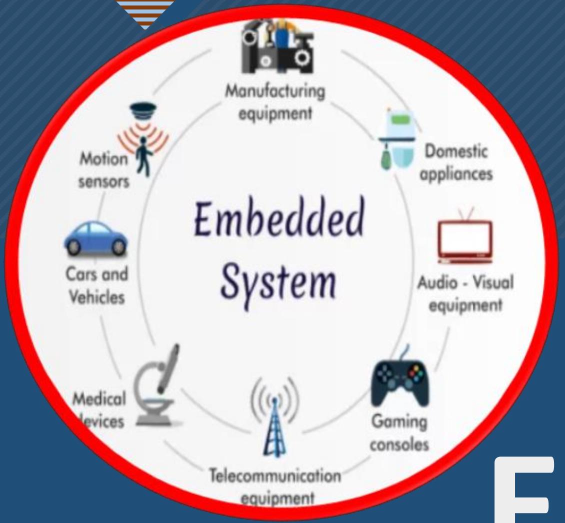



# Electronics and Embedded Systems Course

Comprehensive Curriculum

# Overview

- Introductory Session: Electronics and Embedded Systems
- Circuit Analysis, Instrument Measurement, and Tools
  - Ohms law, voltage divider, opto-coupler, led-driver, BJT-MOSFET switch
  - design, ESD, Voltage regulators and power supply.
  - Schematic capture and simulations, easyeda login
- Communications & Protocols
  - UART-RS-323, RS-485, I2C, SPI, ONE WIRE, SIM, LTE, BLE, Zigbee, LoRa etc.
- Introduction to ESP32: Hardware-Related Programming Environment
  - Arduino - IDE

# Overview

- **Input-Output Devices, Sensors, and Actuators**
  - All sensors available in market, gps, magnetometer, loadcells, thermocouples
  - DC, BLDC motors, solenoids, relays
- **IoT with Arduino + ESP32 Core few weeks**
  - Hardware design and development
  - Industrial automation
  - Embedded systems using C/C++
  - Android for user interface
  - Web development for dashboard
- **PCB Design, Machinery, and Processing**
- **Prototype and 3D Printing**

# Weekly Structure

- Point 1: Assignment (15-min)
- Point 2: Main Course Content (Middle Hours)
- Point 3: Q/A, Task Assignment and Discussion (Last 15-min)
- Online Assignments

# Course Duration

- 4 Hours Per Week
- 4-hrs once a week, Friday-Wednesday 9:00am-1:00pm.
- Total of 12 Weeks 48-hrs

# Day-1 (zoom meeting)

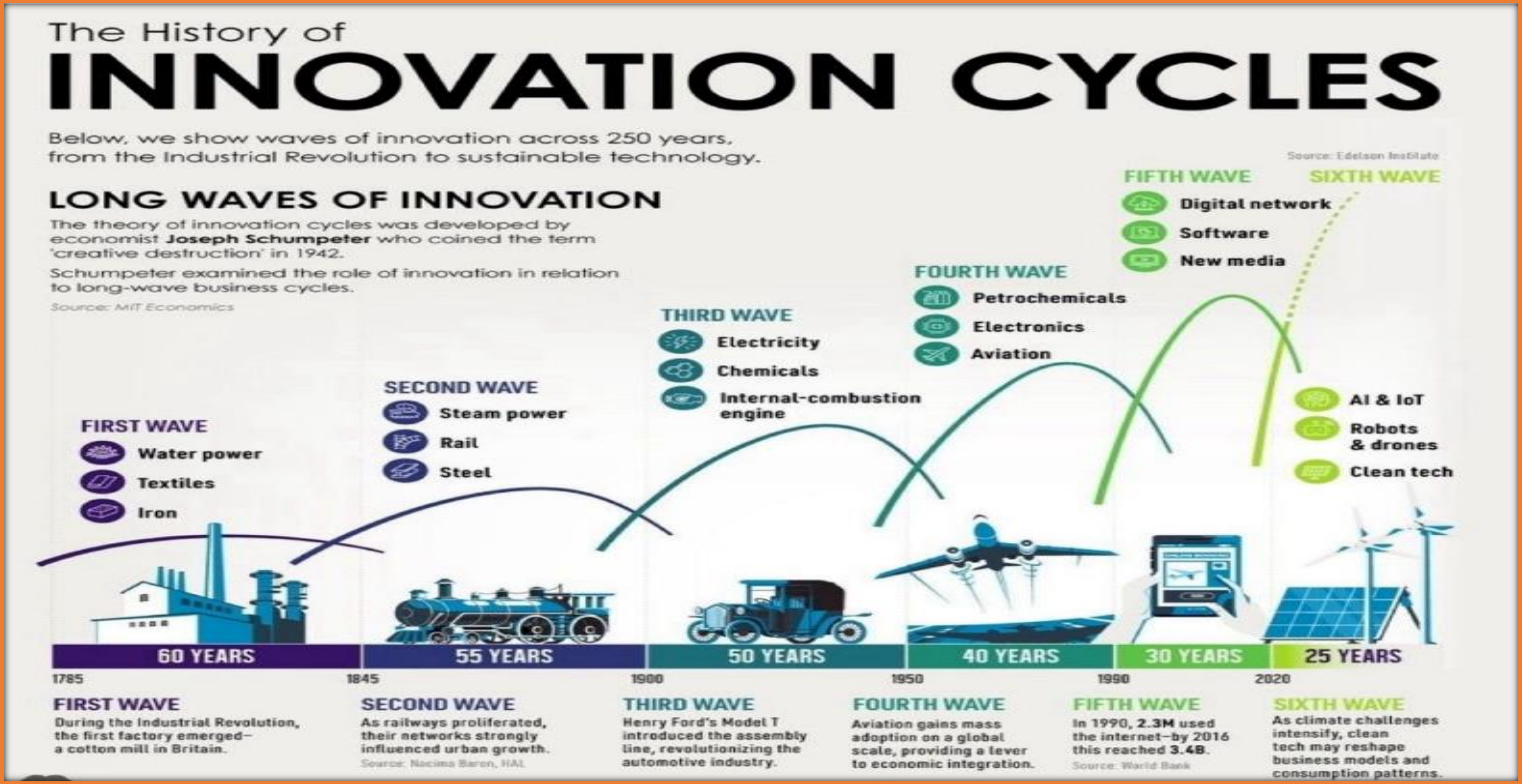
- Introductory Session:
  - Course Objectives: Aamir (15-min)
  - Q/A and student's introduction: (15-min)
  - IoT Big Picture: Sohail (30-min)
  - Electronics and Embedded Systems: Azmat (45-min)
  - Short demos: Mubashir (15-min)

