

**Networking** is the exchange of data between devices.

Example: When you search something in Google, the Google servers send data to your computer / phone through the internet. This data reaches you after it has been routed through multiple networks, so that it can reach your device.

**Networking** can be of various types.

Networking can be local - between two devices at 10m apart from each other.

Networking can be at organization/company/institute level

Or Networking can be international (e.g. Internet, GPS, etc.)

**Networking** is a very important topic for EXTC students, especially for your projects, because networking capability can make any project much better and more useful. In this section, we will show you how you can use the networking capabilities of Raspberry Pi in your projects along with some Networking Fundamentals.

# 1. Networking Fundamentals

**What is a Network?**

Ans. A Network comprises two or more devices that exchange data.

**The Types of Networks (based on extent / coverage of network):**

1. Personal Area Network (PAN): These are networks formed within a short distance of about 10 - 20 metres radius. Examples include bluetooth networks
2. Local Area Network (LAN): These are networks formed at organization / company / institute level. E.g. Internet access provided to all labs in VESIT is a Local Area Network.
3. Wide Area Network (WAN): These are networks with nationwide / global coverage. Examples include Internet, GPS.

**Types of Networks (based on Medium of data transfer):**

1. Wired: Data transfer occurs through cables. Eg. USB cable, Ethernet, Telephone lines ADSL,
2. Wireless: Involves Electromagnetic Transmissions. E.g. RF (Radio Frequency), Microwave (millimeter waves), Radar,
3. Hybrid: Consists of both - Wired and wireless technologies. E.g. WiFi access at VESIT campus.

**Important Terms:**

1. **Protocol:** A protocol is a set of rules and mechanisms that define how communication should take place between two devices.

2. **IP Address:** An IP address is a unique address assigned to each device connected to a network that uses internet protocols.
3. **Nodes:** Each device in a network is called as Node. Nodes can receive, send, create and modify data as it travels through the network.
4. **Routers:** A Router is a communication device that moves data from one network to another.
5. **Port:** A Port is used to identify connections between two devices. A port is like an address on a device where messages are sent/received. Each message is sent to a particular device with IP Address on a particular application with port number.
6. **Peer-to-Peer Communication:** Communication between two devices. E.g. sharing files between two phones over bluetooth.

## 2. Networking Capabilities of Raspberry Pi

Raspberry Pi is a micro-computer with all modern-day communication technologies embedded on-chip. It has Bluetooth and WiFi capability. It has 4 USB Serial ports and 1 Ethernet port as well.

All of these, together make Raspberry Pi, a diverse networking device.

## 3. Wired Communication on Raspberry Pi

### 3.1. Ethernet Port

Raspberry Pi has an ethernet port to connect RJ-45 cable.

Several services can be connected using the Ethernet port like:

1. **Internet Access**
2. **Organization Intranet** - Intranet is a network which is not connected to the outside world. It is restricted within an organization.
3. **SSH (Secure Shell) Access to device** - You can connect your laptop to Raspberry Pi via RJ-45 cable and access Raspberry Pi monitor using SSH. So, you don't need to connect to an external monitor, you can view Raspberry Pi monitor on your laptop / PC using MobaXTerm and SSH (Tutorial: <https://www.youtube.com/watch?v=AJ7skYS5bjI>)

## 3.2. Serial USB Port

Raspberry Pi has 4 USB ports. USB ports can be used to interface any USB device like pendrive, WiFi dongle, Internet dongle, etc. Arduino and other embedded devices with USB interface can also be connected to Raspberry Pi via USB.

### Important terms related to USB and USB port:

1. **Baud rate:** Baud rate is the rate at which each character/symbol is transferred between two devices. Two devices should set their respective USB ports at the same baud rate for communication to take place. Standard baud rates are 1200, 2400, 4800, 9600, 19200, 38400, 76800, and so on
2. **Lock:** Whenever a program accesses a USB port, the Operating System (OS) locks the USB port to that application until the application closes the port. Only one application can access a USB port at a time.

**Note:** USB interfacing should be preferred over GPIO interfacing with embedded devices like Arduino.

## 4. Wireless Technologies

We will be now looking at 4 Wireless Networking Technologies and how to integrate these with Raspberry pi to prepare your project.

1. Bluetooth
2. WiFi
3. Zigbee
4. RFID

### 4.1. Bluetooth

Raspberry Pi has bluetooth capabilities. But let us first learn about Bluetooth.

Bluetooth is a communication protocol for sending & receiving data via 2.4 GHz wireless links.

Bluetooth is perfect for short-range, low-power applications.

Bluetooth should be used when you need peer-to-peer communication between two devices.

### Important processes in Bluetooth:

1. **Scanning / Inquiry:** Bluetooth device scans for other bluetooth devices in vicinity. If a device is found, its name, address and other information is inquired and obtained by the scanning device.

