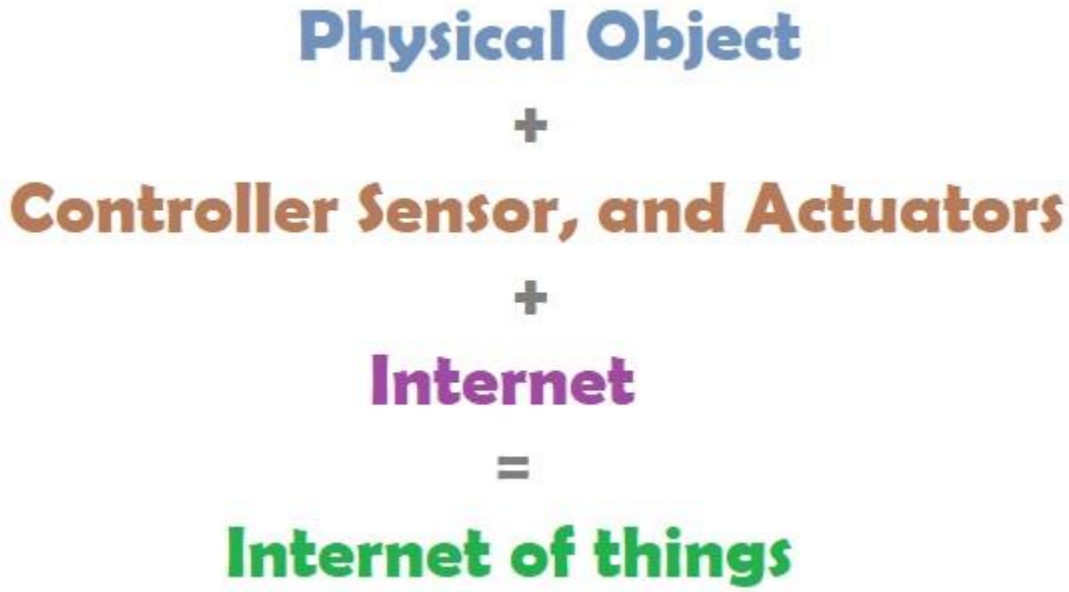
.



Above picture is an Equation of Internet of things. IoT Sensors and Actuators plays main role in any IoT Projects. Without IoT Sensors and Actuators, there's no IoT.

IoT Sensors and Actuators

IoT Sensors

Generally speaking, a sensor is a device that is able to detect changes in an environment. By itself, a sensor is useless, but when we use it in an electronic system, it plays a key role. A sensor is able to measure a physical phenomenon (like temperature, pressure, and so on) and transform it into an electric signal. So Sensors are hardware components that can detect events or changes in its surroundings, and then provide a corresponding output. Sensors are the eyes and ears of any IoT Project. Without sensors, there's no IoT.

Lets explore some of the commonly used sensors in IoT Applications.

1. Temperature Sensors:

TMP36:

The TMP35/TMP36/TMP37 are low voltage, precision centigrade temperature sensors. They provide a voltage output that is linearly proportional to the Celsius (centigrade) temperature. The TMP35/ TMP36/TMP37 do not require any external calibration to provide typical accuracies of ±1°C at +25°C and ±2°C over the −40°C to +125°C temperature range.

LM35:

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range.

DS18B20:

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor.

Waterproof DS18B20:

This sealed digital temperature probe lets you precisely measure temperatures in wet environments with a simple 1-Wire interface. The DS18B20 provides 9 to 12-bit (configurable) temperature readings over a 1-Wire interface, so that only one wire (and ground) needs to be connected from a central microprocessor.

2. Temperature and Humidity Sensors:

DHT11:

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). Its fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds, so when using our library, sensor readings can be up to 2 seconds old.

DHT22:

The DHT22 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It’s fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds, so when using our library, sensor readings can be up to 2 seconds old.

Simply connect the first pin on the left to 3-5V power, the second pin to your data input pin and the rightmost pin to ground. Although it uses a single-wire to send data it is not Dallas One Wire compatible! If you want multiple sensors, each one must have its own data pin.

Recommended: ***DHT11 vs DHT22: Overview***

3. Temperature, Humidity and Barometric Pressure Sensors:

BME280:

The BME280 is as combined digital humidity, pressure and temperature sensor based on proven sensing principles. Its small dimensions and its low power consumption allow the implementation in battery driven devices such as handsets, GPS modules or watches. The BME280 achieves high performance in all applications requiring humidity and pressure measurement.

4. Temperature, Altitude and Barometric Pressure Sensors:

BMP180:

The BME280 is an integrated environmental sensor developed specifically for mobile applications where size and low power consumption are key design constraints. The unit combines individual high linearity, high accuracy sensors for pressure, humidity and temperature in an 8-pin metal-lid 2.5 x 2.5 x 0.93 mm^3 LGA package, designed for low current consumption (3.6 μA @1Hz), long term stability and high EMC robustness.

The humidity sensor features an extremely fast response time which supports performance requirements for emerging applications such as context awareness, and high accuracy over a wide temperature range. The pressure sensor is an absolute barometric pressure sensor with features exceptionally high accuracy and resolution at very low noise. The integrated temperature sensor has been optimized for very low noise and high resolution. It is primarily used for temperature compensation of the pressure and humidity sensors, and can also be used for estimating ambient temperature.

MPL3115A2:

The MPL3115A2 is a compact, piezoresistive, absolute pressure sensor with an I2Cdigital interface. MPL3115A2 has a wide operating range of 20 kPa to 110 kPa, a rangethat covers all surface elevations on earth. The MEMS is temperature compensatedutilizing an on-chip temperature sensor. The pressure and temperature data is fed intoa high resolution ADC to provide fully compensated and digitized outputs for pressurein Pascals and temperature in °C.