IoT SPRING’24

# INTRODUCTION TO INTERNET OF THINGS

*Emerging Technology for Engineering*

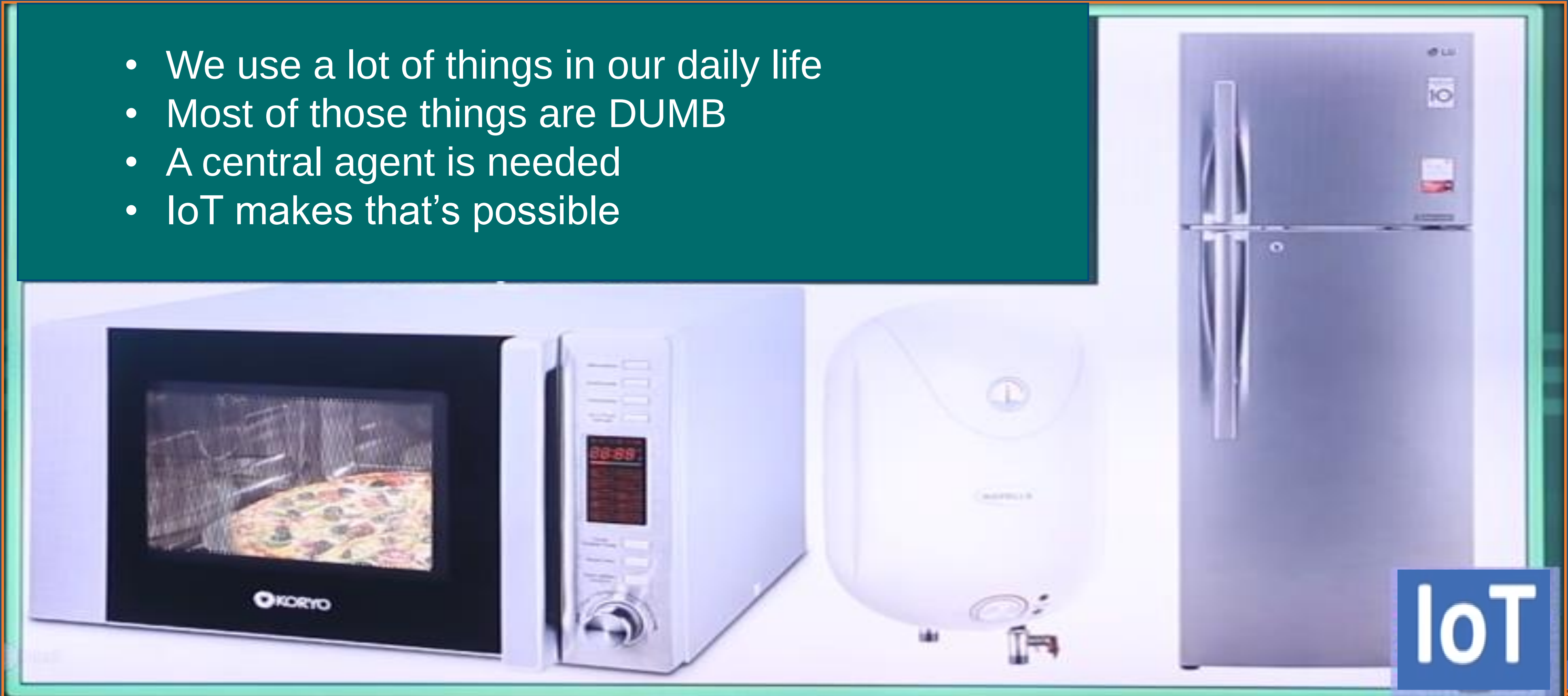
# Contents



The History of
INNOVATION CYCLES
Below, we show waves of innovation across 250 years, from the Industrial Revolution to sustainable technology.
Source: Edelson Institute
LONG WAVES OF INNOVATION
The theory of innovation cycles was developed by economist Joseph Schumpeter who coined the term 'creative destruction' in 1942.
Schumpeter examined the role of innovation in relation to long-wave business cycles.
Source: MIT Economics
FIRST WAVE
Water power
Textiles
Iron
SECOND WAVE
Steam power
Rail
Steel
THIRD WAVE
Electricity
Chemicals
Internal-combustion engine
FOURTH WAVE
Petrochemicals
Electronics
Aviation
FIFTH WAVE
Digital network
Software
New media
SIXTH WAVE
AI & IoT
Robots & drones
Clean tech
60 YEARS
55 YEARS
50 YEARS
40 YEARS
30 YEARS
25 YEARS
1785
1845
1900
1950
1990
2020
FIRST WAVE
During the Industrial Revolution, the first factory emerged—a cotton mill in Britain.
SECOND WAVE
As railways proliferated, their networks strongly influenced urban growth.
Source: Nacima Baron, HAL
THIRD WAVE
Henry Ford's Model T introduced the assembly line, revolutionizing the automotive industry.
FOURTH WAVE
Aviation gains mass adoption on a global scale, providing a lever to economic integration.
FIFTH WAVE
In 1990, 2.3M used the internet—by 2016 this reached 3.4B.
Source: World Bank
SIXTH WAVE
As climate challenges intensify, clean tech may reshape business models and consumption patterns.

# IoT SPRING'24


- We use a lot of things in our daily life
- Most of those things are DUMB
- A central agent is needed
- IoT makes that's possible

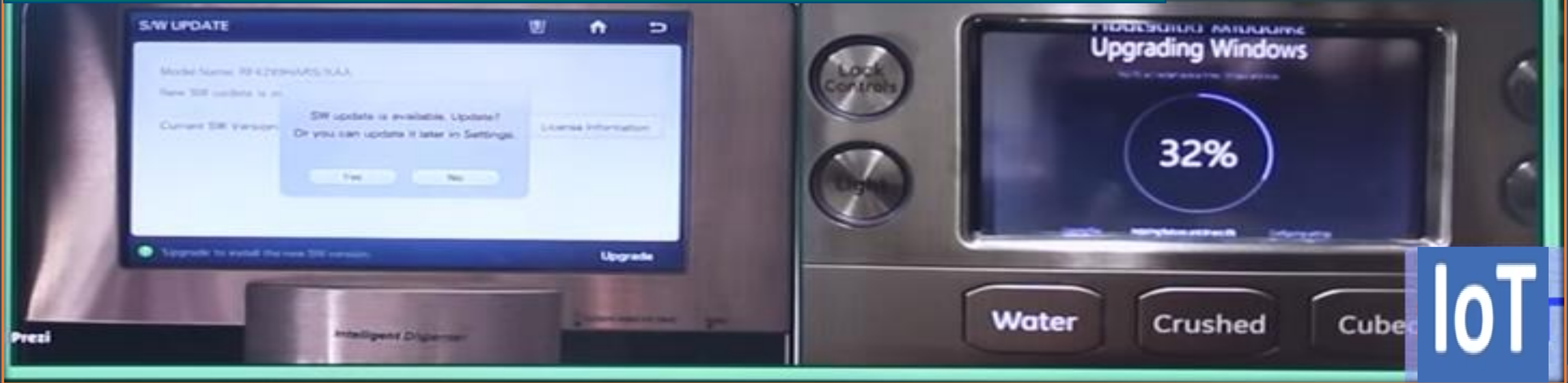


# USES

- Remote monitoring of devices
- Makes life a bit easier & more comfortable
- Allows for feedback loop.
- Improves energy efficiency.
- Timely service repair.

# Risks

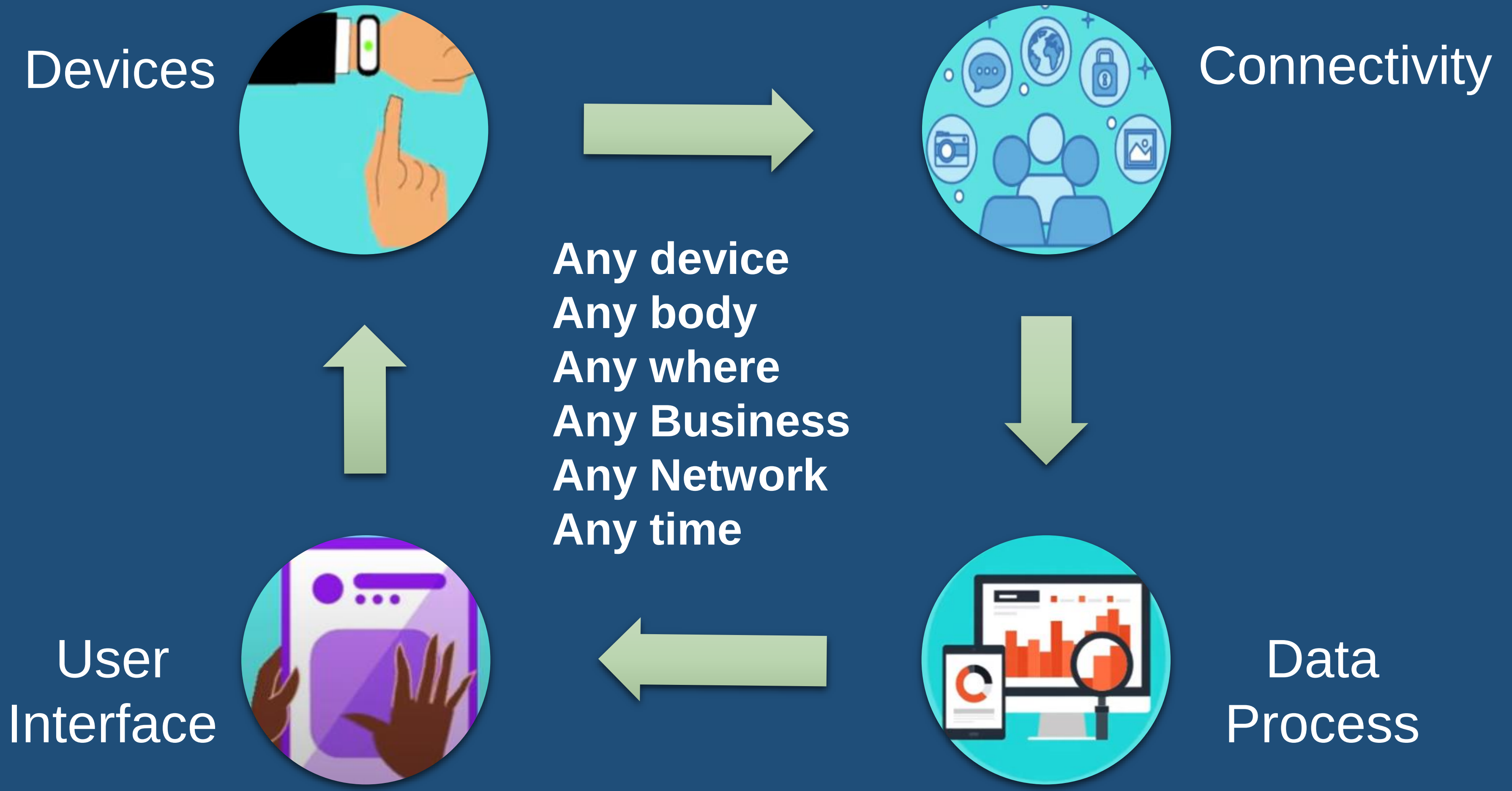
- You are giving up control for comfort
- Complexity being the enemy of reliability
- More and dangerous points of failure
- Everything becoming obsolete
- Makes you more vulnerable to everything