2. **Pairing:** Pairing is the process of sharing addresses, names, secret key between two bluetooth devices. Once, two devices are paired with each other, they can connect automatically when the devices are close together.

#### **Advantages of Bluetooth:**

1. Avoids interference from other wireless devices.
2. Low Power Consumption
3. Low Cost
4. No Line-of-sight required. Can transmit through obstacles like walls.

#### **Disadvantages of Bluetooth:**

1. Short-range upto 10-100 metres.
2. Can communicate with only 8 devices at a time.

## **4.2. WiFi**

WiFi is a popular communication technology for wireless local area networking. It uses the 2.4 GHz Spectrum.

WiFi acts as a wireless bridge between wired internet networks and mobile devices like smart phone, laptops, etc.

#### **Important Terms related to WiFi:**

1. **Access Point (AP):** Access Point is a WiFi device, which is also connected to some other network (mostly internet), thus providing access to the network. E.g. of Access Point is WiFi Router.
2. **Station (STA):** Station is a WiFi device which can communicate with Access Point. E.g. of station: Mobile devices like smartphones and laptops.
3. **SSID:** Service Set ID - used to identify an AP with name.

#### **Connection Process:**

1. STA scans for other WiFi devices in vicinity.
2. AP responds with its information to STA.
3. STA sends association request to AP with SSID and password
4. AP responds with Success / Failure message
5. If the Association is successful, STA & AP can start communicating with each other.

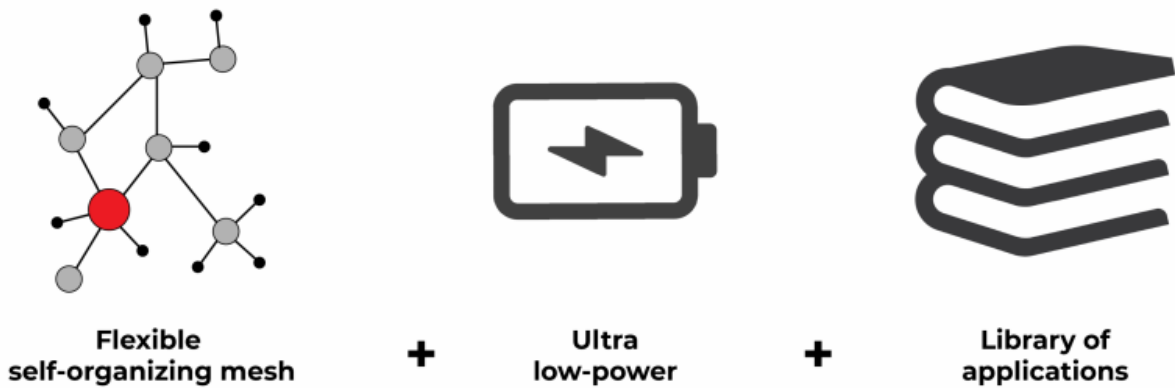
#### **Advantages of WiFi:**

1. High Data rate
2. Avoids interference from other wireless devices

#### **Disadvantages of WiFi:**

1. Low range at low power
2. Difficult to customize for custom use

### 4.3. Zigbee



#### **Advantages of WiFi:**

1. High Data rate
2. Avoids interference from other wireless devices

#### **Disadvantages of WiFi:**

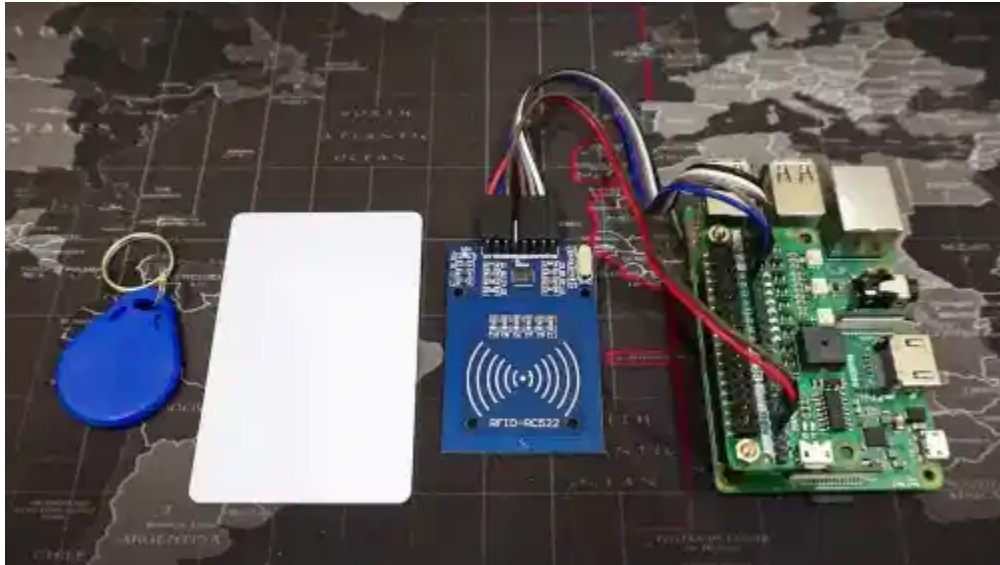
1. Low range at low power
2. Difficult to customize for custom use

### 4.4. RFID

- Radio Frequency Identity
- RFID Tag: Contains Identification information. Transmits this

Information to RFID Reader.

