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DEEMED TO BE UNIVERSITY

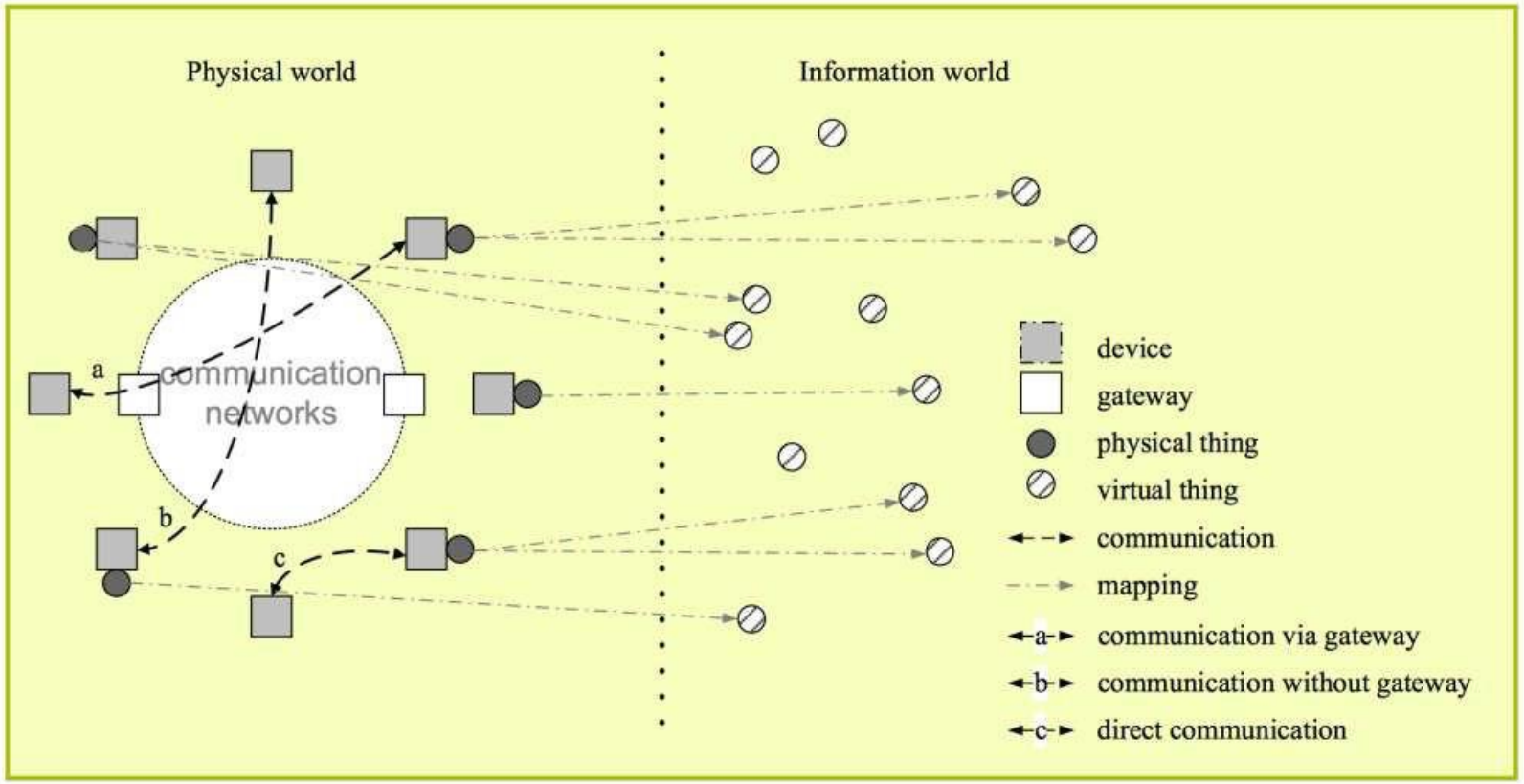
Components in IoT System Design

22AIE211 Introduction To Communication & IoT

Things

- **Physical things** exist in the physical world and are capable of being sensed, actuated and connected. Examples of physical things include the surrounding environment, industrial robots, goods and electrical equipment.
- **Virtual things** exist in the information world and are capable of being stored, processed and accessed. Examples of virtual things include multimedia content and application software