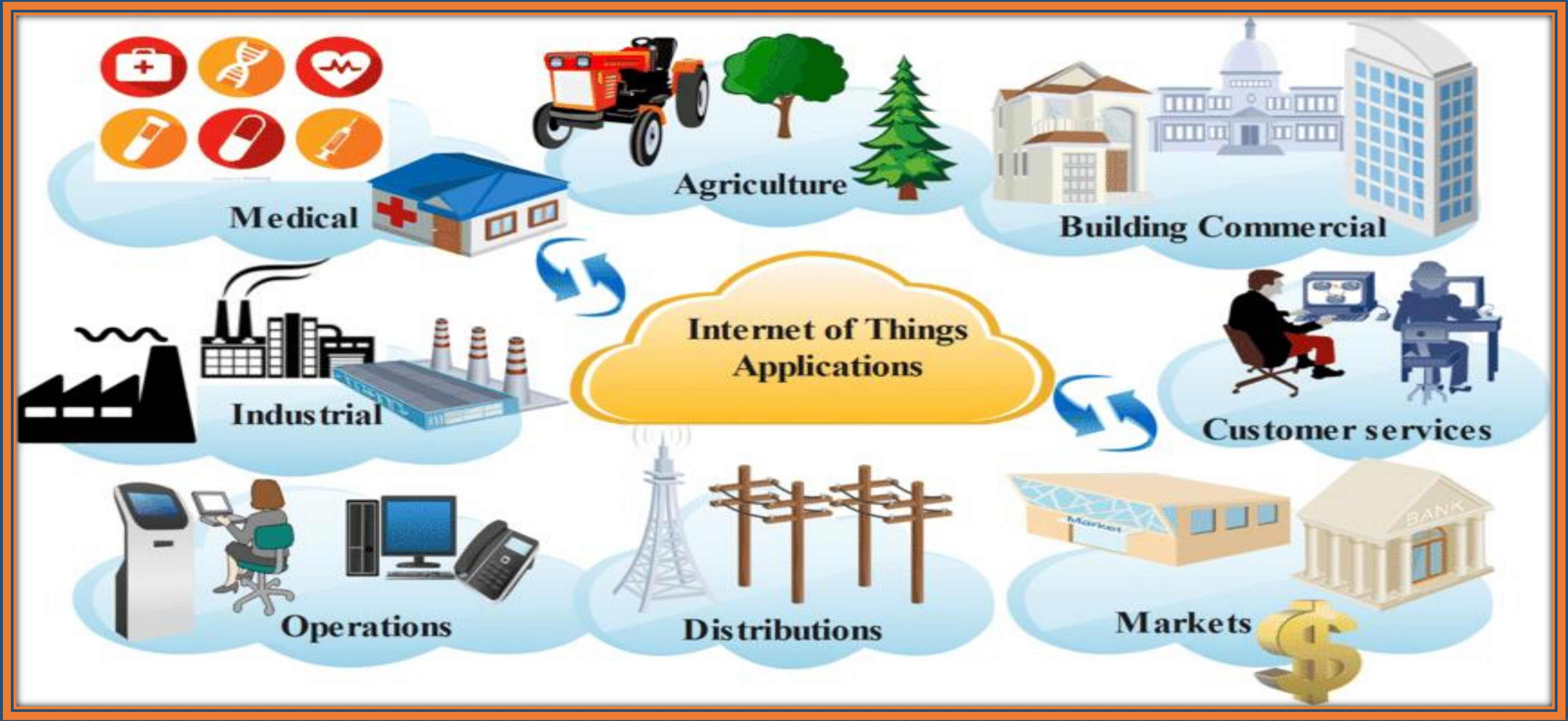
# Who invented IoT ?

- In 1999 Kevin Ashton invented the concept of the internet of things
- The number of IoT devices available has grown from zero to around 27 billion.
- Today, connectivity options include proprietary and cellular wireless transceivers that broadcast data to IoT devices a few feet or a few miles away and satellites that transmit data from orbit.

# IoT Cycle


Devices
Connectivity
Any device
Any body
Any where
Any Business
Any Network
Any time
User Interface
Data Process

# INTERNET OF THINGS INNOVATIVE EXAMPLES



# Applications Of An IoT

- **Smart Home Automation:**

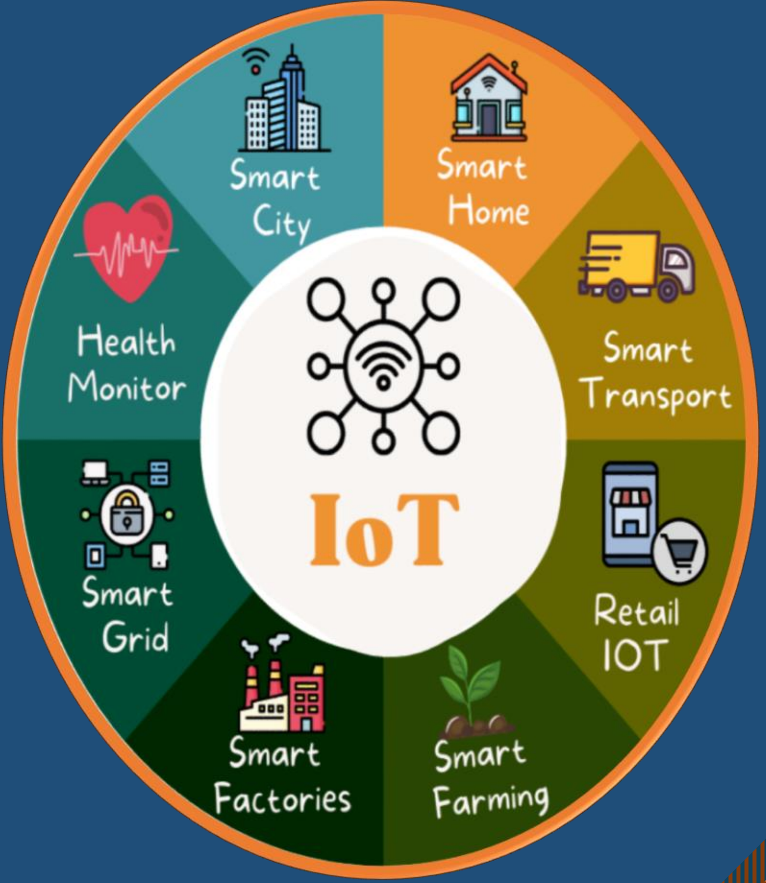
IoT devices such as smart thermostats, lighting systems, security cameras, and connected appliances enable homeowners to automate and control various aspects of their homes remotely.

