INTRODUCTION TO INTERNET OF THINGS

A DEFINITE GUIDE TO LEARN IOT - ENABLING TECHNOLOGIES, CONNECTIVITY, PROTOCOLS AND CLOUD

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PREFACE

This book provides insights on the Internet of Things, from the basics to intermediate knowledge, for beginners. This book includes an overall aspect of the technology in the up-to-date world, primarily for the students and hobbyists. Right from the architecture of the IoT to the cloud and messaging platforms, this book incorporates all the essential topics.

Contents

Chapter 1

WHAT IS INTERNET OF THINGS?

CHAPTER 1

WHAT IS INTERNET OF THINGS?

Just imagine, you are in the 1950s, and you had to wash your clothes with your hand. We didn't have a telephone until 1875. Alexander Graham Bell invented the first telephone when his assistant was trying to reactivate a telegraph transmitter. In 1886, Karl Benz patented the first three-wheeled motorcar known as "Motorwagen." Edison invented the incandescent light bulb. There are so many inventions which made our lives easier and more manageable. The world is moving fast; accordingly, we have to adapt to the speed of the movement. All these devices and appliances have a specific role that made millions of lives simpler. The accessibility of these devices is getting closer to many people despite their financial backgrounds. The usage of cell phones in the year 2000 is way more inferior when compared to the current year. The scope of the usage became an obligation. Currently, we are in the generation of making these devices communicate with us. We will look through the devices which are enabled with IoT in the later chapters.

For a simplistic explanation of the Internet of Things for a beginner, it is the things or devices which function by connecting to the internet. Our day-to-day life activities consist of a bread toaster that we use in the morning until we set up our alarm clock in the night; this technology makes our lives simpler. This technology can connect these devices to the World Wide Web, i.e., extensive information generated in the "cloud" and communicate with us. The Internet of Things is widely used in Industries, Logistics and Transports, Smart homes, Wearables, Precision Farming, Environmental Monitoring, Disaster Management, etc. The Internet of Things has a high demand for technologies and solutions and a benefit for many sectors.

The Internet of Things (IoT) consists of all the web-enabled devices that collect, send and act on data they acquire from their surrounding environments using embedded sensors, processors and communication hardware. The Sensors or the actuators play a vital role here, as it is directly connected to the "things" and grasps the data from them. These "connected" or "smart" devices can sometimes talk to other related devices and act on the information they get from one another. For example, you can control your home appliances through an application or website or even by your voice. Another example is that you have a smartwatch that monitors the health conditions of your body every day and gives statistical data. To elucidate, the sensors are located in these devices that collect the data and sends it to the cloud, which can be accessed only by the user. So here comes the question, can anyone access this data? The answer is No. Only the authenticated and authorized person can able to read and manipulate the data of these devices. Many fundings and research are going on in numerous firms toward the security of the data.

A little bit of History,

Kevin Ashton coined the term "The Internet of Things" in a presentation to Proctor & Gamble in 1999. He is a co-founder of MIT's Auto-ID lab. Also, he pioneered RFID use in supply-chain management. He started Zensi, a company that makes energy sensing and monitoring technology. Besides that, he later sold the company to Belkin. He has been involved in other startups, such as ThingMagic. He is also the author of the book How to Fly a Horse: The Secret History of Creation, Invention, and Discovery.

Chapter 2

IOT ENABLED Vs. NON-IOT ENABLED DEVICES

CHAPTER 2

IOT ENABLED Vs. NON-IOT ENABLED DEVICES

Gartner estimates that about 8.4 billion IoT devices were in use in 2017, up 31% from the previous year, and it will hit 20.4 billion by 2020. The whole world spending on IoT hit about $2 trillion in 2017. Take this estimation on the one hand, and on the other hand, let us think about our lives without appliances or devices with IoT enabled. So, we will use an appliance that is now IoT enabled and not before and compare their results and effectiveness.

There are many examples of IoT enabled devices such as,

- Pacemakers are now WiFi enabled; the doctors can now track the information about the patients. All the implants are becoming IoT enabled nowadays.
- The ornaments and dresses we wear are also becoming IoT enabled as IoT wearables.
- Appliances such as Washing machines, refrigerators, Air Conditioners, Thermostats, Security cameras, Lights are together as a setup now known as Smart Home!
- Agriculture or "Precision Agriculture" – sensors kept in the soil to sense the moisture level, and self-driven tractors are implemented in the farms. Also, it is mandatory in the USA to have sensors fed to the cattle to track them from their birth.
- Smart buildings or Smart parking garages that can talk with trucks and vehicles.
- Traffic lights and parking meters are IoT enabled that can communicate with vehicles.

We will see an example of an appliance that has been made IoT enabled now and which was not earlier.

Washing Machine

Non- IoT enabled: Example WW9000 Washing Machine with eco bubble, 10 kg

The washing machine is primarily used for washing and drying clothes. It comes with two steel tubs: an inner tub and the outer tub, whose role is to prevent water spillage to other parts of the machine. There are so many control knobs such as selecting the load, selecting the water inlet such as hot or cold water, selecting the mode such as save mode or normal mode, and finally a program to select which comes to heavy, normal, light or delicates. In our modern-day non-IoT washing machine appliances, the selectivity of the programs varies.

Operation

Fill, Agitate, Drain and spin are the main functions of a washing machine. It comes with an embedded system where a microcontroller does all the functions. All the operations are connected to the microcontroller; when the machine is ON and the program is selected, the microcontroller is triggered, and it functions.

