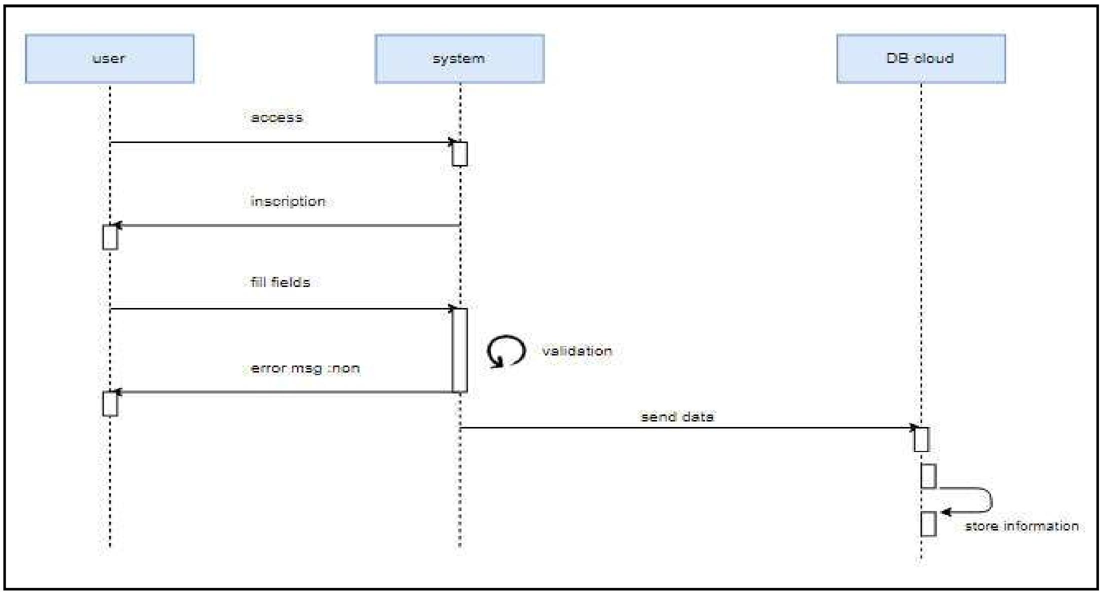

Figure 3.19: Inscription Diagram

3.4.5. Authentication Diagram (Login):

- The user must fill in the fields (Email/Password)
- The system checks the received data.
- If the data are valid the system loads the next page, otherwise it displays an error message

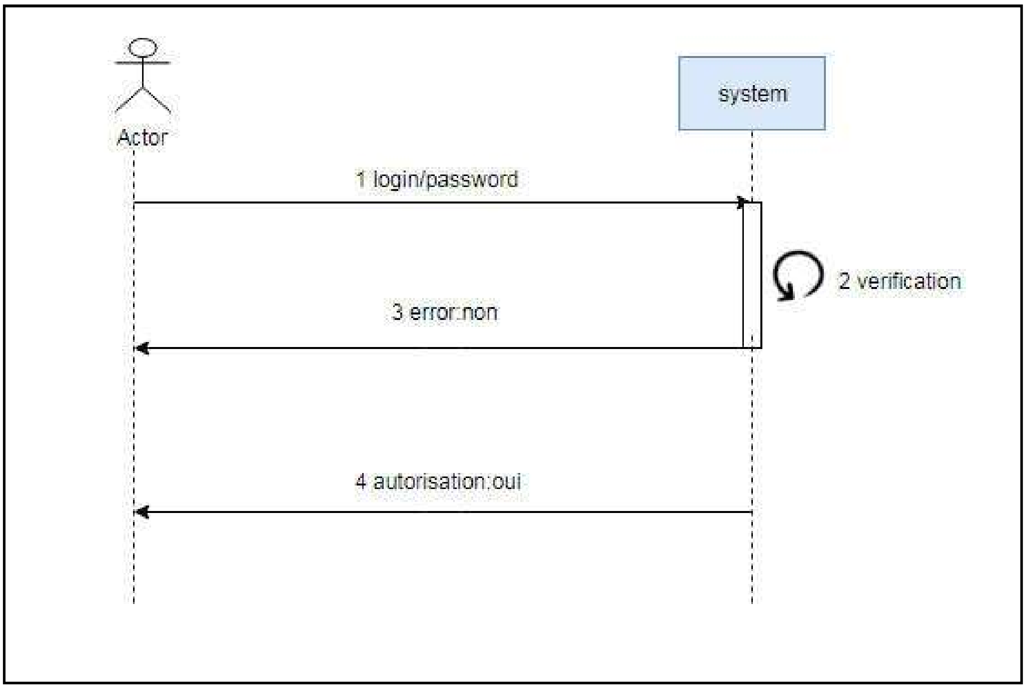

Figure 3.20: Authentication Diagram

3.5.Implementation:

3.5.1. Set up the hardware:

In the material side, we have followed and use this example of hardware during the realization of our project which is composed of a Raspberry Pi 3 platform and BME280 sensor.