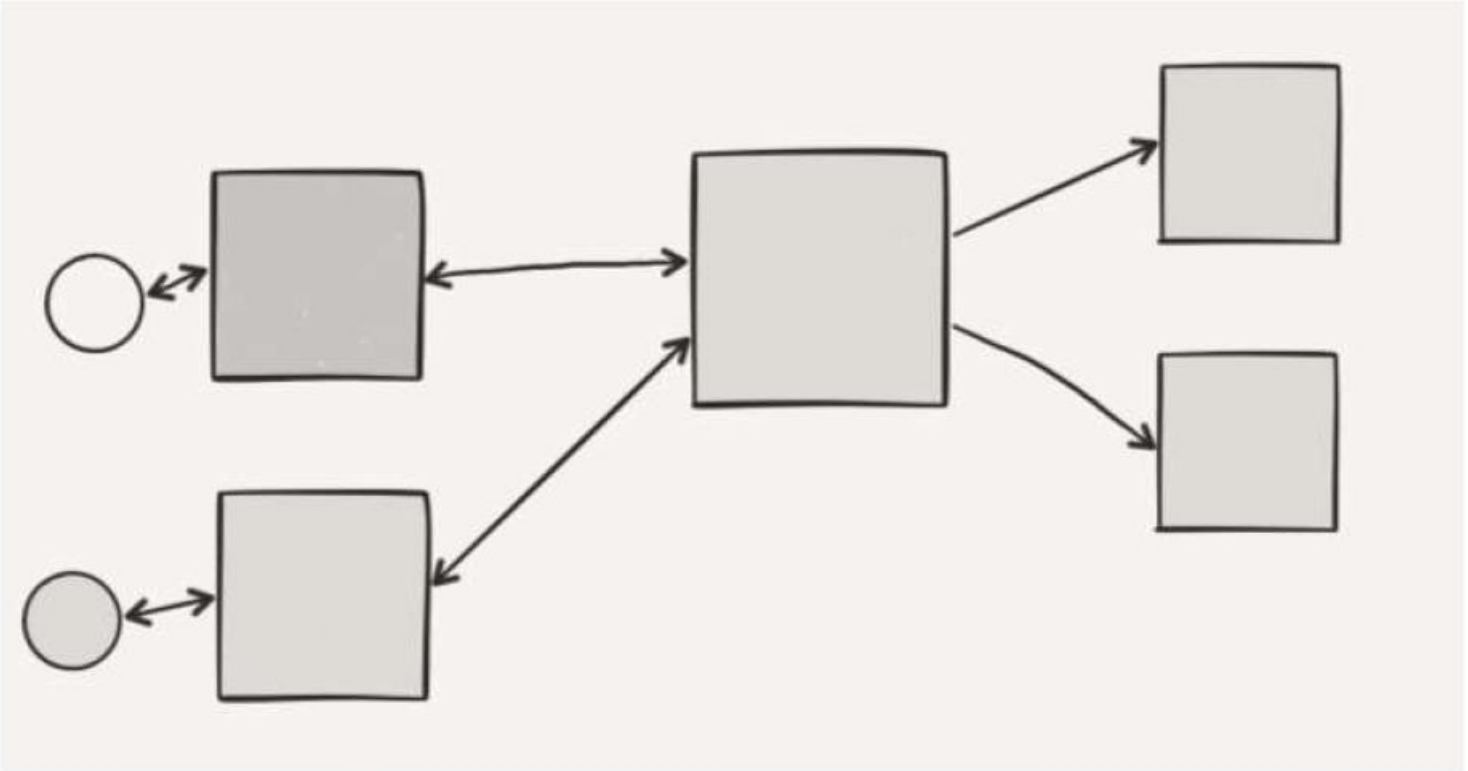
Physical & Virtual world



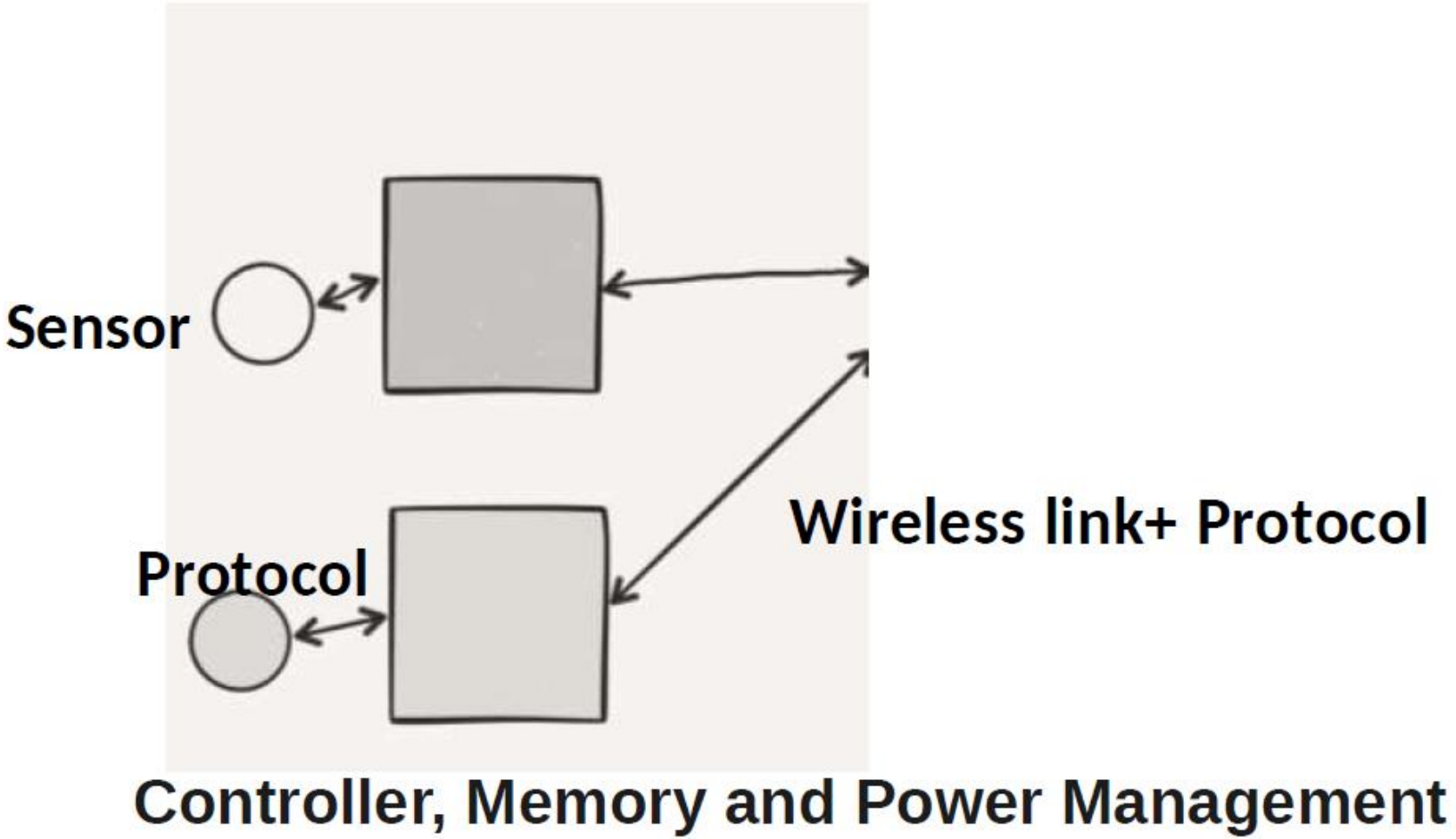
IoT Device – ITU Definition

- IoT device is a piece of equipment with the capabilities of communication and optional capabilities of sensing, actuation, data capture, data storage and data processing. The devices collect various kinds of information and provide it to the information and communication networks for further processing.
- Some devices also execute operations based on information received from the information and communication networks.