About WW9000 Washing Machine with eco bubble, 10 kg:

- Four sensing technologies detect the load size, the amount of water needed and the degree of soil to select the best wash programme. It even adds the right amount of detergent for you.
- Comes with a Digital Inverter Motor and a spin speed of 1600 rpm.

IoT enabled: Example: SAMSUNG WW7800M

- The new WW7800M with QuickDrive technology is Samsung's latest washing machine slated for release in 2019.
- It has an AI-powered laundry assistant called Q-rator.

Three key smart features;

- Laundry Planner
- Laundry Recipe
- HomeCare Wizard.

Laundry Planner:

It comes with a customized timing and a proper schedule for the time period of each wash. It allows the users to manage the laundry schedule.

Laundry Recipe:

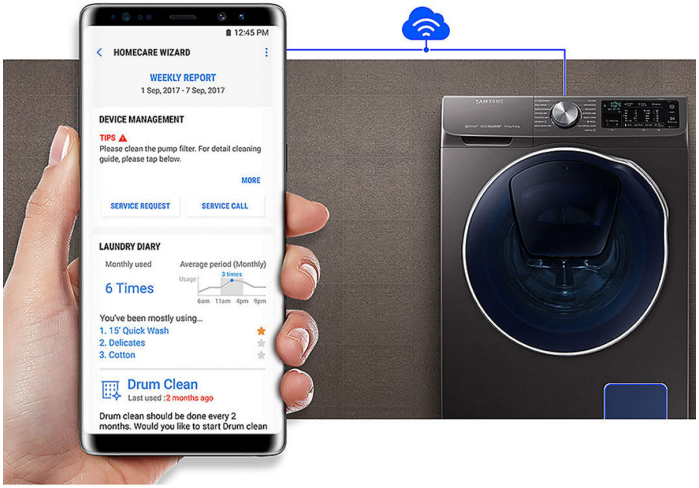
It provides automatic recommendations for optimal wash cycles based on information such as colour, fabric type, and degree of soiling provided by the user.

HomeCare Wizard:

Onboard support structures for alerts of any problems and to provide troubleshooting support if needed. It also allows the users to monitor the washing machine using a remote, i.e., from anywhere in the world.

Q-rator: Samsung's new washing machine WW7800M comes with an Artificial intelligence technology-powered laundry assistant known as Q-rator.

QuickDrive technology: Innovative QuickDrive™ technology reduces the washing time by up to 50% without compromising the cleaning performance.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HOMECARE WIZARD
WEEKLY REPORT
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DEVICE MANAGEMENT
TIPS
Please clean the pump filter. For detail cleaning guide, please tap below.
MORE
SERVICE REQUEST
SERVICE CALL
LAUNDRY DIARY
Monthly used
6 Times
Average period (Monthly)
3 times
Usage
6am 11am 4pm 9pm
You've been mostly using...
1. 15' Quick Wash
2. Delicates
3. Cotton
Drum Clean
Last used :2 months ago
Drum clean should be done every 2 months. Would you like to start Drum clean

Chapter 3

APPLICATIONS OF IOT

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APPLICATIONS OF IOT

As we all know, IoT (Internet of Things) in today's world is one of the most renowned topics and is applied to make life easier. There are so many applications of IoT in the market which is growing day by day. The devices of IoT that connects our data to the devices are on demand. These devices are called real-time devices or smart devices that reduce human efforts. In this chapter, the real-time IoT applications are briefly described. So, now we are going to discuss real-time IoT devices. The following is the applications.

SMART HOME

The smart home is one of the most valuable features of IoT devices on demand. People are very much fond of it. So, it is nothing but an automatic control of home appliances to make human life more straightforward, just like it acts as a human-robot. It adds a wing to the real-time IoT after this innovation.

Now, coming to the point, what makes the craze on smart home devices? It is nothing but the savings of money, energy, efforts of the human being. While sitting on the bed, we can switch off the light, fan, close the door, make dinner, wash clothes, clean the floor and many more. Now think about it, isn't this cool?

Now, so many companies have been developed by making smart home devices. They are getting a huge profit every day by selling their products as home automation become their building block. Some of the examples of smart home devices are:

- Amazon Alexa: It can play music, make a phone call, make a reminder, tell about the news, find the nearby restaurants, get answers to your question, turn on and off the light, lock the door and many more.

- Google Assistant: It is a voice control device. It has google cast plus voice assistant with Bluetooth and USB charging, clock system, multiple alarm, play music, control smartphones and tablet.
- Amazon Echo: It can play music, make a phone call, make a reminder, tell about the news, find the nearby restaurants, get answers to your question, turn on and off the light, lock the door and many more.
- Philips Hue lightbulbs: Gives a pre-set light need as required, stay connected, gives many shades of white light.
- Wink Hub 2: Add voice control by combing with Alexa devices.
- Samsung SmartThings Hub: Connects the smartphones and make them work together. It has a light, speaker, thermostat, sensor and more.

SMART CITY

IoT is exploring its area. Earlier, the smart home or home automation where it operates a home. Now, it is managing a city. Just imagine how life has become easier and simpler.
So, what are the features of a smart city?
It helps people overcome severe problems like pollution, traffic congestion, shortage of energy supply, drainage system, municipal services, etc. People can find the parking slots easily, the map by installing the application on their smartphones. The Internet of Things connected devices connects them.

For example, Smart City for Metropolitan Transportation with an application for the public to view the timings of the Public transport, indicate if there is any accidents or delays, etc. For the Traffic Control application, the citizens can view the route or the directions on the map which is easier to reach the destination.

