
THE INTERNET OF THINGS
The future of technology
Wi Fi

FUNDAMENTALS OF INTERNET OF THINGS

UNIT-I-PART 1

INTRODUCTION

- ## INTERNET:

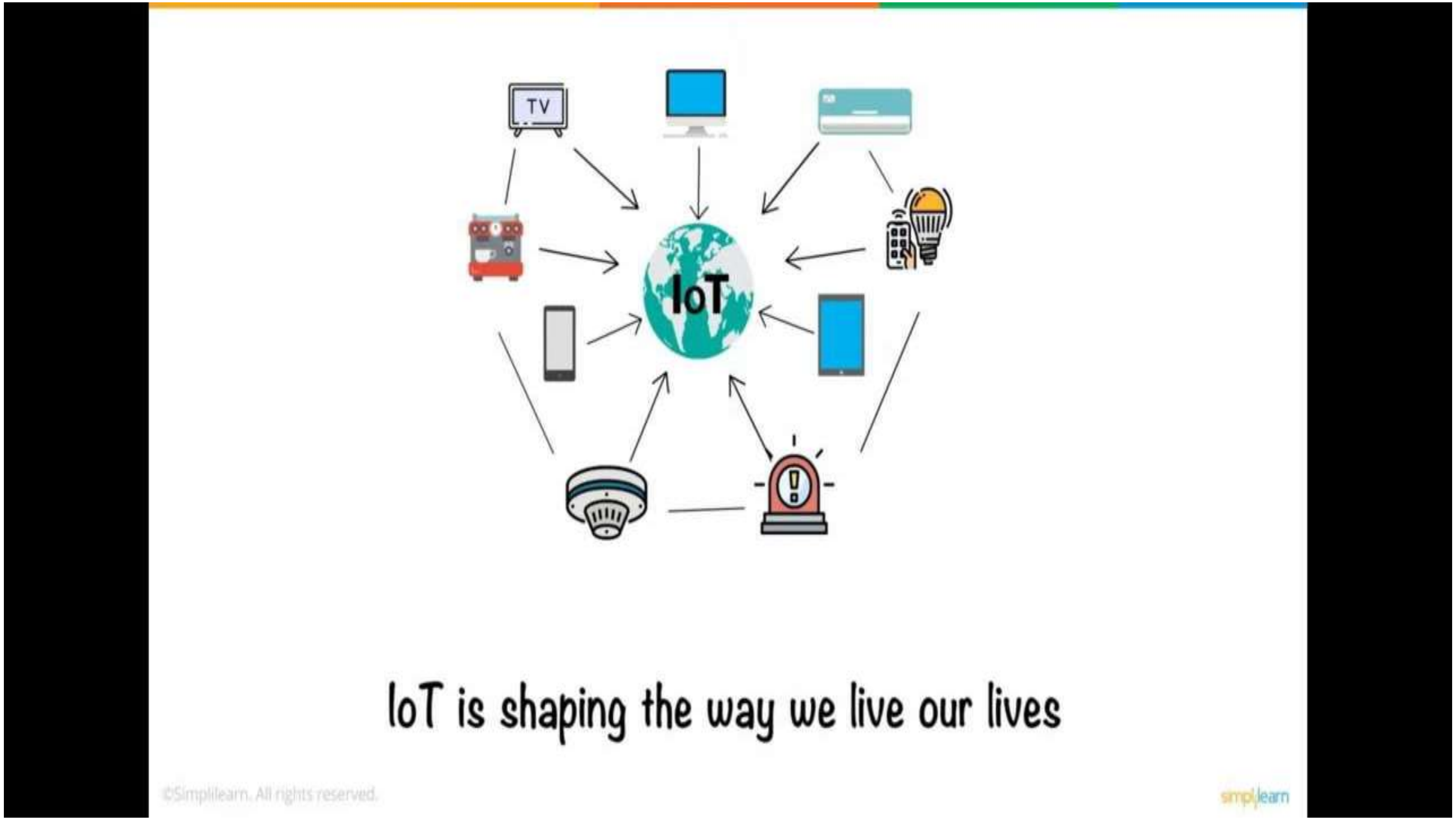
- Internet is a vast global network of connected servers, computers, tablets and mobiles that is governed by standard protocols for connected systems.

- It enables sending, receiving, or communication of information, connectivity with remote servers, cloud and analytics platforms.

Definition of iot

- A dynamic global network infrastructure with self configuring capabilities based on standard and
- interoperable communication protocols where physical and virtual “things” have identities, physical
- attributes, and virtual personalities and use intelligent interfaces and are seamlessly integrated into
- the information network, often communicate data associated with users and their environment.