Figure 3.21: Hardware installation

3.5.2. Data collection:

- **Sensor code:** the sensor captures the environmental data, an important library "**pi4j**" is used

```
import com.pi4j.io.i2c.I2CBus;
import com.pi4j.io.i2c.I2CDevice;
import com.pi4j.io.i2c.I2CFactory;
import java.io.IOException;

public class BME280  {
    private double cTemp;
    private double fTemp;
    private double pressure;
    private double humidity;
```

Figure 3.22: Captured parameters

- **Collection data code:** to collect data from the PI, we have to send a JSON format (**a lightweight format that is used for data interchanging**) at each period which contains the device data to verify device stat and the environmental data to control them.

```java
private static void JsonobjDevice() throws IOException, JSONException, Uns
    try {
        objID = new JSONObject();
        objID.put("SerialNum", encrypt());
        objID.put("PlatformID", PlatformManager.getPlatform().getId());
        objID.put("CPUModelName", SystemInfo.getModelName());
        objID.put("TotalMemory", SystemInfo.getMemoryTotal());
        objID.put("OSName", SystemInfo.getOsName());
        objID.put("OSVersion", SystemInfo.getOsVersion());
        objID.put("OSArch", SystemInfo.getOsArch());
        objID.put("JavaVM", SystemInfo.getJavaVirtualMachine());
        objID.put("JavaRuntime", SystemInfo.getJavaRuntime());
        objID.put("JavaVersion", SystemInfo.getJavaVersion());
        objID.put("JavaVendor", SystemInfo.getJavaVendor());
    } catch (Exception e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    }
    System.out.println("Device Identification : \n" + objID);
}
```

Figure 3.23: Device identification

```java
private static void JsonobjState() throws InterruptedException, IOException, ParseException, JSONException {
    // ..................................................
    try {
        objHD = new JSONObject();
        objHD.put("SerialNum", encrypt());
        objHD.put("CPUTemp", SystemInfo.getCpuTemperature());
        objHD.put("CPUCoreVolt", SystemInfo.getCpuVoltage());
        objHD.put("UsedMemory", SystemInfo.getMemoryUsed());
        objHD.put("FreeMemory", SystemInfo.getMemoryFree());
        objHD.put("SDRAM_C", SystemInfo.getMemoryVoltageSDRam_C());
        objHD.put("SDRAM_I", SystemInfo.getMemoryVoltageSDRam_I());
        objHD.put("SDRAM_P", SystemInfo.getMemoryVoltageSDRam_P());
        objHD.put("temp", sensor.sensorCTemp());
        objHD.put("hum", sensor.sensorHumid());
        objHD.put("pres", sensor.sensorPress());
    } catch (NumberFormatException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    } catch (UnsupportedOperationException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    }
    System.out.println("Device Status : \n" + objHD);
```

Figure 3.24: Device status

- **Executing jar project file in PI:** to execute the program, we export the project as a jar file and execute it in the pi by this command: java -jar test.jar.

```
pi@raspberrypi:~ $ java -jar test.jar
Device Identification :
{"SerialNum":"PRLAwOJUrR9zrQTXrz0RaPJan7TPrxoFfUWybgjUR7T3ZVL9uAhiwg==","JavaRun
time":"Java(TM) SE Runtime Environment","OSArch":"arm","PlatformID":"raspberrypi
","OSVersion":"4.4.50-v7+","JavaVendor":"Oracle Corporation","TotalMemory":97047
7568,"OSName":"Linux","CPUModelName":"ARMv7 Processor rev 4 (v7l)","JavaVersion"
:"1.8.0_65","JavaVM":"Java HotSpot(TM) Client VM"}

WAK REST Service Invoked Successfully..
Collected datas at:Sun May 14 12:20:41 UTC 2017
Device Status :
{"SDRAM_C":1.2000000476837158,"SerialNum":"ErCP8pjKY18Yue7rcdZHm56B/CyCjFQJAR5qI
k4o8zTGoazl2nHKPA==","CPUCoreVolt":1.2812999486923218,"hum":32.8,"temp":37.4,"Us
edMemory":262410240,"pres":16.7,"CPUTemp":47.20000076293945,"SDRAM_I":1.20000004
76837158,"FreeMemory":707805184,"SDRAM_P":1.225000023841858}

WAK REST Service Invoked Successfully..
------------------------------------------------------------
```

Figure 3.25: Execution of jar file in the PI

Among the transmitted data, the serial number of the device is the most important data to know the source of those data that is why we have encrypted this data:

```
private static String encrypt() throws UnsupportedOperationException, IOException, InterruptedException {
    ConfigurablePasswordEncryptor passwordEncryptor = new ConfigurablePasswordEncryptor();
    passwordEncryptor.setAlgorithm(ALGO_CHIFFREMENT);
    passwordEncryptor.setPlainDigest(false);
    return passwordEncryptor.encryptPassword(SystemInfo.getSerial());
}
```

Figure 3.26: Serial number encryption

3.5.3. Create instance in AWS:

- **Create elastic beans talk instance in AWS and Deploy the reset in the server to receive data:**

Create an Elastic Beanstalk application and deploy the app version to a new environment.