SMART HEALTH

IoT has explored its area in well being of people. IoT technology impacts great potential in connected healthcare services. It gives special care to patients. It detects the health of the patients, consult the proper doctor and also the proper treatments, location of the hospitals and store of medicines. Therefore, collecting data helps in personalized analysis. In conclusion, everyone is appreciating this new revolutionary invention of IoT dedicated to peoples' care. There are such companies and applications which helps people in connected healthcare.

SMART AGRICULTURE

Due to the increase in population, the demand for food supply is increasing day by day. In these conditions, the farmers need to apply some technical support to produce more food. The countries are providing technical support to the farmers. So that they can examine soil, control water usage, keep in proper sunlight, moisture, fertilizer. Similarly, they can grow foods sufficiently and are also supplying to the whole world. Smart agriculture makes a productive infrastructure that connects our data to IoT devices using sensors and installed apps. It is the key to the future agricultural industry.

INDUSTRIAL AUTOMATION

Industrial IoT or IIoT is a strategic priority for manufacturing companies. It allows them to give an excellent experience to their customers and improve the cost-efficiency of their internal operations. An outcome, by simplifying field service and reducing TCO(Total Cost of Ownership) for the customer, has become the modern industry's intelligent selling feature. Kaa delivers an essential toolkit for the industrial Internet of Things.

Chapter 4

HOW DOES THE IOT SYSTEM WORK?

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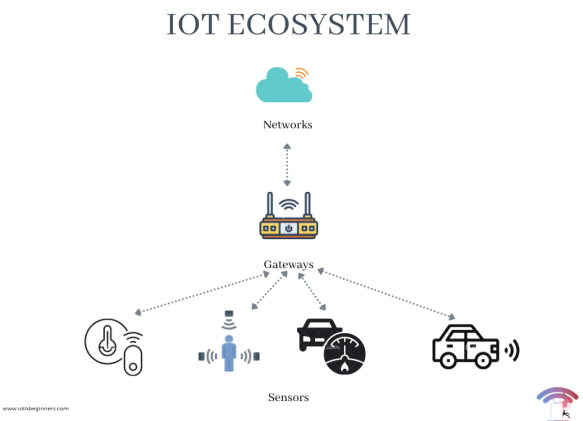
HOW DOES THE IOT SYSTEM WORK?

IoT is a business solution to existing problems of the world. The following diagram shows the basic bi-directional flow of an IoT system. A complete IoT system Integrates distinct components: sensors/devices, connectivity, data processing and a user interface.



The above diagram consists of various components such as sensors and Gateways. Besides that, it is connected to the network. In this chapter, each of the components is briefly explained.

SENSORS

Sensors or actuators can collect terabytes of data, including sensitive information such as business data or customers' personal information. Additionally, IoT platforms or dashboards can be connected to critical systems, such as traffic, power or transportation processes, making it vital to ensure their continuity and integrity.

IoT is a business solution to existing problems of the world. The following diagram shows the basic bi-directional flow of an IoT system. A complete IoT system Integrates distinct components: sensors/devices, connectivity, data processing and a user interface. Many sensors are used in IoT Devices or applications such as temperature sensors, pressure sensors, piezo-electric sensors, magnetic sensors, etc.

Low power consumption has become an important design goal in many electronic systems. The voltage obtained by the sensor is transduced to the expected format. Initially, the embedded systems were standalone devices running assembly or bare metal C code; as the technology evolved, the embedded systems could run OS and connect to a wired or wireless network. Now, it will gather this information from its surroundings with the aid of sensors. Now, when we talk about sensors, we have to talk about micro-controllers to interact with sensors, so indirectly, we are talking about Embedded systems.

GATEWAYS

Internet of Things is an ecosystem of internet-connected devices. Any communication device which connects end terminal devices like sensors or even computers to the internet is called a gateway. It is like your modem or router. It exactly works as an opening path from IoT enabled home or office to the internet. Gateway, as it means, is used to bridge two different environments to allow them to communicate with each other.

NETWORK

The Cloud is an advantageous way to create an IoT platform that monitors different devices spread over a large area. The Cloud and the IoT are related in that smart devices, like lightbulbs and thermostats, talk back to their vendor in the Cloud to be accessible from outside the home. Your smartphone can talk to the vendor's cloud presence, allowing you remote control, monitoring and more.

IoT requires to be operated in a hassle-free manner. Cloud helps by providing device makers and service providers with access to advanced analytics and monitoring. Cloud is used to store and manage data; sometimes, complex calculations are made.

Chapter 5

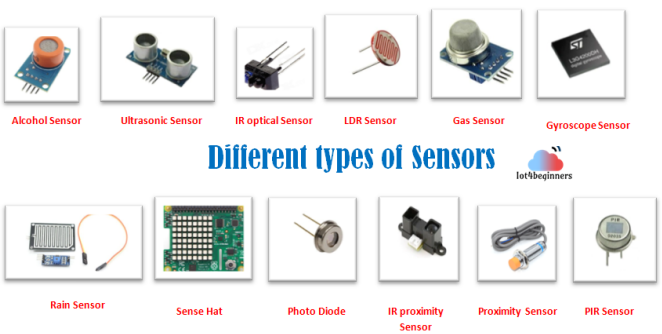
IOT SENSORS

CHAPTER 5

IOT SENSORS

In many cases, sensors are helpful and very important for the devices to fetch the data. The data can be real-time, which includes the current temperature, pressure or humidity. It can also sense the objects and calculate the distance between them. For each purpose, there are sensors available in the market. This article shall discuss various sensors and their applications, which can be used in your DIY IoT projects.

