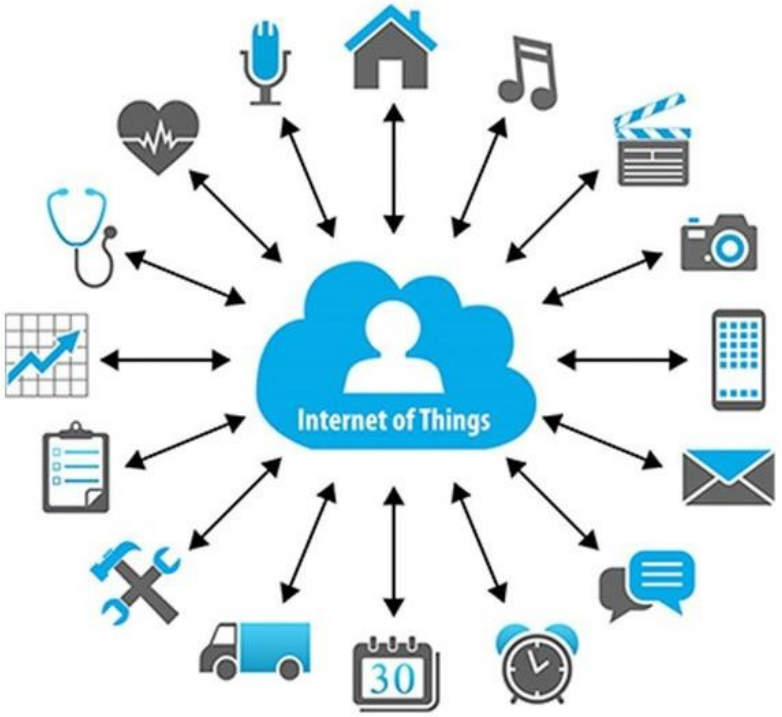
Internet of Things (IoT)

Chapter 4

Learning outcomes

After completing this session, you should be able to

- Describe IoT
- Describe the pros and cons of IoT
- Explain how IoT works
- Explain the architecture of IoT
- Describe application areas of IoT



Internet of Things(IoTs)



Global Network of Smart physical Things

Overview of IoT

- The Internet of Things, or IoT, refers to the set of devices and systems that interconnect real-world **sensors and actuators** to the Internet.
- Internet of Things (IoT) is a network of devices which can sense, accumulate and transfer data over the internet without any human intervention.
- Internet of Things (IoT) is here to change the world we know.
  - Smart cars, smart homes, smart cities, everything around us can be turned into a smart device with the help of Internet of Thing
  - IoT surely brings the coolness factor to technology.

Introduction of Two essential elements

- A sensor is a device that changes a physical parameter to an electrical output
- An actuator is a device that converts an electrical signal to a physical output.
- The sensor situated at the input port to take the input where as an actuator is place at the output port.
- Sensors and actuators are essential elements of the embedded system

Comparisons between Sensors and Actuators

SENSORS

- Basic - Used to measure the continuous and discrete process variables.
- Placed at- Input port
- Out come- Electrical Signal
- Examples- Magnetometer, Cameras, Accelerometer, microphones.
- Sensors present the computer with information about the state of the system.

ACTUATORS

- Impel continuous and discrete processes parameters.
- Output port
- Heat or motion
- LED, Laser, Loudspeaker, Solenoid, motor controllers.
- Actuators accept commands to perform a function.

IAB’s Definition of IoT

According to the Internet Architecture Board’s (IAB) definition,

> IoT is the **networking of smart objects**, meaning a huge number of devices **intelligently communicating** in the presence of internet protocol that cannot be directly operated by human beings but **exist as components** in buildings, vehicles or the environment.

IETF’s Definition of IoT

According to the Internet Engineering Task Force (IETF) organization’s definition,

> IoT is the **networking of smart objects** in which smart objects **have some constraints** such as limited bandwidth, power, and processing accessibility for achieving interoperability among smart objects

