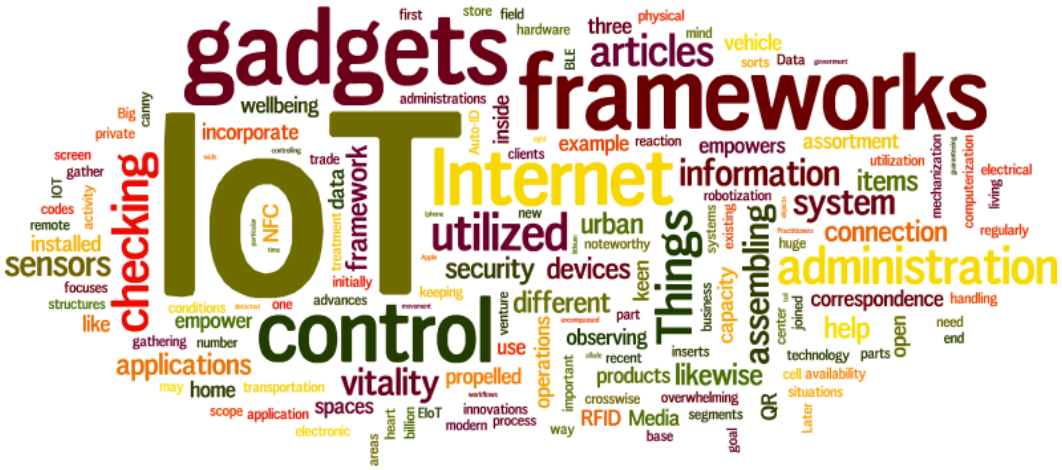
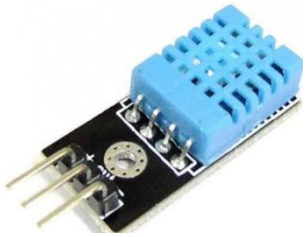
Internet of Things 3

The “Things” in IoT



The “Things”

- Sensors & Actuators are the fundamental building blocks of IoT
  - Sensor senses
  - Actuator acts

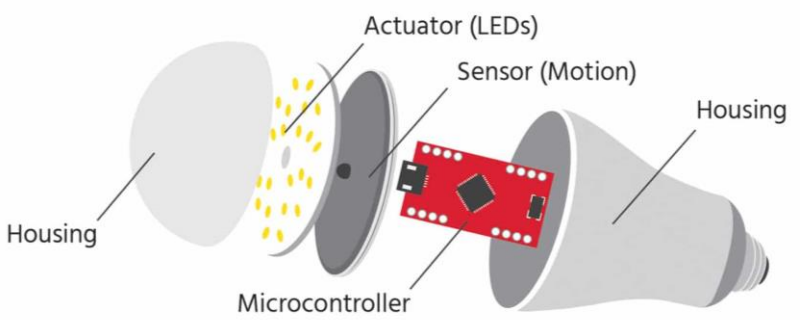


Sensor

- Smart objects are any physical objects that contain
  - Embedded technology
    - Microcontroller unit, memory storage, power supply, communication ports, input and output, timer or counter
  - Sensors and/or actuators

Actuator

- Smart objects are to sense and/or interact with their environment in a meaningful way
  - being interconnected, and
  - enabling communication among themselves or with external agent.



Smart Object

Sensors

- It **measures some physical quantity** and converts that measurement into analog/digital form

- There are a number of ways to group and cluster sensors into different categories

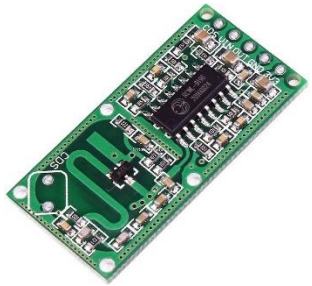
  - Based on external energy requirement
    - Active / Passive
  - Based on placement location
    - Invasive / Non-invasive
  - Based on distance from the sensing object
    - Contact / No-contact
  - Based on application industry
    - Medical / Manufacturing / Agriculture / etc.
  - Based on measuring scale
    - Absolute / Relative
  - Based on sensing mechanism
    - Thermoelectric / Electromechanical / Piezo resistive / Optic / Electric / Fluid mechanics / Photoelastic / etc.
  - Based on sensing parameter
    - Position / Occupancy / Motion / Velocity / Force / Pressure / Flow / Humidity / Light / Temperature / Acoustic / Radiation / Chemical / Biosensors / etc.