Here is the list of Sensors most commonly used in the IoT devices,



TEMPERATURE SENSOR

- A Temperature Sensor senses and measures the temperature and converts it into an electrical signal.
- They have a significant role in Environment, Agriculture and Industries. For example, these sensors can detect the temperature of the soil, which is more helpful in the production of crops.
- There are many temperature sensors, such as NTC thermistors, Resistance Temperature Detectors RTDs, Thermocouples and Thermopiles. They are efficient, easy to install and reliable that responds to human activity.
- The RTDs work on the correlation between the metals and the temperature, as the device's resistance is directly proportional to the temperature.
- The widely used DHT 11 is the temperature and humidity sensor is the basic, low-cost, digital and capacitive sensor. No analogue pins are required for this sensor.

PRESSURE SENSOR

- A pressure sensor senses the pressure applied, i.e., force per unit area, and it converts into an electrical signal.
- It has high importance in weather forecasting. There are various Pressure sensors available in the market for many purposes.
- For example, if there are any water leaks in the residential or commercial areas, a pressure sensor needs to be installed to check if there are any leaks and measures the pressure.
- Another example, all smartphones, wearables have these barometric pressure sensors integrated into them.

PROXIMITY SENSOR

- A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact.
- A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation and looks for changes in the field or return signal.
- The most common application of this sensor is used in cars. While you are taking the reverse, it detects the objects or obstacles, and you will be alarmed.

ACCELEROMETER AND GYROSCOPE SENSOR

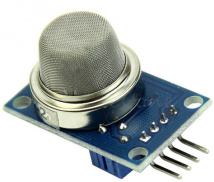
- The difference between Accelerometer and the gyroscope is accelerometer measures linear acceleration based on vibration, whereas; the gyroscope is intended to determine an angular position based on the principle of the rigidity of space.
- Accelerometers in mobile phones detect the orientation of the phone. The gyroscope adds dimension to the information supplied by the Accelerometer by tracking rotation or twist.
- A 3D gyroscope has three gyroscopic sensors mounted orthogonally.
- Accelerometers and gyroscopes are the sensors of choice for acquiring acceleration and rotational information in drones, cell phones, automobiles, aeroplanes, and mobile IoT devices.

INFRARED SENSOR

- An Infrared Sensor is an electronic device that senses its surroundings' specific characteristics by emitting Infrared radiation.
- It can measure the heat emitted by an object and also measures the distance.
- Its uses in Radiation thermometers depend on the material of the object. IR sensors also use in Flame monitors and moisture analysis.
- IR sensors are used in gas analyzers which use absorption characteristics of gases in the IR region. Two types of methods are used to measure the density of gas such as dispersive and nondispersive.
- IR imaging devices are used for thermal imagers and also for night vision.

SMOKE SENSOR

- A smoke sensor detects smoke and its level of attainment. Nowadays, the sensor manufacturers implement it with a voice alarm through ALEXA, which also notifies our smartphones.
- The smoke sensor is of two types, Optical smoke sensor and ionization smoke sensor.
- The optical smoke sensor, also called photoelectric smoke alarms, works using the light scattering principle.
- The alarm contains a pulsed Infrared LED, which pulses a beam of light into the sensor chamber every 10 seconds to check for smoke particles.



Chapter 6

IOT DEVELOPMENT BOARDS AND GATEWAYS

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IOT DEVELOPMENT BOARDS AND GATEWAY

Hardware platforms are the foremost part of your IoT project where your components are connected with that. In this chapter, some of the primary and commonly used hardware platforms for your IoT projects are discussed. You can compare the hardware with the feature, size, cost, power supply, etc. Most of the hardware development boards are microcontrollers and microprocessors, and some of them have inbuilt sensors, come with a very small size, say a coin size.

Some boards have a high bandwidth WiFi radio and Bluetooth, also have USB embedded within the board. So there is plenty of development kits out there in the market with various features integrated within them. At the end of this chapter, you can be confident to choose the kind of hardware platform you will be working on your projects.

Here is a list of IoT development kits for your projects:

- Raspberry Pi
- Arduino Uno
- ESP8266
- Banana Pi
- NodeMCU Dev kit
- BeagleBone Black (Beagleboard)
- Panstamp
- AVR IoT WG Development kit
- Avnet BCM4343W IoT Starter kit

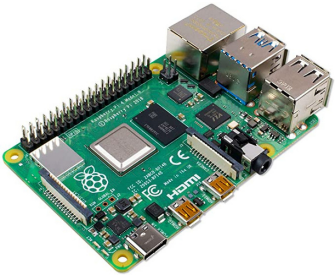
RASPBERRY PI

The Raspberry Pi, also known as RPi, is a small, "Single Board Computer" (SBC) developed in the United Kingdom by Raspberry Pi Foundation. Their main aim is to educate basic computer science in developing countries.
They had released several generations of Raspberry Pi.

- Raspberry Pi Model B (First generation) – February 2012
- Raspberry Pi Model A – February 2013
- Raspberry Pi Compute Model- April 2014
- Raspberry Pi Model B+ – July 2014
- Raspberry Pi 2 – February 2015
- Raspberry Pi Zero- November 2015
- Raspberry Pi 3 Model B – February 2016
- Raspberry Pi Zero W – February 2017
- Raspberry Pi 3 Model B+ – March 2018

The Raspberry Pi was first released on 29 February 2012 with an introductory price of US$35. The System On Chip (SoC) used is Broadcom BCM2837B0 and compatible with plenty of Operating Systems such as Linux, FreeBSD, NetBSD, OpenBSD, Plan 9, RiscOS and Windows 10 IoT Core. The Raspberry Pi 3+ uses a Broadcom BCM2837B0 SoC with a 1.4 GHz 64-bit quad-core ARM Cortex-A53 processor, with 512 KB shared L2 cache. Besides, it comes with a 40 pin General Purpose Input Output (GPIO) connector.