- **Physical object+ controller, sensor and actuator + internet =IOT**


TV
IoT
IoT is shaping the way we live our lives
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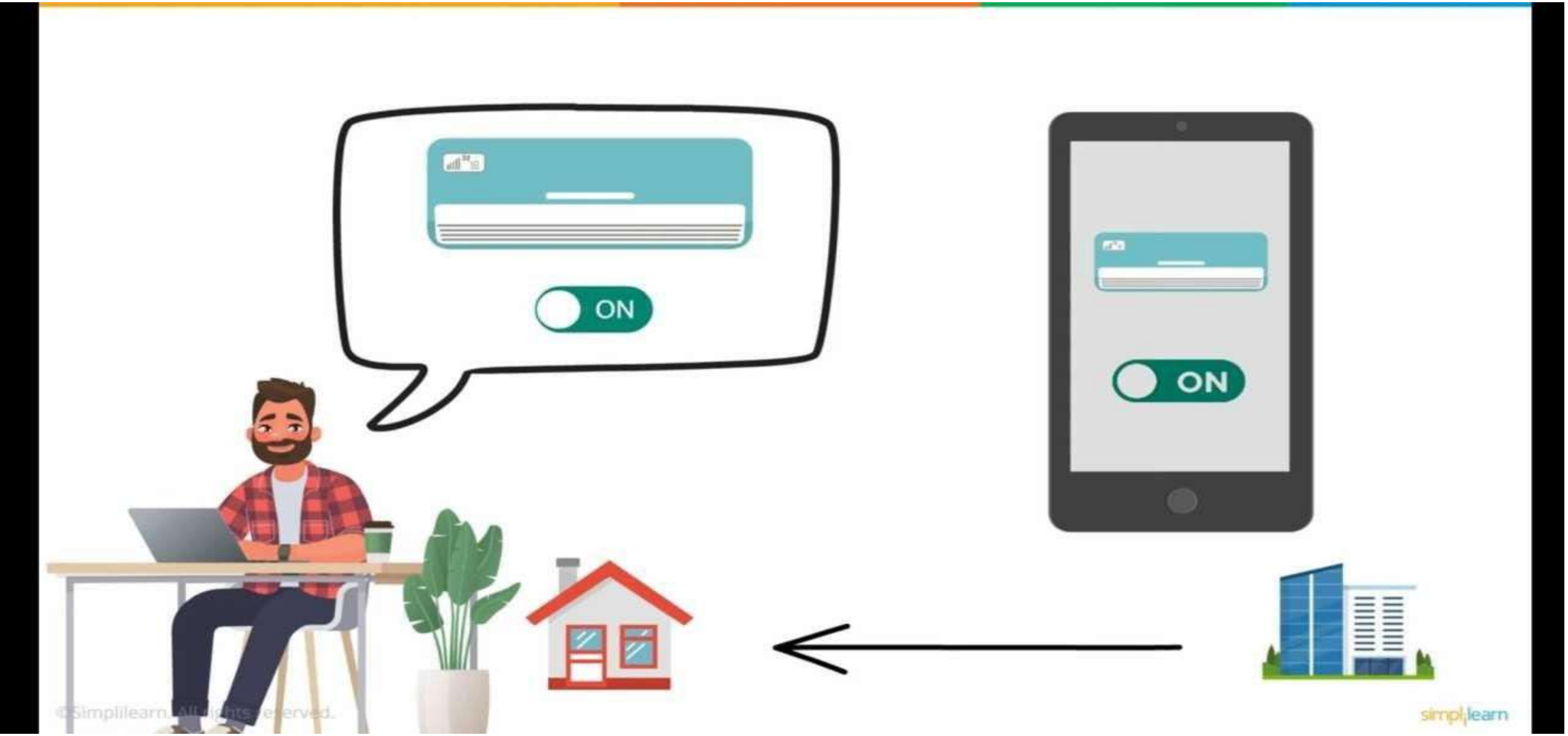
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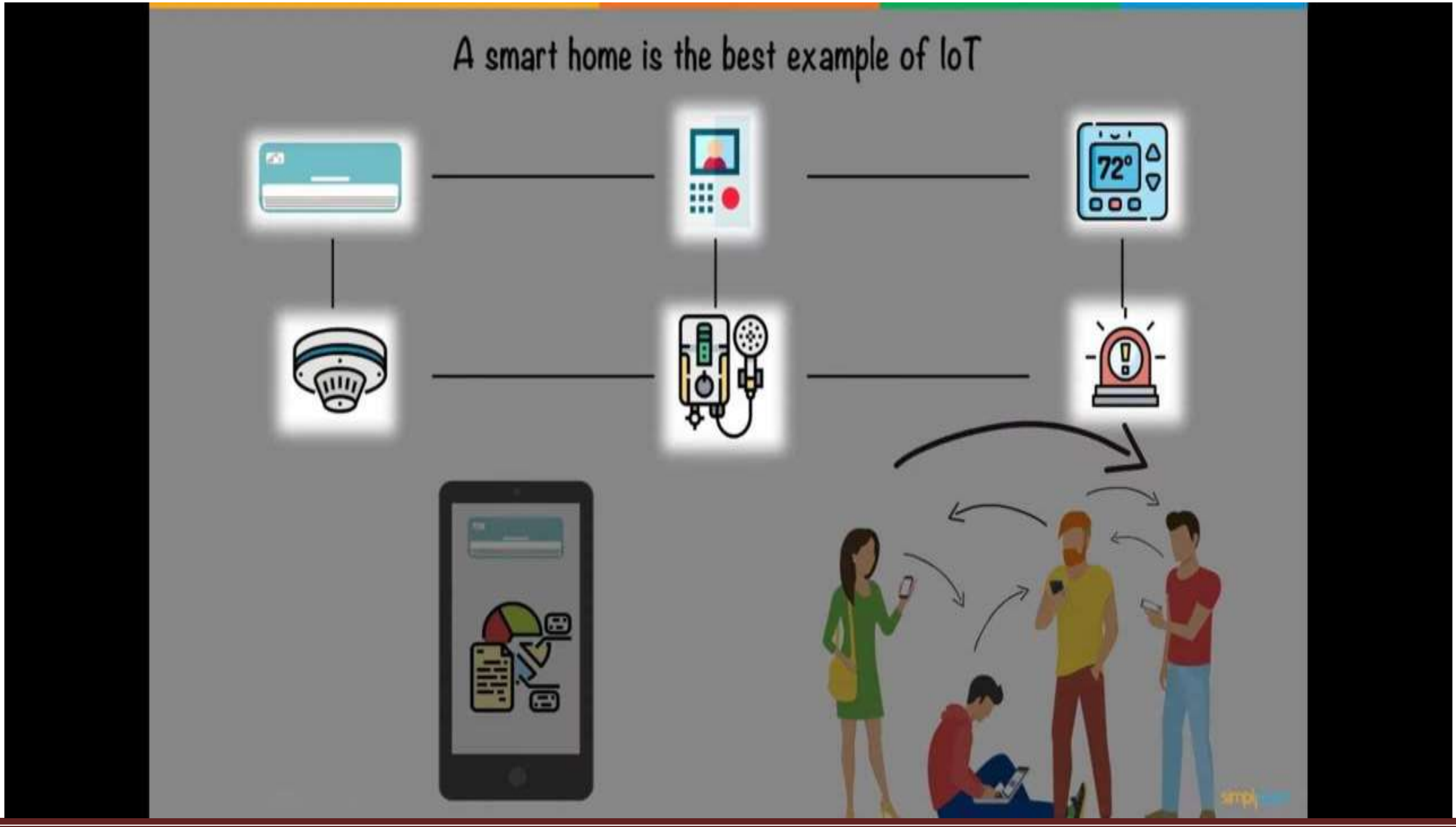
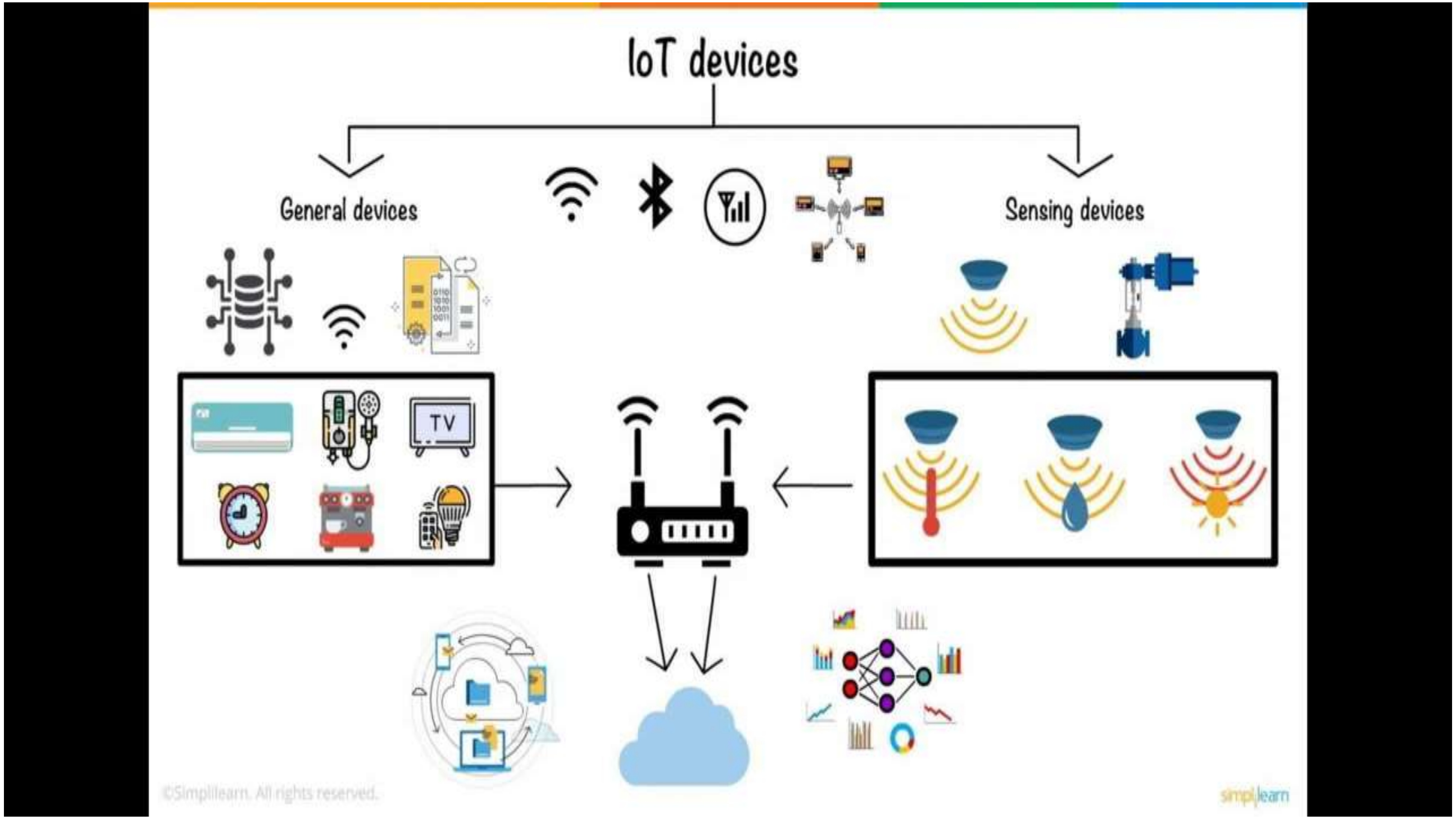

