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
- Online 4 hours once a week 9:00am-1:00pm
- Total of 12 Weeks 48-hours

Day-1
(Zoom meeting)

- **Introductory Session:**
  - IoT Big Picture: Sir Suhail (2 hours)
  - Electronics and Embedded Systems: Sir Azmat (1 hour)
  - Face Time With Students (30-min)
  - Course Objectives: Dr. Aamir (30-min)

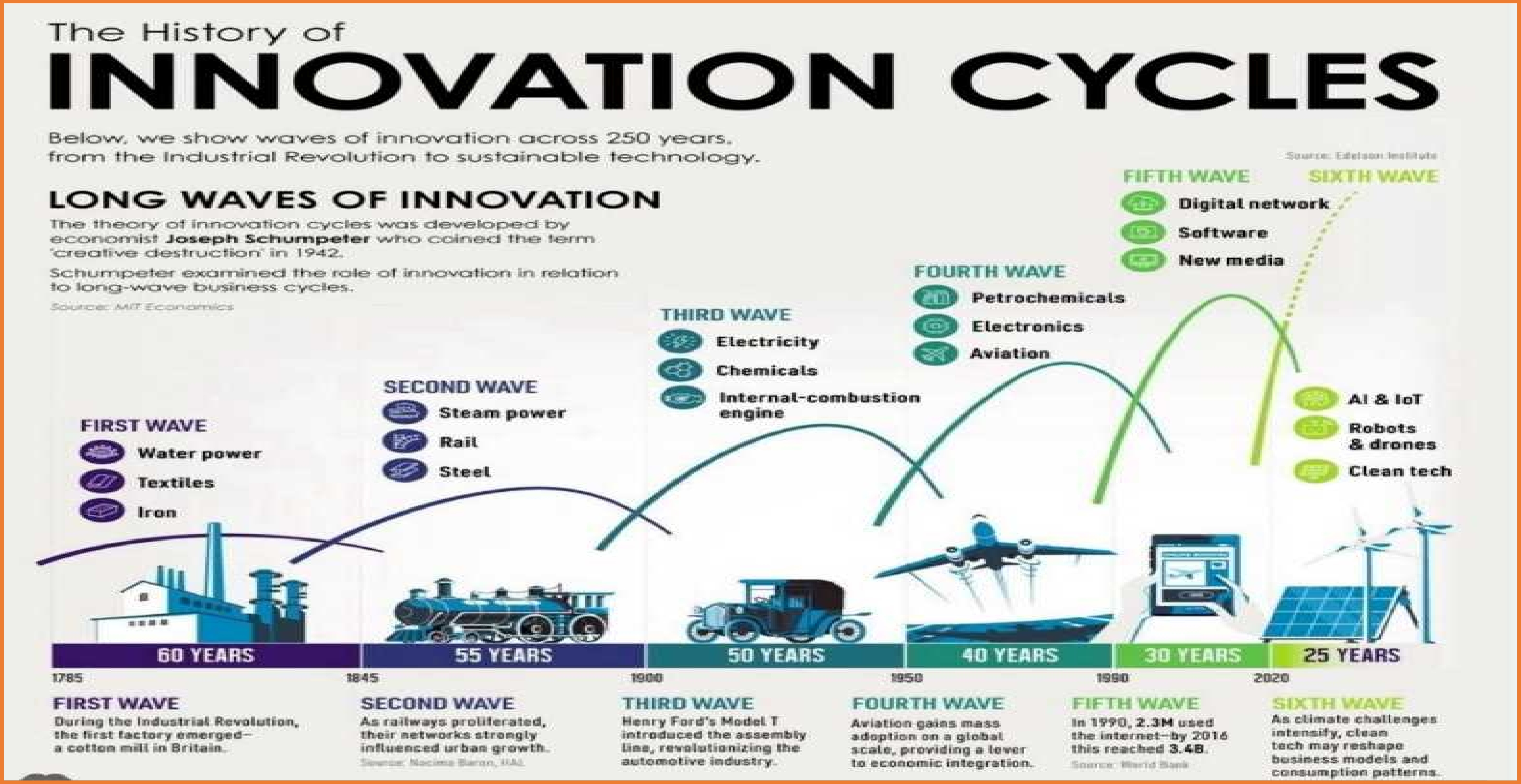
IoT SPRING'24

INTRODUCTION TO INTERNET OF THINGS

Suhail Siddiqui

Emerging Technology for Engineering

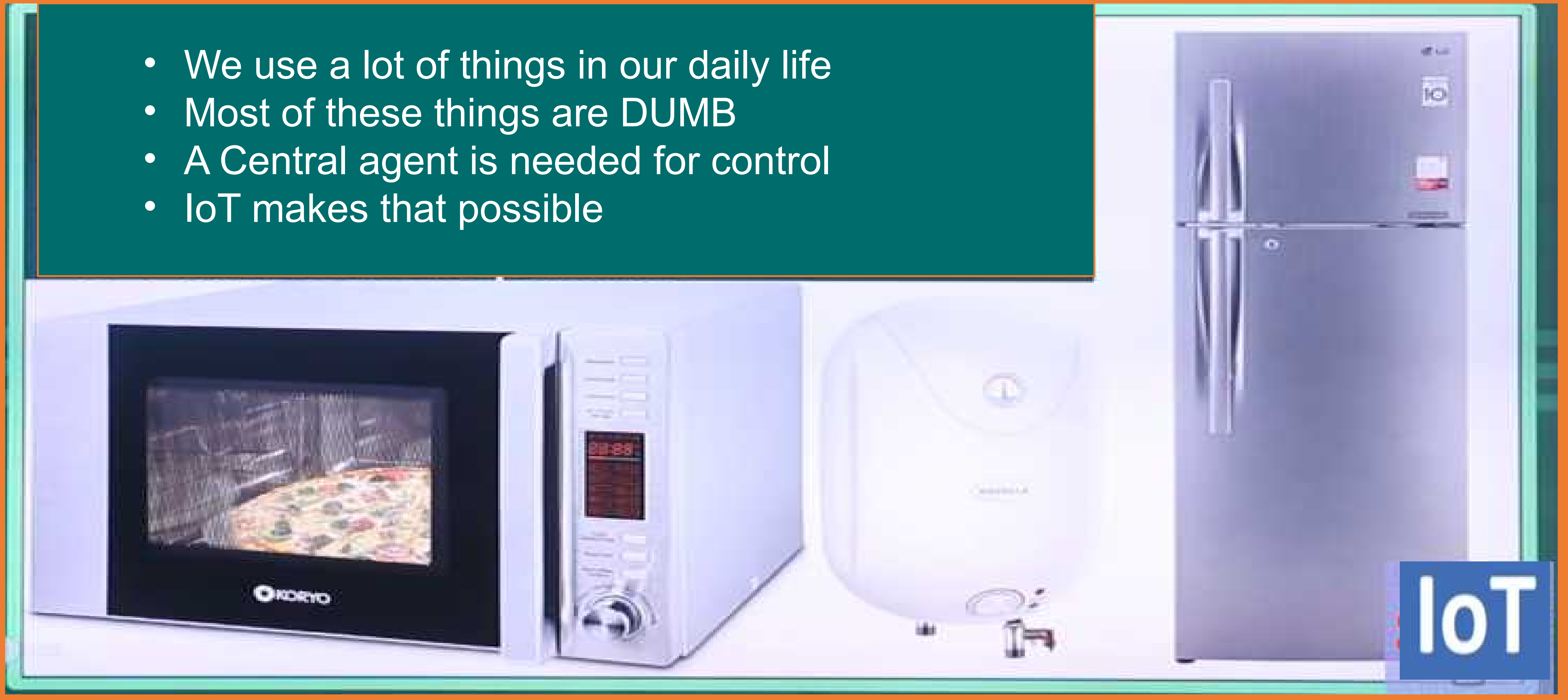
Contents



The History of
INNOVATION CYCLES
Below, we show waves of innovation across 250 years, from the Industrial Revolution to sustainable technology.
