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Introduction

The Internet of Things is the next technological advancement of human being, it come with numerous of opportunities but also setbacks needed to resolve and challenges needed to be overcame. This assignment will demonstrate what are the aspects of IoT, its advantages and disadvantages, how it works and operates.

Necessary and appropriate aspects of IoT

Definition of Internet of Things

According to Arshdeep Bahga and Vijay Madisetti (Arshdeep Bahga, 2014), Internet of Things or IoT is a dynamic global network infrastructure embedded with self-configuring abilities that based on standard communication protocols. Those protocols both physical and virtual objects or "things" have identities, physical attributes, virtual personalities, and intelligent interfaces. They are integrated into an information system that could communicate information and data with its users and environments.

Characteristics of IoT

Dynamic and Self-adapting: An IoT system can dynamically adapting to the changes of environment and context and based on that they could make decisions and take actions. For example, system can sensor the humidity of plants and decide whether to water the plants or not. Another case could be a system sensor your health status and report back to you or your doctor when some thing happened.

Self-configuring: An IoT system could allow numerous of devices to cooperate and work together to render some results or data. For instance, weather monitoring requires wind sensors, humidity sensors, and rain sensors to generate data or predict weather activities.

Interoperable Communication Protocols: This characteristic indicates that an IoT system can communicate with other devices and the infrastructure

Unique Identity: Each device operates in an IoT system have their distinctive identity and identifier such as IP address or URI. This identification allows the system and user to query, monitor, and manage the system more easily and efficiently.

Integrated into Information Network: Most IoT equipment often integrated into an information network that enables them to exchange data and communicate between each other and the system.

The trend of IoT

The Internet of Things is the fourth industrial revolution or the Industry 4.0. In an article from the WIRED magazine (Burgess, 2018), Samsung states that the need to connect every device by 2020 is "critical", and in 2015 Samsung expected that 90% of their products will be integrated in an IoT system by 2017 and 100% by 2020. Gartner predicts that about 21 billion devices will be IoT enabled by 2020.

In an article from the Forbes magazine (Marr, 2019), Bernard Marr predicts that there are five trends of the IoT industry in the future, Business will focus and be more serious with IoT, the huge surge in IoT will happened in 2019 by businesses, 85% of the firms and companies implement or plan to deploy IoT this year. Devices is getting more vocal, we use our voice to control and command smart home devices such as Apple's Siri or Amazon's Alexa. The next predicted trend is the sensors and devices are getting more computational power; algorithm will filter out a large unvalued data. In the future of the Industry 4.0, AI or Artificial Intelligent will heavily affect IoT development, IoT devices will generate a huge amount of data and it could not depend on human to process it, AI and algorithms will play a major role of analyzing and making use of the gathered data. One of the leading trend of IoT is that 5G networks will widen the scope of IoT, 5G is 20 times faster than the average existing mobile data networks and IoT is depend on speed and availability of data service to connect and communicate with each other.

IoT applications

In a research article that was published by IJESC (Keyur K Patel, 2016), IoT holds numerous and diverse application ranging from Transportation, Urban Development, Retail, Agriculture, Logistic, Healthcare, and Industrial Manufacture. Categorizing into fields of IOsL (Internet of smart living), IOsC (Internet of smart cities), IOsE (Internet of smart environment), IOsI (Internet of smart industry), IOsH (Internet of smart health), IOsE (internet of smart energy), and IOsA (internet of smart agriculture).

IOsL (Internet of smart living)

- Remote Control Appliances: turn on and off remotely electronic devices to avoid accident and save energy.
- Weather Monitoring: Show information and figures about humidity, temperature, wind speed, and transmit them over long distance. By installing several of rain sensor, temperature sensors around a city and connect all data from other cities, we could create a network of data that could help the weather forecast to be more correct.

- Smart Home Applications: Information and status of food in your refrigerator, cloths in your washing machine, and cleaning schedule of your cleaning robots all would be displayed in your smartphone or web applications.
- Safety Detection System: Camera can detect intruders, strangers, and smoke detector can perform early warning fire.
- Energy and Water Use: Energy consumption is monitored and regulated to save cost and energy.