Sensor Types: What it measures

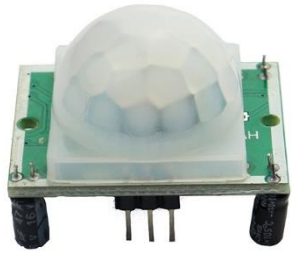
Sensor Type	Description	Example
Position	• Measures the position of an object • Position could be absolute/relative • Position sensor could be linear, angular, or multi-axis	• Proximity sensor • Potentiometer • Inclinometer
Occupancy	• Detects the presence of people and animals in a surveillance area • Generates signal even when a person is stationary	• Radar Sensor
Motion	• Detects the movement of people and objects	• Passive Infrared (PIR) Sensor

Ultrasonic Proximity Sensor

Infrared Proximity Sensor



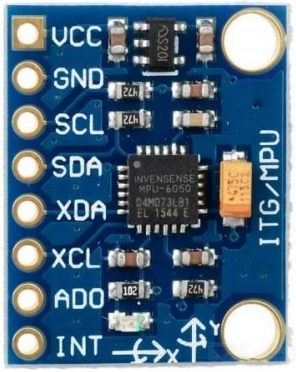
Microwave Radar



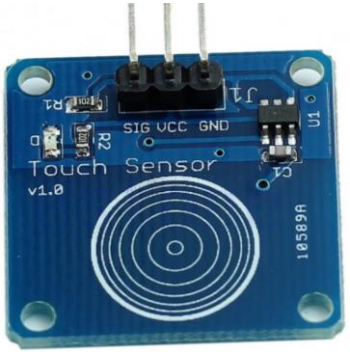
PIR Motion Sensor

Cont…

Sensor Type	Description	Example
Velocity and Acceleration	• Velocity sensor measures how fast an object moves • Acceleration sensor measures the changes in velocity	• Gyroscope • Accelerometer
Force	• Detects whether a physical force is applied and the magnitude of the force	• Tactile sensor • Viscometer
Pressure	• Measuring the force applied by liquids or gases • It is measured as force per unit area	• Barometer • Piezometer



Gyroscope



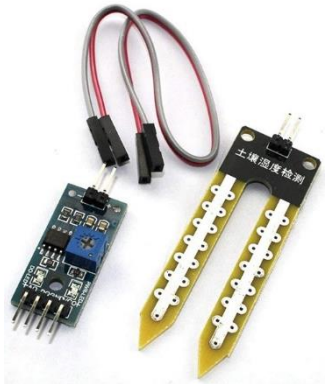
Capacitive Touch Sensor

Barometric Pressure Sensor

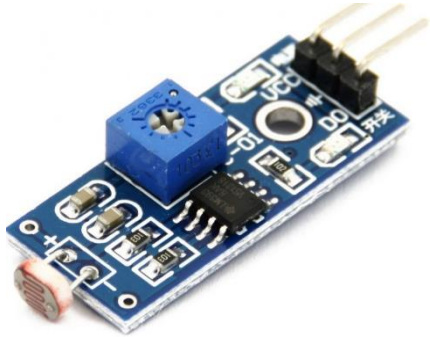
Cont…

Sensor Type	Description	Example
Flow	• Detects the rate of fluid flow through a system in given period of time	• Water meter • Anemometer
Humidity	• Detects amount of water vapour in the air • Can be measured in absolute/relative scale	• Hygrometer • Soil moisture sensor
Light	• Detects the presence of light	• LDR light sensor • Photodetector • Flame Sensor

