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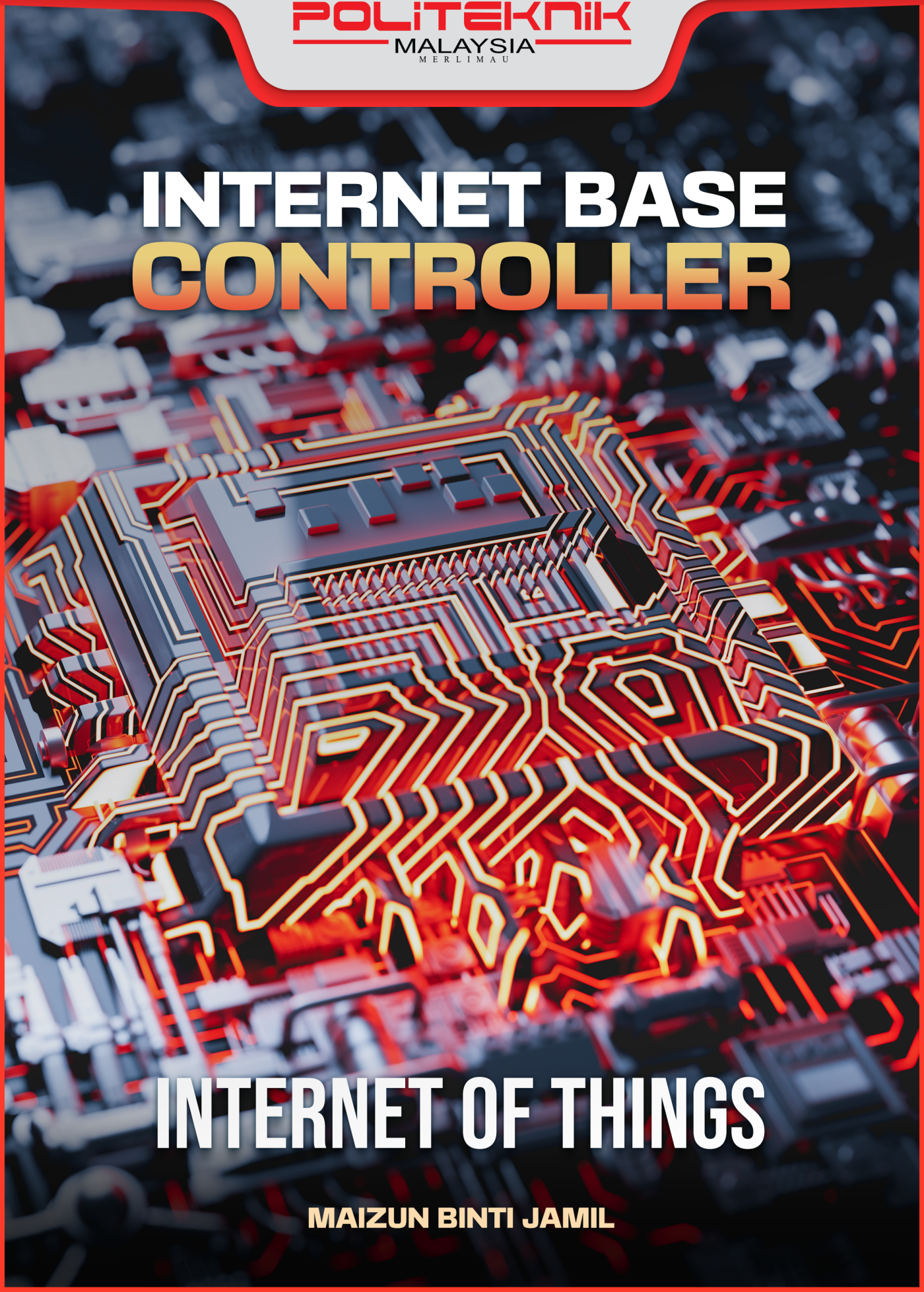
INTERNET BASE CONTROLLER



INTERNET OF THINGS

MAIZUN BINTI JAMIL

INTERNET BASE CONTROLLER

Internet of Things

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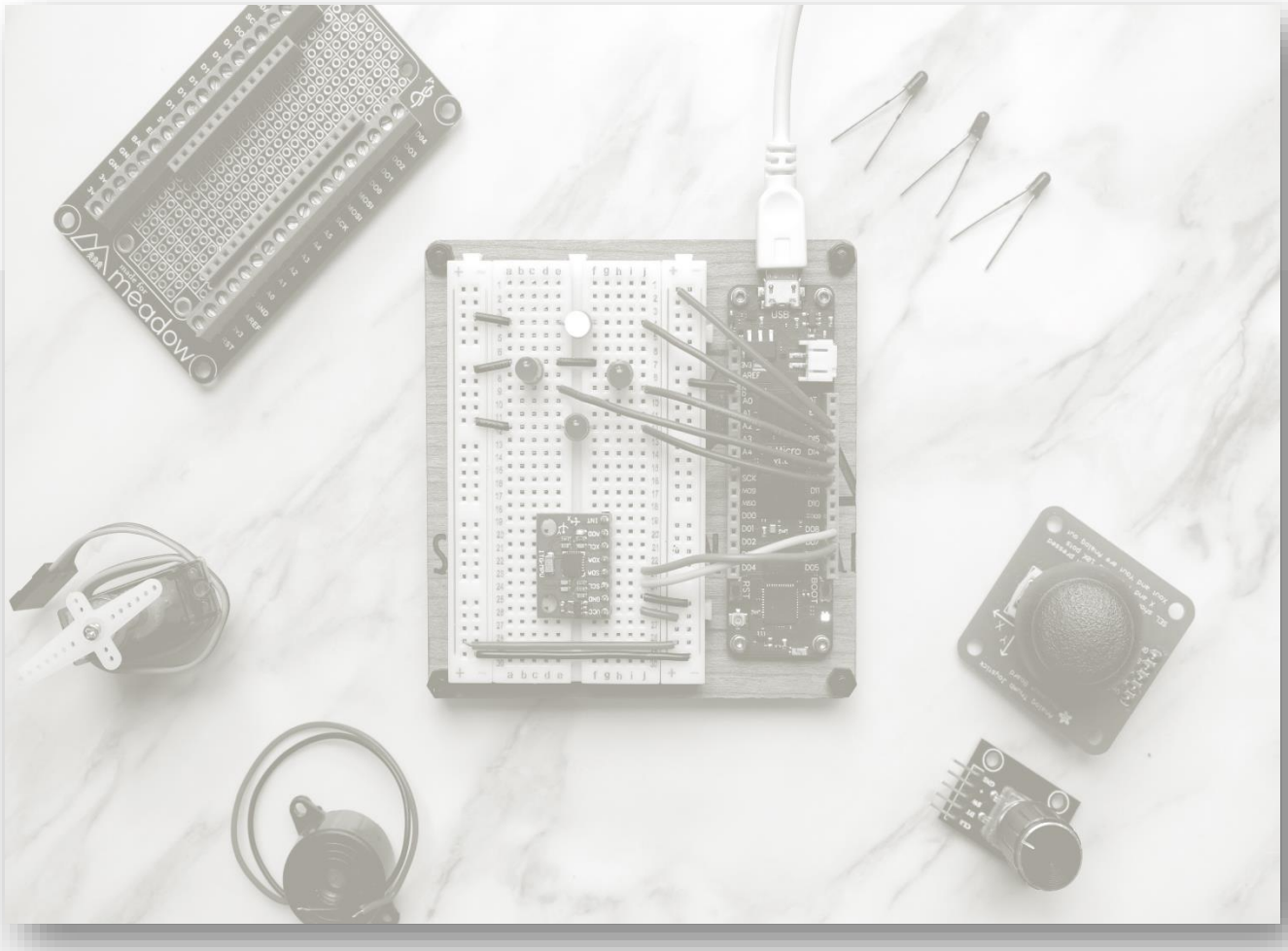

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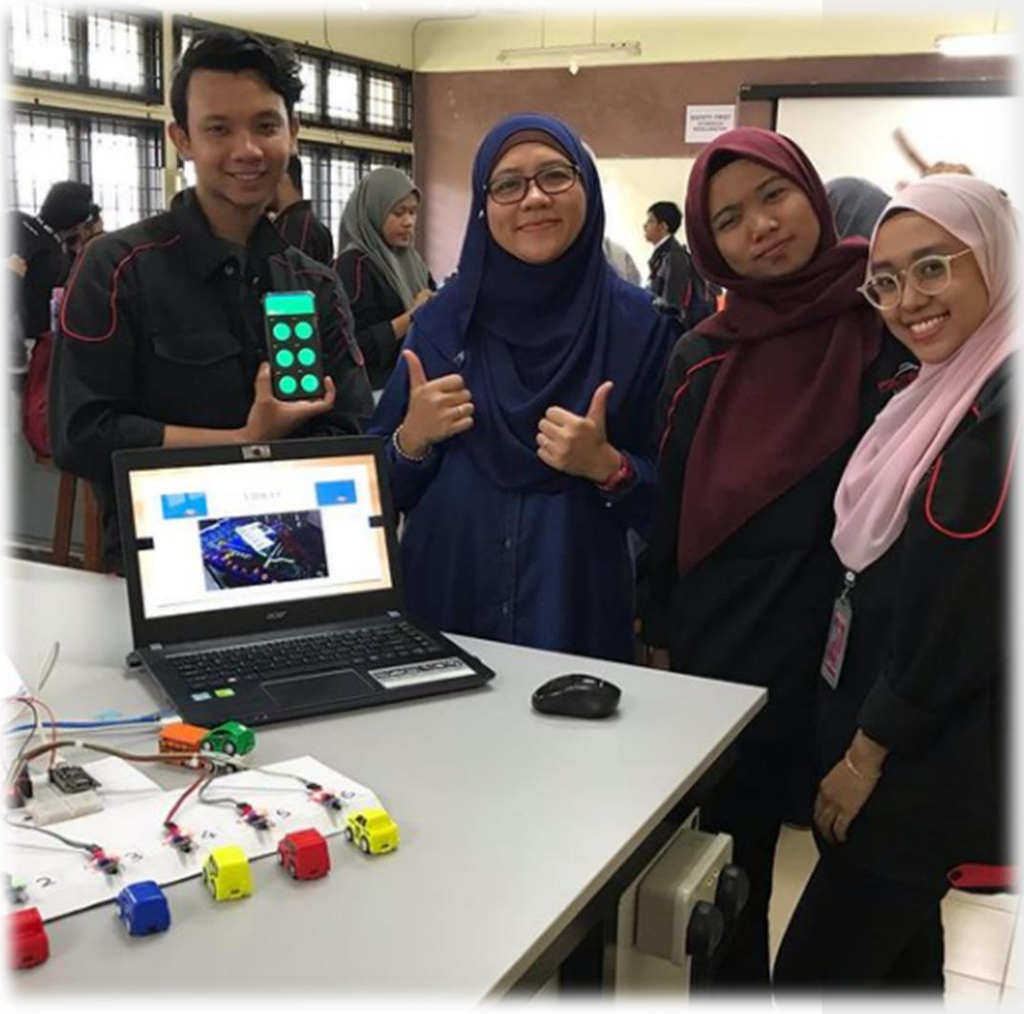
In the name of Allah, the Most Gracious and the Most Merciful.

All praises to Allah and His blessings for the completion of this e-Book. I thank God for all the opportunities, trials and strength that have been showered on me in finishing this e-Book. I experienced so much during this process, not only from the academic aspect but also from the aspect of personality. My humblest gratitude to the Holy Prophet Muhammad (Peace be upon him) whose way of life has been continuous guidance for me. Thank you to everyone who supported me in preparing this e-book. All of the conversations and advisory services have been used to improve the writing of this book.

Preface

This book is one of the additional reference sources for all students who take Internet Base Controller or who are interested in this topic.

The uniqueness of this book is displayed in the form of easy-to-understand text in a compact form to make it easier for students and readers to make references. The book is illustrated with pictures related to the topic discussed, with aims to ensure that the students can relate to the real situation.



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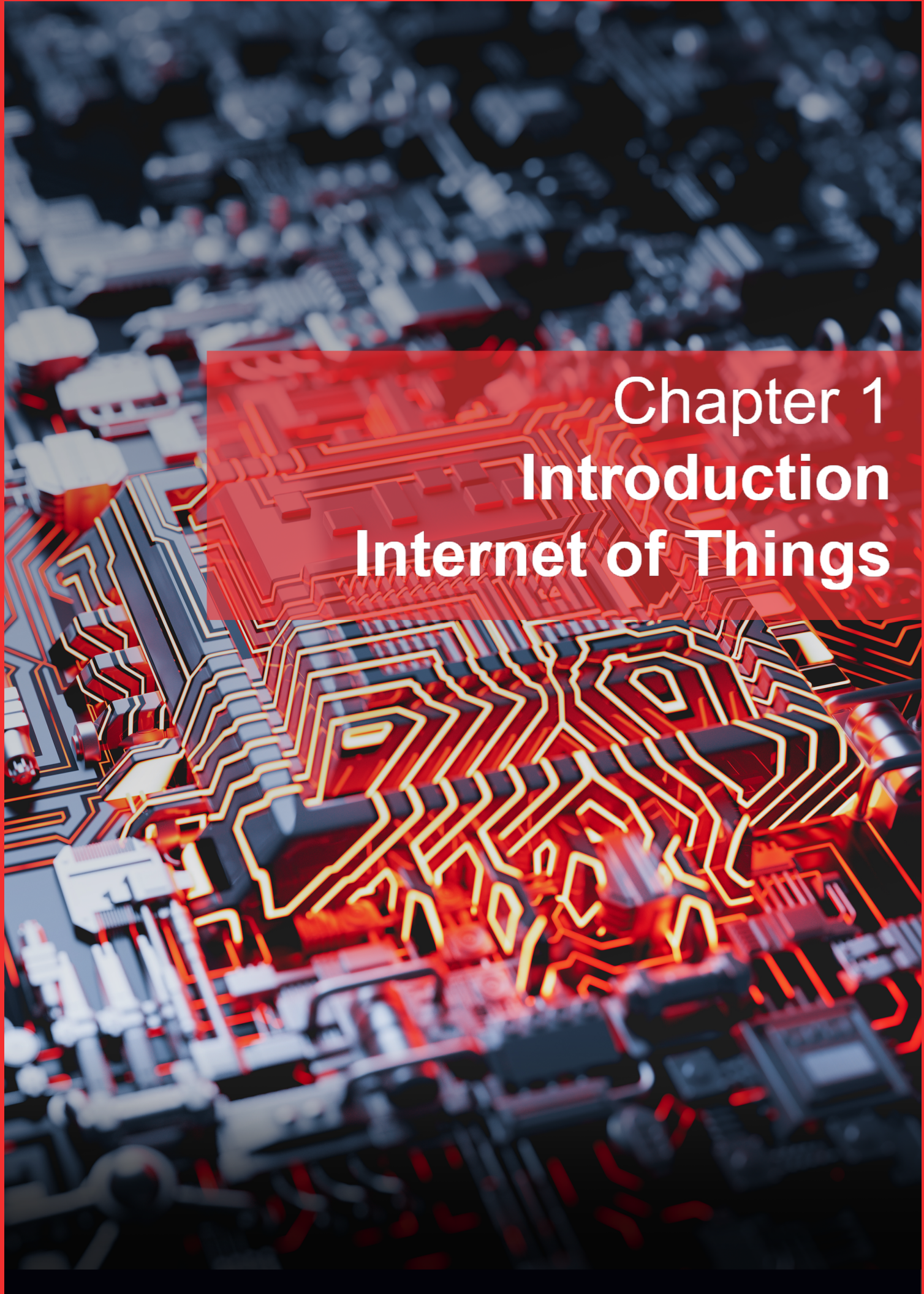
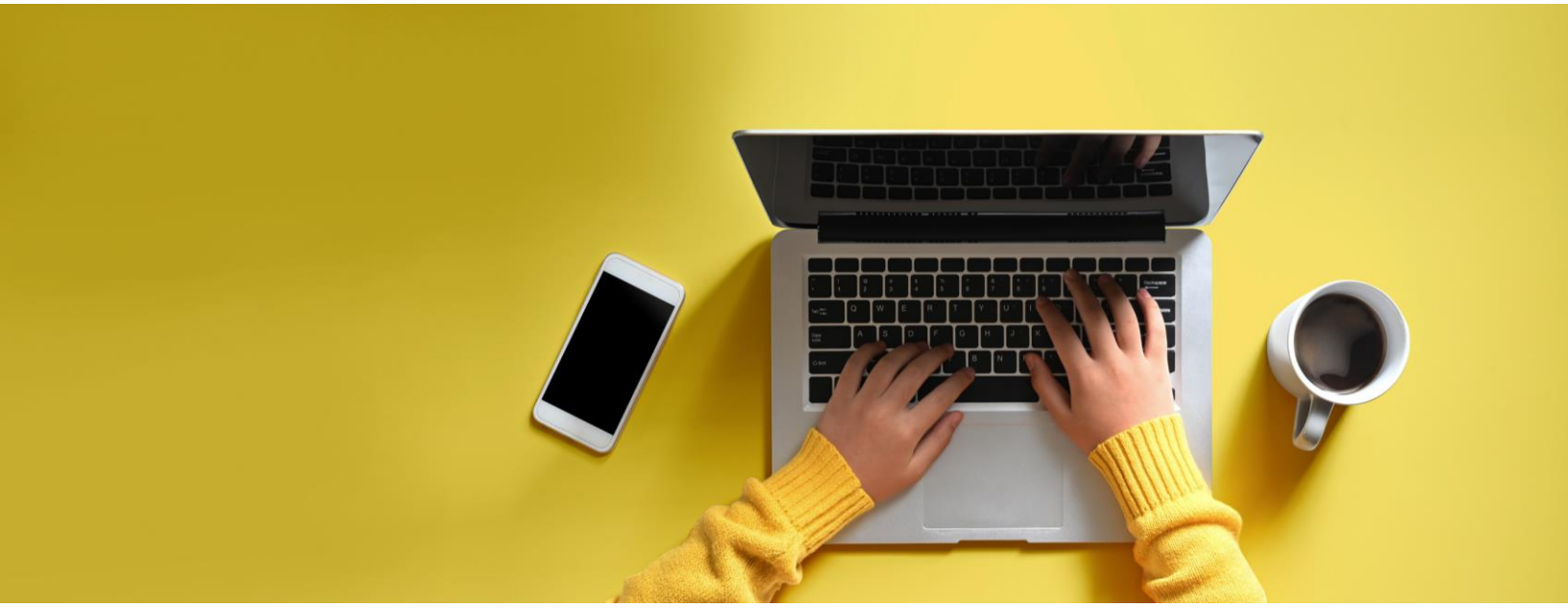


Chapter 1
Introduction Internet of Things

Internet of Things (IoT)

- The Internet of Things (IoT) is a network of physical things or "Things" that are equipped with electronics, software, sensors, and network connectivity, allowing them to collect and share data.
- The Internet of Things (IoT) is a massive network of interconnected things and people that all collect and share data on how they are utilised and the world around them.
- IoT devices capture important data and then autonomously move the data between other devices.
- The purpose of the Internet of Things is to expand internet connectivity beyond traditional devices such as computers, smartphones, and tablets to relatively simple items such as toasters.
- Virtually everything becomes "smart" as a result of the Internet of Things, which uses the power of data collection AI algorithms, and networks to improve elements of our lives.
- This IoT lesson for beginners covers all of the fundamentals of the Internet of Things.



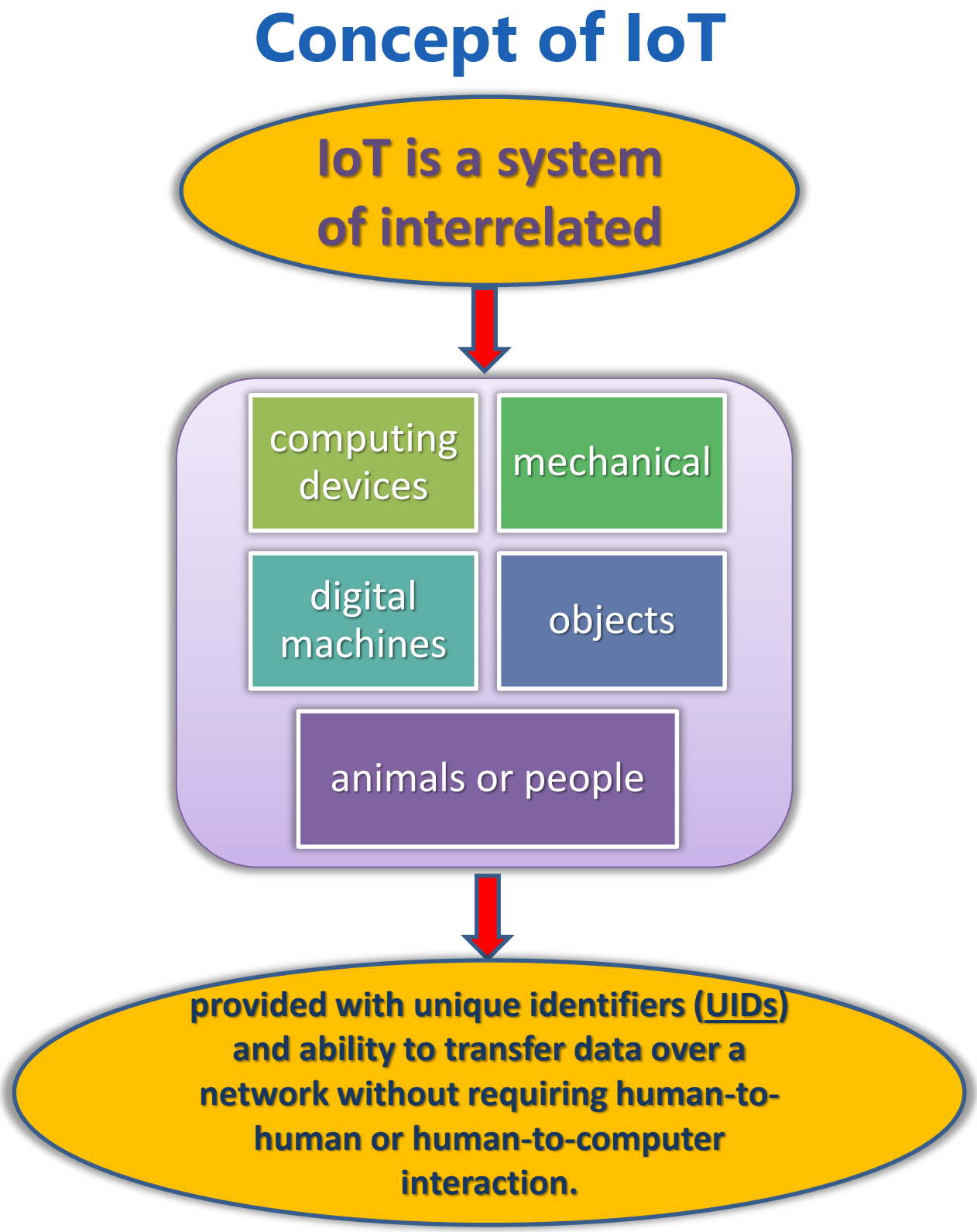


Figure 1.1: Describe Concept IoT

Concept of IoT

1. Web-Enabled Systems

Figure 1.2: Blynk Apps
(https://www.factoryforward.com/)

2. Smart Devices that use Embedded Systems

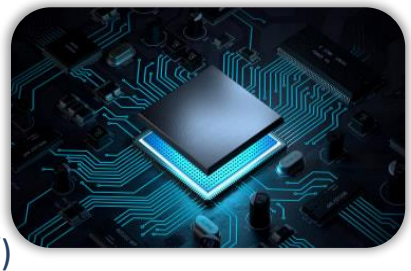


Figure 1.3: Embedded System
(https://www.joyk.com/)

3. Send and act on data

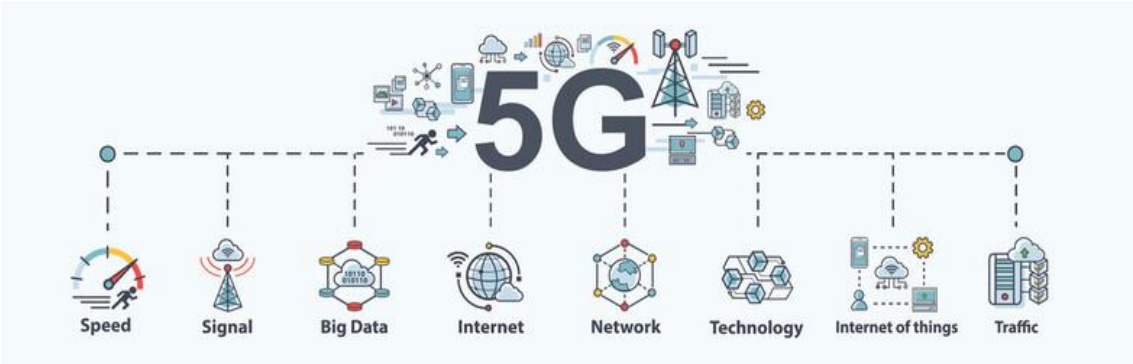


Figure 1.4: 5G
(https://www.4gltemall.com/)

4. Server

Figure 1.5: Server
(https://ideastack.com/)

5. Sensors and communication hardware

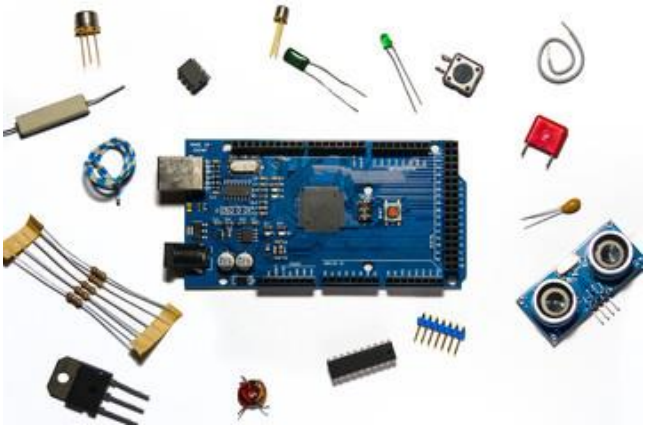


Figure 1.6: Sensor
(https://stock.adobe.com/)

