Higher Nationals in Computing

Unit 43: Internet of Things

ASSIGNMENT 1

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UNIVERSITY of GREENWICH
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BTEC

ASSIGNMENT 1 BRIEF

Qualification	**BTEC Level 5 HND Diploma in Computing**
Unit number	Unit 43: Internet of Things
Assignment title	
Academic Year	2020
Unit Tutor	Ho Hai Van
Issue date	**Submission date**: June 20, 2020
IV name and date	Võ Thị Quỳnh Như

Submission Format:
Format: This assignment is an Individual assignment and specifically including 1 document: You must use font *Calibri size 12, set number of the pages and use multiple line spacing at 1.3. Margins must be: left: 1.25 cm; right: 1 cm; top: 1 cm and bottom: 1 cm.* The reference follows Harvard referencing system. The recommended word limit is *2.000-2.500 words*. You will not be penalized for exceeding the total word limit. The cover page of the report has to be the Assignment front sheet 1. *Submission* Students are compulsory to submit the assignment in due date and in a way requested by the Tutors. The form of submission will be a soft copy posted on http://cms.greenwich.edu.vn/ *Note:* The Assignment *must* be your own work, and not copied by or from another student or from books etc. If you use ideas, quotes or data (such as diagrams) from books, journals or other sources, you must reference your sources, using the Harvard style. Make sure that you know how to reference properly, and that understand the guidelines on plagiarism. *If you do not, you definitely get fail*
Unit Learning Outcomes:

LO1 Analyze what aspects of IOT are necessary and appropriate when designing software applications **LO2** Outline a plan for an appropriate IOT application using common architecture, frameworks, tools, hardware and APIs **LO3** Develop an IOT application using any combination of hardware, software, data, platforms and services. **LO4** Evaluate your IOT application and detail the problem your IOT application solves, the potential impact on people, business, society and the end user and the problems it might encounter when integrating into the wider IOT ecosystem
Assignment Brief and Guidance:
You currently work as a product developer for a new startup where you design IOT products for the consumer, corporate, government and defence clients. As part of your role your manager has tasked you to plan and develop a new IOT product, service or application for a potential client. You are required to identify a target user and conduct tests with this user and include this feedback into multiple iterative versions of your product. **Part 1 (Assignment 1)**:: For the first part, you must: • Plan an IOT application for a specific target end user and the tests you intend to conduct with this user. This plan will be in the form of a document and will include supporting evidence and material, such as user personas and customer journey maps. • Create multiple iterations of your application and modify each iteration with enhancements gathered from user feedback and experimentation. This will follow the pathway outlined in your plan.(log book,) **Part 2 (Assignment 2)**: For the first part, you must: • Show evidence about Developed IOT application using any combination of hardware, software, data, platforms and services (video or images of your IOT system with code snippet) • Evaluate your IOT application and detail the problem your IOT application solves, the potential impact on people, business, society and the end user and the problems it might encounter when integrating into the wider IOT ecosystem

Learning Outcomes and Assessment Criteria		
Pass	**Merit**	**Distinction**
LO1 Analyse what aspects of IOT are necessary and appropriate when designing software applications		
P1 Explore various forms of IOT functionality. **P2** Review standard architecture, frameworks, tools, hardware and APIs available for use in IOT development.	**M1** Evaluate the impact of common IOT architecture, frameworks, tools, hardware and APIs in the software development lifecycle. **M2** Review specific forms of IOT architecture, frameworks, tools, hardware and APIs for different problem-solving requirements.	**D1** Evaluate specific forms of IOT architecture and justify their use when designing software applications.
LO2 Outline a plan for an appropriate IOT application using common architecture, frameworks, tools, hardware and APIs		
P3 Investigate architecture, frameworks, tools, hardware and API techniques available to develop IOT applications. **P4** Determine a specific problem to solve using IOT.	**M3** Select the most appropriate IOT architecture, frameworks, tools, hardware and API techniques to include in an application to solve this problem. **M4** Apply your selected techniques to create an IOT application development plan.	**D2** Make multiple iterations of your IOT application and modify each iteration with enhancements gathered from user feedback and experimentation.

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LO1 Analyze what aspects of IOT are necessary and appropriate when designing software applications

P1 Explore various forms of IOT functionality.

1. **What is IoT?**

Figure 1: What is IoT?

IoT (Internet of Things) is known as a wide network of things all over the world connected to the Internet.

To put it more simply, IoT is all devices that people use are able to connect and interact with each other through the Internet. From there, people easily collect, process and transmit information data.

IoT has many basic features that you need to master:

Interoperability: is the ability of all devices to connect with each other

Heterogeneity: Devices in the IoT network have different hardware and networks, so they are not identical

Flexible changes: The number and status of devices are subject to change

Large scale: IoT networks have many devices connected to each other via the Internet

Satisfying services related to "Things"

Benefits of IoT to people

IoT is considered the key to human success in the near future, it positively affects life and work through many applications:

• Automation of smart home system
• Managing personal devices with a network connection
• Smart shopping through computer software, phones
• Managing the environment and waste in factories and enterprises
• Managing and planning jobs for businesses and companies
• Monitoring health remotely

Most industries today are more developed based on the flexible connection of the IoT network. Including education, agriculture, industry, health, etc.

Typically, factories start to apply sensors to the components that make products. From there track their activity and improve the quality. Or businesses using IoT technology to manage personnel, company data improve performance.

1.1. Internet of Things Underwater

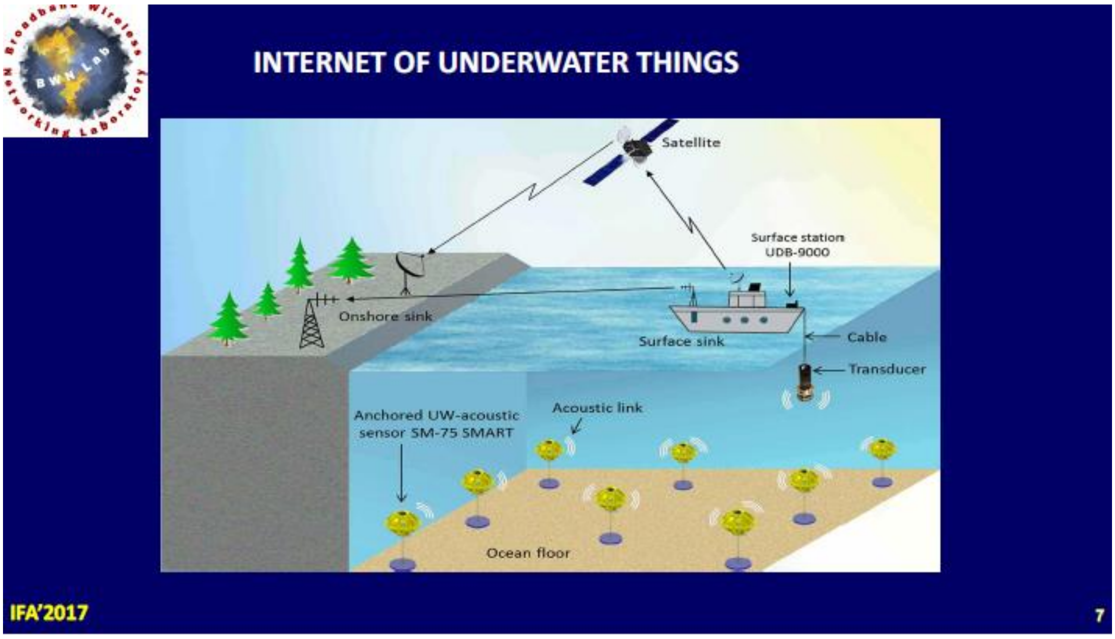

Figure 2: Internet of Things Underwater

The Underwater Internet of Things (IoT Underwater) is a system made up of unmanned vehicles that navigate the sea while communicating with underwater sensors and sending information to networks on the surface. This is going to be done at a regular Internet speed. This information can be used to effectively manage the resources of the planet. It can also be used for a large number of different tasks, including:

- Detect the shaking, earthquake of god.
- Easily collect information to monitor aquatic ecosystems to provide information for educational training and research on aquatic ecosystems.
- Surveying shipwrecks and crashes.
- Easily detecting threats to marine and lake ecosystems in the face of pollution to early find a solution, these critical marine environments can be managed by monitoring oil pipelines. and offshore gas - simultaneously sweeping the ocean floor to look for contaminants.

1.2. Internet of underground thing.

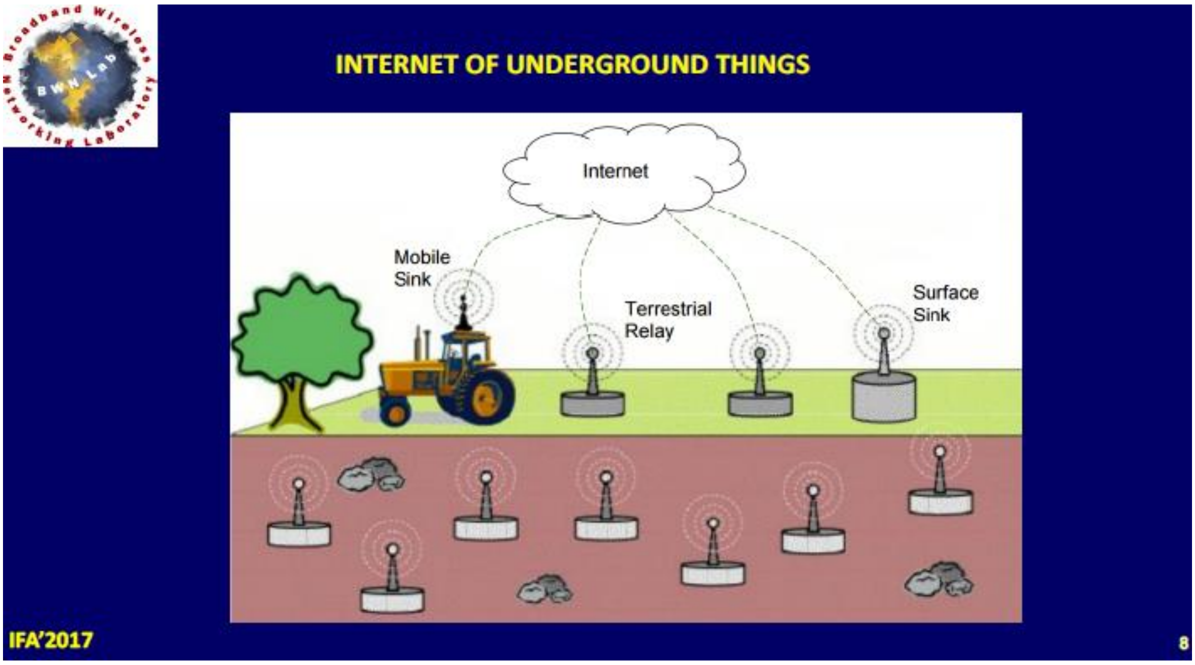

Figure 3: Internet of underground thing

Abstract—The projected increases in World population and need for food have recently motivated adoption of information technology solutions in crop fields within precision agriculture approaches. Internet of underground things (IOUT), which consists of sensors and communication devices, partly or completely buried underground for real-time soil sensing and monitoring, emerge from this need. This new paradigm facilitates seamless integration of underground sensors, machinery, and irrigation systems with the complex social network of growers, agronomists, crop consultants, and advisors. In this paper, state-of-the-art communication architectures are reviewed, and underlying sensing technology and communication mechanisms for IOUT are presented. Recent advances in the theory and applications of wireless underground communication are also reported. Major challenges in IOUT design and implementation are identified.

1.3. Internet of battlefield things

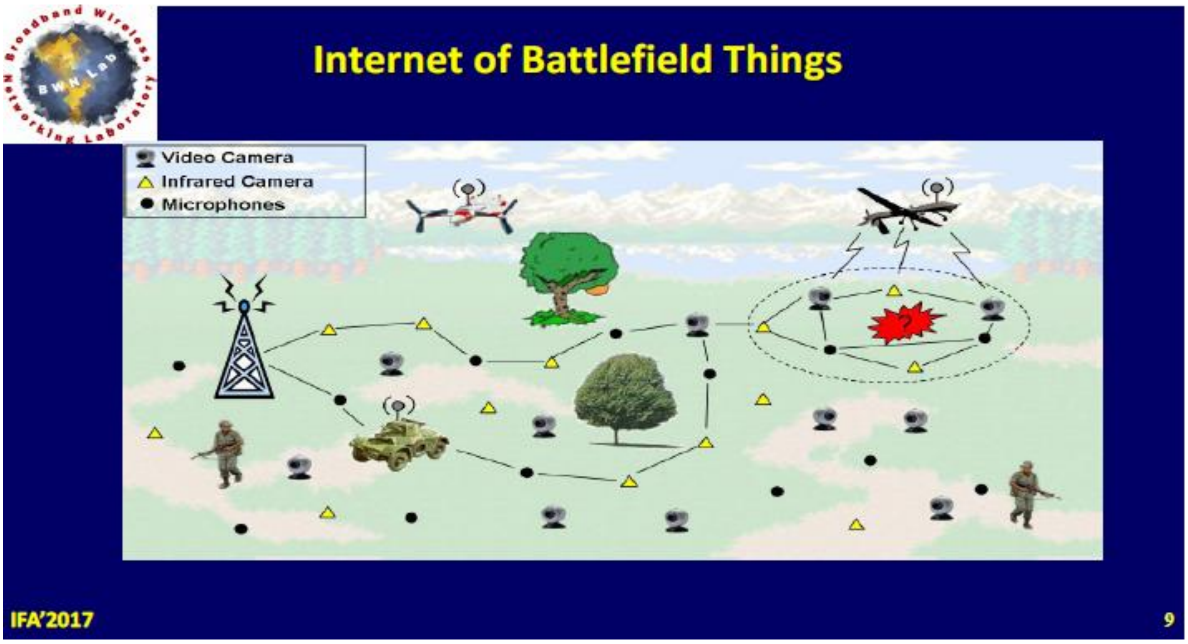

Figure 4: Internet of battlefield things

The Internet of Military Things (IoMT) is a class of Internet of things for combat operations and warfare. It is a complex network of interconnected entities, or "things", in the military domain that continually communicate with each other to coordinate, learn, and interact with the physical environment to accomplish a broad range of activities in a more efficient and informed manner. The concept of IoMT is largely driven by the idea that future military battles will be dominated by machine intelligence and cyber warfare and will likely take place in urban environments. By creating a miniature ecosystem of smart technology capable of distilling sensory information and autonomously governing multiple tasks at once, the IoMT is conceptually designed to offload much of the physical and mental burden that war fighters encounter in a combat setting.

