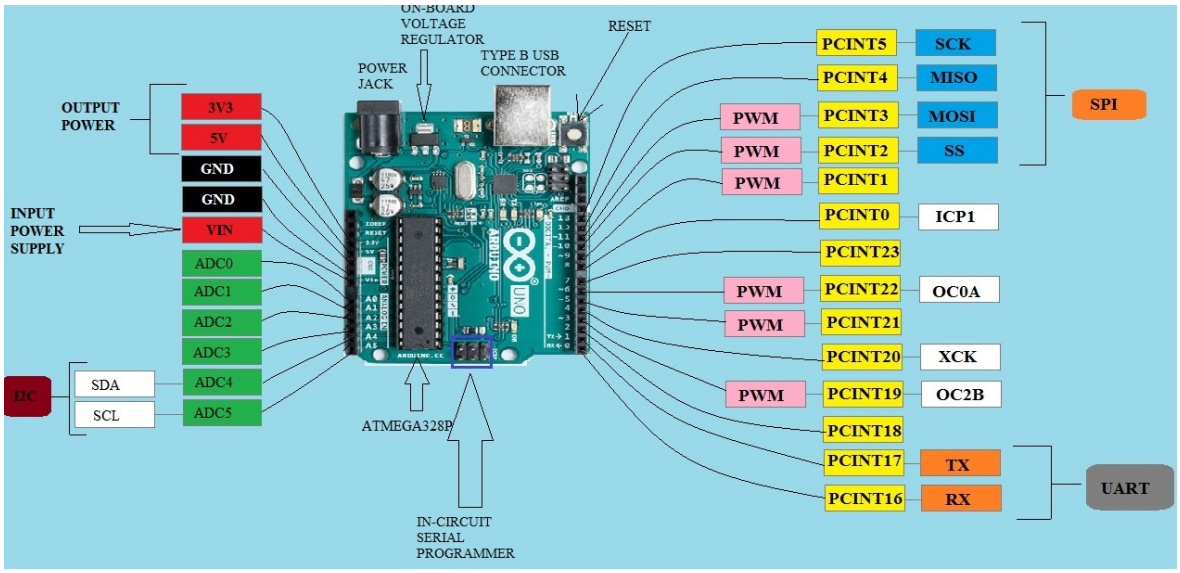
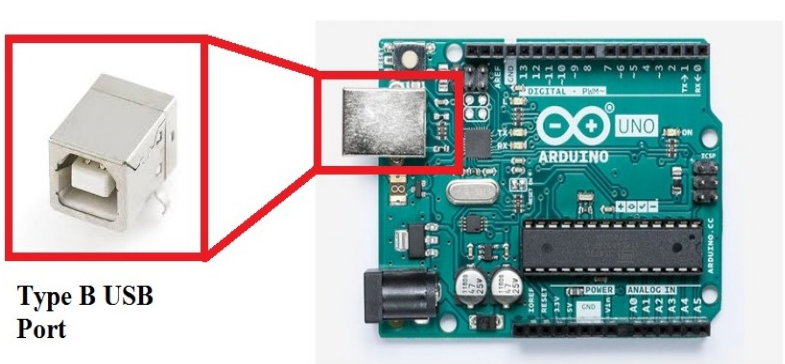
UNIT 2

ARDUINO UNO

Arduino is the open source microcontroller development board based on the ATMEGA328P microcontroller IC designed to provide the simple and cheap platform to the hobbyists and students for designing their digital and embedded systems projects.



Arduino UNO is programmed via type B USB connector mounted on board. A USB cable is used to connect the Arduino board to the PC or laptop. When plugged in to the USB cable it is also powered up which means you do not need an additional power supply while programming your Arduino with your laptop or computer.



Type B USB Port

USB cable used to connect Arduino to the PC

Arduino development board has on-board voltage regulator and can supply 5volts and 3V3 to power up the low power components. Arduino UNO can be powered up with either power jack or it can also be powered up with the help of the pin on the header.

The Arduino microcontroller development board has one UART, SPI (Serial Peripheral Interface) interface and I2C (Inter-Integrated Circuit) interface which means it can communicate to the peripheral ICs that has these interfaces.