Concept of IoT

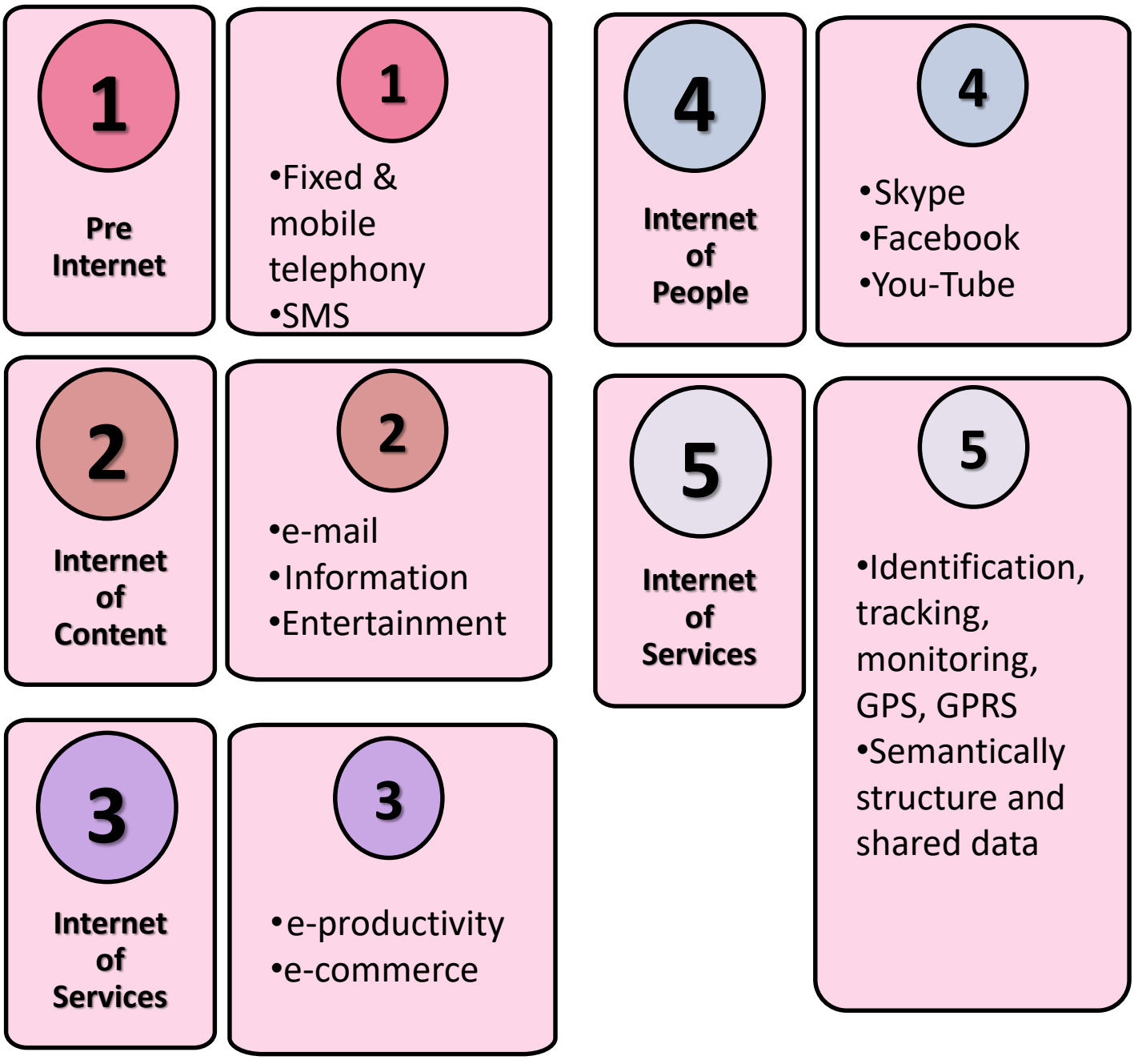


Figure 1.7: Concept IoT

History of IoT

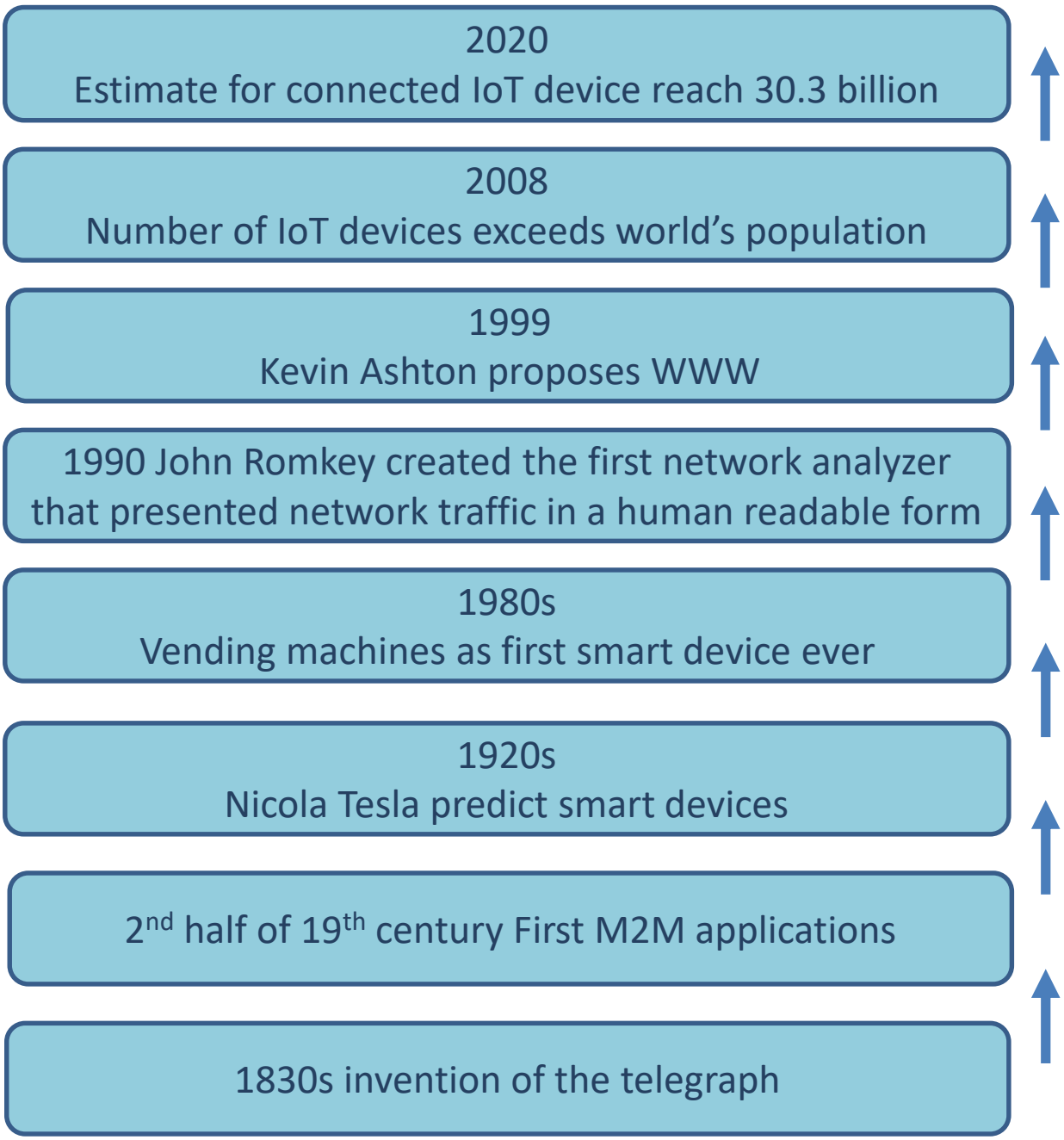


Figure 1.8: History IoT

Features of IoT

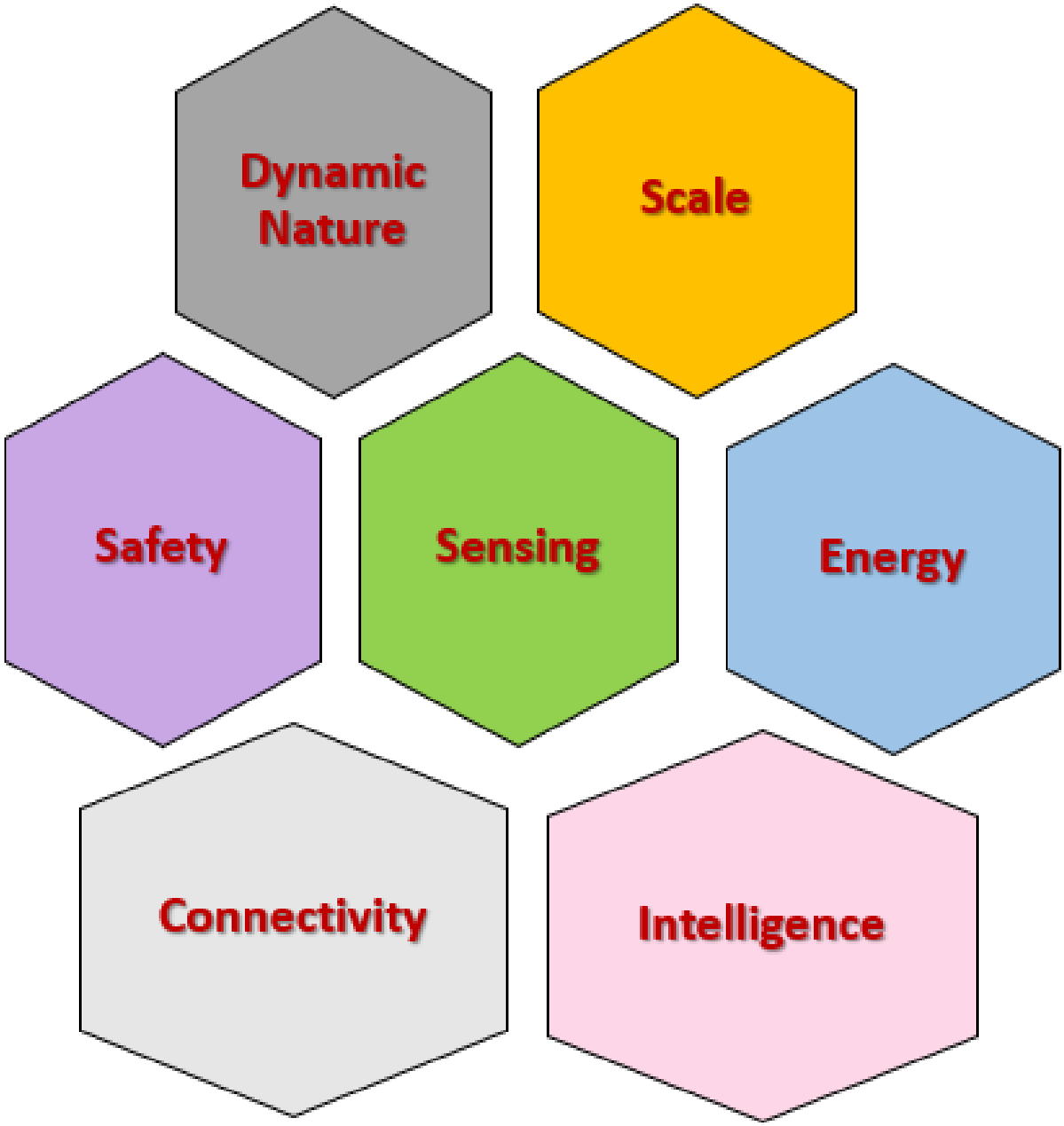


Figure 1.9: Features IoT

Advantages and Disadvantages IoT

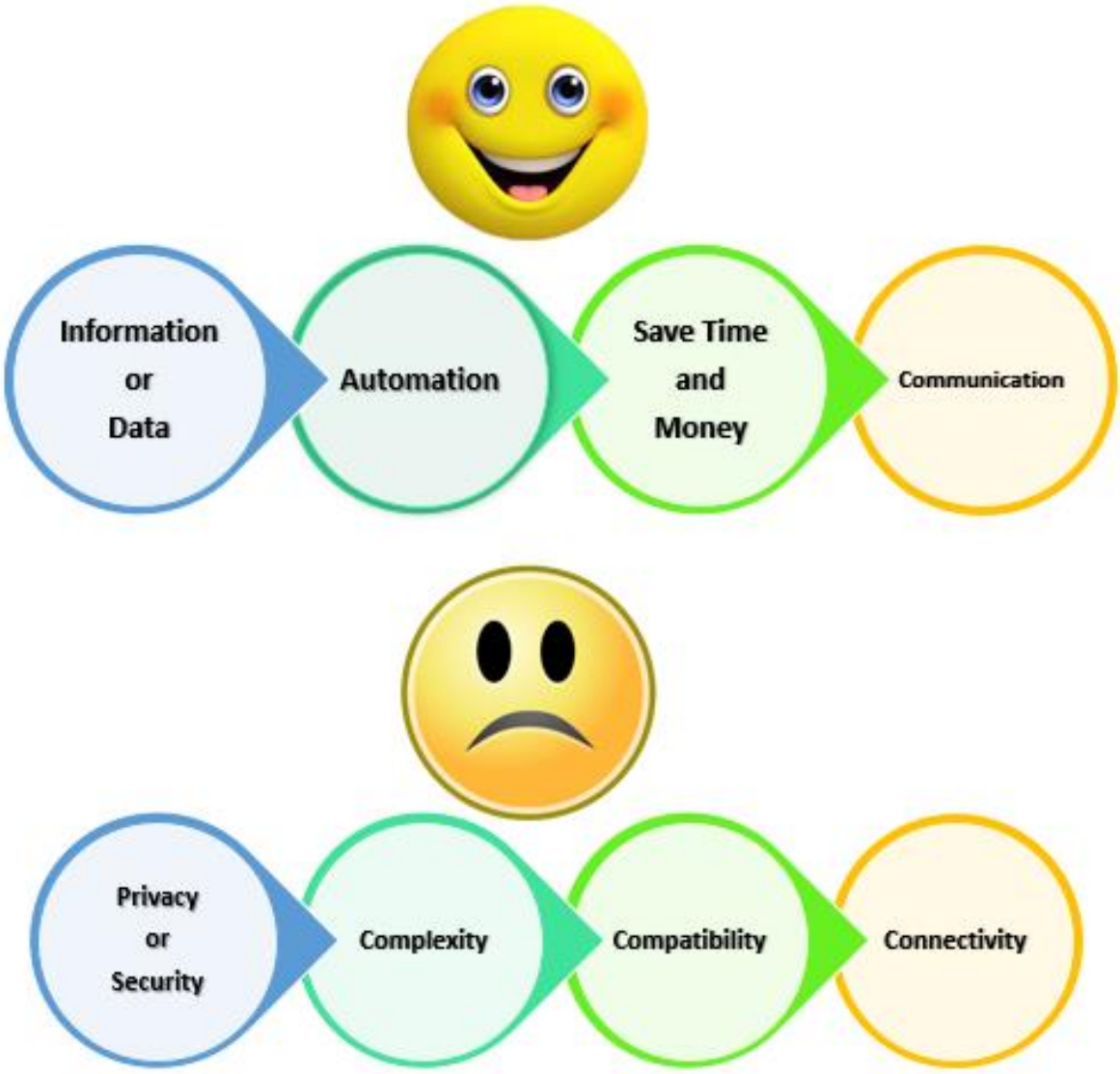


Figure 1.10: Advantages and Disadvantages of IoT

IoT Application

Smart Home

- IoT home automation refers to the capacity to operate household appliances via internet-connected, electronically controlled devices. It might include pre-programming complicated heating and lighting systems, as well as alarms and home security controls, all of which are connected via a central hub and operated remotely via a smartphone app.

- A smart home allows homeowners to operate appliances, thermostats, lighting, and other equipment from anywhere using an internet connection and a smartphone or tablet through Wi-Fi to create smart houses. Smart home technology offers convenience and cost advantages to homeowners.

Figure 1.11: Smart Home
(https://www.propertyguru.com/)

Wearable Devices

- Wearable technologies, often known as "wearables," are electronic devices that people wear on their bodies to track, analyse, and communicate personal data. These "smart" IoT gadgets can measure physiological data such as heart rate and sleep habits, and are gaining popularity in the gaming and fashion sectors.

- Wearable technology has been a welcome addition to the healthcare and sports sectors for a variety of reasons. In order to encourage its consumers to live healthier lifestyles, they track their health data. The information gathered helps to determine more realistic picture of their clients' overall health.

Figure 1.12: Health Sensor
(https://medium.com/)

IoT Application

Smart City

- A smart city is a technologically advanced metropolitan region that collects data using various electronic technologies, voice activation methods, and sensors.
- A smart city collects and analyzes data from IoT sensors and video cameras. In essence, it "senses" the environment so that the city operator can decide how and when to take action. Some actions can be performed automatically.
- A smart city, on the other hand, employs a framework of information and communication technology to develop, deploy, and promote development strategies in order to address urban issues and build a technologically enabled and sustainable infrastructure.

Figure 1.13: Smart City
(https://www.arcweb.com/)

Smart Grid

Figure 1.14: Smart Grid
(https://www.powerelectronicsnews.com/)

- The Smart Grid is a data communications network that is connected with the electricity grid to gather and analyse data from transmission lines, distribution substations, and consumers. Smart Grid projects are becoming more commonplace all around the world.
- Smart grids are a system that allows suppliers and consumers to communicate with one another. The smart metres are the most significant component of the IoT-based smart grid. IoT for smart grid is an issue that needs to be addressed for a variety of reasons, including increasing energy demand, minimising lost energy, increasing energy output, and many others.

IoT Application

Industrial Internet

Figure 1.15: Industrial Internet
(https://www.freepik.com/)

The industrial internet is a set of fully connected, collaborative manufacturing systems that respond in real time to changing demands and conditions in the smart factory, supply chain, and customer requirements. Industry 4.0, is a term for smart industry with smart manufacturing. This is primarily due to rising automation, digital transformation, the bridging of digital and physical environments (as enabled by the Internet of Things or IoT), evolving industrial and manufacturing technologies (such as additive manufacturing), intensive data/analytics usage (with cloud and a shift of intelligence to the edge), industry and manufacturing challenges, human, economic, and societal evolutions and demands, and the integration of information and technology.

Connected Car

Figure 1.16: Connected Car
(https://www.freepik.com/)

A connected car is one that can connect to nearby devices via wireless networks. Connected vehicles are a critical element of the Internet of Things' progress. The applications range from connected entertainment systems that connect to the driver's phone to Internet-connected automobiles that can communicate with other vehicles, mobile devices, and city intersections in both directions. The term "connected vehicle" refers to an Internet of Things (IoT) technology that has far-reaching ramifications. Connected vehicles connect to a network to allow bi-directional communication between vehicles (cars, lorries, buses, and trains) and other vehicles, mobile devices, and infrastructure in order to trigger essential communications and events.

IoT Application

Connected Health

IoT allows healthcare providers to be more alert and proactive in their interactions with patients. Data from IoT devices can assist clinicians in determining the optimal treatment method for their patients and achieving the desired outcomes. The emergency department is an important part of every hospital. Aside from the financial costs, medical procedures in the emergency department can take several hours to complete. The solution to this challenge has been the utilisation of IoT and the creativity aspect. Any hospital or health organisation should prioritise patient safety. To track resources and services, many healthcare institutions around the world are turning to IoT and real-time positioning systems.

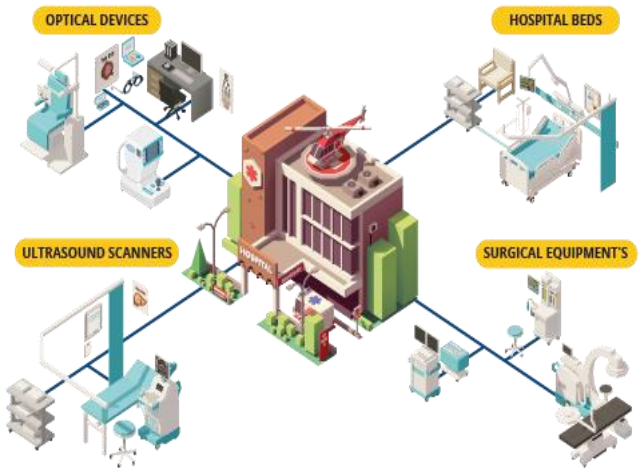


Figure 1.17: Connected Health (https://www.ltts.com/)

Smart Retail

Figure 1.18: SmartRetail (https://www.freepik.com/

Smart retail technology has many innovations developed with the Internet of Things technology. Many business have been restructured as a result of these developments. Labor and mistake rates are reduced when work from multiple business sectors is connected in a chained manner. The Internet of Things technology was able to work in this industry as well because of the reduced worker force and error rate. Many business fields have seen a reduction in error rates as a result of these solutions. Many businesses have decided to use Internet of Things (IoT) technologies. Smart retail analytics has resulted in numerous commercial advancements.

IoT Application

Smart Supply Chain

Figure 1.19: Smart Supply Chain
(http://searcher.techtarget.com/)

The Internet of Things (IoT) supply chain is a system that uses device connectivity to achieve the same end results as traditional supply chains, but more effectively. Traditionally, supply chains have been built to combine human labour with the efficiency and precision of machines in order to achieve large-scale production. Many of the automations installed in factories throughout the world can now be monitored more accurately, with real-time notifications if something goes wrong, Entrepreneurs profit from a more dynamic production environment on a smaller scale, depending on how they connect IoT devices.

Smart Farming

The Smart farming, connected devices and automation, as the Internet of Things (IoT), would find use in agriculture to get result, vastly improving and practically every aspect of it. In the previous decades, farming has undergone a variety of technological changes, becoming more industrialised and technology-driven. Farmers have gained improved control over the process of producing livestock and cultivating crops by utilising various smart agriculture equipment, making it more predictable and efficient. Sensors are used to collect environmental and machine metrics, farmers can make informed decisions, and improve just about every aspect of their work from livestock to crop farming.

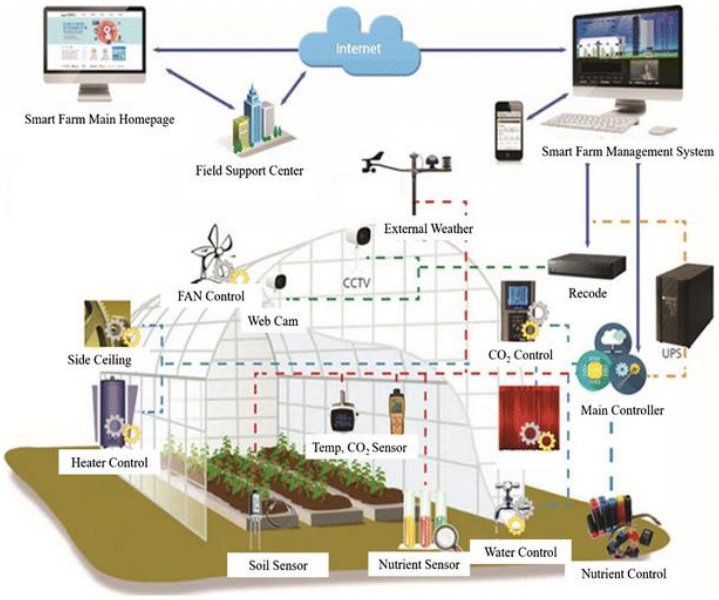


Figure 1.20: Smart Farming
(http://www.smartfarmkorea.net)

IoT Application
More Things

The internet of things (IoT) connects physical items to the internet, data processing, and analytics. Consumers will be able to communicate with the global information network without using a keyboard or a screen; many of their everyday products and appliances will be able to accept orders from the network with minimum human participation. The Internet of Things is made up of devices that collect data. Data must be acquired, processed, filtered, and evaluated in order for it to be valuable. The data is collected from a central location where it is sent from the devices. Data may be moved wirelessly or across wired networks using a variety of ways.

The data can be delivered via the internet to a data centre or cloud with storage and computing capacity, or it can be staged, with intermediary devices gathering the data before sending it on. The data is collected from a central location where it is sent from the devices. Data may be moved wirelessly or across wired networks using a variety of ways. The data can be delivered via the internet to a data centre or cloud with storage and computing capacity, or it can be staged, with intermediary devices gathering the data before sending it on.

Figure 1.21: All in 1, IoT With a Smartphone (https://intratem.com/)

IoT Architecture

"SOA"
Service Oriented Architecture

SOA, or Service-Oriented Architecture, is a method for reusing software components through service interfaces. Each service in a SOA has the code and data integrations needed to perform a single, discrete business function (for example, checking a customer's credit, calculating a monthly loan payment, or processing a mortgage application).
SOA provides considerable benefits to the organization:

Faster time to market and increased corporate agility: The effectiveness of building applications from reusable service interfaces rather than rewriting and reintegrating with each new development project allows developers to respond to new business possibilities considerably more swiftly.

Ability to use legacy technology in new markets: A company have utilized SOA to expose functionality from mainframe-based financial systems to the web, allowing clients to self-serve processes and information that were previously only available through direct interaction with the company's workers or business partners.

Improved business-IT collaboration:
Services in a SOA can be specified in business terms (for example, "create an insurance quote" or "calculate capital equipment ROI"). This allows business analysts to collaborate more effectively with developers on critical insights that might lead to improved results, such as the scope of a business process specified by a service or the business ramifications of modifying a process.

Figure 1.22: Service Oriented Architecture (https://www.itrelease.com/)

IoT Architecture

Internet of Things Architecture

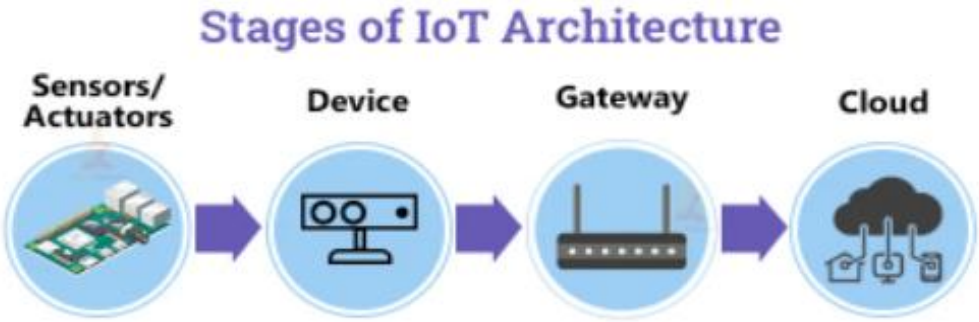


Figure 1.23: IoT Architecture
(https://techvidvan.com/)

Components of IoT architecture

An IoT architecture mainly consists of the following components:

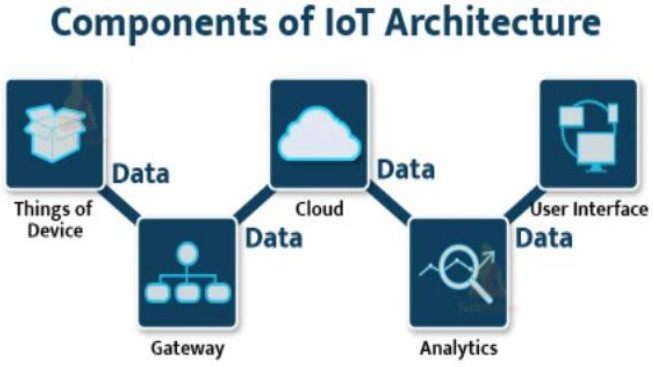
1. Sensing, embedded components: This layer provides accurate and credible data. It collects information from the surroundings. Sensors sense or detect even the slightest changes in the environment. Whereas, actuators respond or act on the signals they receive. For example, temperature control in smart thermostats.

2.Connectivity: Networking, communication and connectivity are the fundamentals of any IoT ecosystem. Without device communication and connectivity, there is in fact no IoT. IoT protocols transfer data from one place to another. The most common wireless protocols are WiFi, Zigbee, LoRa and cellular etc.
Gateways are a mode through which the data passes to reach the cloud or servers. Gateways provide security by limiting unauthorized access.

3. IoT cloud: Cloud stores all the incoming data. Here data processing takes place with the help of data analysis and actions are performed on the data to generate a response in the system. Edge computing is done when there is large amounts of incoming data from the user.

4. Data management: This is a proper mechanism that stores the data and remembers information for future responses.

Regardless of any IoT project, IoT uses some common components:



1.24 Components IoT Architecture
(https://techvidvan.com/)

IoT Architecture

Internet of Things Architecture

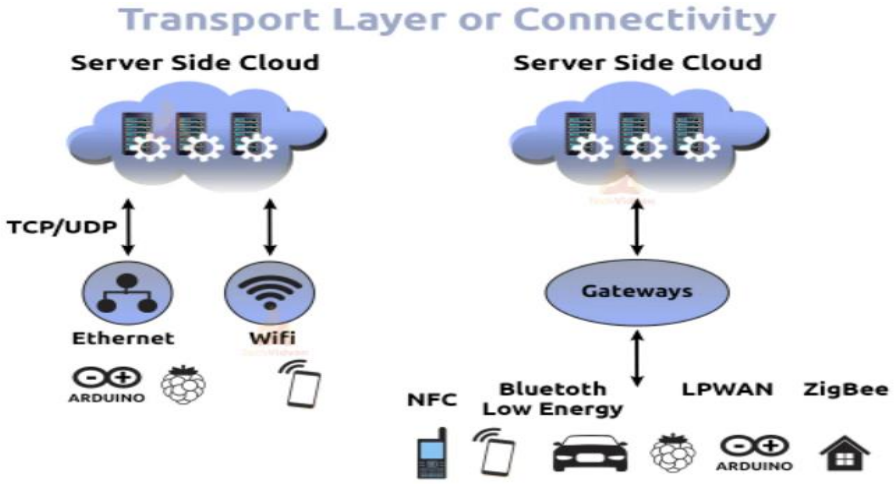


Figure 1.25: Connectivity of IoT Architecture (https://techvidvan.com/)

Stages of IoT Architecture

The designing of the contents of an IoT system is known as the IoT architecture. It works to deliver services through a network of IoT devices and servers. The following are the stages of an IoT architecture:

Stage 1: Perception Layer

First, we have the **perception layer** that contains IoT devices such as sensors, actuators and machines that have the capacity to sense, calculate and connect to other devices. Sensors sense physical changes in the surroundings and gather information. This layer can be called the client side as this layer fits into the clients location or address. The collected information passes on to the aggregation layer or the IoT gateway. This layer combines and computes the data. Operators control this layer and this layer involves servers.

Stage 2: Transport Layer or connectivity

Basically, this layer transports information. It transports physical data from sensors and IoT devices to clouds and servers. It then transports back generated responses back to the appliances. The transportation takes place through a network or via gateways.

The use of various technologies helps in the transportation of data. The most common ones are WiFi, ethernet, Zigbee, Bluetooth, LoRa and cellular networks.

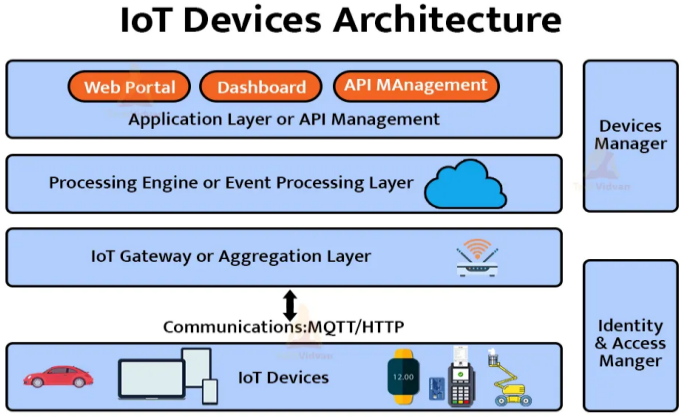


Figure 1.26: Connectivity of IoT Architecture (https://techvidvan.com/)

IoT Architecture
"API"
Application Programming Interface

- A computer interface that defines interactions between numerous applications in an IoT context is known as an application programming interface (API). It specifies the kind of calls and requests that can be made, as well as how they should be made.

- An API allows you to interface with another piece of software programmatically. They are little chunks of code that let digital devices and software to communicate.

- This reduces the amount of code that developers must write while also ensuring uniformity between apps built on the same platform.

- APIs may manage who has access to what hardware and software. The operation, input, and output of software are all expressed via an API.

- Web API Is Basically For Web Servers Or Web Browsers That Can Be Accessed Using The HTTP Protocol. It Can Be Developed Using Java, Python, Etc.

- Also In Web APIs, A Client Can Access The Web Applications But Not The Further Web Details. There Are Four Main Types Or Categories Of Web APIs.