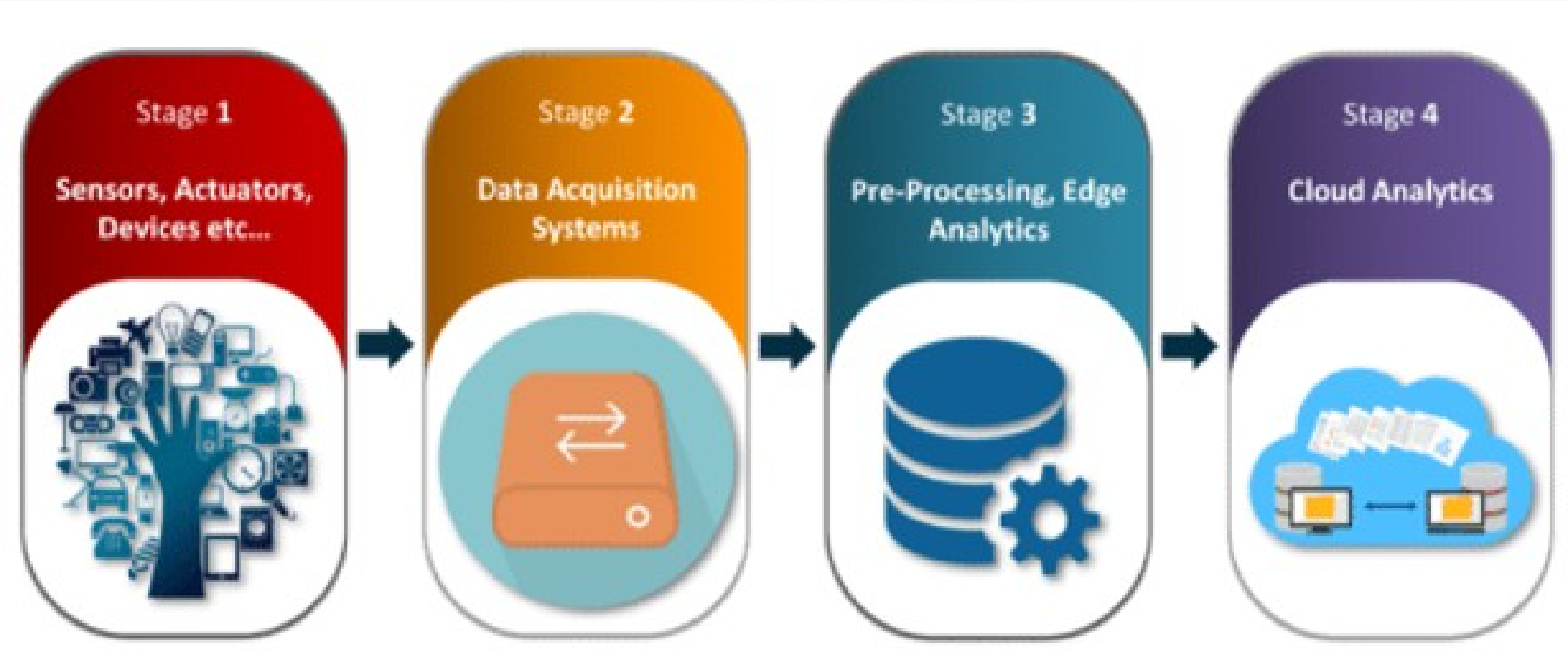
Definition of IoT

The Internet of Things (IoT) is

> the **network of physical objects** or "things" **embedded** with electronics, software, sensors, and network connectivity, which **enables** these **objects** to **collect** and **exchange** data

Simply stated, the **Internet of Things** consists of **any device with an on/off switch connected to the Internet**

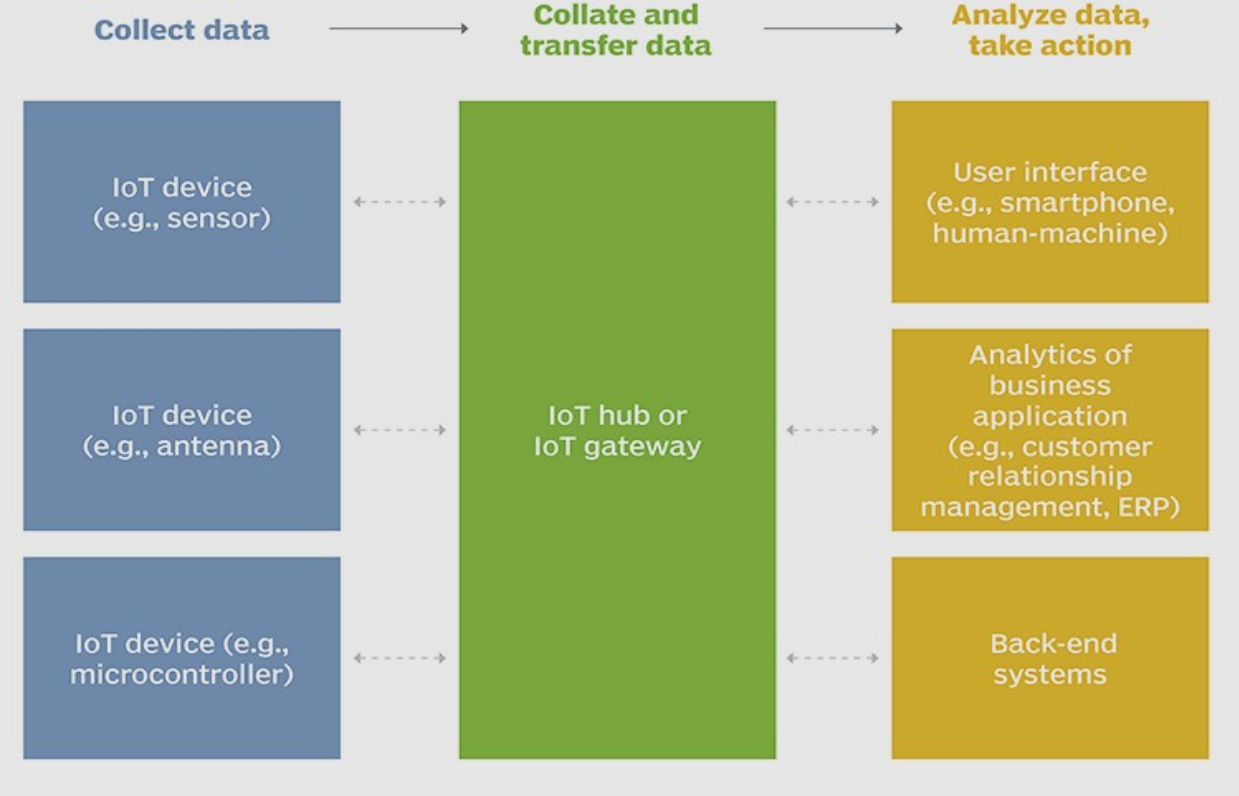
How IoT Works Cont'd…



How IoT Works - the 4 stages

- **Stage 1 (Sensors/Actuators)**
  - A thing in the context of “Internet of Things”, should be equipped with sensors and actuators thus giving the ability to emit, accept and process signals
- **Stage 2 (Data Acquisition Systems):**
  - The data from the sensors starts in analogue form which needs to be aggregated and converted into digital streams for further processing.
    - This stage performs these data aggregation and conversion functions
- **Stage 3 (Edge Analytics)**
  - Once IoT data has been digitized and aggregated, it may require further processing before it enters the data center, this is where Edge Analytics comes in
- **Stage 4 (Cloud Analytics)**
  - Data that needs more in-depth processing gets forwarded to physical data centers or cloud-based systems.