5. Motion Sensors:

PIR Sensor:

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensors.

6. Light Sensors:

LDR:

A photoresistor (or light-dependent resistor, **LDR**, or photocell) is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity.

Photodiode:

A photodiode is a semiconductor device that converts light into current. The current is generated when photons are absorbed in the photodiode. A small amount of current is also produced when no light is present. Photodiodes may contain optical filters, built-in lenses, and may have large or small surface areas.

Phototransistor:

A phototransistor is a light-sensitive transistor. A common type of phototransistor, called a photobipolar transistor, is in essence a bipolar transistor encased in a transparent case so that light can reach the base–collector junction.

7. Gas Sensors:

MQ-135(Air Quality Sensor):

This sensor is used in air quality control equipment for buildings/offices, are suitable for detecting of NH3,NOx, alcohol, Benzene, smoke,CO2 ,etc.

MQ-2 (LPG, Butane, Propane, Methane, Ethanol, Hydrogen, Smoke Sensor):

MQ – 2 is a flammable gas and smoke sensor detects the concentrations of combustible gas in the air and outputs its reading as an analog voltage. It is used for home or factory gas leakage monitoring devices, suitable for liquefied petroleum gas, butane, propane, methane, ethanol, hydrogen, smoke and other monitoring devices.

MQ-3 (Alcohol Sensor):

This module is made using Alcohol Gas Sensor MQ3. It is a low cost semiconductor sensor which can detect the presence of alcohol gases at concentrations from 0.05 mg/L to 10 mg/L. The sensitive material used for this sensor is SnO2, whose conductivity is lower in clean air. It's

conductivity increases as the concentration of alcohol gases increases. It has high sensitivity to alcohol and has a good resistance to disturbances due to smoke, vapor and gasoline. This module provides both digital and analog outputs. MQ3 alcohol sensor module can be easily interfaced with Microcontrollers, Arduino Boards, Raspberry Pi etc.

MQ-6 (LPG, Iso-Butane, Propane):

This propane gas sensor detects the concentrations of LPG, isobutane, and propane in the air and ouputs its reading as an analog voltage. The sensor can measure concentrations of 300 to 10,000 ppm.The sensor can operate at temperatures from -10 to 50°C and consumes less than 150 mA at 5 V.

MQ-7 (Carbon Monoxide Sensor):

This is a simple-to-use Carbon Monoxide (CO) sensor, suitable for sensing CO concentrations in the air. The MQ-7 can detect CO-gas concentrations anywhere from 20 to 2000ppm.

This sensor has a high sensitivity and fast response time. The sensor's output is an analog resistance. The drive circuit is very simple; all you need to do is power the heater coil with 5V, add a load resistance, and connect the output to an ADC.

8. Distance / Proximity Sensors:

HC-SR04 (Ultrasonic Distance Sensor):

This is the HC-SR04 ultrasonic distance sensor. This economical sensor provides **2cm** to **400cm** of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit.

GP2Y0A02YK0F (IR Distance Sensor):

Infrared proximity sensor made by Sharp. Part # GP2Y0A02YK0F has an analog output that varies from 2.8V at 15cm to 0.4V at 150cm with a supply voltage between 4.5 and 5.5VDC. The sensor has a Japanese Solderless Terminal (JST) Connector. We recommend purchasing the related pigtail below or soldering wires directly to the back of the module.

9. Motion / Direction / Location Sensors:

L3G4200D (3-Axis Digital Gyroscope):

This sensor is a carrier/breakout board for the ST L3G4200D three-axis gyroscope, which measures the angular rates of rotation about the roll (X), pitch (Y), and yaw (Z) axes. Angular velocity measurements with a configurable range of ±250°/s, ±500°/s, or ±2000°/s can be read through a digital I²C or SPI interface. The board operates from 2.5–5.5 V and has a 0.1″ pin spacing.

MPU-6050 (3-Axis Digital Gyroscope):

MPU6050 sensor module is complete 6-axis Motion Tracking Device. It combines 3-axis Gyroscope, 3-axis Accelerometer and Digital Motion Processor all in small package. Also, it has additional feature of on-chip Temperature sensor. It has I2C bus interface to communicate with the microcontrollers.

ITG3205 (3-Axis Digital Gyroscope):

The ITG-3200 features three 16-bit analog-to-digital converters (ADCs) for digitizing the gyro outputs, a user-selectable internal low-pass filter bandwidth, and a Fast-Mode I^2C (400kHz) interface. Additional features include an embedded temperature sensor and a 2% accurate internal oscillator.

HMC5883L (3-Axis Digital Compass):

HMC5883L is Honeywell's 3-axis digital compass. Communication with the HMC5883L is simple and all done through an I2C interface. There is no on-board regulator, so a regulated voltage of 2.16-3.6VDC should be supplied.

FGPMMOPA6C / MT3339 (GPS Module):

The GlobalTop FGPMMOPA6C is an ultra-compact POT (Patch On Top) GPS Module, The module utilizes the MediaTek new generation GPS Chipset MT3339 that achieves the industry's highest level of sensitivity (-165dBm) and instant Time-to-First Fix (TTFF) with lowest power consumption for precise GPS signal processing to give the ultra-precise positioning under low receptive, high velocity conditions.