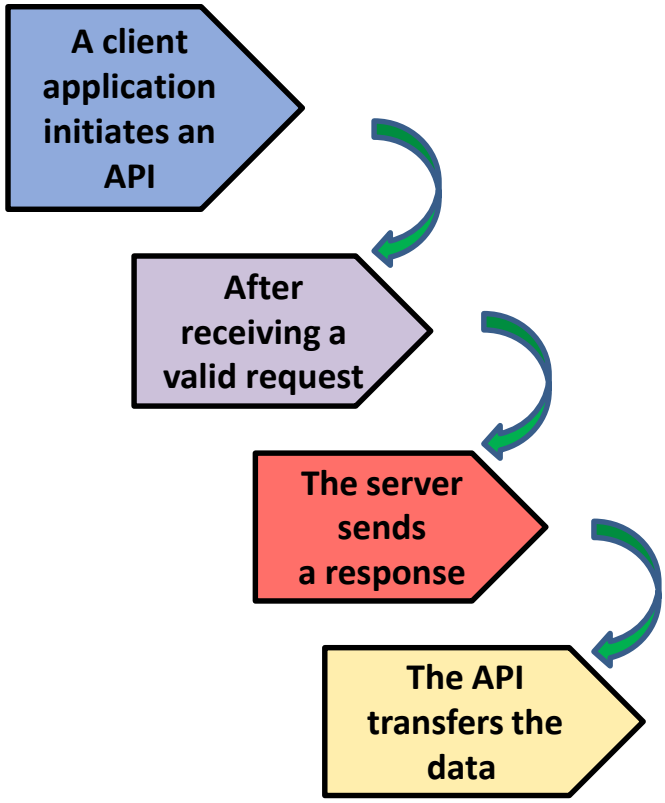


Figure 1.27: Application Programming Interface

IoT Architecture

Application Programming Interface For Bussines

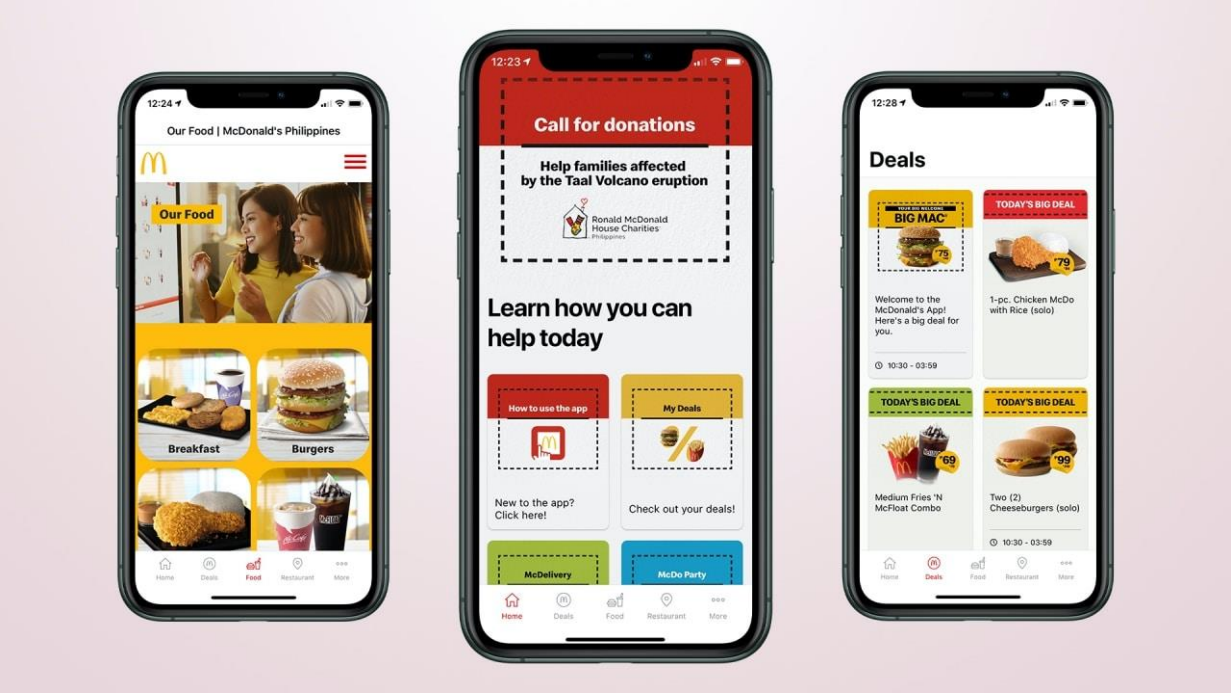


Figure 1.28: API for business (https://www.tripadvisor.com/)

The web, software designed to exchange information via the internet and cloud computing have all combined to increase the interest in APIs in general and services in particular.

Software that was once custom-developed for a specific purpose is now often written referencing APIs that provide broadly useful features, reducing development time and cost and mitigating the risk of errors.

APIs have steadily improved software quality over the last decade, and the growing number of web services exposed through APIs by cloud providers is also encouraging the creation of cloud-specific applications, internet of things (IoT) efforts and apps to support mobile devices and users.

Internet of Things Technology

IoT Technology

The Internet of things (IoT) is the network of physical objects or “things” embedded with electronics, software, sensor and network connectivity, which enables these objects to collect and exchange data. The Internet of Items allows things to be sensed and controlled remotely through existing network infrastructure, allowing for a more direct connection between the real world and computer-based systems, resulting in enhanced efficiency, accuracy, and cost savings.

1

DATA COLLECTION

Sensing, measurements, light data filtering, light data security, and data aggregation are all managed by a programme. Certain protocols are used to let sensors connect to real-time machine-to-machine networks. The data is then collected from many devices and distributed according to the parameters. It also works backwards, spreading data among devices. All captured data is finally sent to a central server by the system.

3

DEVICE INTEGRATION

The body of the IoT system is created by software that binds (dependencies) all system devices. It guarantees that all devices operate together and are connected in a reliable manner. These apps are the IoT network's defining software technology since it would not be an IoT system without them. To enable connectivity, they handle each device's numerous apps, protocols, and constraints.

2

REAL-TIME ANALYTICS

These programmes gather data or input from numerous devices and turn it into actionable steps or patterns that can be analysed by humans. They evaluate data using various settings and designs in order to conduct automation-related activities or offer industry with data.

4

APPLICATION AND PROCESS EXTENSION

They connect preset devices for specific objectives, such as granting access to specific mobile devices or technical instruments. It contributes to increased productivity and more precise data collecting.

Internet of Things Technology
IoT Hardware

IoT Hardware Devices

1. Sensor

A sensor is an Internet of Things device that detects physical changes in the environment and transmits the information to a network for processing. The data is saved in clouds for future use. Data is continually monitored and collected via sensors.

2. Microcontroller

A microcontroller is a mini computer that can execute commands. It is embedded in a semiconductor integrated circuit chip. Microcontollers vary from ordinary computers in that they generally perform only one function.

3. Wearable Devices

These are Internet of Things (IoT) gadgets that individuals may wear on their bodies to monitor and execute various functions. One of the function is these devices can measure monitor heart attack risks, monitor track daily steps and calorie consumption.

4. Basic Devices

Basic devices apply the IoT ecosystem are smartphones, desktop computers, tablets, and telephones are still an important element of any IoT network.

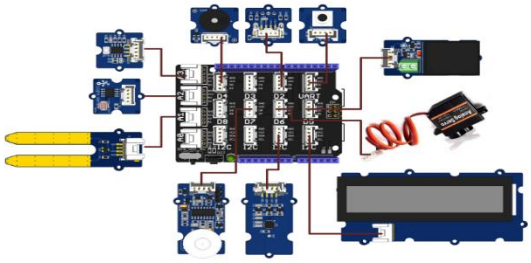


Figure 1.29: IoT Sensors
(https://www.researchgate.net/)

- Hardware may take numerous shapes in the Internet of Things, from the basic processors that drive phones to the sensors that gather data from the actual world to the edge machines that process and analyse the data.

- IoT hardware is at the core of every connected venture, and the technological capabilities of these boards have only grown in importance as the Internet of Things has grown.

- However, picking the correct IoT hardware for a project might be difficult due to the large number of design boards and modules in the room. We'll look at numerous components of IoT hardware in this post, as well as how these devices send data to the internet.

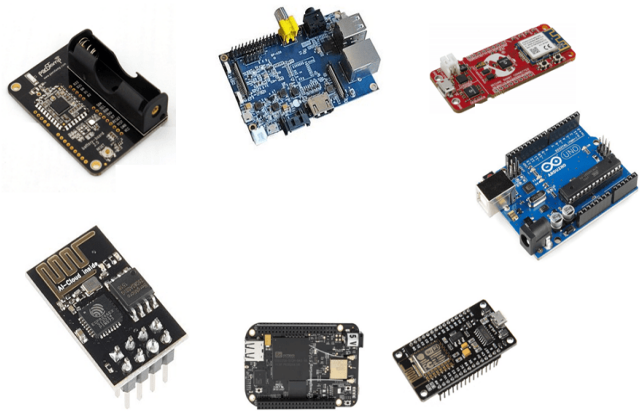


Figure 1.30: IoT Microcontroller
(https://www.researchgate.net/)

Internet of Things Technology

Hardware NodeMCU ESP32

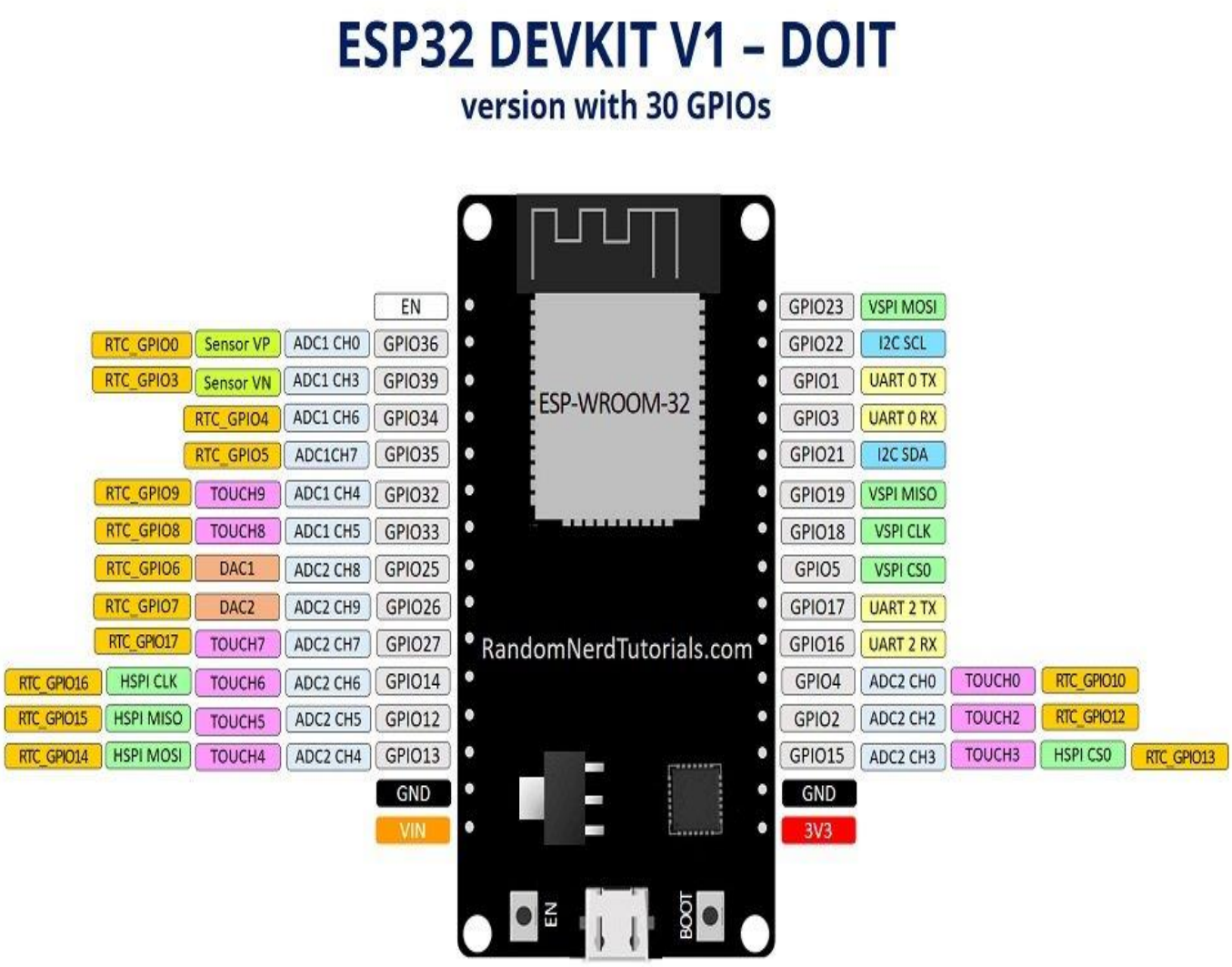


Figure 1.31: Datasheet Node MCU ESP32
(https://my.cytron.io/p-nodemcu)

Hardware and Software

NodeMCU ESP32 Input/Output

- **Processors –** As previously mentioned, the ESP32 uses a Tensilica X tensa 32-bit LX6 microprocessor. This uses 1 or 2 cores.

- **Clock frequency -** Reaches up to 240MHz and it performs up to 600 DMIPS (Dhrystone Million Instructions Per Second). Moreover, its low power consumption allows for ADC conversions, computation, and level thresholds, all while in deep sleep mode.

- **Wireless connectivity –** The ESP32 enables connectivity to integrated Wi-Fi through the 802.11 b/g/n/e/i/. Moreover, dual-mode Bluetooth is made possible with the v4.2 BR/EDR and features Bluetooth Low Energy (BLE).

- **Memory –** Internal memory for the ESP32 is as follows – ROM: 448 KiB (*for booting/core functions*), SRAM: 520 KiB (*for data/instructions*), RTC fast SRAM: 8 KiB (*for data storage/main CPU during boot from sleep mode*), RTC slow SRAM: 8 KiB (*for co-processor access during sleep mode.*

- ***ESP32-D2WD and ESP32-PICO-D4 –*** have internally connected flash. The others are as follows: 0 MiB (*ESP32-D0WDQ6, ESP32-D0WD, and ESP32-S0WD chips*), 2 MiB (*ESP32-D2WD chip*), and 4 MiB (*ESP32-PICO-D4 SiP module*).

- **Security –** IEEE 802.11 standard security features are all supported, including WFA, WPA/WPA2 and WAPI. Moreover, ESP32 has a secure boot and flash encryption.

Figure 1.32: Node MCU ESP32 (https://my.cytron.io/p-nodemcu)

Hardware and Software

NodeMCU ESP32 Input/Output

ESP32 Functions

ESP32 has many applications when it comes to the Internet of Things (IoT). Here are just some of the IoT functions the chip is used for:

1. **Networking:** The module's Wi-Fi Antenna and dual-core enables embedded devices to connect to routers and transmit data.
2. **Data Processing:** Includes processing basic inputs from analog and digital sensors to far more complex calculations with an RTOS or Non-OS SDK.
3. **P2P Connectivity:** Creates direct communication between different ESPs and other devices using IoT P2P connectivity.
4. **Web Server:** Access pages written in HTML or development languages.

ESP32 Applications

The ESP32 modules are commonly found in the following IoT devices:

1. **Smart industrial devices**: including Programmable Logic Controllers (PLCs).
2. **Smart medical devices**: including wearable health monitors.
3. **Smart energy devices**: including HVAC and thermostats.
4. **Smart security devices**: including surveillance cameras and smart locks.

Hardware and Software

Hardware NodeMCU ESP8266

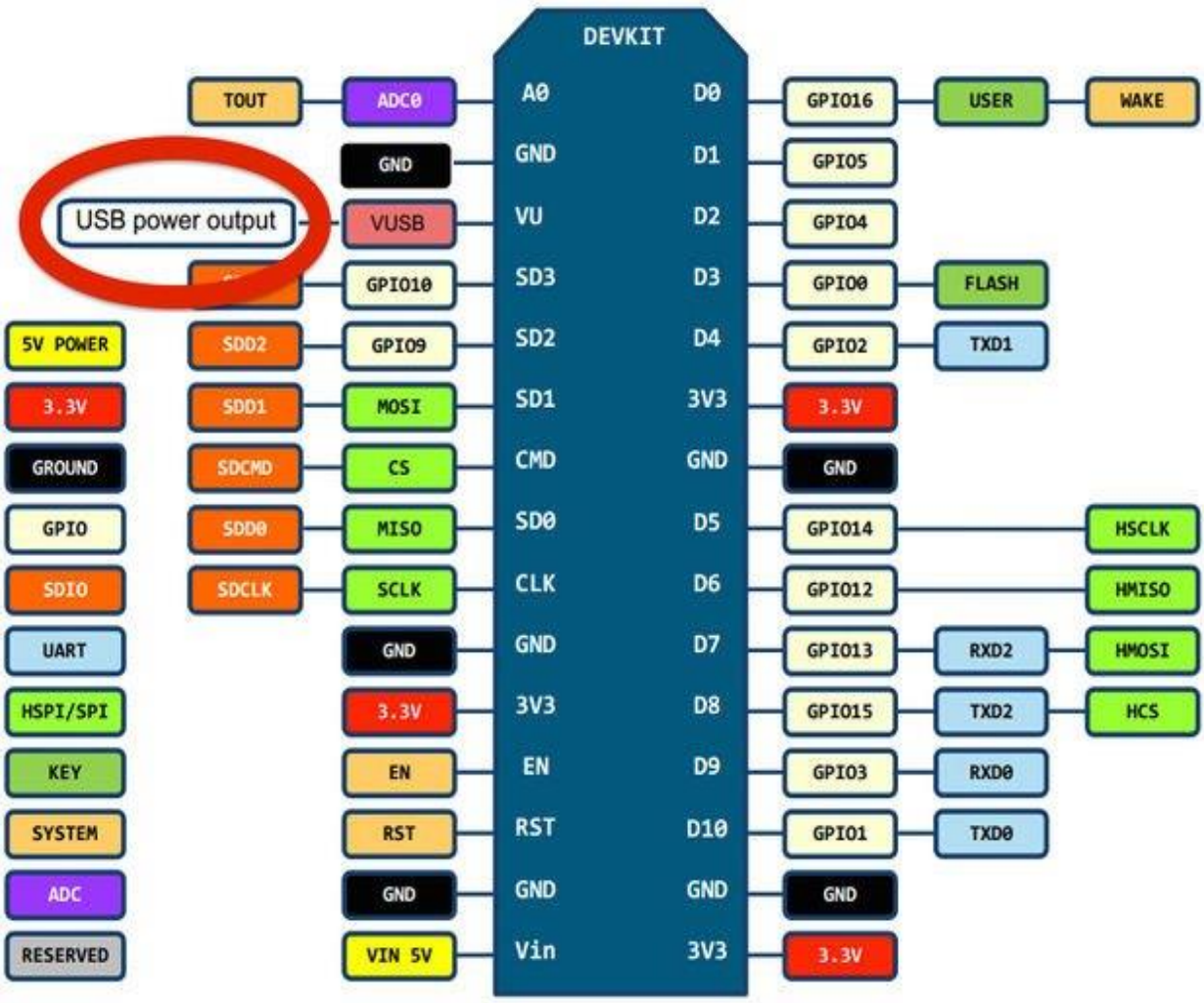


Figure 1.33: Datasheet Node MCU ESP8266
(https://my.cytron.io/p-nodemcu)

Hardware and Software

NodeMCU ESP8266 Input/Output

- It is a powerful Wi-Fi module available in a compact size at a very low price.
- It is based on the L106 RISC 32-bit microprocessor core and runs at 80 MHz
- It requires only 3.3 Volts power supply
- The current consumption is 100 m Amps
- The maximum Input/Output (I/O) voltage is 3.6 Volts.
- It consumes 100 mA current
- The maximum Input/Output source current is 12 mA
- The frequency of built-in low power 32-bit MCU is 80 MHz
- The size of flash memory is 513 kb
- It is used as either an access point or station or both
- It supports less than 10 microAmps deep sleep
- It is programmed using either AT commands, Arduino IDE, or Lua script.
- It is a 2.4 GHz Wi-Fi module and supports WPA/WPA2, WEP authentication, and open networks.
- It provides 10-bit analog to digital conversion
- The type of modulation is PWM (Pulse Width Modulation)
- UART is enabled on dedicated pins and for only transmission, it can be enabled on GPIO2.
- It is an IEEE 802.11 b/g/n Wi-Fi module with LNA, power amplifier, balun, integrated TR switch, and matching networks.
- GPIO pins – 17
- Memory Size of instruction RAM – 32 KB
- The memory size RAM – 32 KB
- Size of User-data RAM- 80 KB
- Size of ETS systems-data RAM – 16 KB

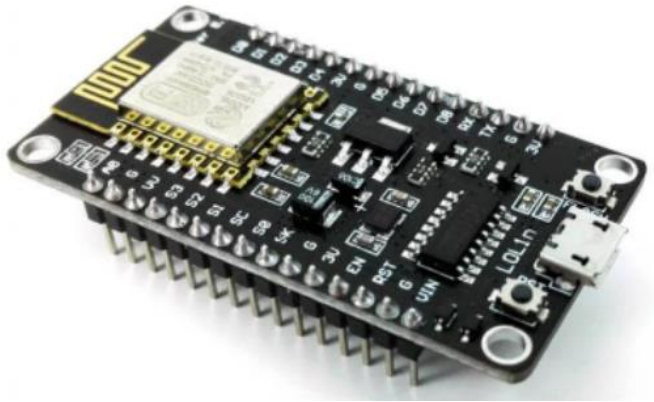


Figure 1.34: Node MCU ESP8266
(https://my.cytron.io/p-nodemcu)

Hardware and Software

NodeMCU ESP8266 Input/Output

ESP8266 Functions

- **Networking:** The module's Wi-Fi antenna enables embedded devices to connect to routers and transmit data.
- **Data Processing:** Includes processing basic inputs from analog and digital sensors for far more complex calculations with an RTOS or Non-OS SDK.
- **P2P Connectivity:** Create direct communication between ESPs and other devices using IoT P2P connectivity.
- **Web Server:** Access pages written in HTML or development languages.

ESP8266 Applications

The ESP8266 modules are commonly found in the following IoT devices:

- Smart security devices, including surveillance cameras and smart locks.
- Smart energy devices, including HVACs and thermostats.
- Smart industrial devices, including Programmable Logic Controllers (PLCs).
- Smart medical devices, including wearable health monitors.

Internet of Things Communication

IoT Communication

Satellite	• Satellite communications enable cell phone communication from a phone to the next antenna of about 10 to 15 miles. GSM, GPRS, CDMA, GPRS, 2G / GSM, 3G, 4G / LTE, EDGE, and others are the different communication speeds.
Wi-Fi	• WiFi is a wireless local area network (WLAN) that operates at 2.4GHz UHF and 5GHz ISM frequencies and follows the IEEE 802.11 standard. WiFi allows devices within range to connect to the Internet (about 66 feet from the access point).
Radio Frequency	• The most straightforward method of communication between devices is radio frequency transmission. Low-power RF radios are installed or retrofitted into electrical products and systems for protocols like ZigBee and ZWave.
RFID	• Radio Frequency Identification is the wireless identification of items using electromagnetic fields. Installing an active reader, or reading tags that hold stored information, such as authentication responses, is typical. The system is known as the Active Reader Passive Tag (ARPT). Short-range RFID ranges from 10 cm to 200 metres.
Bluetooth	• Bluetooth is a short-range wireless technology standard that uses short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz to transmit data.
NFC	• New Field Communication employs electromagnetic induction to construct an air-core transformer between two loop antennas positioned inside each other's near field. It works at speeds ranging from 106 kbit/s to 424 kbit/s in the globally open and unlicensed radio frequency ISM band of 13.56 MHz.

Chapter 2
Hardware and Software

Hardware and Software

Microcontroller (MCU) Core Of IoT Embedded System Platform

IoT Embedded System Platform

- System for Embedded Devices IoT. When studying about IoT or developing IoT projects, it's critical to have a basic understanding of embedded devices.
- Embedded devices are the components of a one-of-a-kind computing system. These devices may or may not have Internet access. A single application runs on an embedded device system.
- These gadgets, on the other hand, may connect to the internet and interact with one other.

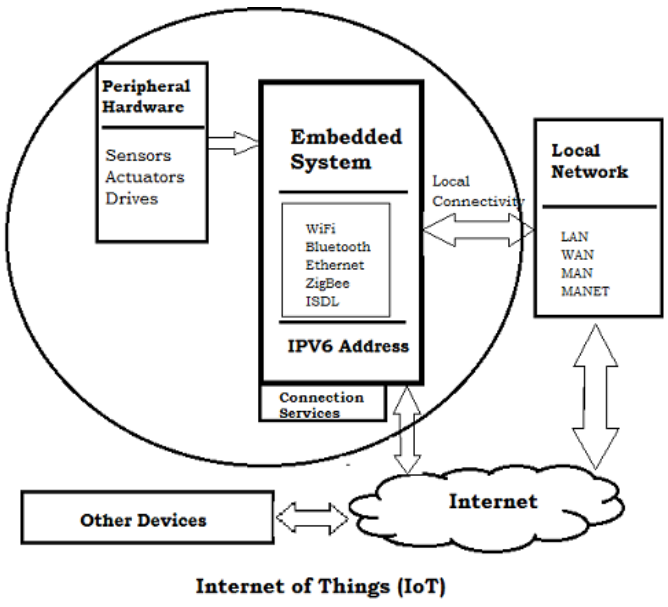


Figure 2.1: IoT Sensors (https://www.researchgate.net/)

Embedded System Hardware

- Hardware for embedded systems Microcontrollers and microprocessors are two types of embedded systems. Both contain an integrated circuit (IC).
- The internal read and writeable memory is what distinguishes microcontrollers with different microprocessors.

Embedded System Software

- The embedded system that employs devices for the operating system is built on the language platform, which is mostly used for real-time operations.
- Electronics, such as vehicles, cellphones, modems, and appliances, all include embedded software. Lighting controls operating on an 8-bit microcontroller are an example of embedded system software.
- It may also be complex software for missiles, process control systems, and aeroplanes, among other things.

Hardware and Software

Microcontroller (MCU) Core Of IoT Embedded System Platform

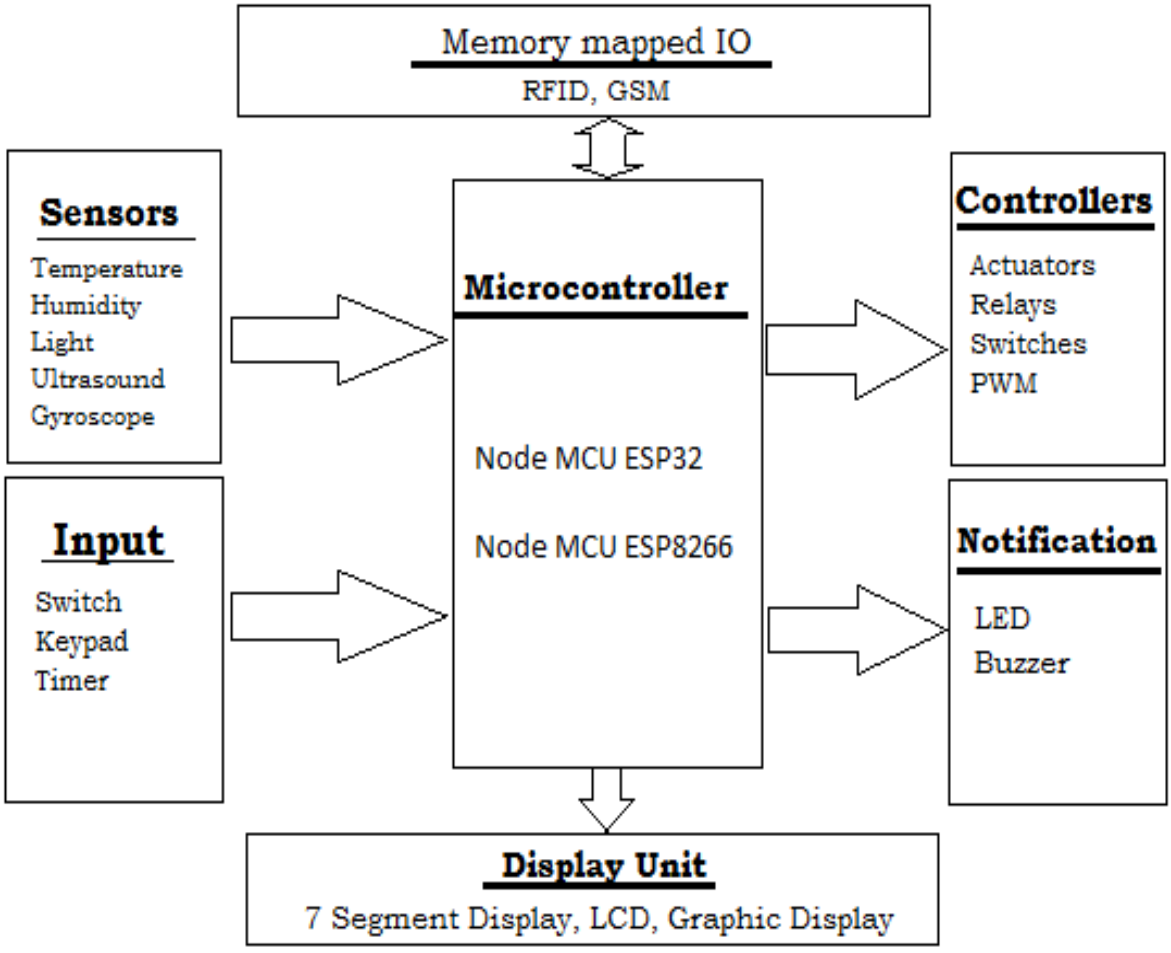


Figure 2.2: IoT Sensors
(https://www.researchgate.net/)

Hardware and Software

Microcontroller (MCU) Core Of IoT Embedded System Platform

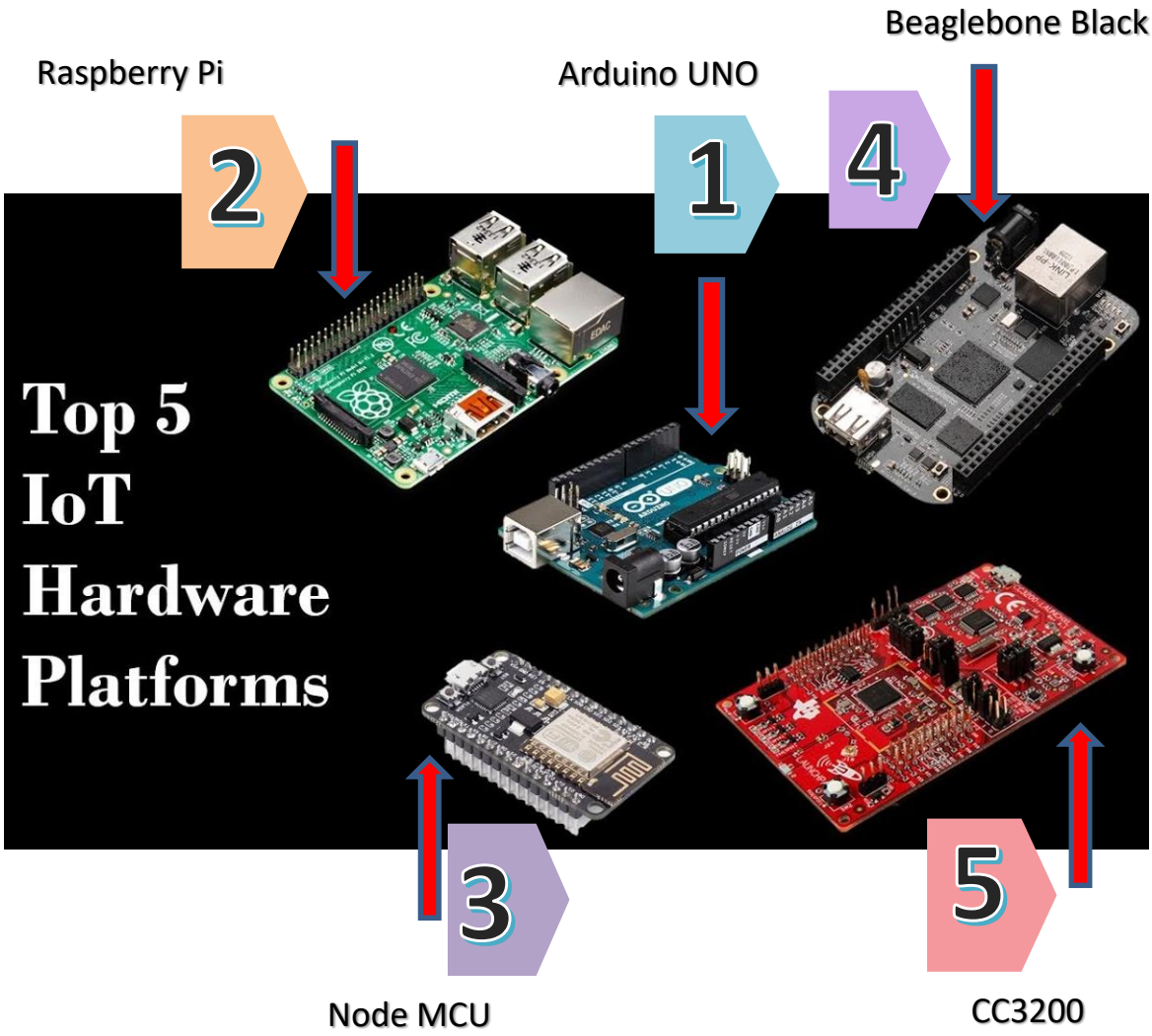


Figure 2.3: MCU Core of IoT Embedded System Platform (https://my.cytron.io/p-nodemcu)

Hardware and Software

Key Features of Microcontrollers

Bits 1	Microcontrollers are typically sold by the number of bits they offer. This impacts the speed with which they are able to perform non-trivial computations.
RAM 2	RAM is fast-access memory that does not retain data in an absence of power. All MCUs come with certain amounts of RAM, which allows your microcontroller to quickly perform various actions. The more you have, the better, but the added RAM increases the cost of the MCU.
Flash 3	Flash is computer memory that retains data in the absence of power. At least some of this is essential, and it's very useful for features like offline storage.
GPIO 4	GPIO stands for general-purpose input/output pins. These are the pins that you will use for connecting your sensors and actuators to the MCU and the internet. The number of pins can range from one to the hundreds depending on the microcontroller.
Connectivity 5	This is how the board (and application) connects to the internet via Wi-Fi, ethernet or some other means. This is an important aspect of connected sensor applications, so we'll go over this topic later in the book.
Power consumption 6	Power consumption is critically important for connected sensor applications, particularly so when your device has to rely on something like battery or solar power. This spec will tell you how power hungry the MCU is by default and whether or not it supports power-conscious programming techniques.
Development tools 7	It's important that there is a mature set of tools, documentation, and community support to help build programs that will run on the MCU you select for your application.