To create an application and environment**:**

1. Open the Elastic Beanstalk console at https://console.aws.amazon.com/elasticbeanstalk
2. Choose **Create New Application**.
3. On the **Application Information** page, enter a name for the app.
4. On the **New Environment** page, choose **Create web server** and chose **Tomcat.**

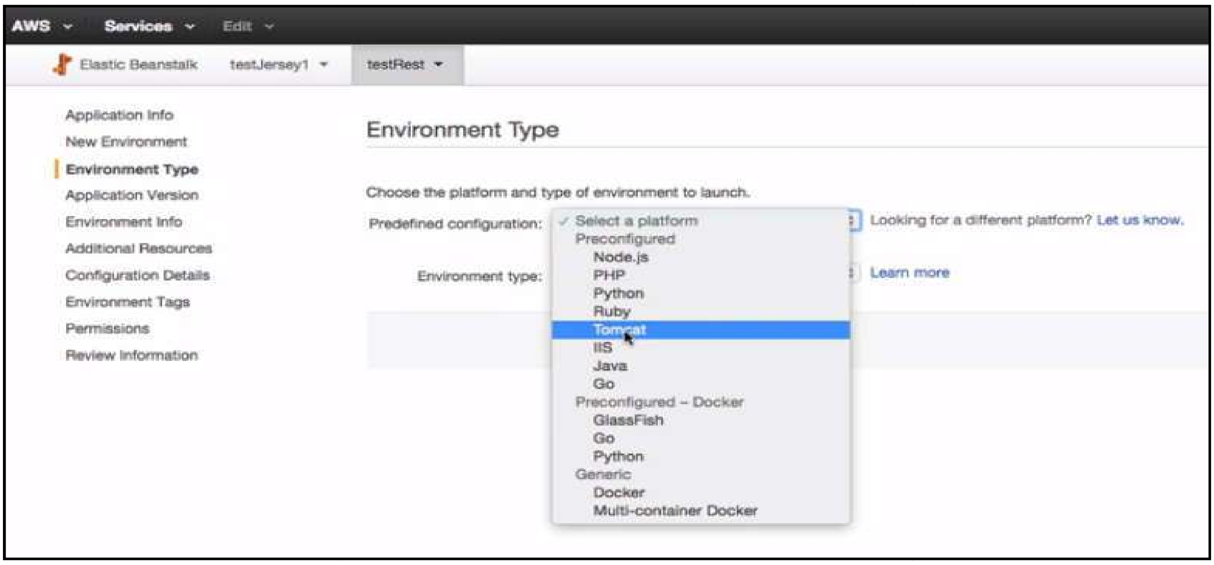

Figure 3.27: Creation of Tomcat web server

5. On the **Application Version** page, select **Upload your own**, choose **Choose File**, and then select the source **WAR** file of the rest api.

6. On the **Environment Information** page, enter an environment name and a unique environment URL.

7. Choose **Check availability** to ensure that your URL is available. Choose **Next**.
8. On the **Review** page, verify your settings, and then choose **Launch**.

On the AWS Elastic Beanstalk dashboard, you can watch in real time as Elastic Beanstalk creates an environment and deploys the app.

- **Deploy user application:** to deploy the web application for consultation, choose upload and deploy on the AWS Elastic Beanstalk dashboard, and upload the war file of application.

