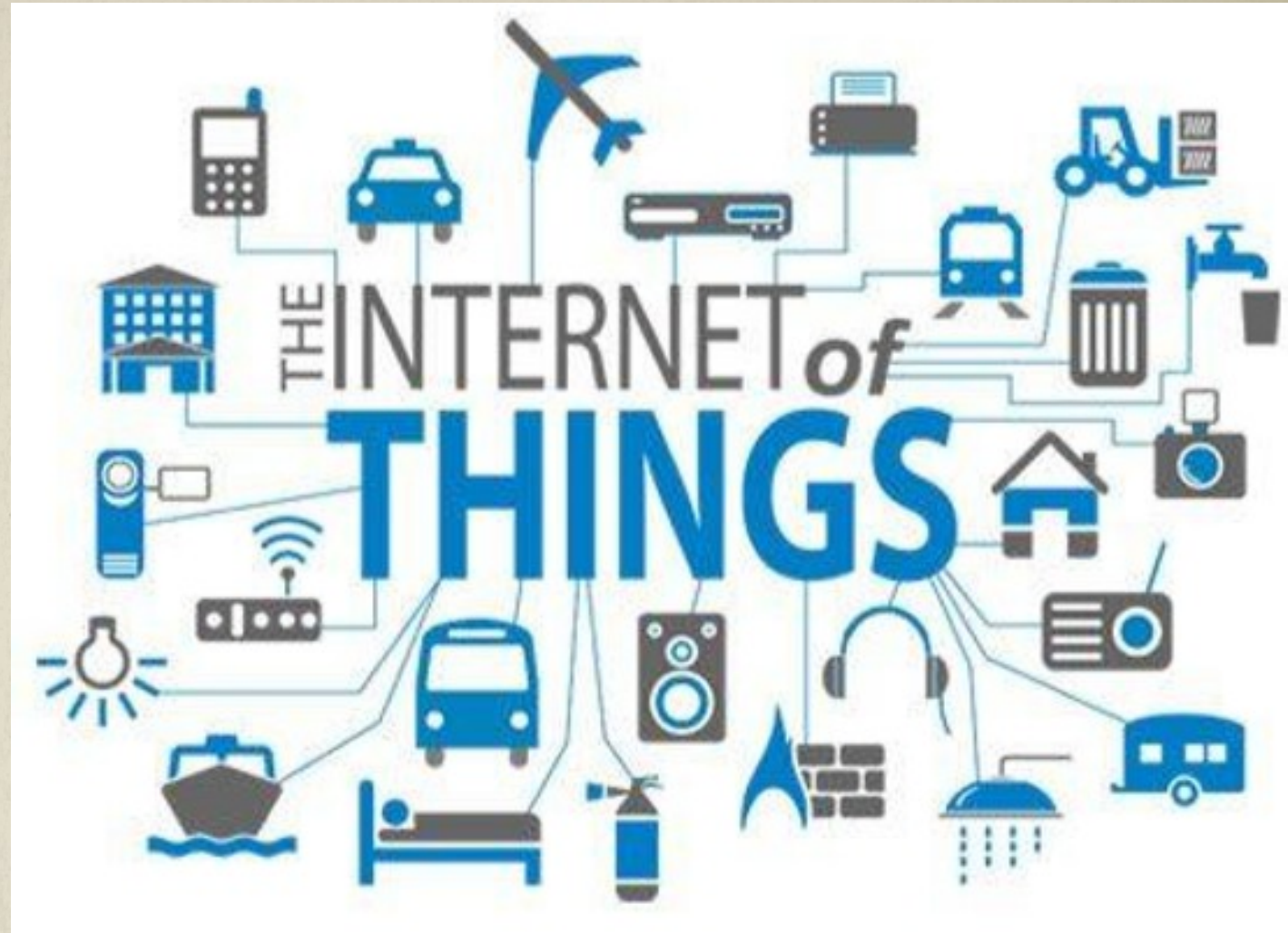


Chapter 4: Internet of Things (IoTs)



Global Network of Smart physical Things

Chapter 4: Objectives

- At the end of this chapters students should understand:
 - Overview and History of IoT
 - Advantages of IoT
 - Challenges of IoT
 - How IoT works (Architectures, IoT Trends, Devices and Networks, Examples of IoT Applications, Management Platform for the Internet of Things)
 - IoT Across Application Domains(Homes, Cities, healthcare, energy, Agriculture, transport ...etc.)
 - IoT Tools and Application Development Platforms
 - IoT Tools
 - IoT Platforms