Hardware and Software

Microcontroller For IoT System

Availability 1	Can you easily get the MCU that you want and in the quantity that you need? This is important to consider at the beginning of the process, especially if you plan on scaling up your system later on.
Power 2	How much power will the MCU need? Will it need to be wired or can you use batteries? Energy efficiency is extremely important to consider for Industrial IoT applications because you'll want to minimize the need for sending maintenance crews to inspect edge infrastructure.
Cost 3	How much does each unit cost? Does the price make sense based on the value it will deliver? Again, you'll want to think about scaling the project up later on.
Development Kit 4	Is a development kit available? Development kits are an excellent way to get started with the MCU you choose because they are designed to give customers an out-of-box experience. This will make the development of your IoT application much easier.
Development Support 5	Is good documentation for your MCU available? What is the community surrounding this board like? These factors are crucial in order to make informed decisions on how to use your MCU properly. A good online community can help guide you when you are stuck or encounter a problem with your implementation.

Hardware and Software

Type of Embedded Controller Module

Table 2.1: Type of Embedded Controller Module

SPECIFICATION	ESP32	ESP8266
MCU	Xtensa ® Dual-Core 32 bit LX6 600 DMIPS	Xtensa ® Single-Core 32 bit LX6 L106
802.11 b/g/n Wi-Fi	Yes, HT40	Yes, HT20
Bluetooth	Bluetooth 4.2 and below	None
Typical Frequency	160 MHz	80 MHz
SRAM	512 kBytes	160 kBytes
Flash	SPI Flash, up to 16 MBytes	SPI Flash, up to 16 MBytes
GPIO	36	17
Hardware/Software PWM	1/16 Channels	None / 8 Channels
SPI/12C/12S/UART	4/2/2/2	2/1/2/2
ADC	12-bit	10-bit
CAN	1	None
Ethernet MAC Interface	1	None
Touch Sensor	Yes	None
Temperature Sensor	Yes	None
Working Temperature	- 40°C - 125°C	- 40°C - 125°C

Hardware and Software

Parameter NodeMCU ESP32 and NodeMCU ESP8266

Table 2.2: Parameter ESP32 and ESP8266

PARAMETER	ESP32	ESP8266
Processor	Xtensa ® Dual-Core 32 bit LX with 600 DMIPS	Xtensa ® Dual-Core 32 bit LX6 with 600 DMIPS
Operating Voltage	2.2V to 3.6V	3.3V
Ports	36	17
Memory	448kB	<45kB
Clock Speed	Up to 240 MHz	26MHz-52 MHz
Power Use	Active Mode, Modem Sleep Mode, Light Sleep Mode, Deep Sleep Mode, Hibernation Mode	Three Low Power Modes: Light Sleep, Modem Sleep and Deep Sleep
Security Features	IEEE 802.11 standard security features all supported, including WFA, WPA/WPA2 and WAPI Secure boot, Flash encryption 1024-bit OTP, up to 768-bit for customers Cryptographic hardware acceleration: AES, SHA-2, RSA, elliptic curve cryptography (ECC), random number generator (RNG)	SSL security Firewall
Connectivity	1/16 Channels	None / 8 Channels
Cost	RM40	RM30
Support (IDE)	Arduino IDE	Arduino IDE, LUA Loader

Hardware and Software

"IDE"

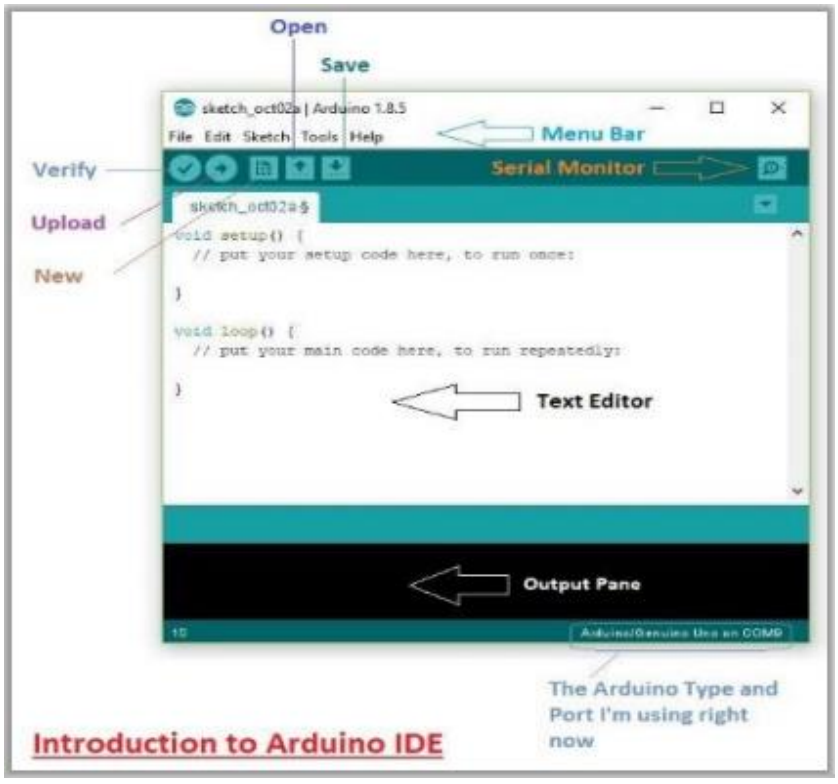
Integrated Development Environment

a An Integrated Development Environment (IDE) is a software application that provides comprehensive facilities to computer programmer for software development.

b An (IDE) normally consists of a source code editor, build automation tools and a debugger.

c The boundary between an integrated development environment and other parts of the broader software development environment is not well-defined.

d Sometimes a version control system or various tools to simplify the construction of a Graphical User Interface are integrated.



e Many modern IDE also have a class browser, an object browser and a class hierarchy diagram for use in object oriented software development

Figure 2.4: Arduino IDE

Hardware and Software

Sensor As A Things

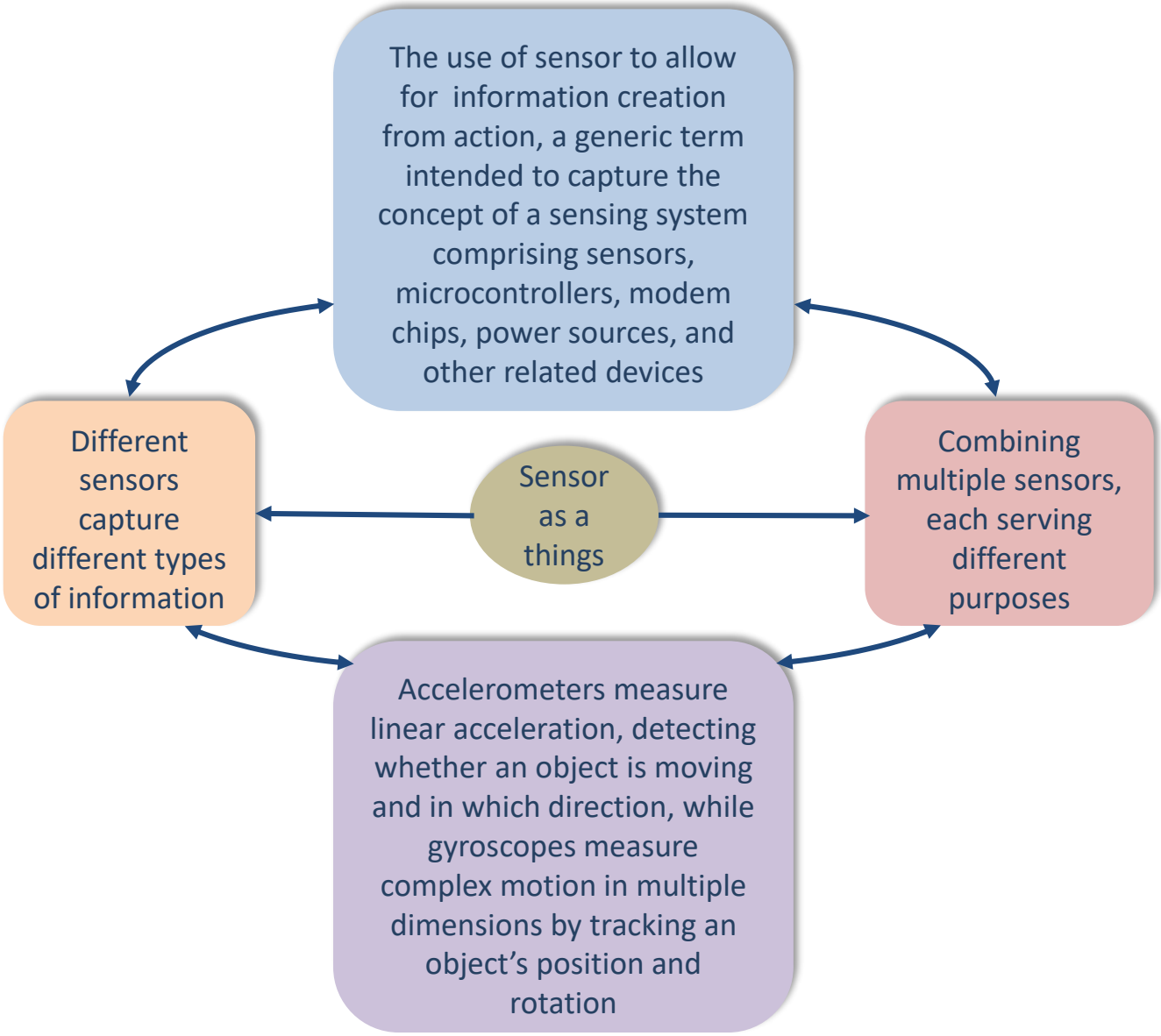


Figure 2.5: Apply Sensor As A Things

Hardware and Software
Sensor As A Things

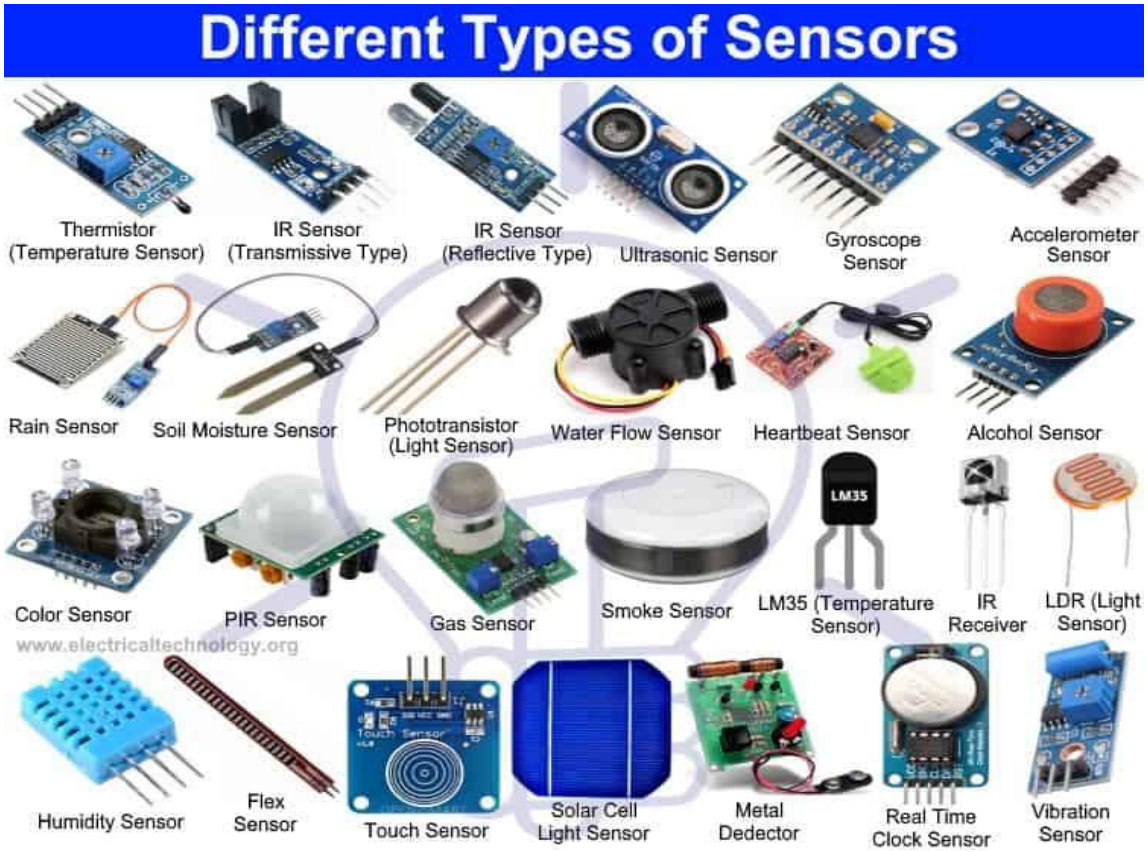


Figure 2.6: Different Types Of Sensors
(https://www.electricaltechtechnology.org/)

- The use of sensor is to allow for information creation from action, a generic term intended to capture the concept of a sensing system comprising sensors, microcontrollers, modem chips, power sources, and other related devices.
- Different sensors capture different types of information. Accelerometers measure linear acceleration, detecting whether an object is moving and in which direction, while gyroscopes measure complex motion in multiple dimensions by tracking an object's position and rotation.
- By combining multiple sensors, each serving different purposes, it is possible to build complex value loops that exploit many different types of information.

Hardware and Software

List of Sensors

POSITION SENSORS

- A position sensor measures the position of an object; the position measurement can be either in absolute terms (absolute position sensor) or in relative terms (displacement sensor).
- Position sensors can be linear, angular, or multi-axis. Example - Potentiometer, inclinometer, proximity sensor.

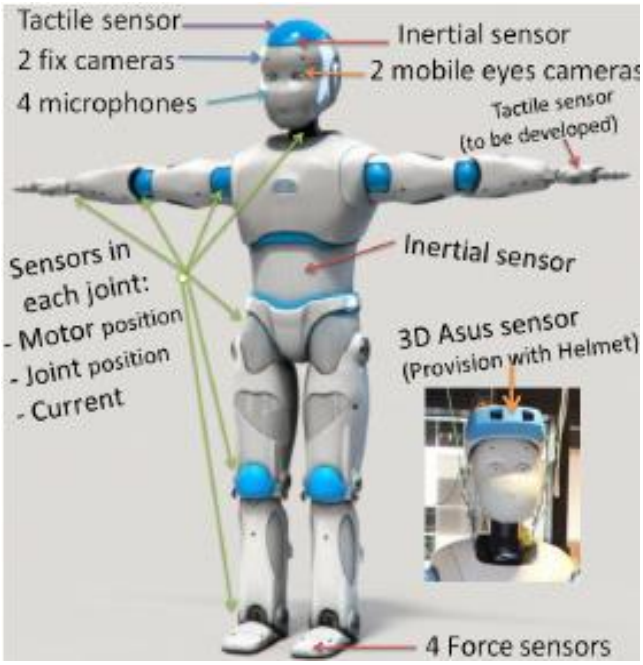


Figure 2.7: Position Sensors (https://www.researchgate.net/)

FORCE AND PRESSURE SENSORS

- Force sensors detect whether a physical force is applied and whether the magnitude of force is beyond a threshold.
- Pressure sensors are related to force sensors and measure the force applied by liquids or gases. Pressure is measured in terms of force per unit area.
- Example - Force gauge, viscometer, tactile sensor (touch sensor), Barometer, bourdon gauge, piezometer.

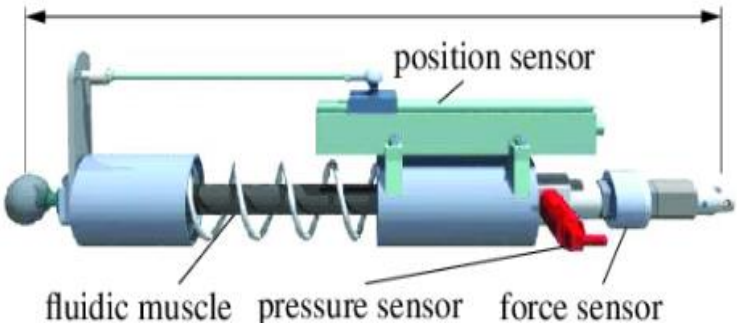


Figure 2.8 Force and Pressure Sensors (https://www.researchgate.net/)

Hardware and Software

List of Sensors

TEMPERATURE AND HUMIDITY SENSORS

- Temperature sensors measure the amount of heat or cold that is present in a system. They can be broadly categorized into two types: contact and non-contact. Contact temperature sensors need to be in physical contact with the object being sensed.
- Non-contact sensors do not need physical contact, as they measure temperature through convection and radiation. Example-Thermometer, calorimeter, temperature gauge.

BIOSENSOR

- Biosensors are used in a variety of applications, including point-of-care monitoring of therapy and illness progression, environmental monitoring, food safety, drug discovery, forensics, and biomedical research.
- Biosensors may be developed using a broad variety of ways. Their combination with high-affinity biomolecules allows them to detect a wide range of analytes in a sensitive and selective manner..

Figure 2.9: Temperature and Humidity Sensors (https:// www. lastminuteengineers.com/)

Figure 2.10: Biosensor (https://www.leeds.iqm.unicamp.br/electrochemical-biosensors/)

Hardware and Software
List of sensors

VELOCITY AND ACCELERATION SENSORS

- Velocity (speed of motion) sensors may be linear or angular, indicating how fast an object moves along a straight line or how fast it rotates.
- Acceleration sensors measure changes in velocity. Example - Accelerometer, gyroscope.

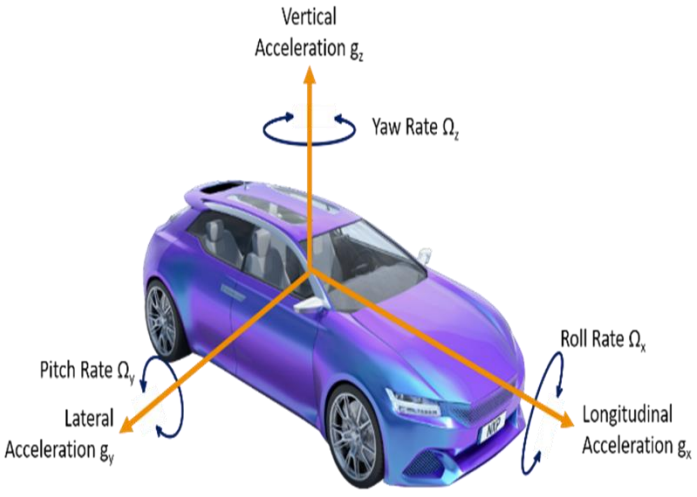


Figure 2.11: Acceleration Sensors (https://trade.mechanic.com.au/)

LIGHT SENSORS

- A Light Sensor produces an output signal that indicates the intensity of light by measuring the radiant energy that occurs in a very restricted range of frequencies known as "light," which runs in frequency from "Infrared" to "Visible" to "Ultraviolet."
- The light sensor is a passive device that converts "light energy" into an electrical signal, whether visible or infrared. Because they transform light energy (photons) into electricity, light sensors are usually referred to as "Photoelectric Devices" or "Photo Sensors" (electrons).
- Light sensors detect the presence of light (visible or invisible). Example - Infrared sensor, photodetector, flame detector.

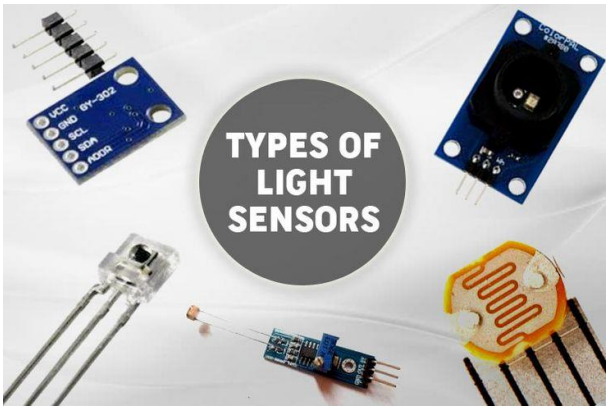


Figure 2.12: Acceleration Sensors (https://in.pinterest.com/)

Hardware and Software

Digital Sensor and Analogue Sensor

DIGITAL SENSOR

- Digital sensors are electrochemical or electrical sensors that transform information to digital representation before transmitting it.
- A digital sensor's output is the discrete digital signal of the amount being measured. And the measured quantities might include conductivity, pH, redox potentials, and a variety of other things. The output is in the form of 1's and 0's, with '1' representing ON and '0' representing OFF.
- This means that a digital signal creates separate (non-continuous) values, and the output is either a single "bit" (serial transmission) or a "byte," which is a combination of many bits (parallel transmission.

ANALOG SENSOR

- Analog sensors include many types of sensors that provide a continuous analogue output signal.
- The analogue sensors give a continuous output signal that is proportional to the measurand.
- Analog sensors come in many different shapes and sizes; practical examples include accelerometers, pressure sensors, light sensors, sound sensors, temperature sensors, and so on.

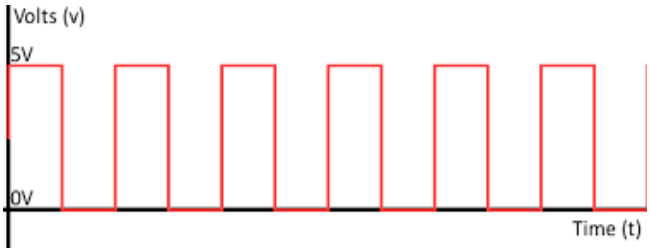


Figure 2.13: Digital Signal (https://learn.sparkfun.com/)

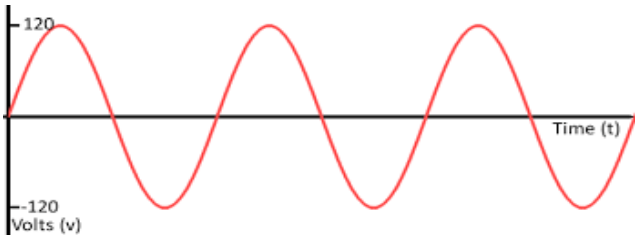


Figure 2.14: Analog Signal (https://learn.sparkfun.com/)

Hardware and Software
Installing
NodeMCU ESP32 or NodeMCU ESP8266

- **Micro-USB jack:** Used to connect the ESP32/ESP8266 to our computer through a USB cable.
- **Reset Button:** Reset button of the ESP module. Pressing this button will reset the code running on the ESP module.
- **Boot Button:** This button is used to upload the Program from Arduino to the ESP module. It has to be pressed after clicking on the upload icon on the Arduino IDE. When the Boot button is pressed along with the EN button, ESP enters into firmware uploading mode. Do not play with this mode unless you know what you are doing.
- **Red LED:** The Red LED on the board is used to indicate the power supply. It glows red when the board is powered.
- **Blue LED:** The Blue LED on the board is connected to the GPIO pin. It can be turned on or off through programming.
- **I/O pins:** This is where major development has taken place. Unlike ESP8266, on ESP32 we can access all the I/O pin of the module through the break-out pins. These pins are capable of Digital Read/Write, Analog Read/Write, PWM, IIC, SPI, DAC and much more. Use data sheet ESP32/ESP8266 for references.

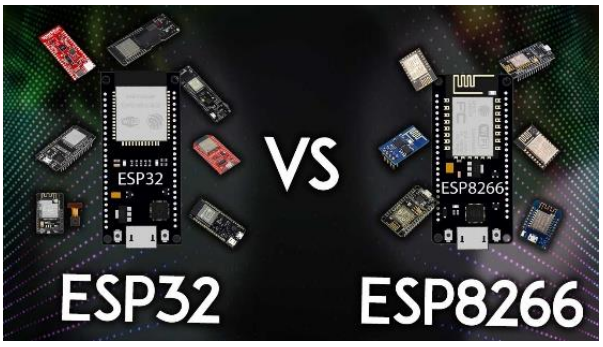


Figure 2.15: Digital Signal
(https://makeradvisor.com/esp32-vs-esp8266/)

Hardware and Software

Installing

NodeMCU ESP32 or NodeMCU ESP8266

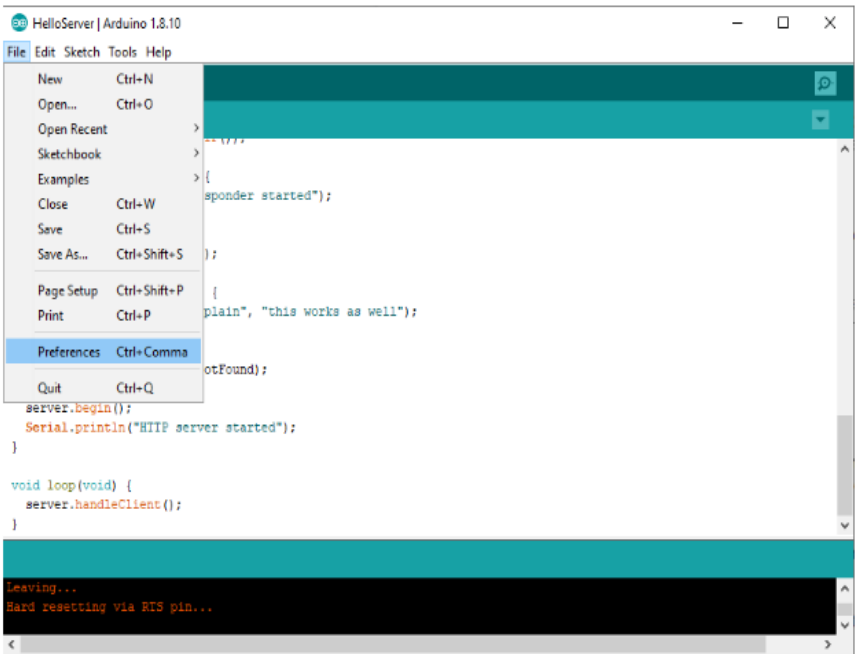


Figure 2.16: Step 1 Installing ESP32 or ESP8266

- Refer Figure 2.16 connect the board to your computer. **NodeMCU ESP 32 or NodeMCU ESP 8266** board uses a microUSB port.
- If computer can't recognize the board, download the Silabs CP2102x driver.
- By the Arduino IDE. And go to *Boards Manager*.

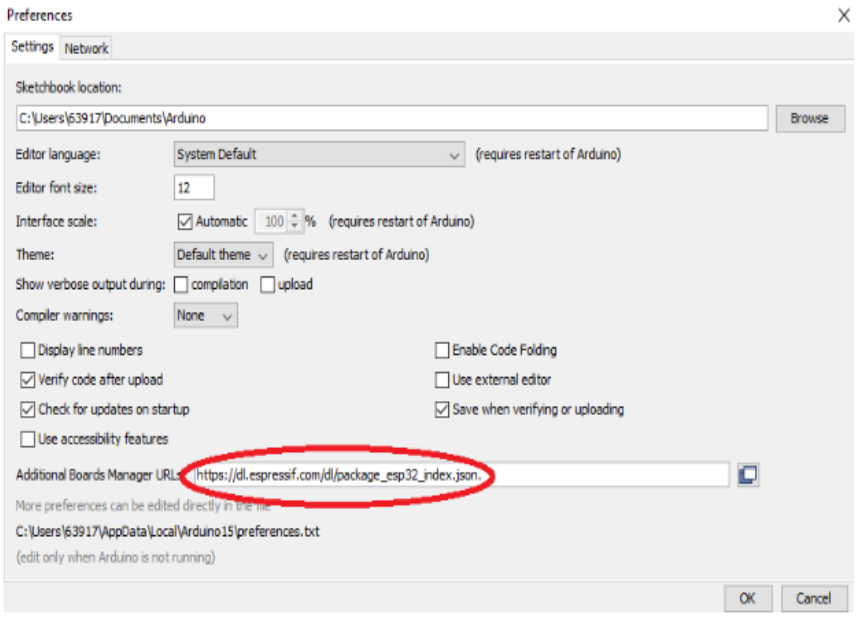


Figure 2.17: Step 2 Installing ESP32 or ESP8266

- Refer Figure 2.17 Go to *File > Preferences.*
- On the additional boards manager field, paste: ***https://dl.espressif.com/dl/package_esp32_index.json***. Then click OK.