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.
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.
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 these things are DUMB
- A Central agent is needed for control
- IoT makes that possible



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USES

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

RISKS

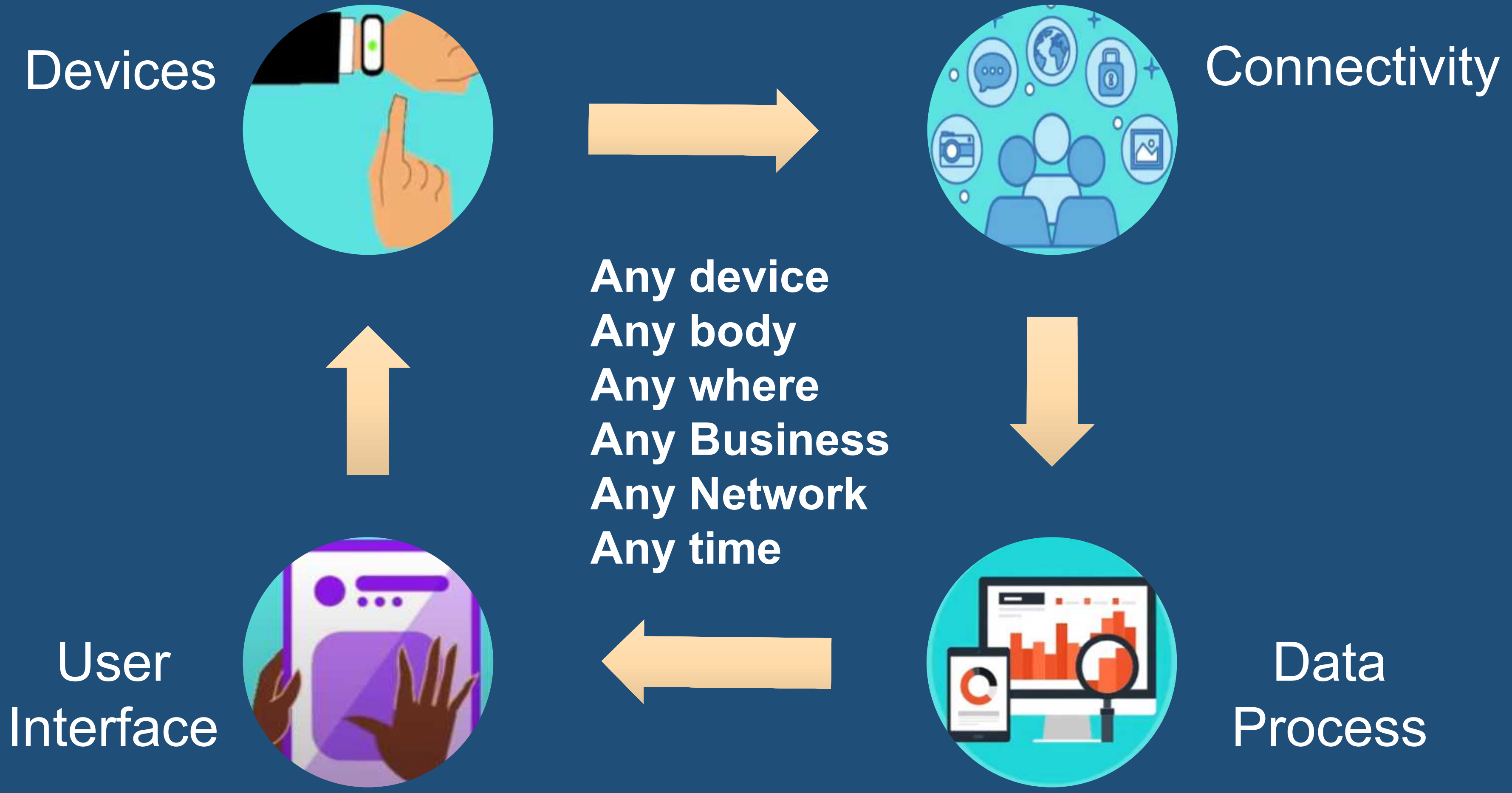
- You are giving up control for comfort
- Complexity being the enemy of reliability
- More and dangerous points of failure
- Everything becoming obsolete
- Makes you more vulnerable to everything