- **Microcontroller IC:** Microchip ATmega3
- **Operating voltage** 5V
- **Input Voltage:** 7 to 20 Volts (Note that this voltage would be apply to the jack only and not on the power supply pins available on the header).
- **Digital I/O Pins:** 14 (of which 6 provide PWM (Pulse Width Modulation) output)
- **Analog Input Pins:** 6
- **DC Current per I/O Pin:** 20 mA (This is the current that can be sourced or sink into and out of the Input / Output pins)
- **DC Current for 3.3V Pin:** 50 mA
- **Flash Memory:** 32 KB of which 0.5 KB used by bootloader
- **SRAM:** 2 KB
- **EEPROM:** 1 KB
- **Clock Speed:** 16 MHz (All the operations are synced by this clock)

Arduino Uno has total 14 digital Input / Output pins. The digital Input / Output pins can receive a digital signal or transfer a digital signal. The pin number 0 named Rx and pin number 1 named Tx are the receive and transmit pins of the UART (Universal Asynchronous Receiver and Transmitter) respectively. Notice in the image of the Arduino that the pin numbers 3, 5, 6, 9, 10 and 11 have a wavy symbol in front of them. This symbol denotes that these pins are the PWM (Pulse Width Modulation Pins). The discussion about the PWM phenomenon and the application of these pins will be discussed later. Note here that apart from being PWM pins these six pins can also behave like other digital input / output pins.

Arduino UNO has total 14 digital input / output pins out of which 6 input / output pins are PWM enabled. Some of these Digital Input / Output pins can also serve as the SPI (Serial Peripheral Interface) or I2C interface (Inter-Integrated Circuit).

RASPBERRY PI

Raspberry Pi, developed by Raspberry Pi Foundation in association with Broadcom, is aseriesofsmallsingle-boardcomputersandperhapsthemostinspiringcomputeravailabletoday.

From the moment you see the shiny green circuit board of Raspberry Pi, it invites you totinkerwithit,playwithit,startprogramming,andcreateyourownsoftwarewithit.Earlier,th e Raspberry Pi was used to teach basic computer science in schools but later, becauseofitslowcostand opendesign,themodelbecamefarmorepopularthan anticipated.

It is widely used to make gaming devices, fitness gadgets, weather stations, and muchmore. But apart from that, it is used by thousands of people of all ages who want to taketheirfirststep in computer science.

Itisoneofthebest-sellingBritishcomputersandmostoftheboardsaremadeintheSonyfactoryin Pencoed,Wales.

GENERATIONS

In 2012, the company launched the Raspberry Pi and the current generations of regularRaspberry Piboardsare **Zero,1,2,3, and 4**.Generation1RaspberryPi hadthefollowingfouroptions:

ModelA

ModelA+

ModelB

ModelB+

Among these models, the **Raspberry Pi B models** are the original credit-card sizedformat.

On the other hand, the **Raspberry Pi A models** have a smaller and more compactfootprintand hence,thesemodelshavethereduced connectivityoptions.

Raspberry Pi Zero models, which come with or without GPIO (general-purpose inputoutput)headersinstalled,arethemostcompactofall theRaspberry Pi boards types.

USES

Likeadesktopcomputer,youcandoalmostanythingwiththeRaspberryPi.Youcanstartand manage programs with its graphical windows desktop. It also has the shell foracceptingtextcommands.

WecanusetheRaspberryPicomputer forthefollowing:

- Playinggames
- Browsingtheinternet
- Wordprocessing
- Spreadsheets
- Editingphotos
- Payingbillsonline
- Managingyouraccounts.

ThebestuseofRaspberryPiistolearnhowacomputerworks.Youcanalsolearnhowtomakee lectronicprojectsorprogramswithit.

Itcomeswithtwoprogramminglanguages,**Scratch**and**Python**.ThroughGPIO(general-purpose input output) pins, Raspberry Pi can be connected to other circuits, so that youcancontrolthe otherdevices ofyourchoice.

COMMUNICATION PROTOCOLS

BLUETOOTH

Bluetooth is a network technology that connects mobile devices wirelessly over a short-range to form a personal area network (PAN). They use short-wavelength, ultra-high frequency (UHF) radio waves within the range 2.400 to 2.485 GHz, instead of RS-232 data cables of wired PANs.