10. Imaging Sensors:

Raspberry Pi Official Camera Module:

This camera module is capable of 1080p video and still images and connects directly to your Raspberry Pi. Connect the included ribbon cable to the CSI (Camera Serial Interface) port on your Raspberry Pi, boot up the latest version of Raspbian and you are good to go.

OV7670/OV7171 (640×480 VGA CMOS Camera):

The ov7670 is an image sensor manufactured by Omnivision. It can provide the full functionality of a single-chip VGA camera and image processor in a small footprint package. The OV7670/OV7171 provides full-frame, sub-sampled or windowed 8-bit images in a wide range of formats, controlled through the Serial Camera Control Bus (SCCB) interface.

11. Magnetic Sensors:

Reed Switch:

The reed switch is an electrical switch operated by an applied magnetic field. It was invented at Bell Telephone Laboratories in 1936 by W. B. Ellwood. When the device is exposed to a magnetic field, the two ferrous materials inside the switch pull together and the switch closes. When the magnetic field is removed, the reeds separate and the switch opens.

Magnetic Switch (Magnetic Door / Window Sensor):

Magnetic Switch is a small reed switch assembly specifically designed to alert you when doors, drawers, or any other aperture opens. These types of switches are primarily used in home security systems. One half of the assembly set on a window or door frame and the other attached to the window or door itself. When the switch set is separated from each other the contact is broken and triggers an alarm.

US1881 (Hall Latch):

The US1881 is a Hall-effect latch designed in mixed signal CMOS technology. The device integrates a voltage regulator, Hall sensor with dynamic offset cancellation system, Schmitt trigger and an open-drain output driver, all in a single package.

SCT-013-000 (Non-invasive AC Current Sensor):

The split core type sensor, is particularly suitable for DIY projects. It can be clipped straight on to either the live or neutral wire coming into the building without having to do any high voltage electrical work. The measured current is alternative, and the sensor is calibrated to measure a max of 100A AC. 100A is the RMS value of the maximum current the sensor can handle.

IoT Actuators

An actuator is a device that converts energy into motion. It is usually used to apply a force on some thing. In our example, the actuator would apply force to switch on the motor of the water pump. Actuators can create linear, oscillatory or rotatory motion based on how they are designed.

Let's explore some of the basic actuators you may use in your IoT projects –

1. Servo Motors:

A **servomotor** is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

2. Stepper Motors:

Stepper motors are DC motors that move in discrete steps. They have multiple coils that are organized in groups called “phases”. By energizing each phase in sequence, the motor will rotate, one step at a time.

With a computer controlled stepping you can achieve very precise positioning and/or speed control. For this reason, stepper motors are the motor of choice for many precision motion control applications.

3. DC Motors (Continuous Rotation Motors):

DC (**Direct Current**) **Motors** are two wire (power & ground), **continuous rotation motors**. When you supply power, a **DC motor** will start spinning until that power is removed. Most **DC motors** run at a high RPM (revolutions per minute), examples being computer cooling fans, or radio controlled car wheels.

4. Linear actuator:

A **linear actuator** is an actuator that creates motion in a straight line, in contrast to the circular motion of a conventional electric motor. Linear actuators are used in machine tools and industrial machinery, in computer peripherals such as disk drives and printers, in valves and dampers, and in many other places where linear motion is required. Hydraulic or pneumatic cylinders inherently produce linear motion. Many other mechanisms are used to generate linear motion from a rotating motor.

5. Relay:

A **relay** is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

6. Solenoid:

A solenoid is simply a specially designed electromagnet. Solenoids are inexpensive, and their use is primarily limited to on-off applications such as latching, locking, and triggering. They are frequently used in home appliances (e.g. washing machine valves), office equipment (e.g. copy machines), automobiles (e.g. door latches and the starter solenoid), pinball machines (e.g., plungers and bumpers), and factory automation.

RIOT OS (An Operating System for IoT)

Introduction

The Internet of Things (IoT) is used with heterogeneous devices. They range from 8 bit to 32 bit microcontrollers from different manufacturers. Traditional Operating system (OS) or the conventional embedded OS may not suit the requirements that these tiny devices demand (low power, small in size and low memory foot print). RIOT Operating system is a free and open source arachtiecture which is friendly to IoT applications and proved to be a perfect OS for IoT Systems.
It started in the year 2008 as an Operating system for Wireless Sensor nodes, later the OS is fine tuned for IOT systems.

Features of RIOT

The OS is actively developed and maintained.

- There are no new programming environments, C or C++ can be used directly with existing tools like gcc, gdb, etc.
- Less hardware dependent code
- Supports 8,16 ad 32 bit microcontroller platforms
- Energy efficieny is maintained
- less interrupt latency, so real time capability is ensured
- multi threading is enabled
- Supports the entire Network Stack of IoT (802.15.4 Zigbee, 6LoWPAN, ICMP6, Ipv6,RPL, CoAP, etc)
- Both static and dynamic memory allocation
- POSIX complaint (Partial)
- All output can be seen the in terminal if hardware is not available, however there is a visualization tool called RIOT-TV is provided
- MSP430
- ARM7
- Cortex-M0, M3 ,M4
- x86, etc
- Radio receivers
- Environmental sensors like humidity, temperature, pressure, alcohol gas sensors
- accelerometer
- gyroscopes
- ultrasonic sensors, light and servo motor

Features	**Contiki OS**	**Tiny OS**	**RIOT OS**
Minimum RAM and ROM needed	<2kb, <30kb	<1kb <4kb	~1.5kb `5kb

C and C++ Support	Partial	No support (nesc)	Full support
Multi threading	No (protothreads are used here)	No	Yes
Real Time	No	No	Yes

