# Unit 5
# Embedded Suite for IoT

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# Introduction to Raspberry Pi

- Raspberry Pi is a small single-board computer. By connecting peripherals like Keyboard, mouse, display to the Raspberry Pi, it will act as a mini personal computer.
- Raspberry Pi is slower than a laptop or desktop but is still a computer that can provide all the expected features or abilities, at low power consumption.
- Raspbian OS is an official Operating System available for free to use. Raspbian has GUI which includes tools for Browsing, Python programming, office, games, etc.
- SD card (minimum 8 GB recommended) to store the OS (operating System).
- It has ARM based Broadcom Processor SoC along with on-chip GPU (Graphics Processing Unit).
- The CPU speed of Raspberry Pi varies from 700 MHz to 1.2 GHz. Also, it has on-board SDRAM that ranges from 256 MB to 1 GB.

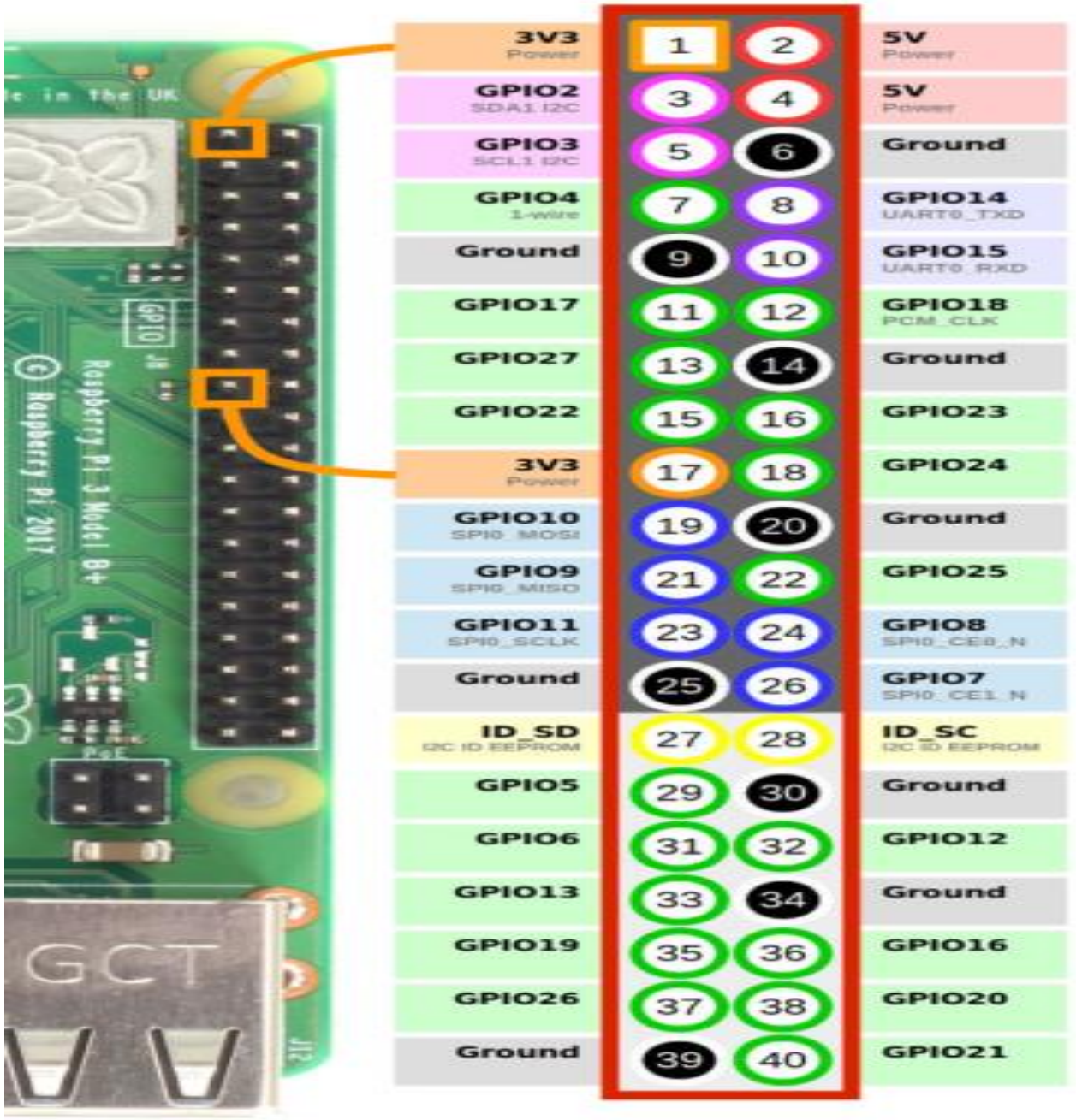
| Features | Raspberry Pi Model B+ | Raspberry Pi 2 Model B | Raspberry Pi 3 Model B | Raspberry Pi zero |
|---|---|---|---|---|
| **SoC** | BCM2835 | BCM2836 | BCM2837 | BCM2835 |
| **CPU** | ARM11 | Quad Cortex A7 | Quad Cortex A53 | ARM11 |
| **Operating Freq.** | 700 MHz | 900 MHz | 1.2 GHz | 1 GHz |
| **RAM** | 512 MB SDRAM | 1 GB SDRAM | 1 GB SDRAM | 512 MB SDRAM |
| **GPU** | 250 MHz Videocore IV | 250MHz Videocore IV | 400 MHz Videocore IV | 250MHz Videocore IV |
| **Storage** | micro-SD | Micro-SD | micro-SD | micro-SD |
| **Ethernet** | Yes | Yes | Yes | No |
| **Wireless** | WiFi and Bluetooth | No | No | No |