Over time, several different terms have been introduced to describe the use of IoT technology for reconnaissance, environment surveillance, unmanned warfare and other combat purposes.

1.4. Internet of space things

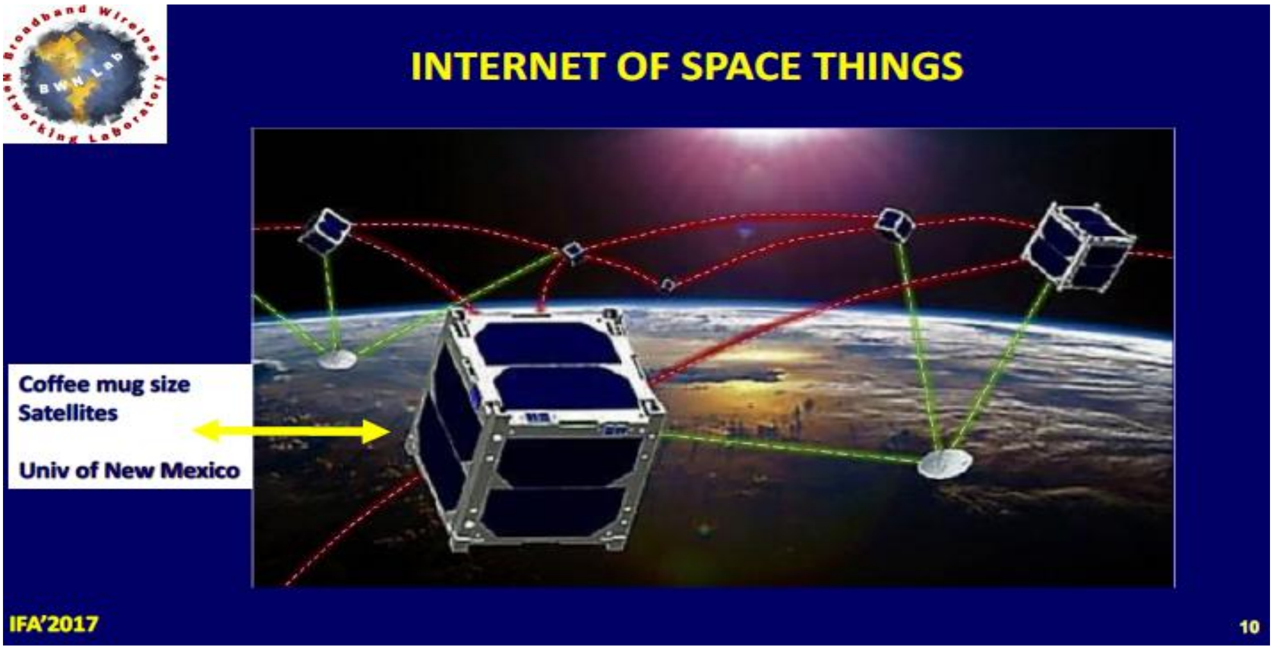

Figure 5: Internet of space things

The Internet of Things (IoT) has been recognized as a key driver of 5G wireless communications, with a projected 50 billion endpoints by 2020 ranging from connected temperature sensors to unmanned aerial vehicles. The long-term success of IoT is tied to its pervasiveness, an area where the heterogeneous connectivity solutions of today fall short by a large margin. The true potential of IoT can only be realized when it is augmented with a ubiquitous connectivity platform capable of functioning even in the most remote of locations. To this end, this project focuses on the development of a novel cyber-physical system spanning ground, air, and space, called the Internet of Space Things/CubeSats (IoST). IoST expands the functionalities of traditional IoT, by not only providing an always-available satellite backhaul network, but also by contributing real-time satellite-captured information and, more importantly, performing integration of on the ground data and satellite information to enable new applications. The fundamental building block for IoST is a new generation of nano-satellites known as CubeSats, which are augmented with SDN and NFV solutions.

The primary research objectives of this project include:

- Development of reconfigurable multi-band radios covering wide spectrums at microwaves, mm-wave, THz band, and optical frequencies to accommodate high-throughput services.

- Design of multi-band antenna arrays based on new materials such as graphene, which allow the creation of programmable antenna architectures with tunable frequency and radiation diagram.
- Deep neural networks-enabled resource allocation strategies for self-learning and optimization of CubeSat network.
- Tackling long delays and temporal variation in network topology through new concepts such as Stateful Segment Routing.
- Proactive handovers through Ground-to-satellite link outage forecasting and satellite diversity.
- Lightweight hardware virtualization for CubeSats with full networking support.

1.5. Internet of nanothings

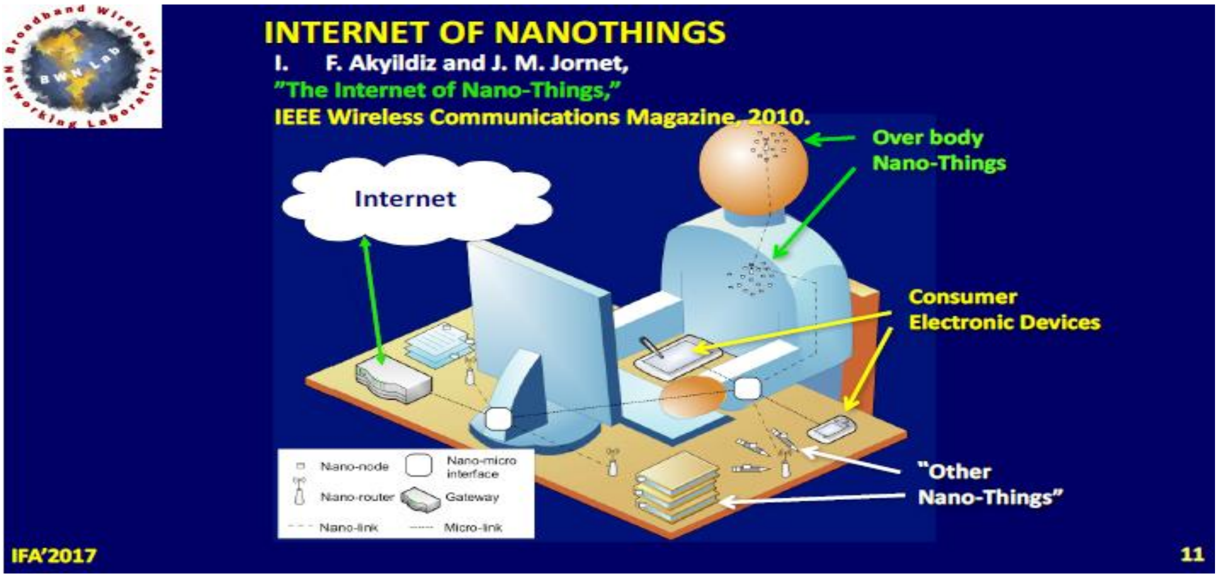

Figure 6: Internet of nanothings

The internet of nano-things (IoNT) is an interrelated system of very small devices to transfer data over a network. Various nanotechnologies integrated into an IoNT system can be used for very specific applications. For example, a smart factory will use IoNT devices to monitor temperature, humidity, gaseous fumes, water quality, and possibly carbon emissions from exhaust systems. Vehicles connected with miniaturized sensors can exchange data such as environmental or spatial information, which will improve the safety and accuracy of vehicle-assistance systems. The internet of nano-things isn't very different from IoT, except in the sense that devices interconnected within IoNT are miniaturized and small enough to be termed nanoscale, which is around .1 to 100 nanometers -- with a nanometer measuring at one-billionth of a meter. For reference, Nano.gov said a sheet of paper is 100,000 nanometers thick, there are 25.4 million nanometers in one inch, and DNA is 2.5 nanometers in diameter.

Most technologies currently in use -- such as sensors in cars and homes that report environmental conditions, or accelerometers and gyroscopes in smartphones that help people use navigation or location services -- are all examples of very small devices that can be miniaturized to fit within very small volumes. Almost all modern automation depends on nanoscale devices that can communicate with each other in order to provide smarter technical options. These technical integrations will drive innovation in all spaces imaginable, from the automotive industry to the healthcare industry, as well as for regular home goods for daily use.

Internet of nano-things electronics are not only sophisticated in terms of design and manufacturing, but they are extremely well-packaged to protect devices from unwanted interference. Interference is particularly challenging to manage because of the electromagnetic methods that allow these devices to communicate with each other wirelessly.

1.6. Internet of bio-nanothings

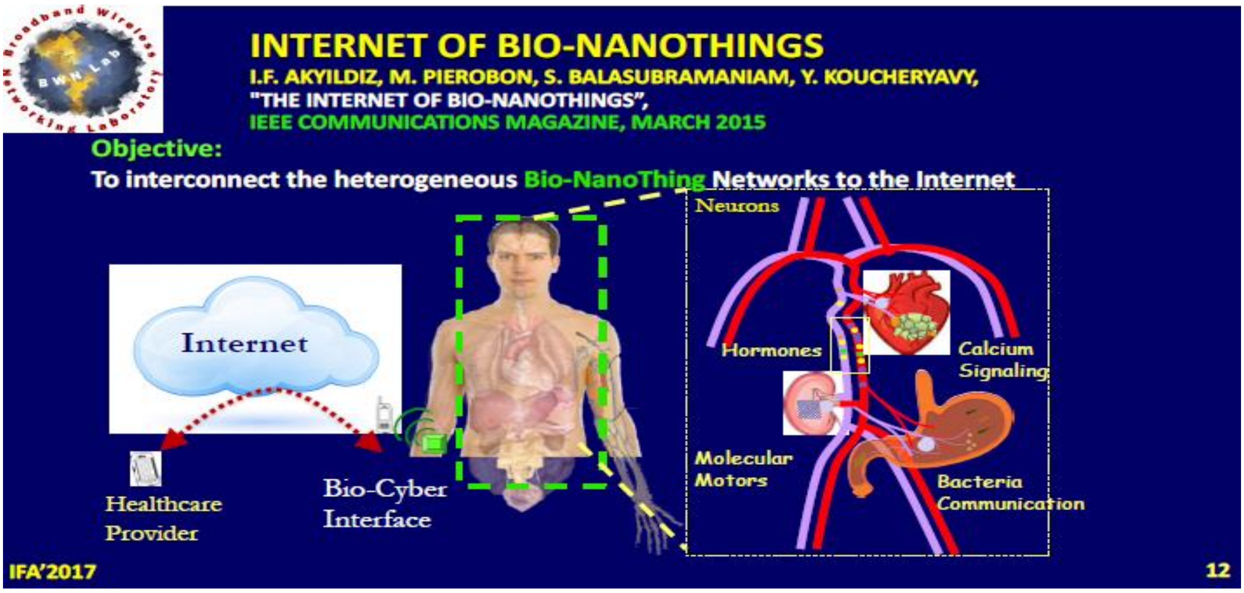

Figure 7: Internet of bio-nanothing

With advances in nanotechnology and biotechnology, bacteria, and pathogens are increasingly being noticed in scientific research as the potential substrate for the Internet of Bio-Nano Things (IoBNT), related to connect and communicate through nano and biological entities. Exploiting the special features of bacteria, pathogens, including autonomy - powered by a naturally embedded propeller motor - the bacteria show promising applications in healthcare and environment. we briefly outline the important features of bacteria that allow for the similarity between them and traditional computerized IoT devices. We argue that such comparisons are important in helping researchers explore the interactions between humans and bacteria, pathogens in the patient's body in the context of IoT and HCI. The applications are controlled by scientists, physicians, allowing them to control pathogens of harmful agents inside the human body, biological nano devices implanted in human body parts to Can promptly identify pathogens to prevent them by providing appropriate drugs, control the environment to detect polluted environment.

1.7. Benefits of IoT

Benefits when we use IoT is any time, any place and anything. Guess what? When we are going outside our parents just come to visit us and we don't stay at home, we can use IoT to open the door to let our parents wait for us, it's so amazing, right? Therefore, without IoT and we fall into this situation, we won't know what to do, right? This situation belongs to human to Thing (H2T). So, if we update this system to checking automatic face of our family, the door will open to let them in, without controlling by us, it calls Thing to Thing (T2T).

P2 Review standard architecture, frameworks, tools, hardware and APIs available for use in IOT development.

1. IoT architecture

1.1. What is IoT architecture and what is it used for?

Internet of Things (IoT) is here to change the world we know. Smart cars, smart homes, smart cities, everything around us can be turned into a smart device with the help of Internet of Things. IoT sure does bring the coolness factor to technology. While IoT is poised to bring the next big boom in the job market, lack of skill is citing the biggest barrier for companies looking to implement this technology. To be considered in any of the roles mentioned earlier, you'll need to be industry ready. Now, if you are starting to wonder what is IoT, you've stumbled onto the right page, this blog will get you going with the basics of Internet of Things.

IoT architecture varies from solution to solution, based on the type of solution which we intend to build. IoT as a technology majorly consists of four main components, over which an architecture is framed.