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

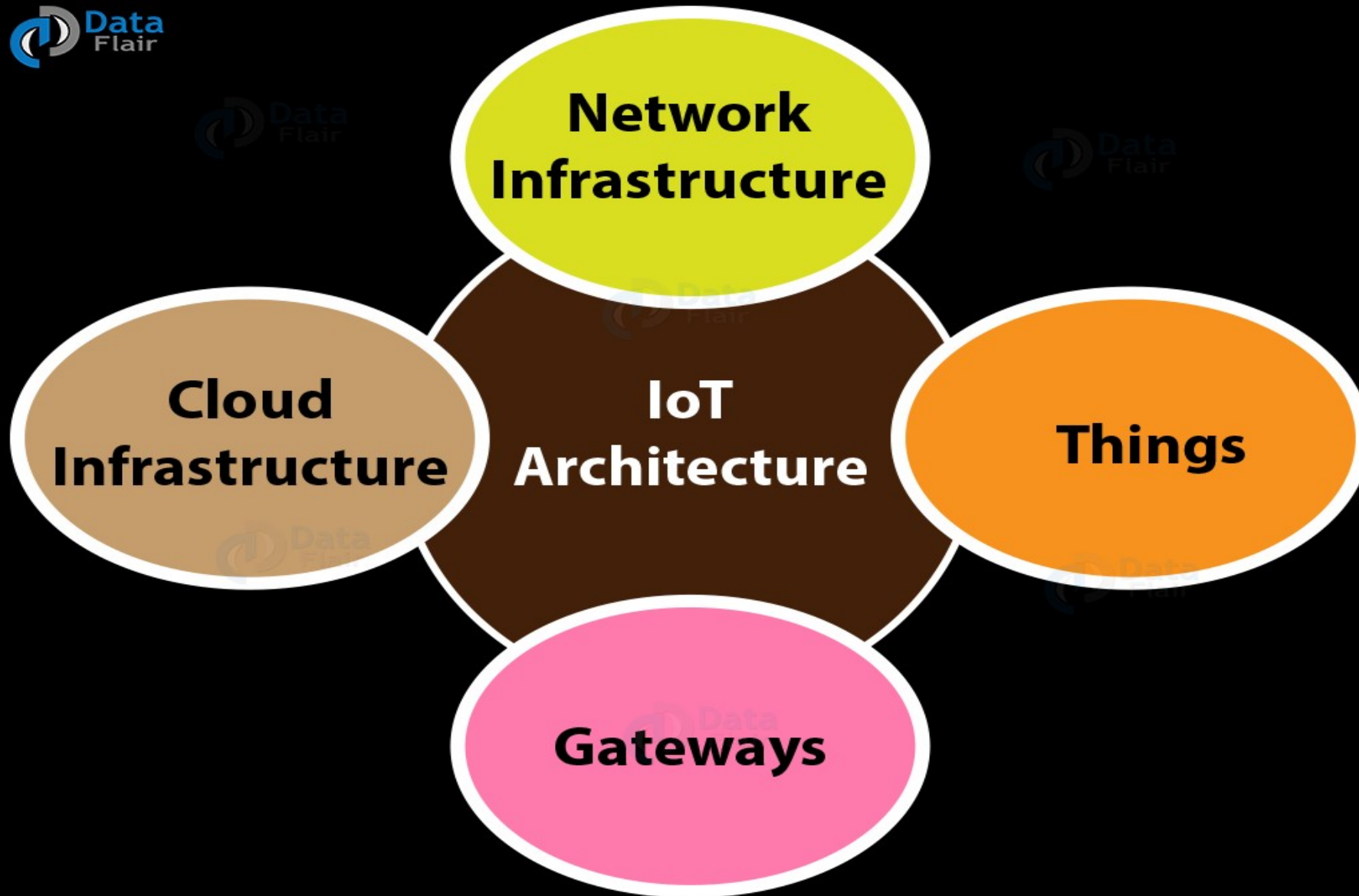
Comparisons between Sensors and Actuators