Hardware and Software

Installing

NodeMCU ESP32 or NodeMCU ESP8266

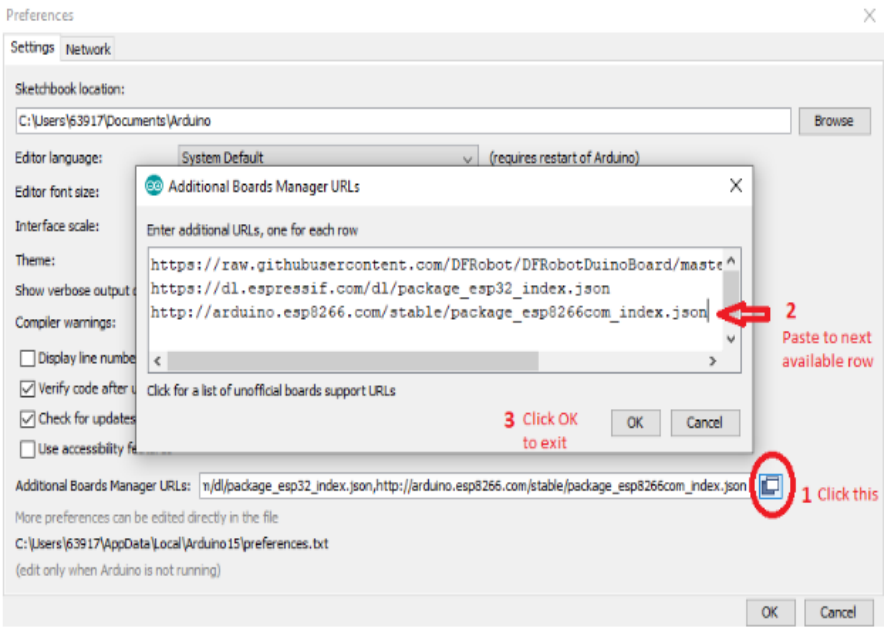


Figure 2.18: Step 3 Installing ESP32 or ESP8266

- Refer Figure 2.18, at the additional Board Manager URL, can type for ESP 32 OR ESP8266.
- 1. https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.jason
- 2. http://arduino.esp8266.com/stable/package_esp8266com_index.json

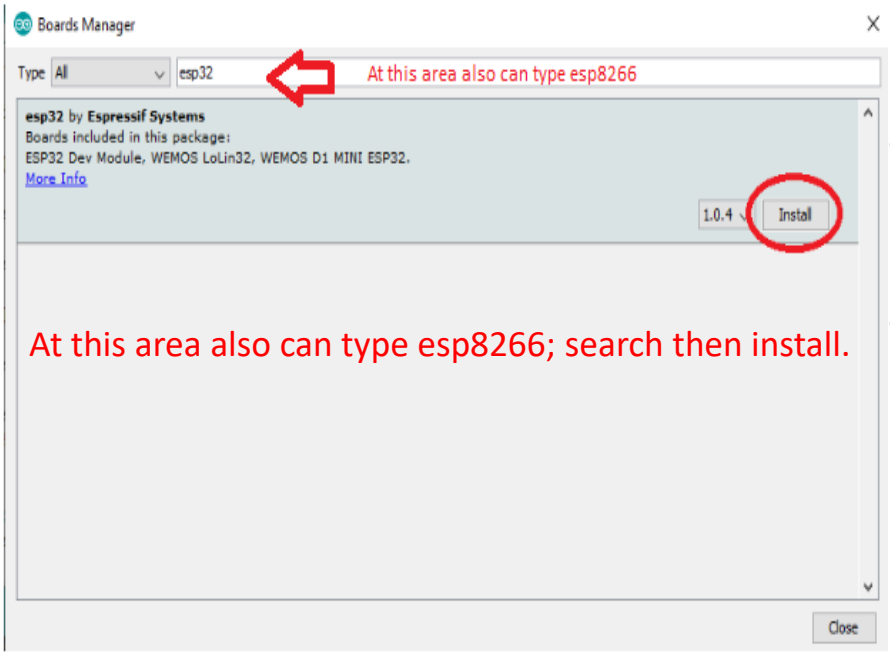


Figure 2.19: Step 4 Installing ESP32 or ESP8266

- Refer Figure 2.19, at the a Board Manager type for ESP 32 OR ESP8266.
- Choose version then click Install.

Hardware and Software

Installing

NodeMCU ESP32 or NodeMCU ESP8266

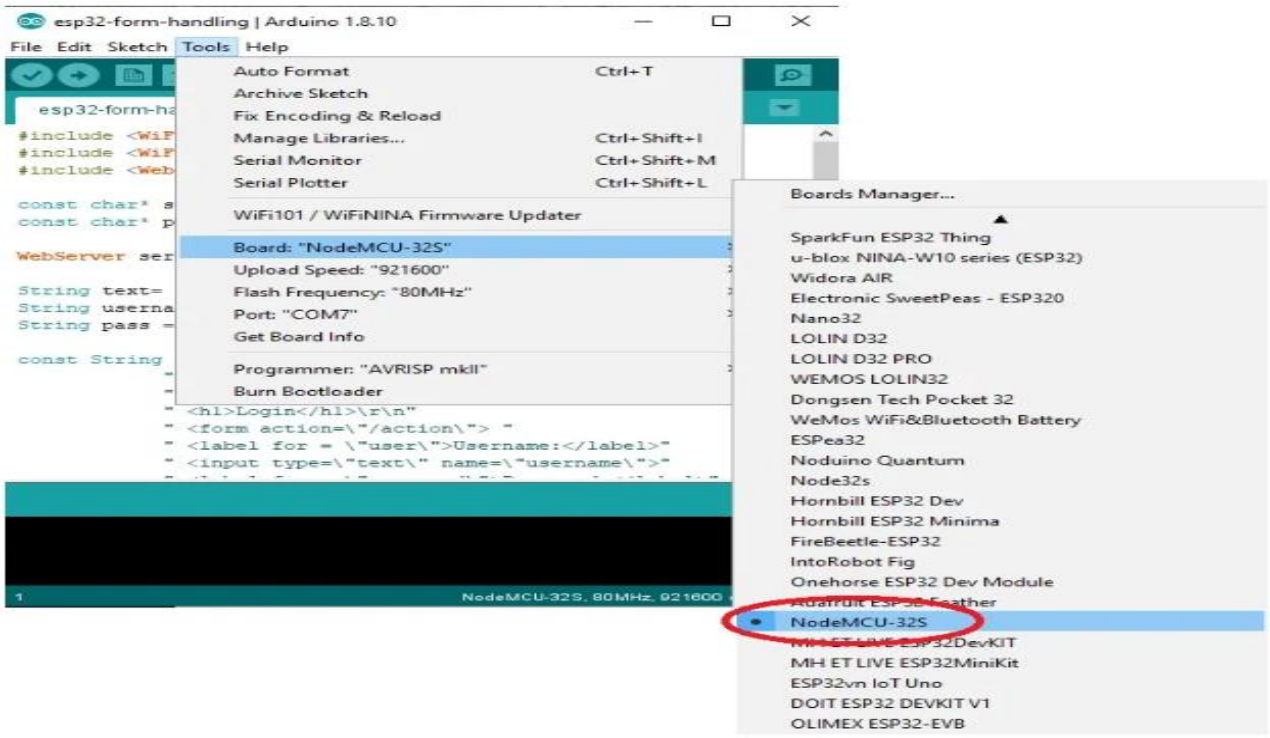


Figure 2.20: Step 5 Installing ESP32 or ESP8266

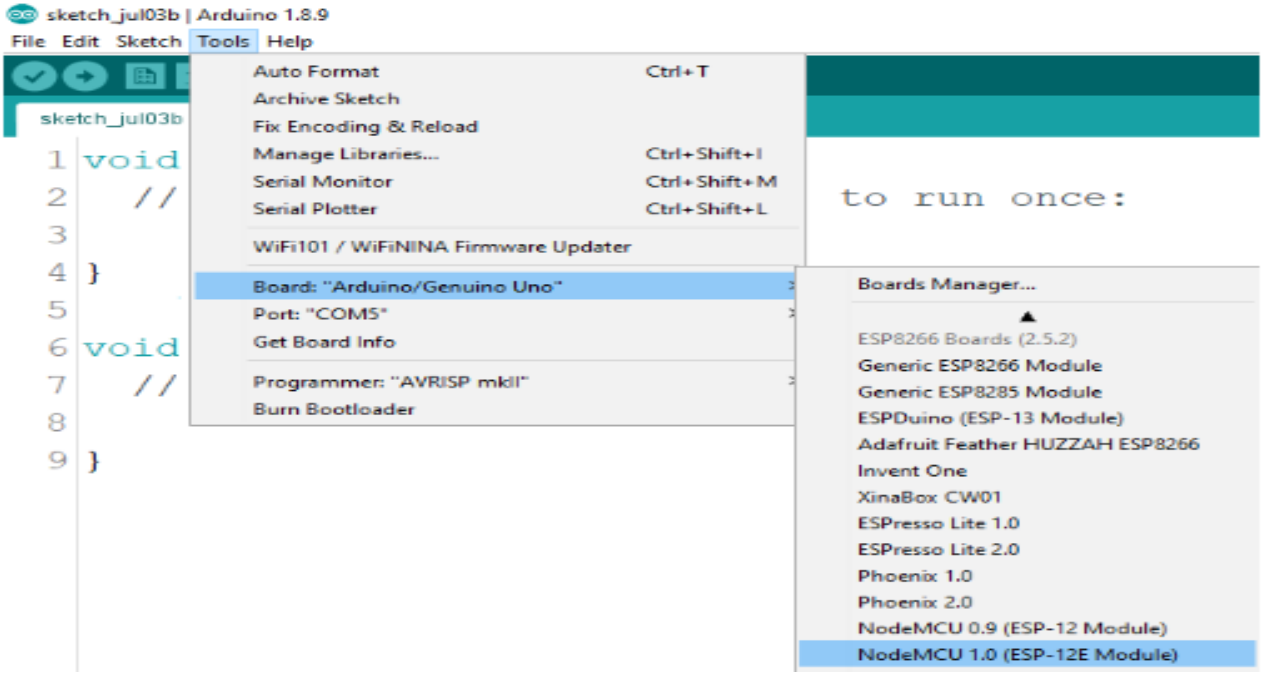
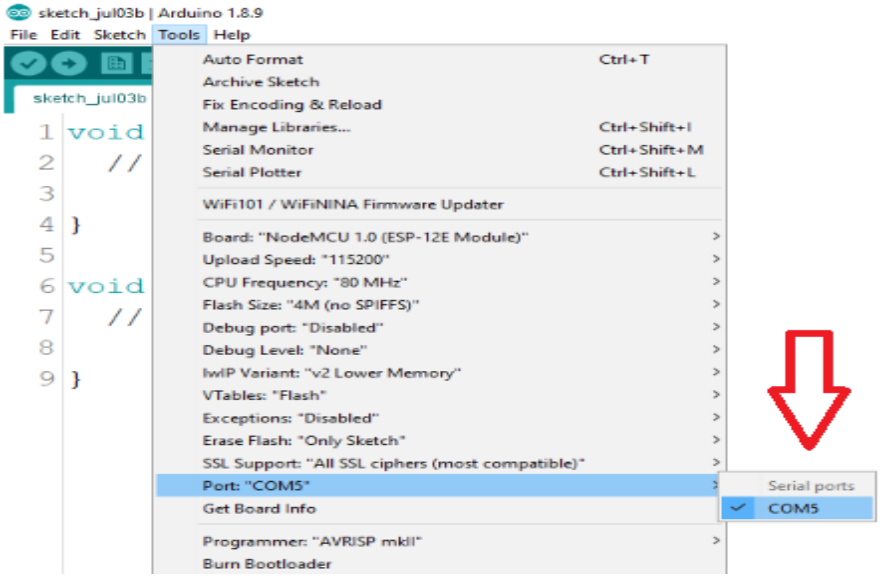


Figure 2.21: Step 6 Installing ESP32 or ESP8266

Hardware and Software

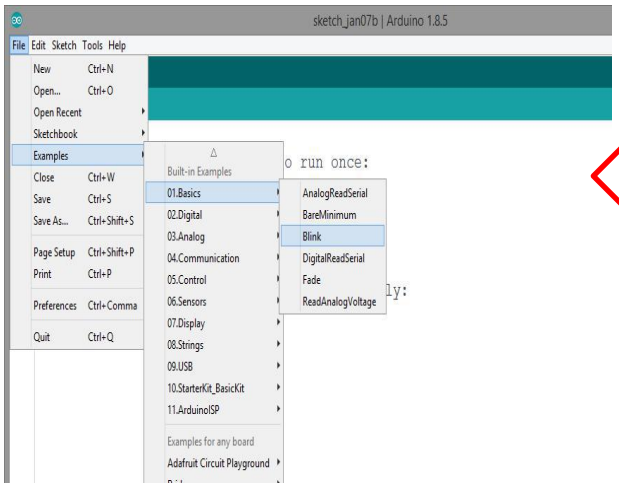
Installing

NodeMCU ESP32 or NodeMCU ESP8266



- Refer Figure 2.22, choose a suitable COM Port.
- To check type a device manager at windows search box.
- Go to Ports (Communications Port).
- Check the number of Port.

Figure 2.22: Step 7 Installing ESP32 or ESP8266



- Refer Figure 2.23, test your installation, go to **File >> Examples >> 01.Basics >> Blink**. This will open up a new window.

Figure 2.23: Step 8 Installing ESP32 or ESP8266

- Refer Figure 2.24, click on the Upload icon, and wait for the compiler and uploader to complete.

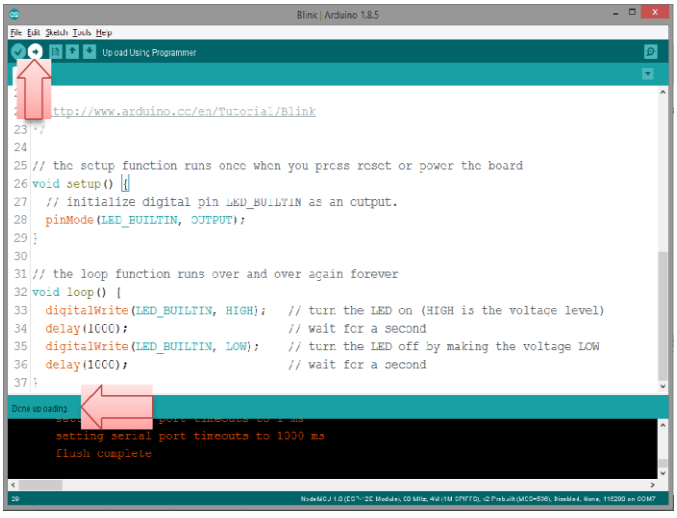


Figure 2.24: Step 9 Installing ESP32 or ESP8266

Hardware and Software

Electrical Actuators DC Motor and Relay

Actuator Electrical

- An electric actuator is a type of gear motor that can operate at various voltages and is the primary torque generator.
- Electric actuator motors typically include a thermal overload sensor installed in the motor windings to prevent excessive current draw.
- This sensor is active in series with the power supply, unlocking the circuit if the motor is stimulated and locking it when the motor reaches a safe working temperature.

DC Motor and Relay

- Relays are switches that open and close circuits electromechanically or electronically.
- Relays control one electrical circuit by opening and closing contacts in another circuit.
- Another problem would be the voltage when switching the motor off, since you have a turning motor on the coils in the motor.

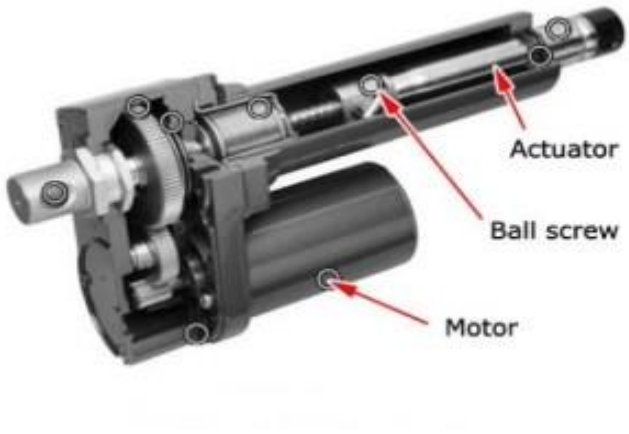


Figure 2.25: Actuator
http://www.electricalidea.com/

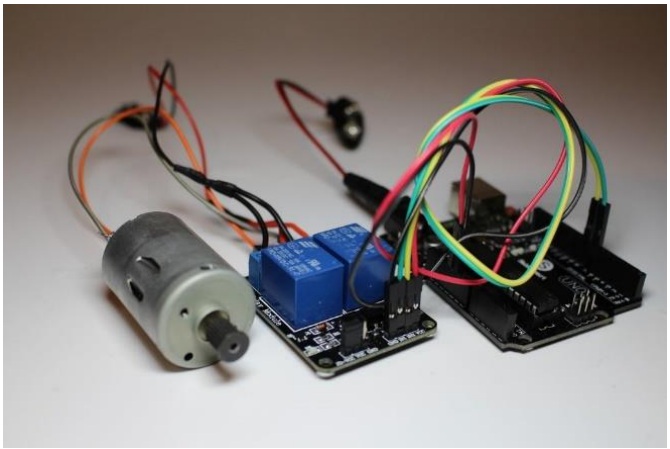


Figure 2.26: DC Motor and Relay
http://www.electricalidea.com/

Hardware and Software

Actuator complement to Sensor Signal

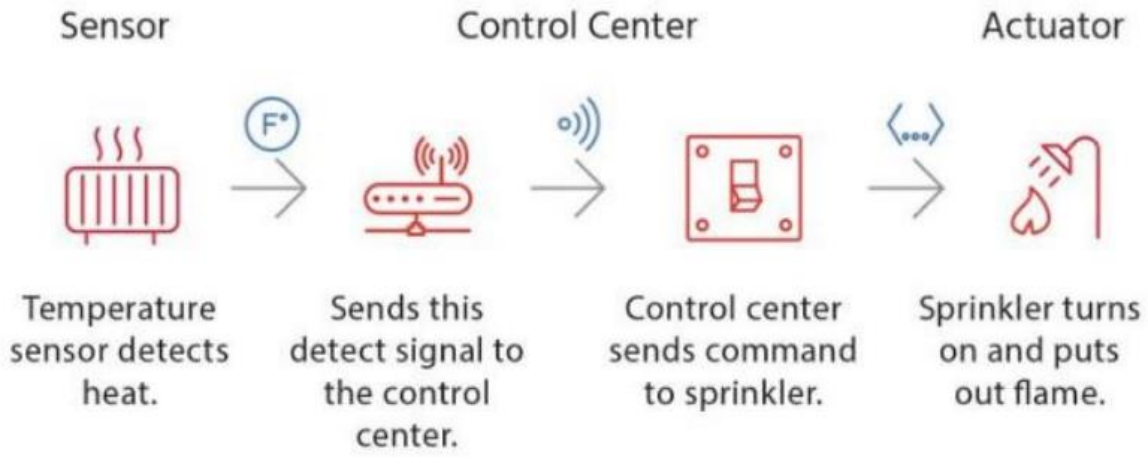


Figure 2.27: Sensor signal in action
(https://bridgera.com/sensors-and-actuators-in-iot/)

- In basic IoT systems, a sensor may gather data and send it to a control center, which makes a judgement and sends a command to an actuator in response to the perceived input.
- There are several varieties of sensors. Flow sensors, temperature sensors, voltage sensors, and humidity sensors are all examples of sensors. The list goes on and on.
- Furthermore, there are several methods for measuring something. For example, airflow might be monitored with a tiny propeller such as the one that you may find on a weather station.
- Alternatively, as in the case of a car. The flow of air through the engine is measured by heating a tiny element to monitor the rate of cooling of the element.

Chapter 3
Internet Communication and Connection

Internet Communication and Connection

Wired Connection and Wireless Connection

WIRED CONNECTION

- Wired communication refers to the transmission of data over a wire-based communication technology,
- Examples include telephone networks, cable television or internet access and fiber-optic communication.
- Anything and everything you see around yourself having wires and uses electricity to operate belongs to wired technology.

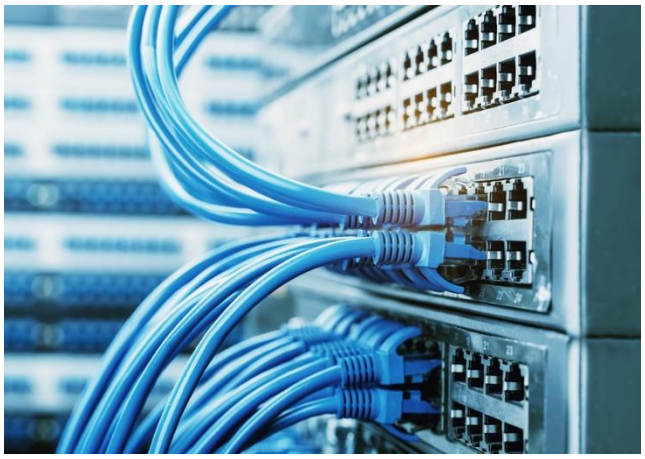


Figure 3.1: Wire Connection
http://www.electricalidea.com/

WIRELESS CONNECTION

• All the wireless devices will have antenna or sensors. Typical wireless devices include cellular mobile, wireless sensors, TV remote, satellite disc receiver, laptops with WLAN card etc.

• Wireless network does not use wires for data or voice communication, instead it use radio frequency waves as mentioned above.

• The other examples are fiber optic communication link and broadband ADSL etc. Examples of wireless network is outdoor cellular technologies such as GSM

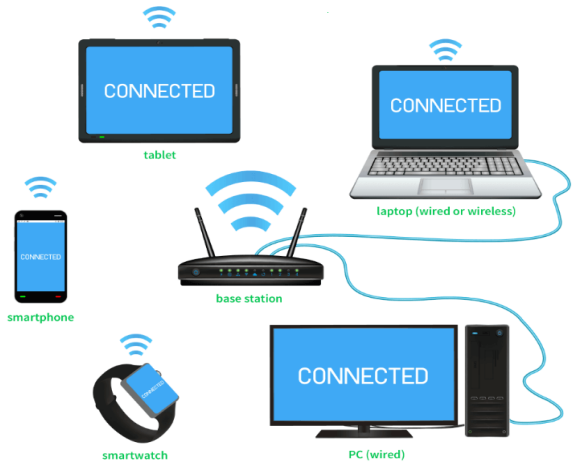


Figure 3.2: Wireless
(https://imoforpcs.com/jaringan-wlan/)

Internet Communication and Connection

Wired Connection and Wireless Connection

Table 3.1: Differences Wired and Wireless Network

Activity/Category	Wired Network	Wireless Network
Freedom of movement for users	Users location is limited by need to use cable/or connect to a port.	Users can access network from anywhere within range
Sharing files	Generally less convenient as you have to be cabled in, but transfer speeds are often faster.	Easier with wireless network as you do not need to be cabled to network through transfer speeds may be slower.
Cables	Lots of cables and ports needed that can be a headache.	For less complicated, disruptive and untidy cabling needed.
Connection speeds	Usually faster than wireless.	Usually slower than wired.
Security	More secure than wireless.	Less secure than wired. Both bandwidth and information can sometimes be accessed.
Setup	Can also be difficult and expensive to set up.	Upgrading to a wireless network can be difficult and expensive.

Internet Communication and Connection

Wired Technology

TWISTED PAIR

- It is made up of a pair of copper wires that are twisted around each other; the wires are 1 to 2 mm thick and are twisted to prevent interference from nearby lines.
- Keep in mind that a current-carrying wire has a magnetic field that might interfere with the magnetic field of another wire when they are near together.
- Eight wires or four pairs are used in computer networks.
- This is sometimes referred to as an Ethernet or RJ-45 cable. The pairs of wires are bundled together and covered by a protective shield.

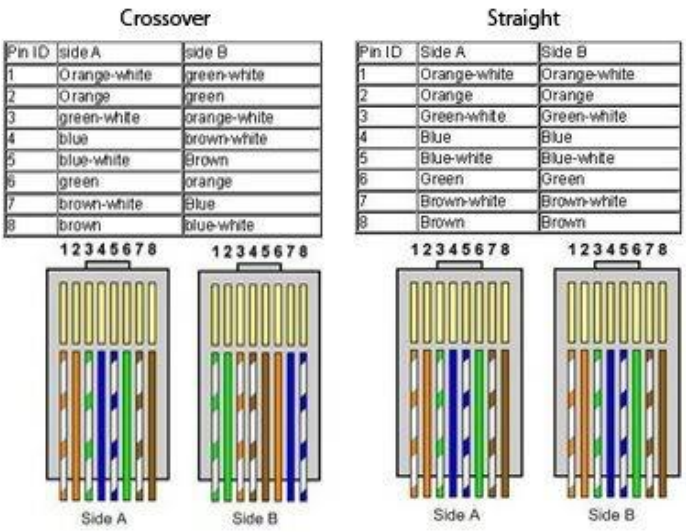


Figure 3.3: Twisted Pair Cable (https://www.home-network-help.com/)

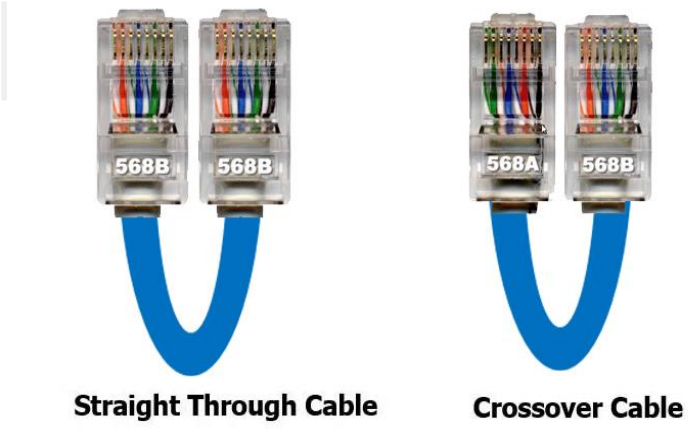


Figure 3.4: Straight and Cross Cable (https://www.fiber-optic-transceiver-module.com/)

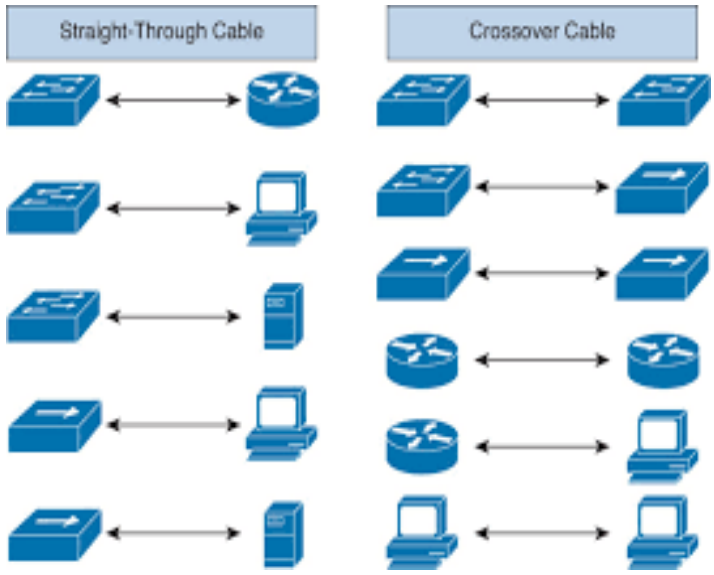


Figure 3.5: Straight and Cross Cable Connection (https://www.cables-solutions.com/)

Internet Communication and Connection

Wired Technology

COAXIAL CABLE

- Offering better data rates and less signal attenuation, a coaxial cable consist of a central copper conductor that is surrounded by a foil shield.
- The foil is covered by yet another shield known as a braided shield.
- Unlike twisted pairs, coaxial cables only have a single copper conductor.
- The conductor and the foil shield are separated by a dielectric.

Figure 3.7: Coaxial Cable
(https://www.stylelaser.com.my/)

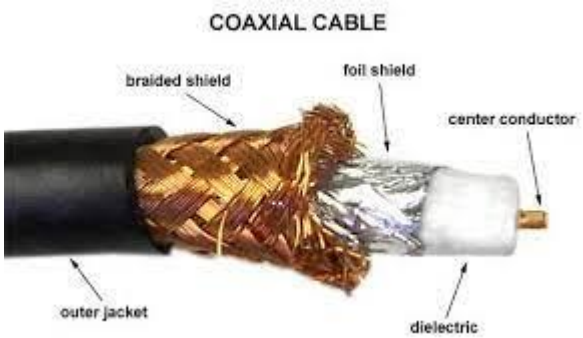


Figure 3.6: Structure Coaxial Cable
(https://www.stylelaser.com.my/)

Figure 3.8: Coaxial Cable Connection
(https://mytv2u.wordpress.com/)

Internet Communication and Connection

Wired Technology

FIBER OPTIC

- It is the most expensive of wired mediums and offers the highest rates of data transmission.
- They are often used in long distance communications and are never affected by any electromagnetic fields. This is because it involves light.
- A fiber optic cable is a thin, flexible, transparent medium made of very fine glass or plastic fibers.
- It utilizes the principle of total internal reflection. Unlike twisted pairs or coaxial cables, a fiber optic uses light pulses generated by laser or an injection diode to transmit data.
- Each pulse of light represents a single bit of data.