A smart home is the best example of IoT
72°


IoT devices
General devices
Sensing devices
TV
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Today, IoT is being used extensively to lessen the burden on humans
Snooze
06:00

IOT VISION

- IOT is a vision where things (wearable watches, alarm clocks, home devices, surrounding objects) become smart and function like living entities by sensing, computing and communicating through embedded devices which interact with remote objects (servers, clouds, applications, services and processes) or persons through the internet or Near-Field Communication (NFC).

Characteristics of IOT

- Dynamic grated and self adapting
- Self configuring
- Interoperable communication protocols
- Unique identity
- Integrated into information network
- Heterogeneity
- Sensing
- Intelligence
- Large scale

DYNAMIC AND SELF ADAPTING:

- IOT devices and systems may have the capability to dynamically adapt with the changing contexts and take action based on their operating conditions, users context or sensed environment.

SELF CONFIGURING:

IOT devices may have self-configuring capability, allowing a large number of devices to work together to provide certain functionality like setup networking, fetch latest software upgrades.

INTEROPERABLE COMMUNICATION PROTOCOLS:

IOT devices may support a number of interoperable communication protocols and can communicate with other devices and also with the infrastructure.

UNIQUE IDENTITY:

- Each IOT has unique identity and unique identifier (such as an IP address or a URI).
- This is helpful in tracking the equipment and at times to query its status.
- Device interface allow users to query the device, monitor the status, control them remotely.

INTEGRATED INTO INFORMATION NETWORK:

- IOT devices are usually integrated into the information network that allows them to communicate and
- exchange data with other devices and systems.

- Can be dynamically discovered by other devices.

- Have the capability to describe themselves to other devices or user application.
- Integration into the information network makes IOT systems “smarter”.

HETEROGENEITY:

- Devices in IOT are based on different hardware platforms and networks and can interact with other devices
- or service platform through different networks. IOT architecture should support direct network
- connectivity between heterogenous networks.

SENSING

INTELLIGENCE

LARGE SCALE

Physical Design of IoT:

Things in IoT
IoT Protocols

Things in IoT:

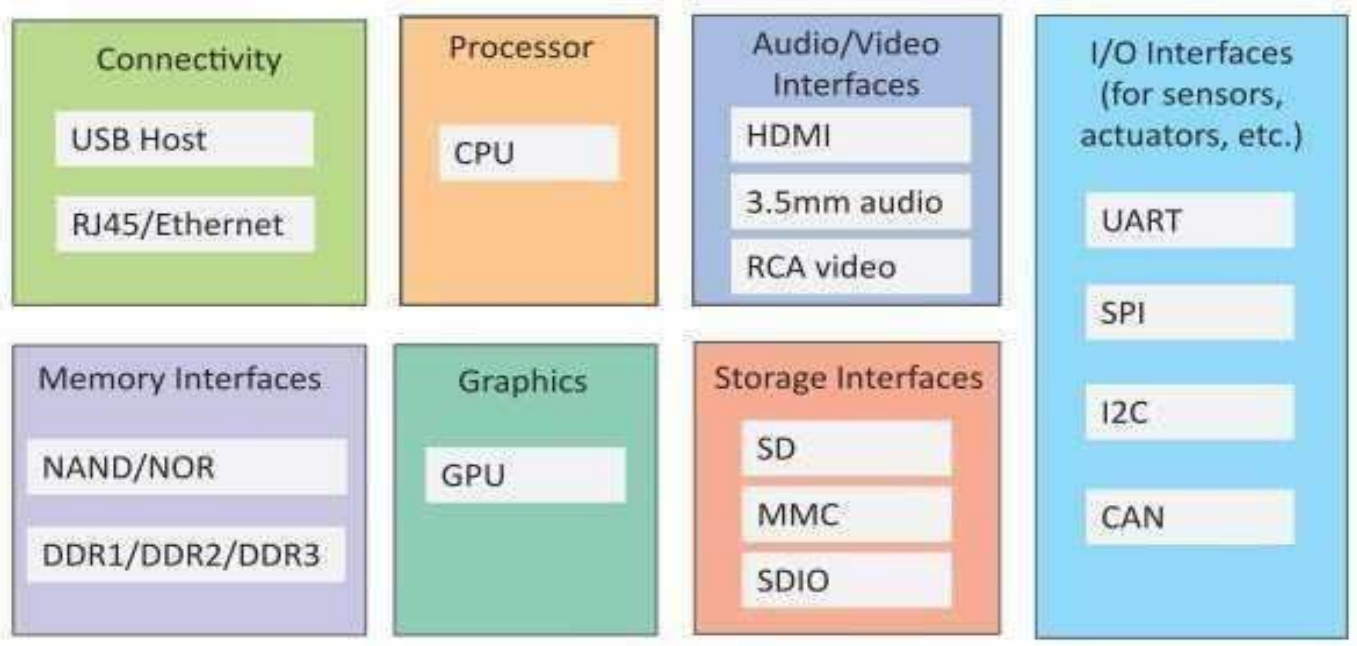
Refers to IoT devices which have unique identities that can perform sensing, actuating and monitoring capabilities.