Features of Bluetooth

- Bluetooth technology was released in 1999 as Bluetooth 1.0, by Special Interest Group (SIG) who continues to manage it.
- It was initially standardized as IEEE 802.15.1.
- Mobile computing devices and accessories are connected wirelessly by Bluetooth using short-range, low-power, inexpensive radios.
- UHF radio waves within the range of 2.400 to 2.485 GHz are using for data communications.
- A PAN or a piconet can be created by Bluetooth within a 10 m radius.
- Presently, 2 to 8 devices may be connected.
- Bluetooth protocols allow devices within the range to find Bluetooth devices and connect with them. This is called pairing. Once, the devices are paired, they can transfer data securely.
- Bluetooth has lower power consumption and lower implementation costs than Wi-Fi. However, the range and transmission speeds are typically lower than Wi-Fi.
- The lower power requirements make it less susceptible to interference with other wireless devices in the same 2.4GHz bandwidth.
- Bluetooth version 3.0 and higher versions can deliver a data rate of 24 Mbps.
- The Bluetooth version 4.0 came in 2010. It is characterized by low energy consumption, multivendor interoperability, the economy of implementation, and greater range.

The radio-wave connection between two devices is used to send and receive data between two Bluetooth devices. The data send and received at a time is equal to 720 Kilo bytes per second. There are 79 frequency channels of a frequency 2.45 Giga Hertz through which the devices send and receive data to each other. When two devices are trying to be paired, they are actually searching for a common frequency through which they can send and receive data. When such a frequency is discovered, the devices are "found". The connecting of two devices does not hamper the connecting of two other devices because they usually use different channels of frequency and hence do not overlap. In simple terms, this is the **principle behind Bluetooth technology**.

.When more than two Bluetooth devices communicate with one another, this is called a **PICONET**. A Piconet can contain up to seven slaves clustered around a single master. The device that initializes establishment of the Piconet becomes the **master**.

The master is responsible for transmission control by dividing the network into a series of time slots amongst the network members, as a part of **time division multiplexing** scheme which is shown below.

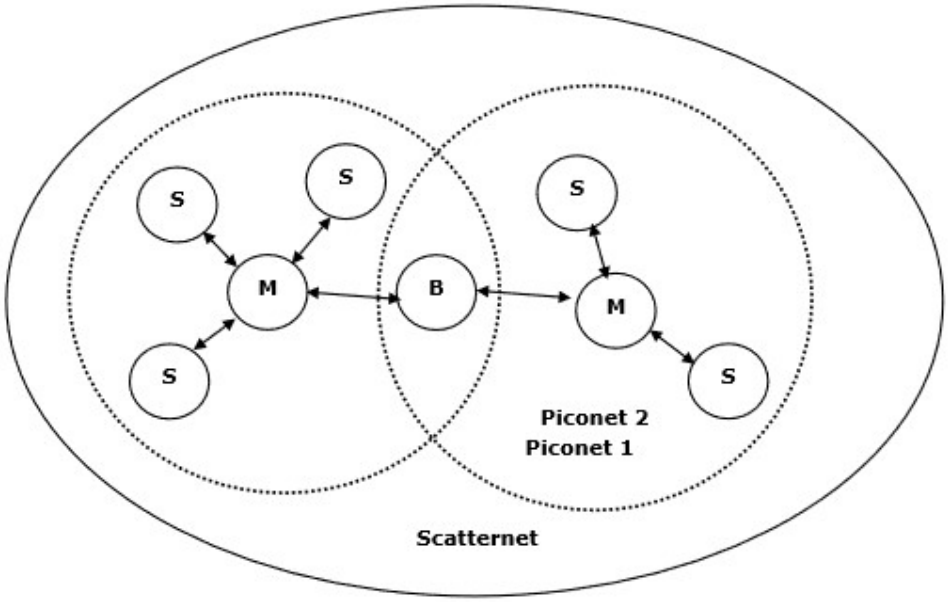


Figure: Piconets and Scatternets

Spectrum

Bluetooth technology operates in the unlicensed industrial, scientific and medical (ISM) band at 2.4 to 2.485 GHZ, using a spread spectrum hopping, full-duplex signal at a nominal rate of 1600 hops/sec. the 2.4 GHZ ISM band is available and unlicensed in most countries.