IoT

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
Data Process
User Interface

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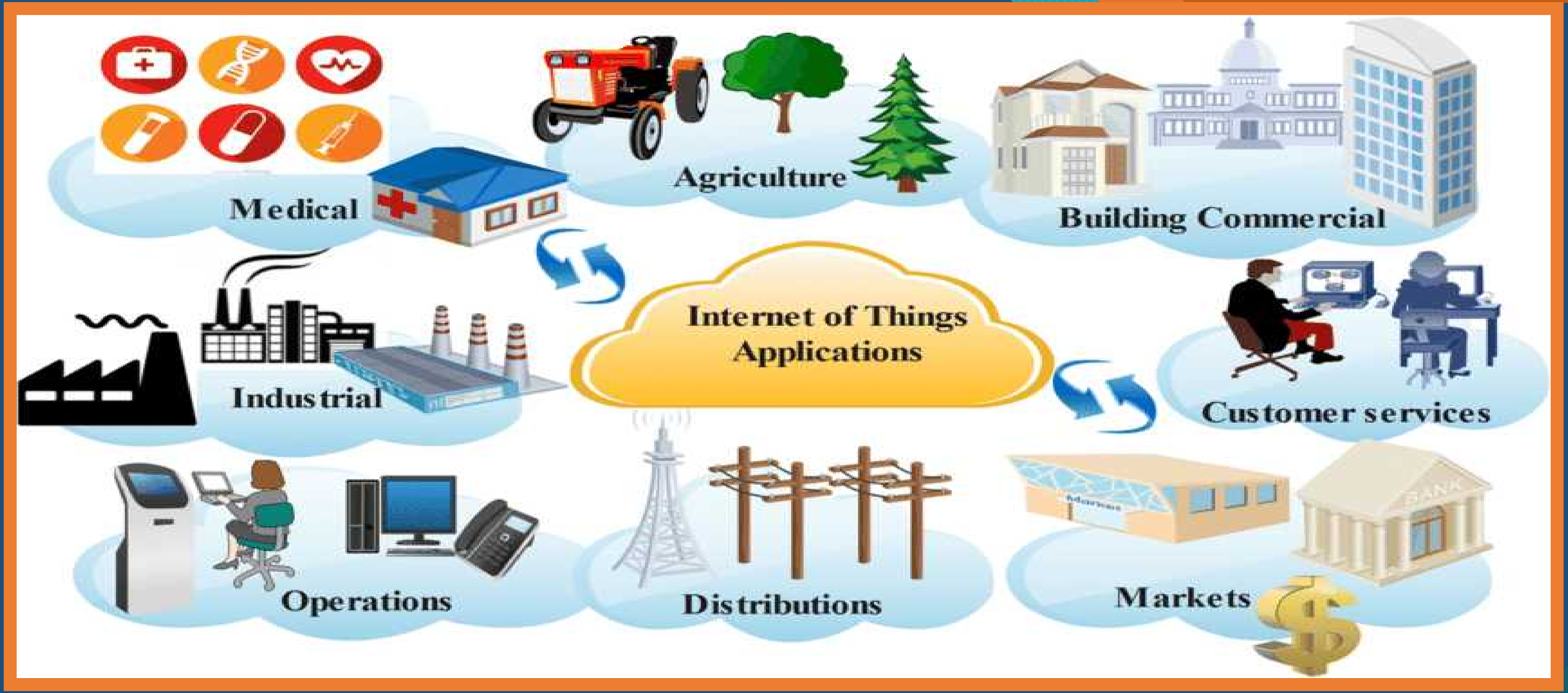
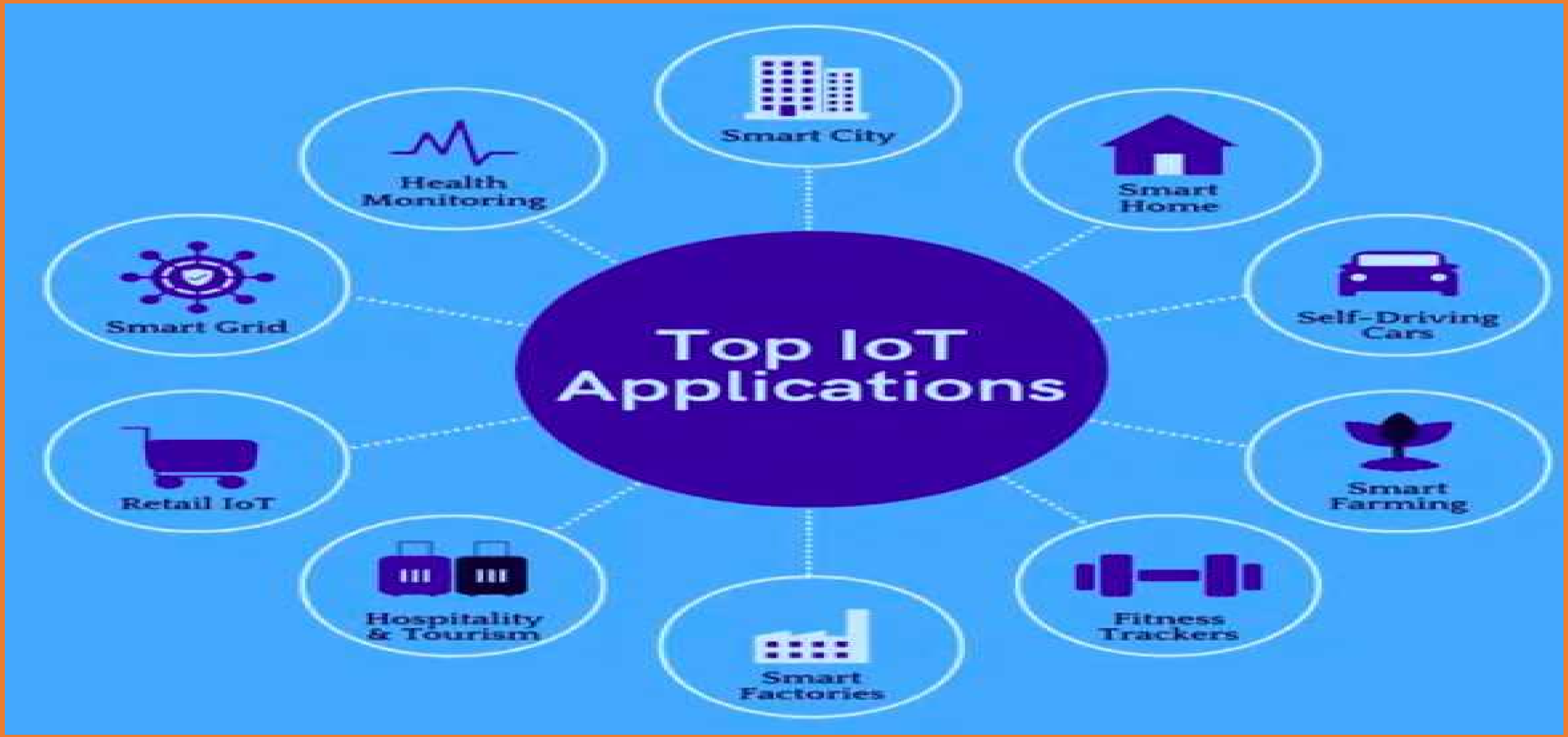
IoT Applications