IoT Architecture

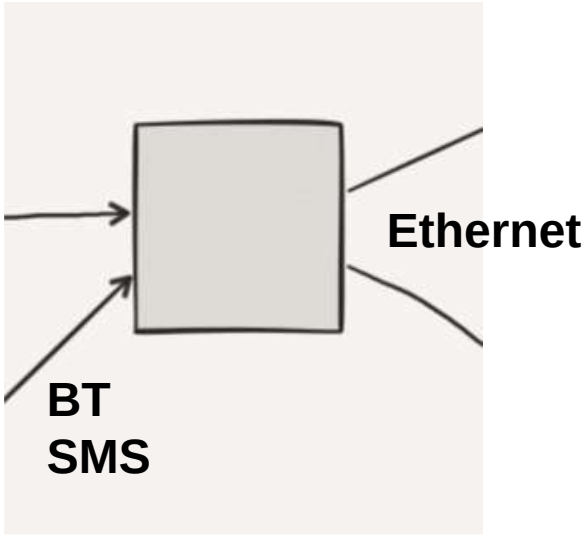


IoT Architecture : Node

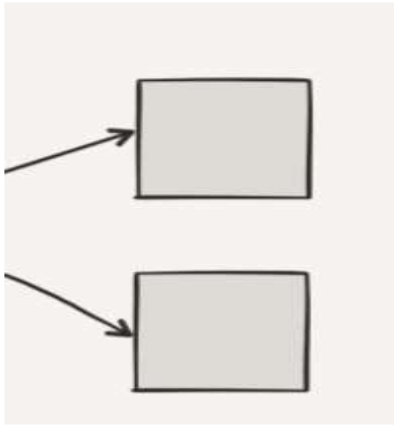


IoT Architecture : gateway & services

- Gateway



Services



Graphing
Machine Learning
Alerting

Sensors

Definition

- A sensor detects (senses) changes in the ambient conditions or in the state of another device or a system, and forwards or processes this information in a certain manner.

"A device which detects or measures a physical property and records, indicates, or otherwise responds to it".

- Oxford Dictionary

References:
1. http://www.businessdictionary.com/definition/sensor.html
2. https://en.oxforddictionaries.com/definition/sensor

Sensors

- They perform some input functions by sensing or feeling the physical changes in characteristics of a system in response to a stimuli.
- For example heat is converted to electrical signals in a temperature sensor, or atmospheric pressure is converted to electrical signals in a barometer.

Transducers

- Transducers convert or transduce energy of one kind into another.
- For example, in a sound system, a microphone (input device)converts sound waves into electrical signals for an amplifier to amplify (a process), and a loudspeaker (output device) converts these electrical signals back into sound waves.

Sensor vs. Transducer

- The word “Transducer” is the collective term used for both Sensors which can be used to sense a wide range of different energy forms such as movement, electrical signals, radiant energy, thermal or magnetic energy etc., and Actuators which can be used to switch voltages or currents

References:

1. http://www.electronics-tutorials.ws/io/io_1.html

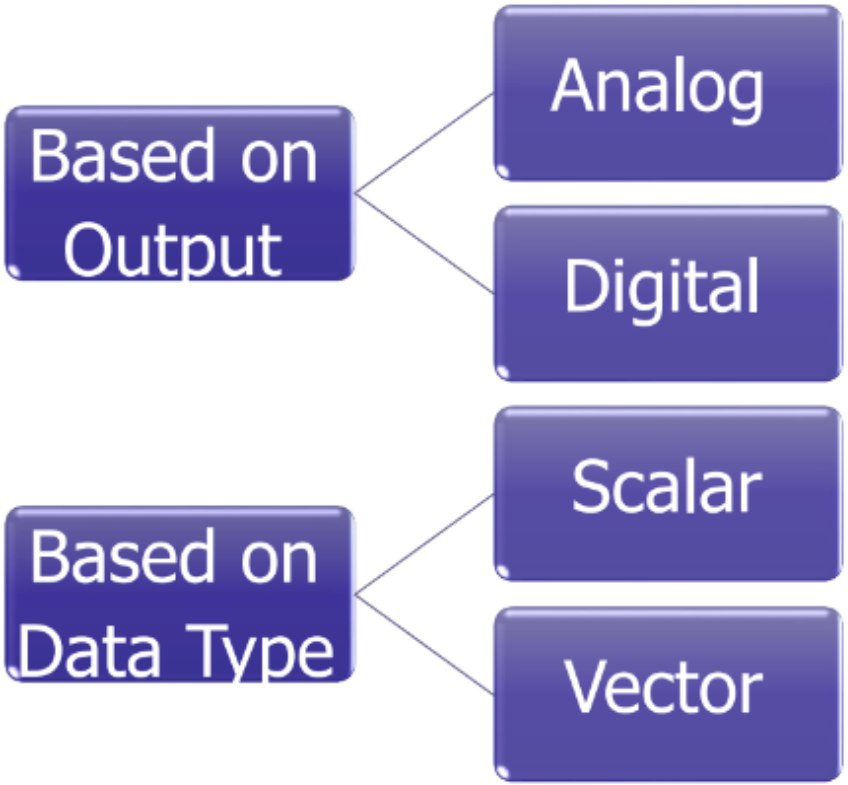
Sensor Features

- It is only sensitive to the measured property (e.g., A temperature sensor senses the ambient temperature of a room.)
- It is insensitive to any other property likely to be encountered in its application (e.g., A temperature sensor does not bother about light or pressure while sensing the temperature.)
- It does not influence the measured property (e.g., measuring the temperature does not reduce or increase the temperature).