- RFID Reader: Reads RF Identification Information

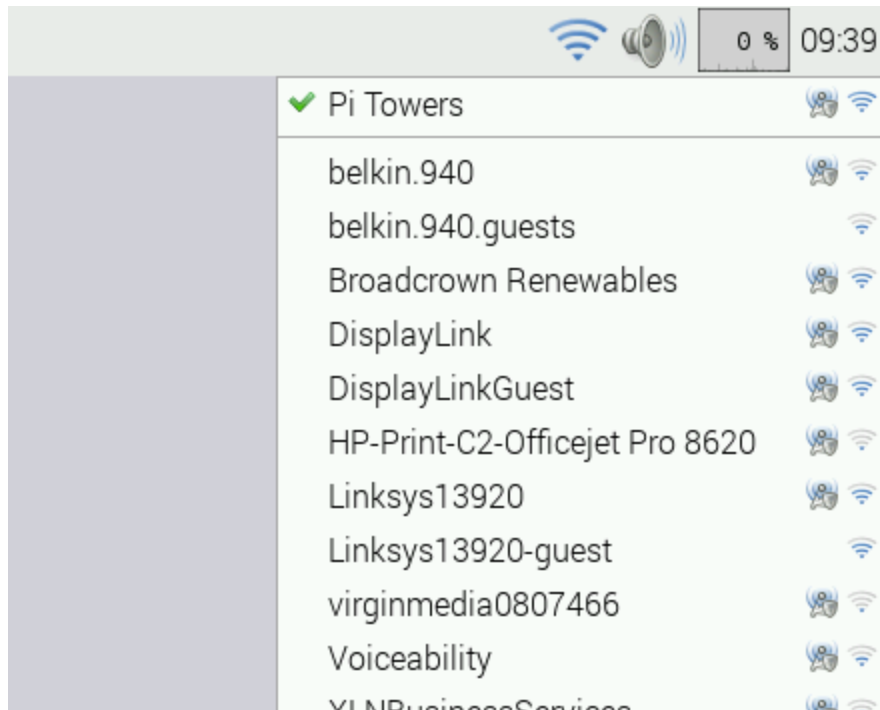


Now, that we have learned the basics of Bluetooth, WiFi, Zigbee & RFID, let us see how these technologies can be used along with Raspberry Pi.

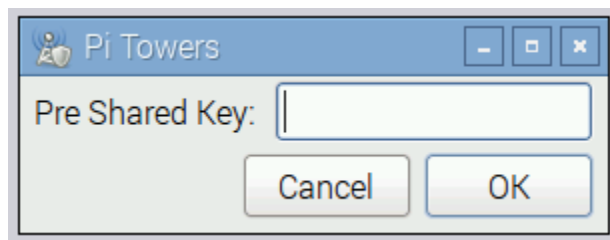
## 5. Using WiFi on Raspberry Pi

**Connecting to another WiFi Hotspot / Access Point:**

1. Check for the WiFi icon on top right of desktop in the taskbar.



2. Click on the WiFi icon and select the AP you want to connect with.
3. Enter password / key if the AP is WAP-secured.



### Setting Up / Programming WiFi functionality using Python:

wifi is a python library for scanning and connecting to wifi networks on linux. You can use it to scan and connect to wireless networks.