IOsC (Internet of smart cities)

- Structural Health: Sensing material condition and vibrations of buildings.
- Lightning: Weather auto-adjustment to save energy and enhance usage.
- Safety: Digital camera detecting unusual activities, fire detecting and public announcement system.
- Transportation: Roads and highway that display traffic congestion status and suggest new routes and diversion.
- Smart Parking: Tracking empty parking slots and reserve in advance and show the nearest parking space.
- Waste Management: Manage the plastic and waste in the water.

IOsE (Internet of smart environment)

- Air Pollution Monitoring: Tracking the CO2 level, pollution gases that emitted by cars and industrial factories.
- Forest Fire Detection: Tracking temperature and moisture to mapping alert zones for preemptive fire control.
- Weather monitoring: Monitor wind speed, temperature, moisture, humidity, rain.
- Earthquake Early Detection: Vibration from underground around volcano, tectonic plate to predict earthquake and potential tsunami.
- Water Quality: Detect and manage drinkable water source from rivers, lake.
- River Floods: Tracking water level changes in rivers, dams, and reservoir around the year.
- Protecting wildlife: Using GPS devices to track wild animal.

IOsI (Internet of smart industry)

- Explosive and Hazardous Gases: Tracking difference types of gases surround industrial factories, and mines. Monitor the toxic gas pollution and hazardous chemical leak to ensure workers safety.

- Maintenance and repair: predict equipment failures by install sensors to provide early maintenance.

IOsH (Internet of smart health)

- Patients Surveillance: Monitoring and tracking health status of patients and elders at home and inside medical facility by wearable devices.
- Medical Fridges: Manage quality, amount, conditions, and status of vaccines, medicines, and organic element inside special storage system.
- Fall Detection: Alarms and notify authorities if any strange movement happened to independent disable people or elderly citizen.
- Dental: Sensor in toothbrush tracking brushing habits and report to personal dental service for better care.
- Physical Activity Monitoring: Wearable smart watch senses heart rate, motions, footsteps, and travel distance to analyze the physical activity of each user and provide instructions and suggestion.

IOsE (internet of smart energy)

- Smart Grid: Energy consumption tracking and control.
- Wind Turbines/Powerhouse: Monitoring, regulating, and switching between the electric grid and wind power generator based on consumption pattern.
- Power Supply Controllers: Controller for AC-DC power supplies, which identifies required energy, and improve energy saving with less energy lavish for power supplies linked to consumer electronics applications.
- Photovoltaic Installations: Tracking and optimizing performance in solar energy farms.

IOsA (internet of smart agriculture)

- Green Houses: Regulating in-house climate to maximize crops and production of plants.
- Compost: Monitoring and controlling the humidity and temperature in hay and straw to prevent fungus contamination.
- Animal Farming/Tracking: Sensors detect and monitor air and environment in the farm, GPS system tracking animals motion and movement in large field.
- Offspring Care: Monitor and tracking mating behaviors and seasons of animal to increase production.

Advantages and disadvantages of IoT

The Internet of Things or IoT is on the rising trend to be the next technological advancement of the human race. IoT is hoped to be the technology that would change the way of life of billions people. They have many applications that benefit our life; however, beside those advantages is their downsides and challenges. This journal (Soumyalatha & Hegde, 2019) will lay out some of the advantages as well as the disadvantages of IoT projects.

Advantages

Communication: IoT is the connection between physical devices; therefore, devices are able to stay connected with lesser inefficient and higher quality.

Automation and Control: Machines can operate autonomously without any human oversight; this could lead to faster and more efficient output.

Monitoring saves money and time: Smart sensors tracking and monitoring many aspects of human life, with numerous of application, they can detect any error before it happened; therefore, it could save more time and money.

Better Quality of Life: IoT based applications increases comfort and better management in our daily life; thereby improving the quality of life.

New business opportunities: New trend of technology advancement creates new business opportunities and jobs.

Better Environment: IoT devices monitor and control many factors of the environment, with the vast amount of data gathered, we could regulate the output of CO2 and polluted gases, and this could help out planet to be more sustainable and greener.

Disadvantages

Compatibly: Difference manufactures of IoT devices are needed to be interconnected in an environment and there are no international standard of compatibility to monitoring equipment.

Complexity: IoT systems are mostly complex and diverse, many aspects could affect its performance such as bugs and errors, sometime even a power failure could cause trouble.