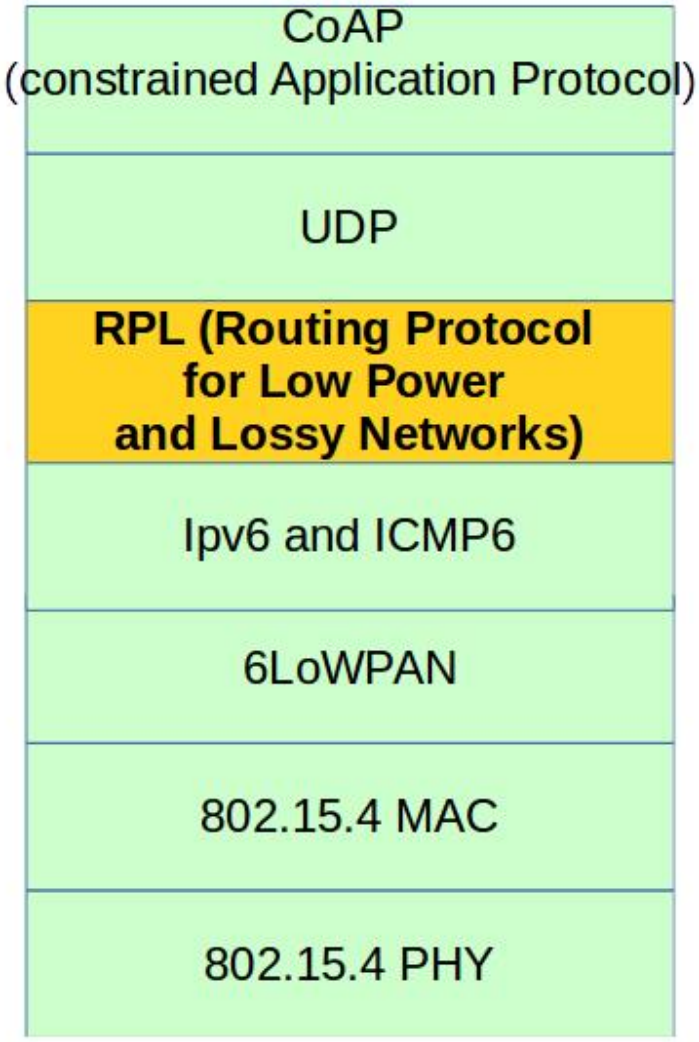
- **msp 430 GCC compiler**
- **msp 430 libraries**
- **avr utils,**
- **arm based gcc**
- **gcc multilibrary**
- **etc**

Architecture, Board and Driver Support

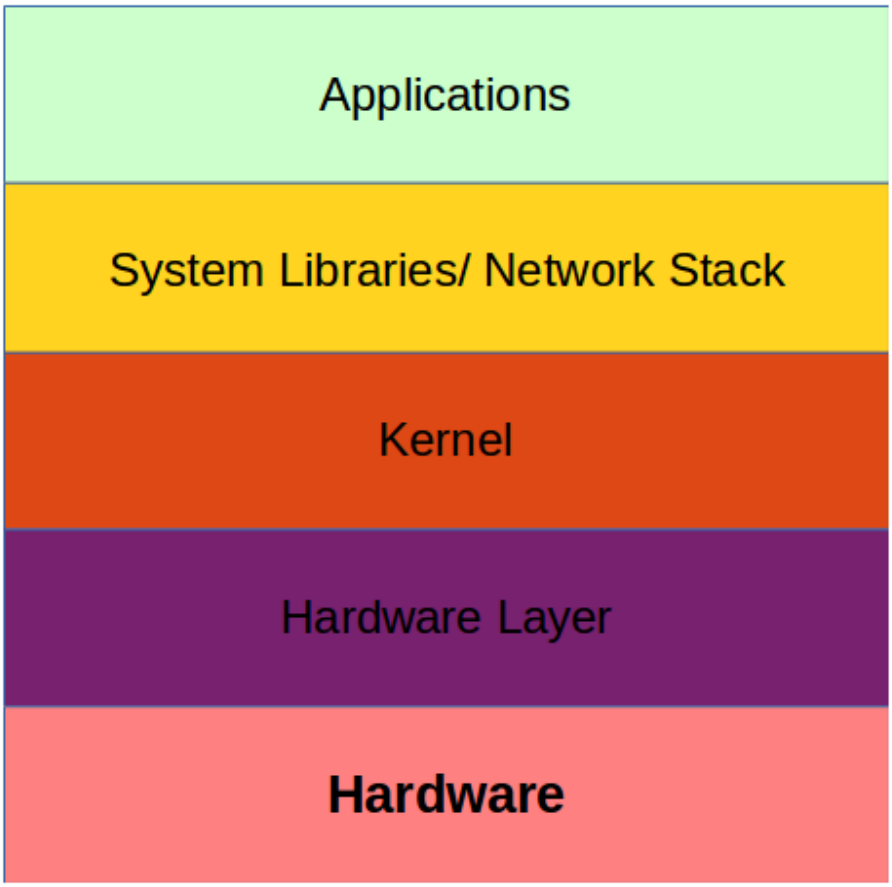
It supports various architecture like
and it supports the native port, where one can simulate the output within the OS it was running. So RIOT is supported in Linux as well as OS X.
There are in built drivers for the following sensors (without a need of hardware, these sensors can be modeled in native mode also)
Most of the sensor boards have support from this OS like TelosB, ST Microcontroller sensor boards, Zolertia, MSP 430 boards,Aruduino sensors, Atmel, and the list is so huge.
It also support virtualization that the code and application can run as a simple unix process. It also uses wireshark for packet sniffing.