- **Healthcare Monitoring:**

Wearable devices equipped with sensors can monitor vital signs, track physical activity, and send real-time health data to healthcare professionals, providing timely insights and improving patient care.

- **Industrial Internet:**

IoT is extensively used in industries for predictive maintenance, asset tracking, and process optimization. Connected sensors on machines and equipment enable proactive maintenance, reducing downtime and improving efficiency.



# Applications Of An IoT

- **Smart Cities:**

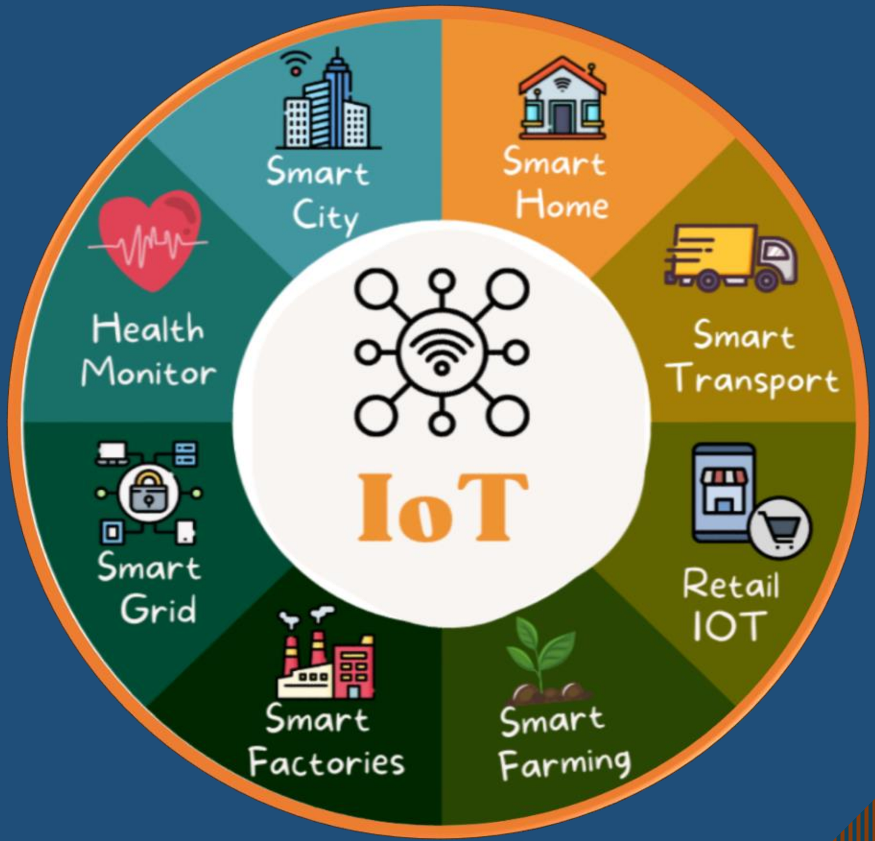
IoT sensors and meters to collect and analyze data to improve infrastructure, public utilities and services.

- **Agricultural Monitoring:**

IoT smart agriculture products (Soil sensors and Drones) are designed to help monitor crop fields. Farmers and associated brands can easily monitor the field conditions from anywhere without any hassle.

- **Retail and Inventory Management:**

Retailers use IoT for inventory tracking, supply chain optimization, and enhancing the overall shopping experience through technologies like smart shelves and connected beacons.



# Applications Of An IoT

➢ **Environmental Monitoring:**

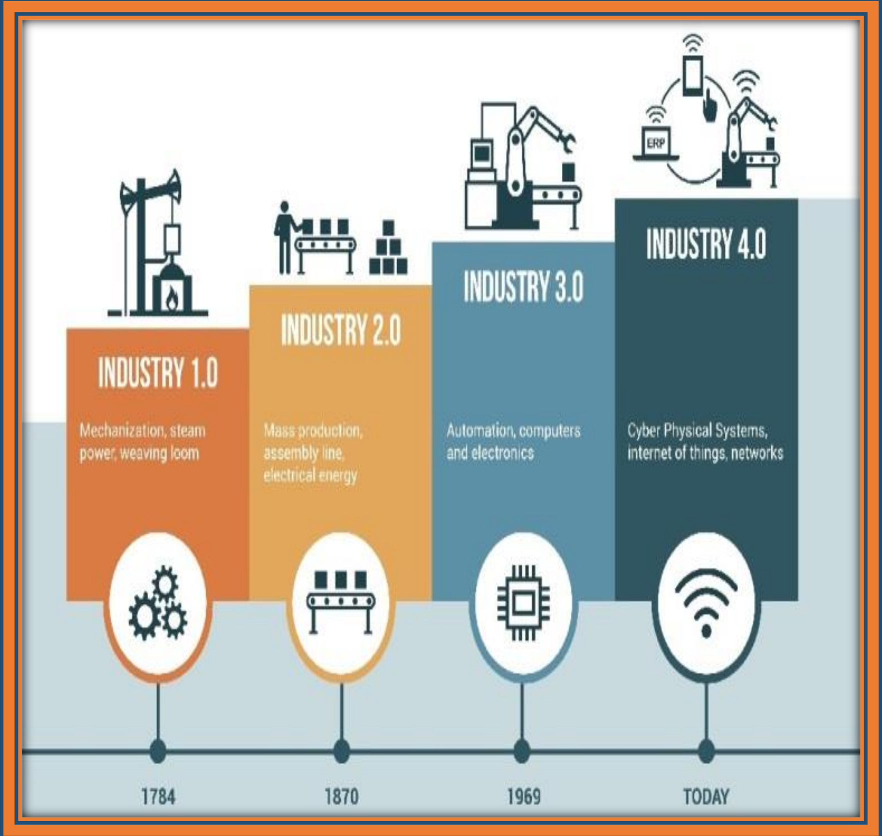
For early monitoring of environmental issues. IoT sensors detect, collect and measuring data on environmental conditions, including air and water quality.

➢ **Connected Vehicles:**

IoT systems is integrated into vehicles for real-time monitoring, predictive maintenance, improve traffic flow and to enhance safety.

➢ **Energy Management:**

Smart meters, sensors, and connected devices help optimize energy consumption in homes, businesses, and industries, contributing to energy efficiency and cost savings.



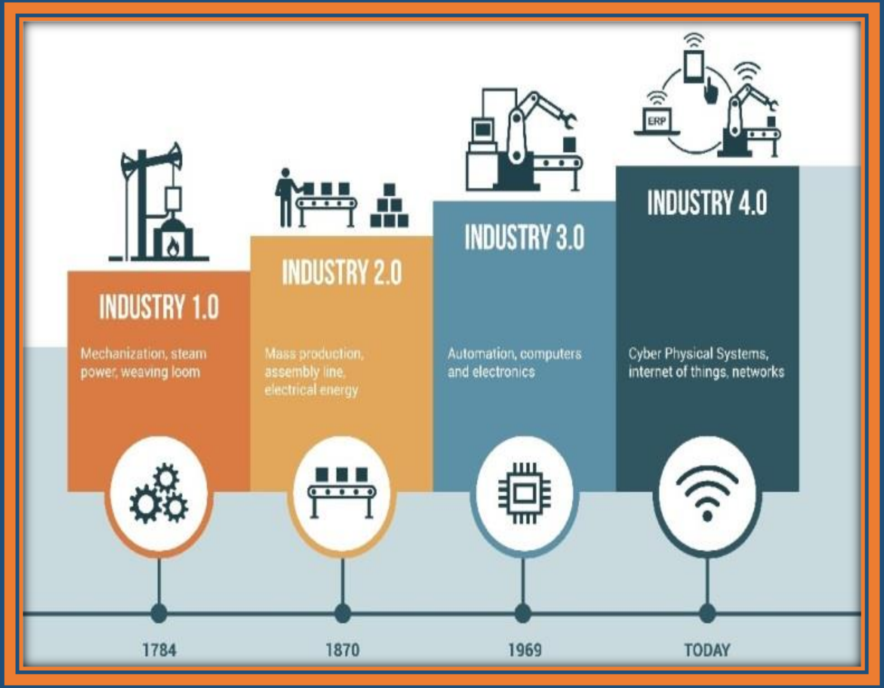
# Applications Of An IoT

## Supply Chain Visibility:

IoT provides real-time tracking, visibility of operations, improves logistics efficiency, reduce delays and prevent issues such as theft or spoilage.