Privacy/Security: IoT systems consist of many components, sensors, and devices, also many companies and entities would monitor it. Because there are a vast amount of data will be transmitted between entities, the risk of losing private data is enormous.

Lesser employment of menial staff: IoT have involved in autonomous factories to replace human labor, with this rising trend of integrating IoT, it could create unemployment issues in the society.

Technology Takes Control of Life: Our lives have already depended on smart devices, with the rapid development of IoT, we could be even more dependence on technology to take care of our daily life.

IoT usage in software development lifecycle

According to a journal from ScienceDirect (Rahmana et al., 2018), a typical software development lifecycle consists of 6 stages: analysis, design, implementation, testing, deployment, and maintenance. In IoT field, they have adopted the Service Oriented Architecture or SOA to identify the component of an IoT system: IoT device, IoT service, and IoT application.

Generic Life Cycle for IoT Device

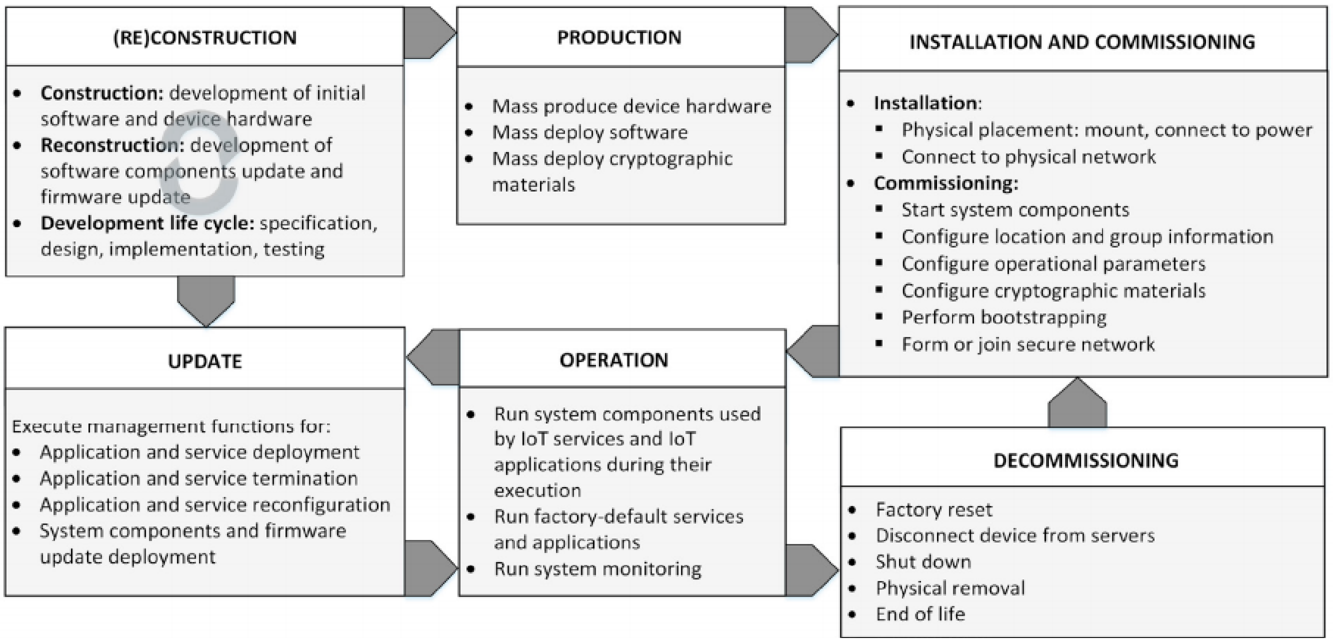

Figure 1 Generic life cycle for IoT devices (Rahmana et al., 2018)

As we can observe in Fig1, the Construction Phases consist of the development of initial software and hardware. In this phase we decide what sensors or devices needed to be installed, and what platform or framework should it be applied. For example, in a smart home IoT system, we would have to decide what data will be used to choose the suitable sensors, how the data can be used to determine the software needed to analyze them. Continue to the Installation Stage, we have to determine the networking protocols needed to be applied, for instance if the system is operated in a city scale, we have to use the Ethernet to connect and transmit data quickly and efficiently.