Example of an IoT System

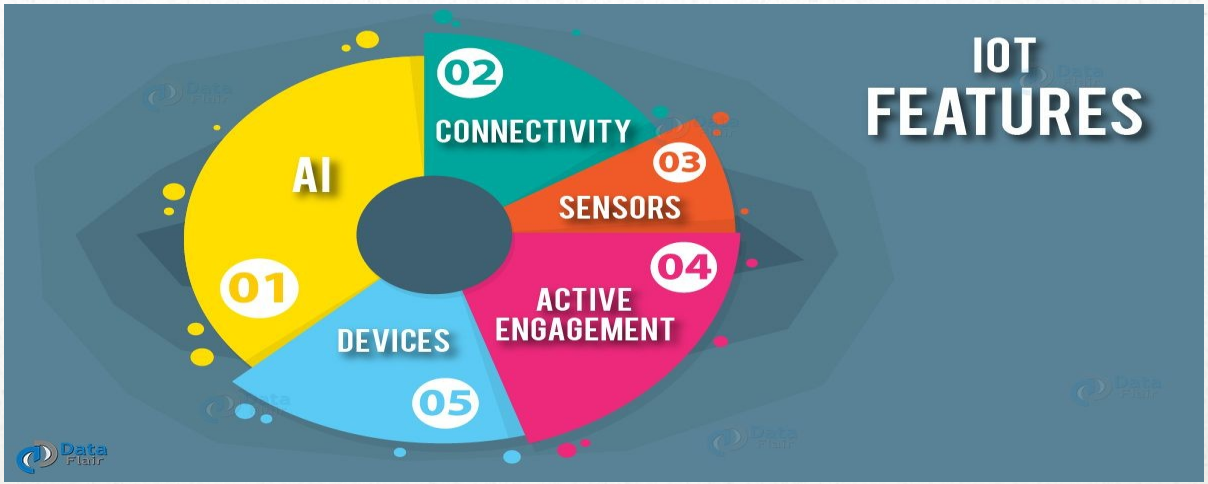


Prerequisites for learning IoT

- Some basic knowledge of networking, databases, programming, and related technology and you are good to go.

Features of IoT

Here, in this part of IoT Tutorial, we will discuss the most important features of IoT in areas of artificial intelligence, sensors, connectivity. A brief review of these features is given below:



Overview of IoT

The most important features of IoT include

Artificial Intelligence

To make virtually anything “smart”

Connectivity

To creates small networks between its system devices

Sensors

defining instruments that makes IoT device an active system capable of real-world integration

Overview of IoT

The most important features of IoT include

Active engagement

IoT introduces a new paradigm for active content, product, or service engagement

Small Device

IoT exploits **purpose-built small devices** to deliver its **precision**, **scalability**, and **versatility**

Features of IoT

- **AI**– IoT technically makes things smart, meaning that it enhances different aspects of life through proper usage of that data, networks, and algorithms. This can range from something as simple as improving or enhancing your refrigerator by embedding it with sensors that automatically detect when milk and eggs run low, to placing an order with your choice of the grocer.
- **Connectivity**–The notion of networking doesn't always have to restrict to large networks, it can also exist on a smaller and cheaper scale without compromising its efficiency. IoT comes into the picture and creates these small networks between its system devices.
- **Sensors**–The true essence of IoT would not hold effective without sensors. They are basically the reason and the crux of why this technology stands out. They play a major role in defining boundaries of IOT by converting it from a passive to an active network.
- **Active Engagement**–Today's interaction between different connected technologies happens through passive engagement. IoT has set an example by bringing in active content, product, or service engagement.
- **Devices**–Devices are more powerful, cheaper and smaller over time. Internet of Things

IoT – Advantages

Improved Customer Engagement

IoT enables to achieve richer and more effective engagement with audiences

Technology Optimization

IoT can be used to improve device use, and to aid in more potent improvements to technology

Reduced Waste

IoT provides real-world information leading to the more effective management of resources

Enhanced Data Collection

It allows an accurate picture of everything through data

IoT – Disadvantages

The more information is shared between devices, the more **potential that a hacker could steal confidential information**

If there’s a bug in the system, it’s likely that every **connected device will become corrupted**

IoT device **incompatibility** due to lack of international standard

Challenge in collecting and managing data from huge number of devices

Challenges of IoT

Security

constantly connected devices communicating over networks exposes users to various kinds of security attack

Privacy

substantial personal data in extreme detail might leak without even the active participation of users

Challenges of IoT

Complexity

- in terms of design, deployment, and maintenance
- use of multiple technologies and a large set of new enabling technologies

Compliance

Its complexity makes the issue of compliance seem incredibly challenging

How IoT work?

An IoT ecosystem consists of **web-enabled smart devices**

These devices **collect**, **send** and **act on** data they acquire from their environments using their

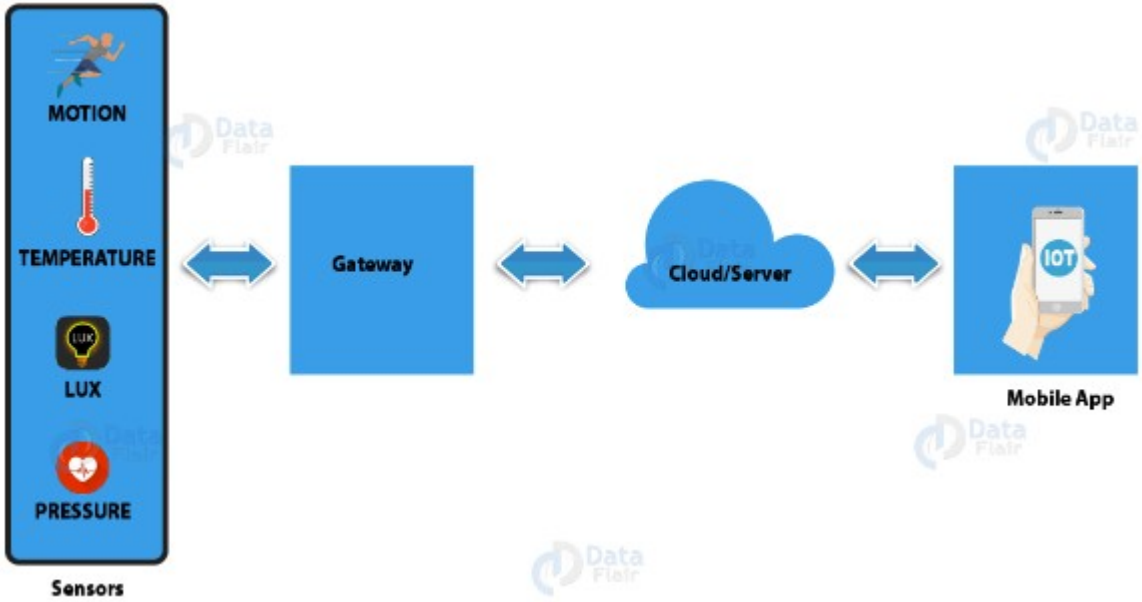
sensors,

embedded processors, and

communication hardware

How IoT work?