Comparison with Contiki OS and Tiny OS

There are other two OS called Contiki OS (Already featured in OSFY) and Tiny OS which are suitable for IoT applications. But RIOT takes an upper hand in terms of memory usage and support.
The following table shows the comparision between these OS
Table 1: Comparison of various OS for IoT
Figure 1 and Figure 2 represents the block and Network stack diagram of IoT. Except for RPL, all the modules have the support from RIOT OS (for RPL alone, there is a partial support from RIOT)



Network Stack for IoT



Component of IoT

Installation of RIOT in LinuxOS Used for installing : Linux Mint 17.2 and Ubuntu 14.04.2Architecture used: 64 bit OS Installing RIOT needs lot of packages that are prerequisites like
Assume if you have installed just now, follow the steps to install

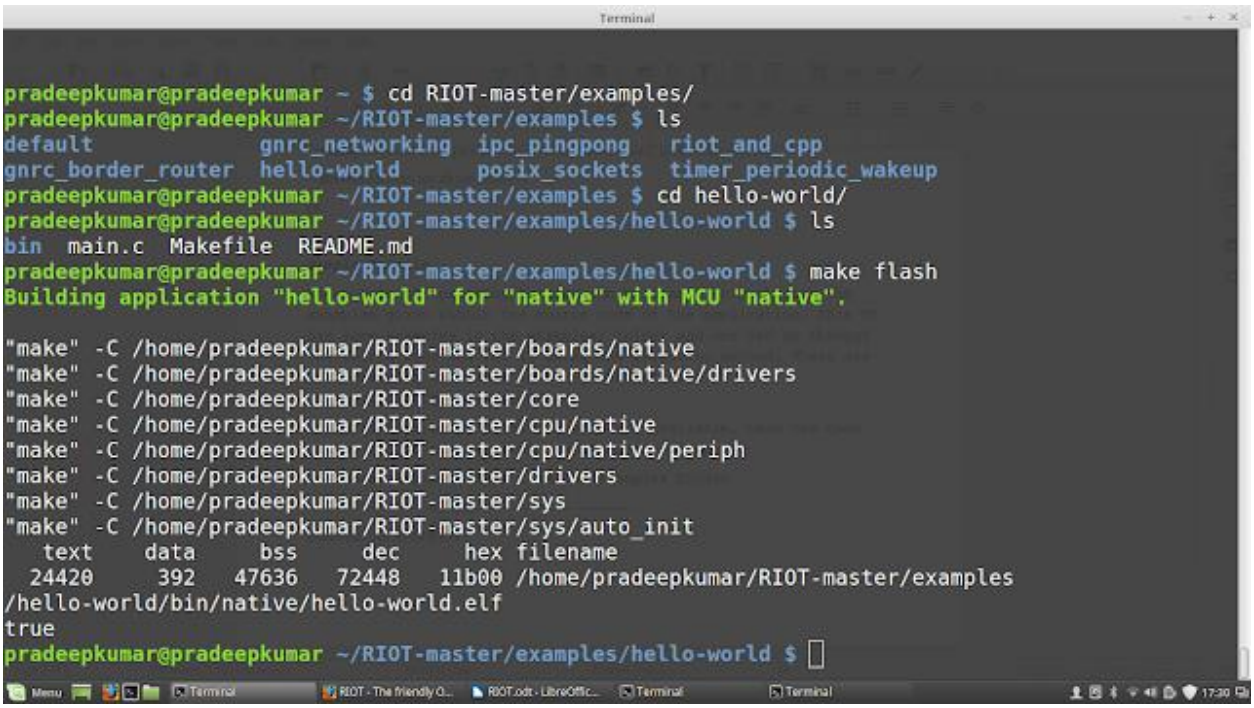
```
pradeepkumar $] sudo apt-get update
pradeepkumar $] sudo apt-get install libc6-dev-i386 build-essential
binutils-msp430 gcc-msp430 msp430-libc libncurses5-dev openjdk-7-jre
openjdk-7-jdk avrdude avr-libc gcc-avr gdb-avr binutils-avr mspdebug
msp430mcu autoconf automake libxmu-dev gcc-arm-none-eabi openocd git
bridge-utils gcc-multilib socket
```

The OS can be downloaded as a zip file from github (https://github.com/RIOT-OS/RIOT/archive/master.zip) , else you can clone it using the following command