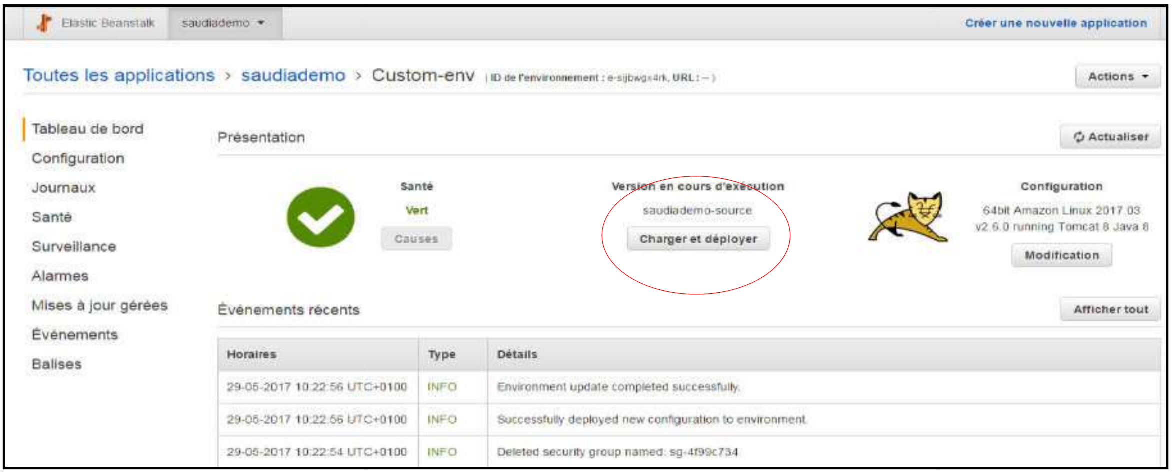

Figure 3.28: AWS Elastic Beanstalk dashboard

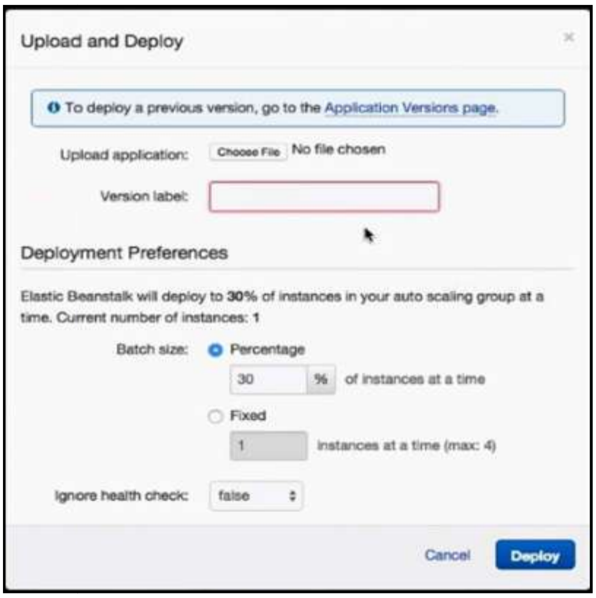

Figure 3.29: Application deployment

- **Create our storing service in AWS (RDS):**
  Amazon Relational Database Service (Amazon RDS) makes it easy to set up, operate, and scale a relational database in the cloud. In order to create a MySQL database instance, sign into the AWS Management Console and open the Amazon RDS console at

https://console.aws.amazon.com/rds. Once signed in, from the RDS Dashboard click on launch a DB Instance. We will be using a MySQL database.

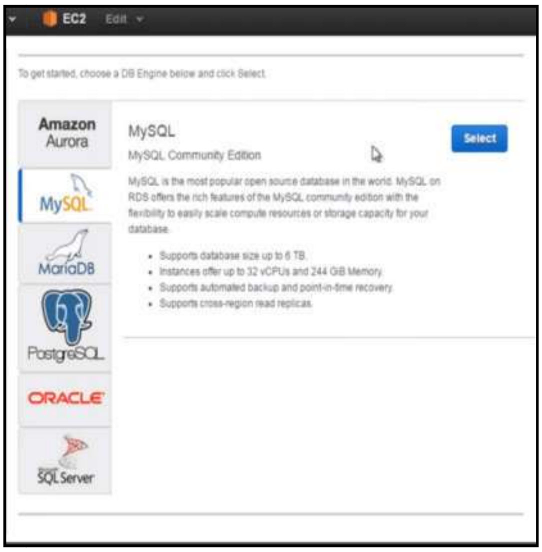

Figure 3.30: MySQL DB Engine

Now, review the settings and click Launch DB Instance.

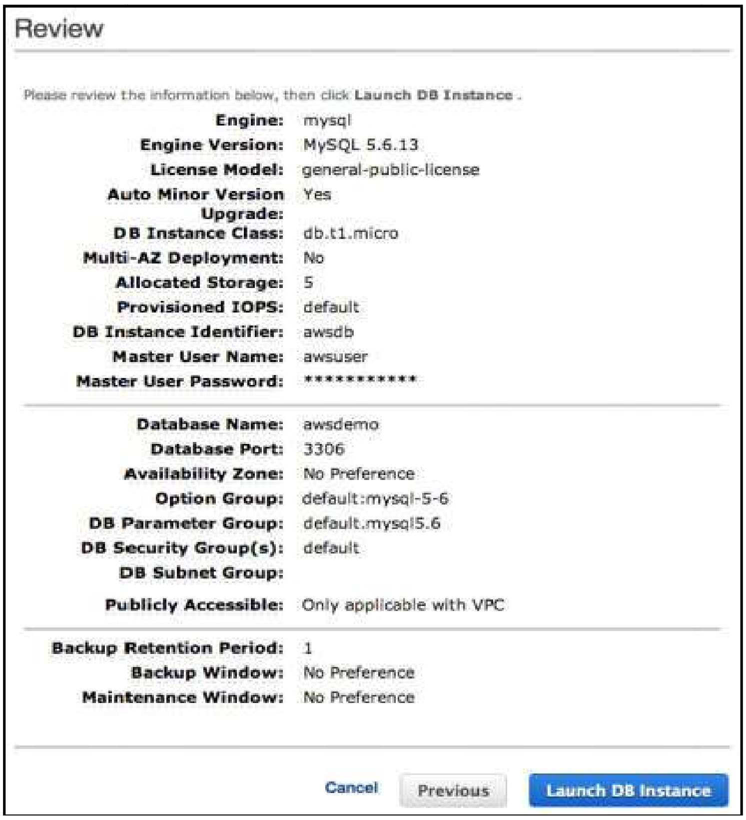

Figure 3.31: DB instance settings

Now, locate the **"Security Groups"** option. To be able to access this instance, we will have to create a new authorization with our IP so that we can access it from the MySQL client tool on our machine.