IoT devices share the sensor data they collect by connecting to an **IoT gateway** or another **edge device** where data is either sent to the **cloud** to be analyzed or ar



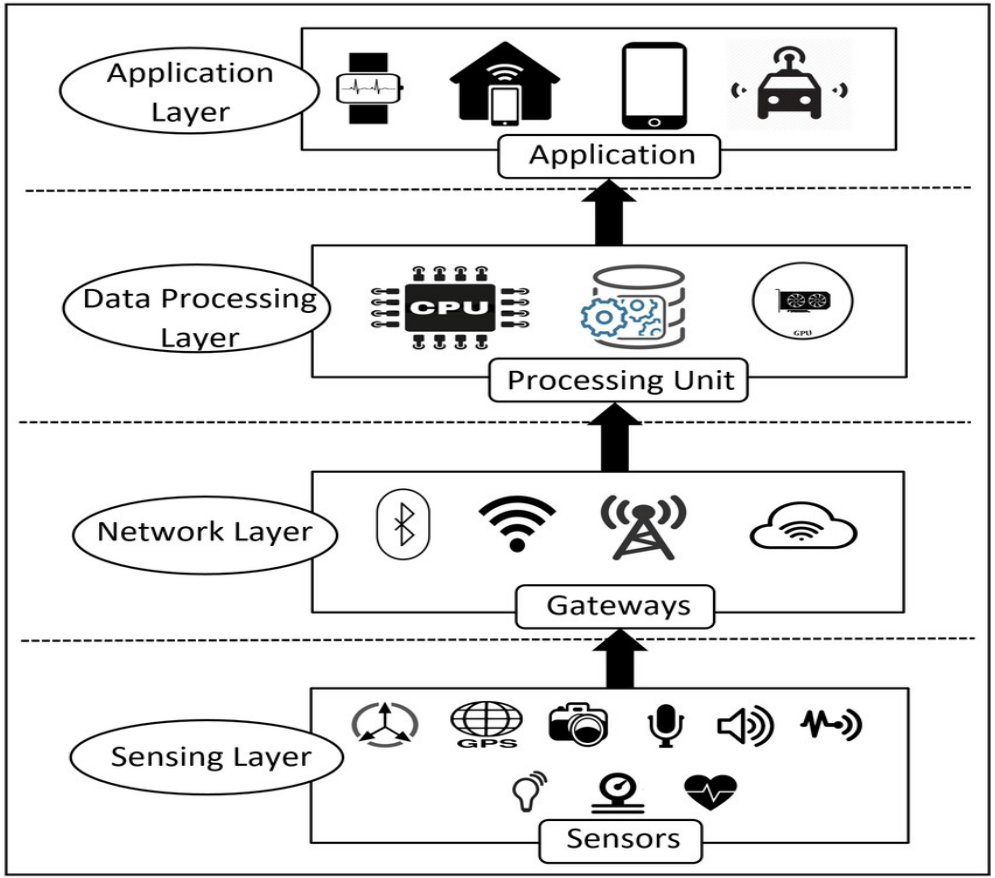
Architecture

Sensing Layer

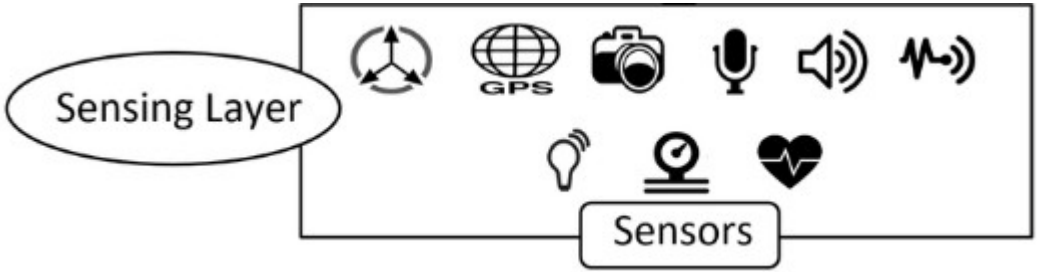
Network Layer

Data Processing Layer

Application Layer



Architecture of



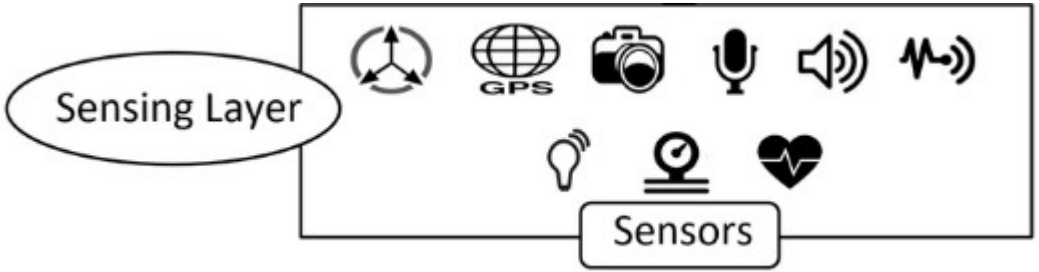
Sensing Layer

identify any phenomena in the devices' peripheral and obtain data from the real world

Sensors in IoT devices are usually integrated through **sensor hubs**

A **sensor hub** is a common connection point for multiple sensors that accumulate and forward sensor data to the processing unit of a device