Sensor Resolution

- The resolution of a sensor is the smallest change it can detect in the quantity that it is measuring.
- The resolution of a sensor with a digital output is usually the smallest resolution the digital output it is capable of processing.
- The more is the resolution of a sensor, the more accurate is its precision.
- A sensor's accuracy does not depend upon its resolution.

Sensor Classes



Analog Sensors

- Analog Sensors produce a continuous output signal or voltage which is generally proportional to the quantity being measured.
- Physical quantities such as Temperature, Speed, Pressure, Displacement, Strain etc. are all analog quantities as they tend to be continuous in nature.
- For example, the temperature of a liquid can be measured using a thermometer or thermocouple (e.g. in geysers) which continuously responds to temperature changes as the liquid is heated up or cooled down.

Digital Sensors

- Digital Sensors produce discrete digital output signals or voltages that are a digital representation of the quantity being measured.
- Digital sensors produce a binary output signal in the form of a logic “1” or a logic “0”, (“ON” or “OFF”).
- Digital signal only produces discrete (non-continuous) values, which may be output as a single “bit” (serial transmission), or by combining the bits to produce a single “byte” output (parallel transmission).

Scalar Sensors

- Scalar Sensors produce output signal or voltage which is generally proportional to the magnitude of the quantity being measured.
- Physical quantities such as temperature, color, pressure, strain, etc. are all scalar quantities as only their magnitude is sufficient to convey an information.
- For example, the temperature of a room can be measured using a thermometer or thermocouple, which responds to temperature changes irrespective of the orientation of the sensor or its direction.

Vector Sensors

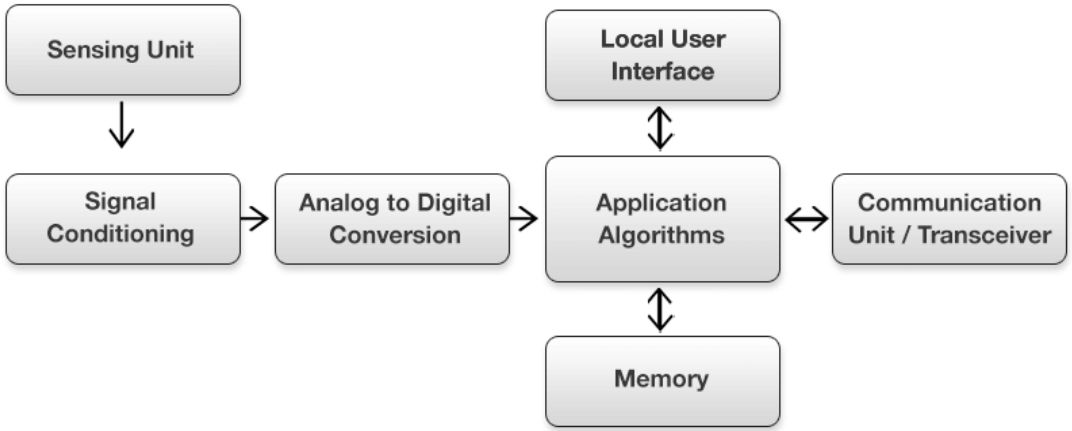
- Vector Sensors produce output signal or voltage which is generally proportional to the magnitude, direction, as well as the orientation of the quantity being measured.
- Physical quantities such as sound, image, velocity, acceleration, orientation, etc. are all vector quantities, as only their magnitude is not sufficient to convey the complete information.
- For example, the acceleration of a body can be measured using an accelerometer, which gives the components of acceleration of the body with respect to the x,y,z coordinate axes.

Different Types of Sensors

Mobile Phone – A sensor hub

Smart Sensor

- Sensors with integrated electronics that can perform Data conversion, Bidirectional communication, take decisions and perform logical operations
- A sensor with built-in integrated circuit (microcontroller, and sensor) which provides the physical parameter as output on connecting it to a supply voltage and programming it.



Actuator

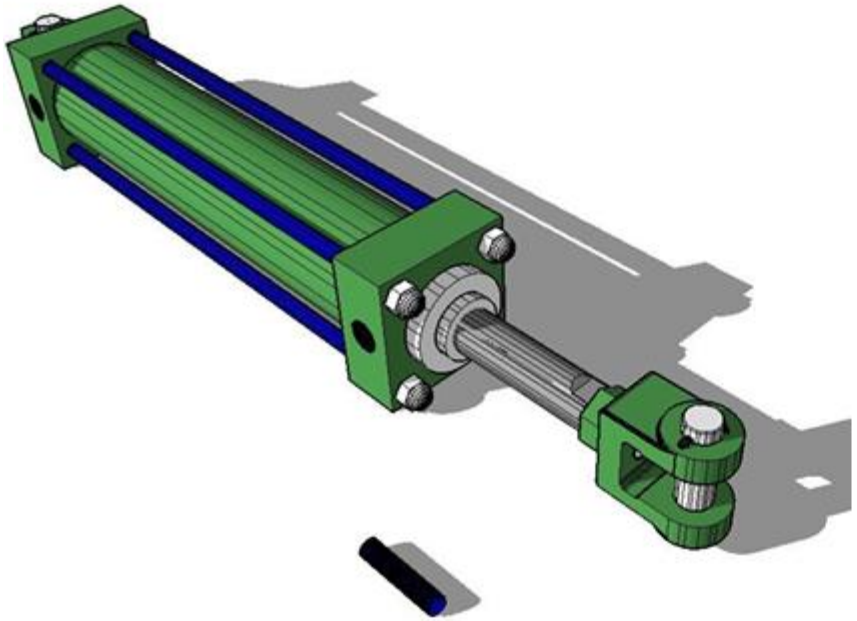
- An actuator is a component of a machine or system that moves or controls the mechanism or the system.
- An actuator is the mechanism by which a control system acts upon an environment
- An actuator requires a control signal and a source of energy.
- Upon receiving a control signal is received, the actuator responds by converting the energy into mechanical motion.
- The control system can be simple (a fixed mechanical or electronic system), software-based (e.g. a printer driver, robot control system), a human, or any other input.