Range

Bluetooth operating range depends on the device Class 3 radios have a range of up to 1 meter or 3 feet Class 2 radios are most commonly found in mobile devices have a range of 10 meters or 30 feet Class 1 radios are used primarily in industrial use cases have a range of 100 meters or 300 feet.

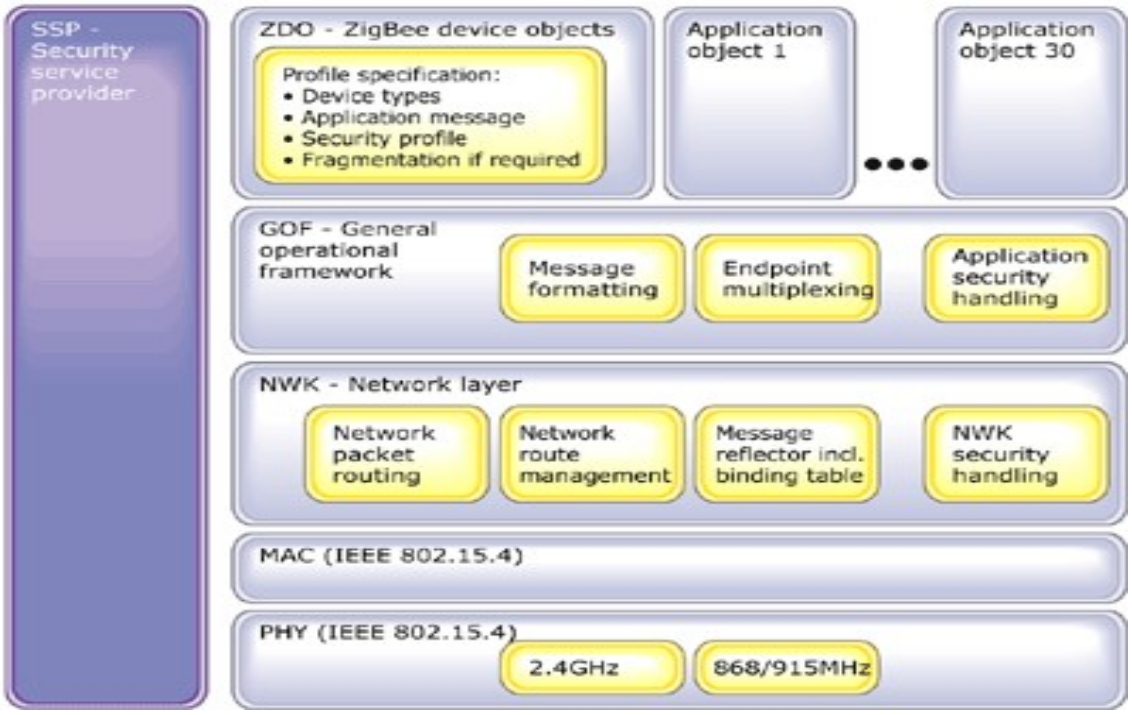
Data rate

Bluetooth supports 1Mbps data rate for version 1.2 and 3Mbps data rate for Version 2.0 combined with Error Data Rate.

ZIGBEE

- Layer on top of 802.15.4
- ZigBee is similar to Bluetooth and is majorly used in industrial settings.
- It has some significant advantages in complex systems offering low-power operation, high security, robustness and high and is well positioned to take advantage of wireless control and sensor networks in IoT applications.
- Zigbee - set of high level communication protocols based upon the specification produced by 802.15.4
- IEEE 802.15.4 - Standard released in May 2003 for LR-WPAN-Low-Rate Wireless Personal Area Network (LR-WPAN)
- Routing (pass messages on)
- Ad-hoc network creation
- Self-healing
- The ZigBee Alliance is an association of companies working together to enable reliable, cost-effective, low-power, wirelessly networked, monitoring and control products based on an open global standard.