## Asset Tracking:

Companies use IoT to track the location, performance, and condition of mobile assets, vehicles, and equipment.



# IoT Components

- Device The Thing
- Local Network
- Internet
- Backend Services
- Applications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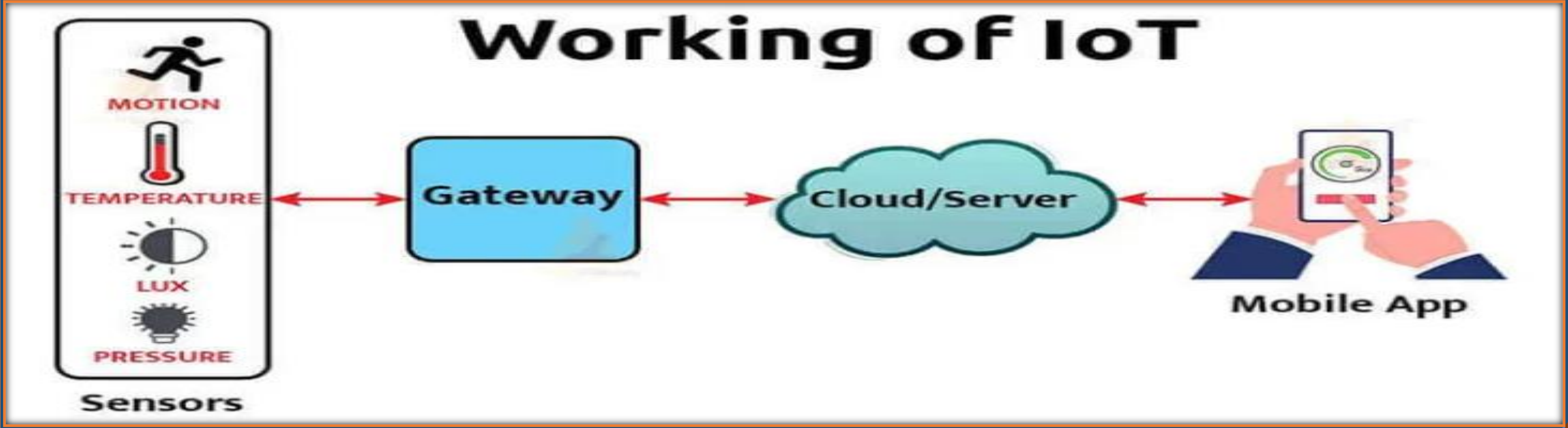
# How does IoT work?

IoT devices share the sensor data they collect by connecting to an IoT gateway, which acts as a central hub where IoT devices can send data. Before the data is shared, it can also be sent to an edge device where that data is analyzed locally and send it to cloud platform via internet. The software then analyzes and transmits the data to users via an app or website.





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# Features of IOT

The most important features of IoT on which it works are sensing, connectivity, analyzing, active engagement, endpoint management and many more. Some of them are listed below:

**Sensing :**

The sensor devices used in IoT technologies detect and measure any change in the environment and report on their status. IoT technology brings passive networks to active networks. Without sensors, there could not hold an effective or true IoT environment.

**Connectivity :**

Connectivity refers to establish a proper connection between all the things of IoT to IoT platform it may be server or cloud. After connecting the IoT devices, it needs a reliable, secure and bi-directional communication.

**Analyzing :**

After connecting all the relevant things, it comes to real-time analyzing the data collected and use them to build effective business intelligence. If we have a good insight into data gathered from all these things, then we call our system has a smart system.


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# Features of IOT

**Active Engagement :**

IoT makes the connected technology, product, or services to active engagement between each other.

**Endpoint Management :**

It is important to be the endpoint management of all the IoT system otherwise, it makes the complete failure of the system. For example, if a coffee machine itself order the coffee beans when it goes to end but what happens when it orders the beans from a retailer and we are not present at home for a few days, it leads to the failure of the IoT system. So, there must be a need for endpoint management.

**Artificial Intelligence :**

IoT makes things smart and enhances life through the use of data.
An example would be Robots making intelligent decisions (using AI), removing faulty parts manufactured in an assembly line, based upon physical inspection (optical image) of the parts.


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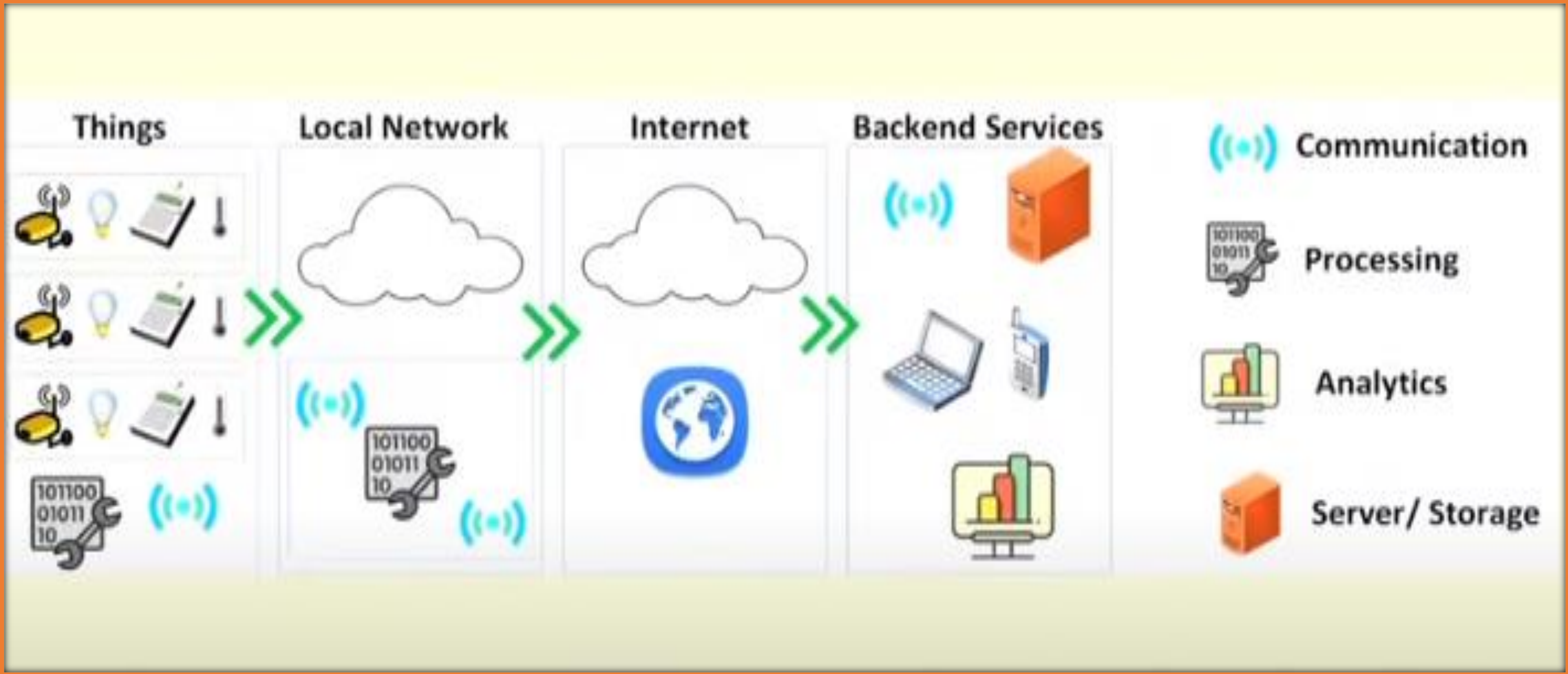
# Scenarios of IoT





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## Functional Components of IoT

- › Component for interaction and communication with other IoT devices
- › Component for processing and analysis of operations
- › Component for Internet interaction
- › Component for handling Web services of applications
- › Component to integrate application services
- › User interface to access IoT

# IoT Categories

## Industrial IoT

- IoT device connects to an IP network and the global network.
- Communication between the nodes done using regular as well as industry specific technologies.