# Raspberry Pi

- Raspberry Pi 4 GPIO Pinout has 40 pins:
- 26 GPIO pins, two 5V pins, two 3V3 pins, and 7 ground pins (0V).
- GPIO pins of RPI 4 are capable of generating PWM output and the board supports SPI, I2C, and UART serial communication protocols.
- The Raspberry Pi 4 Model B is the latest board launched by the Raspberry Pi Foundation in June 2019.
- This model has the latest high-performance quad-Core 64-bit Broadcom 2711, Cortex A72 processor clocked at 1.5GHz speed.
- This processor uses 20% less power and offers 90% greater performance than the previous model.
- Raspberry Pi 4 model comes in three different variants of 2 GB, 4 GB, and 8 GB LPDDR4 SDRAM. (Low-Power Double Data Rate)

# Raspberry Pi 4 Specs:

- Broadcom BCM2711 chip consists of Quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
- 2GB, 4GB, and 8GB of LPDDR4 SDRAM (depending on the version of the board)
- Dual-channel 2.4/5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE
- Gigabit Ethernet
- Two USB 3.0 ports and two USB 2.0 ports.
- Raspberry Pi standard 40 pin GPIO header
- Two micro-HDMI ports (support up to 4kp60 resolution)
- 2-lane MIPI DSI display port
- 2-lane MIPI CSI camera port
- 4-pole stereo audio and composite video port
- Micro-SD card slot for loading operating system and data storage
- Operating temperature: 0 – 50$^{o}$C


3V3 Power
1
2
5V Power
GPIO2 SDA1 I2C
3
4
5V Power
GPIO3 SCL1 I2C
5
6
Ground
GPIO4 1-wire
7
8
GPIO14 UART0_TXD
Ground
9
10
GPIO15 UART0_RXD
GPIO17
11
12
GPIO18 PCM_CLK
GPIO27
13
14
Ground
GPIO22
15
16
GPIO23
3V3 Power
17
18
GPIO24
GPIO10 SPI0_MOSI
19
20
Ground
GPIO9 SPI0_MISO
21
22
GPIO25
GPIO11 SPI0_SCLK
23
24
GPIO8 SPI0_CE0_N
Ground
25
26
GPIO7 SPI0_CE1_N
ID_SD I2C ID EEPROM
27
28
ID_SC I2C ID EEPROM
GPIO5
29
30
Ground
GPIO6
31
32
GPIO12
GPIO13
33
34
Ground
GPIO19
35
36
GPIO16
GPIO26
37
38
GPIO20
Ground
39
40
GPIO21