IoT devices can exchange data with other connected devices or collect data from other devices and process the data either locally or send the data to centralized servers or cloud – based application back-ends for processing the data.

Generic Block Diagram of an IoT Device:

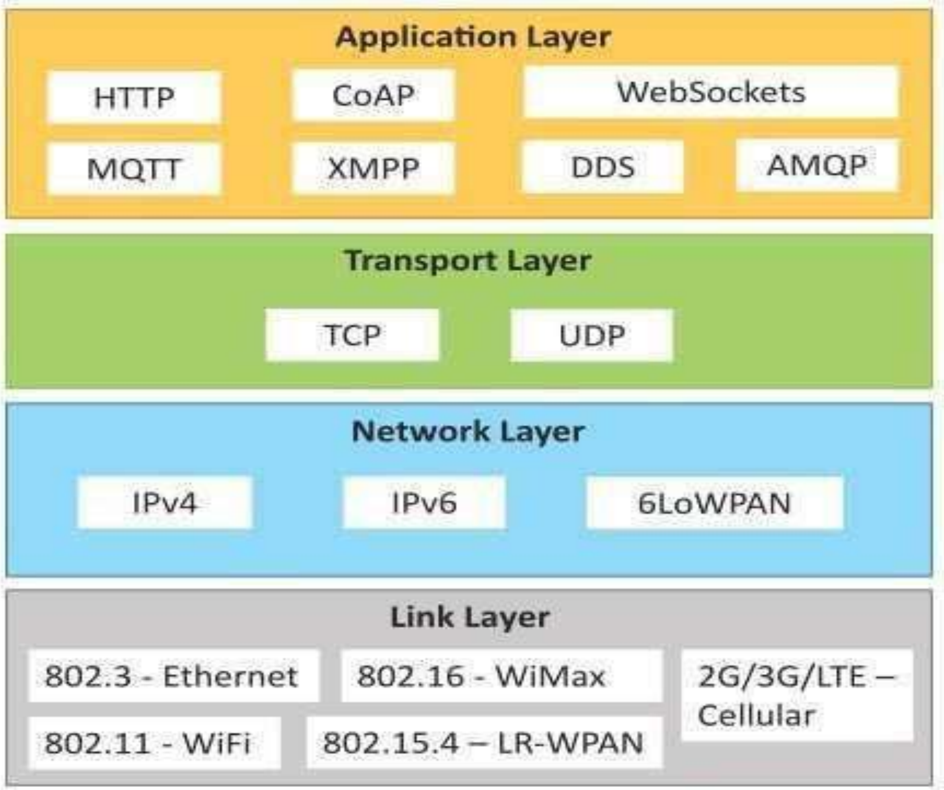
An IoT device may consist of several interfaces for connections to other devices, both wired and wireless.

- I/O interfaces for sensors
- Interfaces for internet connectivity, Memory and storage interfaces ,Audio/video interfaces


Connectivity
USB Host
RJ45/Ethernet
Processor
CPU
Audio/Video Interfaces
HDMI
3.5mm audio
RCA video
I/O Interfaces (for sensors, actuators, etc.)
UART
SPI
I2C
CAN
Memory Interfaces
NAND/NOR
DDR1/DDR2/DDR3
Graphics
GPU
Storage Interfaces
SD
MMC
SDIO

IoT Protocols:

- Link Layer
- Network/Internet Layer
- Transport Layer
- Application Layer



Link Layer:

The link layer is the group of methods and communications protocols confined to the link that a host is physically connected.

Ethernet Standard:

Sr. No	Standard	Shared medium
1	802.3	Coaxial Cable
2	802.3.i	Copper Twisted pair
3	802.3.j	Fiber Optic
4	802.3	Fiber…..10Gbits/s

	.ae	

S.No	Standard	Operates in
1	802.11a	5 GHz band
2	802.11b and 802.11g	2.4GHz band
3	802.11.n	2.4/5 GHz bands
4	802.11.ac	5GHz band
5	802.11.ad	60Hz band

WiFi: Data Rates from 1Mb/s to 6.75 Gb/s

WiMax: Data Rates from 1.5Mb/s to 1 Gb/s

S.No	Standard	Data Rate
1	802.16m	100Mb/s for mobile stations 1Gb/s for fixed stations

- LR-WPAN: Collection of standards for low-rate wireless personal area networks, Basis for high level communication protocols such as Zigbee, Data Rates from 40Kb/s to 250Kb/s

2G/3G/4G -Mobile Communication: Data Rates from 9.6Kb/s (for 2G) to up to 100Mb/s (for 4G)

Network/Internet Layer:

- Responsible for sending of IP datagrams from source to destination network
- Performs the host addressing and packet routing
- Host identification is done using hierarchical IP addressing schemes such as IPV4 or IPV6

- IPV4
  - Used to identify the devices on a network using hierarchical addressing scheme Uses 32-bit address scheme
- IPV6
  - Uses 128-bit address scheme
- 6LoWPAN (IPV6 over Low power Wireless Personal Area Network)
  - Used for devices with limited processing capacity
  - Operates in 2.4 Ghz
  - Data Rates of 250Kb/s