Learn more about this library: <https://wifi.readthedocs.io/en/latest/>

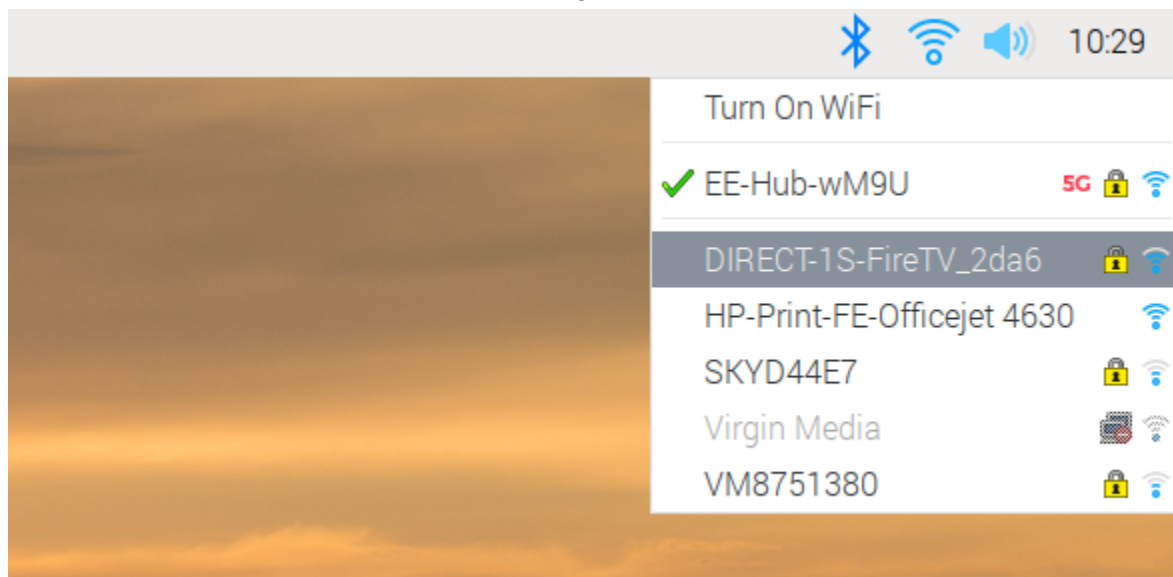
Here's more ways of setting up / using WiFi on Raspberry Pi:

<https://www.raspberrypi.org/documentation/configuration/wireless/>

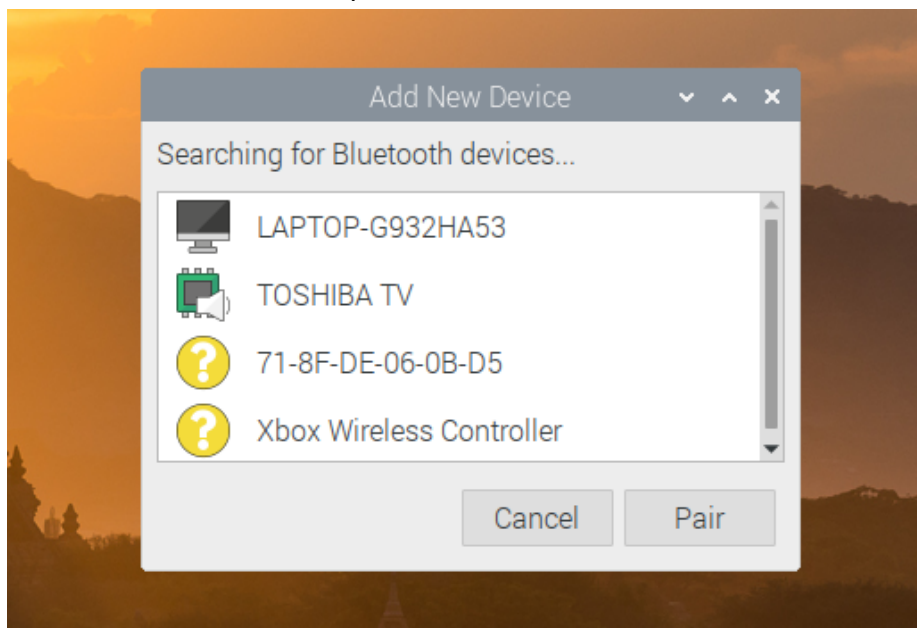
## 6. Using Bluetooth on Raspberry Pi

### Connecting to another WiFi Hotspot / Access Point:

1. Click on BLuetooth Icon on the top-right of the desktop in the taskbar.



2. Select Device to connect / pair





## 7. Connecting Arduino / Zigbee / Any embedded device to Raspberry Pi through USB

Being able to program Serial Ports of Raspberry Pi is important since it is the safest way to interface Arduino / Zigbee / Any other embedded device to Raspberry Pi.

Let us look into pyMultiSerial, a library for monitoring multiple serial ports simultaneously. This library can help you to send and receive data on USB ports not only on Raspberry Pi, but on any device with Python installed.

pyMultiSerial monitors all of your USB ports on your device and lets you decide what actions to perform on detecting a serial port, on receiving data from serial port and on disconnection of a serial port device.

Link to Library: <https://github.com/SunitRaut/pyMultiSerial>

Check this example code: <https://github.com/SunitRaut/pyMultiSerial/blob/main/example1.py>

Important References to learn more:

1. <https://www.ibm.com/cloud/learn/networking-a-complete-guide>
2. <https://learn.sparkfun.com/tutorials/bluetooth-basics/all>
3. <https://www.elprocus.com/how-does-bluetooth-work/>
4. <https://www.raspberrypi.org/documentation/configuration/wireless/>
5. <https://www.electronicwings.com/raspberry-pi/using-raspberry-pi-3-on-board-bluetooth-for-communication>
- 6.