| | | | |
|---|---|---|---|
| 3.3v | 1 | 2 | 5V |
| GPIO 2 Serial Data (I2C) | 3 | 4 | 5V |
| GPIO3 Serial Clock (I2C) | 5 | 6 | Ground |
| GPIO 4 | 7 | 8 | GPIO 14 (UART TX) |
| Ground | 9 | 10 | GPIO 15 (UART RX) |
| GPIO 17 Chip Enable-CE1 (SPI1) | 11 | 12 | GPIO 18 Chip Enable-CE0 (SP1) [PWM] |
| GPIO 27 | 13 | 14 | Ground |
| GPIO 22 | 15 | 16 | GPIO 23 |
| 3.3v | 17 | 18 | GPIO 24 |
| GPIO 10 MOSI (SPI 0) | 19 | 20 | Ground |
| GPIO 09 MISO (SPI 0) | 21 | 22 | GPIO 25 |
| GPIO 11 SCLK (SPI 0) | 23 | 24 | GPIO 8 Chip Enable-CE0 (SPI0) |
| Ground | 25 | 26 | GPIO 7 Chip Enable-CE1(SPI0) |
| GPIO 0 EEPROM Serial DATA (I2C) | 27 | 28 | GPIO 1 EEPROM Serial Clock (I2C) |
| GPIO 5 | 29 | 30 | Ground |
| GPIO 6 | 31 | 32 | GPIO 12 (PWM) |
| GPIO 13 (PWM) | 33 | 34 | Ground |
| [PWM] GPIO 19 MISO (SPI 1) | 35 | 36 | GPIO 16 Chip Enable-CE2 (SPI 1) |
| GPIO 26 | 37 | 38 | GPIO 20 MISO (SPI 1) |
| Ground | 39 | 40 | GPIO 21 SCLK (SPI 1) |

# Raspberry Pi 4 Board Layout:

- **CPU:** It consists of a Broadcom BCM2711 chip which contains a 1.5GHz 64-bit quad-core ARM Cortex-A72 processor (using an ARMv8-architecture core).
- **GPU:** Broadcom VideoCore VI @ 500 MHz  was released in 2009.
- **RAM:** It comes with 2GB, 4GB, and 8GB (depends on different versions) variants of LPDDR4 SDRAM
- **USB port:** It consists of two USB 3.0 and two USB 2.0 ports to connect it to an external keyboard, mouse, or other peripheral devices.
- **HDMI port:** Two micro HDMI ports capable of supporting up to  4k@60HZ resolution.
- **Ethernet Port:** It comes with true Gigabit Ethernet capable of sending *Ethernet* frames at a rate of one *gigabit* per second (1 billion bits per second).
- **Composite Video Output:** Both the audio output socket and the video composite socket reside in a single 4-pole 3.5mm socket.