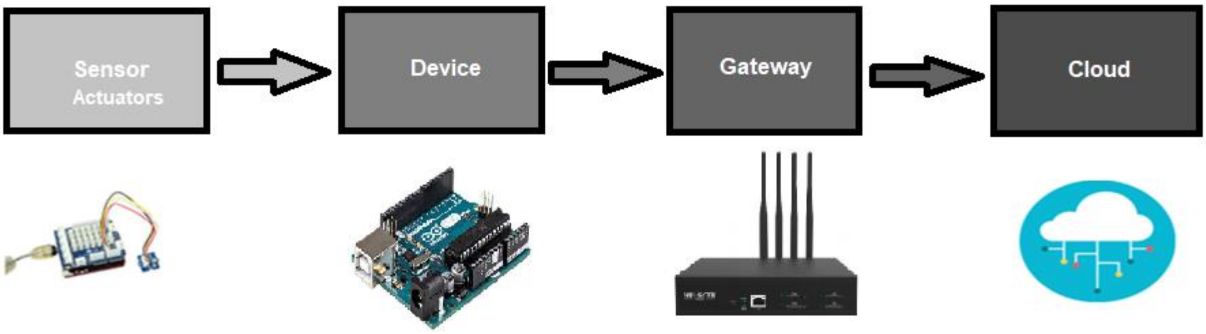

Figure 8: IoT architecture

The following is the basic 4 Stage Architecture of IoT example:

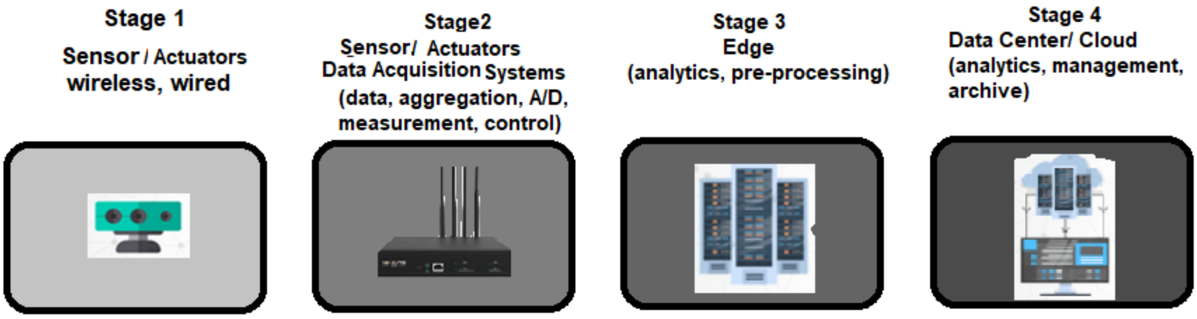

Figure 9: The basic 4 Stage Architecture of IoT

STAGE 1:

- **Sensors:** 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.
- **Actuators:** is 1 actuator, transmit motion from up to down motion, left to right, rotation to up and down motion, rotation to rotation.
- **Sensing/Actuating** stage covers everything. Example: Industrial devices to robotic camera systems, water-level detectors, air quality sensors, accelerometers, and heart rate monitors

Stage 2:

Stage 2 devices are frequently positioned in near proximity to sensors and actuators. For example, a pump may contain half a dozen sensors and actuators that feed data into a data aggregation device that also digitizes data. This system can be physically connected to the pump. The adjacent gateway or server would then process the data and forward it to Stage 3 or Stage 4 system.

Stage 3:

- Remarks Once IoT data has been digitized and aggregated, it is ready to be transferred to the IT realm.
- However, the data may require further processing before entering the data center
- This is where edge IT systems, which perform more analysis, come into play
- Edge IT processing systems may be located in remote offices or other edge locations, but generally these are located in a facility or location where the sensors are located closer to the sensors, such as in a wiring closet.

Stage 4:

- Stage 3 data is sent to physical data centers or cloud-based systems where more powerful IT systems are able to process, handle and store data securely
- Although it takes longer to get results when you wait until the data reaches Stage 4, you can perform a more in-depth analysis and combine your sensor data with data from other sources for deeper insight.
- Stage 4 processing may take place on-site, in the cloud, or in a hybrid cloud system, but the type of processing carried out at this stage remains the same, regardless of the platform.

2. IoT PTC Design Framework

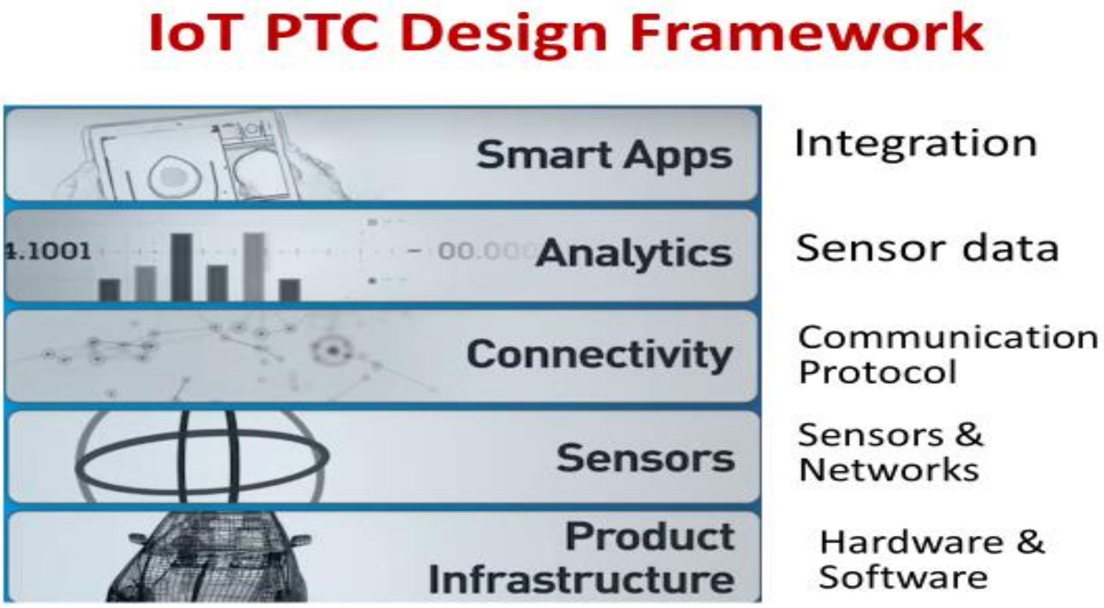

Figure 10: IoT PTC Design Framework

2.1. Product Infrastructure layer

The first layer of the IoT architecture system is where the physical and digital sections of the smart connected device are specified. This starts with the hardware of the device. What's it going to be like? Which type of products would it be made of? The digital model of the product will also be defined.

2.2. Sensors layer

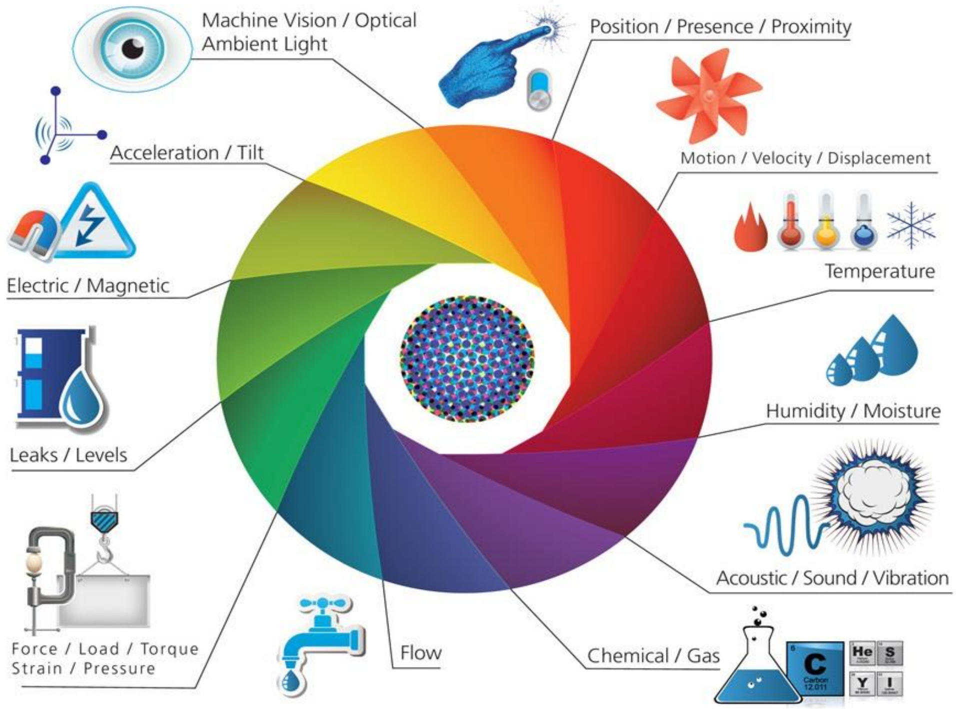

Figure 11: Sensors layer

This layer helps us identify and transform external environmental information into electrical signals to help control other devices.

Types of popular sensor now

The most common types of sensors are classified based on data such as: electric or magnetic or magnetic sensors, velocity sensors, humidity sensors, flow or liquid sensors, level sensor, gas sensor, pressure sensor, temperature or heat sensor, optical sensor, position sensor, chemical sensor, environmental sensor, magnetic switch sensor, ...

2.3. Connectivity Layer

Figure 12: Connectivity Layer

The main components that complete connectivity layer are sensors and devices. Sensors collect the information and send it off to the next layer where it is being processed. With the advancement of technology, semiconductor technology is used that allows the production of micro smart sensors that can be used for several applications.

The main components are: Proximity detection, Humidity or Moisture Level, Temperature sensors and thermostats, Pressure sensors, RFID tags.

The modern smart sensors and devices use various ways to be connected. The wireless networks like LORAWAN, Wi-Fi, and Bluetooth makes it easy for them to stay connected. They have their own advantages and drawbacks that are classified in various forms like efficiency rate, data transfer, and power.

2.4. Analytics layer

The analog data of devices and sensors are converted into a format that is easy to read and analyze. This is all possible due to the IoT ecosystem that manages and helps in improving the system. The main factor that is influenced is security.

The most important function of IoT technology is that it supports real-time analysis that easily observes the irregularities and prevents any loss or scam. Preventing the malicious things to attack the smart devices will not only give you a sense of security but also it will save all your private data from being used for illegal purposes.

The big companies collect the data in bulk and analyze it to see the future opportunity so that they can easily develop more business advancement and gain something out of it. This analysis easily helps in setting future trends that have a capability to rule the market. From this analysis, they can be one step ahead of the time and easily achieve success. Data may be a small word but it holds the power to make or break the business if used correctly.

2.5. Smart Apps layer

Figure 13: Smart Apps layer

This is another factor on which IoT ecosystem depends immensely. It provides a visible and physical part that can be easily accessed by the user. It is important for the developer to create a user-friendly interface that could be accessed without putting any extra efforts in it and that can help in easy interaction.

With the help of advancement, there are various interactive designs that could be used easily and that can easily solve any complex query. For examples, at home people have started to use the colorful touch panels instead of the hard controls that were used earlier. It is increasing day by day as now the touchpads are also launched that can switch on the air conditioners from a distance.

This has set out a trend for the digital generations and have managed to hype up today's competitive market. The user interface is the first thing that user pay attention to before buying a device. Even customers are oriented to buy the devices that are user-friendly and less complex that could be used with wireless connectivity.

3. Tools

IoT platforms and tools are considered as the most significant component of the IoT ecosystem. Any IoT device permits to connect to other IoT devices and applications to pass on information using standard Internet protocols. IoT platforms fill the gap between the device sensors and data networks. IoT platforms connect the data to the sensor system and give insights using back-end applications to create a sense of the plenty of data developed by the many sensors.
The Internet of Things (IoT) is the future of technology that helps the Artificial intelligence (AI) to regulate and understand the things in a considerably stronger way.

3.1. Tinkercad

Figure 14: Tinkercad logo

Tinkercad is a free online collection of software tools that help people all over the world think, create and make. We’re the ideal introduction to Autodesk, the leader in 3D design, engineering and entertainment software.

3.2. Ciscopacket tracer

Figure 15: Ciscopacket tracer logo

Packet Tracer is a cross-platform visual simulation tool designed by Cisco Systems that allows users to create network topologies and imitate modern computer networks. The software allows users to simulate the configuration of Cisco routers and switches using a simulated command line interface. Packet Tracer makes use of a drag and drop user interface, allowing users to add and remove simulated network devices as they see fit. The software is mainly focused towards

Certified Cisco Network Associate Academy students as an educational tool for helping them learn fundamental CCNA concepts. Previously students enrolled in a CCNA Academy program could freely download and use the tool free of charge for educational use.

3.3. Arduino

Figure 16: Arduino logo

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. It is both a hardware specification for interactive electronics and a set of software that includes an IDE and the Arduino programming language. The website explains that Arduino is "a tool for making computers than can sense and control more of the physical world than your desktop computer." Project: A Smart night lamp for kids- Lights up when dark and changes color automatically. Step by step tutorial with full source code!

4. Hardware

IoT Hardware includes a wide range of devices such as devices for routing, bridges, sensors etc. These IoT devices manage key tasks and functions such as system activation, security, action specifications, communication, and detection of support-specific goals and actions.

4.1. Adruino uno

Arduino Uno is an open source microcontroller board based on the Microchip ATmega328 microcontroller developed by Arduino.cc. The board is equipped with Digital and Analog input / output pins that can interface with various expansion boards. The Arduino Uno circuit is suitable for newcomers and enthusiasts about electronics, programming ... Based on the open platform provided by Arduino.cc, you can easily build yourself the fastest project (programming Robots, self-propelled vehicles, LED on and off control ...).

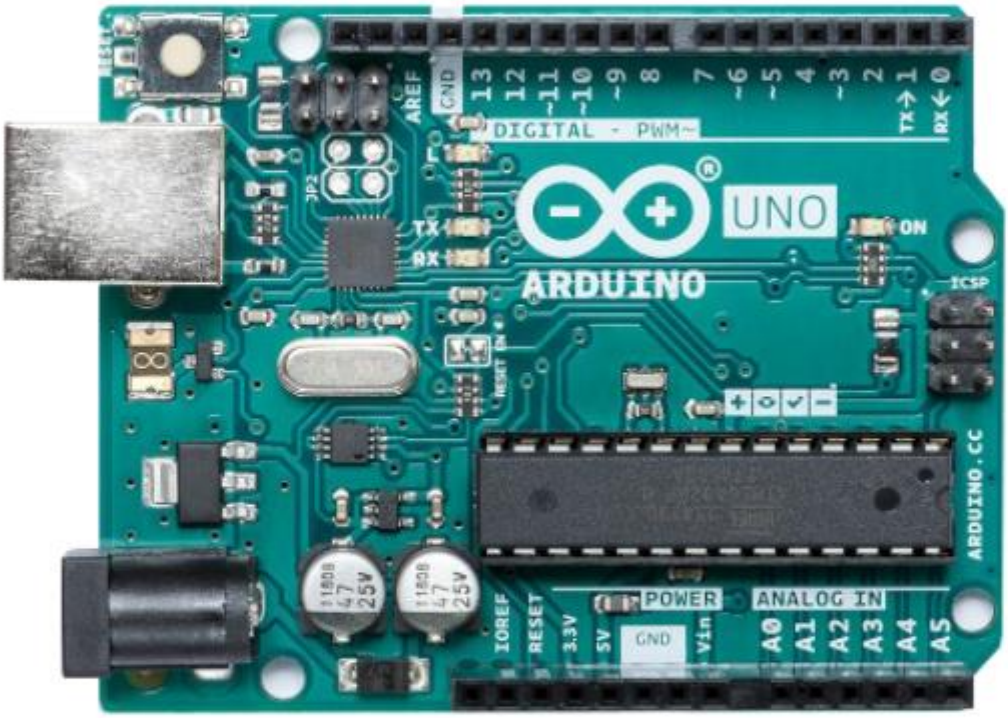

Figure 17: Adruino uno

4.2. Raspberry Pi 2

which is a very affordable and tiny computer that can incorporate an entire web server. Often called “RasPi,” it has enough processing power and memory to run Windows 10 on it as well as IoT Core. RasPi exhibits great processing capabilities, especially when using the Python programming language.