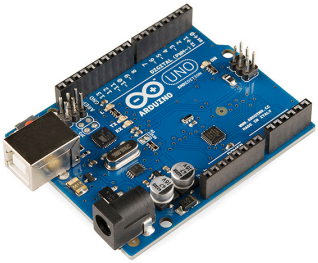
The Keyboard and mouse can be connected with the USB, and other components such as sensors can be connected with the GPIO pins. The RPi has no built-in real-time clock, so it cannot track the time of the day. It comes with lots of accessories like a Camera, SenseHat (which has lots of built-in sensors), Gertboard, Official Display, etc.



ARDUINO

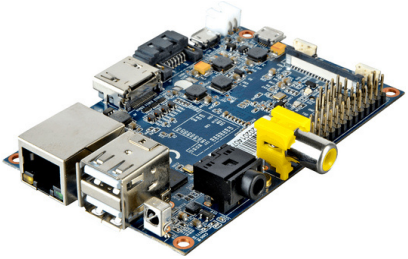
The Arduino Uno is open-source hardware developed by arduino.cc. It is a microcontroller board based on a Microchip ATmega328P microcontroller. It has SRAM memory, and it uses Flash and EEPROM for storage. Its operating voltage is 5 volts, where you can plug it in your laptops for the input voltage; also, you can use an external 9-volt battery as the Arduino accepts voltage from 7 to 20 volts. The Arduino Uno has 6 Analog pins, 14 Digital pins, where 6 of them provide Pulse Width Modulation output. The digital pin 13 is for LED; it works as if the pin is HIGH, the LED is ON, and vice versa.

It comes with a ground pin and a reset button. 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.



BANANA PI

The Banana Pi is a low cost, Single Board Computer developed by a Chinese company Shenzhen SINOVOIP Co. Ltd. The Raspberry Pi influences the hardware design also; both are compatible with each other. It runs on Operating systems such as Android, Ubuntu, Debian, Arch Linux, Raspbian and NetBSD. The Banana Pi M2 is a single-board computer with a quad-core version (A31S ARM Cortex-A7 Quad-Core) and supports onboard WiFi.
BPI-BC95 is an NB-IoT development board with rich features and a small form factor. It supports 1080 HD video output. The SoC used is Allwinner A31; later on, they have stopped the production of the boards since the company Allwinner ran out of chips. Based on 96Boards' specification, it runs HuaWei LiteOS, and can easily port to other Real-Time Operation Systems.



ESP8266

The ESP8266 is a coin-size, low-cost WiFi microchip with a TCP/IP stack and a 32-bit microcontroller developed by a Chinese manufacturer called Espressif Systems. A third-party company, Ai- Thinker, manufactured a module called ESP-01, which allows the microcontroller to connect with the WiFi connections and make simple TCP/IP connections. It has 16 GPIO pins for inputs and outputs for Voltage, ground, receiver and transmitter data, reset, chip power-down.

The VCC is +3.3 volt, and it can handle up to 3.6 voltage. It also has a Serial Peripheral Interface (SPI), 32 KiB instruction RAM and an 80 KiB user-data RAM. It has a Software Development Kit (SDK) in which there is no need for a microcontroller and can be directly programmed. It has two versions, one is from FreeRTOS, and another one is a callback. Also, there are many open-source SDKs, which includes NodeMCU, Arduino, Sming and so on.

NODEMCU

The NodeMCU is an open-source, single-board microcontroller, low cost, simple and smart IoT development board with a few simple Lua scripts. It gives a high-level interface to hardware with simple configurations. Based on the Lexin esp8266 NodeMCU development board, with GPIO, PWM, I2C, 1-Wire, ADC and other functions, combined with NodeMcu firmware to provide the fastest way for your prototyping. It can be powered by USB, with a memory of 128KByets and storage of 4MBytes.

WHAT IS AN IoT GATEWAY?

All data moving to or from a cloud goes through a gateway, a hardware device or software program. An IoT gateway is a device or program that connects the cloud and controllers, sensors or smart devices. This is also known as an intelligent gateway or a control tier. A gateway also acts as a platform to pre-process the data locally before sending it to the cloud. This is particularly important when there is significant points of data is being generated. The response time and network transmission costs are also impacted by the depreciation of the volume of data being sent. The IoT gateway can even provide additional security for the network and data in both directions. IoT gateways have now become widely popular and have a plethora of purposes. They have evolved to perform tasks from data filtering and visualization to even complex analytics. Below is a simple pictorial representation of an IoT gateway in a practical application. This makes it evident that the gateway acts as a bridge.

What basic functionalities should an IoT gateway have?

Secure upstream Internet and downstream LAN connectivity

Like a router, the IoT Gateway provides Internet connectivity and packet routing between the devices and IoT application servers using some other type of internet connectivity like WiFi. The IoT Gateway creates a LAN (Local Area Network) that can be wired, wireless or P2P. This is then used by sensors or other devices to connect to it. It also provides secure data connectivity between the device and the gateway and from the IoT Gateway to the cloud/application server.

Edge embedded application

The edge application runs within an application environment that the inbuilt microcontroller or microprocessor. This provides secure connectivity and protocol implementation. Some gateways also provide storage within the data and some logic control as part of the edge embedded applications.

HOW TO CHOOSE A GATEWAY?

If you are thinking about integrating an IoT gateway into your project, there are a few factors you need to take into consideration. This will help evaluate which will work best for the main objective and functionality that you.