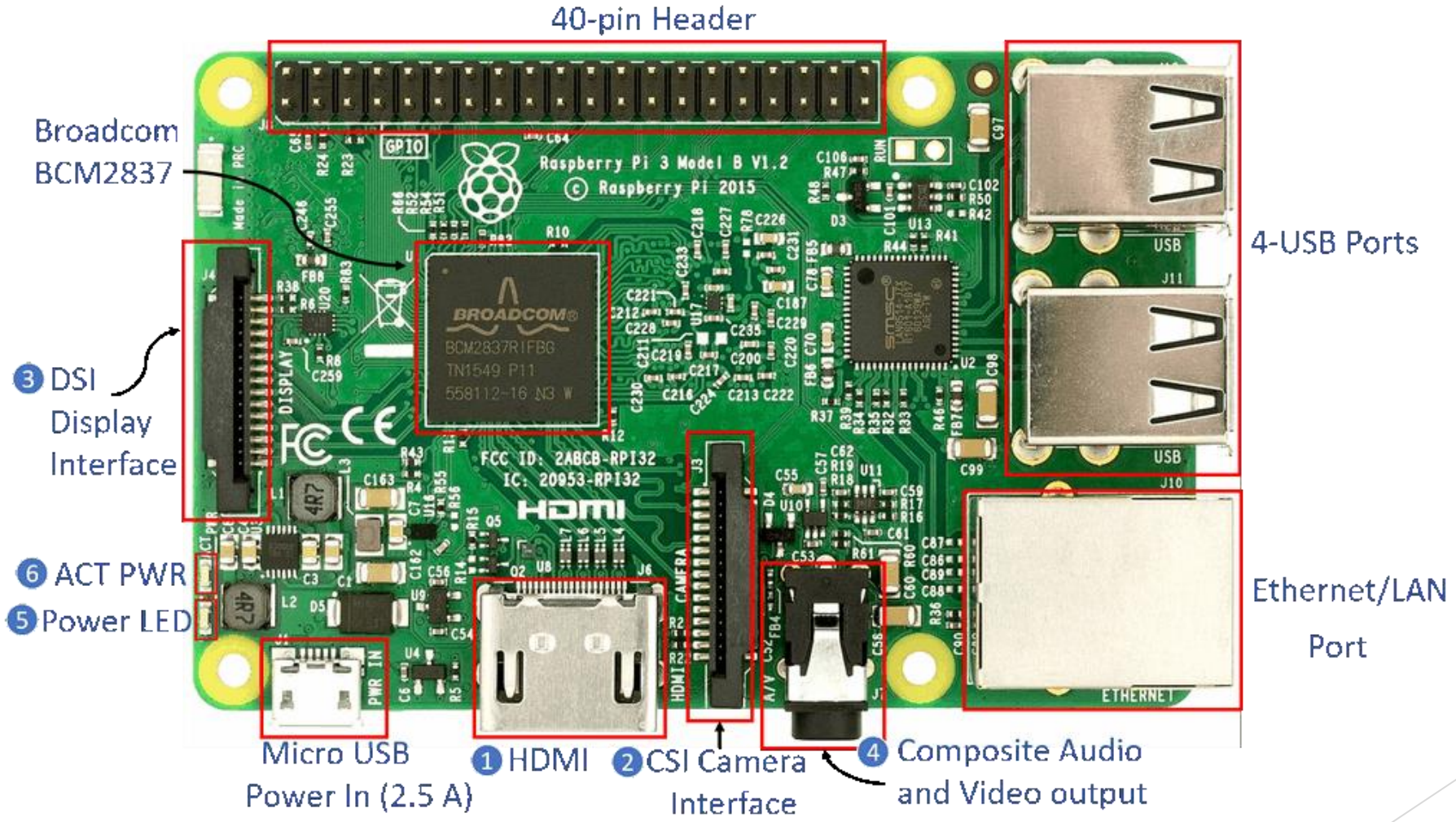
# Raspberry Pi 4 Board Layout:

- **SD card Slot:** A micro-SD card slot is used for booting up the operating system and storage purposes.
- This model B consists of a 40-pin GPIO header. Out of these 40 pins, 26 pins are GPIO pins.
- The raspberry pi 4 model B board consists of two 5V pins, two 3V3 pins, and 7 ground pins (0V).
- A pin that can be set as an input or output and is controlled in run time is called a GPIO pin.
- Input voltage between 1.8V and 3.3V is read as HIGH by the Raspberry pi. And when the input voltage is lower than 1.8V, it is read as LOW.
- PWM (pulse-width modulation) pins:
- Hardware PWM is available on these pins only: GPIO12, GPIO13, GPIO18, GPIO19.

# Raspberry Pi 4 Board Layout:

- SPI pins on RPi 4:
- SPI (Serial Peripheral Interface) is a type of serial communication protocol. It is used by the Raspberry Pi for master-slave communication to quickly communicate between one or more peripheral devices.
- I2C Pins on RPi 4:
- I2C pins on the Raspberry Pi board are used to communicate with peripheral devices that are compatible with Inter-Integrated Circuit (a low-speed two-wire serial communication protocol).
- UART pins on RPi 4:
- The UART (Universal Asynchronous Receiver / Transmitter) is an asynchronous protocol that provides a way to communicate between two microcontrollers or devices.