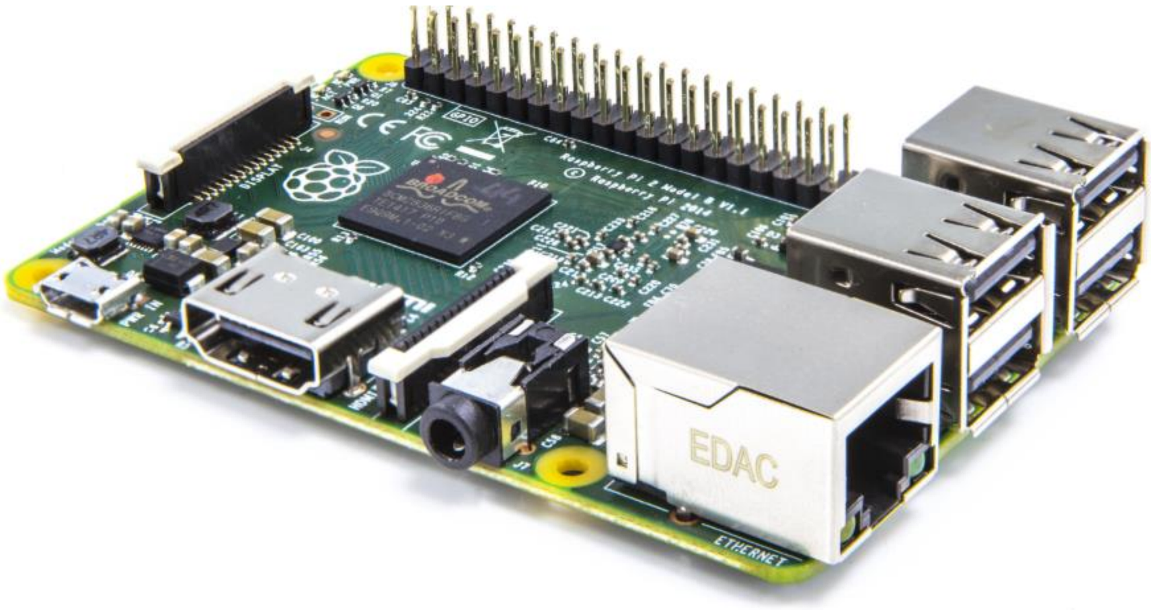

Figure 18: Raspberry Pi 2

5. What is API?

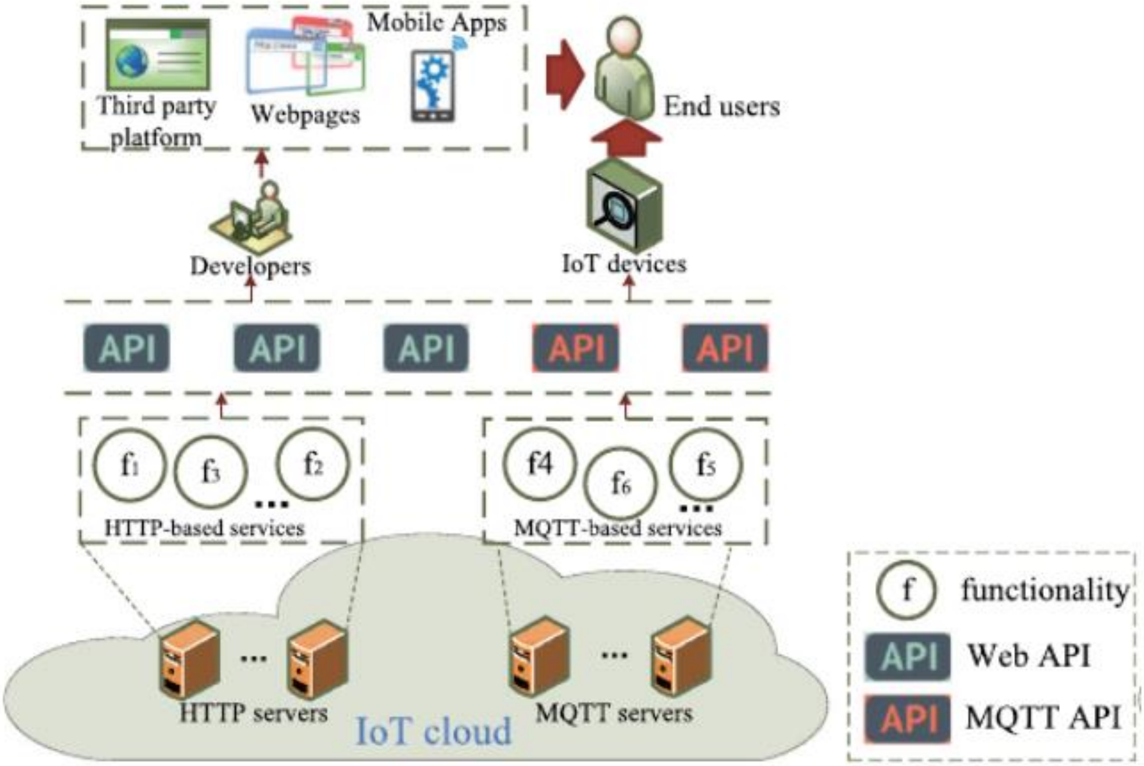

Figure 19: IoT standard APIs – Web API & MQTT API

APIs are methods and protocols that connect to other libraries and applications. It stands for Application Programming Interface. The API provides the ability to access a set of commonly used functions. And from there it is possible to exchange data between applications.

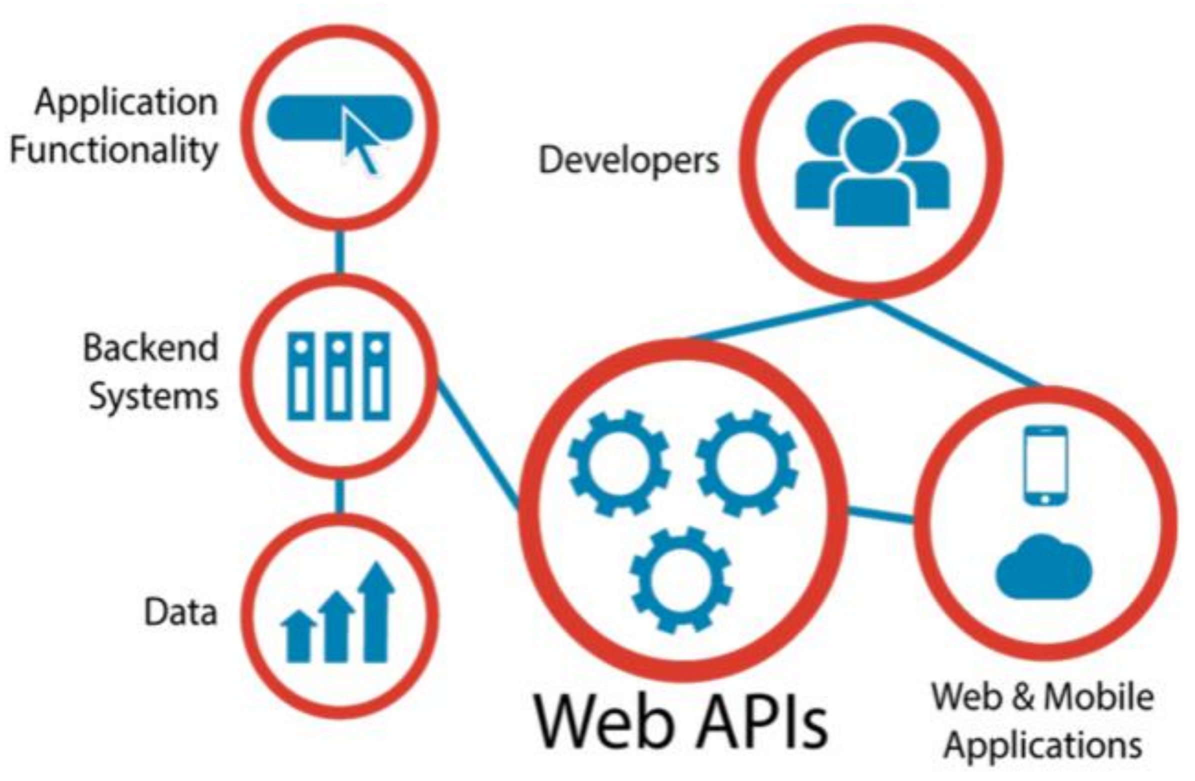

Figure 20: What is API?

Today almost all web services like Facebook,Twitter etc have APIs that enable developers to create applications that interact with the platform.

5.1. But What exactly is an API (Application Programming Interface)?

An API is an interface used by programs to access an application.
It allows a program to send commands to another programs and receive responses back from that application.
Many of the APIs today are Web API’s and are designed to use the HTTP protocol.
Many are also REST (representational State Transfer) APIs .REST is a design architecture and doesn’t really concern us as we will be using them and not designing them, however for more details see What is REST.
Although http based APIs are common on the web MQTT is becoming the main IOT protocol, and we will likely see a large growth of MQTT based APIs.

All of the main IOT providers like Amazon,Azure and IBM provide both http and MQTT APIs to access their services.

5.2. What is the Web API?

Web API is a method used to allow different applications to communicate and exchange data back and forth. The data returned by the Web API is usually in JSON or XML format via HTTP or HTTPS protocols.

5.3. Where is the Web API commonly used?

Web API is the API system used in website systems. Most websites have web API applications that allow you to connect, retrieve data or update databases. For example: You design the login function via Google, Facebook, Twitter, Github ... This means you are calling API's. Or like mobile applications that get data via API.

5.4. How does the Web API work?

The first is to build the API URL so that third parties can send data requests to content service providers through HTTP or HTTPS.
At the content server web server, the source application will perform validation checks if available and look for appropriate resources to create content that returns results.
The server returns the result in JSON or XML format via HTTP / HTTPS protocol.
Where the original request is a web or mobile application, JSON / XML data will be parsed to retrieve the data. After obtaining data, continue to perform activities such as saving data to Database, displaying data ...

5.5. What is MQTT (Message Queue Telemetry Transport)?

MQTT is a lightweight messaging protocol designed for lightweight communication between devices and computer systems. MQTT was originally designed for SCADA networks, production scenarios and low bandwidth, MQTT has gained popularity recently due to the development of Internet-of-Things (IoT).

5.6. What are the advantages of MQTT?

The MQTT protocol allows your SCADA system to access IIoT data. MQTT brings many powerful benefits to your process:

- Transfer information more efficiently
- Increase scalability
- Dramatically reduces network bandwidth consumption

- Reduce the update speed to seconds
- Very suitable for control and spying
- Maximize available bandwidth
- Extremely light cost
- Very secure with permission-based security
- Used by oil industry, Amazon, Facebook and other large businesses
- Save development time
- The publish / subscribe protocol collects more data with less bandwidth than the old protocol.

LO2 Outline a plan for an appropriate IOT application using common architecture, frameworks, tools, hardware and APIs

P3 Investigate architecture, frameworks, tools, hardware and API techniques available to develop IOT applications.

1. **Architecture**

Just like Internet has changed the way we work & communicate with each other, by connecting us through the World Wide Web (internet), IoT also aims to take this connectivity to another level by connecting multiple devices at a time to the internet thereby facilitating man to machine and machine to machine interactions.

People who came up with this idea, have also realized that this IoT ecosystem is not limited to a particular field but has business applications in areas of home automation, vehicle automation, factory line automation, medical, retail, healthcare and more.

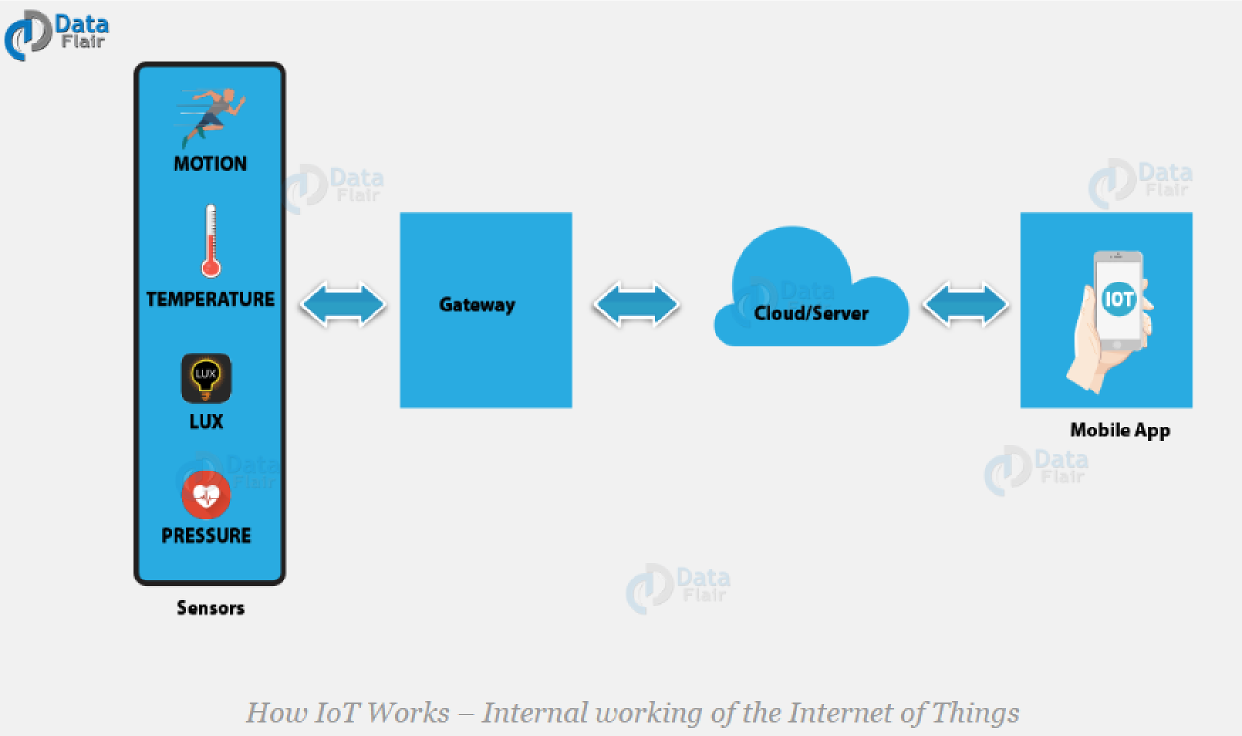

Figure 21: Architecture

Here, 4 fundamental components of IoT system, which tells us how IoT works.