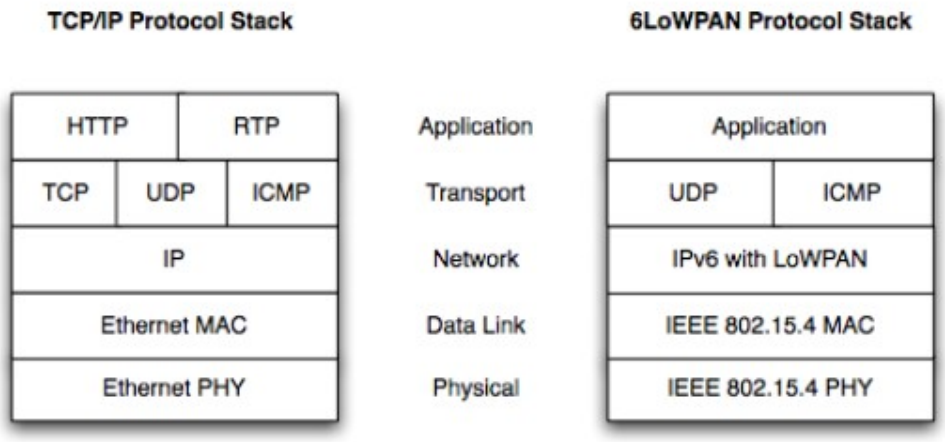
Architecture



6LoWPAN

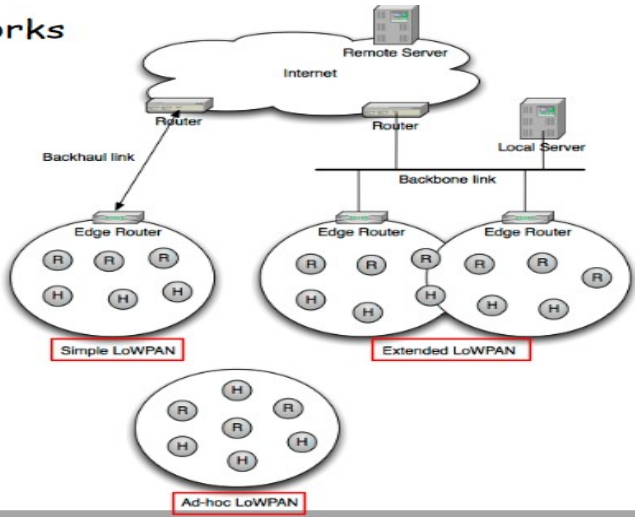
- IPv6 over Low-Power wireless Area Networks (LoWPAN)
- LowPAN = LLN?
- Defined by IETF standards
- Stateless header compression
- Enables a standard socket API
- Minimal use of code and memory
- Direct end-to-end Internet integration
    - Multiple topology options

Protocol Stack



Architecture

- LoWPANs are stub networks
- Ad-hoc LoWPAN
  - No route outside the LoWPAN
- Simple LoWPAN
  - Single Edge Router
- Extended LoWPAN
  - Multiple Edge Routers with common backbone link



Sensors

A sensor is a transducer that converts a physical stimulus from one form into a more useful form to measure the stimulus

Two basic categories:

1. Analog
2. Discrete
   - Binary
   - Digital (e.g., pulse counter)

Basic electronic Device

Convert a physical quantity/ measurements into electrical signals

Can be analog or digital

Types of Sensors: Some commonly used sensors :

- IR
- LDR
- Temperature
- Humidity
- Compass
- Light
- Sound
- Accelerometer
- Dials on a radio are simply potentiometers
- Temperature

- Light
- Angle
- Switches
- did the user throw a switch or push a button?
- Accelerometer (measures motion and tilt)
- Infrared sensor & light
- Hall effect sensor and magnet
- Ball tilt sensor (for measuring orientation)

ACTUATORS

- A device which converts one form of energy to another
- An actuator is a device which causes something to happen, This could be a robot movement, which is often achieved using motors.
- An **Actuator** is a kind of motor that moves or controls a mechanism or system.
- It is powered by an energy source, typical electric current, hydraulic fluid pressure, or air pressure, and converts this energy into motion.
    - Examples: Engine, Pump, Valve, etc.

TYPES OF ACTUATORS

1. Electrical actuators
    - Electric motors
        - AC motors
        - DC servomotors
        - Stepper motors
    - Solenoids
2. Hydraulic actuators
    - Use hydraulic fluid to amplify the controller command signal
3. Pneumatic actuators
    - Use compressed air as the driving force