Architecture of

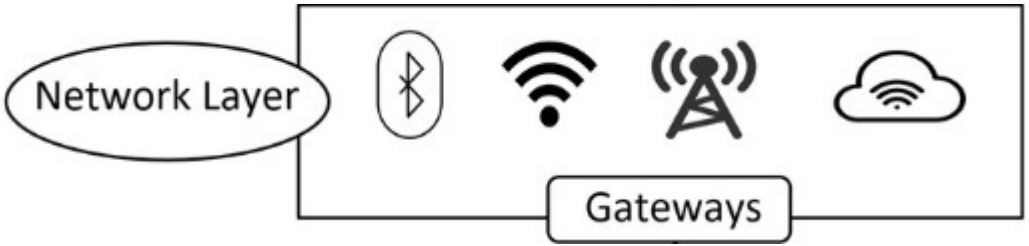


Sensing Layer

Sensors in IoT devices can be classified into three broad categories

1. **Motion Sensors**: measure the change in motion (angular or linear) as well as the orientation of the devices
2. **Environmental Sensors**: sense the change in environmental parameters in the device's peripheral. E.g. Light and Pressure sensors
3. **Position sensors**: deal with the physical position and location of the device. E.g. Global Positioning System (GPS) and Magnetic Sensors

Architecture of



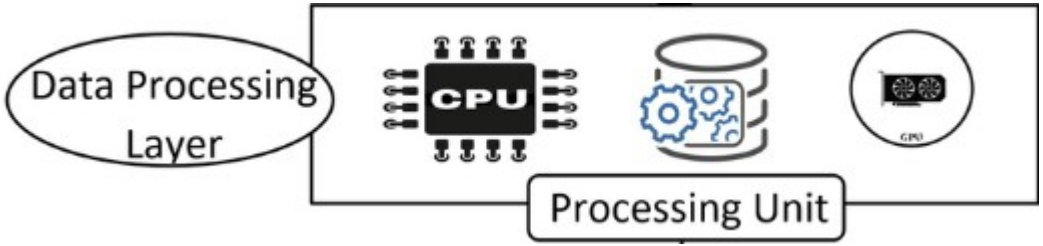
Network Layer

acts as a communication channel to transfer data, collected in the sensing layer, to other connected devices

this layer is implemented by using diverse communication technologies such as

Wi-Fi, **Bluetooth**, **Zigbee**, **Z-Wave**, **LoRa**, **Cellular Network**

Architecture o



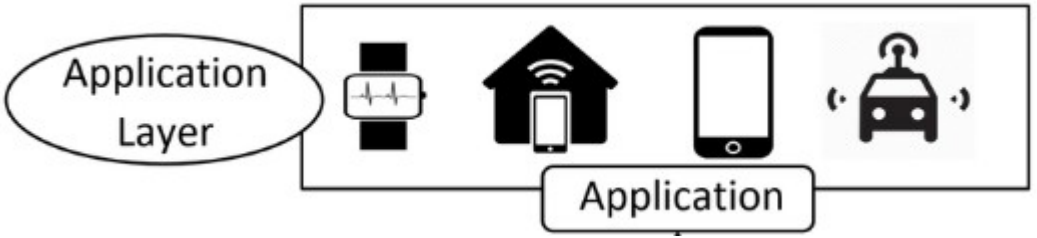
Data Processing Layer

takes data collected in the sensing layer and **analyses the data to make decisions** based on the result

in some IoT devices (e.g., Smart Watch and Smart Home Hub), the data processing layer **also saves the result** of the previous analysis to improve the user experience

this layer **may share the result of data processing** with other connected devices via the network layer

Architecture of



Application Layer

Implements and presents the results of the data processing layer to accomplish disparate applications of IoT devices

Is a user-centric layer that executes various tasks for the users

Devices and Networks

Connected IoT devices can be categorized into three main groups

Consumer, **Enterprise** and **Industrial**

Consumer connected devices include

Smart TVs, **Smart Speakers**, **Toys**, **Wearables**, and **Smart Appliances**

Enterprise and Industrial connected devices include

Smart Meters, **Commercial Security Systems** and **Smart City** technologies

Other technologies such as

Smart Air Conditioning, **Smart Thermostats**, **Smart Lighting**, and **Smart Security**, span consumer, enterprise, and industrial uses

Devices and Networks

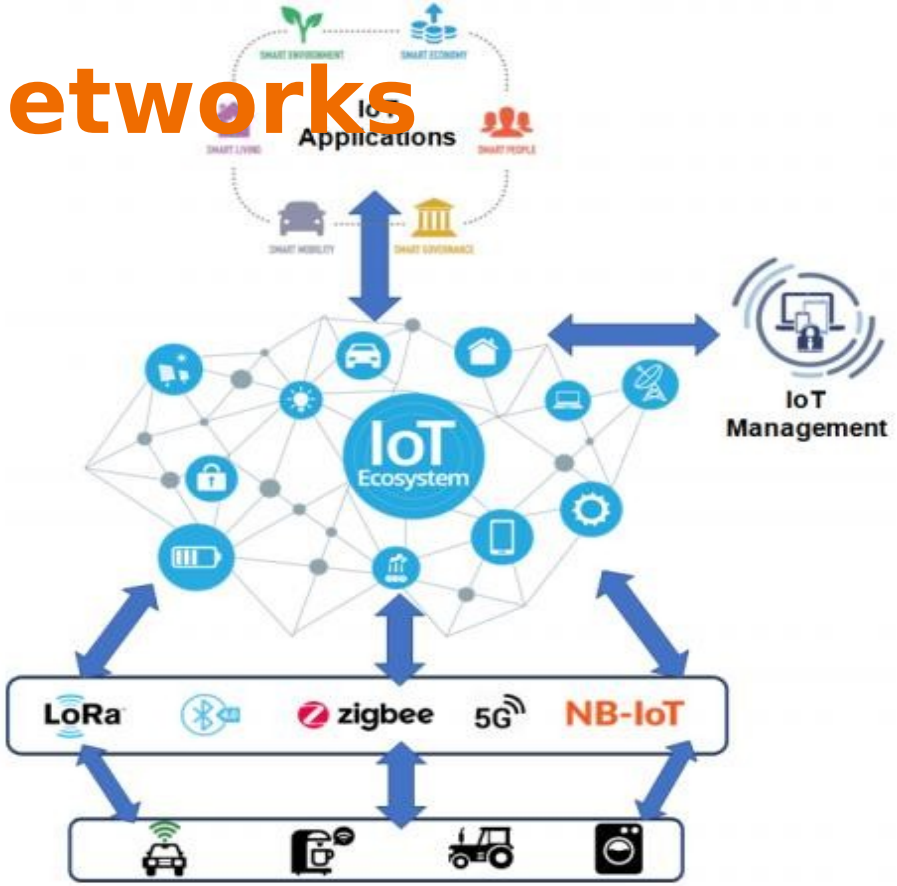
IoT network typically includes a number of devices with constrained resources such as power, processing, and memory