IoT Examples



IoT Applications

- **Agriculture:**

  Automates farming processes using IoT to overcome rural labor shortages and ensure efficient agricultural development

- **Consumer Applications:**

  Enhances daily life with IoT-enabled devices like electronics, watches, and health trackers, contributing to a diverse market for lifestyle management

- **Healthcare:**

  Utilizes wearable IoT devices for remote patient monitoring, collecting essential health data and benefiting both patients and healthcare providers

- **Insurance:**

  Disrupts traditional insurance models with streamlined claim processes, reduced costs, and additional revenue through IoT-enabled digital networking

IoT Applications

- **Manufacturing:**

  Creates a technically-driven environment by automating development cycles, optimizing production flow, and efficiently managing inventories

- **Retail:**

  Uses IoT devices to gather and analyze data on product shopping life cycles, enabling informed decisions for improving retail operations and enhancing the customer experience

- **Transportation:**

  Integrates personal and commercial vehicles with IoT applications for route optimization, tracking, weather monitoring, and efficient information distribution

- **Utilities/Energy:**

  Implements IoT in utility grids with intelligent meters and sensors, optimizing energy distribution, improving efficiency, and conserving resources

IoT Applications

- **Traffic Monitoring:**

  Enhances urban decision-making with IoT-based traffic monitoring systems, providing real-time updates on incidents and congestion to save commute time

- **Hospitality:**

  Utilizes IoT for centralized control in hotels, managing air conditioning, heating, and ventilation, along with devices alerting staff about appliance status for proactive maintenance

IoT Components

- Device The Thing
- Local Network
- Internet
- Backend Services
- Applications

How does IoT work ?

- **Internet of Things platform**

  An IoT platform manages device connectivity. It can be a software suite or a cloud service. The purpose of an IoT platform is to manage and monitor hardware, software, processing abilities, and application layers

- **Sensor technologies**

  IoT sensors, sometimes called smart sensors, convert real-world variables into data that devices can interpret and share. Many different types of sensors exist. For example, temperature sensors detect heat and convert temperature changes into data. Motion sensors detect movement by monitoring ultrasonic waves and triggering a desired action when those waves are interrupted

- **Unique identifiers**

  The core concept of the IoT is communication among devices and users. Unique identifiers (UIDs) establish the context of a device within the larger network to enable this communication. Identifiers are patterns, like numeric or alphanumeric strings. One example of a UID that you might be familiar with is an internet protocol (IP) address. They can identify a single device (instance identifier) or the class to which that device belongs (type identifier)

How does IoT work?

- **Internet connectivity**

  Sensors can connect to cloud platforms and other devices through a host of network protocols for the internet. This enables communication between devices

- **Artificial intelligence (AI) and machine learning**

  Natural language processing (NLP) in IoT devices makes it easier for users to input information and interact with devices. One common example of an IoT device that utilizes NLP technology is the Amazon Alexa. Machine learning also enhances the analytical capabilities of IoT devices

- **Edge computing**

  Edge computing is a computing framework. It aims to conserve resources and speed up response time by moving computational resources like data storage closer to the data source. The IoT accomplishes this by utilizing edge devices like IoT gateways