Generic Life Cycle for IoT Service

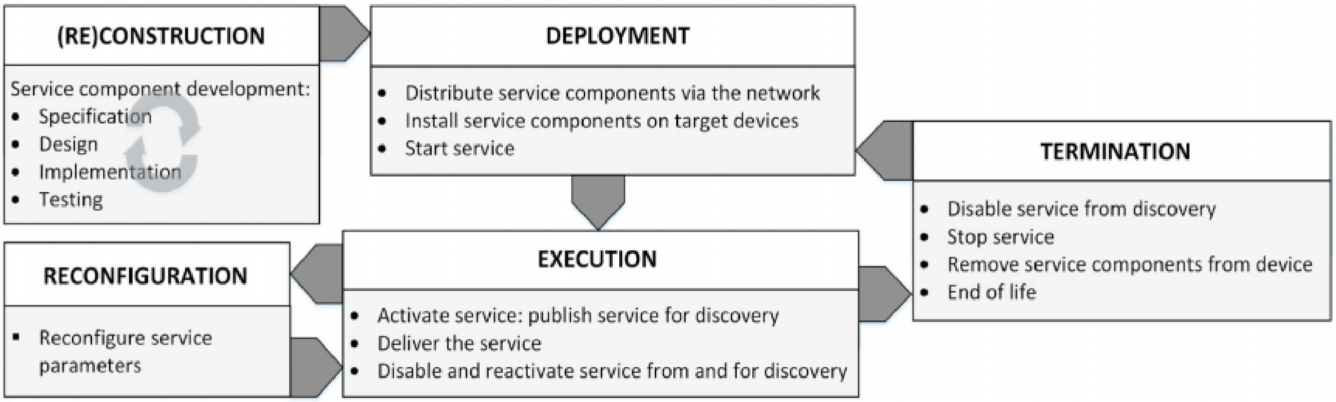

Figure 2 Generic Life Cycle for IoT Service (Rahmana et al., 2018)

A service is to specify the overall functionality of an entity; an IoT service is used by IoT applications to meet their goals. The construction stage relates to the construction and installation of service factors for IoT devices. The goal of this stage is to develop services and make sure that their intended functional appropriateness and interoperability with other application in the run-time period. The deployment stage is to realize service deployment via network, this phase is important for modifiability. Next is the Execution Phases, in this phase we enable the service to be used by many applications and services while maintain its performance.

Generic Life Cycle for IoT Application

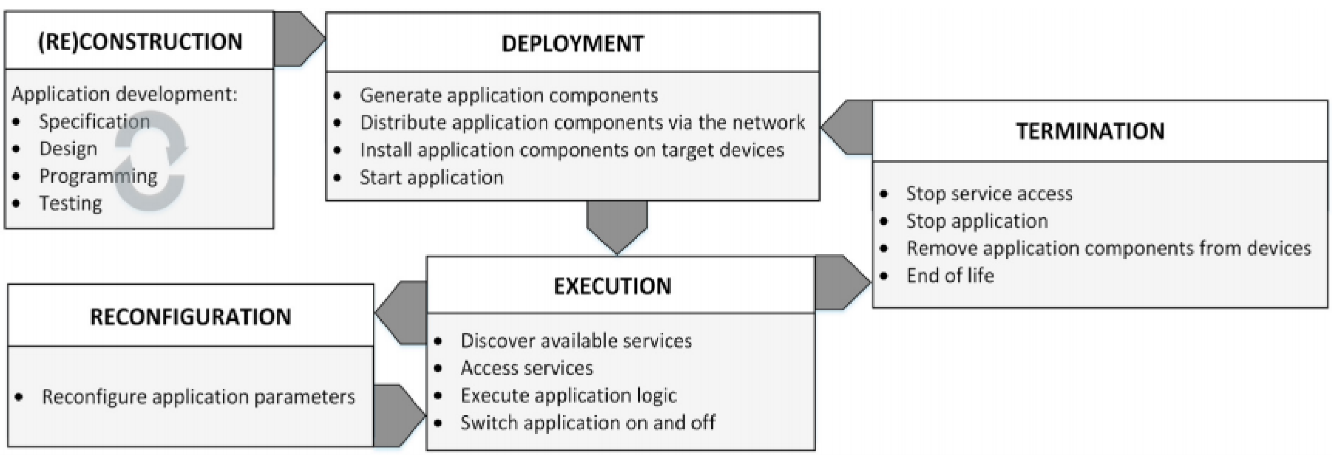

Figure 3 Generic life cycle for IoT applications (Rahmana et al., 2018)