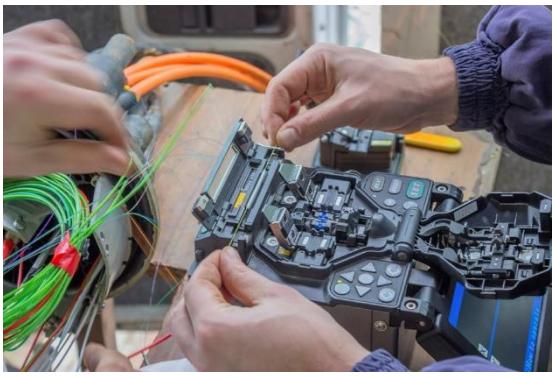


Figure 3.10: Fiber Optic Splicing Process (https://www.fiberopticshare.com/)

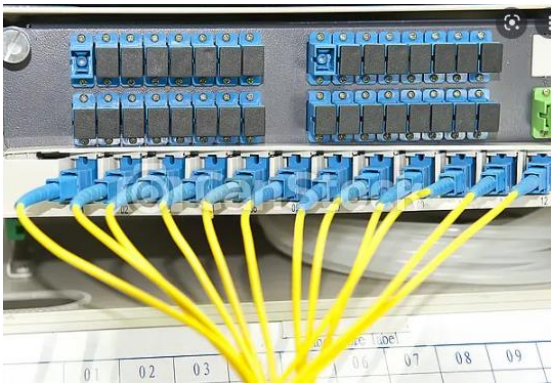
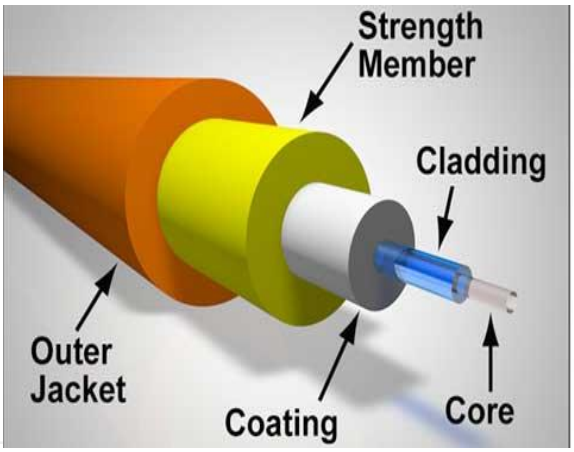


Figure 3.11: Fiber Optic Connection (https://www.canstockphoto.com/)



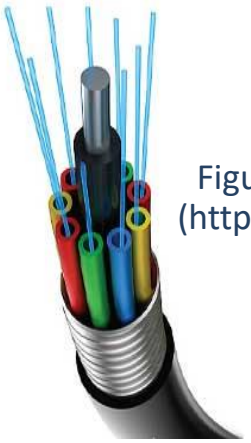


Figure 3.9: Structure Fiber Optic (https://engineer-educators.com/)

Internet Communication and Connection

Wireless Technology

Types of Wireless Network in Cellular Communication:

- Cellular wireless communication, commonly referring to a scenario where a device like a mobile phone/smartphone or a sim card enabled tablet, or laptop computer connects to a cellular tower to facilitate internet access on the go.

- Cellular communication typically uses radio waves of specific frequency for data and voice transmission.

3G

- 3G is the third generation of wireless mobile telecommunication technology. Most often, it is found in mobile phones/smartphones, and sim card enabled tablets.

4G

- 4G is a loose term for the fourth generation of cellular telecommunication technologies, up to about ten times faster than 3G.

LTE

- LTE stands for Long Term Evolution which has sometimes been marketed as 4G, but LTE is technically not 4G but rather an evolution of 3G. Still, the performance of both 4G and LTE is comparable in most everyday scenarios where coverage is not an issue, blurring the difference between 4G and LTE for most users.

5G

- 5G is the fifth-generation technology standard for cellular networking, providing further bandwidth (speed) improvements over the past iterations of cellular wireless networks.

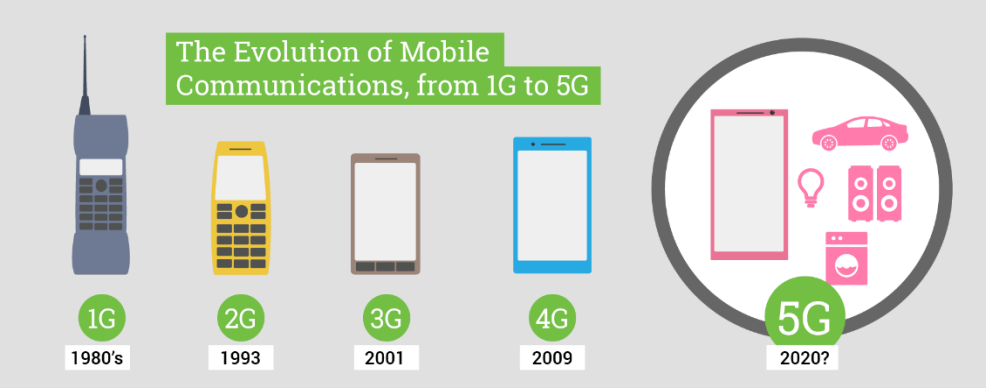


Figure 3.12: The Evolution of Mobile Communication (https://electronics360.globalspec.com/)

Internet Communication and Connection

Wireless Communication in Short Range

Bluetooth

- Bluetooth is a wireless radio technology that allows a variety of devices to communicate and collaborate. It was created as a low-cost wireless replacement for wired keyboards, headphones, speakers, and other devices suitable for Personal Area Network (PANs).

- Bluetooth is now used by a wide range of products, including mobile phones, stereos, health monitors, and safety trackers.

- Bluetooth reduces energy consumption that is less expensive to set up than Wi-Fi. Its reduced power also makes it less susceptible to interference from other wireless devices operating in the same 2.4GHz radio band.

Figure 3.13: Bluetooth (https://www.samma3a.com/)

Infrared

- Infrared radiation (IR), often known as infrared light, is a kind of radiant energy that is invisible to the naked eye but may be felt as heat.

- Infrared (IR) is a form of electromagnetic radiation that is created when atoms absorb and then release energy.

- Electromagnetic radiation comprises gamma rays, X-rays, ultraviolet radiation, visible light, infrared radiation, microwaves, and radio waves, from highest to lowest frequency.

- The electromagnetic spectrum is made up of all of these different forms of radiation.

Figure 3.14: Infrared (https://www.travelpulse.com/)

Internet Communication and Connection

Wireless Communication in Short Range

Zigbee

- ZigBee is a new wireless technology. The Zigbee 3.0 protocol was created to transmit data in loud RF environments like those seen in commercial and industrial settings.
- It has low energy consumption and is designed for multi-channel control systems, alarms systems and light control.
- It also has various home and industry applications.
- ZigBee is more economical than Wi-Fi and Bluetooth protocol as they consume more energy.

Figure 3.15: Zigbee
(https://github.com/)

Mesh Network

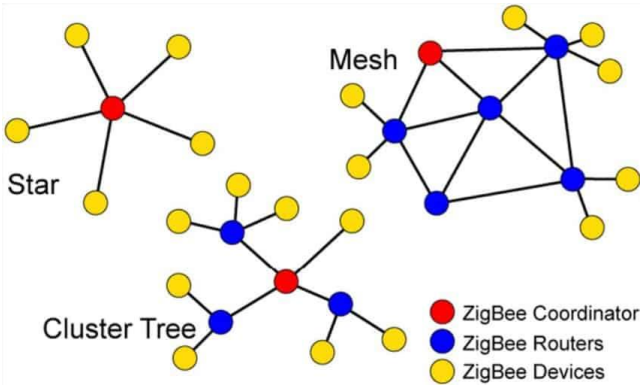


Figure 3.16: Mesh Network
(https://gadget-freakz.com/)

- Mesh networks are decentralized in nature; each node is capable of self-discovery on the network. Also, as nodes leave the network, the mesh topology allows the nodes to reconfigure routing paths based on the new network structure.
- Zigbee enables broad-based deployment of wireless networks with low-cost, low-power solutions. It can run for years on cheap batteries, making it ideal for a variety of monitoring and control applications. Lighting controls, building automation systems, tank monitoring, medical devices, and fleet applications are just a few of the many areas where Zigbee technology is making considerable progress.

Internet Communication and Connection

Wireless Communication in Long Range

RF (Radio Frequency)

- The oscillation rate of electromagnetic radiation spectrum, or electromagnetic radio waves, is measured in radio frequency (RF), which ranges from 300 gigahertz (GHz) to as low as 9 kilohertz (kHz). An RF field may be used for many sorts of wireless broadcasting and communications by using antennas and transmitters.

- The number of cycles per second that a radio wave transmits is measured in hertz (Hz). Radio waves range in frequency from thousands (kilohertz) to millions (megahertz) to billions (gigahertz) of cycles per second. The wavelength of a radio wave is inversely proportional to its frequency. The human eye cannot see radio frequencies. Electromagnetic energy manifests itself as microwaves, infrared radiation (IR), visible, ultraviolet, X-rays, and gamma rays as frequency exceeds that of the RF spectrum.

- RF fields are used in a variety of wireless devices. The RF spectrum is used by cordless and smartphones, radio and television broadcast stations, Wi-Fi and Bluetooth, satellite communications systems, and two-way radios.

- In addition, microwave ovens and garage door openers, which are not related to communications, use radio frequencies. IR frequencies, which have shorter electromagnetic wavelengths, are used by some wireless devices such as TV remote controls, computer keyboards, and computer mouse.

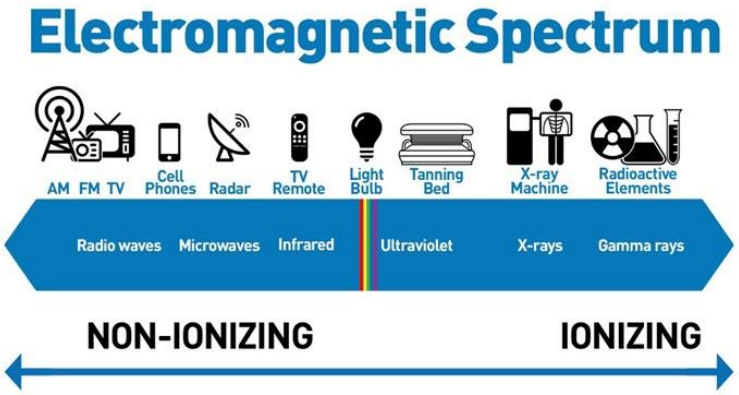


Figure 3.17: RF (Radio Frequency) (https://www.fda.gov/)

Internet Communication and Connection

Wireless Communication in Long Range

Long Range -LoRa

- The IoT industry is bringing lots of technology and solutions to the market with chip manufacturers investing heavily in the market, growing the industry exponentially.

- However, there are some difficulties. One of the most difficult aspects of developing the internet of things is ensuring that the "things" or end nodes can interact with it.

- IoT devices now communicate with one another using a variety of methods, but none of them are perfect for the purpose and application of today.

- Wi-Fi is already omnipresent, but it consumes a lot of energy and sends a lot of data. While this is excellent, it isn't the best answer for IoT devices that don't have as much energy or just need to communicate tiny quantities of data because of the restrictions of the modulation techniques utilised, access points can only manage a small number of devices at a time.

- Long Range Radio, or LoRa, is mostly used in M2M and IoT networks. This technology will make it possible for public or multi-tenant networks to connect many apps that are running on the same network.

- Each LoRa gateway is capable of supporting millions of nodes. Because the signals can travel a long distance, less infrastructure is necessary, making the network construction process considerably cheaper and faster.

Figure 3.18: LoRA Technology (https://www.fda.gov/)

Internet Communication and Connection

Wireless Communication in Long Range

GSM

- (Global System for Mobile communication) is a digital mobile network that is widely used by mobile phone users in Europe and other parts of the world.

- GSM is a second generation cellular standard developed to cater voice services and data delivery using digital modulation.

- However, GSM has long been one of the most common cellular IoT connection options. Modern IoT developers must determine if 2G connection is still a feasible choice for their application in the location where it will be deployed

- GSM uses a variation of time division multiple access (TDMA) and is the most widely used of three digital wireless telephony technologies (TDMA, GSM and CDMA).

- GSM network provides for:

i. Mobile voice communication
ii. International roaming
iii. Mobile fax
iv. Text messaging
v. Data services

- GSM networks have been around for three decades, and there are now three generations of cellular networks with significantly faster data transmission speeds, more secure connections, and sophisticated networking capabilities.

- Telecommunications companies have performed enhancements throughout the years to squeeze more mileage out of GSM-based networks, but 2G is coming to an end in numerous nations. This has little impact on users because most phones accept various technologies.

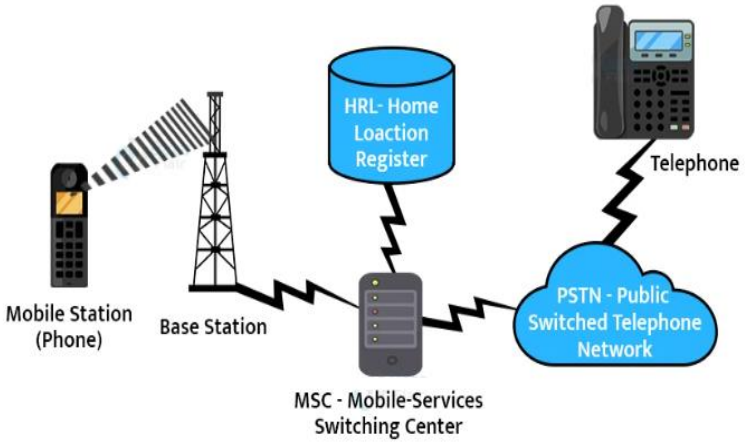


Figure 3.19: LoRA Technology (https://data-flair.training/)

Internet Communication and Connection
Wireless Sensor Network (WSN)

WSN

- (Wireless Sensor Network) is a collection of sensors that may transfer information collected from a monitored field over wireless networks.

- A wireless sensor network typically consists of hundreds of thousands of sensor nodes. Radio transmissions allow the sensor nodes to communicate with one another.

- Sensing and processing devices, radio transceivers, and power components are all included in a wireless sensor node.

- Individual nodes in a wireless sensor network (WSN) are resource constrained by design: processor speed, storage capacity, and communication bandwidth are all limited.

Figure 3.20: Wireless Sensor Network (https://www.axsysautomation.com/)

Figure 3.21: Wireless Sensor Network (https://techutzpah.com/)

- After being installed, the sensor nodes are responsible for self-organizing an adequate network architecture, which commonly includes multi-hop communication.

- The built-in sensors then begin gathering data of importance. Wireless sensor devices also respond to requests for particular instructions or sensing samples given from a "control site." Potential applications of sensor networks include:

1. Industrial automation
2. Automated and smart homes
3. Video surveillance
4. Traffic monitoring
5. Medical device monitoring
6. Monitoring of weather conditions
7. Air traffic control
8. Robot control.

Internet Communication and Connection

Application of Sensor Network

ENVIRONMENTAL APPLICATIONS

- These sensor networks have a huge number of applications in the environment.
- They can be used to track movement of animals, birds and record them. Monitoring of earth, soil, atmosphere context, irrigation and precision agriculture can be done through these sensors.
- • They can also used for the detection of fire, flood, earthquakes, and chemical/biological outbreak etc

HOME CONTROL

- As the technology is advancing, it is also making its way in our household appliances for their smooth running and satisfactory performance.
- These sensors can be found in refrigerators, microwave ovens, vacuum cleaners, security systems and also in water monitoring systems.
- The user can control devices locally as well as remotely with the help of the WSNs

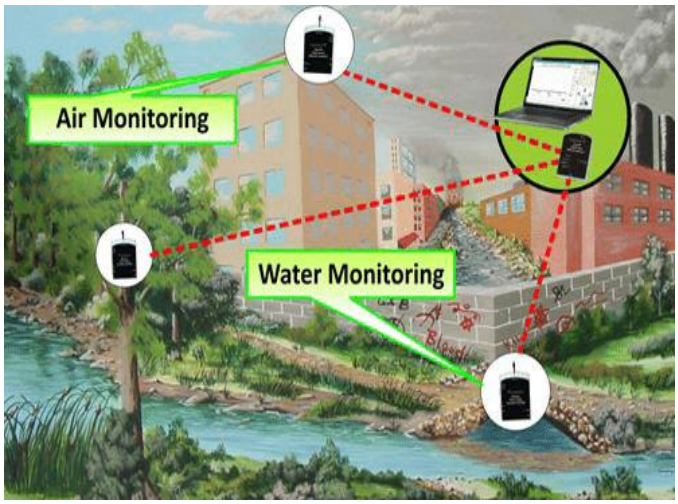


Figure 3.22: Environmental Applications (https://www.researchgate.net/)

Figure 3.23: Home Control (https://blog.techdesign.com/)

Internet Communication and Connection

Application of Sensor Network

BUILDING AUTOMATION

Figure 3.24: Building Automation (https://www.indiamart.com/)

- Building maintenance can be started automatically if aberrant patterns are noticed, before a failure occurs. This may lower overall maintenance costs, both scheduled and unforeseen, while also keeping occupants satisfied.
- Sensor may be used to track patterns in important stress indicators like temperature and vibration.
- These are just a few of the innovative ways that the Internet of Things is making our smart buildings.

MEDICAL APPLICATION

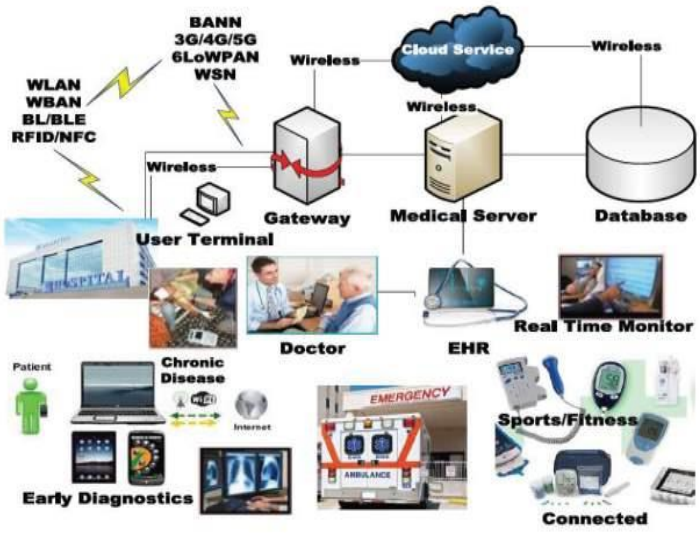


Figure 3.25: Building Automation (https://www.indiamart.com/)

- The Internet of Things (IoT) has opened up a world of possibilities in medicine: when connected to the internet, ordinary medical devices can collect invaluable additional data, give extra insight into symptoms and trends, enable remote care, and generally give patients more control over their lives and treatment.
- IoT devices may remotely monitor patients' vital signs, securely send and receive sensitive data, monitor medical equipment like MRIs, and even let people track their own health via wearable gadgets.

Internet Communication and Connection

Application of Sensor Network

SENSOR AND ROBOT

- Sensors are devices that have mechanical, electrical, or chemical properties built in. The transduction concept is crucial to their operation. The transfer of energy from one form to another.

- Robotic sensing mainly gives the robots the ability to see, touch, hear and move and it uses algorithms that require the environmental feedback.

- A Robot Sensor is used to monitor the robot's health and the environment around it. Sensors send electronic impulses to robots, which they use to complete tasks.

- Sensors that assist robots regulate themselves are required. These sensors aid robots in responding to orders. These sensors aid in the development of a feel-and-see characteristic in them, allowing them to complete a variety of jobs with ease. Understanding the surroundings can assist a robot in determining the temperature, closeness of objects, sound, or chemical reaction and acting appropriately.

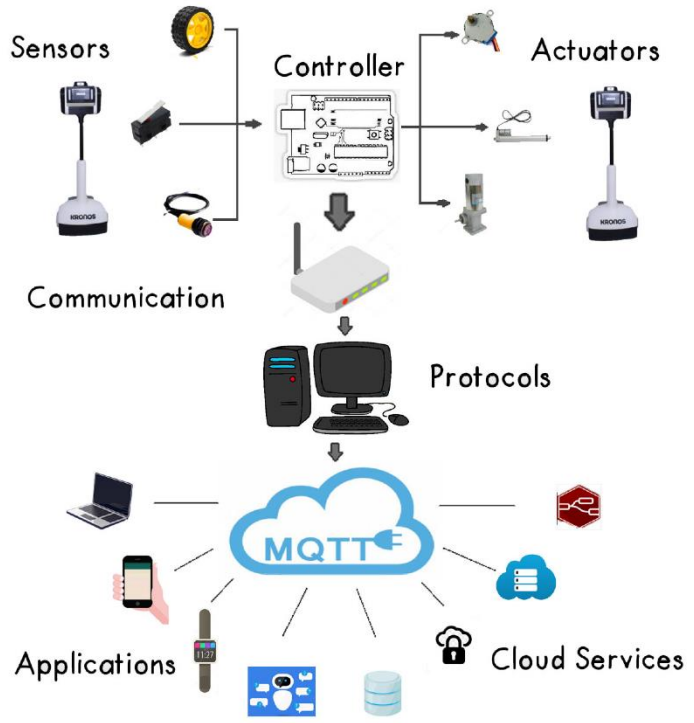


Figure 3.26: Integration of Robots and Sensors (https://srituhobby.com/)

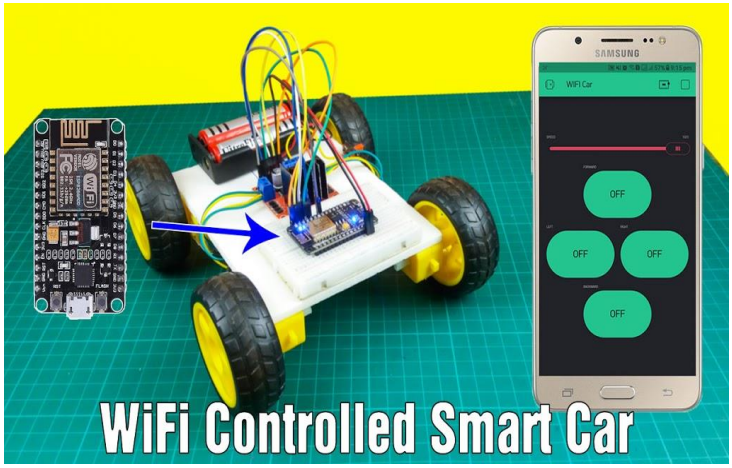


Figure 3.27: Wi-Fi Controlled Smart Car (https://srituhobby.com/)

Chapter 4
IoT Communication Protocol

IoT Communication Protocol

Hyper Text Transfer Protocol

Hyper Text Transfer Protocol

- HTTP means HyperText Transfer Protocol. HTTP is the underlying protocol used by the World Wide Web and this protocol defines how messages are formatted and transmitted, and what actions Web servers and browsers should take in response to various commands.

- For example, when you enter a URL in your browser, this actually sends an HTTP command to the Web server directing it to fetch and transmit the requested Web page.

- The other main standard that controls how the World Wide Web works is HTML, which covers how Web pages are formatted and displayed.

- The Hypertext Transfer Protocol (HTTP) is designed to enable communications between clients and servers. HTTP works as a request-response protocol between a client and server.

Hyper Text Transfer Protocol

- A web browser may be the client, and an application on a computer that hosts a web site may be the server.

- Example: A client (browser) submits an HTTP request to the server; then the server returns a response to the client. The response contains status information about the request and may also contain the requested content. HTTP Methods: GET, POST, PUT, HEAD, DELETE, PATCH, OPTIONS

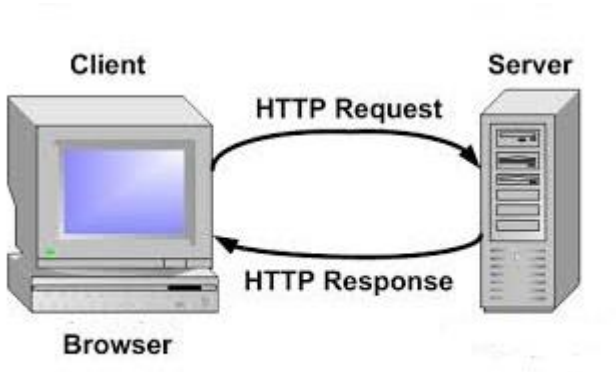


Figure 4.1: HTTP https://www.httpdebugger.com/)

IoT Communication Protocol

Hyper Text Transfer Protocol

GET METHOD

GET is used to request data from a specified resource. GET is one of the most common HTTP methods.

- Some other notes on GET requests:
  - •GET requests can be cached
  - •GET requests remain in the browser history
  - •GET requests can be bookmarked
  - •GET requests should never be used when dealing with sensitive data
  - •GET requests have length restrictions
  - •GET requests is only used to request data (not modify)

Figure 4.2: HTTP GET and POST methods in HTTP Protocol (https://www.tektutorialshub.com/)

POST METHOD

POST is used to send data to a server to create/update a resource.

POST is one of the most common HTTP methods.

- Some other notes on POST requests: POST requests are never cached
- POST requests do not remain in the browser history
- POST requests cannot be bookmarked POST requests have no restrictions on data length

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

Part A : CONTROL OUTPUT FROM WEB BROWSER

ESP8266 Board Configuration

1) Open Arduino IDE platform.

2) From Tools menu, select Board "NodeMCU 1.0 (ESP-12E Module)" and select the correct Port depends on Ports (COM & LPT) shown in Device Manager (**Figure A1**)

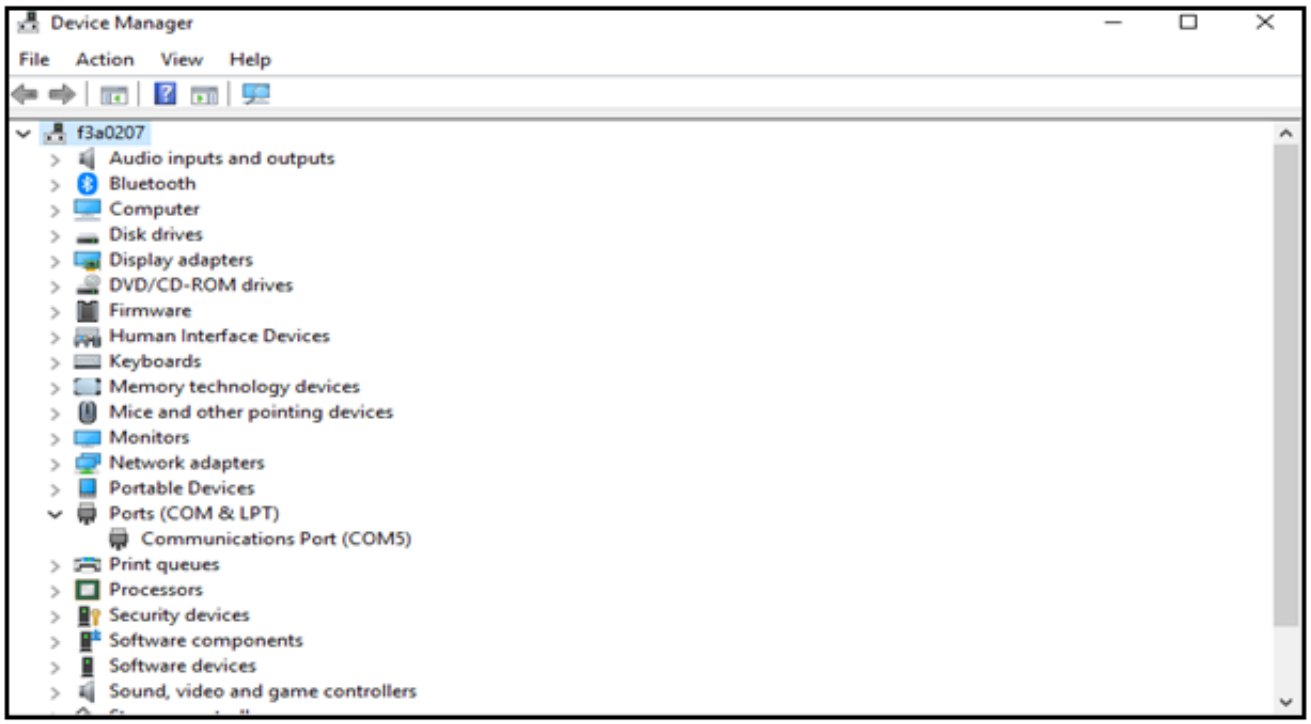


Figure A1

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

Hardware Connection

3) Make the connection of 2 LEDs, 2 resistors with Nodemcu as shown in **Figure A2**.

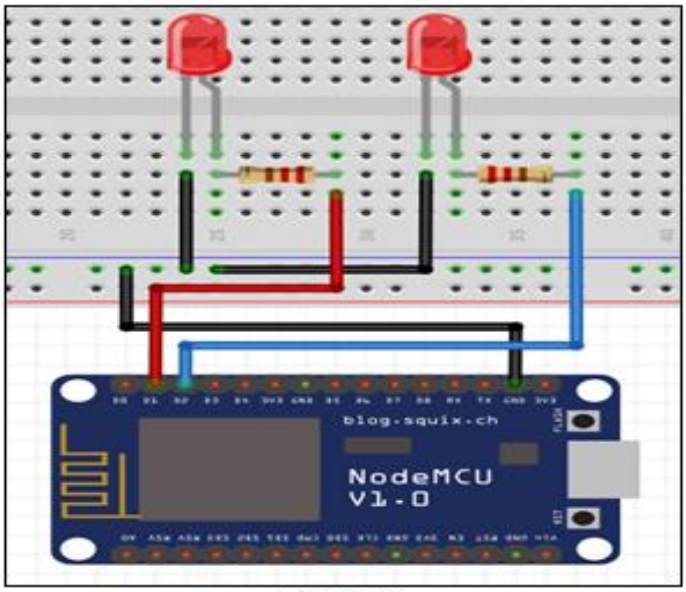


Figure A2

Figure A3 show the schematic diagram using NodeMCU ESP8266.

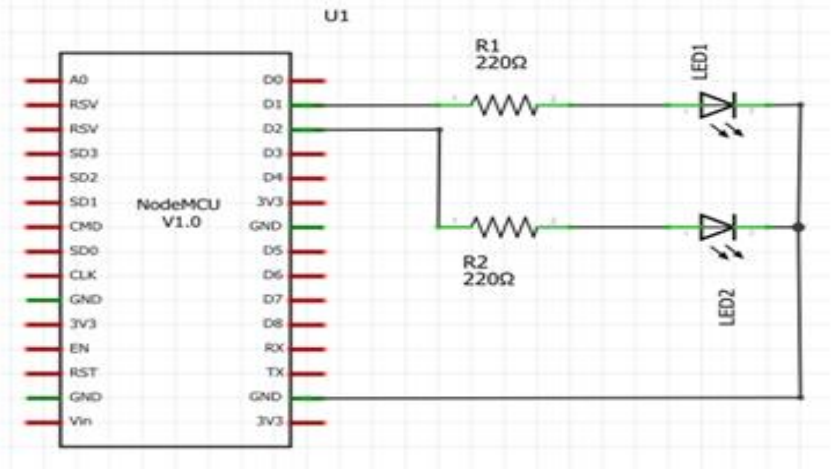


Figure A3

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

Writing Arduino Sketch

4) Write the source code as in Appendix 1.