Water meter



Soil moisture sensor



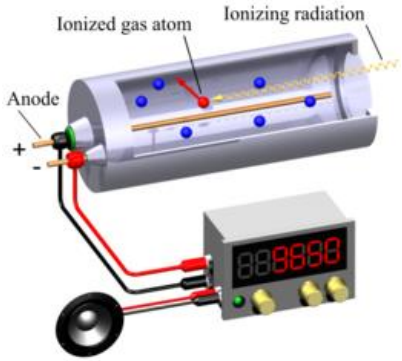
LDR light sensor

Flame sensor

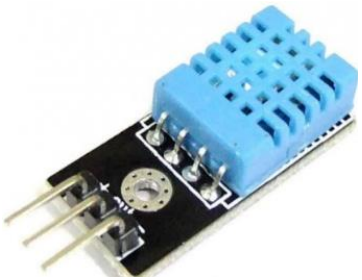
Cont…

Sensor Type	Description	Example
Radiation	• Detects the radiation in the environment	• Neutron detector • Geiger-Muller counter
Temperature	• Measures the amount of heat or cold present in the system • Two type: contact / non-contact	• Thermometer • Temperature gauge • Calorimeter

Neutron detector



Geiger-Muller counter

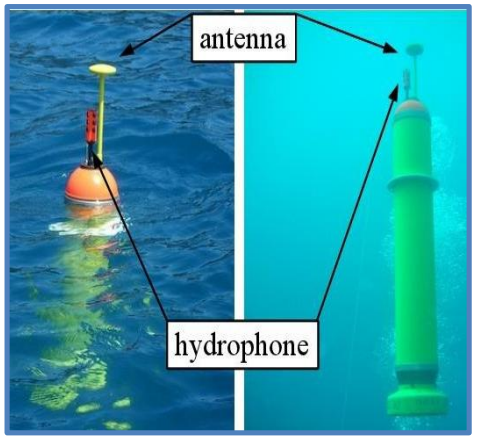


Temperature Sensor

Thermo-Hygrometer

Cont…

Sensor Type	Description	Example
Acoustic	• Measures sound level	• Microphone • Hydrophone
Chemical	• Measures the concentration of a chemical (e.g. CO_2) in a system	• Smoke detector • Breathalyzer
Biosensor	• Detects various biological elements, such as organisms, tissues, cells, enzymes, antibodies, nucleic acid, etc.	• Pulse oximeter • Electrocardiograph (ECG) • Blood glucose biosensor