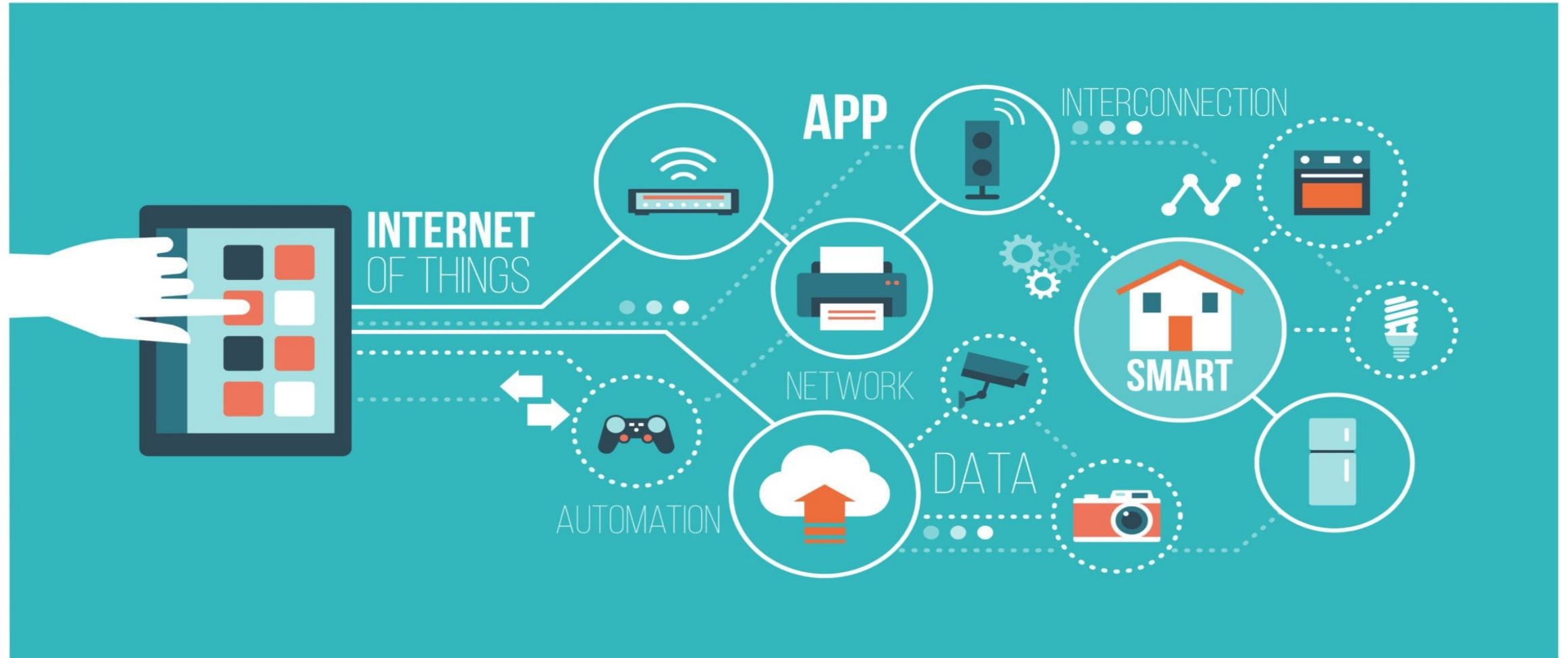
SENSORS

- 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.