IoT Gateway Certification

The gateway model should be FCC/CE/IC certified, following the standard compliance required for electronic products. There are also certifications such as Mobile PTCRB/GCF and safety certifications.

The volume of data collection

The number of sensors being used determines the volume of data. You may require just a few sensors, a couple hundred or even thousands. The data volume that results from these sensors is a question you need to ask yourself seriously. This information is necessary for choosing which and how many gateways you want to invest in.

Data storage within the gateway

If the data being transported through the gateway is sensitive, the gateway may need to store the data in the case of network or power failure. Factors like the duration over which it can be stored and expansion of memory need to be taken into account.

Filtering

As we know, IoT gateways can perform some pre-processing analysis on the data before it is sent to the cloud. Thus depending on the requirement, you will have to look into edge-analytics-enabled gateways capable of complex analysis.

Location and longevity

Hardly gateways are needed for usage in certain conditions and over a duration of time. Some gateway models can operate in various conditions regardless of pressure, temperature and other external factors. So depending on your need, that too will have to be taken into account.

WHAT FEATURES DO YOU REQUIRE?

It may sometimes be sufficient for your project to use connectivity features such as Bluetooth, Ethernet, Wi-Fi and LAN. However, in some cases, longer-range options are needed as well. This increases the budget you will need to purchase a versatile gateway.

Security

Most gateways now come with built-in security measures. But, depending on the need, encryption standards, password protection, and tamper detection are features not all gateway offers but some users might require.

In conclusion, IoT gateways are a helpful addition to your IoT project. Depending on the scale and use, it might be a worthwhile investment. Large industries very often turn to IoT gateways for smooth and secure data transportation. Incorrect choice of the gateway can be a setback in effort and financial strain. So, evaluating the criteria that to choose the right gateway will make a huge overall difference.

Chapter 7

IOT COMMUNICATION PROTOCOLS

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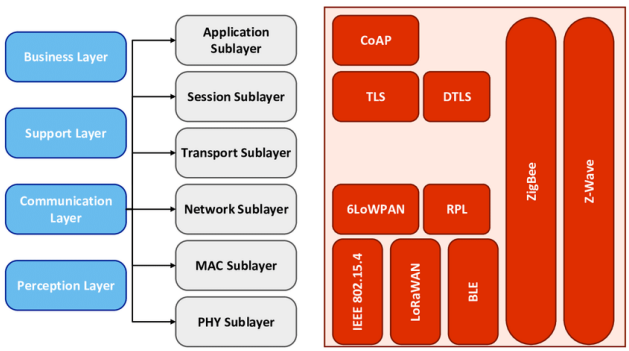
IOT COMMUNICATION PROTOCOLS

According to Gartner's statistics, nearly 20.4 billion IoT devices are connected to the internet by 2020. These devices communicate with the internet through various channels. It always depends on the application and based on that the solution is provided. In the given image below, the left blocks indicate the TCP/IP protocol and the right-side blocks indicate the communication protocols for IoT.

Mostly the Internet of Things follows device-to-device communication. It is about connecting various sensors/actuators or devices to the internet. These are called sensor nodes or motes (used in America). They communicate over many types of networks, including IP networks or the Internet, but most often use protocols like WiFi, Bluetooth, Z-Wave, and ZigBee.



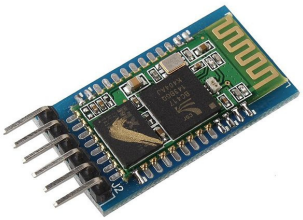
Bluetooth Low Energy (BLE)

Bluetooth provides wireless communication through a radio frequency (2.45 GHz). It is low cost, highly reliable and low power usage. Bluetooth Low Energy (BLE) is a modified version of Bluetooth that decreases power usage and data rates by allowing incoming connections to control when the device uses power. The Data Rate is up to 0.27 MB per second and the range is medium up to 100 meters. The IoT product developers chose BLE for its efficiency and small chip size.

Physical range: Typically less than 10 m (33 ft), up to 100 m (330 ft); Bluetooth 5.0: 40–400 m (100–1,000 ft).

Applications

- Audio Signal Transmission (Bluetooth Earphone, Bluetooth speaker),
- Industrial (Replacing the cable The original thought of Bluetooth, SPP (Serial Port Profile), Multi UART Port, Makes it easy to transfer data wirelessly to smartphones / PC, Makes it possible to upgrade parameter/program wirelessly),
- Smart Home (Remote Control for A.C, TV, … Door Bell /Lock, Illumination, Music /Audio, Security, Valve for Water/Gas, Windows/Curtain, Power Socket)
- Wearable Devices (Smartwatch, Smartpen, Smart shoes, etc)
- BLE Broadcast
- Short Range Real-time communications



Wi-Fi (Wireless Fidelity)

Wi-Fi is based on the IEEE 802.11 family of standards originally released in 1997 to replace the ethernet. It uses wireless transmitters and radio signals to transmit broadband Internet to devices. Wi-Fi is known for its high bandwidth, ease of device operability and moderate cost. Wi-Fi is more suitable for IoT applications, where more number of data transfer is made. The data rate is high up to 54 MB per second and the range of Wi-Fi technology is up to 50 meters but can be provided up to 30 kilometres by private antennas.

The security standard, Wi-Fi Protected Setup, allows embedded devices with a limited graphical user interface to connect to the Internet with ease. Wi-Fi Protected Setup has 2 configurations: The Push Button configuration and the PIN configuration. These embedded devices are also called The Internet of Things and are low-power, battery-operated embedded systems. A number of Wi-Fi manufacturers design chips and modules for embedded Wi-Fi, such as GainSpan.