## Consumer IoT

- IoT device communicates with in the locally networked devices.
- Local communication is done mainly via Bluetooth, Zigbee or Wifi.
- Generally limited to local communication by a Gateway.


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# IoT Challenges

- Security
- Interfacing
- Scalability
- Interoperability
- Energy efficiency
- Data storage
- Bandwidth management
- Data Analytics
- Modeling and Analysis
- Complexity management (e.g., SDN)


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# Considerations

- Communication between the IoT devices and the outside world dictates the network architecture.
- Choice of communication technology dictates the IoT device hardware requirements and costs.
- Due to the presence of numerous applications of IoT enabled devices, a single networking paradigm not sufficient to address all the needs of the consumer or the IoT device.


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# Complexity of Networks

- Growth of Networks
- Interference among devices
- Network management
- Heterogeneity in the networks
- Protocols standardization within networks


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# Wireless Networks

- Traffic and load management
- Variations in wireless networks – Wireless Body Area Networks and other Personal Area Networks
- Interoperability
- Network management
- Overlay networks

## Scalability

- Flexibility within internet
- IoT integration
- Large scale deployment
- Real-time connectivity of billions of devices


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# RISKS

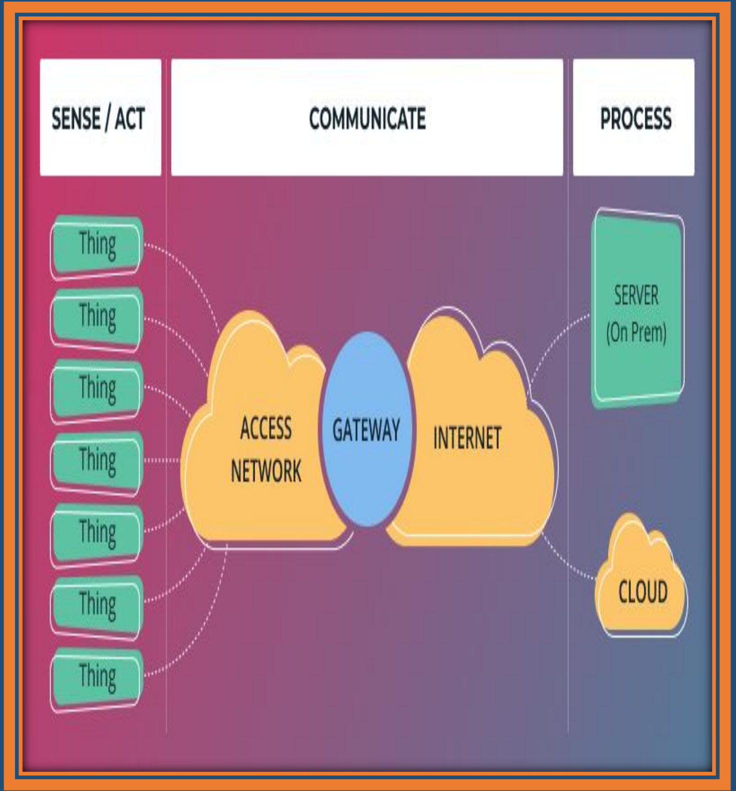
The Internet of Things (IoT) introduces specific risks and challenges due to the interconnected nature of devices and the massive amounts of data they generate. Some of the key risks associated with IoT include:

## Security Risks:

IoT devices may become targets for cyberattacks, leading to unauthorized access, data breaches, or manipulation of device functionalities. Insecure communication channels, weak authentication, and inadequate encryption can contribute to security vulnerabilities.

## Privacy Concerns:

The extensive data collection capabilities of IoT devices raise privacy concerns. Personal and sensitive information may be collected without proper consent, leading to potential misuse or unauthorized access to individuals' data.



# Final thoughts about IoT

Undoubtedly, IoT's rapid growth will fundamentally change the world we live in.

Having outlined the past, present, and future of the IoT (internet of things), we've come to the conclusion that interconnected technology is evolving swiftly despite increasing cybersecurity challenges. IoT solutions are guaranteed to continue to evolve in the years ahead, and in turn they will change the way we live and work for the better.

**Here are several crucial factors spurring this rapid IoT expansion:**

1- Falling sensor costs

2- Falling costs of data collection and storage due to cloud solutions

3- Widely expanding internet connectivity

4- Increasing computing power

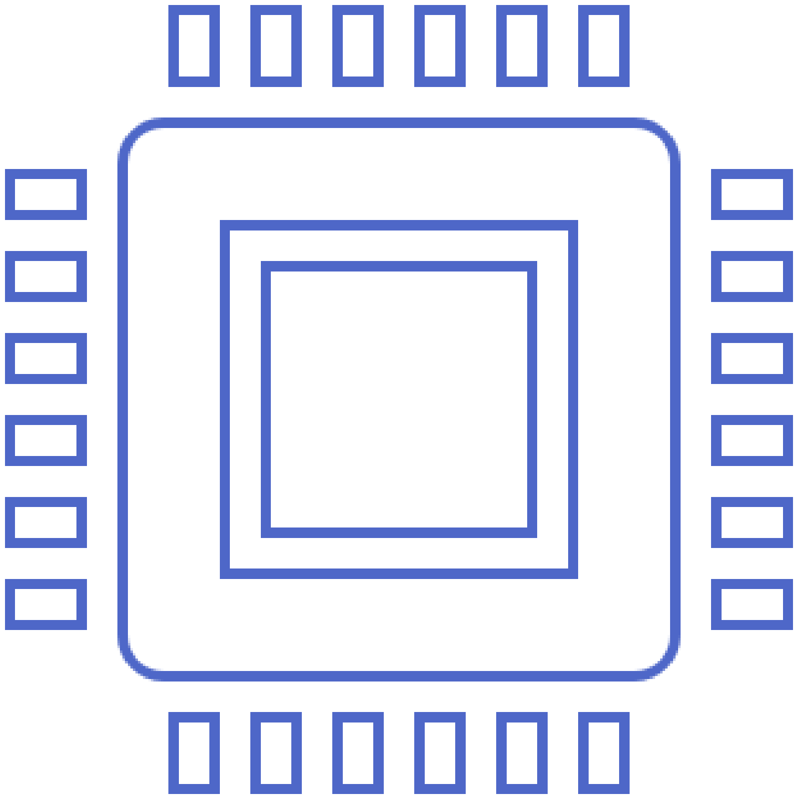
5- Increasing smartphone and tablet penetration

# IOT ESSENTIALS

## AN INTRODUCTION

**ELECTRONICS AND EMBEDDED SYSTEMS**

Azmat



# OVERVIEW OF ELECTRONICS

Unlocking the world of Electronics

# Agenda

### Overview of Electronics

Definitions, Role of Electronics, Applications, and Basic Components

### Introduction to Embedded Systems

Definitions, Role of Embedded Systems and Applications, Components of Embedded Systems and the mix of Electronics and Embedded Systems

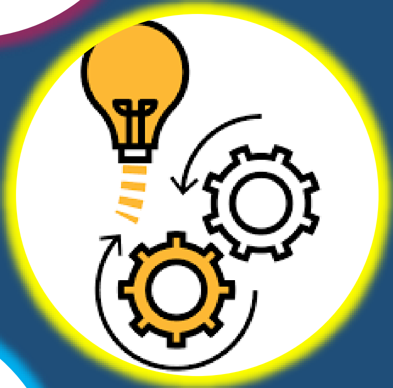
### Recap and Q&A

Recap with some basic quiz questions and Q&A

# ROLE OF ELECTRONICS

## Information Processing

Embedded systems automate specific functions within devices, streamlining processes and enhancing efficiency. For example, they control the timing and execution of tasks in a car's engine management system.



## Enabling Modern Life

They enable instantaneous responses to external stimuli, crucial for applications like anti-lock braking systems in vehicles, ensuring precise and timely interventions for enhanced safety.

## Connected World

Electronics play a pivotal role in pioneering smart solutions, connecting devices, and shaping a seamlessly integrated and interconnected world.