Actuator Types

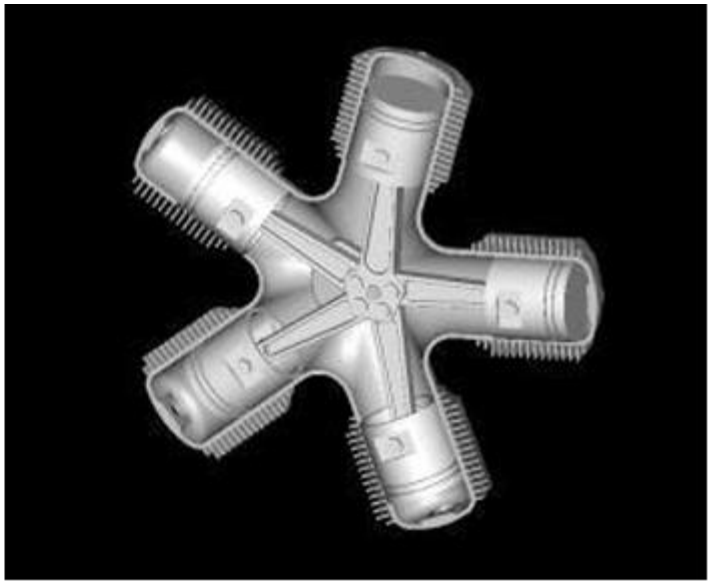
Hydraulic Actuators

- A hydraulic actuator consists of a cylinder or fluid mo tor that uses hydraulic power to facilitate mechanical operation
- The mechanical motion is converted to linear, rotary or oscillatory motion.
- Since liquids are nearly impossible to compress, a hy draulic actuator exerts considerable force.
- The actuator's limited acceleration restricts its usage

Reference: https://en.wikipedia.org/wiki/Actuator



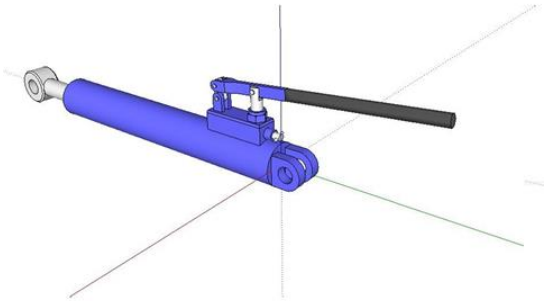
An oil based hydraulic actuator



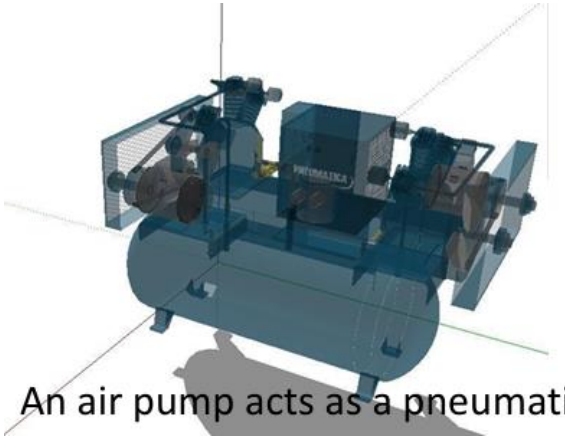
A radial engine acts as a hydraulic actuator

Pneumatic Actuators

- A pneumatic actuator converts energy formed by vacuum or compressed air at high pr essure into either linear or rotary motion.
- Pneumatic rack and pinion actuators are used for valve controls of water pipes.
- Pneumatic energy quickly responds to starting and stopping signals.
- The power source does not need to be stored in reserve for operation.
- Pneumatic actuators enable large forces to be produced from relatively small pressure changes (e.g., Pneumatic brakes can are very responsive to small changes in pressure applied by the driver).
- It is responsible for converting pressure into force



A manual linear pneumatic actuator



An air pump acts as a pneumatic actuator

Hydraulic Actuators

- An electric actuator is generally powered by a motor that converts electrical energy into mechanical torque.
- The electrical energy is used to actuate equipment such as solenoid valves which control the flow of water in pipes in response to electrical signals.
- Considered as one of the cheapest, cleanest and speedy actuator types available.