Applications

- Office IoT
- Smart Home IoT
- Smart city (Public Wi-fi)

Zigbee

Zigbee is a short-range wireless communication protocol based on the IEEE 802.15.4 protocol, which is widely used in home automation and the industry as a low-power, low-cost, low-bandwidth protocol. Zigbee uses mesh networking–connections to other connected devices–to connect its devices to each other and the Internet. Zigbee's range is 10 meters, but this range can be up to 100 meters in certain situations. Its maximum data rate is 250 kbps. It is necessary only for small amounts of data transfer in a short-range area.

Applications:

- Home automation
- Monitoring Sensor data
- Industrial device sensing and controlling

Cellular (Mobile Network)

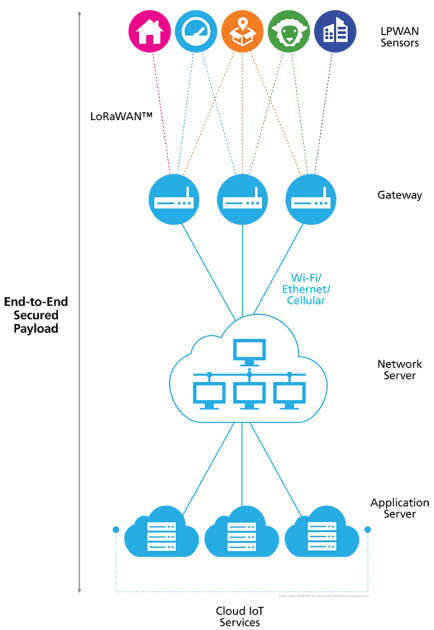
The cellular network or the mobile network connects to the internet by sending a wireless signal to the nearby cell towers. The cellular network is wireless communications protocols such as 2G, 3G, 4G, and 5G. The fifth-generation will be deployed in the year 2020 and will be a turning point for all the IoT devices which is 20 times faster than the 4G (only 1 Gbps). The cellular network uses significant amounts of power and however the IoT devices should be within the network range. Hence the need for high power is a disadvantage of this tech. The cellular network is known for its security, reliability, and range of about 200 kilometres. The cost to set up with the network is very complicated and should maintain relationships with the network providers, and the cost alone subjects to more than $10000 excluding the monthly payments.

LoRa

LoRa (Long Range) network is a low power communication technology patented and owned by a company called Semtech. It was first introduced in the year 2008 and doesn't have much documentation on this protocol. The advantage of this protocol is, it is highly reliable, medium cost, and has low power usage with long-range. But it has a low data rate up to 50Kbps.

Application

- Smart City
- Energy Management
- Supply Chain Management



Chapter 8

IOT CLOUD

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IOT CLOUD

So why do we need a Cloud service?

Say for example, if you are connecting an LED to a Raspberry Pi and you need that to blink whenever you get a notification from your Twitter account. The platform for connecting the LED to the RPi is called the Hardware platform. Besides, the platform for connecting your Twitter account to your Raspberry Pi you need a Cloud platform obviously. There are a billion things connected to the internet and for that, it is harder to maintain the data. Also, sending the data, store, and process all your data is not possible in your home and it's not practical. So there are great cloud services available to upgrade, maintain and secure your data.

Here is a list of the best cloud platforms available today.

Amazon Web Services IoT Platform

Amazon Web Services (AWS) is one of the best cloud services for its trusted security of data. It offers computing power, database storage, content delivery, and other functionality to help businesses scale and grow. Companies like Netflix, Kelloggs, Philips, GE, Dropbox, Foursquare, etc rely on the services of Amazon Web Services. In 2017, the famous Gartner ranked AWS as the leading international provider of Cloud Computing. The AWS cloud spans around 60 availability zones, 20 Geographic Regions and 1 Local region around the world (as of 2019).

The well-known services of AWS are EC2 and S3. The EC2 (Elastic Compute Cloud), the operation of non-persistent virtual servers with Windows or Linux. The S3(Simple Storage Service) is a service for file hosting via HTTP/HTTPS. AWS is not only for top companies like Netflix or Reddit, even we can host servers on AWS. It is not a fixed contract, as it is billed monthly or even hourly. The AWS provides certifications on various levels and different domains.

Microsoft Azure IoT Hub

From the core point of view, Microsoft Azure is a public cloud computing platform developed by Microsoft. Its initial release was in the year 2010 as "Windows Azure" before that it had a name called "Project Red Dog". On March 25, 2014, it was renamed "Microsoft Azure".

It is developed for building, testing, deploying and managing applications through a global network of Microsoft managed data centres. It also provides SaaS (Software as a Service), Paas (Platform as a Service), IaaS (Infrastructure as a Service) and supports many programming languages and Microsoft specific including third-party software and systems.

Google Cloud IoT

Cloud IoT Core is a fully managed service that allows you to easily and securely connect, manage, and ingest data from millions of globally dispersed devices. In combination with other services on Google Cloud Platform, provides a complete solution for collecting, processing, analyzing, and visualizing IoT data in real-time to support improved operational efficiency. Cloud IoT Core - Secure device connection and management service for the Internet of Things. cloud IoT Edge brings AI to the Edge computing layer. Google Cloud Platform is available in 17 regions and 52 zones. They have different pricing methods.

IBM Watson IoT Platform

IBM Watson IoT Platform is a managed, cloud-hosted service designed to make it simple to derive value from your IoT devices. Watson IoT Platform and its additional add on services - Blockchain service and analytic service - enable organizations to capture and explore data for devices, equipment, and machines, and discover insights that can drive better decision-making.
IBM Watson captures real-time data helps to identify valuable insights, optimizes operations and resources, analytics service and blockchain service. Overall, it securely connects, manages and analyzes IoT data. You will get 100 MB free every month.