The **efficient management** of IoT networks requires **considering** both the **constraints** of low power IoT devices and the **deployment complexity** of the underlying communication infrastructure

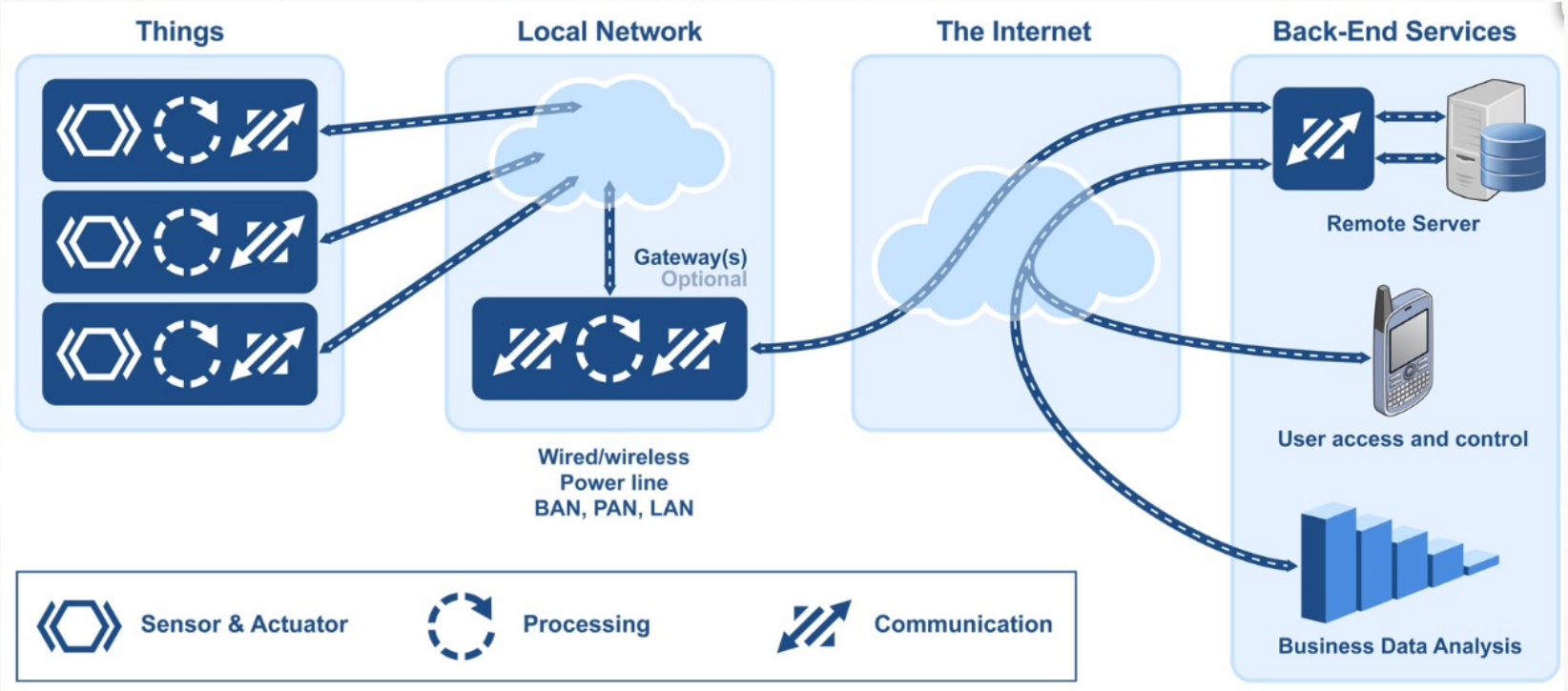
To ensure the correct functioning of those connected devices, they must be **remotely accessed to configure** or **monitoring** their status

Efficient and autonomic management of IoT networks take into account several elements such as **Scalability**, **Interoperability**, **Energy Efficiency**, **Topology Control**, **Quality of Service (QoS)**, **Fault Tolerance**, and **Security**