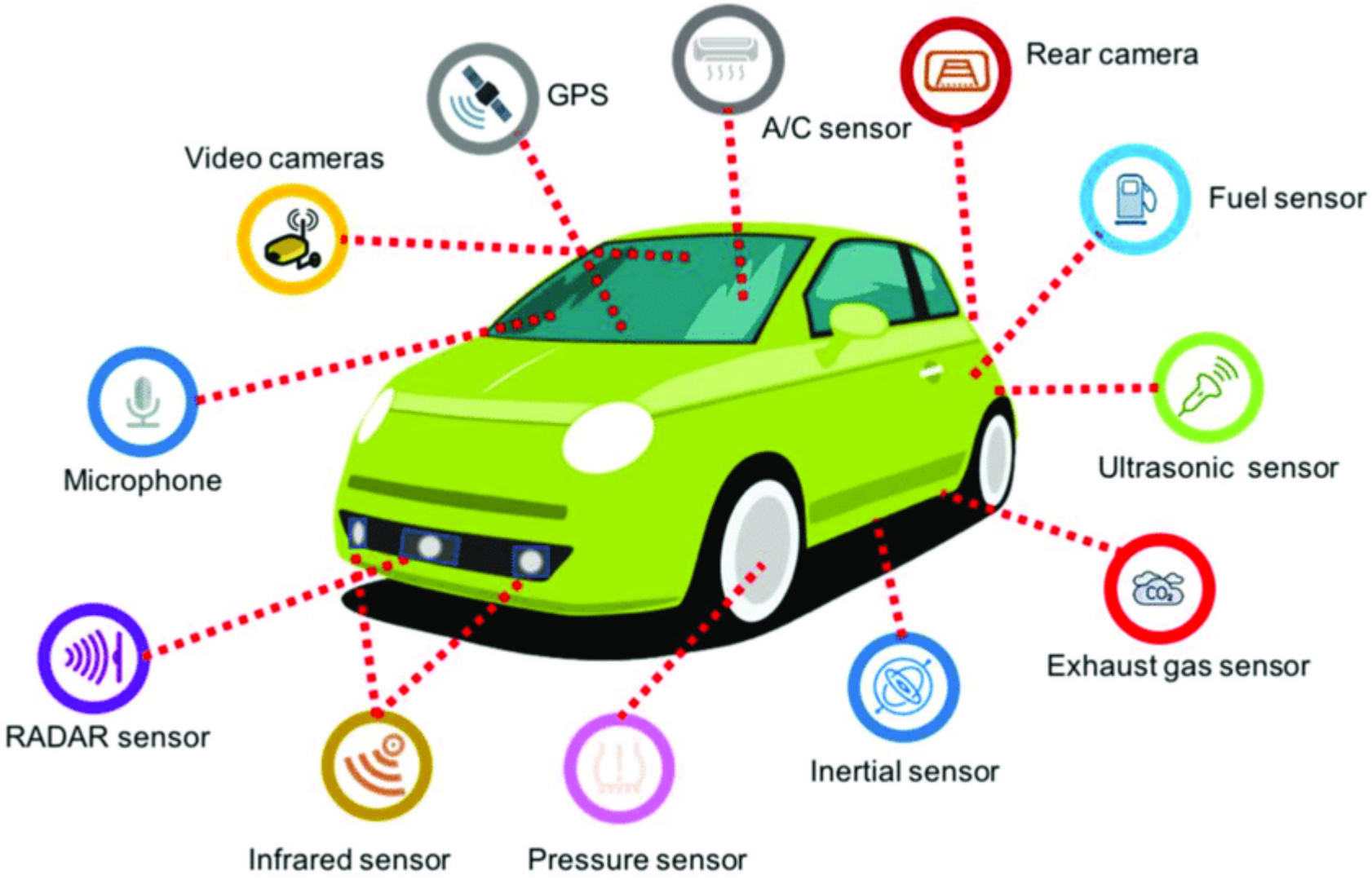


Hydrophone

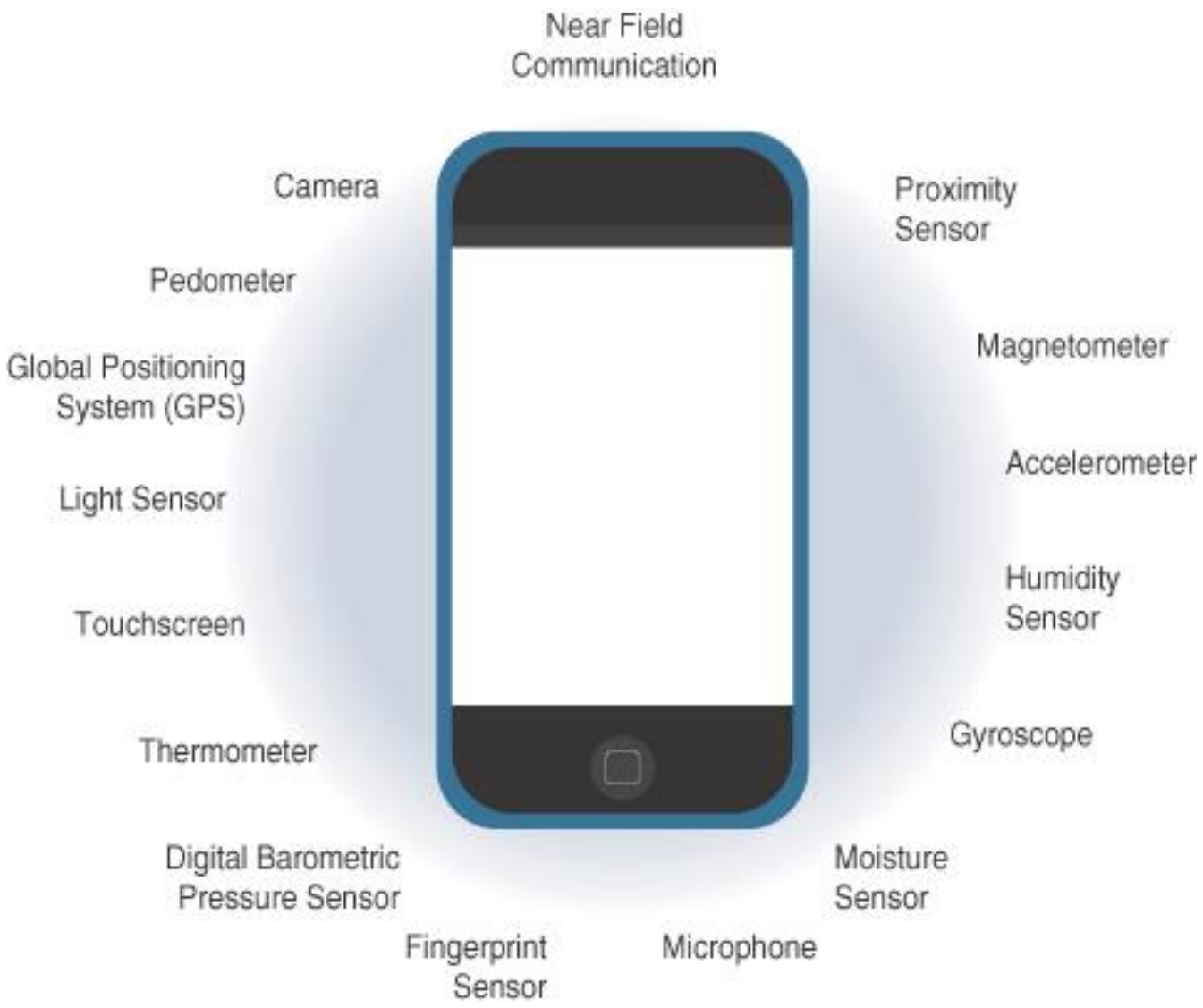
Breathalyzer

Pulse oximeter

Sensors in a Smart Car

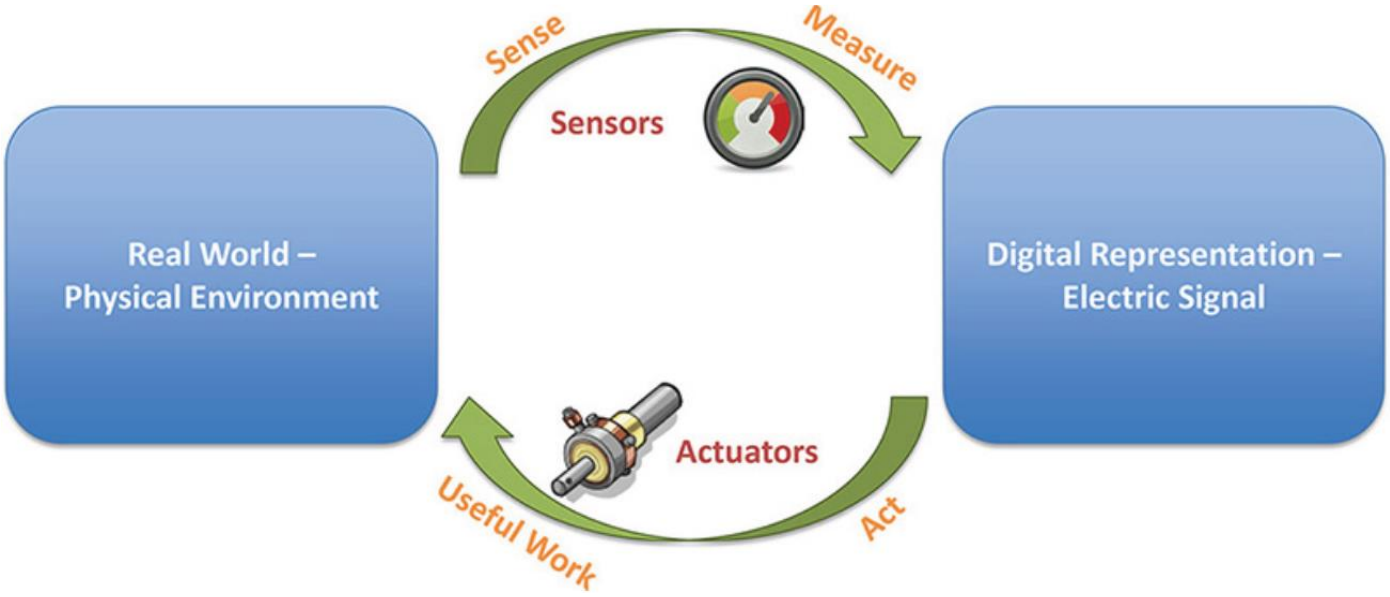