Figure 3.32: Security Groups

Now that we have authorized machine to connect to the RDS instance, check and verify that the RDS instance is **available**

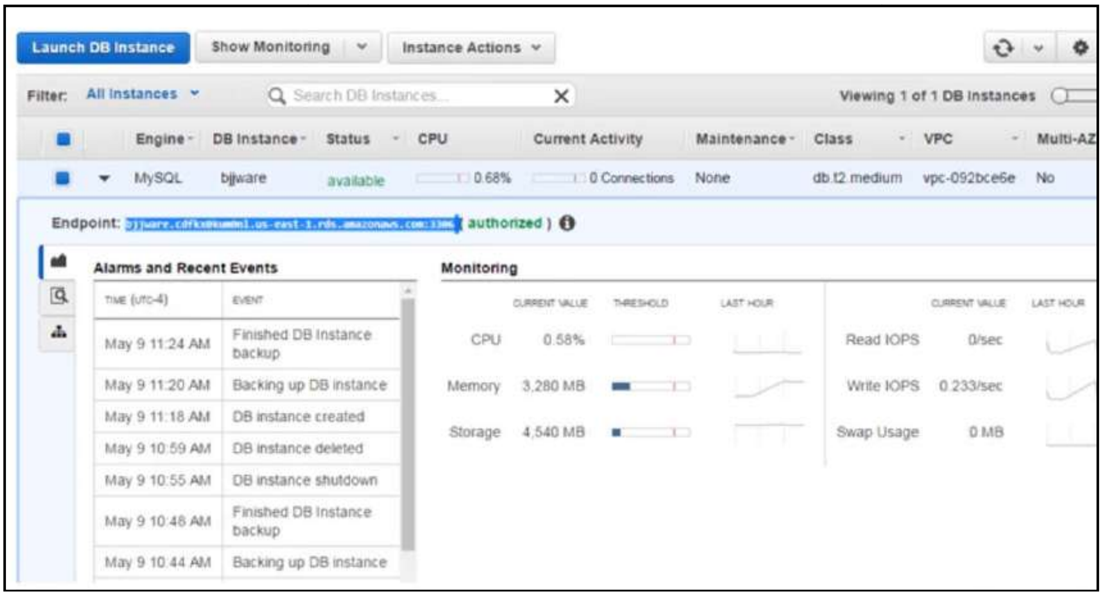

Figure 3.33: Endpoint availability

We will use the newly created MySQL database instance (in the cloud) from our MySQL workbench, to do this:

1. Open MySQL workbench and **setup New Connection** then provide a Connection Name.
2. Connection Method is set to **Standard (TCP/IP)**
3. In the Hostname provide your **RDS end point**
4. Port is **3306**
5. Enter the username what you have given in the RDS.

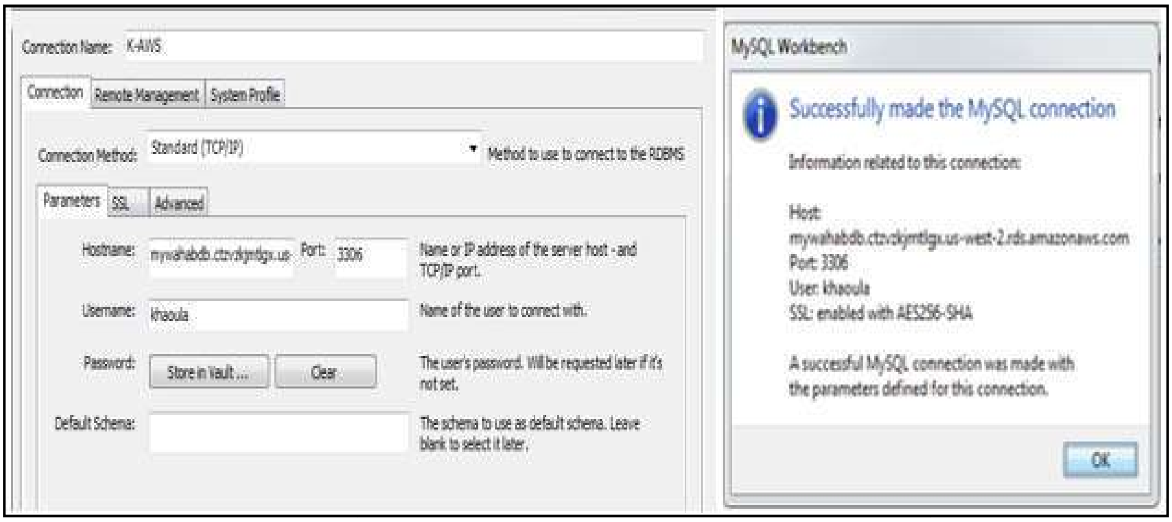

Figure 3.34: Setting of new connection

6. Test Connection, and provide the password.

Figure 3.35: MySQL new connection

3.5.4. Data reception:

For the reception of data at the deployed server in the AWS beanstalk and data storing in the database a connection must be established between the server and the database, here the serial number will be decrypted before storing in the database.

```java
@POST
@Path("/oak")
@Consumes(MediaType.APPLICATION_JSON)
public Response crunchifyREST(InputStream incomingData) {
    StringBuilder oakBuilder = new StringBuilder();
    try {
        BufferedReader in = new BufferedReader(new InputStreamReader(incomingData));
        String line = null;
        while ((line = in.readLine()) != null) {
            oakBuilder.append(line);
        }
    } catch (Exception e) {
        System.out.println("Error Parsing: - ");
    }
    //System.out.println("Data Received: " + oakBuilder.toString());
    //transJSON(oakBuilder);
    grincho = transJSON(oakBuilder);
    try {
        if( decrypt(grincho.getSerialNum())  ){

            /* Instanciation de notre DAOFactory */
            this.daoFactory = DAOFactory.getInstance();
            this.deviceDao = daoFactory.getDeviceDao();
            if(deviceDao.deviceConx(grincho)  ){
                //System.out.println("Serial verif : True" );
                grincho = null;
            }
        } else {
            oakBuilder = null;
            grincho = null;
```