# Raspberry Pi On-chip Hardware



# Hardware Components

1. **HDMI (High-Definition Multimedia Interface):** It is used for transmitting uncompressed video or digital audio data to the Computer Monitor, Digital TV, etc. Generally, this HDMI port helps to connect Raspberry Pi to the Digital television.
2. **CSI Camera Interface:** CSI (Camera Serial Interface) interface provides a connection between Broadcom Processor and Pi camera. This interface provides electrical connections between two devices.
3. **DSI Display Interface:** DSI (Display Serial Interface) Display Interface is used for connecting LCD to the Raspberry Pi using a 15-pin ribbon cable. DSI provides a fast High-resolution display interface specifically used for sending video data directly from GPU to the LCD display.
4. **Composite Video and Audio Output:** The composite Video and Audio output port carry video along with audio signal to the Audio/Video systems.
5. **Power LED:** It is a RED-colored LED that is used for Power indication. This LED will turn ON when power is connected to the Raspberry Pi. It is connected to 5V directly and will start blinking whenever the supply voltage drops below 4.63V.
6. **ACT PWR:** ACT PWR is Green LED that shows the SD card activity.

# Setup in Raspberry pi

set up BOARD and GPIO numbering schemes

- GPIO.BOARD -- Board numbering scheme. The pin numbers follow the pin numbers on header P1.
- GPIO.BCM -- Broadcom chip-specific pin numbers. These pin numbers follow the lower-level numbering system defined by the Raspberry Pi's Broadcom-chip brain.

To specify in your code which number-system is being used, use the GPIO.setmode() function.

- GPIO.setmode(GPIO.BCM) will activate the Broadcom-chip specific pin numbers

Setting a Pin Mode

- use the setup([pin], [GPIO.IN, GPIO.OUT] function
- GPIO.setup(18, GPIO.OUT)

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# Functions

Digital Output

- To write a pin high or low, use the GPIO.output ([pin], [GPIO.LOW, GPIO.HIGH]) function.

  For example, if you want to set pin 18 high, write:

- GPIO.output(18, GPIO.HIGH)

Inputs

- If a pin is configured as an input, you can use the GPIO.input([pin]).
- The input() function will return either a True or False indicating whether the pin is HIGH or LOW.

```
if GPIO.input(17):
    print("Pin 11 is HIGH")
else:
    print("Pin 11 is LOW")
```

# Functions

Delays

- If you need to slow your Python script down, you can add delays.
- To incorporate delays into your script, you'll need to include another module: time.
- import time
- time.sleep([seconds])
- You can use decimals to precisely set your delay.
- For example, to delay 250 milliseconds, write: time.sleep(0.25)

- **set up a GPIO port as an input**

```
import RPi.GPIO as GPIO
GPIO.setmode(GPIO.BCM)  # set up BCM GPIO numbering
GPIO.setup(25, GPIO.IN) # set GPIO 25 as input
```

- **Reading inputs**

```
if GPIO.input(25): # if port 25 == 1
print "Port 25 is 1/GPIO.HIGH/True"
```

```
import RPi.GPIO as GPIO
GPIO.setmode(GPIO.BCM)       # set up BCM GPIO numbering
GPIO.setup(25, GPIO.IN)      # set GPIO 25 as input

 if GPIO.input(25):           # if port 25 == 1
    print "Port 25 is 1/GPIO.HIGH/True"
else:
  print "Port 25 is 0/GPIO.LOW/False"
GPIO.cleanup()               # clean up after yourself
```

# LED Blinking

```
import RPi.GPIO as GPIO
import time
GPIO.setmode(GPIO.BCM)
GPIO.setup(12,GPIO.OUT)
GPIO.setup(16,GPIO.OUT)
GPIO.setup(20,GPIO.OUT)
GPIO.setup(21,GPIO.OUT)
```

```
while True:
GPIO.output(12,True)
GPIO.output(16,True)
GPIO.output(20,True)
GPIO.output(21,True)
time.sleep(2)
GPIO.output(12,False)
GPIO.output(16,False)
GPIO.output(20,False)
GPIO.output(21,False)
GPIO.cleanup()
```

# Web Services

- A web service is a software module that is intended to carry out a specific set of functions.
- Web services in cloud computing can be found and invoked over the network.
- web service is a set of open protocols and standards that allow data to be exchanged between different applications or systems.
- Web services can be used by software programs written in a variety of programming languages and running on a variety of platforms to exchange data via computer networks such as the Internet.
- Any software, application, or cloud technology that uses standardized web protocols (HTTP or HTTPS) to connect, interoperate, and exchange data messages – commonly XML (Extensible Markup Language) – across the internet is considered a web service.
- XML and HTTP is the most fundamental web services platform.