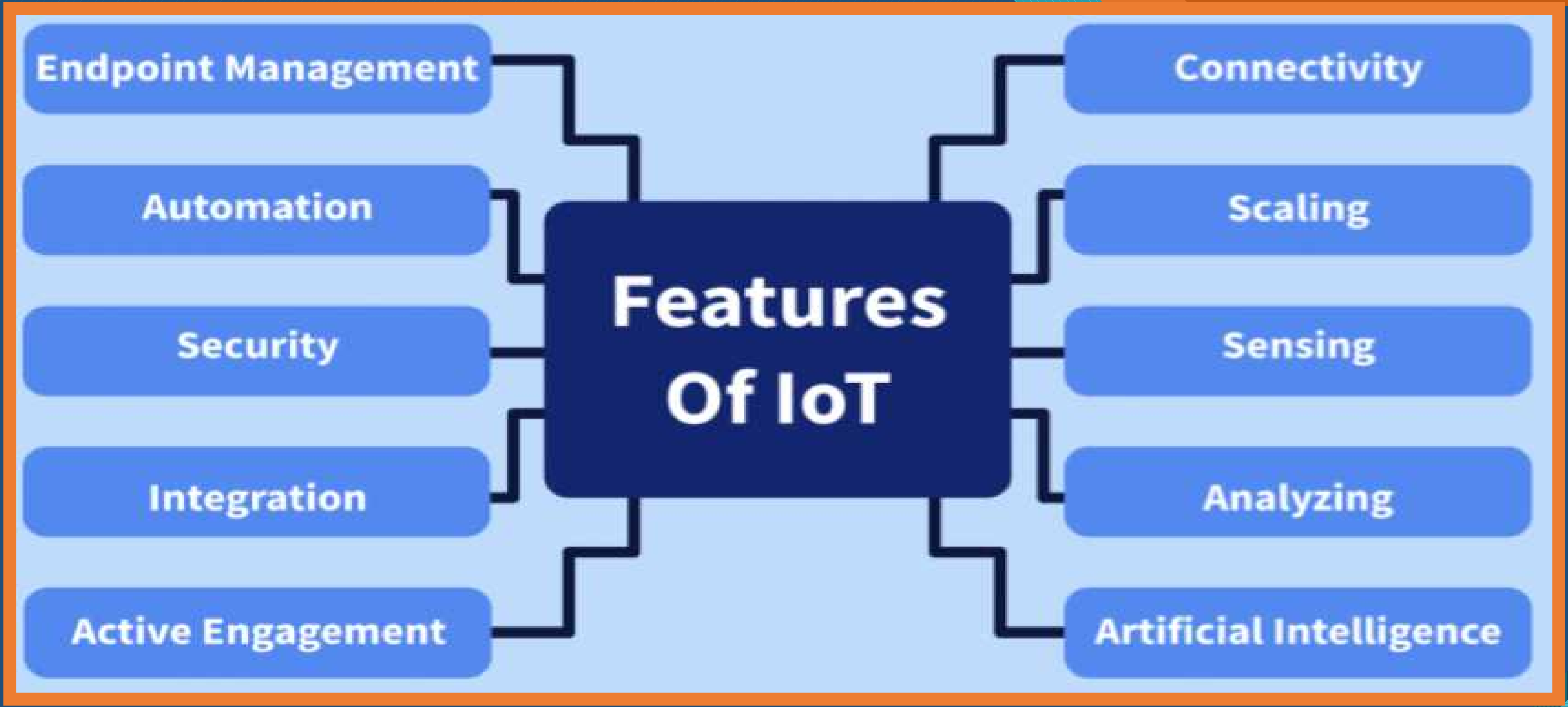
Features of IoT

- Connectivity: Establishes communication between diverse devices via radio waves, Wi-Fi, Bluetooth, or wires, linking IoT with cloud computing, AI, and blockchain
- Scaling: Adapts device numbers dynamically based on demand for optimal system performance
- Sensing: Uses sensors for environmental data (temperature, light, sound) to automate decision-making
- Analyzing: Processes raw data through AI for meaningful insights and improved functionality
- Artificial Intelligence: Integrates machine learning models for devices to understand and adapt to surroundings
- Smaller Devices: Compact semiconductor chips and sensors deliver precision and performance
- Dynamic Nature: Adapts to environmental changes, e.g., smart air conditioners adjusting based on sensor data
- Active Engagement: Connects devices with cloud computing, AI, and block chain for collaborative data manipulation