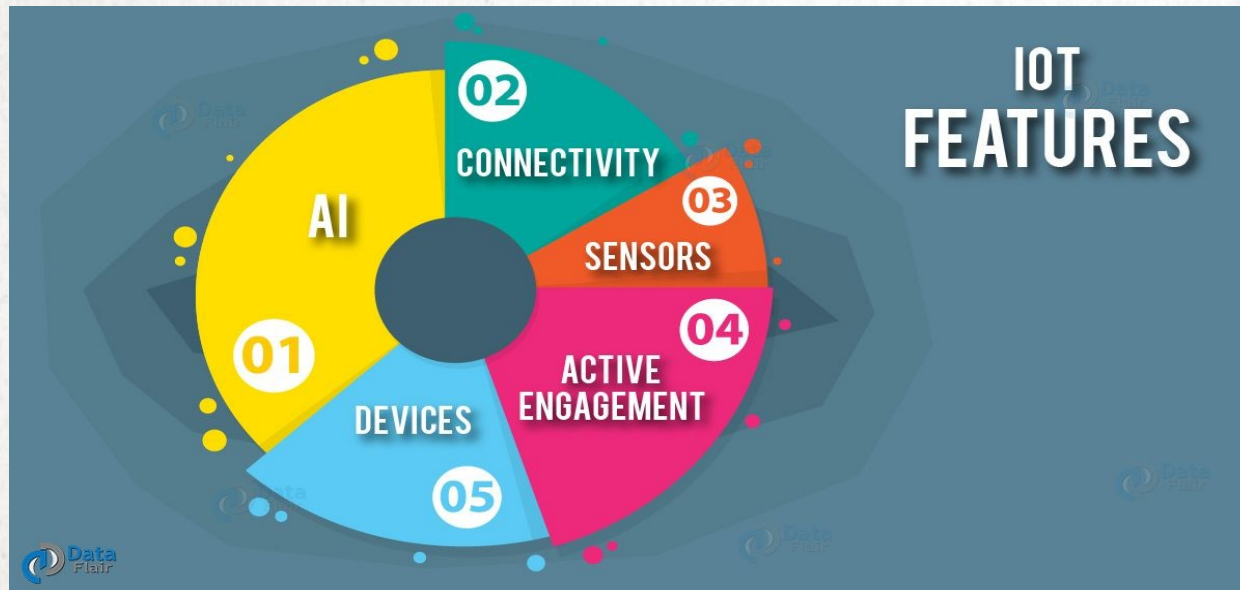


Prerequisites for learning IoT

- 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.



AI—Review of this feature is given below 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.

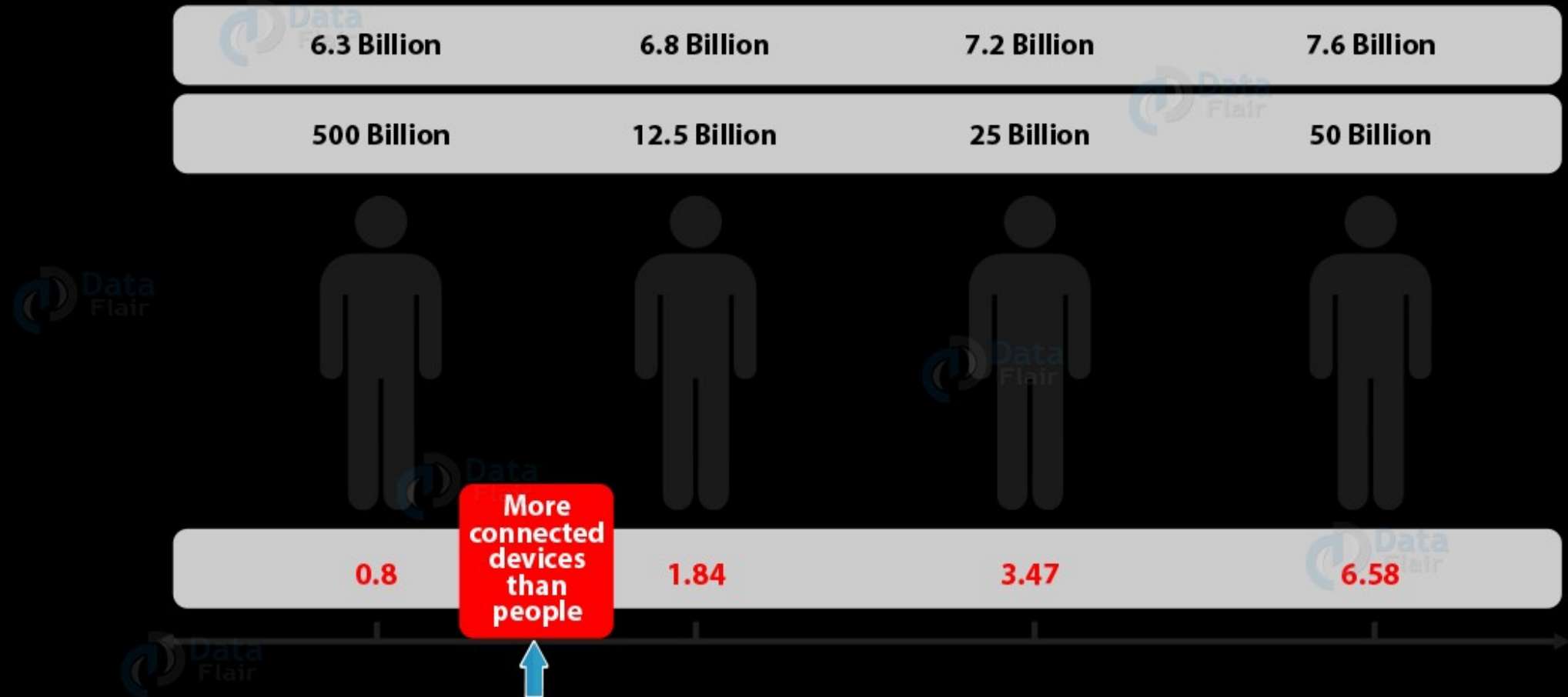
Connectivity—The notion of networking doesn't always have to restrict to large networks, it can also exist on a smaller and cheaper scale without compromising its efficiency. IoT comes into the picture and creates these small networks between its system devices.