Sensors in a Smartphone



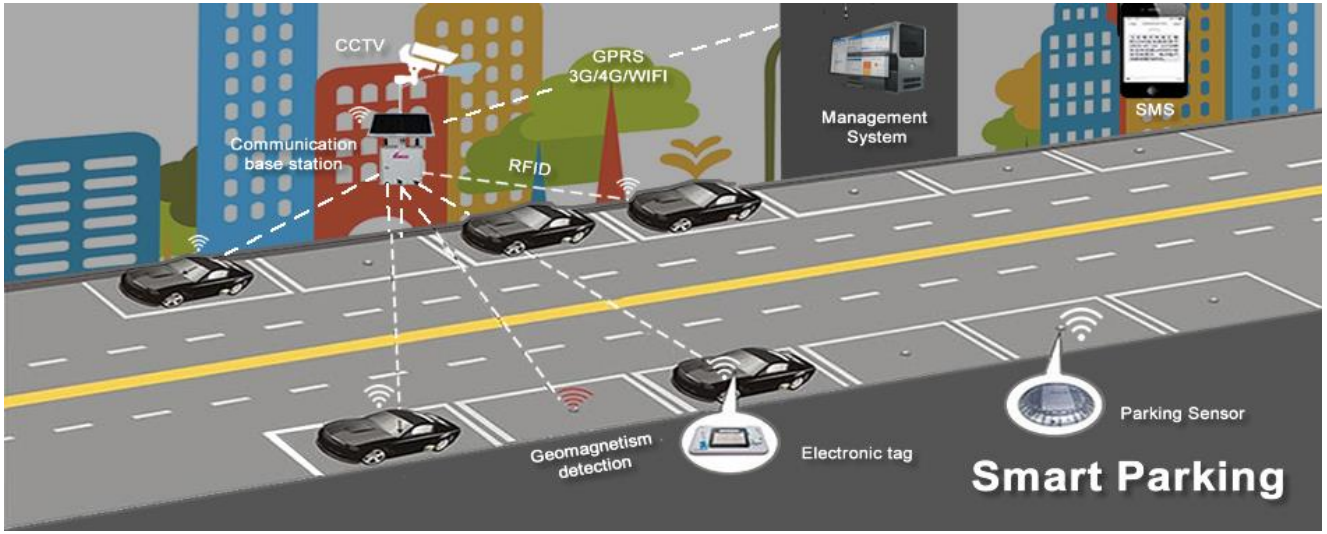
Actuators

- Sensors are designed to sense and measure the surrounding environment
- Actuators receive some type of control signal (commonly an electrical signal or digital command) that **triggers a physical effect**, usually some type of motion, force, and so on.