1.1. Sensors/Devices

First, sensors or devices help in collecting very minute data from the surrounding environment. All of this collected data can have various degrees of complexities ranging from a simple temperature monitoring sensor or a complex full video feed.

A device can have multiple sensors that can bundle together to do more than just sense things. For example, our phone is a device that has multiple sensors such as GPS, accelerometer, camera but our phone does not simply sense things.

The most rudimentary step will always remain to pick and collect data from the surrounding environment be it a standalone sensor or multiple devices.

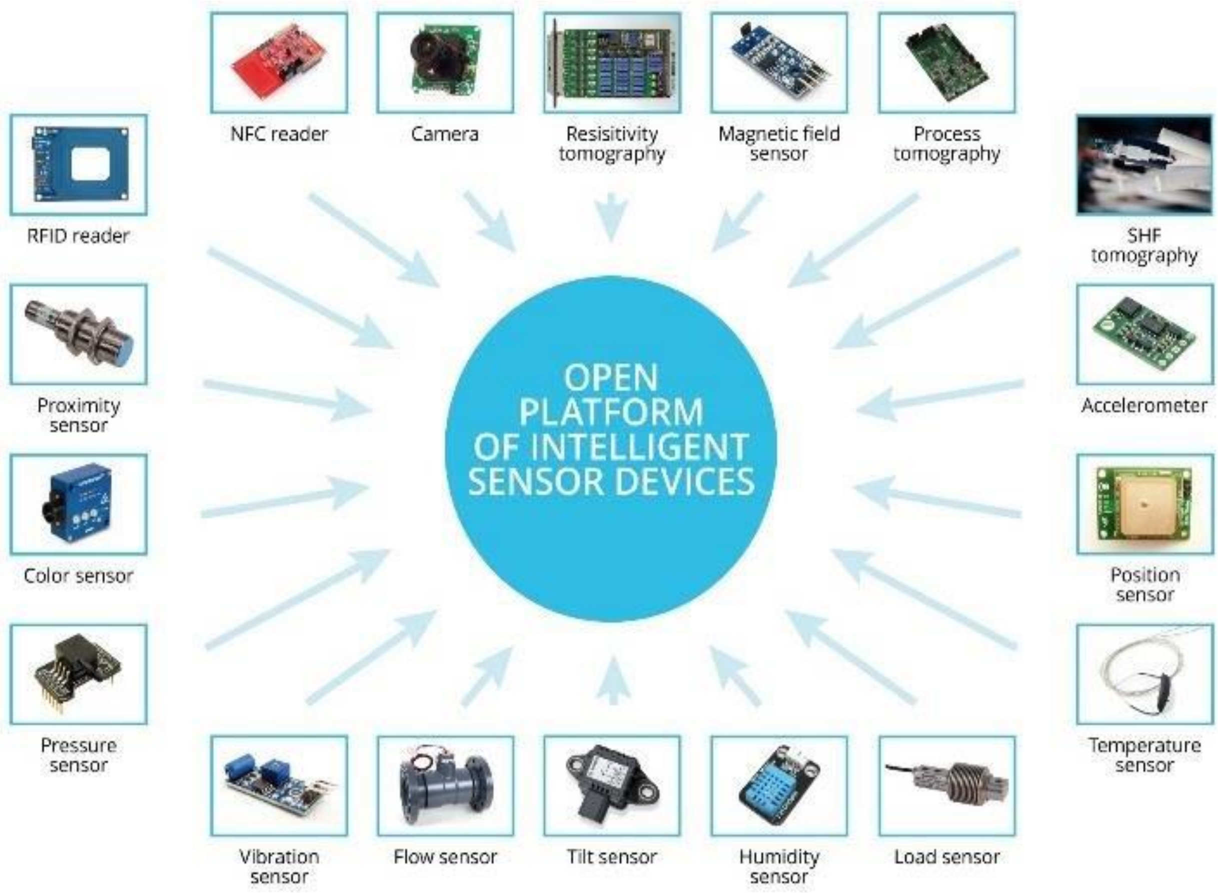

Figure 22: Sensors/Devices

1.2. Connectivity

Next, that collected data is sent to a cloud infrastructure but it needs a medium for transport.

The sensors can be connected to the cloud through various mediums of communication and transports such as cellular networks, satellite networks, Wi-Fi, Bluetooth, wide-area networks (WAN), low power wide area network and many more.

Every option we choose has some specifications and trade-offs between power consumption, range, and bandwidth. So, choosing the best connectivity option in the IOT system is important.

Figure 23: Connectivity

1.3. Data Processing

Once the data is collected and it gets to the cloud, the software performs processing on the acquired data.

This can range from something very simple, such as checking that the temperature reading on devices such as AC or heaters is within an acceptable range. It can sometimes also be very complex, such as identifying objects (such as intruders in your house) using computer vision on video. But there might be a situation when a user interaction is required, example- what if when the temperature is too high or if there is an intruder in your house? That's where the user comes into the picture.

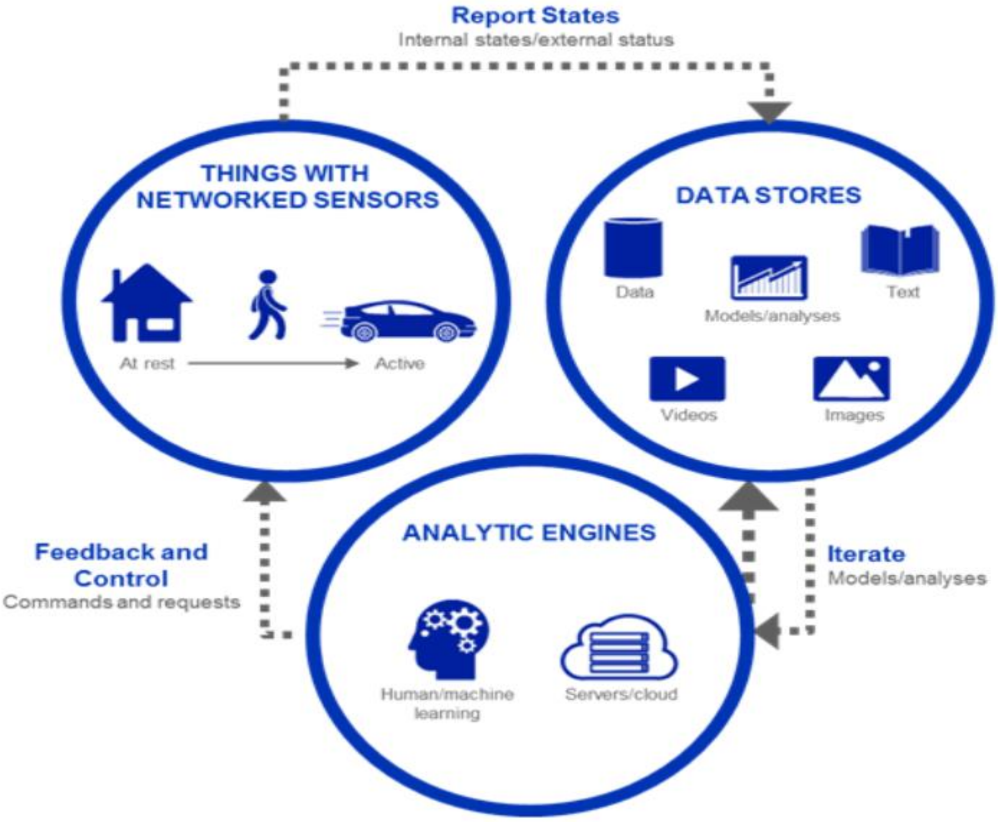

Figure 24: Data Processing

1.4. User Interface-Smart app

Next, the information made available to the end-user in some way. This can achieve by triggering alarms on their phones or notifying through texts or emails.

Also, a user sometimes might also have an interface through which they can actively check in on their IOT system. For example, a user has a camera installed in his house, he might want to check the video recordings and all the feeds through a web server.

However, it's not always this easy and a one-way street. Depending on the IoT application and complexity of the system, the user may also be able to perform an action that may backfire and affect the system. For example, if a user detects some changes in the refrigerator, the user can remotely adjust the temperature via their phone.

There are also cases where some actions perform automatically. By establishing and implementing some predefined rules, the entire IOT system can adjust the settings automatically and no human has to be physically present. Also, in case if any intruders are sensed, the system can generate an alert not only to the owner of the house but to the concerned authorities.

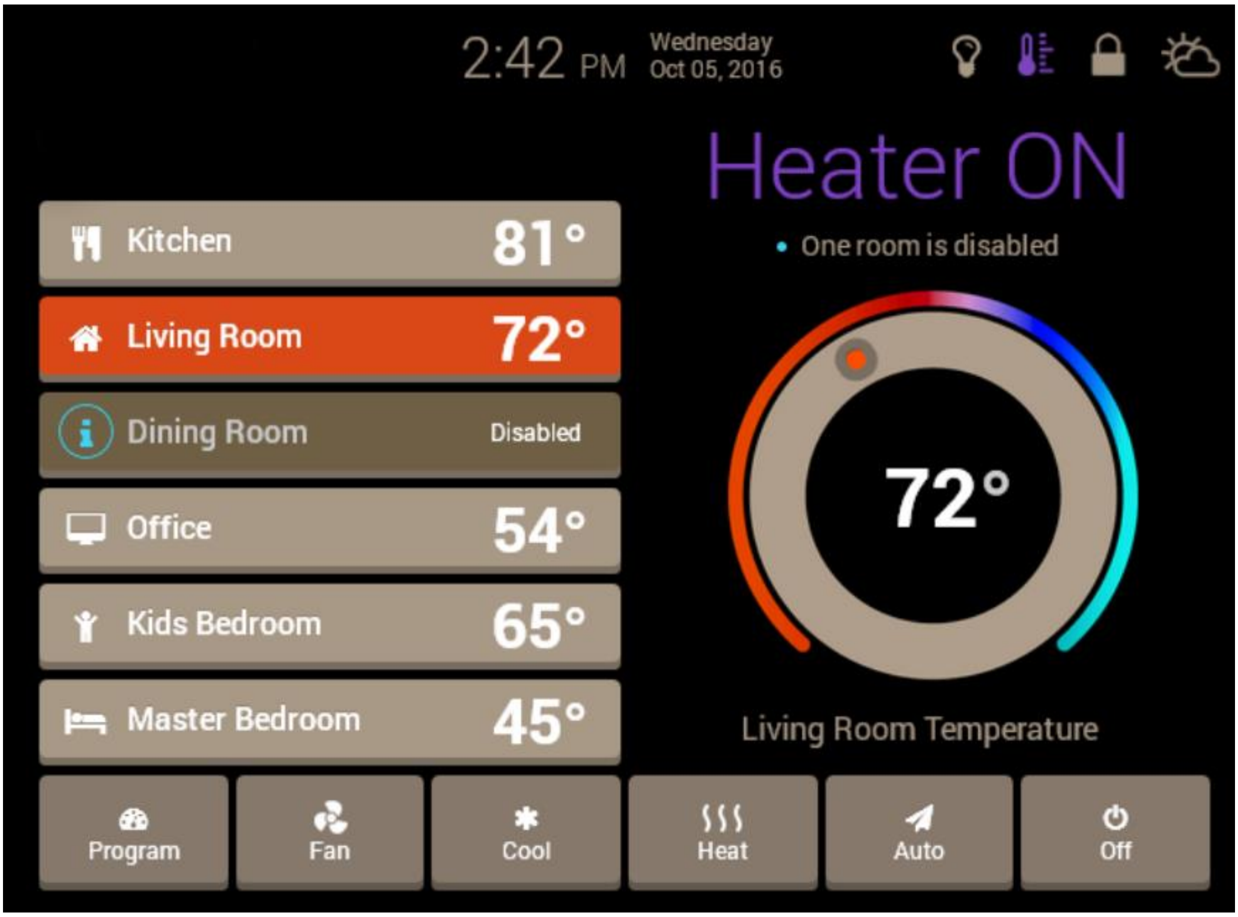

Figure 25: User Interface-smart app

2. Framework

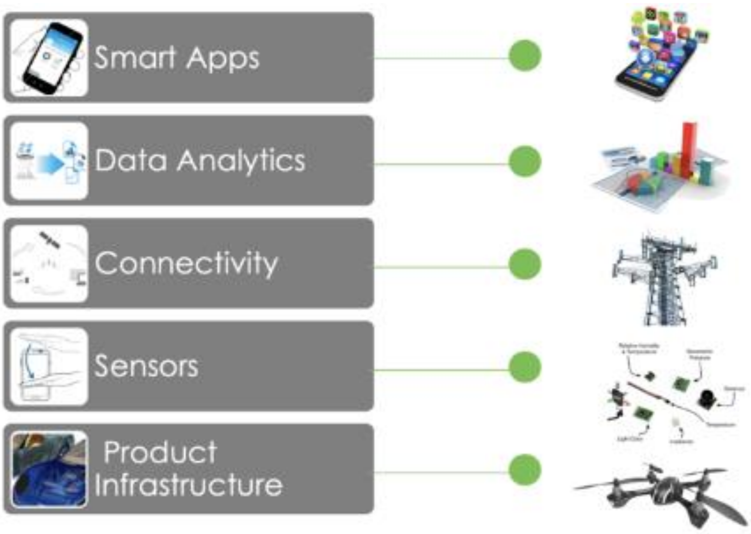

Figure 26: Framework

2.1. Product Infrastructure layer

Remote control air conditioner

Figure 27: Product Infrastructure

2.2. Sensors layer

We use the home-made temperature Sensor to get the temperature measurement from the home-set furnace via the ipad. These types of temperature sensor vary from simple ON / OFF thermostatic devices which control a domestic hot water heating system to highly sensitive semiconductor types that can control complex process control furnace plants.

We remember from our school science classes that the movement of molecules and atoms produces heat (kinetic energy) and the greater the movement, the more heat that is generated. Temperature Sensors measure the amount of heat energy or even coldness that is generated by an object or system, allowing us to "sense" or detect any physical change to that temperature producing either an analogue or digital output.