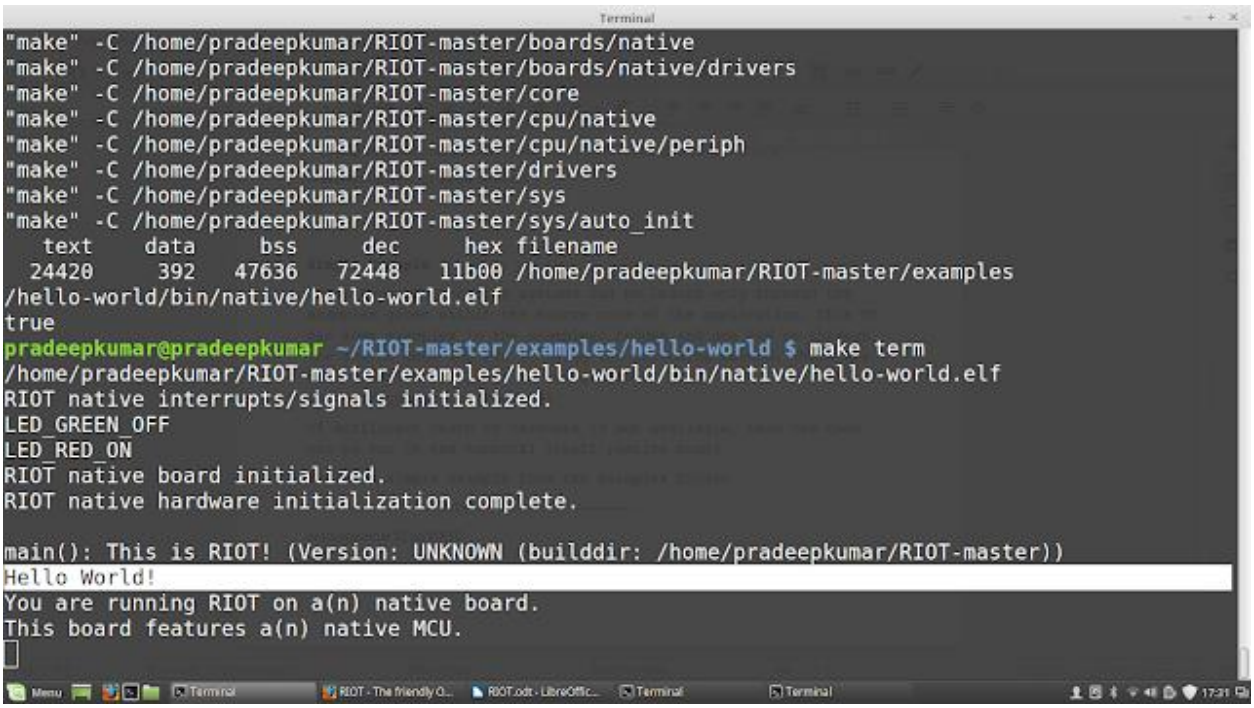
```
pradeepkumar $] git clone https://github.com/RIOT-OS/RIOT.git
```

The folder RIOT/ or RIOT-Master/ contains various subfolders
->boards (This folder has all the drivers for the boards that are supported by the OS)
->cpu (this folder contains the architecture supported by RIOT)
->cores (Core of the OS like kernel, modules, etc)
->doc (Documentation)
->examples (some examples like hello word, border router, Ipv6 formation, etc)
->drivers (drivers for all the sensors)
etc
Simple Example
These type of Operating systems can be learnt only through the examples given within the source code of the application. This OS has some examples in the examples/ folder and one can go through the source code and run it using the following method. There are more examples available in the github of RIOT (https://github.com/RIOT-OS)
If sufficient board or hardware is not available, then the code can be run in the terminal itself (native mode)
To run the hello-world example from the examples folder

```
pradeepkumar $] cd RIOT-Master/examples/hello-world
pradeepkumar $] make flash
pradeepkumar $] make term
```



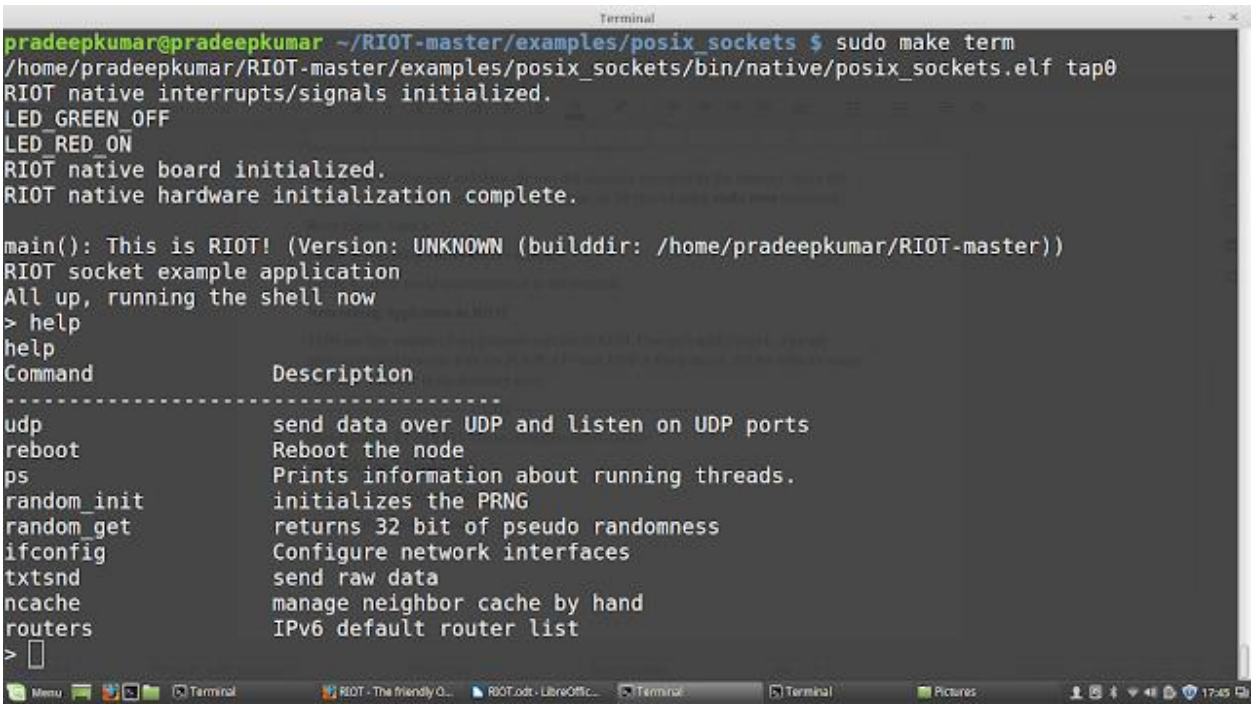
Running a hello-world example



hello world application run in the terminal

-----OUTPUT-----
/home/pradeepkumar/RIOT-master/examples/hello-world/bin/native/hello-world.elf
RIOT native interrupts/signals initialized.
LED_GREEN_OFF
LED_RED_ON
RIOT native board initialized.
RIOT native hardware initialization complete.
main(): This is RIOT! (Version: UNKNOWN (builddir: /home/pradeepkumar/RIOT-master))
Hello World!You are running RIOT on a(n) native board.
This board features a(n) native MCU.
Press Ctl+C to quit the application
----------CODE----------
make flash will compile and show the text and data size occupied by the memory. Since this application is run under native mode, the output can be viewed using ***make term*** command.