# Electronics Used Everywhere!

**1**

### Smartphones

Information processing at your fingertips

**2**

### IoT

Enabling a modern life-style

**3**

### Medical

Precision healthcare, remote monitoring

**4**

### Electric Vehicles

Sustainable mobility revolution

# BASIC COMPONENTS

- **Sources**

Voltage and current sources

- **Switches**

Controlling the flow of Electrons

- **Active Components**

Diodes, Transistors and ICs

- **Passive Components**

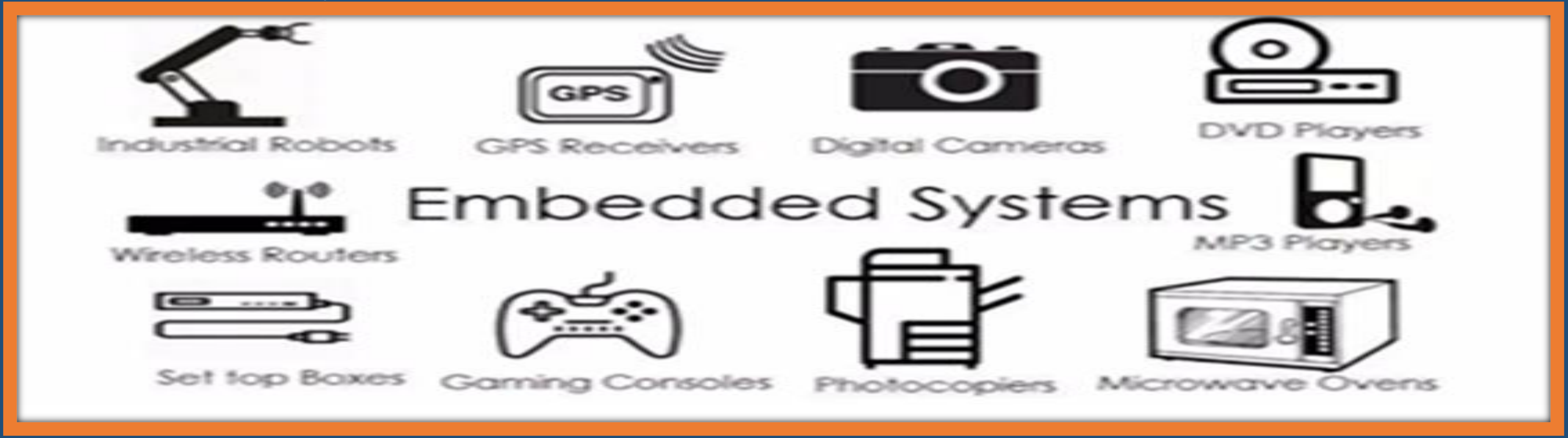
Resistors, Capacitors and Inductors

- **Ground**

Reference point for Voltage Level

# What is Embedded System

- An embedded system is an electronic/electro-mechanical system designed to perform a specific function and a combination of hardware and firmware (software).
- Every embedded system is unique and the hardware as well as the firmware is highly specialized to the application domain.
- Embedded system are becoming an inevitable part of any product or equipment, industrial control, consumer products, etc.





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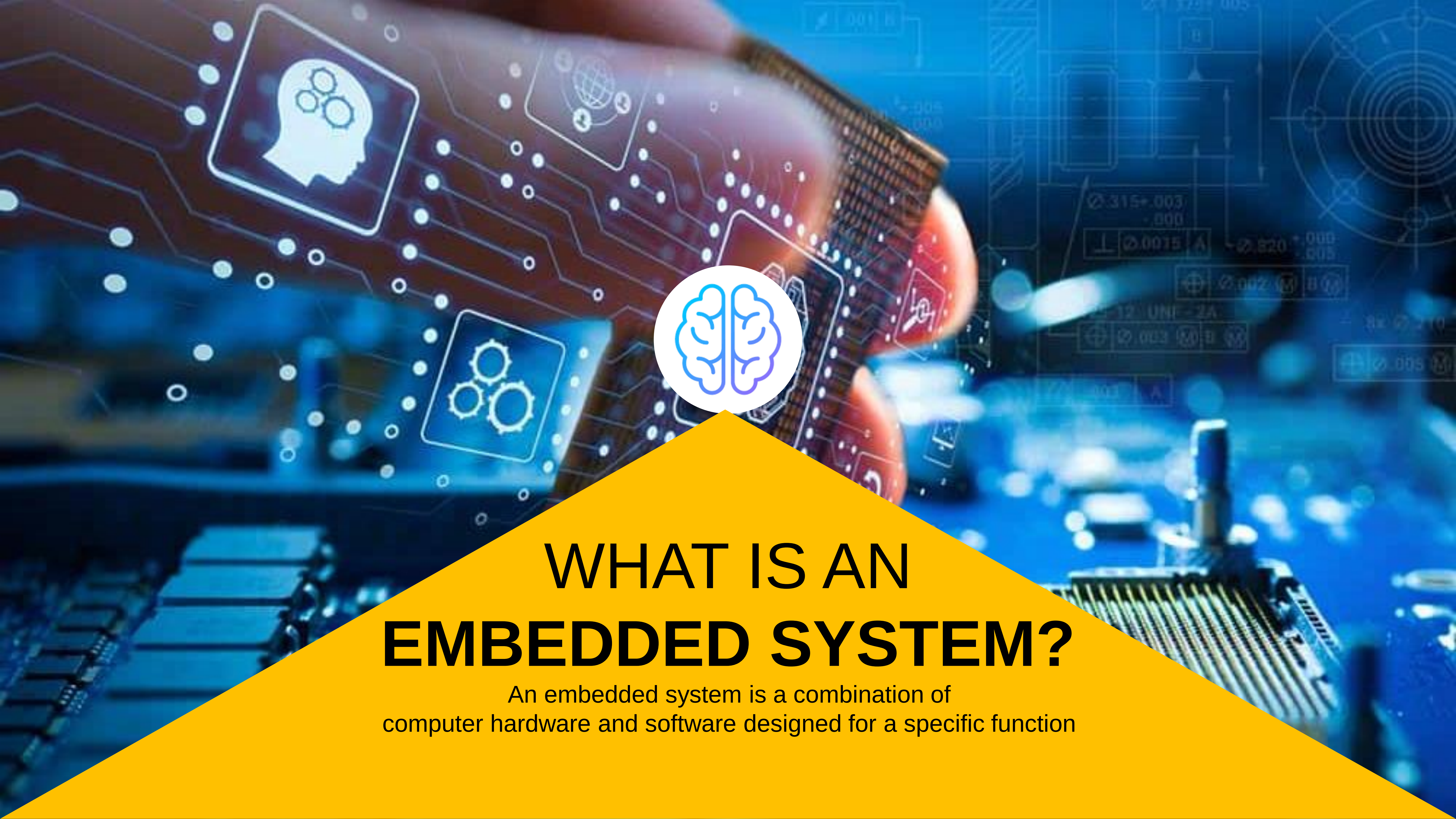
# INTRO TO EMBEDDED SYSTEMS

Exploring the heart of Technology



# WHAT IS AN
# EMBEDDED SYSTEM?

An embedded system is a combination of
computer hardware and software designed for a specific function

# ROLE OF AN EMBEDDED SYSTEMS

## The Silent Intelligence

The intricate network of embedded systems silently orchestrating modern technology, enhancing efficiency, and automating everyday tasks.