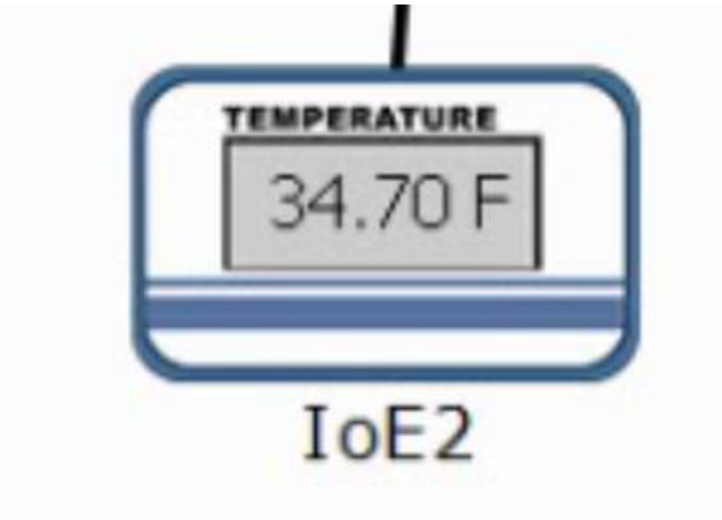

Figure 28: Temperature sensor

2.3. Connectivity Layer

Next, that collected data is sent to a cloud infrastructure but it needs a medium for transport. The sensors can be connected to the cloud through various mediums of communication and transports such as cellular networks, satellite networks, Wi-Fi, Bluetooth, wide-area networks (WAN), low power wide area network and many more.

Every option we choose has some specifications and trade-offs between power consumption, range, and bandwidth. So, choosing the best connectivity option in the IOT system is important.

2.4. Analytics layer

Temperature parameters start to rise up to room temperature when we haven't turned on the air conditioner yet, the temperature decreases when the air conditioner is on.

2.5. Smart Apps layer

We access the website address on the server to access the control website. We can see the parameters from the Temperature sensor so that we can control the air conditioner remotely and see how the temperature changes abnormally, in case the air conditioner is not turned off or exploded.

Figure 29: Smart app

3. Tools

3.1. Tinkercad

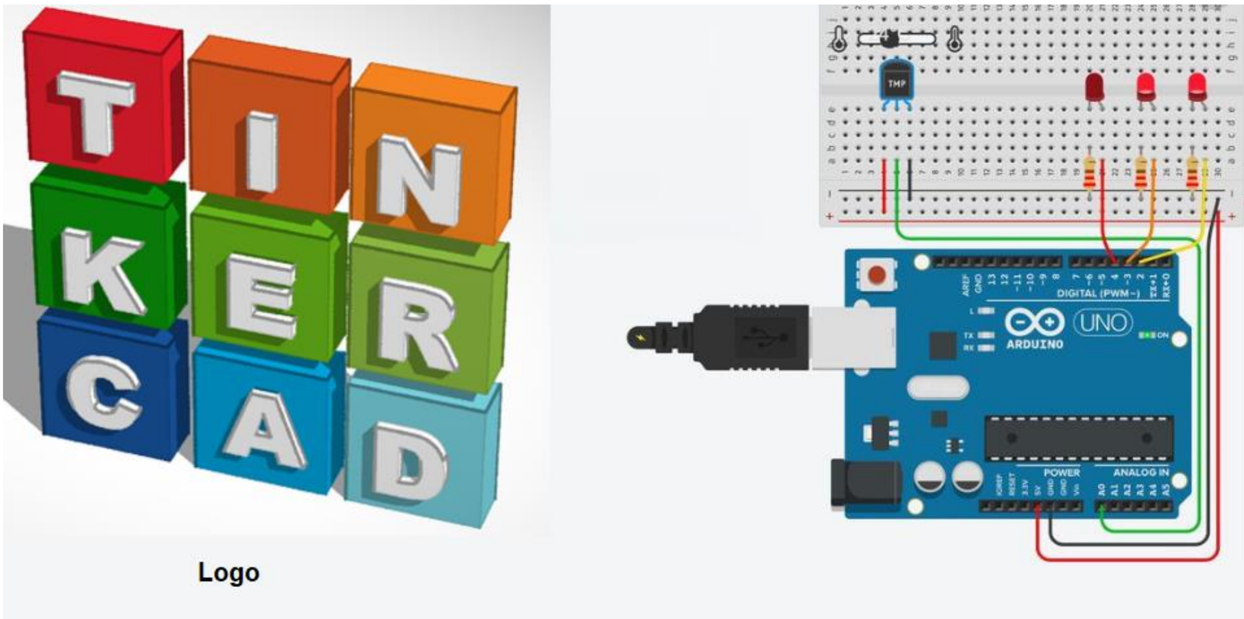

Figure 30: Tinkercad

Tinkercad is a free online collection of software tools that help people all over the world think, create and make. We're the ideal introduction to Autodesk, the leader in 3D design, engineering and entertainment software.

3.2. Ciscopacket tracer

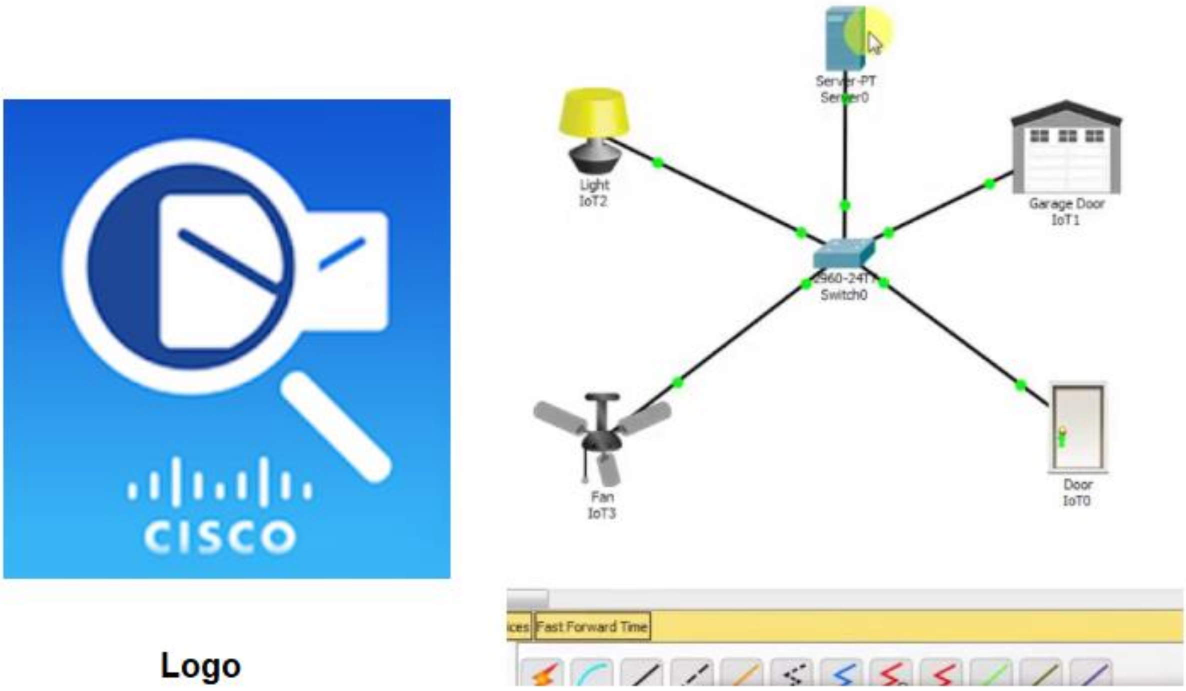

Figure 31: Ciscopacket tracer

Packet Tracer is a cross-platform visual simulation tool designed by Cisco Systems that allows users to create network topologies and imitate modern computer networks. The software allows users to simulate the configuration of Cisco routers and switches using a simulated command line interface. Packet Tracer makes use of a drag and drop user interface, allowing users to add and remove simulated network devices as they see fit. The software is mainly focused towards Certified Cisco Network Associate Academy students as an educational tool for helping them learn fundamental CCNA concepts. Previously students enrolled in a CCNA Academy program could freely download and use the tool free of charge for educational use.

3.3. Aduino

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software.
This software can be used with any Arduino board.
Refer to the Getting Started page for Installation instructions.

4. Hardware

4.1. Adruino uno

Figure 32: Adruino uno

Microcontrollers	ATmega328 8bit family
Operating voltage	5V DC (supplied via USB only)
Operating frequency	16 MHz

Consumption line	about 30mA
Recommended input voltage	7-12V DC
Input voltage limit	6-20V DC
Number of Digital I / O pins	14 (6 pins hardware PWM)
Analog pin number	6 (10bit resolution)
Maximum current per I / O pin	30 mA
Maximum output current (5V)	500 mA

Energy

The Arduino UNO can be powered by 5V via the USB port or an external power supply with a recommended voltage of 7-12V DC and a limit of 6-20V. Generally, a 9V square battery is best if you don't already have a USB port. If the power supply exceeds the upper limit, you will damage the Arduino UNO.

The power pins

GND (Ground): cathode of power supply for Arduino UNO. When you use devices that use separate power sources, these pins must be connected to each other.

5V: 5V output voltage level. The maximum allowable current at this pin is 500mA.

3.3V: voltage level 3.3V output. The maximum allowable current at this pin is 50mA.

Vin (Voltage Input): To supply external power to Arduino UNO, you connect the positive pole of the source to this pin and the negative pole of the source to the GND pin.

IOREF: The operating voltage of the microcontroller on Arduino UNO can be measured at this pin. And of course it is always 5V. However, you must not take 5V power from this pin for use because its function is not to supply power.

RESET: Pressing the Reset button on the board to reset the microcontroller is equivalent to the RESET pin connected to GND via a 10KΩ resistor.

Code for micro servo

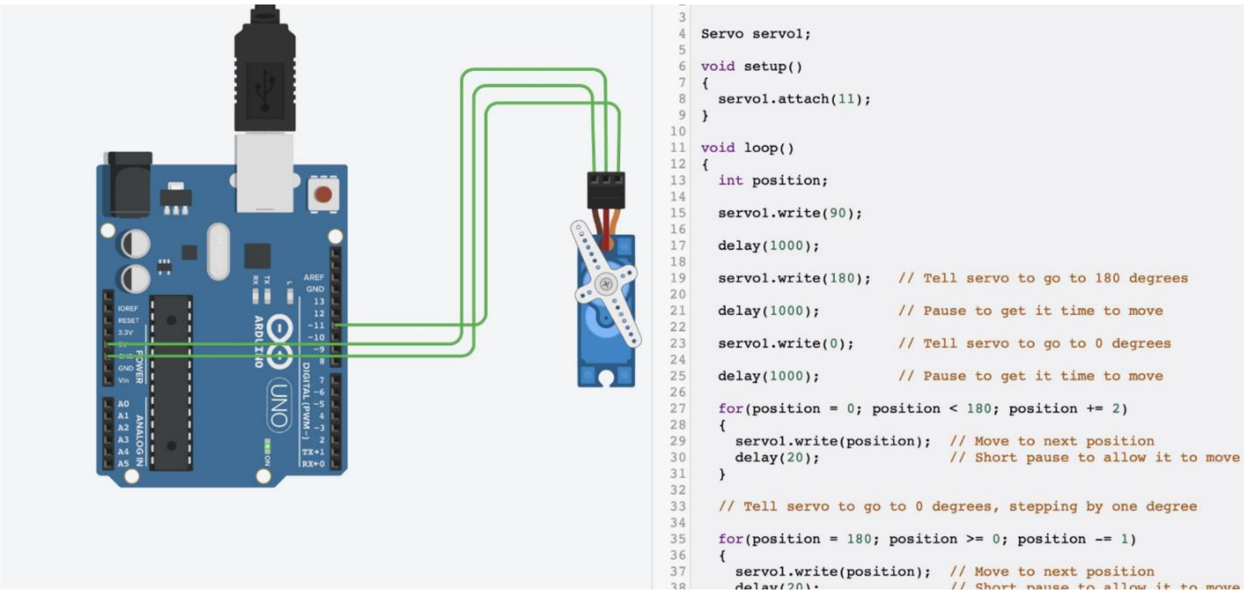

Figure 33: Code for micro servo

Based on this picture we can see that the rotor of the micro servo rotates with the rotating base and rotation distance as what is set on the program executed via Adruino. We set it up in the C programming language.

Code for Led

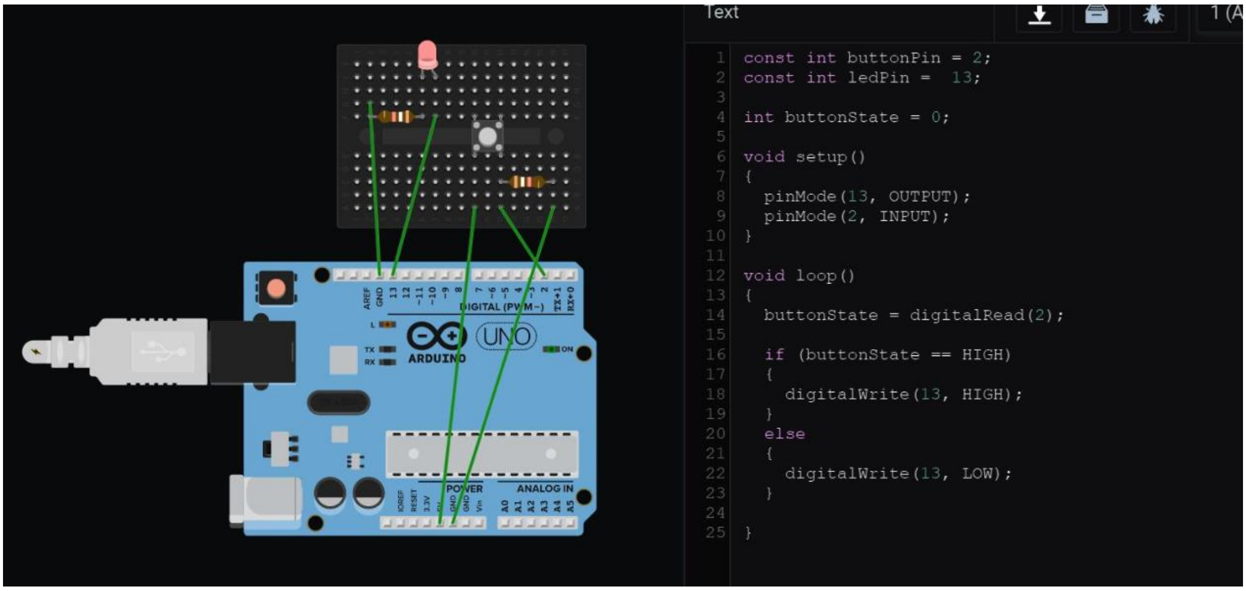

Figure 34: Code for Led

Based on this picture we can see that the light bulb will light up when we press the button at digital port 2 as what is set on the program implemented via Adruino. We set it up in the C programming language.