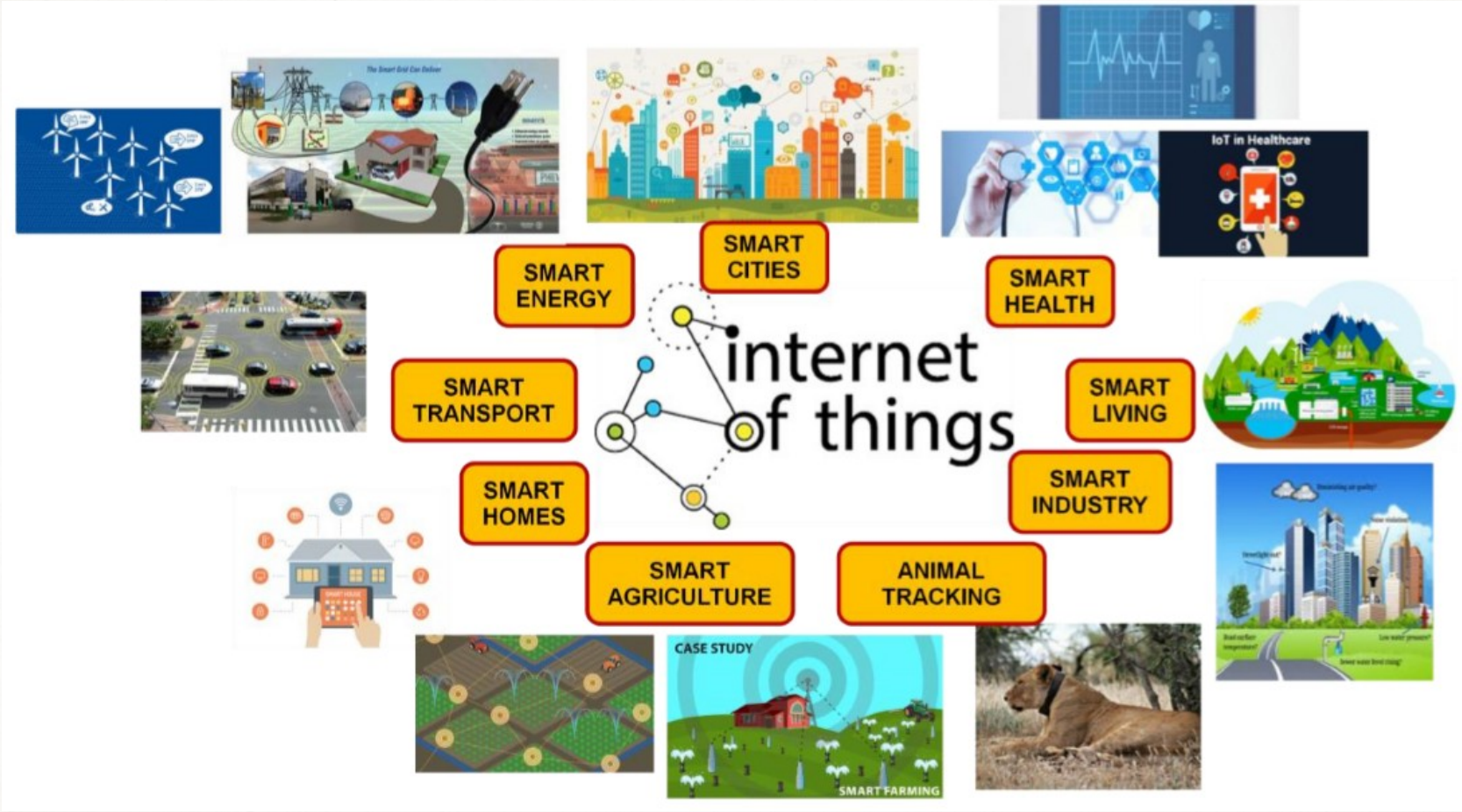
Devices and Networks



The Internet of Things from an embedded systems point of view



IoT Across Application Domains



Applications of IoT: Agriculture

Monitoring and **management** of microclimate conditions for indoor planting

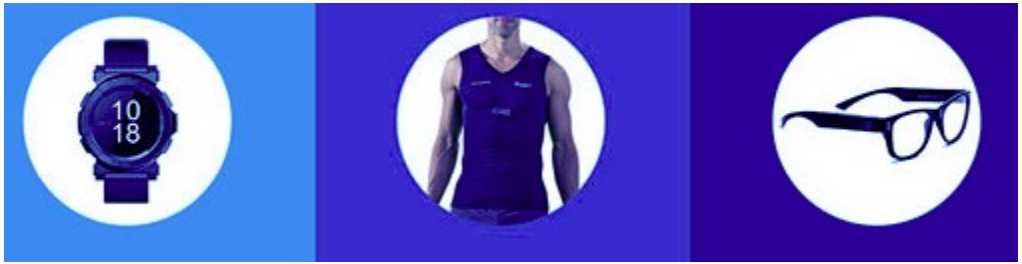
Sense soil moisture and nutrients, in conjunction with weather data, better **control smart irrigation** and fertilizer systems

Applications of IoT: Agriculture



Applications of IoT: Consumer Use

IoT devices such as **Fitbit**, **Smart Phones**, **Apple Watches**, **Health Monitors** help improve **entertainment**, **health**, and **fitness**



Applications of IoT: Consumer Use

Smart homes take care of things like activating environmental controls so that your house is at peak comfort when you come home

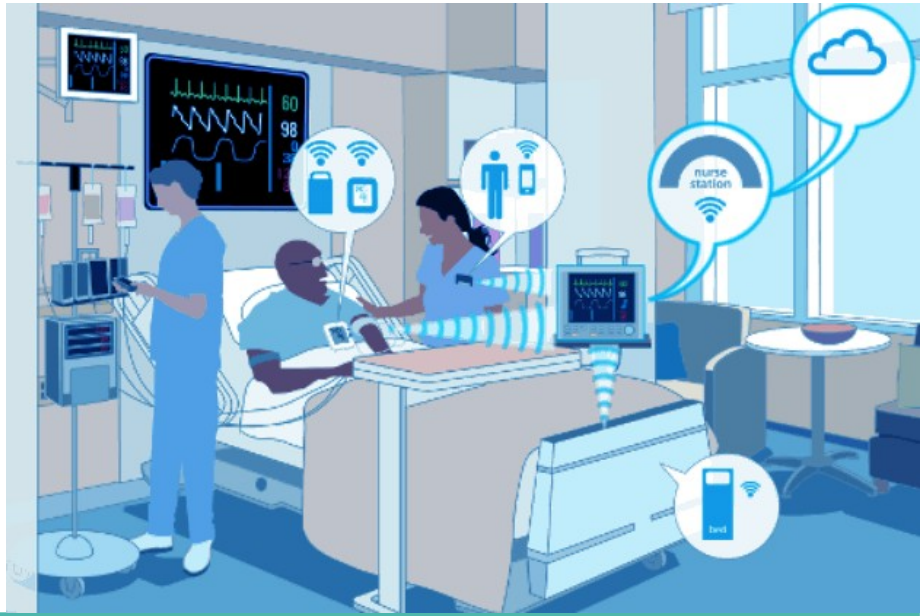
Appliances such as Oven, Lights, and security devices such as Smart Locks can be controlled remotely



Applications of IoT: Healthcare

Help monitor patients' health at home, thereby reducing hospital stays while still providing up to the minute real-time information that could save lives