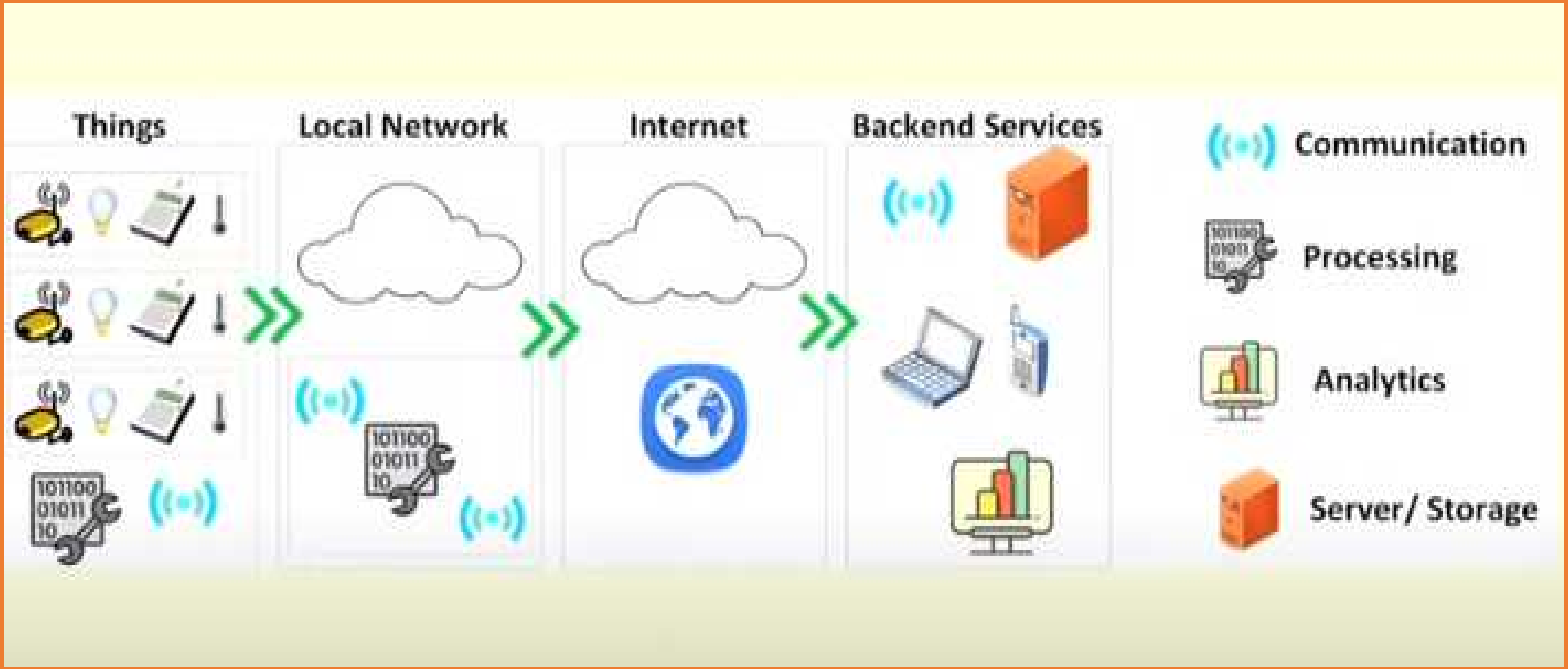
Features of IoT

- Smaller Devices: Employs compact devices like semiconductor chips and sensors to efficiently deliver precision and performance, enhancing overall quality of living
- Dynamic Nature: Adapts to changes in the environment, exemplified by a smart air conditioner adjusting temperature and humidity based on real-time sensor data
- Active Engagement: Connects devices with technologies like cloud computing, AI, and block chain, fostering collaboration for data manipulation and business use
- Integration: Combines cross-domain technologies like cloud computing, AI, big data, and deep learning into an interconnected ecosystem, evolving from IoT to the "internet of everything"
- Automated: Emphasizes automation to simplify life and business processes, such as IoT farming systems automating irrigation to reduce water wastage
- Security: Prioritizes robust security measures to safeguard sensitive information stored and transmitted within IoT systems, ensuring user trust and demand
- Endpoint Management: Crucial for successful IoT implementation, managing endpoints to prevent system failures, such as unnecessary grocery orders in the absence of users

Features Of An IoT



Scenarios of An IoT



IoT Components

- 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

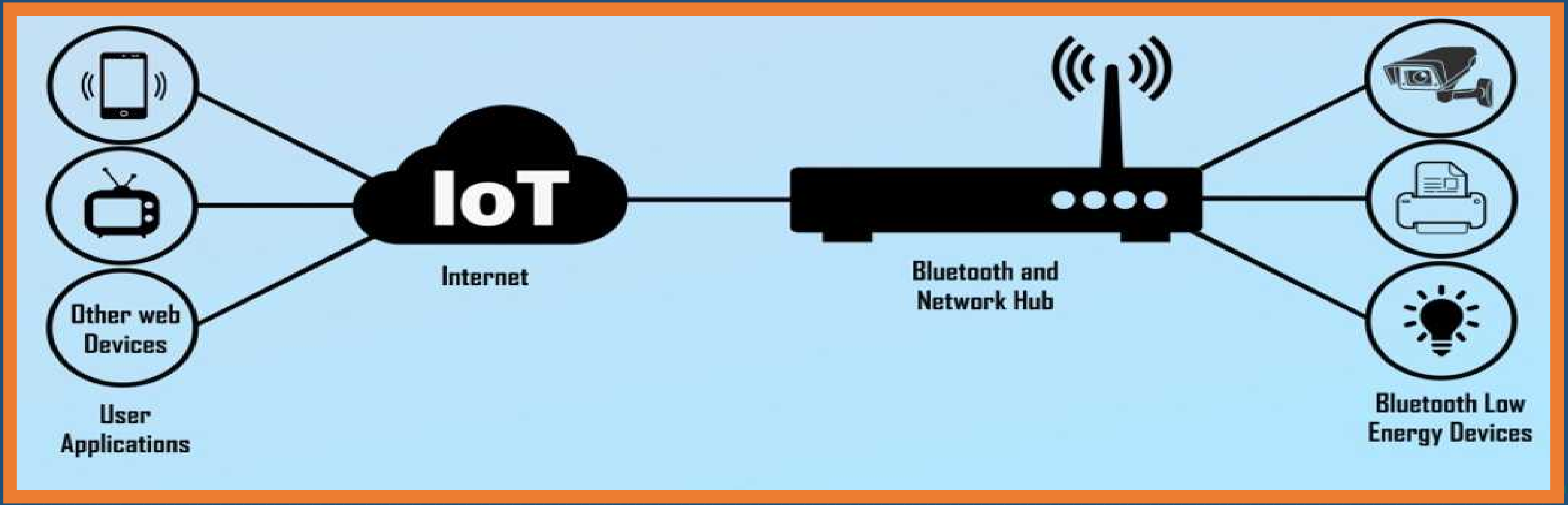
- IoT device communicates with in the locally networked devices
- Local communication is done mainly via ESPNOW, LoRa, Bluetooth, Zigbee or Wifi
- Generally limited to local communication by a Gateway

IoT Challenges

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

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



Complexity of Networks

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

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

RISKS

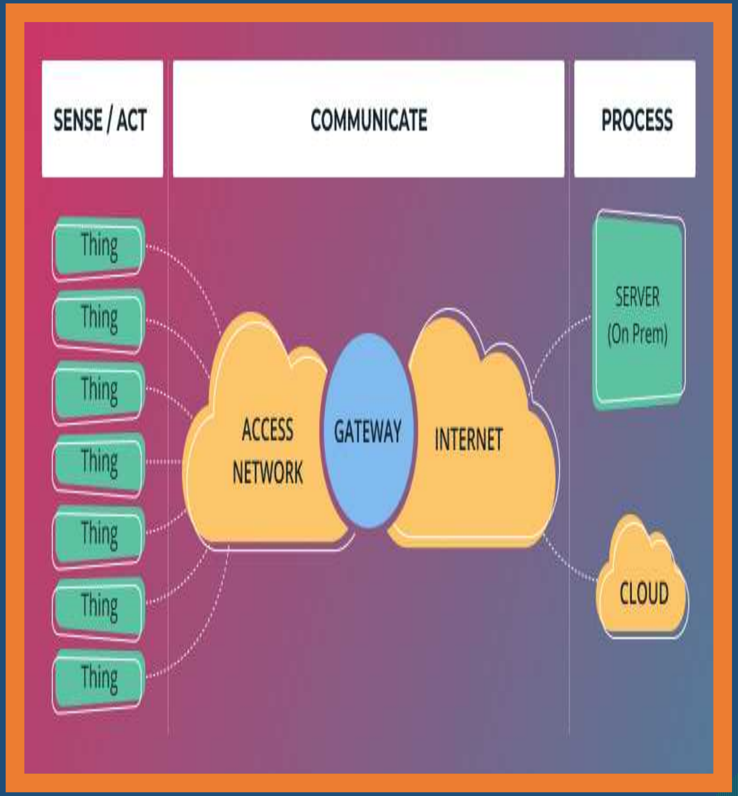
The Internet of Things (IoT) introduces specific risks and challenges due to the interconnected nature of devices and the massive amounts of data they generate. Some of the key risks associated with IoT include.