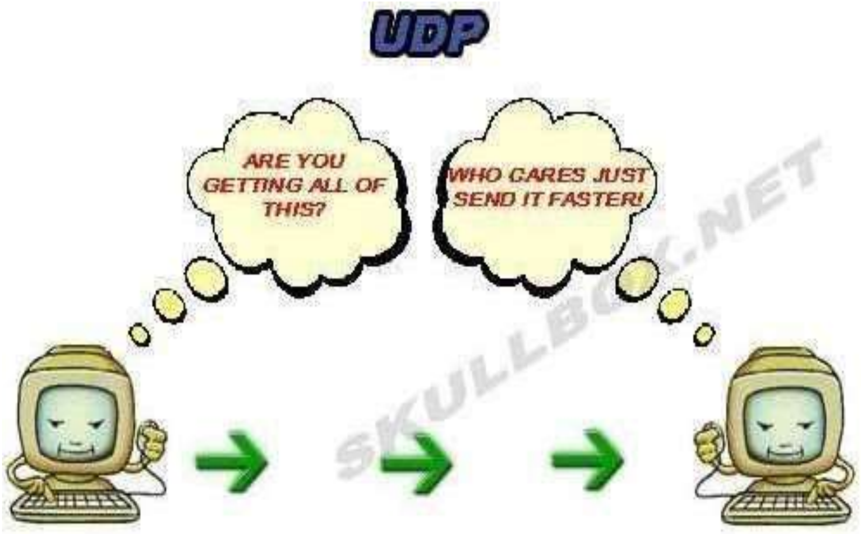
Transport Layer:

- Provide end-to-end message transfer capability independent of the underlying network
- It provides functions such as error control, segmentation, flow-control and congestion control

TCP:

- Transmission Control Protocol
- Connection Oriented
- Ensures Reliable transmission
- Provides Error Detection Capability to ensure no duplicity of packets and retransmit lost packets
- Flow Control capability to ensure the sending data rate is not too high for the receiver process
- Congestion control capability helps in avoiding congestion which leads to degradation of n/w performance

UDP:



- User Datagram Protocol
- Connectionless
- Does not ensures Reliable transmission
- Does not do connection before transmitting
- Does not provide proper ordering of messages
- Transaction oriented and stateless

Application Layer:

Hyper Transfer Protocol:

- Forms foundation of World Wide Web(WWW)
- Includes commands such as GET,PUT, POST, HEAD, OPTIONS, TRACE..etc
- Follows a request-response model
- Uses Universal Resource Identifiers(URIs) to identify HTTP resources

CoAP:

- Constrained Application Protocol
- Used for Machine to machine (M2M) applications meant for constrained devices and n/w’s
- Web transfer protocol for IoT and uses request- response model
- Uses client -server architecture
- Supports methods such as GET,POST, PUT and DELETE

- **WebSocket:** Allows full-duplex communication over single socket, Based on TCP, Client can be a browser, IoT device or mobile application
- **MQTT:** Message Queue Telemetry Transport , light- weight messaging protocol, Based on publish- subscribe model, Well suited for constrained environments where devices have limited processing, low memory and n/w bandwith requirement
- **XMPP:** Extensible messaging and presence protocol, For Real time communication and streaming XML data between n/w entities, Used for Applications such as Multi-party chat and voice/video calls

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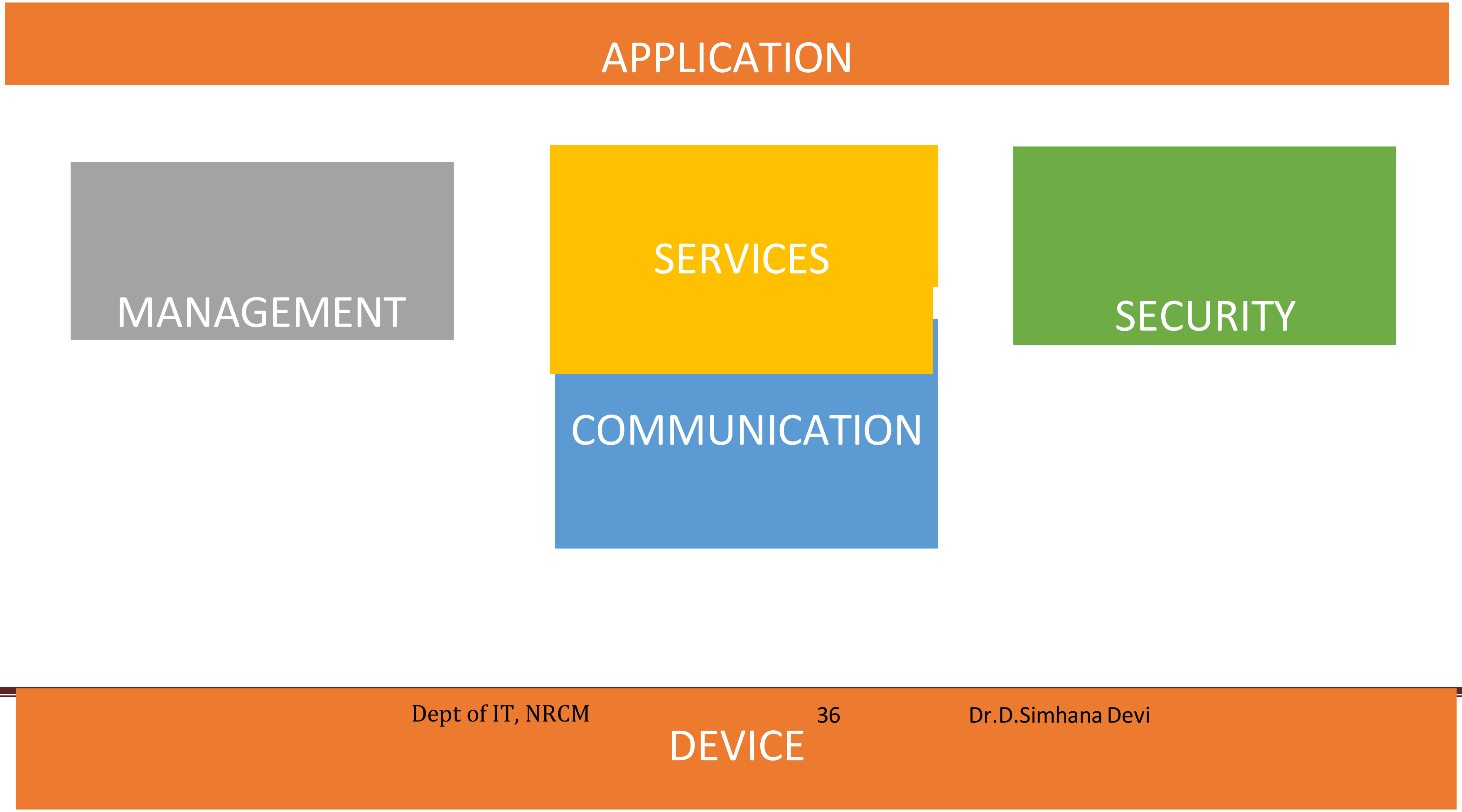
Functional blocks of IOT

- An IOT system comprises of a number of functional blocks that provide the system the capabilities for
- identification, sensing, actuation, communication and management.