The IoT applications render abstractions for users and customers the network and platform details of a complex system. In this phase, we design and develop an IoT application that includes: GUI, DSL, and APIs for voice command, etc. We use programming languages such as C, C++, and Java to develop a user-friendly application for user, if your system interacts with user via a mobile application, you might consider developing in both iOS and Android by using Swift, Java or C# Xamarin, if it operate through a web app, you might considering develop by HTML/CSS/Javascript and Python, Java.

Forms of IoT functionality

The architecture of the Internet of Things

According to Uviase and Kotonya (Onoriode Uviase, 2018), an IoT basic architecture consists of 4 layers. The physical layer contains embedded devices such as sensors to gather data from the real world. Next, the gateway layer gives mechanism and protocols for the sensors to transmit data to the Internet via Wi-Fi, Ethernet and many others. The application layer is used by users and consumers to send command and receive data that gathered through the Internet, mobile or web application.

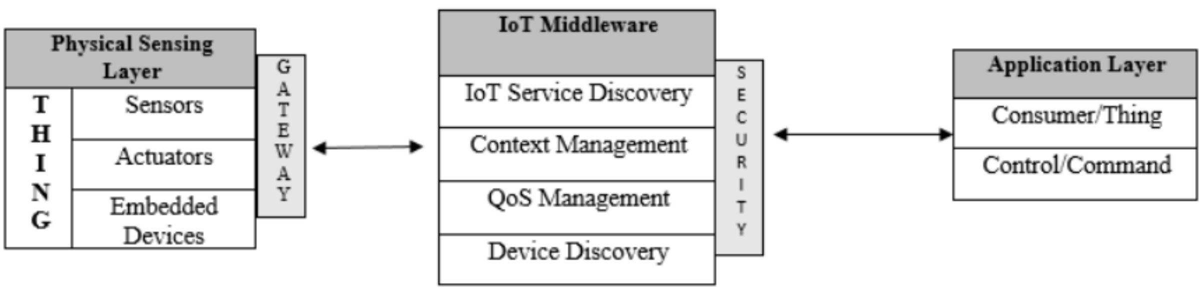

Figure 4 IoT basic architecture (Onoriode Uviase, 2018)

The IoT frameworks

For achieving integration and interoperability in IoT, a framework should have some minimal measures (Uviase & Kotonya, 2018):

Contract Decoupling: is the capability of service customers and producers to develop independently without breaking the agreed contract between them. For example, a service requires full knowledge of C++ to operate but service consumers require a more easy way to operate the system. The framework should provide an API that eases the process of using the framework.

Scalability: a framework should be easy to expanse and develop to accommodate and support millions and billions of devices that highly appear in the future.

Ease of Development: an IoT integration framework should render a method of easy development for developers, they should provide documentary about the development of the framework that could be understood by both developers and non-developers.

Fault Tolerance: an effective integration framework must have self-healing, self-troubleshooting features; they should be capable of error handling since the device could switch from online to offline mode and back.

Lightweight Implementation: a framework should be easy to install, maintain, activate and deactivate, update, and adaptable. They should have a lightweight overhead both in development and deployment stage.

Service Coordination: is the orchestration and choreography of services. The orchestration of services is the coordination of multiple services by a mediator that acting as centralized part. On the contrary, the choreography of services is the chaining of services to perform a particular transmission. A framework must support one of those features or in the best case are both.

Inter Domain Operability: a framework should be capable of supporting inter domain communication. For instance, a smart house should give data about energy consumption to the central power grid in the smart city domain to manage the energy consumption of the city.

There are some IoT frameworks that contribute to the IoT development:

Eclipse Smarthome Framework

Eclipse Smarthome Framework or ESH framework is designed for ease of resolution of IoT systems. ESH has become more famous in the smart home domain. They can operate on various on OS system such as Linux, macOS, and Window. They have been integrated in many products of Belkin WeMo, PhilipHue, Sonos. They focus on home automation; therefore, it support for offline communication capabilities.