4.2. Raspberry Pi 2

• **Specifications:**

- CPU: BCM2836 900MHz
- GPU: GPU 1Gpixel / s, 1.5Gtexel
- RAM: 1GB SDRAM.
- Memory card: Micro SD card slot
- Size: 85 x 56 x 17mm.
- Source: Micro USB 5V, 2A.-USB 2.0 interface x 4
- Ethernet: Ethernet port 10 / 100M.
- Video: HDMI supports version 1.3 / 1.4 and Composite RCA (PAL and NTSC) .
- Audio: Output 3.5 and HDMI.
- USB: 4 ports USB 2.0.-GPIO : 40 pins.-Camera: Connector 15-pin MIPI Camera Serial Interface (CSI-2) .
- Display: Connector Display Serial Interface (DSI) .
- Memory Card Slot: MicroSD.
- Operating System: Manufacturer
- View: NOOBS

• NOOBS LITE

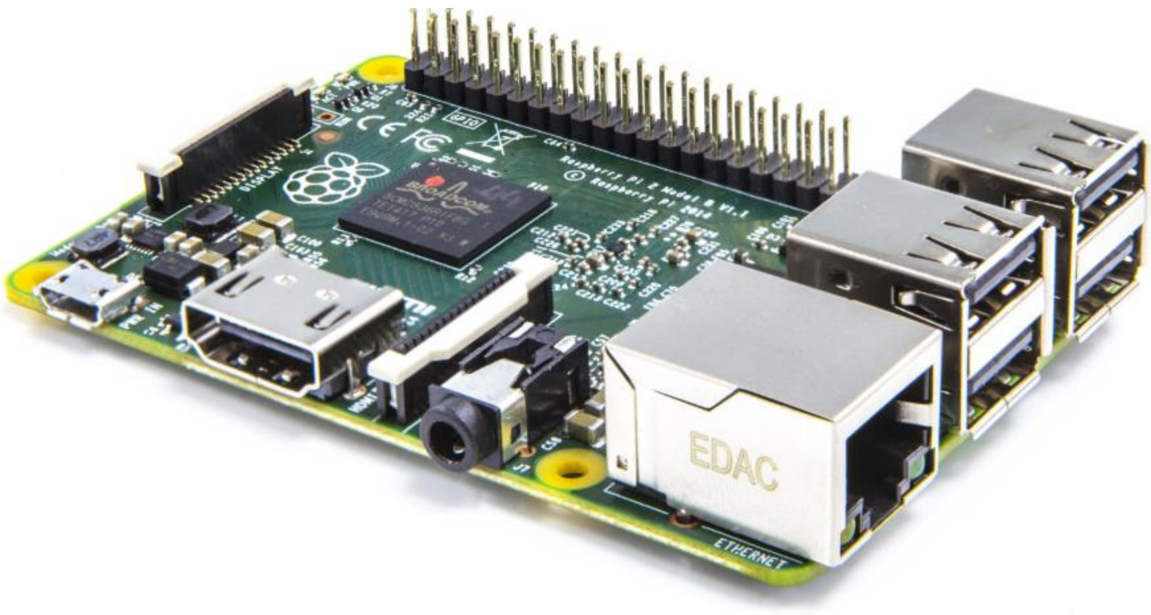

Figure 35: Raspberry Pi 2

Code for Raspberry Pi 2

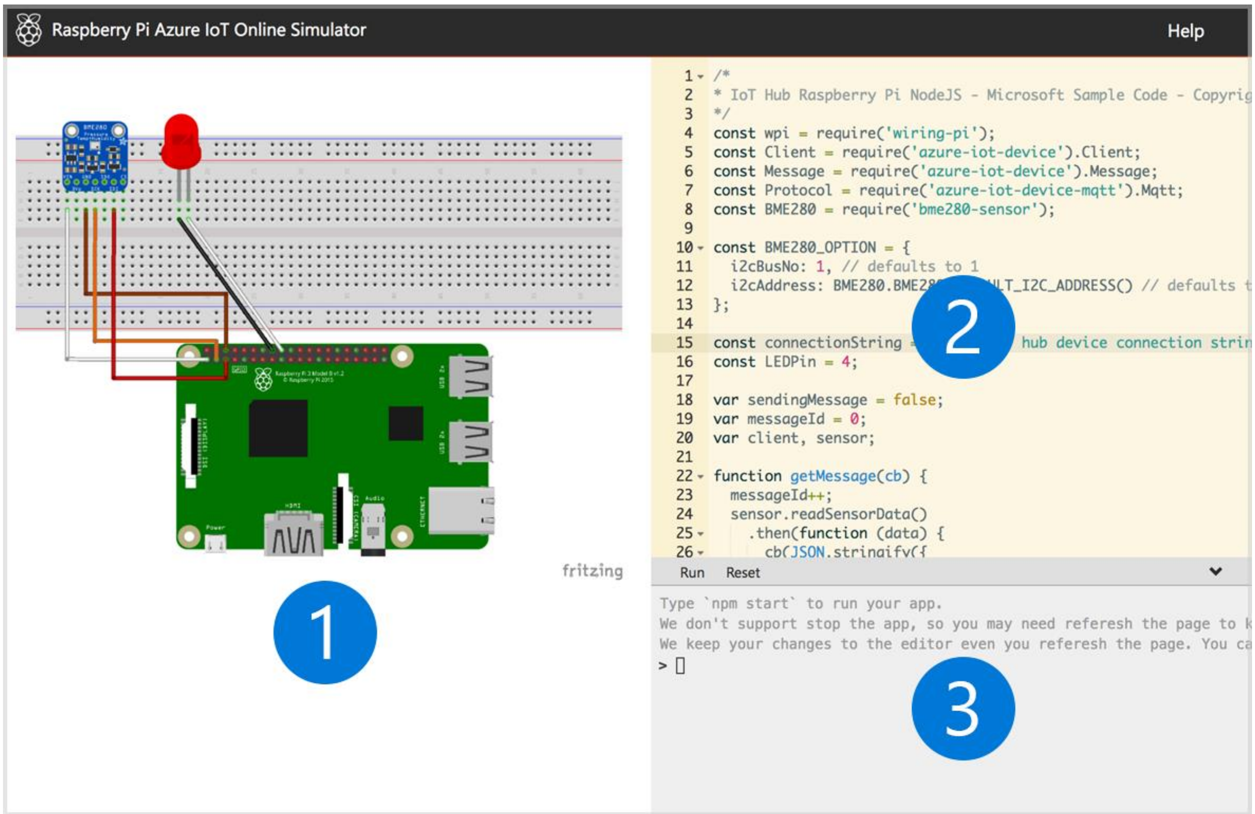

Figure 36: Code for Raspberry Pi 2 example

Based on this picture we can see the code on the right that is programmed so that the light bulb is connected directly to the Raspberry Pi 2. We set it up in the javascript programming language.

5. APIs

This is one of the new frameworks that will help you in building HTTP services very simply and quickly. Open source so you can be used by any client that supports XML, JSON. It also has full support for HTTP components: URIs, request / response headers, caching, versioning, and content forma. You can use hosts that are part of the application or on IIS. An extremely suitable architecture for devices with limited bandwidth such as smartphones, tablets. Usually it has a data format of JSON, XML or any other data type.

5.1. Web API

This type of API is currently very popular, all major websites provide API systems that allow you to connect, retrieve data or update data into the system.

For example, if you use Shopee's online sales service, you will need to perform a number of tasks such as creating new products, updating new products. Assuming you have 1000 items, updating the quantity of inventory by hand is very difficult, not to mention the mistake due to subjective importers. Shopee provides API system, from here you can build a connection from your system to Shopee and everything (including inventory, inventory ...) will be synchronized with each other.

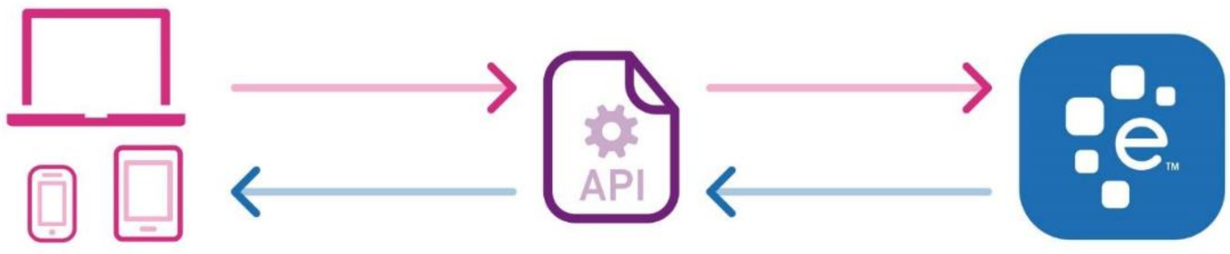

Figure 37: Web API

5.2. MQTT

The high-level architecture of MQTT consists of 2 main parts: Broker and Clients.
In particular, the broker is considered as the center, it is the intersection point of all incoming connections from the client. The main task of the broker is to receive mesage from the publisher, arrange the messages in a queue and then forward them to a specific address. The broker's secondary task is that it can take on a few more features related to the communication process such as message security, message storage, logs, etc.
Clients are divided into 2 groups: publisher and subscriber. Clients are software components that work on edge devices, so they are designed to be lightweight. The client only does at least one of two things to publish messages on a specific topic or subscribe to a certain topic to receive messages from this topic.

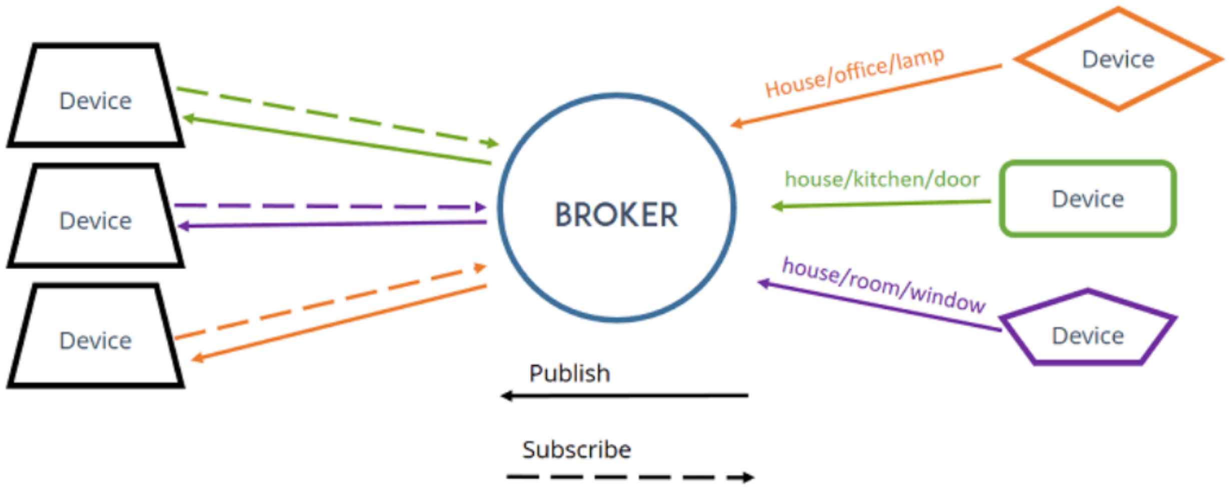

Figure 38: MQTT

MQTT Clients is compatible with most existing operating system platforms: MAC OS, Windows, LInux, Androids, iOS ...

You can imagine the broker is like a newsstand. Publishers are newspaper publishers. Newsroom editor and transfer to newsstand. People reading newspapers to newsstands, choose the newspaper they need to read (subscriber).

Because this protocol uses low bandwidth in high latency environments, it is an ideal protocol for M2M (Machine to machine) applications.

Publish, subscribe

In a system using the MQTT protocol, many station nodes (called mqtt clients - referred to as the clients) connect to an MQTT server (called broker). Each client will subscribe to several channels (topic), such as "/ client1 / channel1", "/ client1 / channel2". This sign up process is called "subscribe", just like we subscribe to a YouTube channel. Each client will receive data when any other station sends data and the registered channel. When a client sends data to that channel, it's called "publish".

QoS

There are 3 QoS (Qualities of service) options when "publishing" and "subscribing":

QoS0 Broker / client will send data exactly once, the sending process is confirmed by TCP / IP protocol, just like the way you leave the market.

The QoS1 Broker / client will send data with at least 1 confirmation from the other end, meaning there may be more than 1 confirmation received.

The QoS2 Broker / client makes sure that when sending data, the receiver only receives it once, this process has to go through 4 handshaking steps.