Source: https://cdn2.hubspot.net/hubfs/1878050/Landingpages/Events/Schwabengipfel/Guido_Schmutz_IoT-Cloud-or-OnPrem.pdf?t=1501051153000

IoT based Automated Systems



Smart Parking System

Source:
https://www.mobiloitte.com/blog/smart-parking-solution-using-iot/

Smart Irrigation System

Source:
https://www.hydropoint.com/what-is-smart-irrigation/

Actuator Classification

- Common ways to classify actuators:

  ✓ Type of motion they produce
    - e.g. linear, rotary, one/two/three axes

  ✓ Power output
    - e.g. high power, low power, micro power

  ✓ Binary / Continuous output
    - Based on number of stable-state outputs

  ✓ Area of application
    - Specific industry or vertical where they are used

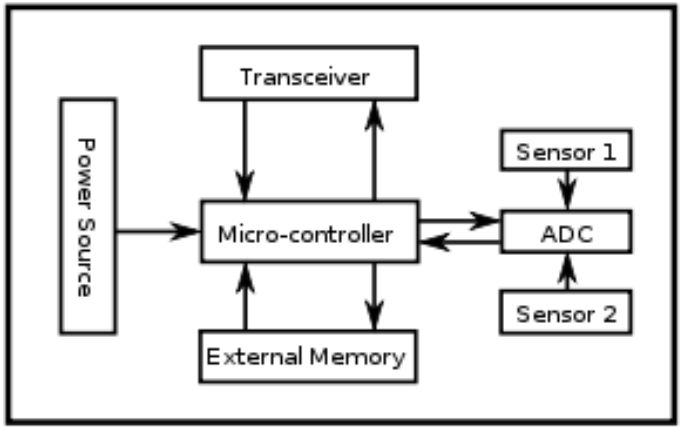
  ✓ Type of energy
    - e.g. mechanical energy, electrical energy, hydraulic energy, etc.

Actuators by Energy Type

Type	Examples
Mechanical actuators	Lever, Screw jack, Hand crank
Electrical actuators	Thyristor, Bipolar transistor, Diode
Electromechanical actuators	AC motor, DC motor, Step motor
Electromagnetic actuators	Electromagnet, Linear solenoid
Hydraulic and Pneumatic actuators	Hydraulic cylinder, Pneumatic cylinder, Piston, Pressure control valve, Air motor
Smart material actuator (includes thermal and magnetic actuators)	Magnetorestrictive material, Bimetallic strip, Piezoelectric bimorph

Smart Objects

- It is the building blocks of IoT
- Smart object has the following five characteristics:
  - Sensor(s) and/or Actuator(s)
  - Processing unit
    - For acquiring sensed data from sensors,
    - processing and analysing sensing data,
    - coordinating control signals to any actuators, and
    - controlling many functions (e.g. communication unit, power unit).
  - Memory
    - Mostly on-chip flash memory
    - user memory used for storing application related data
    - program memory used for programming the device
  - Communication unit
    - Responsible for connecting a smart object with other smart objects and the outside world (via the network using wireless/wired communication)
  - Power source
    - To powered all components of the smart object