Functional Block of IOT



Functional blocks are:

- **Device:** An IoT system comprises of devices that provide sensing, actuation, monitoring and control functions.
- **Communication:** Handles the communication for the IoT system.
- **Services:** services for device monitoring, device control service, data publishing services and services for device discovery.

- **Management:** This blocks provides various functions to govern the IoT system.

- **Security:** This block secures the IoT system and by providing functions such as authentication , authorization, message and content integrity, and data security.

- **Application:** This is an interface that the users can use to control and monitor various aspects of the IoT system.

Application also allow users to view the system status and view or analyze the processed data.

TRANSDUCER

- A transducer is any device which converts one form of energy into another. Examples of common transducers include the following

- A **microphone** converts sound into electrical impulses and a loudspeaker converts electrical impulses into sound (i.e., sound energy to electrical energy and vice versa).
- A **solar cell** converts light into electricity and a thermocouple converts thermal energy into electrical energy.
- An **incandescent light bulb** produces light by passing a current through a filament. Thus, a light bulb is a transducer for converting electrical energy into optical energy.
- An **electric motor** is a transducer for conversion of electricity into mechanical energy or motion.

SENSORS

- A sensor is a device that receives and responds to a signal.

- This signal must be produced by some type of energy, such as heat, light, motion, or chemical reaction.

- Once a sensor detects one or more of these signals (an input), it converts it into an analog or digital representation of the input signal.

- sensors are used in all aspects of life to detect and/or measure many different conditions.
- Human beings are equipped with 5 different types of sensors.

Basic Concepts of Sensors

- **Sensors detect the presence of energy, changes in or the transfer of energy. Sensors detect by receiving a signal from a device such as a transducer, then responding to that signal by converting it into an output that can easily be read and understood.**

- Typically sensors convert a recognized signal into an electrical – analog or digital – output that is readable. In other words, a transducer converts one form of energy into another while the **sensor converts the output of the transducer to a readable format.**

- Consider the previous examples of transducers. They convert one form of energy to another, but they do not quantify the conversions.
- The light bulb converts electrical energy into light and heat; however, it does not quantify how much light or heat.
- A battery converts chemical energy into electrical energy but it does not quantify exactly how much electrical energy is being converted.
-
- If the purpose of a device is to quantify an energy level, it is a sensor.

Different types of sensors

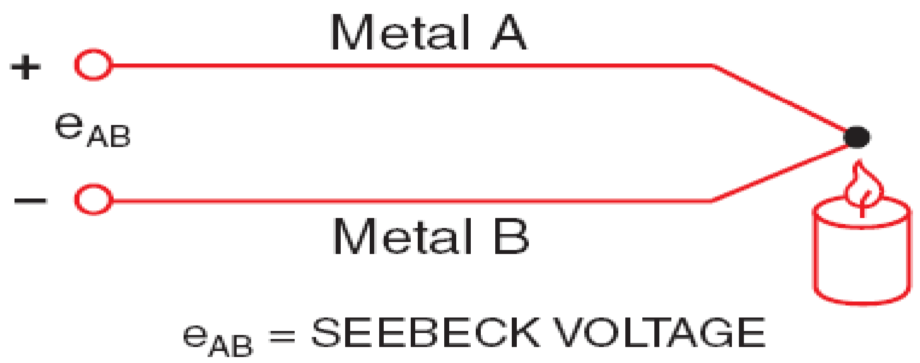
- **Basically sensors are being subdivided into**
- Thermal Sensors
- Mechanical Sensors
- Electrical Sensors
- Chemical Sensors
- **Thermal Sensors**
- Thermometer – measures absolute temperature (*discussed in the previous section)*
- Thermocouple gauge– measures temperature by its affect on **two dissimilar metals**
- Calorimeter – measures the heat of chemical reactions or physical changes and heat capacity

A thermocouple is a device that directly converts thermal energy into electrical energy.

When two dissimilar metal wires are connected at one end forming a junction, and that junction is heated, a voltage is generated across the junction.

If the opposite ends of the wires are connected to a meter, the amount of generated voltage can be measured.

This effect was discovered by Thomas Seebeck, and thus named the Seebeck Effect or Seebeck coefficient. **The voltage created in this situation is proportional to the temperature of the junction..**



Mechanical Sensors

- Pressure sensor – measures pressure
- Barometer – measures atmospheric pressure
- Altimeter – measures the altitude of an object above a fixed level
- Liquid flow sensor – measures liquid flow rate
- Gas flow sensor – measures velocity, direction, and/or flow rate of a gas

- Accelerometer – measures acceleration

Pressure sensor:

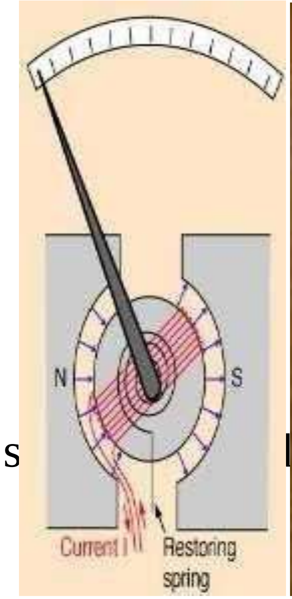
A pressure sensor senses the pressure applied ie, force per unit area, and it converts into an electrical signal. It has high importance in weather forecasting.

There are various Pressure sensors available in the market for many purposes.

For example, all the smartphones, wearables have these biometric pressure sensors integrated into them.

Electrical Sensors

- Ohmmeter – measures resistance
- Voltmeter – measures voltage
- Galvanometer – measures current
- Watt-hour meter – measures the amount of electrical energy s
business



Chemical Sensors

Chemical sensors detect the presence of certain chemicals or classes of chemicals and quantify the amount and/or type of chemical detected.

- Oxygen sensor – measures the percentage of oxygen in a gas or liquid being analyzed
- Carbon dioxide detector – detects the presence of CO2

- Chemical sensing is an application that really benefits from the use of microtechnology.
-
- chemical sensors can detect a wide variety of different gases.

- The advantage of the MEMS sensors is that they can be incorporated into objects for continuous sensing of a gas or selection of gases.

- These devices have numerous medical, industrial, and commercial applications such as environmental, quality control, food processing, and medical diagnosis.