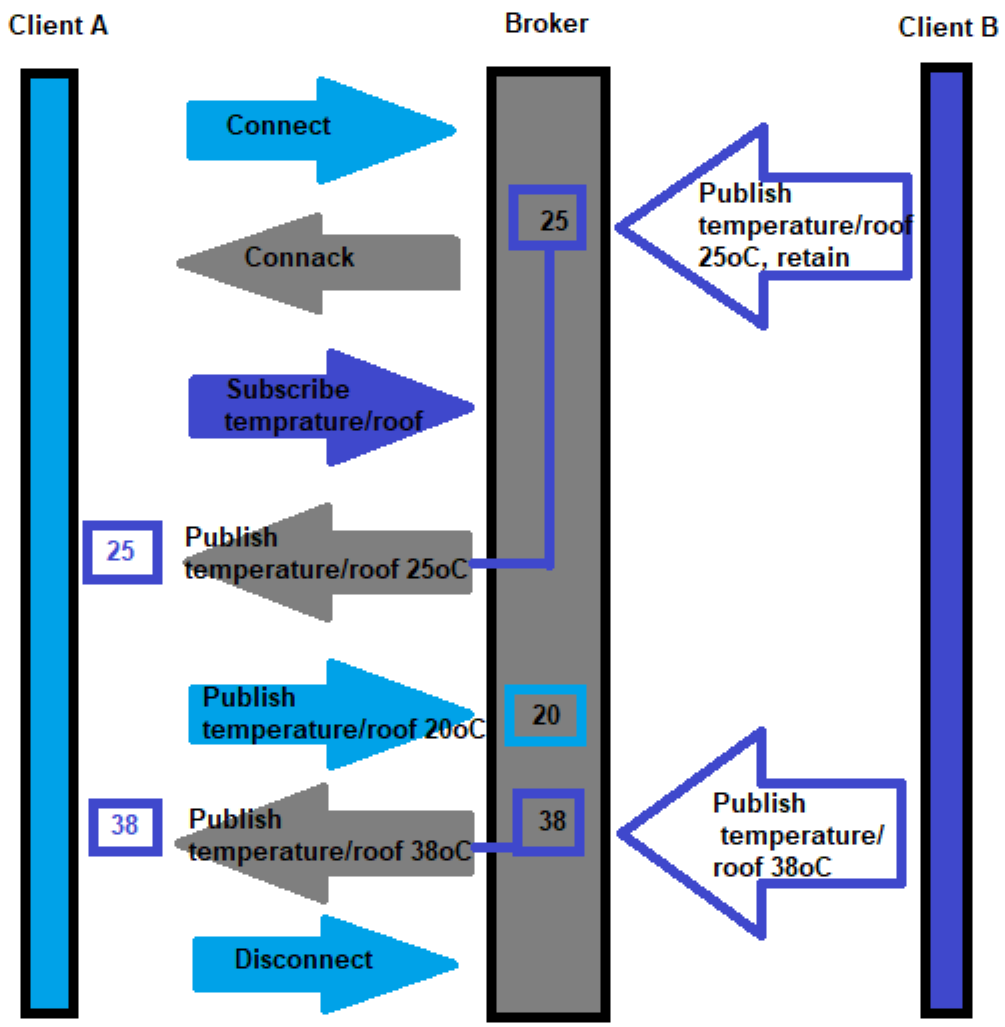

Figure 39: QoS (Qualities of service) options when "publishing" and "subscribing"

A packet can be sent at any QoS, and clients can also subscribe to any QoS request. This means the client will choose the maximum QoS it has to receive. For example, if a packet is published with QoS2, and the client subscribes with QoS0, then the packet received to this client is sent by the broker with QoS0, and another client registers the same channel with QoS 2, then it will be sent by Broker with QoS2 data.

As another example, if a client subscribes to QoS2 and the packet sent to that channel publishes with QoS0, that client will be sent by Broker with QoS0. The higher the QoS, the more reliable it is, and the higher the latency and bandwidth required.

Retain

Retain is a flag attached to a message of the MQTT protocol. Retain only receives values 0 or 1 (corresponding to 2 logical values false or true). If retain = 1, the broker will save the last message of a topic with the corresponding QoS level. When the client starts subscribing to the topic where the message is saved, the client immediately receives the message.

Application of MQTT

I have a sensor, which sends important and very infrequent data. It has registered with Broker a lwt message on topic / node / gone-offline with its id message. And I also subscribe to topic / node / gone-offline, will send SMS to my phone whenever I receive a message on the channel I follow. During operation, the sensor always stays connected with Broker by sending keepAlive packets. But if for some reason, this sensor switches offline, the connection to the Broker timeout is due to the fact that the Broker no longer receives the keepAlive package. At this time, since my sensor has registered for LWT, the broker will close the sensor's connection, and will publish a packet of the sensor's Id into / node / gone-offline, of course I also will receive a message telling me that my beloved Sensor is offline.

There are several projects implementing MQTT. Example is:

Facebook Messenger. Facebook has used the aspects of MQTT in Facebook Messenger to chat online. However, it is not clear how much MQTT is used or for what.

IECC Scalable, DeltaRail latest version of their IECC performance control system 's using MQTT for communication in different parts of the system and other components of the signaling system. It provides the basic communication framework for a system that complies with the CENELEC standards for important safety communications.

Amazon Web Services announced Amazon IoT based on MQTT in 2015.

The Geospatial Organization SensorThings API standard specification has an MQTT extension in the standard as an additional binding notification protocol. It has been proven in an IoT pilot of the US Department of Homeland Security.

OpenStack Upstream Infrastructure services are connected by an MQTT unified messaging bus with Mosquitto, an MQTT broker.

Adafruit launched a free MQTT cloud service for IoT experiment and learners called Adafruit IO in 2015.

Microsoft Azure IoT Hub uses MQTT as the main protocol for remote messages.

XIM, Inc. launched the MQTT client called MQTT Buddy in 2017. This is the MQTT application for Android and iOS, but not F-Droid, which is available in English, Russian and Chinese.

Node-RED has supported MQTT nodes since version 0.14, to properly configure TLS connections.

The open source Home Assistant software automation platform is MQTT enabled and offers four options for MQTT brokers.

P4. Determine a specific problem to solve using IoT.

1. Scenario

I don't have much free time, I'm busy with my work, my grandmother has difficulty walking so I want to make some daily chores in the house easier to make some things in the house I became more popular. Smarter, more convenient, more secure by installing some sensors and remote control via web server located at home. Some smart settings like fire detectors, self-opening doors, watering plants, turning on fans and lights remotely with wifi so my grandmother can use them more easily. We will use cisco package tracking tool to solve problems for our home.

2. Identify and identify the problem

What is the Problem?	I am so busy, my grandmother has difficulty walking so she cannot prepare everything in the house well.
Who has this problem and what do we know about them?	My grandmother has difficulty walking.
What are their concerns and needs?	I had to go to work all day, my grandmother had difficulty walking so I wanted them to be installed remotely so my grandmother could use them easily.
How do they interact with their environment?	My grandmother had trouble moving due to old age.
What causes the problem?	She had difficulty moving, and I rarely stayed home, so turning on and off things at home like making coffee, opening and closing doors, turning appliances on and off like air-conditioners, ceiling fans, became more difficult.
When does this problem occurs?	When I want to go out, I want to open the door with a remote phone so that it can be easier to save effort. My house has many rooms and is large, every night it is difficult to turn on the lights or the fans in each room so I want them to be faster by a single press.
Can you turn this problem into a question?	How to control home appliances remotely?

3. Give a solution

What is the Problem?			
I am too busy my grandmother has difficulty walking so I cannot prepare everything in the house well.			
Available solutions to this problem or similar, including those discovered through research	**Pros and Cons of this solution? Cost and practicality?**	**How is it relevant, innovative and/or disruptive?**	**What are the limits of this solution?**
Connect the device to the home internet network and control by web app.	Cons: It costs a lot of money to buy networking equipment. The price of the home gateway is about $ 44 Pros: everything becomes convenient and easy to use, saves a lot of time and effort, my grandmother will save a lot of travel and do heavy work.	The inconvenience is so busy and difficult to use directly.	It costs money and electricity.
What can you identify as the key factors of success?			
Simple, easy to use, remote control with my grandmother will be easier, reducing the time effort.			

4. Process diagrams

The picture below depicts the process of handling the problem of her having difficulty walking, I rarely stay at home so turning on and off items at home such as making coffee, opening and closing doors, turning on and off appliances such as air-conditioners, ceiling fans , become more difficult. I first chose the microprocessor as the central microprocessor to calculate, perform logical operations, control the system and store data. The microprocessor processes the input / output data (input / output) of the external device and returns the results for them to work.

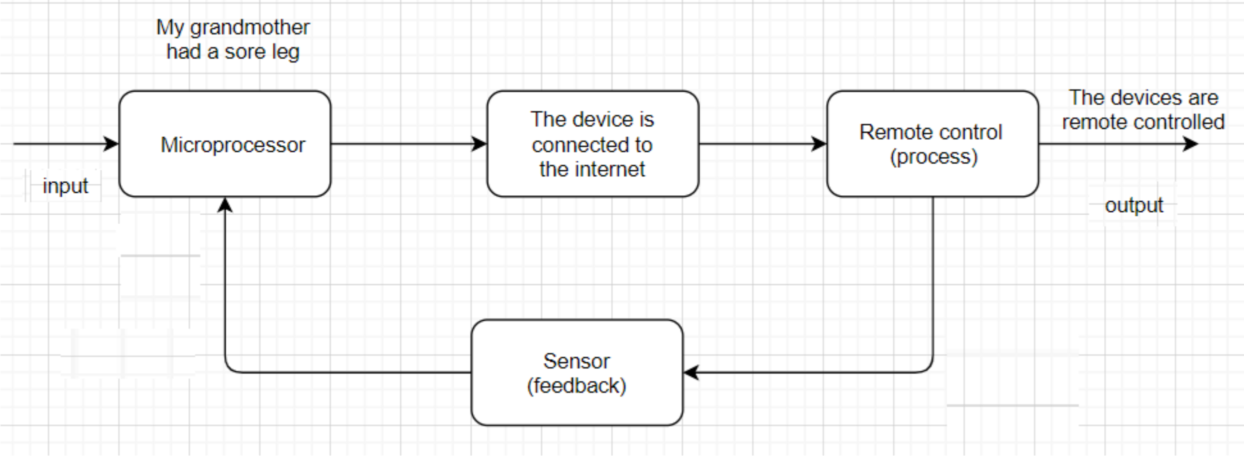

Figure 40: Process diagrams

5. Design a system: Choosing sensors

Sensors	Durability and stability	Power consumption	Connection range	Cost
Siren	1-1,5 year	12-30VDC	1-2m	30$
HomeGateway	1-2 year	15-20VDC	60m	44$
Smoke Detector	1-2 year	12-30VDC	1-2m	17$

6. Design a system: Connecting devices

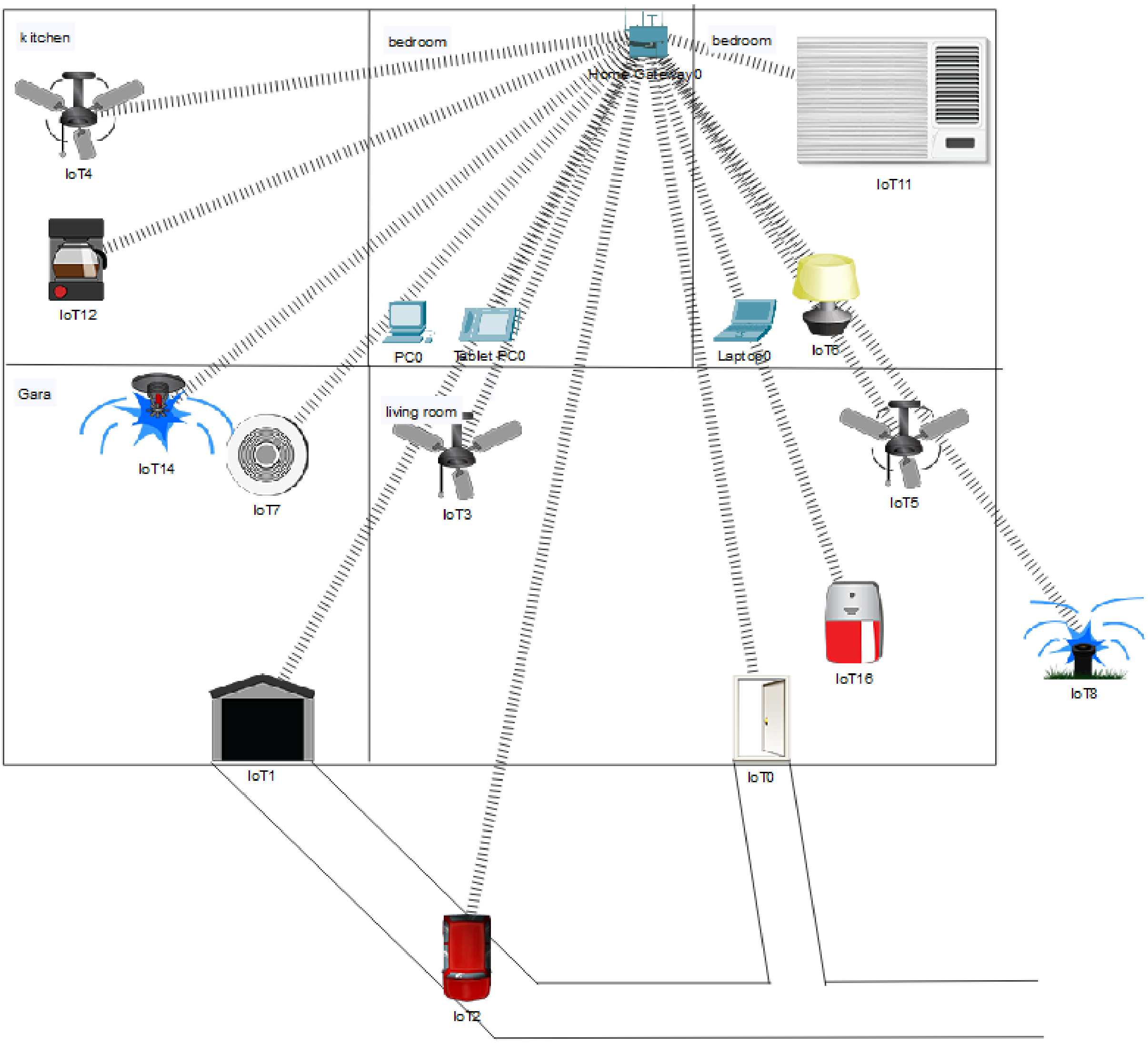

Figure 41: Design a system: Connecting devices

This is a smart home system designed based on my house architecture, every item is connected to the internet making the control very convenient and easy, our house has a total of 5 zones. area: garage and living room on the ground floor, the first floor has 3 rooms for the kitchen and 2 bedrooms and this is the design of the smart parts in each area.

Garage: designed with a fire alarm because the parking area is quite hot and the system may malfunction and explode, here we equip Fire Sprinkler and Smoke Detector so that when the sensor detects smoke then it will notify the gateway and order Fire Sprinkler to spray water to put out the fire, open the door by remote application.

Living room: in this area we have 2 ceiling fans, the main door, siren detects noise to prevent theft and can be controlled remotely via the app

Kitchen: including 1 remote control coffee machine, automatically brewing coffee when controlled by application and remote control fan.

Bedroom: Some laptops, PCs and tablets used to control home appliances remotely, night lights and air conditioners are also connected to the internet.

7. Security requirement

7.1. Aim of system

By using this system, we will recognize the risk of fire in the house, so that my grandmother can control the air conditioner, ceiling fan lights, doors remotely because she is very inconvenient.

7.2. Scope of system

In order for the IoT system to work properly, the items must ensure no damage to the system, the items must be placed within the internet and within the detection range of the sensor.

7.3. Security home gateway account

In order for the settings and controls in my in-house IoT model to be safer and more secure, to avoid other invasive factors that harm property and the safety of our family members in need of security. To access the configuration system of the home gateway, we will configure it on the home gateway so that it recognizes that the admin object has the right to change and control devices in the home.

7.4. Security user account

The account is only allowed to access the internet.

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