TelosB Mote

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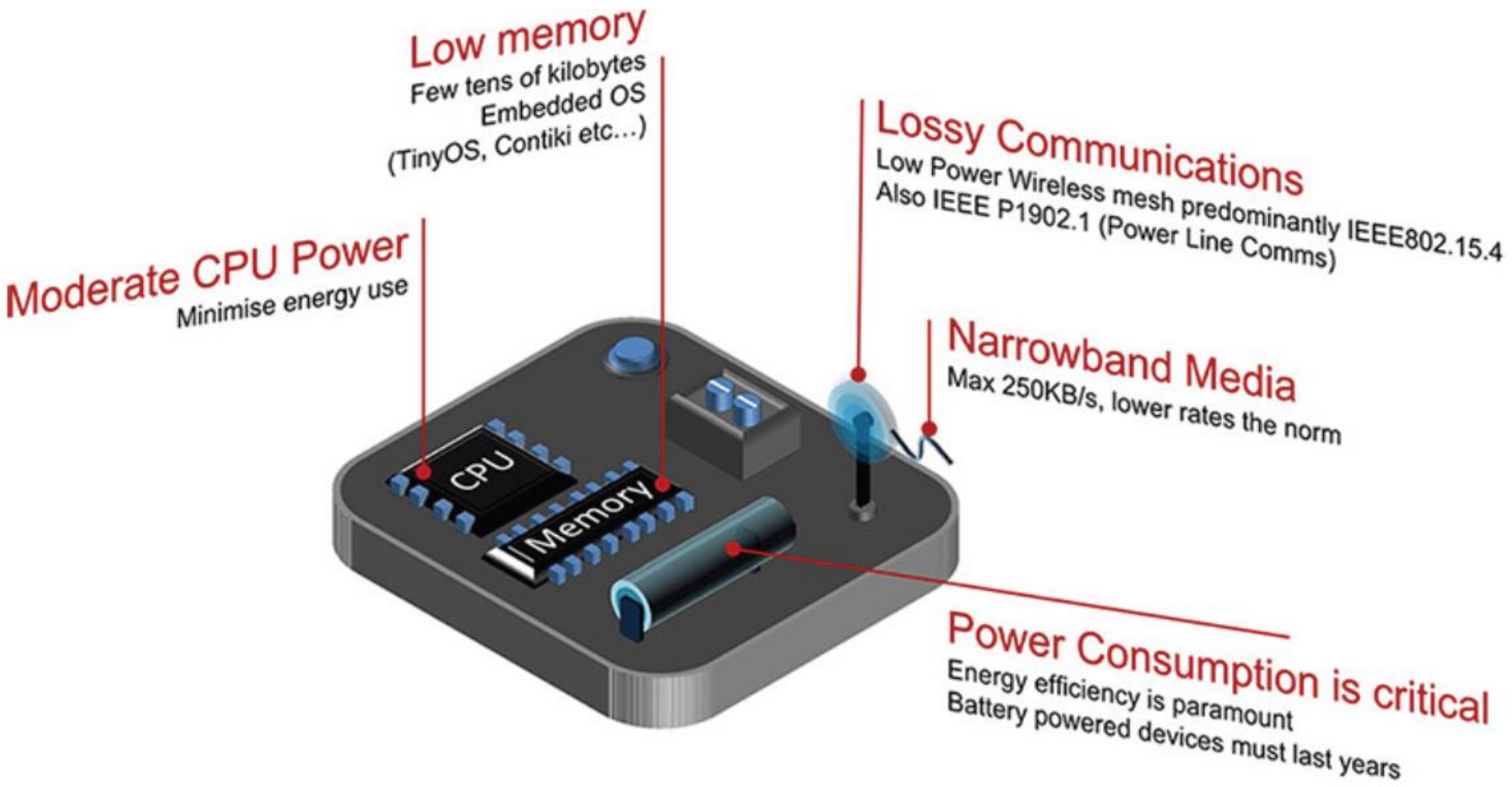

Source: Cisco

Present Trends in Smart Objects

- Size is decreasing
- Power consumption is decreasing
- Processing power is increasing
- Communication capabilities are improving
- Communication is being increasingly standardized

Lessons Learned

- ✓ What is “Things” in IoT
- ✓ Classification method of Sensors
- ✓ Different Sensors based on Sensing parameter
- ✓ Classification method of Actuators
- ✓ Different Actuators based on Energy type
- ✓ What is “Smart object” in IoT

Thanks!

Figures and slide materials are taken from the following Books:

1. David Hanes *et al.*, "**IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things**", 1st Edition, 2018, Pearson India.