Calvin Framework

The Calvin Framework is a hybrid framework of IoT and Cloud programming. They explicate the complexity of distributed programming, diverse programming languages, and communication protocols.

SOCRADES

SOCRADES is a service –oriented based integration architecture. They render generic components to assist modeling of well detailed process. It focus on smart objects in manufacturing domain that represents their behavior as a web service to enhance their capabilities.

Software used in IoT development

Software plays an important role in IoT development. They appear at every step of developing and deploying an IoT system take the smart sprinkler system in the smart agriculture for instance:

Mobile and website applications that designed and programmed in Java, Swift, HTML, Python, and PHP gather information about the weather forecast and records in the past, and display them in an user friendly interface online via iOS, Android devices, or a PC.

Sensors programmed in Python, C, or Java detects and analyzes the wind speed, earth moisture, and temperature in the environment.

Software will collect the data and send to a cloud system to store and make smart instructions about watering time and amount.

Embedded programming language software written in C/C++ or Python controls and manages water dispense.

Hardware in IoT

In my opinion, the Internet of Things is all about connecting objects or "Things", and things here are hardware and software. Just important as software, hardware is one of the elements that make IoT possible. There are some basic hardware components in the IoT field such as sensors, actuators, microprocessor (or CPU), and microcontroller (or MCU).

Sensors, according to Sharma (Sharma, 2019) serve to gather data and share it to a network that connecting devices. That collected data enable devices to independently working and functioning. Sensors could be temperature sensor to sense the temperature in environment, proximity sensor to sense a present of an object, and gas sensor to detect gases.

Actuators take electrical input and turn it into physical action; they can be an electric motor, light bulb, and pneumatic system (Eller, 2017).

Microprocessor or the Central Processing Unit (or CPU) "is the brain of all computers and many household and electronic devices. Multiple microprocessors, working together, are the "hearts" of datacenters, super-computers, communications products, and other digital devices" (Intel Corporation, 2018).

Microcontroller unit or MCU is a compact and self-contained computer that integrated on a single circuit or a microchip. Different from CPU, MCU is dedicated to a single function and mostly embedded into other devices such as cellphones (particle.io, 2019).

In a report of CBR the Computer Business Review (Clark, 2017), in 2016, Gartner said that 6 billion IoT devices were installed, and that has given the IoT market a valuation over $1 trillion. Another report from HPE Aruba found 57% of firms have integrated IoT technologies and that number would rise to 85% in this year 2019.

One of the reasons why there is such a development is the contribution of the open source community. Those communities constantly develop, combine, and create novel applications and experiments. The list below shows some of the open source software tools for IoT development

Arduino

Arduino is one of the most famous platform since they provide both software and hardware solutions. They provide an IDE that assists users to use their development kit. They have a cloud system that contains of a MQTT broker, which helps developer to transmit messages between boards.

Raspberry Pi

The Raspberry Pi Foundation (raspberrypi.org, 2019) is a UK-based charity which operates to enable the power of computing to the crowd. They render low-cost and high-performance computers that assist people, student to learn how to solve problems and have fun.

DeviceHive

DeviceHive is a free open-source framework that develops machine-to-machine communication methods or M2M. Via its cloud-based API, they can be controlled remotely regardless of network configuration. They have many applications such as smart home technology, remote sensors, automation, and security.

Home Assistant

Home Assistant is focusing on home automation; they operate on a Python based codeing system that can be manipulated in both mobile and PC browsers. They also an open-source platform, that have advantage in ease of use, high security, and privacy.

ThingSpeak

ThingSpeak is an old IoT platform but it is one of the most reliable. They primary operate on alerts, tracking location, and sensor logging. An example of the platform is using a Raspberry Pi device and a camera, it can be able to analyze and visualize traffic pattern.

Standard architecture, frameworks, tools, hardware and APIs available in IoT Application Development

IoT development model

An IoT model could be built based on the TCP/IP model that consists of 4 layers: Application Layer, Transport Layer, Network Layer, and Link Layer. Below is the investigation of Hanes and his co-workers (Hanes et al., 2017) into the architecture model of IoT.

Application Model

Traditionally, the application layer contains application protocols such as HTTP and XMTP; however, they are not a suitable candidate due to the constrained environment of large number of devices. Instead of that, two more lightweight protocols are needed to solve this problem in IoT, those are Constrained Application Protocol (or CoAP) and Message Queuing Telemetry Transport (or MQTT).