5) From the source code change the SSID and password with your network credentials as shown in **Figure A4**.

```
#include <ESP8266WiFi.h>
#include <WiFiClient.h>
#include <ESP8266WebServer.h>
#include <ESP8266mDNS.h>

MDNSResponder mdns;

// Replace with your network credentials
const char* ssid = "HUAWEI-4234";
const char* password = "Muhaini123";

ESP8266WebServer server(80);
```

Figure A4

6) Click the "Upload Button" in the Arduino IDE and wait a few seconds until "Done uploading" message is shown in the bottom left corner.

7) Observe if there are any errors while compiling and uploading.

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

Getting ESP8266 IP Address

8) Open the Arduino serial monitor at top right corner in Arduino IDE and set the baud rate in to 115200.

Figure A5

9) After a few seconds, your IP address should appear.

10) Write down the IP Address in Table 1 as a result.

Table 1: An IP Address

An IP Address

Connect To Web Server

11) Open any browser from your computer.

12) Then type the IP address and click Enter.

13) Print screen the appeared layout from the browser and paste in Table 2 as a result.

Table 2: Layout from the browser

Internet network connection successfully

Control LEDs from Web Server

14) Click at Socket #1 ON/OFF to turn on or off LED1 and click Socket #2 ON/OFF to turn on or off LED2.

15) Observe what happen to the LED when you click ON and OFF button at browser and write down your observation as result in Table 3.

Table 3: LED result

LED result control from browser

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

PART B: DISPLAY DATA FROM SENSOR TO WEB BROWSER

Setting Up ThingSpeak

1) Go to www.thingspeak.com and Sign Up / Sign In.
2) Under My Channels, click New Channel
3) Give your channel a name, and enable one field(s) a **figure B1**.

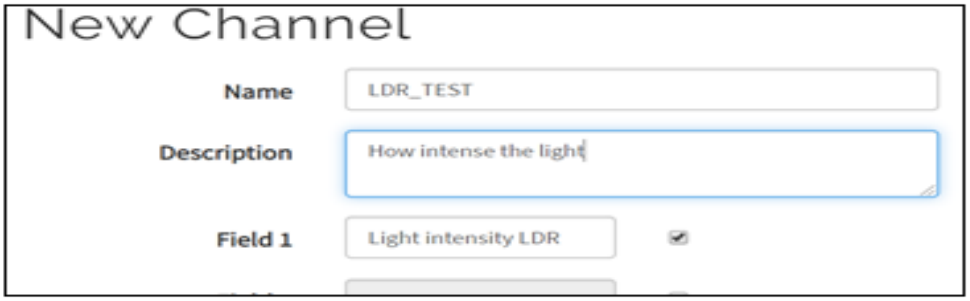


Figure B1

4) Click Save at the bottom of the page.
5) Click API Keys tab as shown in **Figure B2**.

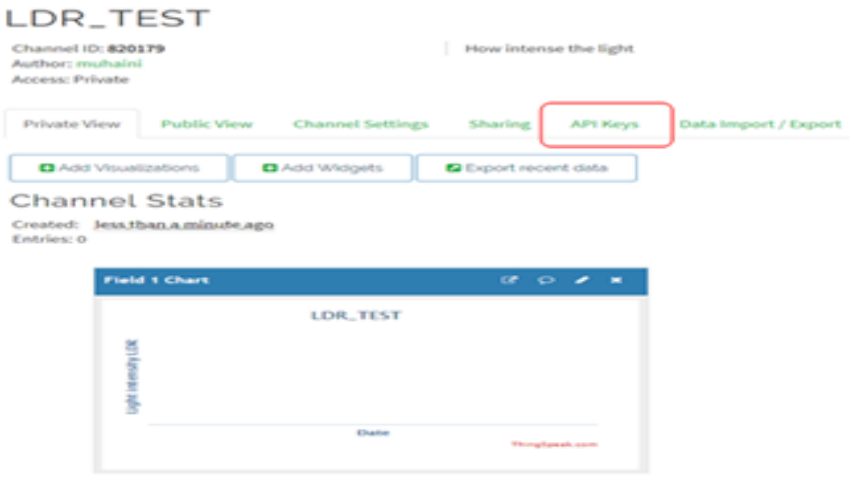


Figure B2

6) Observe the graph generated from the LDR Test and draw the output in Table 4.

Table 4: LDR Test result

LDR Test result from ThingSpeak

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

7) API keys will appear as in **Figure B3**.

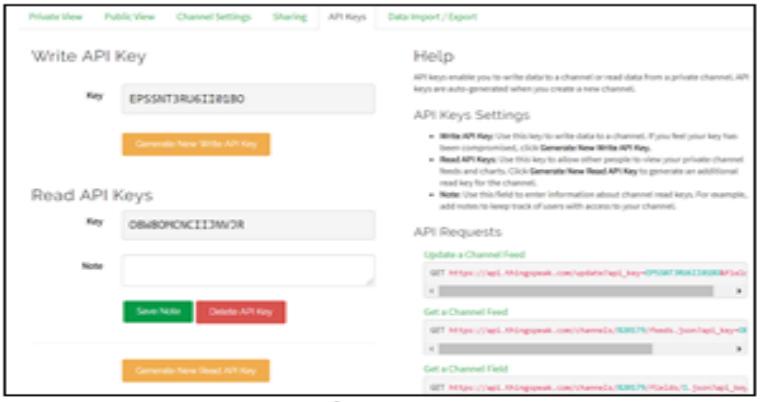


Figure B3

8) Write down your Channel ID and Write API Key at Table 5 as result.

Table 5: Channel ID and API Key

Write Channel ID and Write API Key

Hardware Installation

9) Make hardware connection of sensor (LDR) as shown in **Figure B4.**

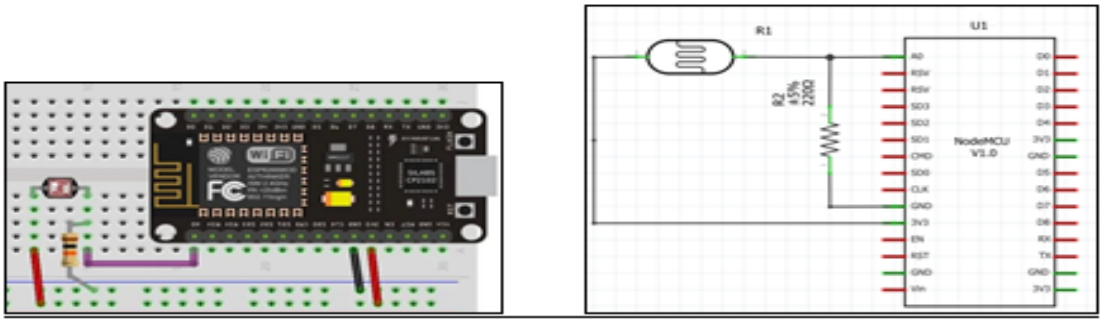


Figure B4

Installing ThingSpeak Library

10) Install Library Manager > ThingSpeak Library by clicking at Sketch > Include Library > Manage Libraries.

11) At Library Manager search for ThingSpeak then install.

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

Upload Sketch

12) At Arduino sketch, write the code as in Appendix 2.

13) Replace the following content in the code,

'Your SSID Here' – Your Wi-Fi Name ***'Your Password Here'*** – Your Wi-Fi Password ***'YYYYYY'*** – Your ThingSpeak Channel Number (without Quotes) ***'XXXXXXXXXXX'*** – Your Thing Speak API Key.

14) Then verify and upload the code.

15) Now we can display the data from sensor to web browser.

16) Print screen the display as a result in Table 6.

Table 6: Channel ID and API Key

Replace SSID, Password, Channel ID & API key

PART C: DISPLAY DATA FROM SENSOR TO MOBILE APPS

Install ThingSpeak App

1) Go to Google Play or App Store in your handphone and install ThingView – ThingSpeak viewer and open ThingView application as shown in **Figure C1**.

Figure C1

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

2) Click + icon to Add channel as shown in Figure C1.
3) Insert the Channel ID and API Key. Then click Search button as shown **Figure C2**.

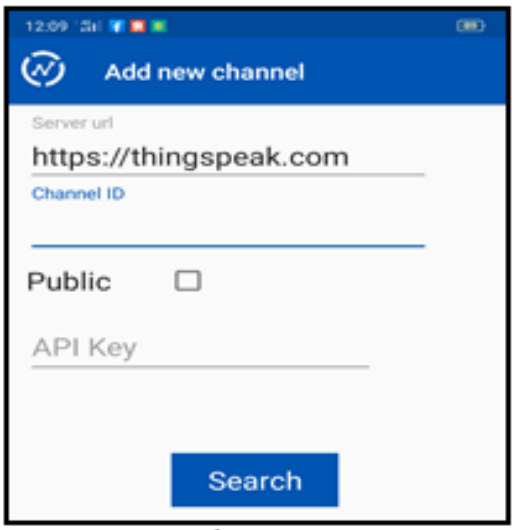


Figure C2

Table 7: Channel ID and API Key from Mobile Apps

Replace SSID, Password, Channel ID & API Key

4) Observe the graph generated from Mobile Apps and print screen the output and paste in Table 8 as result.

Table 8: Graph Generated from Mobile Apps

Graph Generated from Mobile Apps result

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

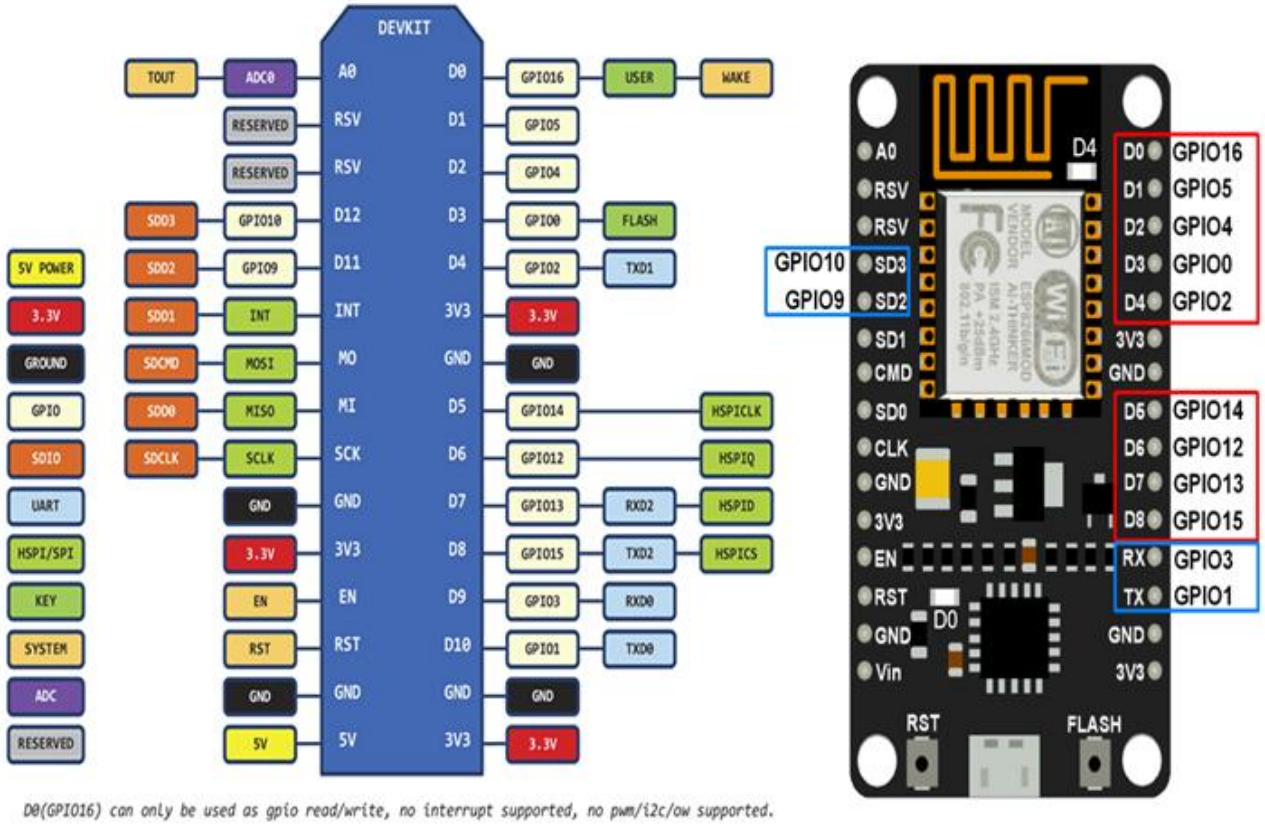


Figure 4.3: General Purpose Input/Output (https://randomnerdtutorials.com/)

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

APPENDIX 1

```
#include <ESP8266WiFi.h>
#include <WiFiClient.h>
#include <ESP8266WebServer.h>
#include <ESP8266mDNS.h>

MDNSResponder mdns;

// Replace with your network credentials

const char* ssid = "YOUR_SSID";
const char* password = "YOUR_PASSWORD";

ESP8266WebServer server(80);
String webPage = "";

int gpio5_pin = 5;
int gpio4_pin = 4;

void setup(void){

  webPage += "<h1>ESP8266 Web Server</h1><p>Socket #1 <a
href=\"socket1On\"><button>ON</button></a> <a
href=\"socket1Off\"><button>OFF</button></a></p>";
  webPage += "<p>Socket #2 <a href=\"socket2On\"><button>ON</button></a> <a
href=\"socket2Off\"><button>OFF</button></a></p>";

  // preparing GPIOs

  pinMode(gpio5_pin, OUTPUT);
  digitalWrite(gpio5_pin, LOW);
  pinMode(gpio4_pin, OUTPUT);
  digitalWrite(gpio4_pin, LOW);

  delay(1000);
```

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

```
Serial.begin(115200);
WiFi.begin(ssid, password);
Serial.println("");

// Wait for connection

while (WiFi.status() != WL_CONNECTED) {
  delay(500);
  Serial.print(".");
}
Serial.println("");
Serial.print("Connected to ");
Serial.println(ssid);
Serial.print("IP address: ");
Serial.println(WiFi.localIP());

if (mdns.begin("esp8266", WiFi.localIP())) {
  Serial.println("MDNS responder started");
}

server.on("/", []{
  server.send(200, "text/html", webPage);
});
server.on("/socket1On", []{
  server.send(200, "text/html", webPage);
  digitalWrite(gpio5_pin, HIGH);
  delay(1000);
});
server.on("/socket1Off", []{
  server.send(200, "text/html", webPage);
  digitalWrite(gpio5_pin, LOW);
  delay(1000);
});
```

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

```
  server.on("/socket2On", []{
  server.send(200, "text/html", webPage);
  digitalWrite(gpio4_pin, HIGH);
  delay(1000);
 });
 server.on("/socket2Off", []{
  server.send(200, "text/html", webPage);
  digitalWrite(gpio4_pin, LOW);
  delay(1000);
 });
 server.begin();
 Serial.println("HTTP server started");
}

void loop(void){
 server.handleClient();
}
```

IoT Communication Protocol

Internet Connection and Display Data From Sensor To Web Browser

APPENDIX 2

```
#include <ESP8266WiFi.h>;
#include <WiFiClient.h>;
#include <ThingSpeak.h>;

const char* ssid = "Your SSID Here"; //Your Network SSID
const char* password = "Your Password Here"; //Your Network Password
int val;
int LDRpin = A0; //LDR Pin Connected at A0 Pin
WiFiClient client;

unsigned long myChannelNumber = YYYYYY; //Your Channel Number (Without Brackets)
const char * myWriteAPIKey = "XXXXXXXXXXXXXXX"; //Your Write API Key

void setup()
{
Serial.begin(9600);
delay(10);
// Connect to WiFi network
WiFi.begin(ssid, password);
ThingSpeak.begin(client);
}
void loop()
{
val = analogRead(LDRpin); //Read Analog values and Store in val variable
Serial.print(val); //Print on Serial Monitor
delay(1000);
ThingSpeak.writeField(myChannelNumber, 1,val, myWriteAPIKey); //Update in ThingSpeak
delay(100);
}
```

IoT Communication Protocol

Message Queuing Telemetry Transport (MQTT)

Message Queuing Telemetry Transport-(MQTT)

- Message Queuing Telemetry Transport (MQTT) is an acronym for Message Queuing Telemetry Transport. It's a lightweight messaging protocol designed for usage in situations where clients require a minimal code footprint and are linked to unreliable networks or networks with restricted capacity.
- It's mostly utilised for M2M (machine-to-machine) communication and Internet of Things communications.
- MQTT uses a PUSH/SUBSCRIBE topology to run on top of TCP/IP. There are two sorts of systems in MQTT architecture: clients and brokers.
- The server with which the clients communicate is known as a broker. Client communications are received by the broker, who then forwards them to other clients.
- Clients connect to the broker rather than communicating directly with one another. Each customer can be a publisher, a subscriber, or both at the same time.
- MQTT is a protocol that is triggered by events. There is no continuous or periodic data transmission. As a result, transmission is kept to a bare minimum.
- A client only publishes when new data is available, and a broker only sends out information to subscribers when new data is available.

IoT Communication Protocol

Message Queuing Telemetry Transport (MQTT)

Message Queuing Telemetry Transport-(MQTT) Messages

- MQTT uses a PUSH/SUBSCRIBE topology to run on top of TCP/IP.
- There are two sorts of systems in MQTT architecture: clients and brokers.
- The server with which the clients communicate is known as a broker.
- Client communications are received by the broker, who then forwards them to other clients.
- Clients connect to the broker rather than communicating directly with one another.
- Each customer can be a publisher, a subscriber, or both at the same time.
- MQTT is a protocol that is triggered by events.
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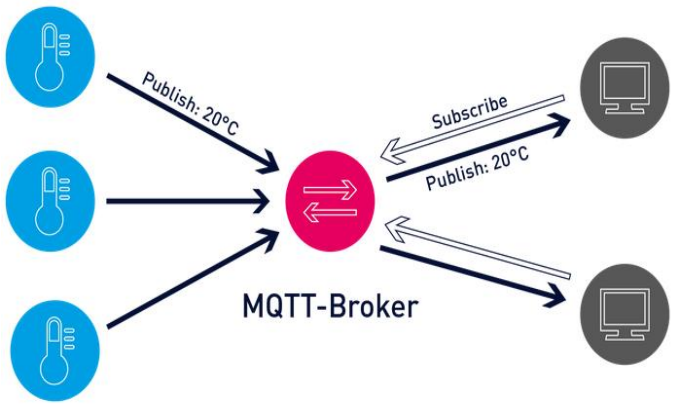


Figure 4.3: Message Queing Telemetry Transport (https://www.paessler.com/it-explained/mqtt/)

Chapter 5
IoT Project Development

IoT Project Development
IoT Platform As A IoT Middleware

- Internet of Things middleware is software that serves as an interface between components of the IoT, making communication possible among elements that would not otherwise be capable.
- IoT platform as the middleware IoT platforms originated in the form of IoT middleware, which purpose was to function as a mediator between the hardware and application layers.
- Its primary tasks included data collection from the devices over different protocols and network topologies, remote device configuration and control, device management, and over the air firmware updates.
- To be used in real-life heterogeneous IoT ecosystems, IoT middleware is expected to support integration with almost any connected device and blend in with third-party applications used by the device.
- This independence from underlying hardware and overhanging software allows a single IoT platform to manage any kind of connected device in the same straightforward way.

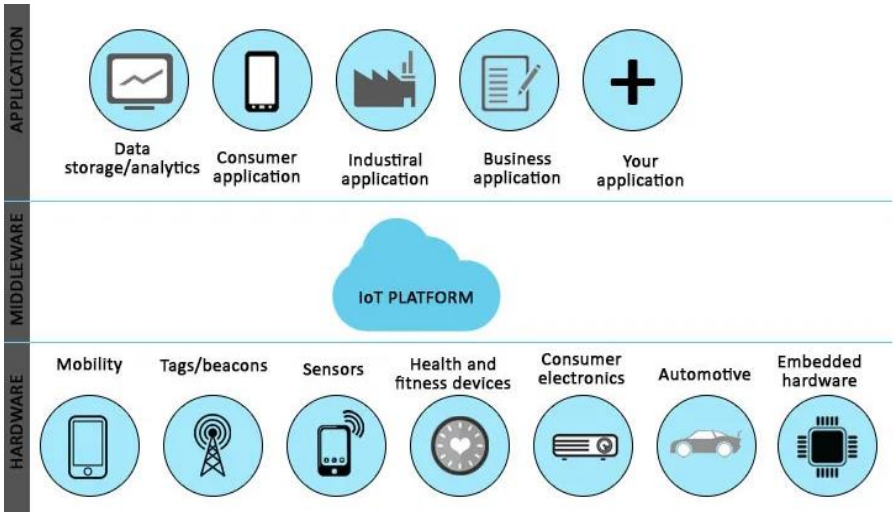


Figure 5.1: IoT As A Middleware
(https://medium.com/schaffen-softwares/)

IoT Project Development

General Services of IoT

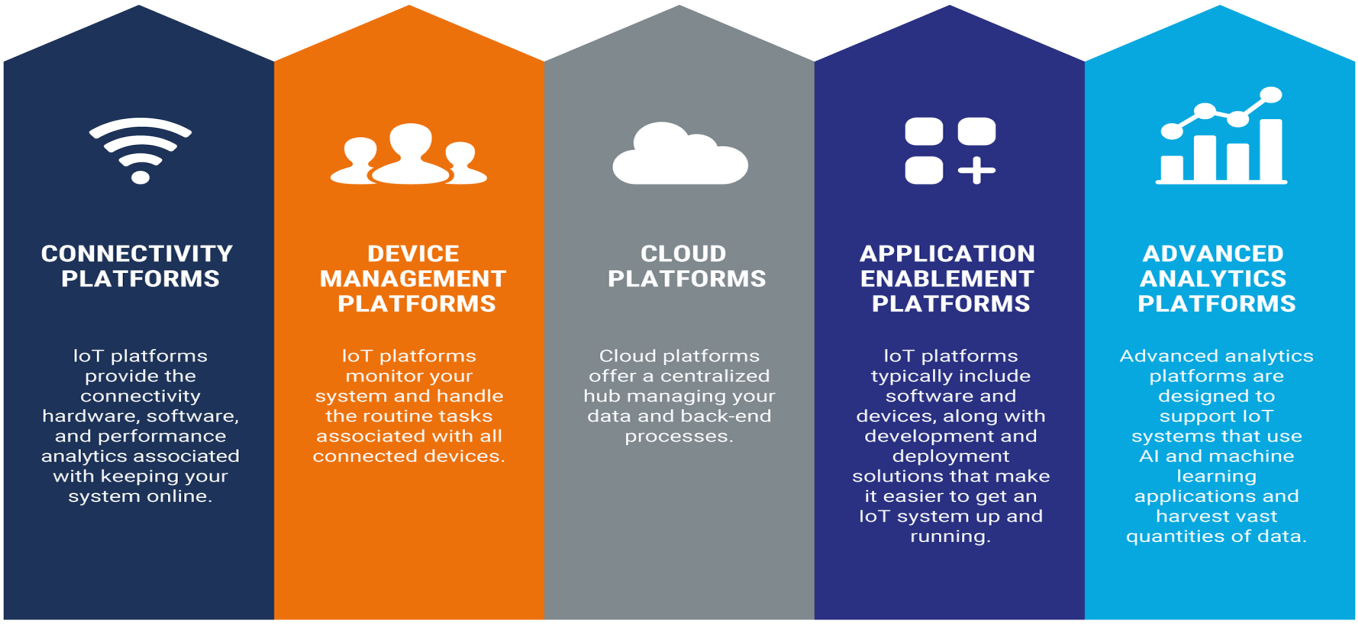


Figure 5.2: General Services of IoT
(https://www.3pillarglobal.com/)

- IoT platforms are middleware, which means they're intended to operate as a link between the hardware and application levels.
- Platforms facilitate connectivity with third-party apps, sensors, legacy equipment, and other connected devices in heterogeneous IoT environments, allowing enterprises to manage all operations in a consistent manner.
- Platforms, similar to the operating system of a computer, handle application functionality, devices, and data flow, as well as facilitating smooth connectivity throughout the whole IoT system.
- While IoT platform solutions vary greatly, they often include the following features: Connect gadgets, sensors, and machines, among other things.
- Handle a variety of different communication protocols.
- Devices, data, and networks should all be kept safe. Capture, analyze, and arrange data from a variety of sources.

IoT Project Development

IoT Application
Embedded System Board Based On Theme

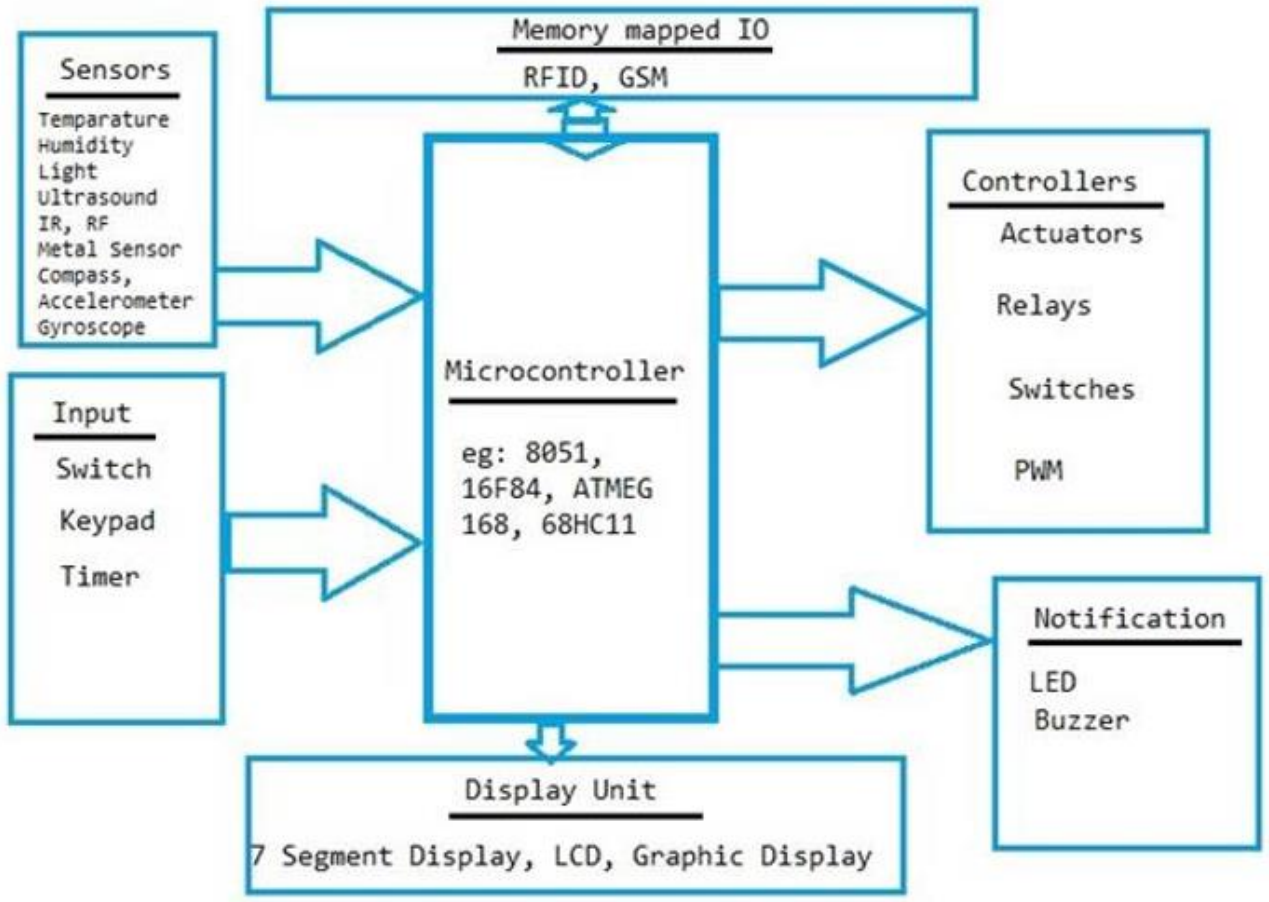


Figure 5.3: Embedded System Board Based On Theme
(https://www.codeproject.com/Articles/832492/)

IoT Project Development

IoT Application
Embedded System Board Based On Theme

- The fundamental embedded system can be given as a board with certain plug and play capabilities.
- The IoT refers to embedded systems and smart devices that are linked to the internet and have a unique IP address that can be identified and communicated via the internet.
- IoT devices may include external components such as actuators and sensors.
- Mobile phones are one of the most ubiquitous items we notice in our daily lives.
- A mobile phone is essentially an embedded system with a CPU, display, and keypad at its heart. They work with a wide range of sensors, including ambient light sensors, accelerometers, and gyroscopes, among others.
- They have access to the internet. IP addresses are assigned to mobile phones, allowing them to connect to the internet.
- To put it another way, it practically matches every definition of IoT.

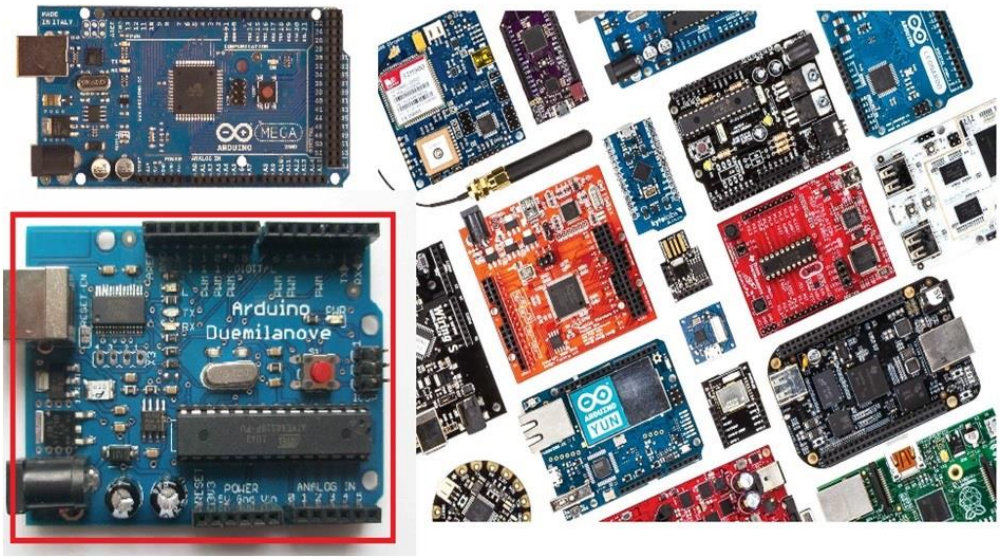


Figure 5.4: Different Embedded System Board
(https://www.codeproject.com/Articles/832492/)

IoT Project Development

IoT Application
Embedded System Board Based On Theme

- Any devices in a network must have unique IP addresses in order to be discovered.
- Because the number of IoT devices on the internet is predicted to exceed 20 billion, and IPv4 can only accommodate up to 4 billion unique addresses, IoT devices will mostly use the IPv6 addressing method.
- All of these devices have type v6 IP addresses that are either fixed or subnet masked.
- IoT devices are discoverable on the internet as independent nodes because to their unique IP address This is the most crucial notion to remember while learning about IoT.