Other Types of Sensors

Optical

- Light sensors (photodetectors) – detects light and electromagnetic energy
- Photocells (photoresistor) – a variable resistor affected by intensity changes in ambient light.
- Infra-red sensor – detects infra-red radiation

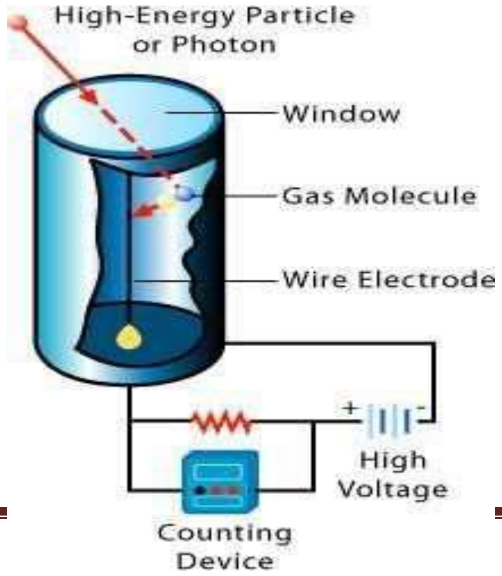
Acoustic

- Seismometers – measures seismic waves
- Acoustic wave sensors – measures the wave velocity in the air or an environment to detect the chemical species present

Other

- Motion – detects motion
- Speedometer – measures speed
- Geiger counter – detects atomic radiation *(see graphic)*
- Biological – monitors human cells

Geiger Counter: Detects Atomic Radiation



Proximity sensor:

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact.

A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation and looks for changes in the field or return signal.

A most common application of this sensor is used in cars. While you are taking the reverse , it detects or objects or obstacles and you will be alarmed.

Accelerator sensor:

Accelerometers in mobile phones are used to detect the orientation of the phone.

INFRARED SENSORS:

- An infrared sensor is an electronic device, which senses certain characteristics of its surroundings by emitting infrared radiation
- It has the ability to measure the heat being emitted by an object and also measures the distance.
- It has implemented in various applications. It is used in radiation thermometers depend on the material of the object.
- Level sensors
- Image sensors
- Water quality sensors
- Chemical sensors
- Gas sensors
- Smoke sensors
- Humidity sensors

- optical sensors

Basic Concepts of Actuators

1)An actuator is something that actuates or moves something. More specifically, an actuator is a device that coverts energy into motion or mechanical energy. Therefore, an actuator is a specific type of a transducer.

2)Thermal Actuators One type of thermal actuator is a bimetallic strip. This device directly converts thermal energy into motion. This is accomplished by utilizing an effect called thermal expansion. Thermal expansion is the manifestation of a change in thermal energy in a material.

When a material is heated, the average distance between atoms (or molecules) increases. The amount of distance differs for different types of material. This microscopic increase in distance is unperceivable to the human eye. However, because of the huge numbers of atoms (or molecules) in a piece of material, the material expands considerably and, at times, is noticeable to the human eye.

The opposite reaction occurs for a decrease in temperature when most materials contract.

When exposed to the elements, a material constantly expands and contracts with ambient temperature changes. Consider a piece of steel 25 meters long.

If the temperature of the steel increases by 36oC, (the difference between a cold winter day and a hot summer day), that piece of steel lengthens approximately 12 cm.

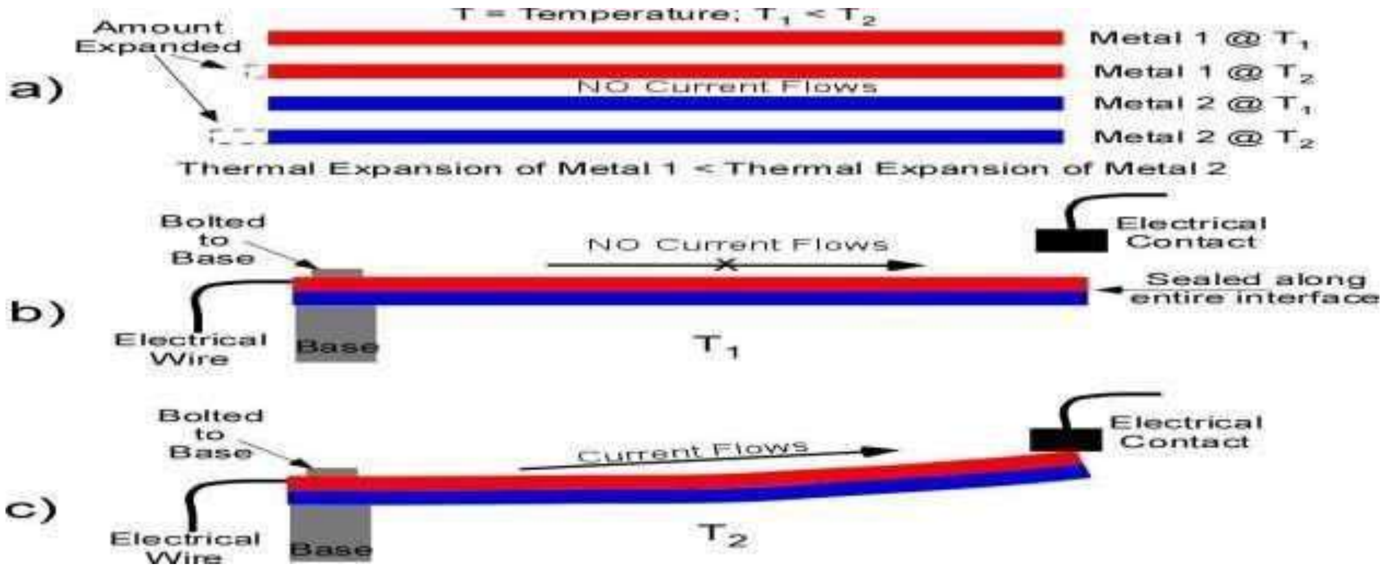
This change in length is the thermal linear expansion. It is calculated by using the following formula: $\delta_L = aL_o\Delta T$

Where δ_L is the change in length, *a* is the coefficient of linear expansion, L_o is the original length, and ΔT is the change in temperature in Celsius.