# Web Services

- Web services have the advantage of allowing programs developed in different languages to connect with one another by exchanging data over a web service between clients and servers.
- A client invokes a web service by submitting an XML request, which the service responds with an XML response**.**

There are a few central types of web services: XML-RPC, UDDI, SOAP, and REST

- **XML-RPC** (Remote Procedure Call) is the most basic XML protocol to exchange data between a wide variety of devices on a network.
- It uses HTTP to quickly and easily transfer data and communication other information from client to server.
- **UDDI** (Universal Description, Discovery, and Integration) is an XML-based standard for detailing, publishing, and discovering web services.
- It’s basically an internet registry for businesses around the world. The goal is to streamline digital transactions and e-commerce among company systems.

# Web Services

- **SOAP(Simple Object Access Protocol)**is an XML-based Web service protocol to exchange data and documents over HTTP or SMTP (Simple Mail Transfer Protocol).
- It allows independent processes operating on disparate systems to communicate using XML.
- **REST** provides communication and connectivity between devices and the internet for API-based tasks. Most RESTful services use HTTP as the supporting protocol.

# Application Programming Interface

- It is a software interface that allows two applications to interact with each other without any user intervention.
- APIs provides product or service to communicate with other products and services without having to know how they're implemented.
- Example: Restaurant for lunch, you go to the movie site, you enter your movie, name, and credit card information, and behold, you print out tickets.

**Need of API**

- API helps two different software's to communicate and exchange data with each other.
- It helps you to embed content from any site or application more efficiently.
- APIs can access app components. The delivery of services and information is more flexible.
- Content generated can be published automatically.
- It allows the user or a company to customize the content and services which they use the most.
- Software needs to change over time, and APIs help to anticipate changes.

# API

## Features of API

- It offers a valuable service (data, function, audience,.).
- It helps you to plan a business model.
- Simple, flexible, quickly adopted.
- Managed and measured.
- Offers great developer support.

## Types of API

- There are mainly four main types of APIs:

- **Open APIs:** These types of APIs are publicly available to use like OAuth APIs from Google. It has also not given any restriction to use them. So, they are also known as Public APIs.
- **Partner APIs:** Specific rights or licenses to access this type of API because they are not available to the public.
- **Internal APIs:** Internal or private. These APIs are developed by companies to use in their internal systems. It helps you to enhance the productivity of your teams.
- **Composite APIs:** This type of API combines different data and service APIs.

# Difference between Web Services and API

| Web Service | Application Programming Interface(API) |
| --- | --- |
| All web services are APIs. | All APIs are not web services. |
| It supports XML. | Responses are formatted using Web API's Media Type Formatter into XML, JSON, or any other given format. |
| You need a SOAP protocol to send or receive and data over the network. Therefore it does not have light-weight architecture. | API has a light-weight architecture. |
| It can be used by any client who understands XML. | It can be used by a client who understands JSON or XML. |
| Web service uses three styles: REST, SOAP, and XML-RPC for communication. | API can be used for any style of communication. |
| It provides supports only for the HTTP protocol. | It provides support for the HTTP/s protocol: URL Request/Response Headers, etc. |
| | |

# Additional information

- MIPI - Mobile Industry Processor Interface. The mobile industry processor interface (MIPI®) standard defines industry specifications for the design of mobile devices such as smartphones, tablets, laptops and hybrid devices.
- Power over Ethernet (PoE) is a technique for delivering DC power to devices over copper Ethernet cabling, eliminating the need for separate power supplies and outlets.
- Camera Serial Interface (CSI) is a camera port providing an electrical bus connection between the two devices.
- DSI stands for Display Serial Interface and it defines a high-speed serial interface between a host processor and a display module.
- JSON is an open standard file format and data interchange format that uses human-readable text to store and transmit data objects consisting of attribute-value pairs and arrays