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.



Dr. Aamir Farooqui

Goals

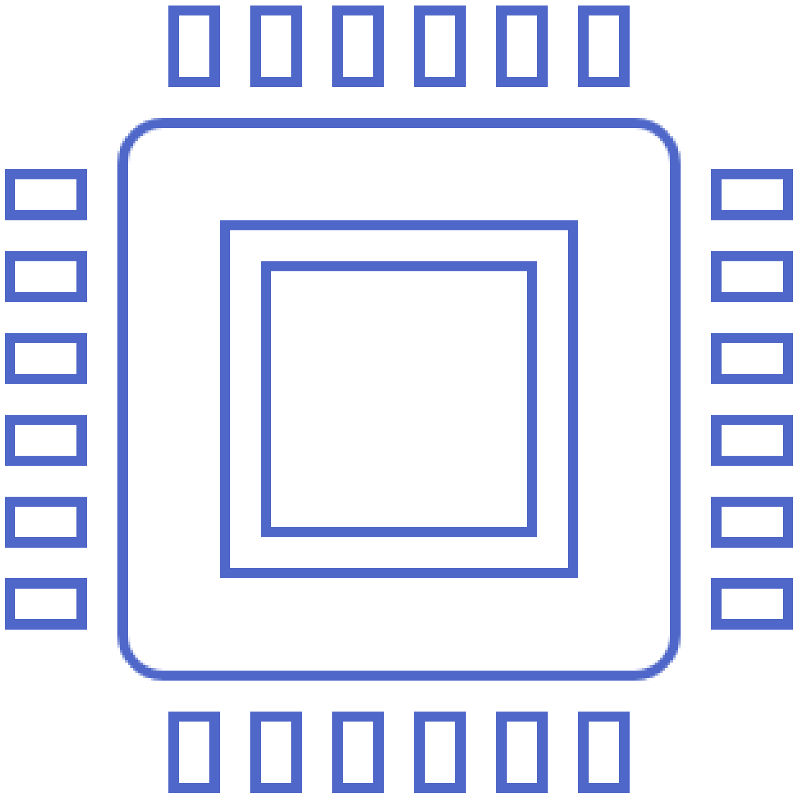
- Transferring practical knowledge and expertise to you
- How to use your engineering knowledge and skills for the well being of humanity
- Provide useful pointers on how to earn good income or establish own startup
- Select few Interns
- Seed fund startups

IOT ESSENTIALS

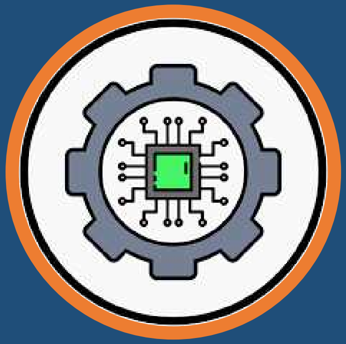
AN INTRODUCTION

ELECTRONICS AND EMBEDDED SYSTEMS

Azmat Hussain



Internet Of Things



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

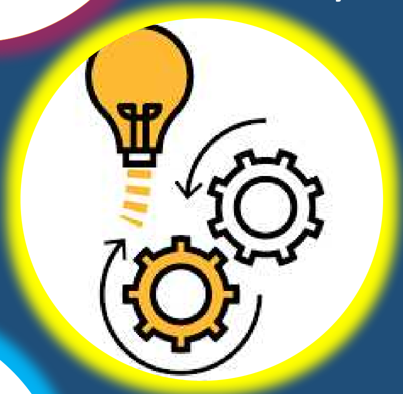
Recap and Q&A

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 an 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.