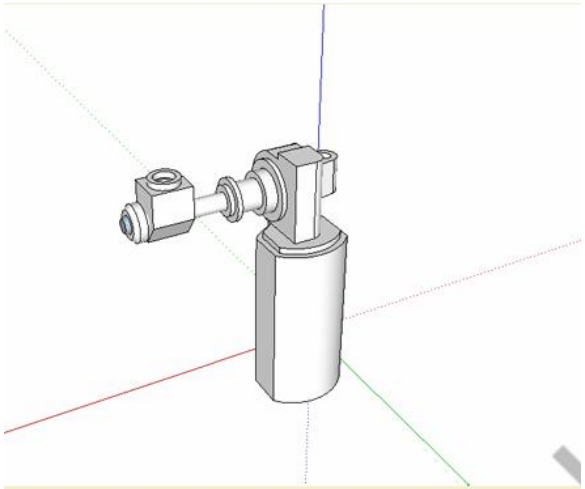
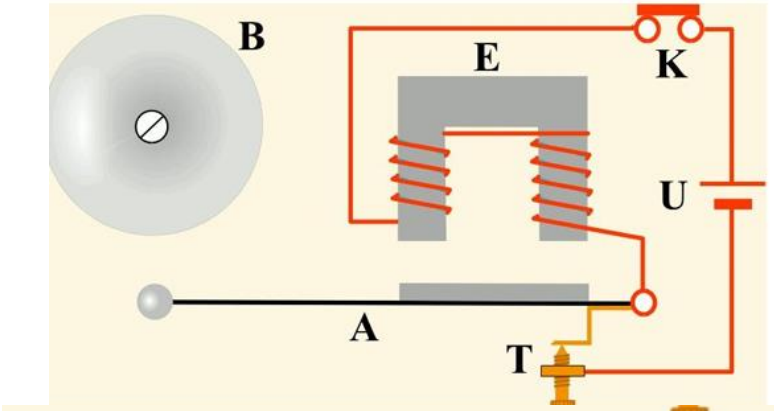


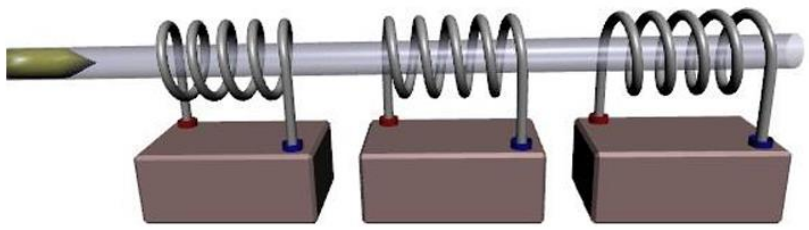
Fig: A motor drive-based rotary actuator



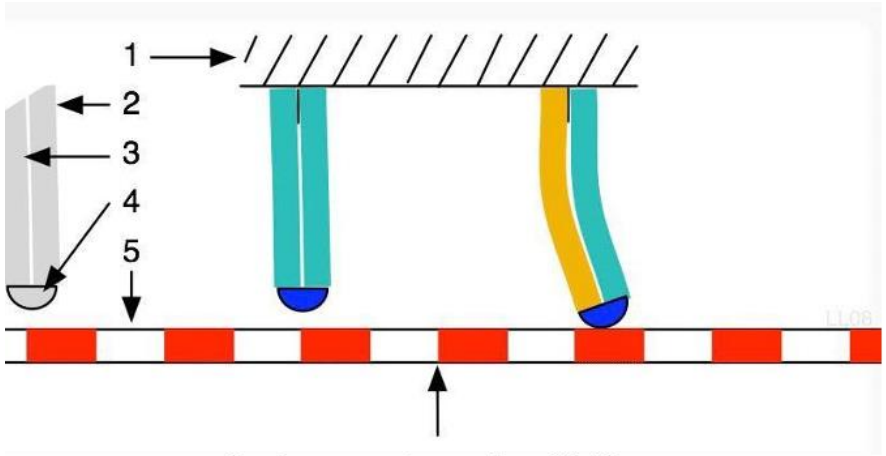
A solenoid based electric bell ringing mechanism

Thermal or Magnetic Actuators

- These can be actuated by applying thermal or magnetic energy.
- They tend to be compact, lightweight, economical and with high power density.
- These actuators use shape memory materials (SMMs), such as shape memory alloys (SMAs) or magnetic shape-memory alloys (MSMAs).
- Some popular manufacturers of these devices are Finnish Modti Inc. and American Dynalloy.



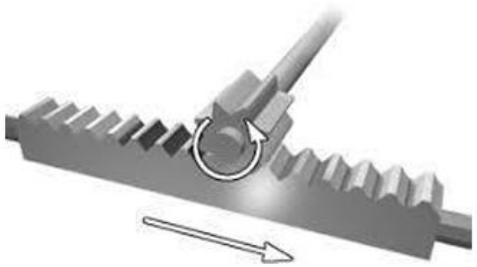
A coil gun works on the principle of magnetic actuation



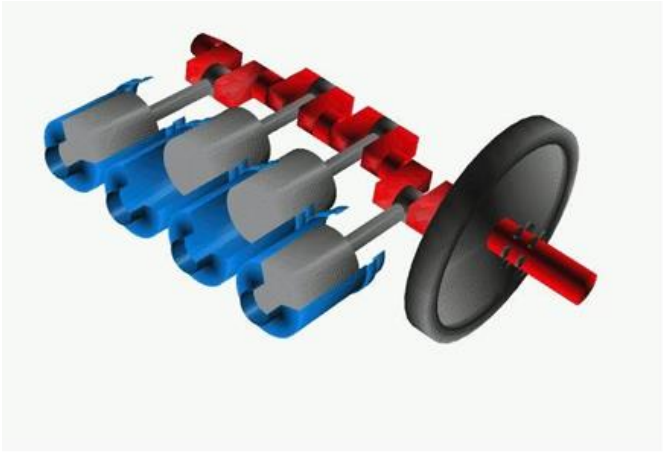
A piezo motor using SMA

Mechanical Actuators

- A mechanical actuator converts rotary motion into lin ear motion to execute some movement.
- It involves gears, rails, pulleys, chains and other devic es to operate.
- Example: rack and pinion