Bosch IoT Suite

The Bosch IoT Suite is a cloud-ready software package for the development of Internet of Things (IoT) services and applications. It is part of the Bosch IoT Cloud and provides an open IoT platform for a variety of applications. With its IoT Suite, the Bosch company offers a software package on the basis of which applications and services of the Internet of Things (IoT) can be developed and implemented. The Bosch IoT Suite is cloud-enabled and integrated in the Bosch IoT Cloud. It is an open IoT platform that can be classified as a platform-as-a-service (PaaS) in the cloud computing model.

Cisco IoT

Cisco IoT accelerates digital transformation, delivering insight and action from your data. It provides the Cisco Kinetic IoT platform to extract, compute and move from data. It protects your IoT data with secure IoT solution architecture enhanced with IoT security services. It uses familiar tools like Cisco DNA Center and Field Network Director to integrate IT and OT infrastructure. Control IoT edge applications with IOx. Cisco has a solution in almost all the fields related to IoT in Energy, Manufacturing, Transportation, Cities and communities, Retail, Education and much more.

Oracle IoT Cloud

Oracle IoT is more into logistics operations and supply chain management derived data from the connected devices. It is secure and scalable with real-time insights. It supports industrial protocols, backhaul WAN technologies, and transport protocols like RESTful and MQTT.

Salesforce

Salesforce is an on-demand Customer Relationship Management (CRM) that provides suites for small and midsize enterprises with a focus on sales and support. The Cloud management of Salesforce is provided by Thunder which is focussed on high speed and real-time decision making in the cloud. Its motive is to create more customer interactions.

Some more examples of companies that have IoT platform

- AT&T - AT&T IoT platform
- Ericsson - Application Platform for IoT
- Gemalto - SensorLogic
- HPE - HPE Universal IoT platform
- PTC- ThingWorx Technology Platform
- SAP - SAP HANA Cloud Platform for the Internet of Things
- Siemens - Mindsphere
- Particle
- KAA
- Carriots
- Axeda

Chapter 9

IOT MESSAGING PROTOCOLS

CHAPTER 9

IOT MESSAGING PROTOCOLS

The IoT devices use these messaging protocols at various levels for communication. There is a wide variety of protocols to choose from, in this chapter, we will look at four of the most used protocols in today's world namely MQTT, DDS, XMPP and HTTP. The choice of messaging protocols depends mainly on your use case. Here we will compare the protocols on the basis of a few key parameters relevant to IoT.

MQTT - Message Queuing Telemetry Transport

MQTT is a messaging protocol that stands for Message Queue Telemetry Transport. This messaging protocol is a publish-subscribe based messaging protocol and is extremely simple to use. It is usually used to connect a huge number of IoT devices together. This protocol is one of the most commonly used in the industry. MQTT is a message centric protocol. MQTT is known for its low power consumption and hence can save battery on IoT devices. It also sends very few data packets and hence has low network usage.

HTTP

HTTP stands for Hyper Text Transfer Protocol. It has been extensively used to maintain connections between a client and a web server. It sends data over in the ASCII format and hence the message sizes are comparatively bigger. HTTP is also a document-centric transfer protocol.

XMPP

XMPP itself is very robust and powerful, owing mostly to its standardized and decentralized nature. It stands for Extensible Messaging and Presence Protocol. This messaging protocol is based on the Extensible Markup Language (XML). XMPP is a Message Centric protocol. It also has no provision for Quality of Service (QoS). XMPP is also extendable and adaptable, allowing for the creation of bots in the lines of IRC bots.

DDS

Another frequently used messaging protocol is DDS. DDS stands for Data Distribution Service. It enables scalable, real-time, reliable, high performance and interoperable data exchanges between publishers and subscribers. DDS is also a data-centric protocol. DDS is also one of the only protocols that are both data-centric and provides extensive support for QoS (Quality of Service).

Factors of Comparison

Here is a brief description of the factors considered in the comparison of the previously mentioned protocols.

Centricity

The centricity of a protocol defines the broad purpose and use case of that protocol. It is mainly of three types – Data-Centric, Message Centric and Document Centric.

- Data-Centric

In a data-centric system, the focus is mainly on the data defined by the user. The unit of exchange in this type of system is the data.

- Message Centric

A message centric system requires the users to share data through the exchange of messages. This makes message centric systems a little harder to maintain as it requires the user to spend time writing message handling logic.

- Document Centric

A document-centric system is that system in which the major data type that gets transferred is documents. HTTP has for long been used to transfer HTML documents around the web. Essentially HTTP was built keeping in mind the transfer of documents rather than messages or data (which is important for IoT).

Quality of Service (QoS)

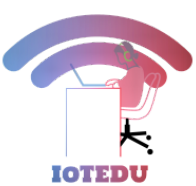
The Quality of Service (QoS) is an agreement between the sender of a message and the receiver of a message that defines the guarantee of delivery for a specific message. Here we will compare whether each of the protocols has a provision to support QoS software.

Transport

Software at the transport layer is responsible for establishing temporary communication sessions between two application programs and delivering data as requested by those applications.

The Transmission Control Protocol (TCP) is used for applications in which reliable connections between hosts are necessary. TCP checks for transmission errors, lost packets, packets out of order, etc.

The User Datagram Protocol (UDP), is an unreliable transport protocol with no sessions or flow control and optional error checking. UDP just sends packets as soon as requested and forgets about them. However, it is faster than TCP.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