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 system

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

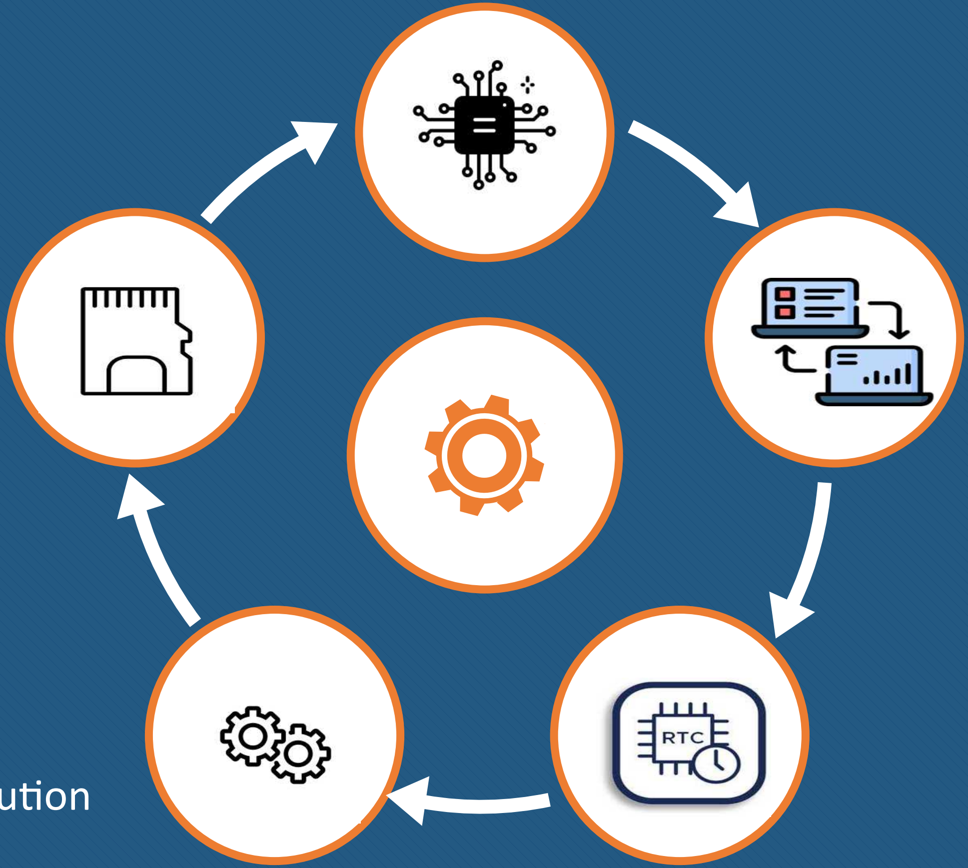
Microcontroller
Central Processor

Communication
Data Exchange

Real-time clock
Timing precision

Sensors/Actuators
Input perception/output execution

Memory
Data Storage

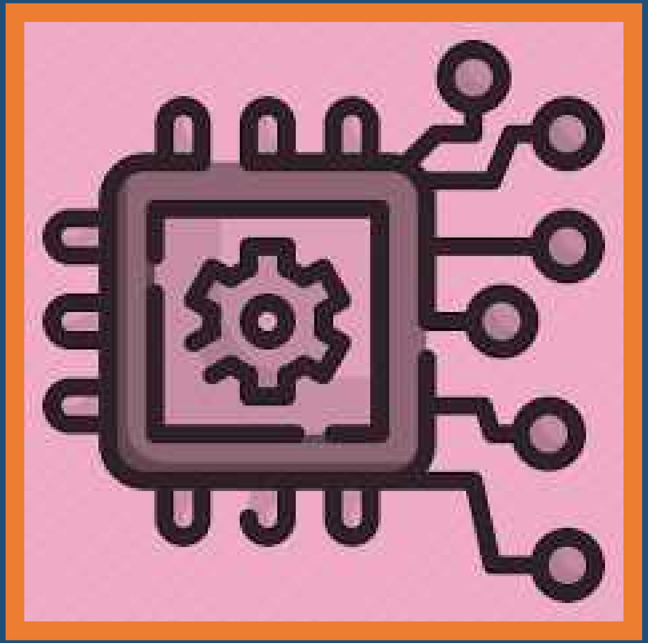


EMBEDDED SYSTEM

SYNERGY OF ELECTRONICS AND EMBEDDED SYSTEMS

Integration of Electronics

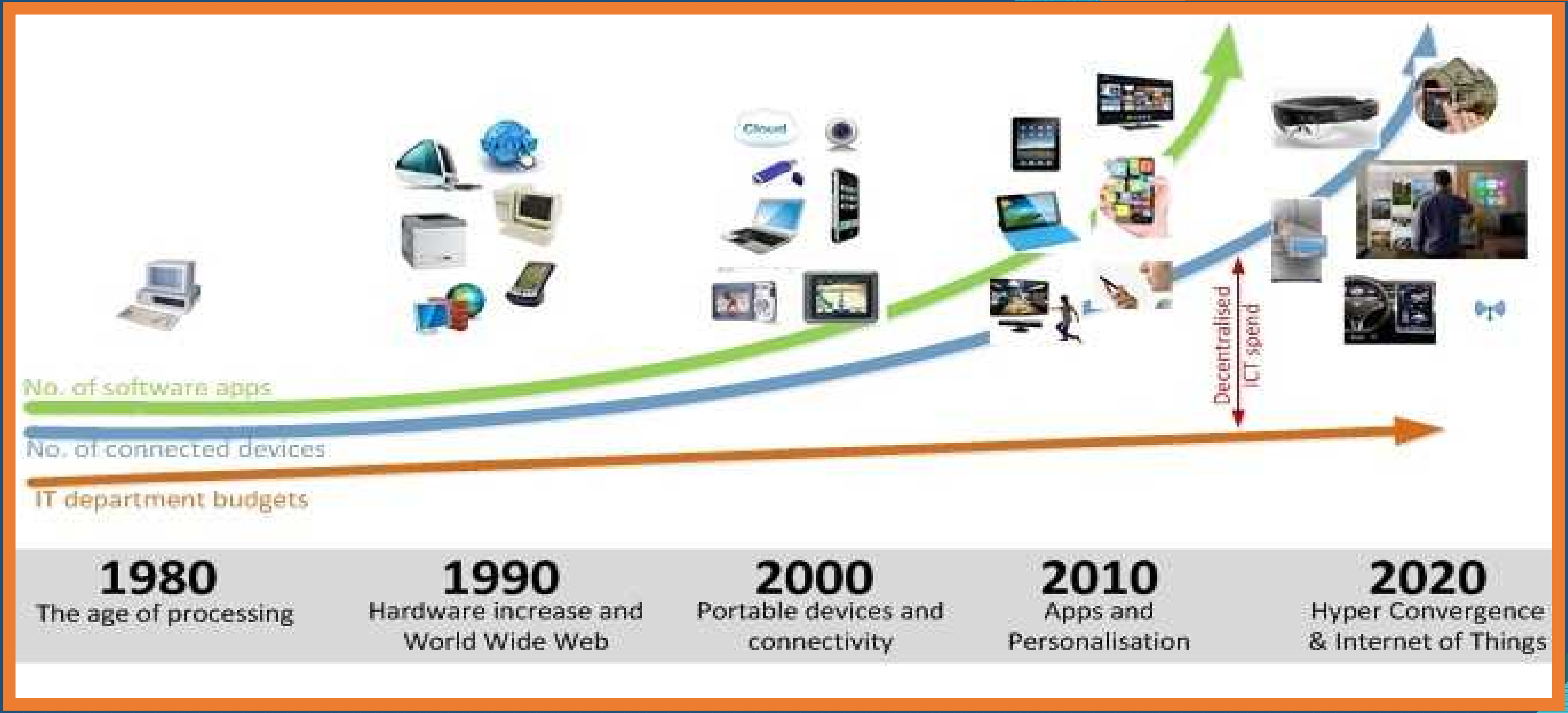
Embedded systems heavily rely on electronic components, including microcontrollers, sensors, and actuators, to perform dedicated functions. Electronics serve as the foundational building blocks for embedded systems, providing the necessary hardware for computation and control.



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

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QUESTIONS?

THANK YOU.