## The Nervous System of IoT

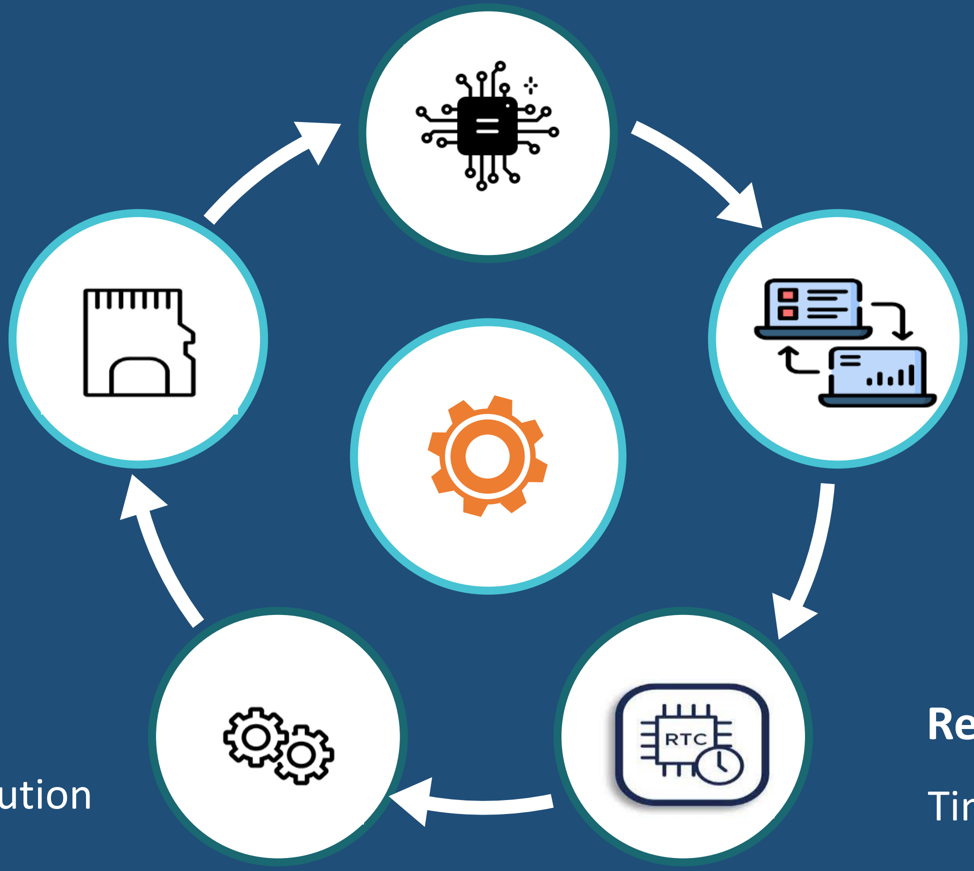
Serving as the neural network, embedded systems play a pivotal role in connecting, sensing, and controlling devices within the vast ecosystem of the Internet of Things.

## Bridging the Physical and Digital Realms

Acting as the bridge between the physical and digital worlds, embedded systems seamlessly merge hardware and software to power diverse applications in our connected environment.

# BUILDING BLOCKS

**Microcontroller**
Central Processor




**Communication**
Data Exchange

**Memory**
Data Storage

**Real-time clock**
Timing precision

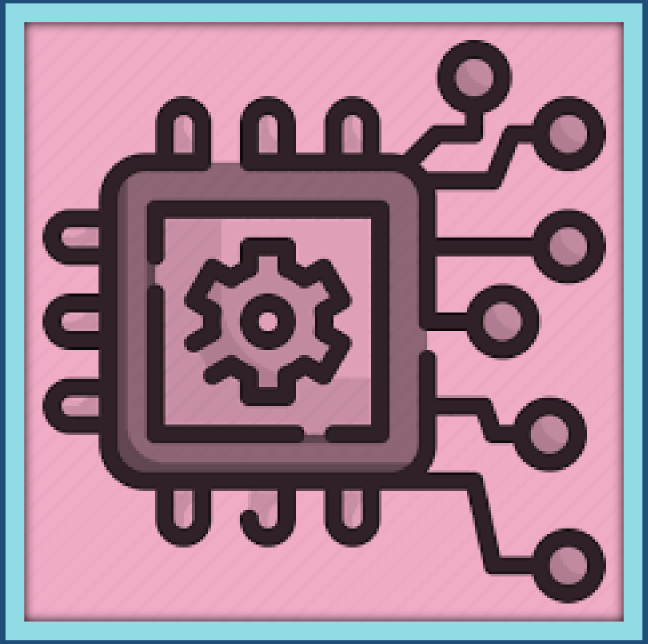
**Sensors/Actuators**
Input perception/output execution

# EMBEDDED SYSTEM

## SYNERGY OF ELECTRONICS AND EMBEDDED SYSTEMS

**Integration of Electronics**

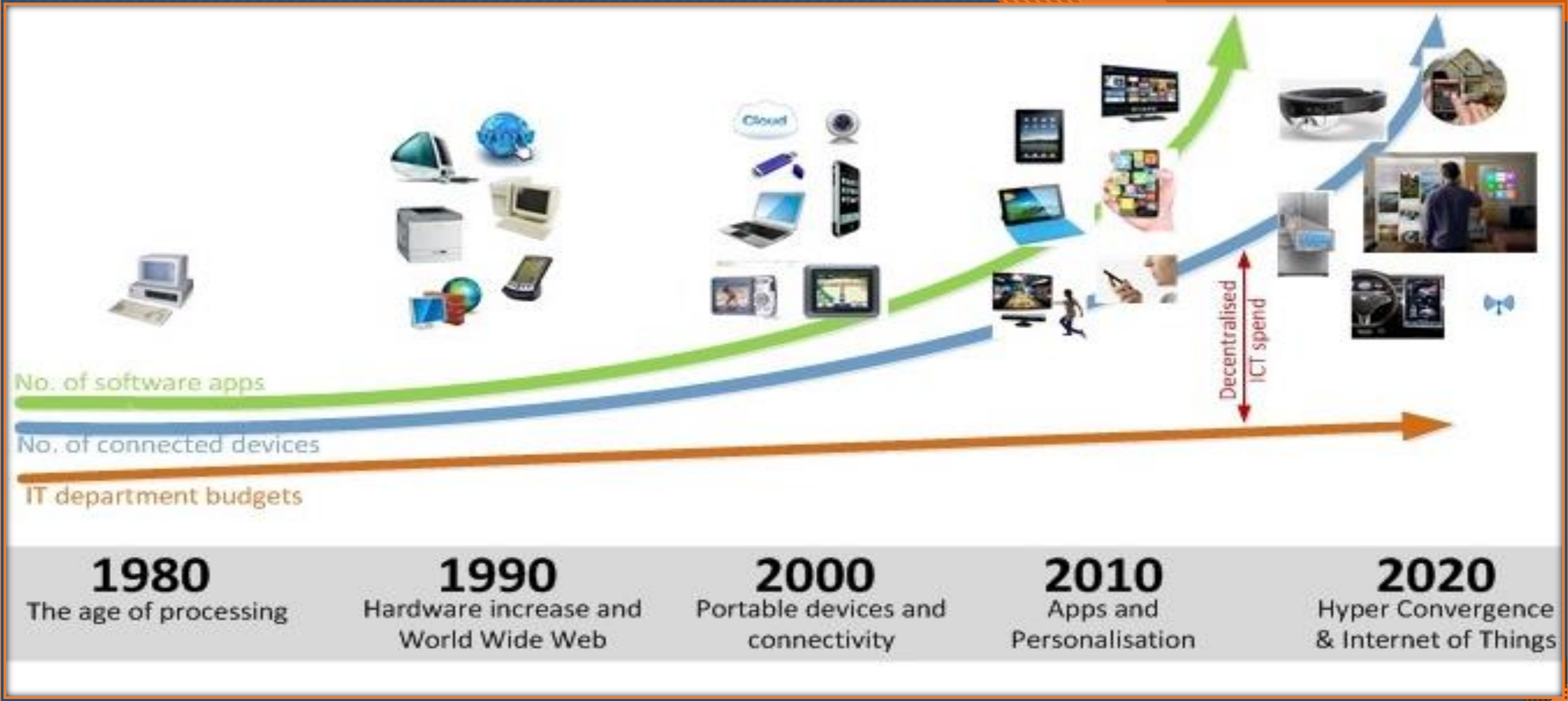
Embedded systems heavily rely on electronic components, including microcontrollers, sensors, and actuators, to perform dedicated functions. Electronics serve as the foundational building blocks for embedded systems, providing the necessary hardware for computation and control.



**Embedded Intelligence**

Electronics empower embedded systems with the intelligence to interact with the surrounding environment. Through the integration of sensors and processing units, electronics enable embedded systems to sense, process, and respond to real-world data, facilitating automation and smart functionalities.

# TECHNOLOGY TIMELINE



# Reference Links


- https://www.techtarget.com/iotagenda/definition/Internet-of-Things-IoT
- https://link.springer.com/article/10.1007/s11036-018-1090-3
- https://jasupdates.com/iot/
- https://www.slideshare.net/ShreeDevi42/iot-module-1-pptpptx
- https://www.hexacta.com/iot-security-mitigating-the-risk-of-an-attack-on-your-system/