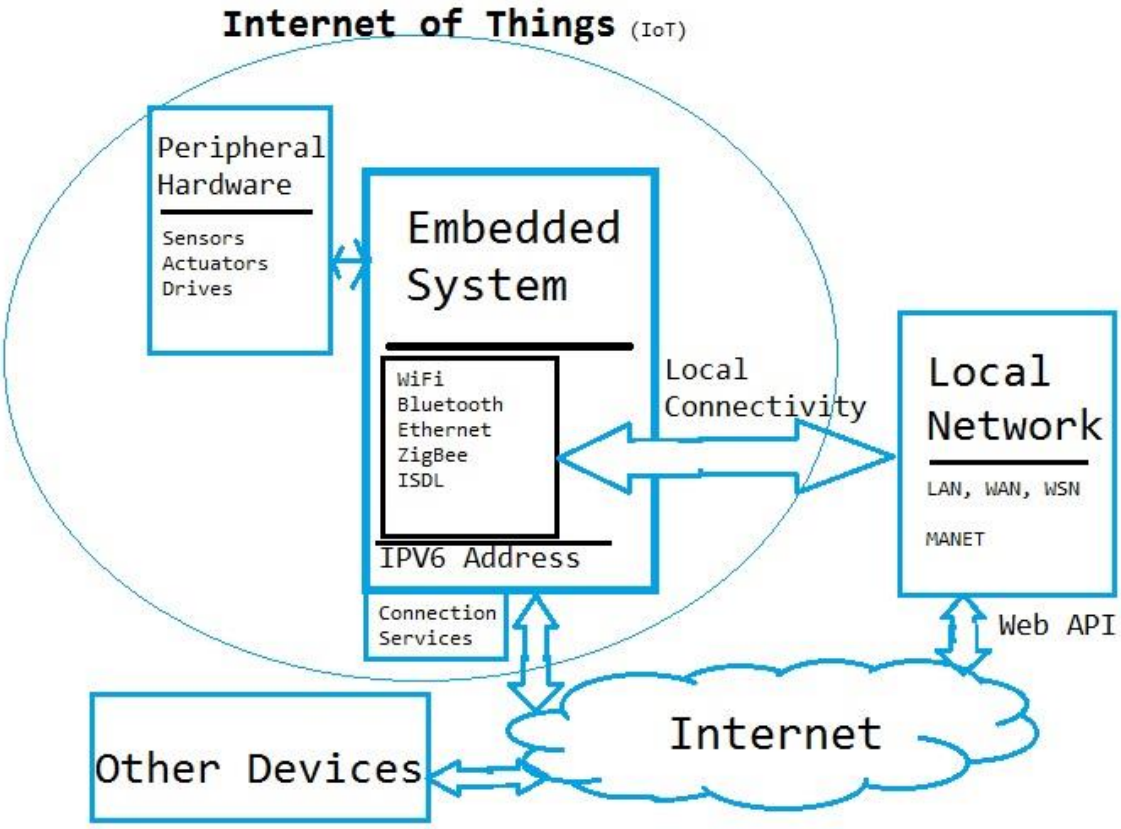
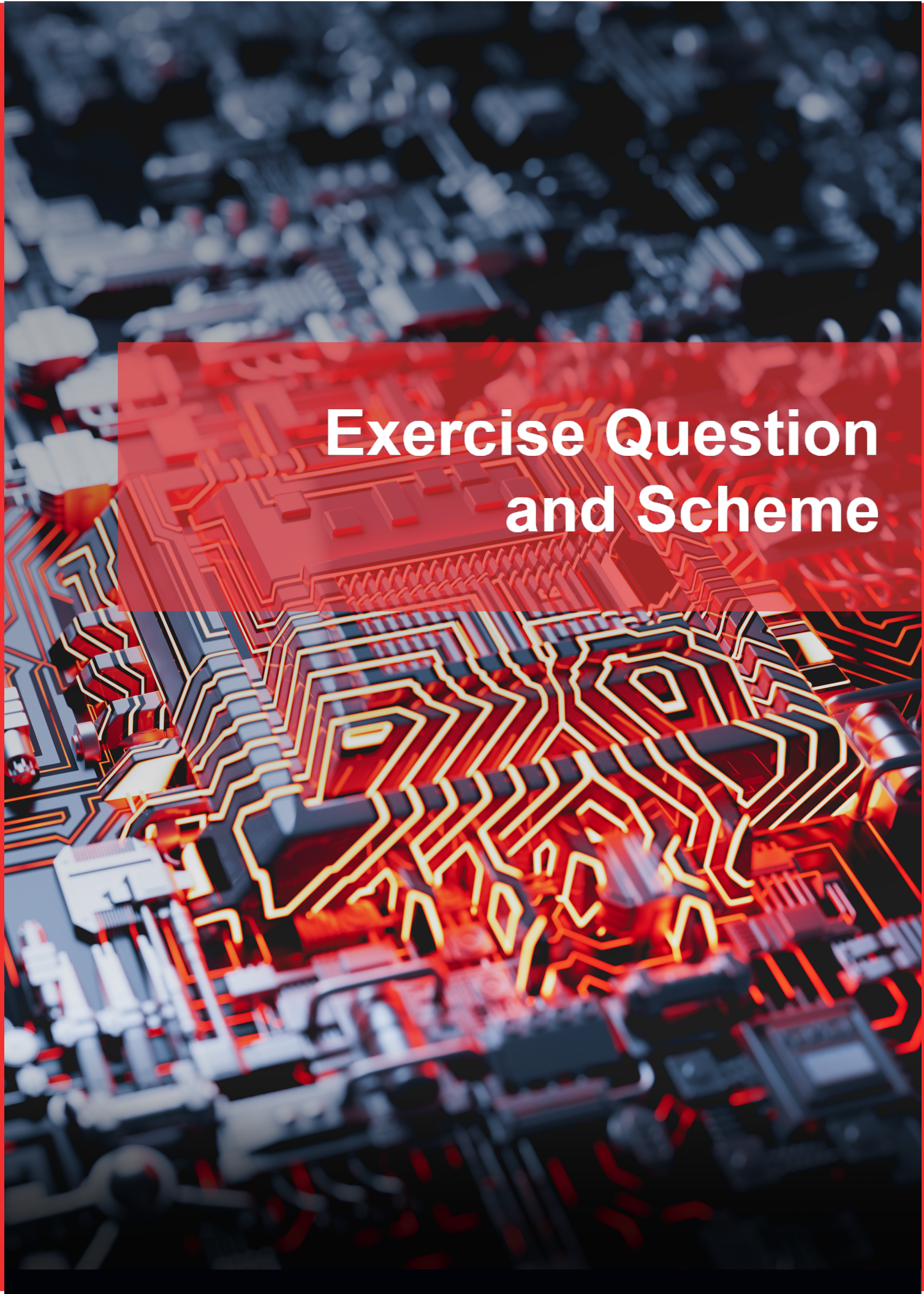


Figure 5.5: Embedded System in IoT Architecture (https://www.codeproject.com/Articles/832492/)



Exercise Question and Scheme

Question Set 1

Answer **ALL** questions

Section A: Objective Question

INSTRUCTION: ANSWER ALL QUESTIONS

1. Give the definition Internet of Things?

_____

_____

_____

(2 mark)

2. Explain IoT Technology:

i. Hardware

_____

_____

_____

ii. Software

_____

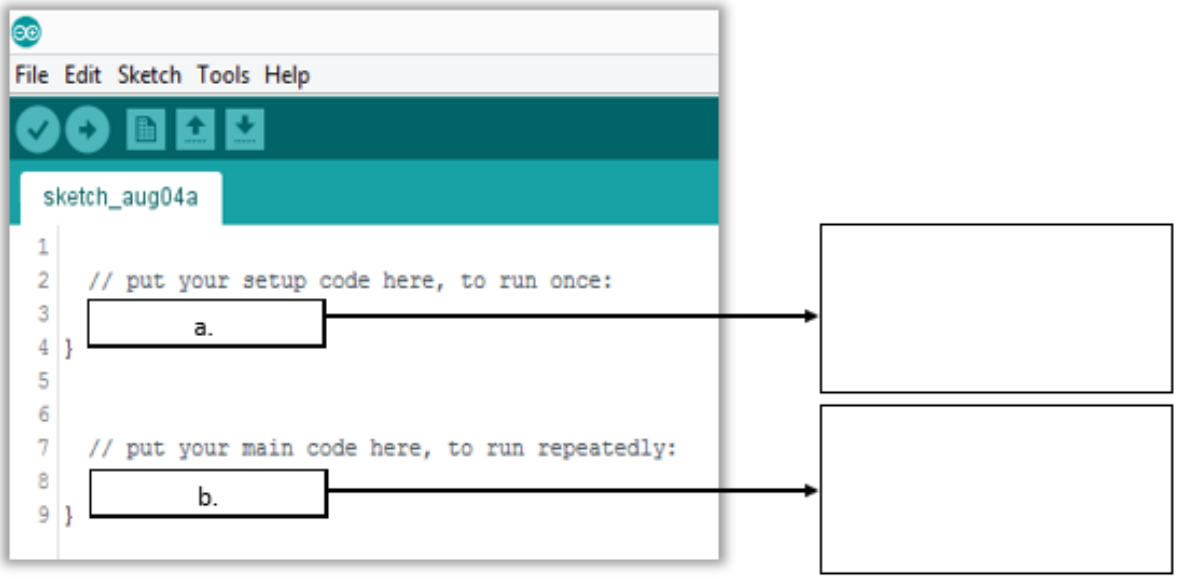
_____

_____

(5 marks)

3(a.) Figure 1 shows the IDE using Arduino. Complete the missing codes in the basic programming at line 1 and line 6.

(3 marks)



Answer Set 1

Answer **ALL** questions

Section A: Objective Question

INSTRUCTION: ANSWER ALL QUESTIONS

1. Give the definition Internet Of Things?

The Internet of Things (IoT) is the network of physical object or "things" embedded with electronics, software, sensors and network connectivity which enables these objects to collect and exchange data.

[2 mark]

2. Explain IoT technology:
   - **i. Hardware**

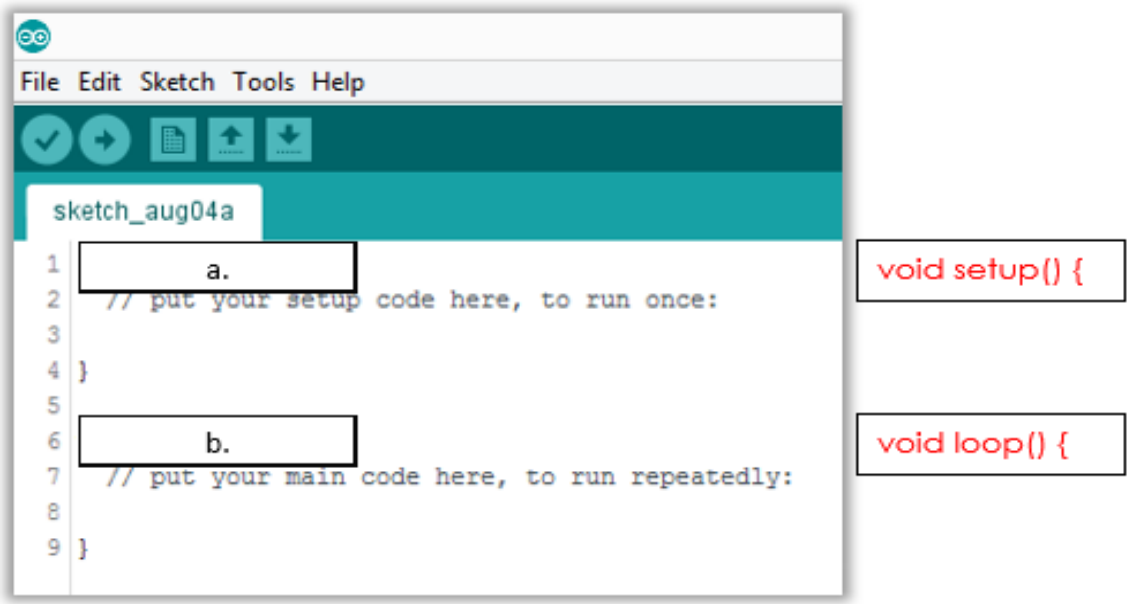
The most important hardware in IoT lies with its sensors. These devices consist of energy modules, power management modules, RF modules, and sensing modules. RF modules manage communications through their signal processing, WiFi, ZigBee, Bluetooth, radio transceiver, duplexer, and BAW.

   - **ii. Software**

IoT software addresses its key areas of networking and action through platforms, embedded systems, partner systems, and middleware. These individual and master applications are responsible for data collection, device integration, real-time analytics, and application and process extension within the IoT network. They exploit integration with critical business systems (e.g.,ordering systems, robotics, scheduling, and more) in the execution of related tasks.

[5 marks]

3(a.) Figure 1 shows the IDE using Arduino. Complete the missing codes in the basic programming at line 1 and line 6.



Question Set 2

Section A : STRUCTURE QUESTION

INSTRUCTION : ANSWER ALL QUESTIONS

1. Describe a Wired Technology in Internet Connectivity.

_____

_____

_____

(2 mark)

2. Explain the background of Wireless Sensor Network (WSN) and its applications.

_____

_____

_____

_____

_____

_____

_____

_____

(5 marks)

3. Demonstrate a Wireless Sensor Network (WSN) applications in:

i) Building Automation
ii) Medical Application

(8 marks)

Answer Set 2

Section A : STRUCTURE QUESTION

INSTRUCTION : ANSWER ALL QUESTIONS

1. Describe a Wired Technology in Internet Connectivity.

Wired Technology refers to the transmission of data over a wire-based communication technology.
Examples: telephone networks, cable television, internet access and fibre-optic communication

[2 mark]

2. Explain the background of Wireless Sensor Network (WSN) and its applications.

- A wireless sensor network is a group of specialized transducers with a communications infrastructure for monitoring and recording conditions at diverse locations.
- Commonly monitored parameters are temperature, humidity, pressure, wind direction and speed, illumination intensity, vibration intensity, sound intensity, power-line voltage, chemical concentrations, pollutant levels and vital body functions.
- A sensor network consists of multiple detection stations called sensor nodes, each of which is small, lightweight and portable.
- The transducer generates electrical signals based on sensed physical effects and phenomena.

Applications:
- Industrial automation, Automated and smart homes, Video surveillance, Traffic monitoring, Medical device monitoring, Monitoring of weather conditions, Air traffic control, Robot control.

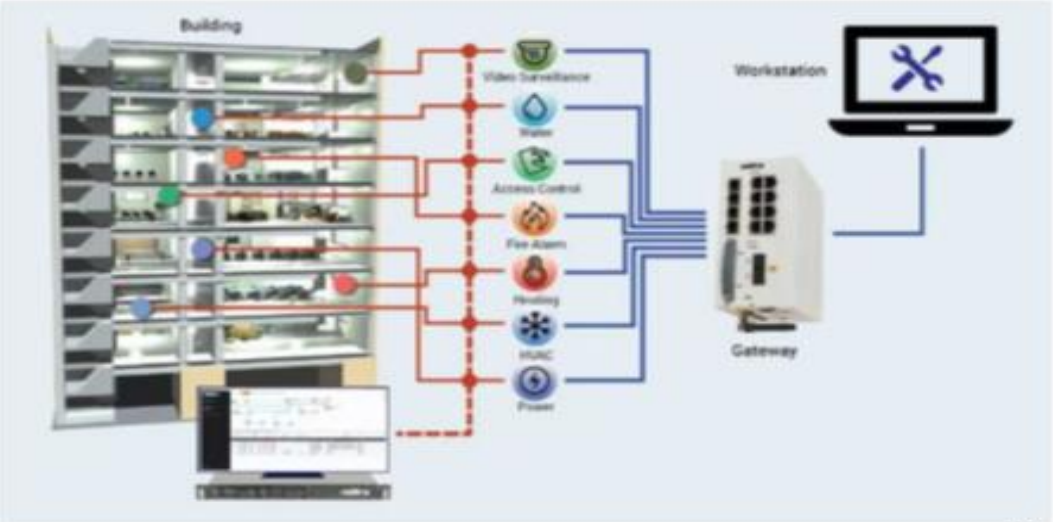
[5 marks]

3. Demonstrate a Wireless Sensor Network (WSN) applications in :

i.) Building Automation

- Building automation is the automatic centralized control of a building's heating, ventilation and air conditioning, lighting and other systems through a building management system or building automation system (BAS).
- WSN prove to be more reliable and efficient than traditional systems that employ cabled networks.

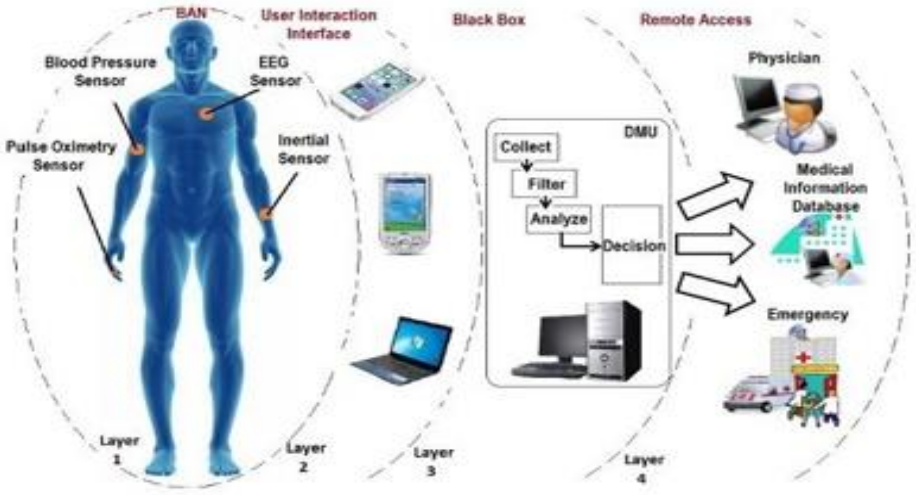
Answer Set 2



[4 marks]

ii.) Medical Application

- Wireless sensor network benefits are being explored by many hospitals and medical centres around the world.
- Sensors can be implanted in patient body or connected to him in order to collect information about his vital signs such as heart beat, blood pressure and oxygen level in blood.
- This information can be transferred patient's medical record for future examinations and long-term inspections.
- It also can be displayed in real-time or alert physicians based on the sensor program in case of any sudden change in under-care patient condition.



[4 marks]

Question Set 3

Answer **ALL** questions

Section A: Objective Question

INSTRUCTION: ANSWER ALL QUESTIONS

QUESTION 1

a. Describe the basic concept of IoT?

(1 mark)

_____

_____

_____

b. Give **TWO (2)** of the IoT application:

(2 marks)

_____

_____

_____

_____

_____

QUESTION 2

A sensor is a device that detects and responds some type of input from the physical environment.

a. Illustrate list of **FOUR (4)** types of sensors?

(4 marks)

i. _____

ii. _____

iii. _____

iv. _____

b. Give **ONE (1)** situation to apply one of the sensors mentioned an above.

_____

_____

(3 marks)

Question Set 3

QUESTION 3

Develop a programming that refer to the statements below.

Encik Ahmad wants to develop SINGBOARD at a small room. The purpose is to notify the user that the room is in use. One microcontroller and one small Lamp are used. He must produce a programming language using Arduino Integrated Development Environment (IDE) platform. The small lamp needs ON and OFF repeatedly.

[10 marks]

Answer:

Answer Set 3

Answer **ALL** questions

Section A: Objective Question

INSTRUCTION: ANSWER ALL QUESTIONS

QUESTION 1

a. Describe the basic concept of IoT?

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

[1 mark]

b. Give **TWO (2)** of the IoT application **(choose any TWO)**

Smart Home
A smart home is a residence that uses internet-connected devices to enable the remote monitoring and management of appliances and systems, such as lighting and heating.

Smart City
Uses different types of electronic Internet of things (IoT) sensors to collect data and then use these data to manage assets and resources efficiently.

Smart Grids
The Smart Grid is part of an IoT framework, which can be used to remotely monitor and manage everything from lighting, traffic signs, traffic congestion, parking spaces, road warnings, and early detection of things like power influxes as the result of earthquakes and extreme weather.

Industrial Internet
Refers to interconnected sensors, instruments, and other devices networked together with computers, industrial applications, including manufacturing and energy management.

[2 marks]

Answer Set 3

QUESTION 2

A sensor is a device that detects and responds some type of input from the physical environment.

a. Illustrate list of **FOUR (4)** type of sensors.

(4 marks)

1. Force and Pressure Sensor
2. Temperature and Humidity
3. Biosensor
4. Velocity and Acceleration

b. Give **ONE (1)** situation to apply one of the sensors mentioned an above.

(3 marks)

1. **Force And Pressure Sensor**
   Force sensors detect whether a physical force is applied and whether the magnitude of force is beyond a threshold. Pressure sensors are related to force sensors and measure the force applied by liquids or gases. Pressure is measured in terms of force per unit area. Example - Force gauge, viscometer, tactile sensor (touch sensor), Barometer, bourdon gauge, piezometer.

2. **Temperature and Humidity**
   Temperature sensors measure the amount of heat or cold that is present in a system. They can be broadly of two types: contact and non-contact. Contact temperature sensors need to be in physical contact with the object being sensed. Non-contact sensors do not need physical contact, as they measure temperature through convection and radiation. Example- Thermometer, calorimeter, temperature gauge.

3. **Biosensor**
   A biosensor is an analytical device, used for the detection of a chemical substance, that combines a biological component with a physicochemical detector., soil moisture sensor.

4. **Velocity and Acceleration**
   Velocity (speed of motion) sensors may be linear or angular, indicating how fast an object moves along a straight line or how fast it rotates. Acceleration sensors measure changes in velocity. Example - Accelerometer, gyroscope

Answer Set 3

QUESTION 3

Develop a programming that refer to the statements below.

Encik Ahmad wants to develop SINGBOARD at a small room. The purpose is to notify the user that the room is in use. One microcontroller and one small Lamp are used. He must produce a programming language using Arduino Integrated Development Environment (IDE) platform. The small lamp needs ON and OFF repeatedly.

[10 marks]

Answer:

```
void setup()                          _____ 1
{                                     _____ 0.5
   pinMode(Lamp1, OUTPUT);            _____ 2
}                                     _____ 0.5

void loop()                           _____ 1
{                                     _____ 0.5
 digitalWrite(Lamp1, HIGH);           _____ 1
 delay(1000);                         _____ 1

 digitalWrite(Lamp1, LOW);            _____ 1
 delay(1000);                         _____ 1
}                                     _____ 0.5
```

Question Set 4

Answer **ALL** questions.

Subjective Questions

INSTRUCTION: ANSWER ALL QUESTIONS

QUESTION 1

(a.) Give 5 point to describe the basic concepts of IoT, refer to the Figure 1: Smart Home.

Figure 1: Smart Home

1. _____

2. _____

3. _____

4. _____

5. _____

[10 marks]

Question Set 4

(b.) What are the main parts of IoT systems, and draw an example of IoT Wireless Communication.

[6 marks]

QUESTION 2

(a.) Describe the situation actuator complement to a sensor signal into an action.
Refer to the Figure 2: Sensor to actuator flow.

[10 marks]

1. _____
2. _____
3. _____
4. _____
5. _____

Question Set 4

(b.) Write a successful coding to make sure **LED at Node MCU ESP 8266 WILL START BLINKING.**

[10 marks]

QUESTION 3

(a.) There are several types of wireless communication technology. Describe the characteristics of LORA and Bluetooth technologies.

LORA

1._____

2._____

Bluetooth

1._____

2._____

[4 marks]

Question Set 4

(b.) Wireless Sensor Network consists of multiple detection stations called sensor nodes. Every sensor node is equipped with a transducer, microcomputer, transceiver and power source. Implement the Wireless Sensor Network in home automation application to control 3 output if the user is not at home by draw the situation.

[5 marks]

Question Set 4

(c.) For the following coding, write the output at serial monitor if it is successfully connected to wifi and the IP address is 192.168.7.1

[5 marks]

```
const char* ssid = "myNetwork";
const char* password = "abc1234";

// Wait for connection
  while (WiFi.status() != WL_CONNECTED)
{
  delay(500);
  Serial.print(".");
}
Serial.println("");
Serial.print("Connected to ");
Serial.println(ssid);
Serial.print("IP address: ");
Serial.println(WiFi.localIP());
```

Answer:

Answer Set 4

Answer **ALL** questions.

Subjective Questions

INSTRUCTION: ANSWER ALL QUESTIONS

QUESTION 1

(a.) Give 5 point to describe the basic concepts of IoT, refer to the Figure 1: Smart Home.
(Student can use their own word or ideas)

Figure 1: Smart Home

1. Internet of Things can connect devices embedded in various systems to the internet. When devices/objects can represent themselves digitally, they can be controlled from anywhere.

2. The connectivity then helps us capture more data from more places, ensuring more ways of increasing efficiency.

3. Smart home technology, also often referred to as home automation provides homeowners security, comfort, convenience and energy efficiency by allowing them to control smart devices, often by a smart home app on their smartphone or other networked device.

4. A part of the internet of things (IoT), smart home systems and devices often operate together, sharing consumer usage data among themselves and automating actions based on the homeowners' preferences.

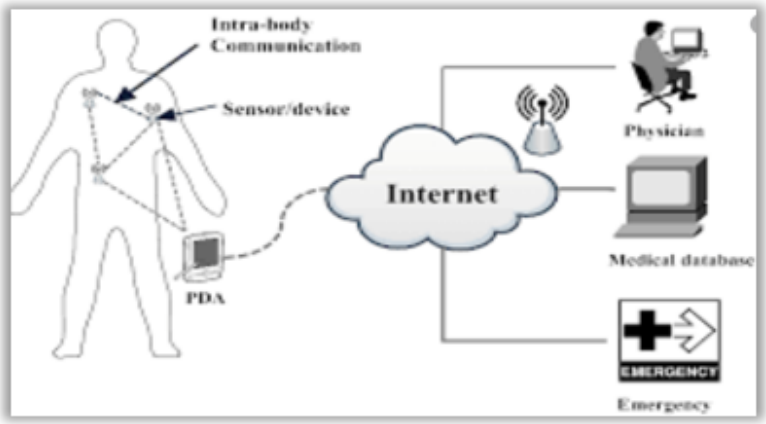
5. A smartphone application is used to control and monitor home function using wireless communication techniques.

[10 marks]

Answer Set 4

(b.) What are the main parts of IoT systems, and draw an example of IoT Wireless Communication
(Student can use their own drawing and ideas)

1. Sensors
2. Network connectivity
3. Data storage applications



[6 marks]

QUESTION 2

(a.) Describe the situation actuator complement to a sensor signal into an action.
(Student can use their own drawing and ideas)

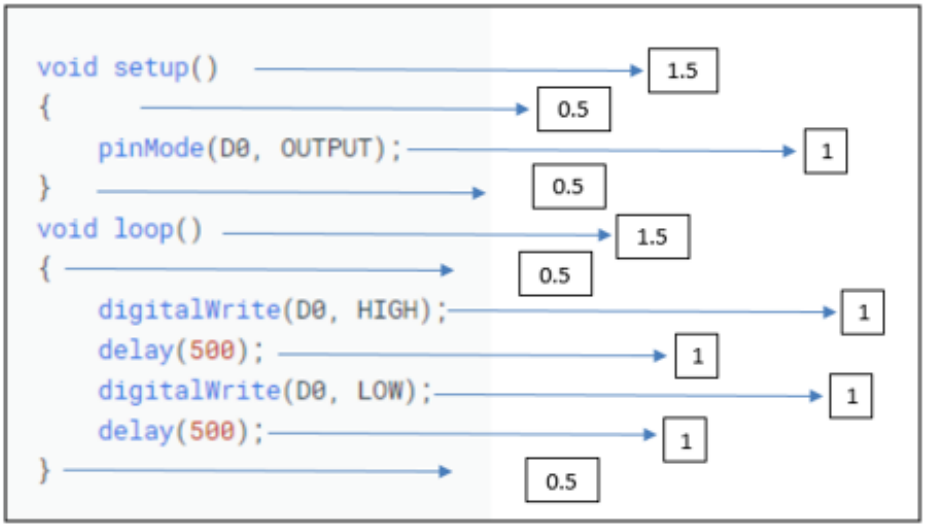
[10 marks]

In typical IoT systems, a sensor may collect information and route to a control center where a decision is made and a corresponding command is sent back to an actuator in response to that sensed input. There are many different types of sensors. Flow sensors, temperature sensors, voltage sensors, humidity sensors, and the list goes on. In addition, there are multiple ways to measure the same thing. For instance, airflow might be measured by using a small propeller like the one you would see on a weather station. Alternatively, as in a vehicle measuring the air through the engine, airflow is measured by heating a small element and measuring the rate at which the element is cooling.

Answer Set 4

(b.) Write a successful coding to make sure **LED at Node MCU ESP 8266 WILL START BLINKING.**

[10 marks]



QUESTION 3

(a.) There are several types of wireless communication technology. Describe the characteristics of LORA and Bluetooth technologies.

LORA

1. low power wireless device (1m)
2. for long range (1m)

Bluetooth

1. for short range transmission (1m)
2. low power signal (1m)

[4 marks]

Answer Set 4

For the following coding, write the output at serial monitor if it is successfully connected to wifi and the IP address is 192.168.7.1

[5 marks]

```
const char* ssid = "myNetwork";
const char* password = "abc1234";

// Wait for connection
  while (WiFi.status() != WL_CONNECTED)
{
  delay(500);
  Serial.print(".");
 }
 Serial.println("");
 Serial.print("Connected to ");
 Serial.println(ssid);
 Serial.print("IP address: ");
 Serial.println(WiFi.localIP());
```

.....	(1 m)
Connected to myNetwork	(2m)
IP address: 192.168.7.1	(2m)

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INTERNET BASE CONTROLLER