Constrained Application Protocol (or CoAP)

CoAP is based on HTTP protocol, by using the Representation State Transfer (or REST) standard. The lightweight RESTful interface is designed in CoAP for resource-constrained devices in IoT. CoAP support both IPv4 and IPv6.

CoAP operates 2 main operations of messaging and request.

The four types of messages in CoAP:

- Confirmable (for reliable transmission)
- Non-confirmable (for unreliable transmission)
- Piggyback (acknowledgement)
- Separate (reset)

The four types of request in CoAP:

- GET (receive)
- PUT (create)
- PUSH (update)
- DELETE

Message Queuing Telemetry Transport (MQTT)

MQTT is a lightweight protocol that suitable for constrained environment, it was introduced by IBM in 1999. MQTT protocol is the publish-subscribe communication framework of nodes.

There are 3 components in the MQTT network:

- Publisher (client)
- Subscriber (client)
- Message broker (server)

Transport Layer

IoT applications primary use TCP, UDP, and DTLS for providing security services for UDP communications.

TCP is a connection-oriented protocol, which ensures the connection between senders and receivers before data transmission.

UDP is a connectionless protocol that has low overhead and fast transmission capabilities, however, they do not have guarantee for the message transmission. DTLS is the transport layer protocol, which based on the Transport Layer Security (or TLS); it gives the security services for UDP communications and transmission.

Network Layer

The IPv4 and IPv6 are two Internet protocols. The differences between them are the addresses, IPv4 uses 32 bit addresses and IPv6 uses 128 bit addresses. IPv6 renders larger number of addresses to accommodate rapid growth of internet users in the future.

6LoWPAN ot IPv6 over Low-Power Wireless Personal Area Networks, the IPv6 addresses are too long for an IoT data frames and methods. IoT system requires the IPv6 datagram to be encapsulated in small packets and the 6LoWPAN is the first protocol to perfectly execute it.

Physical Layer

One of the most challenging obstacles of the IoT is interoperability, which is the ability to communication and understanding between sensors and devices. Therefore, there are many technologies that dedicate to solve these problems. The list below is based on the work of Arun Shankar (Shankar, 2017).

The most innovation happened in wireless networking protocols that could be divided into these characteristics: Size of transmitted data, range of connectivity, power consumption, and network topology.

Firstly, **Bluetooth** is a short range of communication method that was embedded inside many smartphones and handheld devices. It operates in frequency of 2,4 GHz, range of 150m with 1Mbps of data rates.

Secondly, **Zigbee** is an industry-standard wireless networking technology. They capable of transmitting data with low rates in range of 100m, they are typically install in a home or building. The advantage of Zigbee is to operate with low-power consumption and complex system, along with that is the high security and scalability. They also support wireless control through applications.

Next is **Z-Wave**, it has low power consumption; low data rate and designed for home automation. It can be scaled up to 232 devices with range of 30m.

LoRaWAN or Long Range Wide Area Network is designed for wide-area network applications with low power consumption that includes mobile connection in IoT, smart city, and industry applications. It can support thousands or even millions of sensors and devices in a range from 2-15 km depend on the city construction, the data transmission rate is very low at below 50 kbps.

Continue is **6LowPAN** or IPv6 Low-power wireless Personal Area Network. 6LowPAN is a networking protocol and often be operated across Ethernet, Wi-Fi, 802.15.4, and sub-1GHz industrial bands. IPv6 stack plays a key role to enable IoT. This technology is designed for building automation and complex transportation system via low-power wireless connection.

Wi-Fi connectivity is the most choice for IoT developers and system that operate within home range and LAN. It renders fast connectivity and capable of handling large quantities of data. However, the power requirement might be too high for some IoT projects.

Finally is **Cellular**, the 3G, 4G, and next is 5G connection is suitable for high volume of data, but the expense for the power and management of high volume of data transmission could be too high for some project. It operates in frequencies of 900, 1800, 1900, 2100MHz in a range from 35km for GMS to 200km for HSPA. The data rate is ranging from 170kps to 10Mbps depend on each technology.