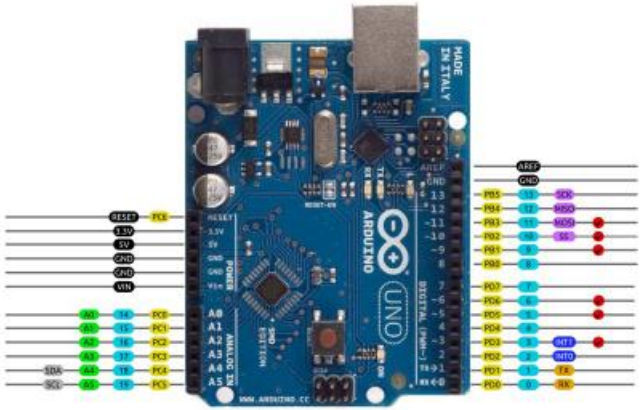
A rack and pinion mechanism



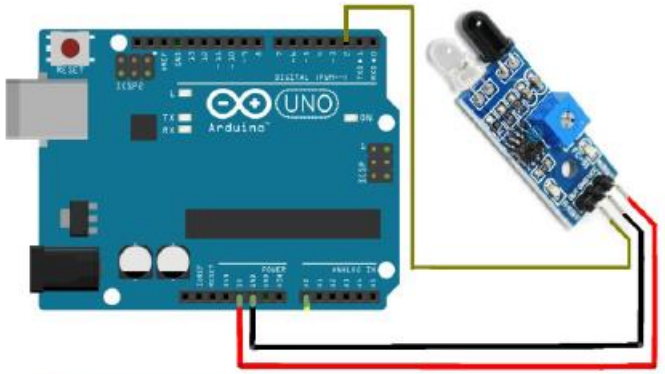
A crank shaft acting as a mechanical actuator