Networking Applcation in RIOT
There are few number of applications avaiable in RIOT. One such application is a socket application which works with the POSIX API with UDP as the protocol. All the relevant source codes are avaialble in the directory itself
----------CODE----------
pradeepkumar $] cd RIOT-Master/examples/posix-socket/
pradeepkumar $] make flash
pradeepkumar $] sudo make term
output of the above command
/home/pradeepkumar/RIOT-master/examples/posix_sockets/bin/native/posix_sockets.elf tap0
RIOT native interrupts/signals initialized.
LED_GREEN_OFF
LED_RED_ON
RIOT native board initialized.
RIOT native hardware initialization complete.
main(): This is RIOT! (Version: UNKNOWN (builddir: /home/pradeepkumar/RIOT-master))
RIOT socket example application
All up, running the shell now
> help



POSIX Application

Command

---

udp send data over UDP and listen on UDP ports

reboot Reboot the node

ps Prints information about running threads.

random_init initializes the PRNG

random_get returns 32 bit of pseudo randomness;

ifconfig Configure network interfaces

txtsnd send raw data

ncache manage neighbor cache by hand

routers IPv6 default router list

Figure 5 shows the above configuration: Routers can be configured, txt messages can be sent, running processes details can be found out, etc can be done using the application

----------CODE----------

Conclusion

There are only limited number of Operating systems available for the IoT sensors and among these OS, RIOT really has a well documented API with huge support for most of the boards, architecture and sensors. The main advantage being, RIOT is actively developed and maintained, there is a incremental version every month. Students and electronic hobby enthusiasts are using arduino and Raspberry Pi for

their IoT applications these days, RIOT really help these boards and sensors to achieve low memory footprint and low energy efficiency without any compromise on the performance of the IoT Systems.

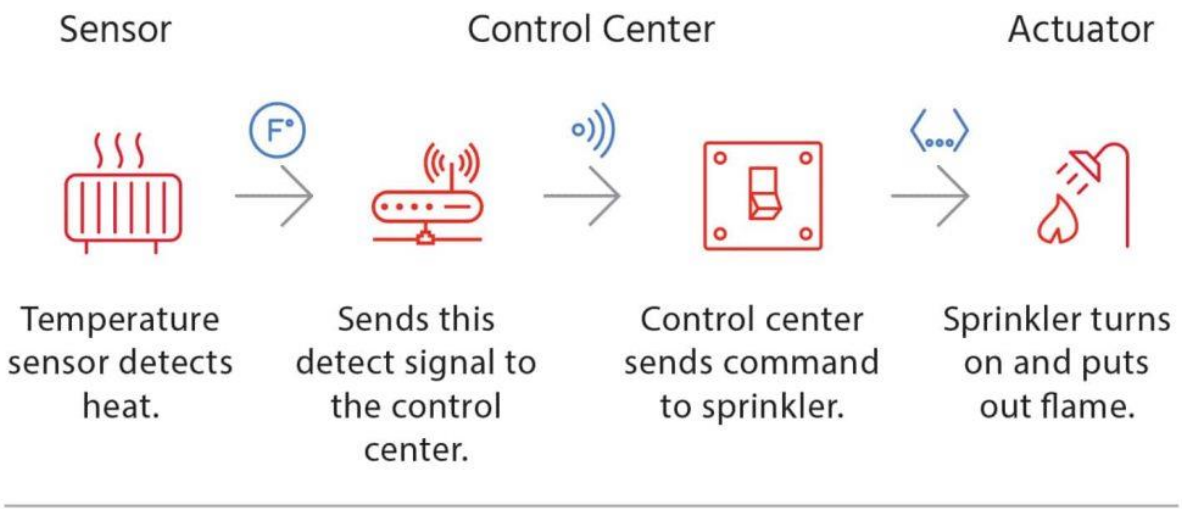
The Internet of Things is rarely discussed without the conversation steering to data and the new Data Economy. The intelligence and value from an IoT system is based on what can be learned from the data. Sensors are the source of IoT data.

Driven by new innovations in materials and nanotechnology, sensor technology is developing at a never before seen pace, with a result of increased accuracy, decreased size and cost, and the ability to measure or detect things that weren't previously possible. In fact, sensing technology is developing so rapidly and becoming so advanced that we will see a trillion new sensors deployed annually within a few years.

A better term for a sensor is a transducer. A transducer is any physical device that converts one form of energy into another. So, in the case of a sensor, the transducer converts some physical phenomenon into an electrical impulse that can then be interpreted to determine a reading. A microphone is a sensor that takes vibrational energy (sound waves) and converts it to electrical energy in a useful way for other components in the system to correlate back to the original sound.

Another type of transducer that you will encounter in many IoT systems is an actuator. In simple terms, an actuator operates in the reverse direction of a sensor. It takes an electrical input and turns it into physical action. For instance, an electric motor, a hydraulic system, and a pneumatic system are all different types of actuators.