Problem that can be solved by the Internet of Things

Our project is focusing on taking care of domestic pets such as cats and dogs. In our modern day, people are very busy with their work, spouse, domestic and diplomat issues. They might have to go abroad, vacation, business trip, and visiting relative. In short, they could not have time for their pets, even the basic activities such as feeding and taking care of pet health.

The solution could be a system that could create a feeding schedule, monitoring pet's health, and providing customers the information about the status of their pets. Moreover, it could be able to connect customers and their pets, users can see live images and videos of their pet and talk to them at the same time, give them treats and play some simple games.

Based on that problem and requirement, we design a system that has 2 components, the hardware that connected to a mobile application.

The hardware system that we called "Feedy My Petty", the system could feed domestic cats and dogs, monitor weight, temperature, and movement of pets, and provide a screen, speaker and microphone.

The other component is a mobile application that operates in iOS and Android devices, the software system that could assist user to set feeding schedule, oversight the health status of their pet, and communicate and interact with them.

The application sends commands to the "Feedy My Petty" device at home, the device could operate autonomously offline and online, based on the feeding schedule, the device could dispend food in exact time setting, get the health data and send it to the app and the app will process and analyze it. Furthermore, the "Feedy My Petty" device could create video and audio interactions between owners and their pets through screen, camera and microphone.

The IoT Design Planning for the "Feedy My Petty" device

IoT design product	- The "Feedy My Petty" device
Intended function	- Setup feeding schedules - Monitor health status of pets - Giving a mean of communication and interaction
Outline of the process	- Customers can setup a feeding schedule for their pet and the amount of food. - Weight, temperature, and movement of pet are monitored to diagnose pet's health condition and suggest feeding plan accordingly. - Detect the present of the pet and send notification to its owner via a mobile application, the owner can decide whether to talk, interact, give them treats, or just ignore the notification.
Required devices to be connected	- Sensor: Motion sensor, Temperature sensor, Load Cell.
	- Actuator: Step motor
	- Intermediate Device: Wi-Fi modules, Microcontroller, Camera, Screen, and Microphone/Speaker.
IoT protocol Considerations	The "Feedy My Petty" device can be able to operate independently offline and online. However, they might need Wi-Fi connection or Bluetooth with an app to configure settings. The range needed is just only around the resident which is around 5-10m. The system is immobile so it can be more efficient to be connected to the electrical grid; furthermore, they have batteries in case of electricity blackout.
IoT protocol choice	Wi-Fi, LAN: the system mostly operated in a home, with high data rate and reliable and economical. Since the device will be plugged in the

		home electrical grid, they will be supported with high power. Internet Connectivity: to upload data to cloud for storage and connect to the mobile application and to configure the system. Bluetooth: to configure the setting regardless of Internet connection.
Data	-	Type generated: Weight each day, Temperature each day, Movement each time the pet walk by.
	-	Storage solution: Cloud
	-	Analysis overview: Based on the data gathered about the pet's weight and temperature changes. The system can give advice on adjusting the diet and nutrition.
Programming required	-	Device function: Programmed with algorithms that could give recommendation about diet adjusting
	-	Network Requirement: Internet Wi-Fi to upload data to the cloud for analyzing and interact with owner.
	-	Data Management: Algorithm to identify unhealthy sights.

Table 1 The IoT Design Planning

This project could be executed by using The Eclipse Smart Home or ESH since they specialized in the smart home domain and they could operate both offline and online.

Different Version of the System

In the first iteration, there are only the core function of the feeding machine is to automatically dispense food.

The next version will be added with time setting schedule for automatically feeding through Bluetooth and a simple mobile application.

The third version would give the device Internet connection so owner can configure the device from anywhere.

The fourth version is to integrate weigh and temperature sensor to collect data and send to owner phone and the cloud. Base on the data, the app will suggest a healthy diet for the pet.

The final iteration is to construct the device with screen, microphone, speaker, camera, and motion sensor. Since the device is connected to the Internet, customer can have conversation and interaction with their pet from anywhere.

Conclusion

This essay has discovered many aspects of IoT, the challenges ahead and how it developed in recent past. Also how it operate by frameworks, tools, software and hardware. IoT is worked under many protocols and technologies, they are the connection and interaction between many devices that capable to sensing the environment and produce valued data. IoT could make our lives much easier and meaningful if we overcome its challenges.

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