Figure 3.36: Data reception

3.5.5. Data exploitation online:

For the web exploitation, we have developed a web application where the admin is the only one who control the assignment of the users with their zones.

Here we will site how our system works:

- Preparation of the environment, by the system administrator, through Creation of different zones, as well as its constraints values required.
- Inscription and registering system users for future authentication.
- Consultation of possible statistics for the predefined zones.
- Save these statistics on electronic formats.

- **The interface of the admin:**

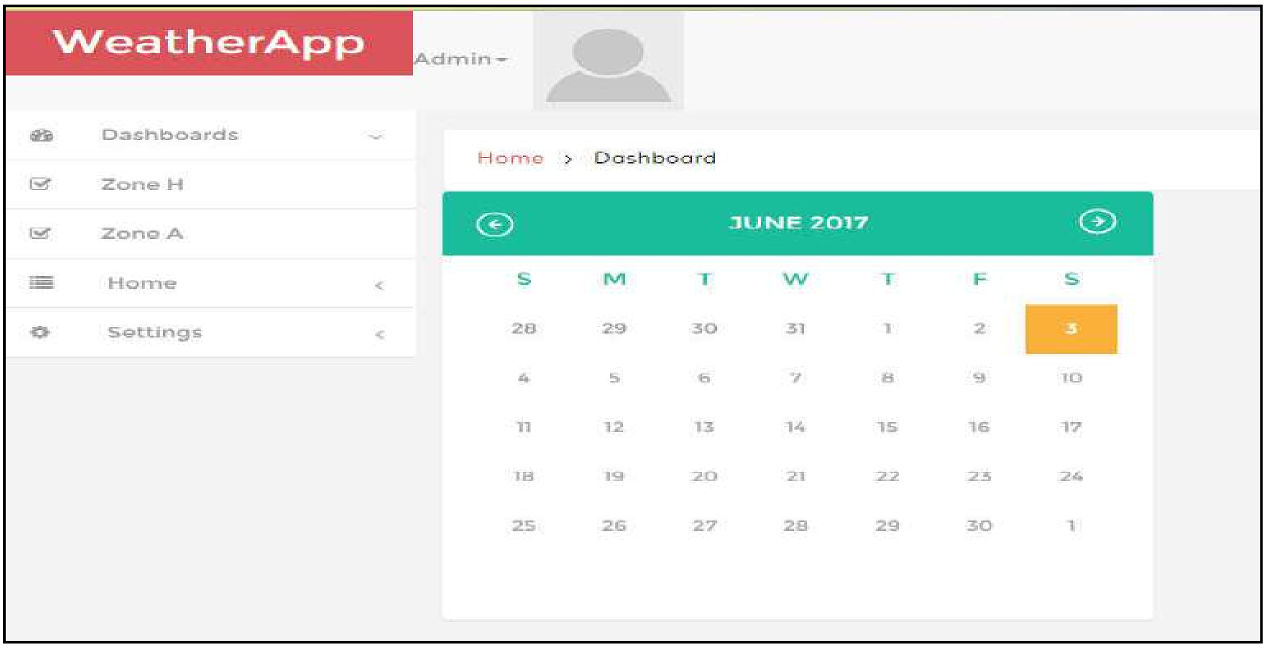

Figure 3.37: Admin interface

- **Adding of new users and new devices:**

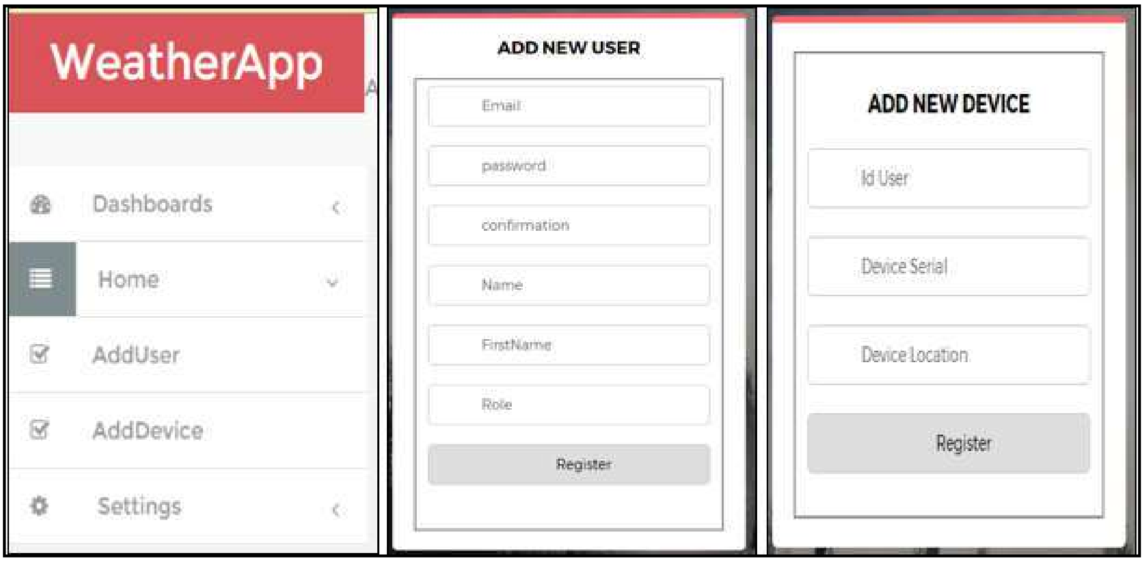

Figure 3.38: Addition of users and devices

- **The interface of the user:** Every system user has the authorization only to consult the parameters of the specific area that he is attributed to it.

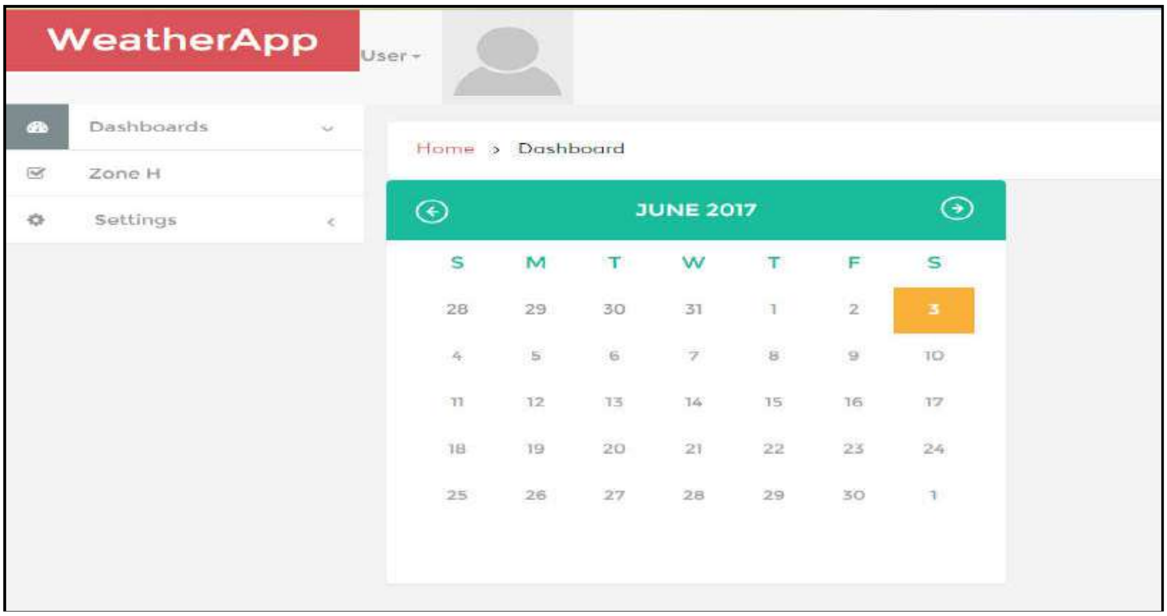

Figure 3.39: User interface

3.5.6. Data consultation:

In the consultation of the weather parameters, the data are presented into linear graphs and gauges containing the different changes in data values.

Graphs are for the daily parameters changes:

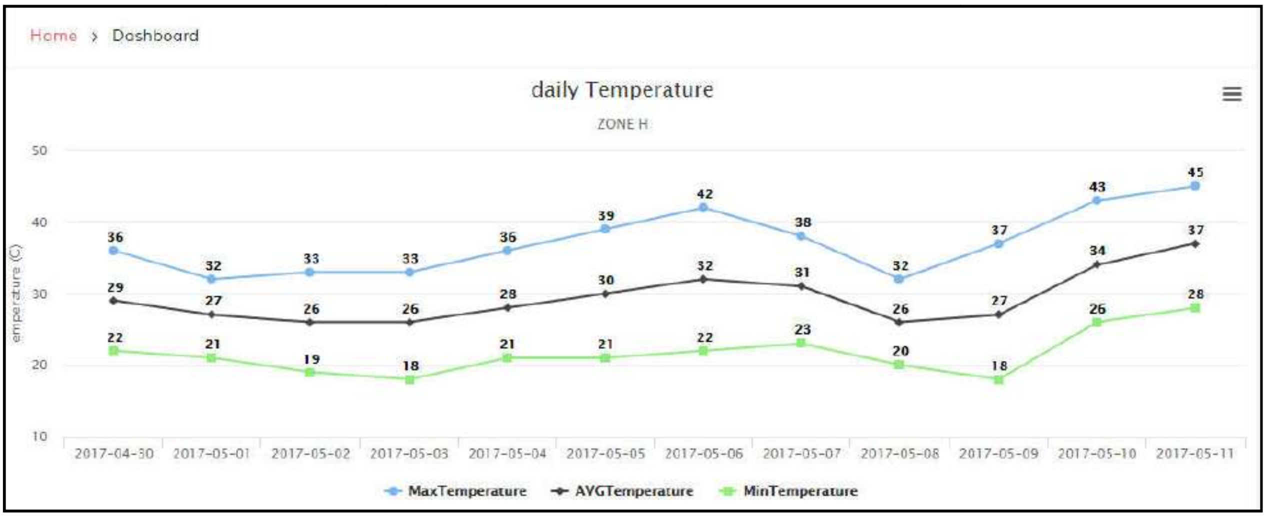

Figure 3.40: Temperature graph

The gauges are for the parameters changes every five(5) minutes:

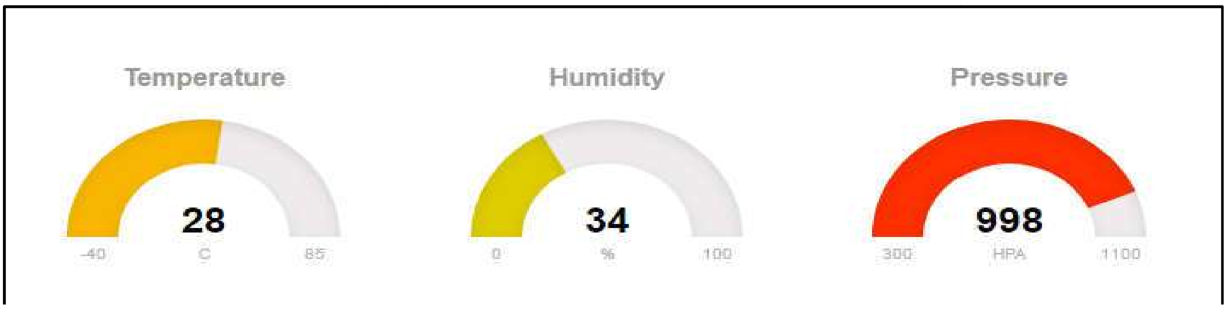

Figure 3.41: Parameters gauges

3.6.Discussion of results :

At the end of our project, we have achieved to our goal, the RPi send captured data with sensor to a cloud REST application using internet layer, a REST store data in cloud database, a web application is developed to be used for exploit this data by users where the weather parameters humidity,pressure and temperature are reprsented in graphs ,this application allows the user to check their assigned zones and the admin can add users and zones .

3.7.Advantages and disadvantages :

We can say that the advantages of our system are the same of others systems that use the cloud computing conception

- Advantages:
  - Cost saving: in two sides, storing information in the cloud gives almost unlimited storage capacity and Cloud computing uses remote resources, saving organizations the cost of servers and other equipment.
  - Accessibility: once you are registered in the application, you can access the information from anywhere, where there is an Internet connection
  - Data recovery: since all your data is stored in the cloud, backing it up and restoring the same is relatively much easier than storing the same on a physical device.
  - Easy use and manipulation of data
- Disadvantages:
  - The loss of data in case of absence of connection to the cloud.
  - The absence of notification in case of danger for critical areas

3.8.Conclusion:

Throughout this chapter, we have presented the different functionalities provided by our system. We have detailed the steps to be taken since capturing the physical quantities of the environment for particular places through the sensor for storing and processing at the AWS Cloud to provide a set of Services, in the form of graphical statistics published in user interface.

General conclusion

In the course of our brief, we were interested in setting up an environmental monitoring system based on the IOT technology using wireless sensor networks for a mission to control areas, with serious consequences in case of climate changes (temperature, humidity and pressure). It required a lot of new hardware and software technologies.

In hardware part we use a raspberry pi platform with a temperature, humidity, pressure sensor, using Wi-Fi to send informations to the internet. The environmental parameters are informations collected and sent to the web application interface and then plot the sensor data as graphical statistics. The cloud offers the development of the web application for the monitoring and the storage of the collected data into a database**.**

We have achieve the fixed goals from the beginning of our project, we have succeed to set up of different physical components and install the required softwares and the development tools that we have used for a best exploitation of our hardware, the result of our work is modeled as a user interface which is in the form of a web application which ensure set of services for the clients. Here we have integrated the IOT technology by using the cloud to store weather parameters and deploy our application.

This project allowed us to discover new domain, new manner of programming to accomplish the realization of our application, we get in touch with the different technologies of IoT concerning the hardware as the Raspberry Pi or software as Amazon Web Services .

The result of our realization is a gateway which stocks the data collected from a group of devices, the Gateway will be responsible of sending data to the cloud when the connection is available, and user can exploit data of particular location in graphical interface which present the change in weather parameters.

Actually in our project if there is no connection to the cloud there will be a loss of data, the cloud become inaccessible, for that we have as perspective to establish a gateway contains a local database for storage and synchronizes the data when the connection is restored where the device will never communicate with the cloud directly a solution for offline activities in the Sahara or the mountains for example.

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