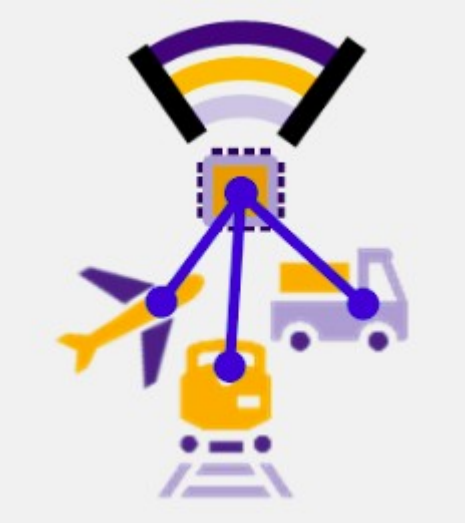




Applications of IoT: Manufacturing

RFID and **GPS** technology can help a manufacturer track a product from its start on the factory floor to its placement in the destination store, the whole **supply chain** from start to finish

Sensors can **gather** information on **travel time**, **product condition**, and **environmental conditions** that the product was subjected to



Applications of IoT: Retail



IoT can help analyze mall traffic to enhance the customer's shopping experience

IoT helps retailers target customers (for instance for advertisement) based on past purchases

Automated checkout,

store layout optimization

Smart shelves, Beacons



Applications of IoT: Transportation

IoT for Self-Driving cars

GPS data can be used to determine traffic patterns, parking space demand, and road construction and maintenance



Applications of IoT: Utilities

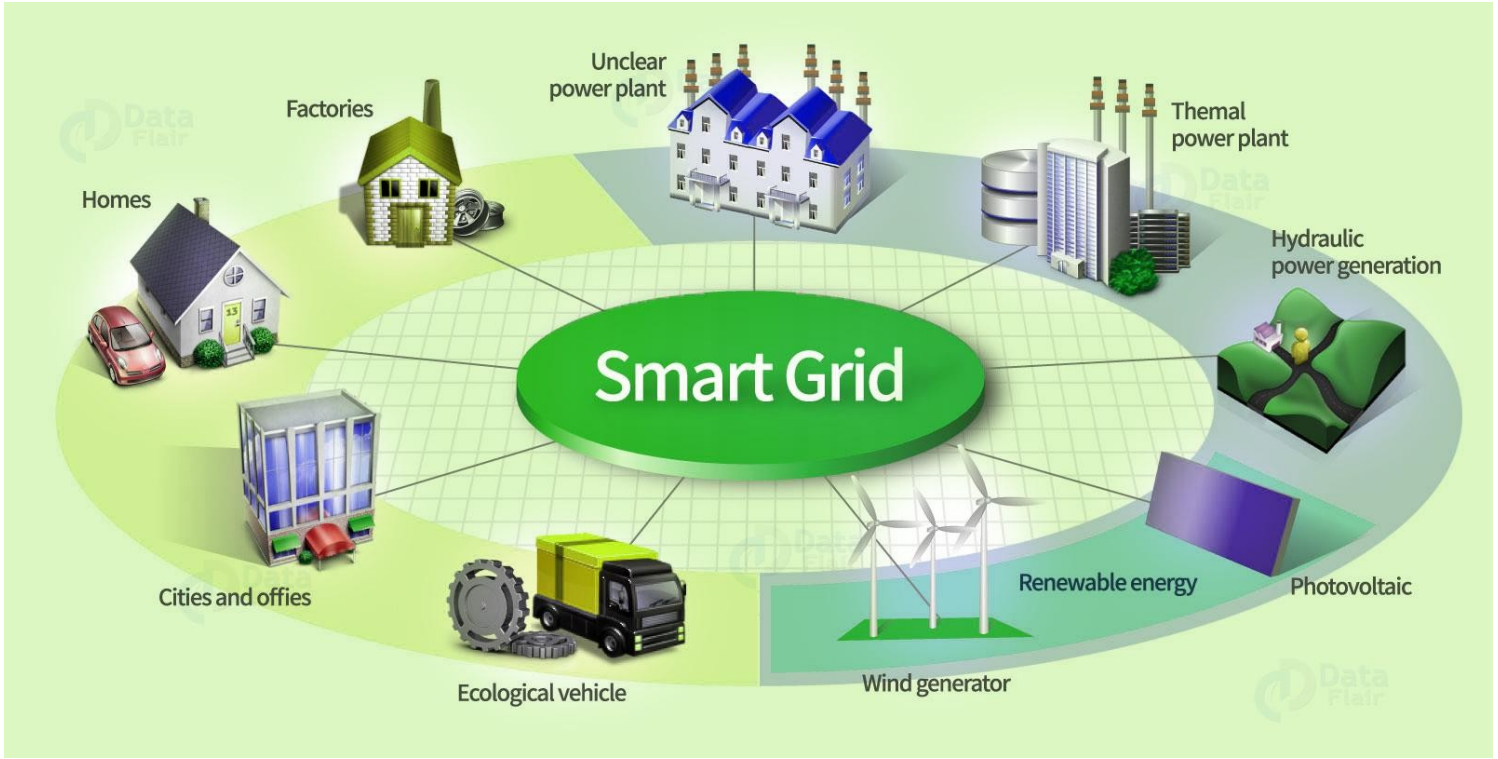
IoT sensors can be employed to monitor environmental conditions such as **humidity**, **temperature**, and **lighting**

With IoT-driven environmental control, businesses and private residences can experience significant **energy savings**

Data gathered by the Internet of Things can be used to help run municipal power grids more efficiently, analyzing factors such as usage

Sensors can help pinpoint outages faster

Applications of IoT: Utilities



IoT Tools and Application Development Platforms

- **IoT Development Platforms**
  - Top-class IoT development tools that can be employed by both developers and for all those who wish to pursue IoT include
    - Tessel 2
    - Eclipse IoT
    - Arduino
    - PlatformIO
    - Kimono Create
    - IBM Watson
    - Raspbian (**Raspberry Pi**)
    - OpenSCADA
    - Node-RED
    - Device Hive

IoT hardware platforms - So many IoT Chips