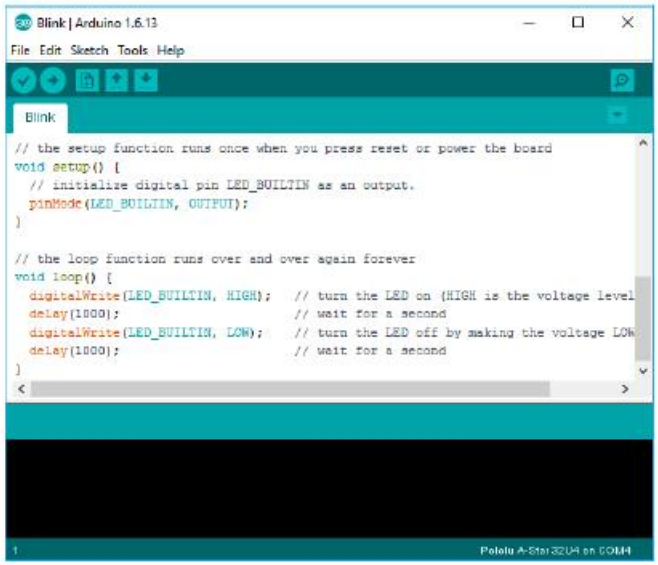
Arduino

Arduino Uno SMD Pinout



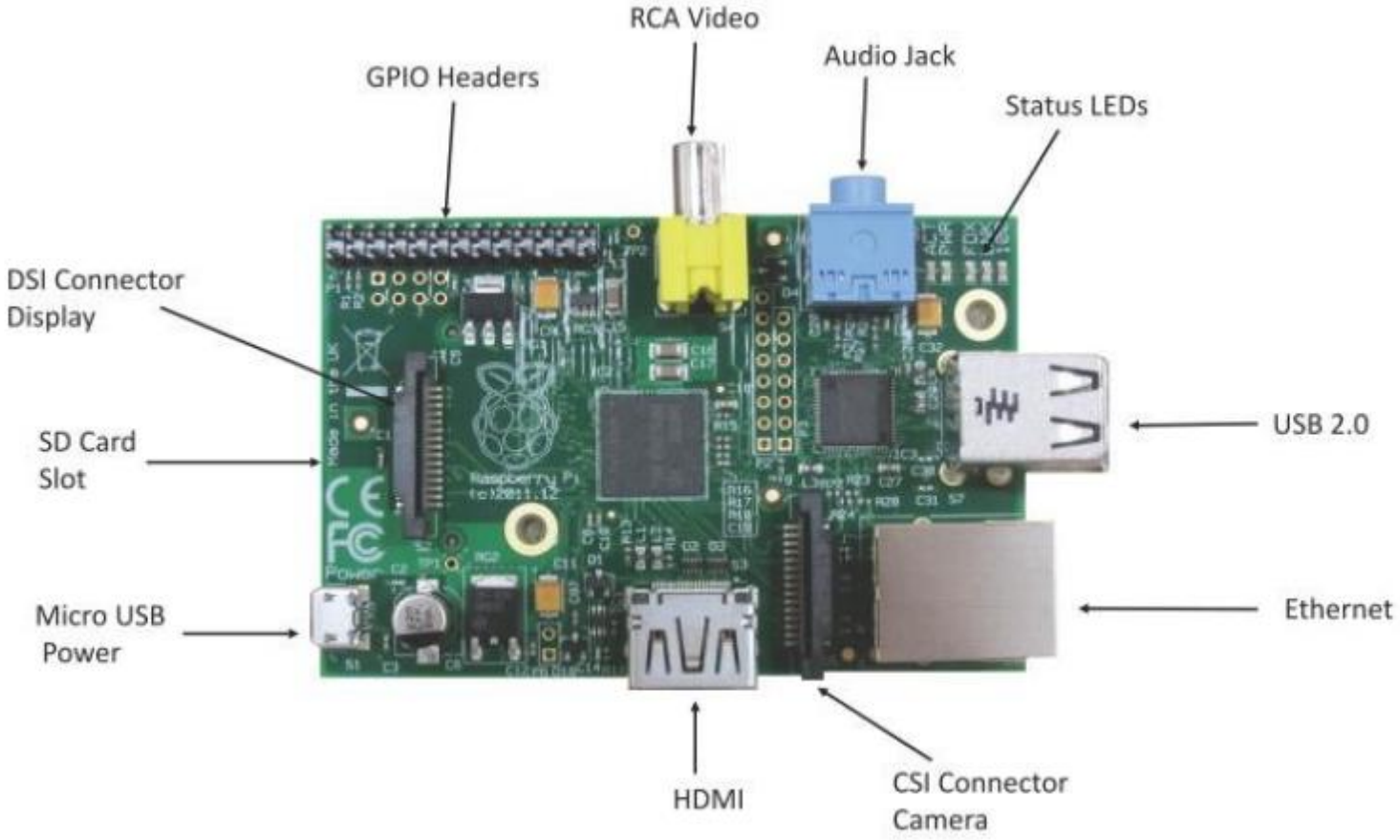
AVR DIGITAL ANALOG POWER SERIAL SPI I2C PWM INTERRUPT





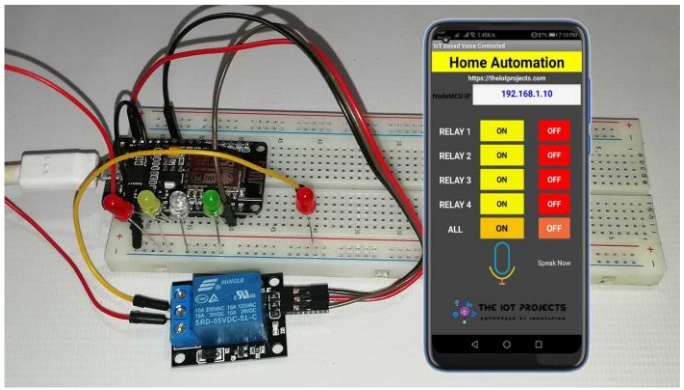
Raspberry Pi

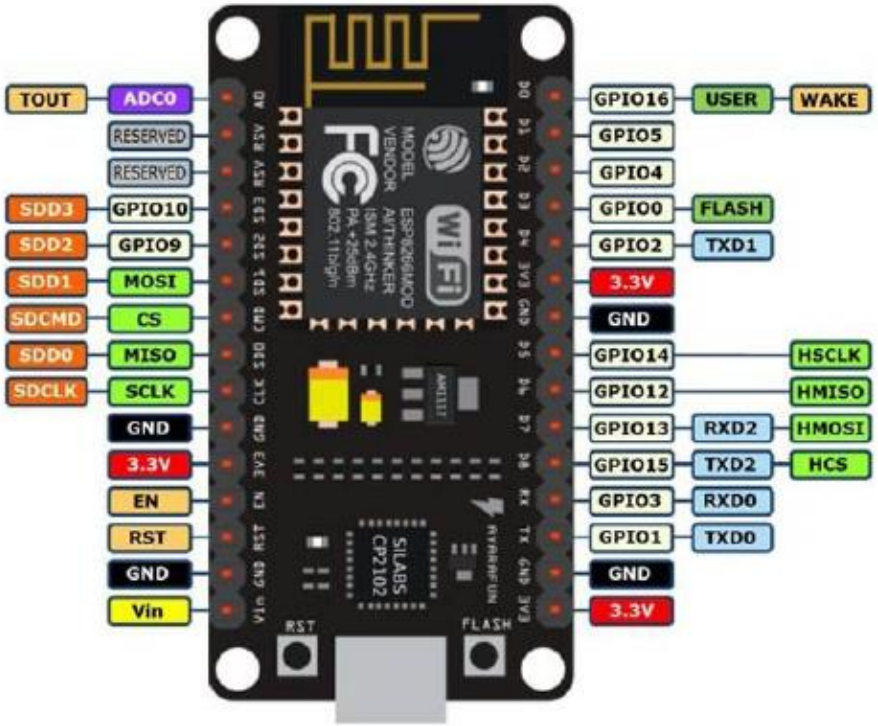
- Low cost mini computer, allows interfacing sensors though GPIOs, runs Raspbian OS (a Liux variant), supports Python



NodeMCU

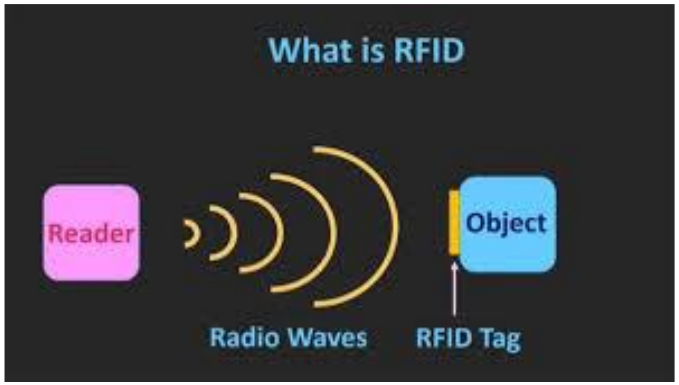
- NodeMCU is a low-cost open source IoT platform. It initially included firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which was based on the ESP-12 module. Later, support for the ESP32 32-bit MCU was added.
- Memory: 128kBytes
- Developer: ESP8266 Opensource Community
- CPU: ESP8266(LX106)
- Storage: 4MBytes





RFID (Radio Frequency ID) Technology in IoT

- Identification System – Tagging and Labelling
- Tiny chips : Passive/Active; battery powered when reader near wireless
- Communication range : 10cm to 200m
- Standard frequency : 120-150KHz, 13.56MHz,433MHz and higher in UHF
- regions
- Applications : Tracking, inventory control



Summary

- Things
- Sensors
- Actuators
- Embedded Devices - hardware