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.



Sensor to **Actuator** Flow

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.

Different applications call for different ways of measuring the same thing.

The Importance of Accurate Sensors

Imagine that you are a bar owner and you want to measure the amount of beer coming out of one of your taps. One way you might do this is to install a sensor in line with the line that runs from the keg of beer to the tap. This sensor would most likely have a small impeller inside of it. When the beer ran through the sensor, it would cause the impeller to spin, just like the propeller on a weather station.

When the impeller spins, it will send a stream of electrical impulses to a computer. The computer will interpret the impulses to determine how much beer is flowing through. Sounds simple, right?

This is where sensors get interesting. If you look back at our description, you'll see that we never directly measured the amount of beer flowing through the sensor; we interpreted it from a stream of electrical impulses. That means that we must first figure out how to interpret it. Calibration.

To calibrate the sensor, we'd have to take a container with a known carrying capacity, say, a pint glass. Then we'd have to fill that container under a variety of conditions to determine what the electrical pulse signal looked like.

For instance, the first pour off a new keg might tend to have more foam, which would read differently than a pour from the middle of the keg that was all beer. It's only through repeated trials and a lot of data that we gain confidence that we can interpret the data and determine how much beer was poured.

Once the correlation is well known, a protocol can be developed to always assure the sensor is reading correctly. This is called calibration. Reputable manufacturers will deliver fully calibrated devices and provide instruction on how to re-calibrate to verify sensor accuracy.

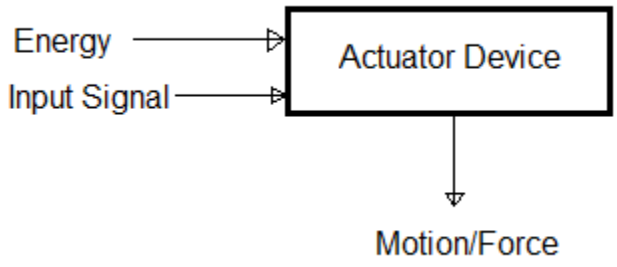
The accuracy of sensed data is paramount, since you will make mission-critical decisions based on later analysis of the data, which will hold little value if the data is wrong.

Different types of Actuators | Basics of Actuator types

This article covers different **types of Actuators** and mentions functional basics of these **Actuator types**. It describes different types of Actuators viz. Hydraulic actuator, Pneumatic actuator, Electrical actuator, Mechanical actuator, Thermal or Magnetic actuator, Soft actuator etc.

What is Actuator?

Introduction:
• The component of a system (or machine) which moves or controls mechanism or the system is called actuator.
• An actuator requires control signal and source of energy.
• Upon receiving control signal, actuator responds by converting energy into mechanical motion.
• The control system can be simple (fixed mechanical or electric system), software based (e.g. a printer driver, robot control system), a human or any other input.



Let us understand major functions or applications of different types of actuators.

Actuator Types | Types of Actuators with their functions

Let us understand different types of Actuators with their functions or applications.

Hydraulic actuator

• This actuator converts mechanical motion into linear, rotary or oscillatory motion.
• The hydraulic actuator consists of cylinder or fluid motor which uses hydraulic power to help mechanical operation.
• Liquids are nearly impossible to compress, hydraulic actuator maintains considerable force. Limited acceleration of actuator restricts its usage.
• **Example:** Hydraulic brake in vehicle

Pneumatic actuator

• This actuator converts energy formed by vacuum or compressed air at high pressure into linear or rotary motion.
• They are responsible to convert pressure into force.
• **Advantages:** 1. Pneumatic energy responds quickly to start and stop signals. 2. It does require power source to be stored in reserve for its operation. 3. Pneumatic actuators produce large forces from relatively small pressure changes.
• **Examples:**
➤Rack and Pinion actuators used for valve controls of pipes
➤Pneumatic brakes are very responsive to small pressure changes applied by the driver.

Electrical actuator

• It is powered by motor which converts electrical energy into mechanical torque.
• Electrical energy is used to actuate equipments (e.g. solenoid valves) which control water flow in pipes with response to electrical signals.
• **Advantages:** cheap, clean, speedy type of actuator.
• **Examples:** Solenoid based electric bell ringing mechanism

Mechanical actuator

• It converts rotary motion into linear motion.
• It consists of gears, pulleys, rails, chains and other devices for its operation.
• **Examples:** Rack and pinion mechanism and Crank shaft

Thermal or Magnetic actuator

• This actuator can be actuated by application of thermal or magnetic energy.
• This actuator uses shape memory materials e.g. shape memory alloys
• Advantages: Compact, light in weight, economical, offers high power density
• **Examples:** Thermal actuator is thermostat, magnetic actuator is electro magnet

Soft actuator

• It is polymer based and are designed to handle fragile objects like fruit harvesting in agriculture or manipulating the internal organs in biomedicine.
• Examples: Shape Memory polymers, Photo polymers
• Shape memory polymer is functions similar to our muscles. It also provides response to range of stimuli e.g. light, electrical, heat, magnetic, pH, moisture changes etc. The advantages of such polymers are low density, high strain recovery, bio-compatibility, bio-degradability etc.
• Photo polymers are known as light activated polymers. They are special type of shape memory polymers which are activated by light stimuli.

Other Actuator Types

Following are the other types of Actuators.
• Comb drive
• Electric motor
• Digital micromirror device
• Electroactive polymer
• Piezoelectric actuator
• Screw Jack
• Hydraulic Cylinder