If we are considering steel, the coefficient of linear expansion is $1.3\text{x}10^{-5}$, the original length is 25 meters, and of course the change of temperature is 36^{o}C. This results in an expansion of .12 m or 12 cm.[11,12]

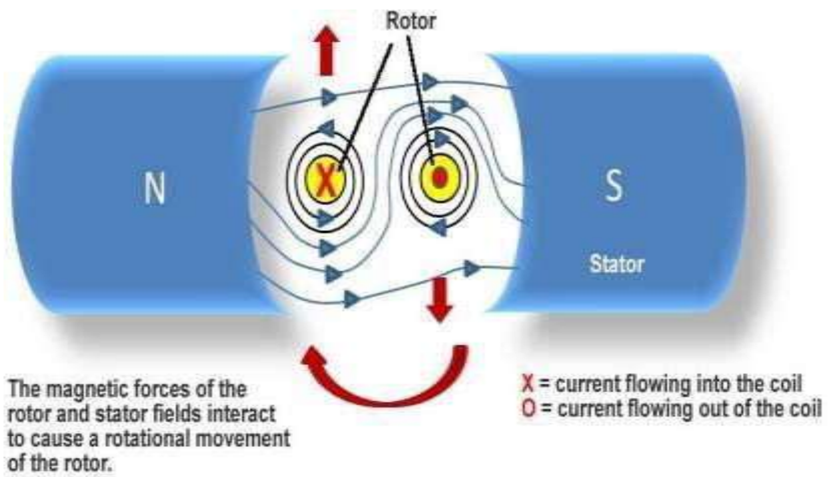
Now consider 40 pieces of steel 25 meters long laid end to end to make a 1 km long bridge. The bridge's length will change roughly 480 cm between the winter and summer! Fortunately, expansion joints are built into bridges allowing for this expansion, ensuring bridges are safe in all seasons

A bimetallic strip takes advantage of the thermal expansion effect to generate motion.
Two dissimilar strips of metal are joined together along their entire lengths. When heat is applied, the bimetallic strip bends in the direction of the metal with the smaller coefficient of thermal expansion, (see the figure below).
Bimetallic strips have many uses. One common use is in thermostats used to control the temperature in homes and offices. At the microscale, bimetallic actuators are used in microthermostats and as microvalves.



Schematic showing how a bimetallic strip works. This particular bimetallic strip is being used as a thermostat. a) Two dissimilar strips of metal are used that have different coefficients of thermal expansion, b) The two strips of metal are joined along their entire interface at some temperature (T1), c) When the temperature increases temperature, T2, the bimetallic strips deflect enough to touch the upper contact and allow a current to flow in the bimetallic strip turning on the air conditioner.

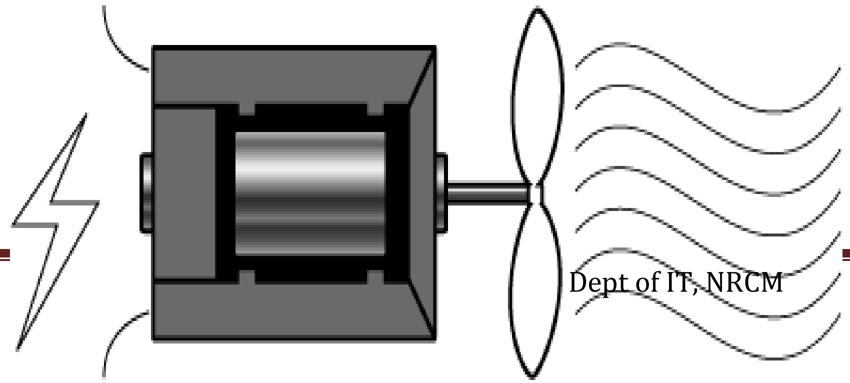
Electric Actuators



An electric motor is a type of an electric actuator (see graphic). Most direct current (DC) motors operate by current flowing through a coil of wire and creating a magnetic field around the coil.

The coil is wrapped around the motor's shaft and is positioned between the poles of a large permanent magnet or electromagnet. The interaction of the two magnetic fields causes the coil to rotate on its axis, rotating the motor's shaft (see figure above).

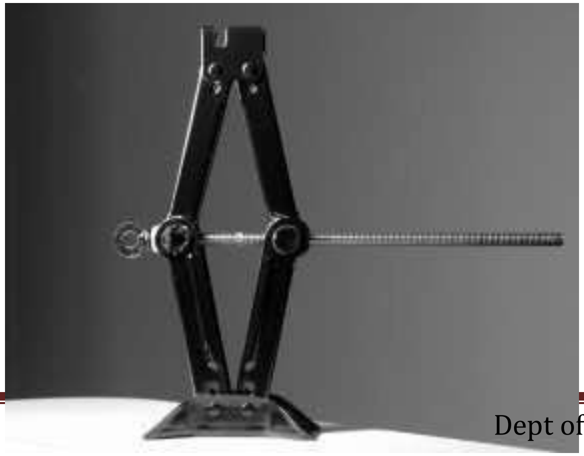
Thus, an electric motor is a transducer AND an actuator because it converts electrical energy to magnetic energy to mechanical energy or motion



An electric motor is an actuator that transforms electrical energy into mechanical energy or motion

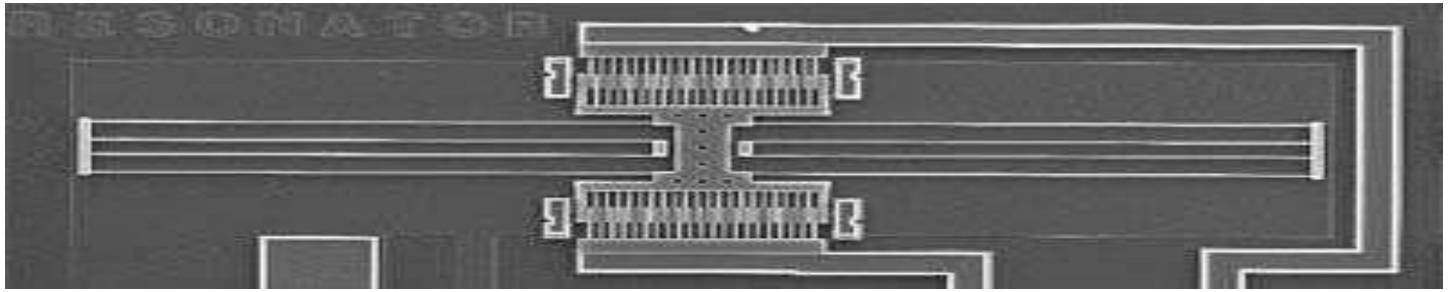
Mechanical Actuators

Mechanical actuators convert a mechanical input (usually rotary) into linear motion.
A common example of a mechanical actuator is a screw jack.
The figure below shows a screw jack in operation. Rotation of the screw causes the legs of the jack to move apart or move together.
Inspecting the motion of the top point of the jack, this mechanical rotational input is clearly converted into linear mechanical motion.
Mechanical actuators can produce a rotational output with the proper gearing mechanism.



A screw jack converting rotational energy into linear motion (to lift a car possibly)

An example of a microdevice which acts as an actuator is the electrostatic combdrive.
These combdrives are used in many MEMS applications such as resonators, microengines, and gyroscopes.
The force generated is low, usually less than 50 μN. However, these devices are predictable and reliable making them highly used.



SEM of a typical comb-drive resonator

The image above is an example of a MEMS electrostatic combdrive resonator.
A resonator is a device which naturally oscillates at its resonance frequencies.
The oscillations in a resonator can either be electromagnetic or mechanical (i.e acoustic).
Resonators are used to generate waves of desired frequencies or to extract specific frequencies from a given signal.