•**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 purposely makes use of small

Current Status & Future Prospect of IoT



"change is the only thing permanent in this world"

IoT Applications

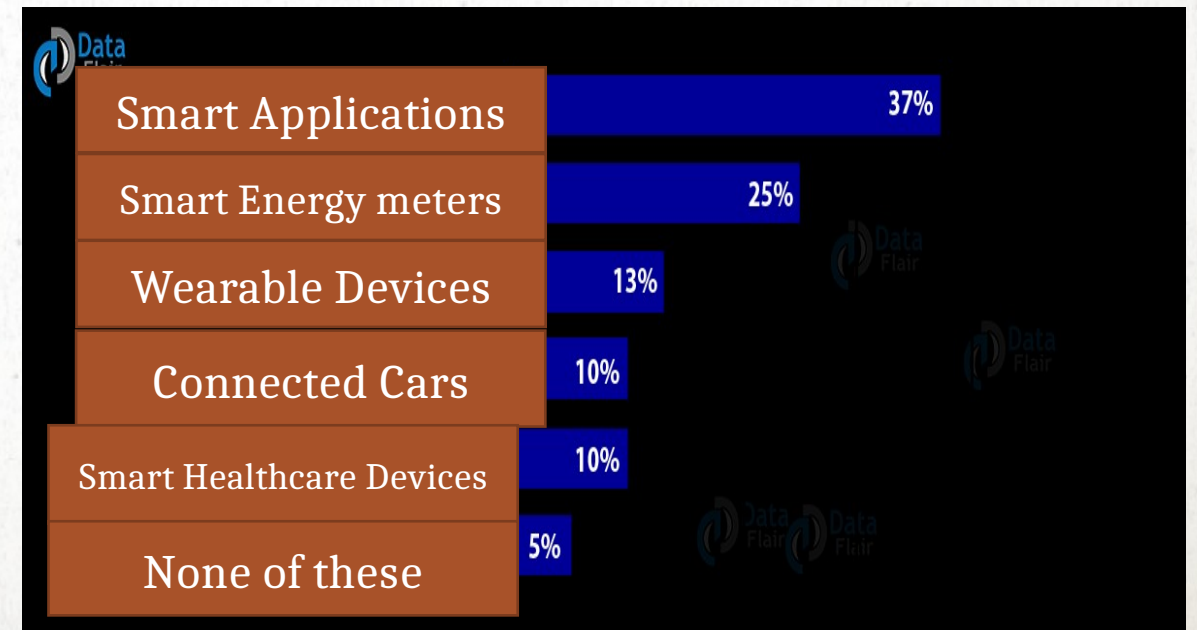
Healthcare Application: These days we have digital watches and fitness monitoring devices that have changed the ways of healthcare monitoring. People can now monitor their own health at regular intervals of time.

These days if a person is being rushed to the hospital by an ambulance, his/her healthcare statistics are already given to the doctor, and the treatment gets started well in time.

Also, data collected from different patients are now being put to use for the cure.

Energy Applications: The energy rates have become paramount. All Individuals and organizations, both are searching for ways to reduce and control the consumption of energy.

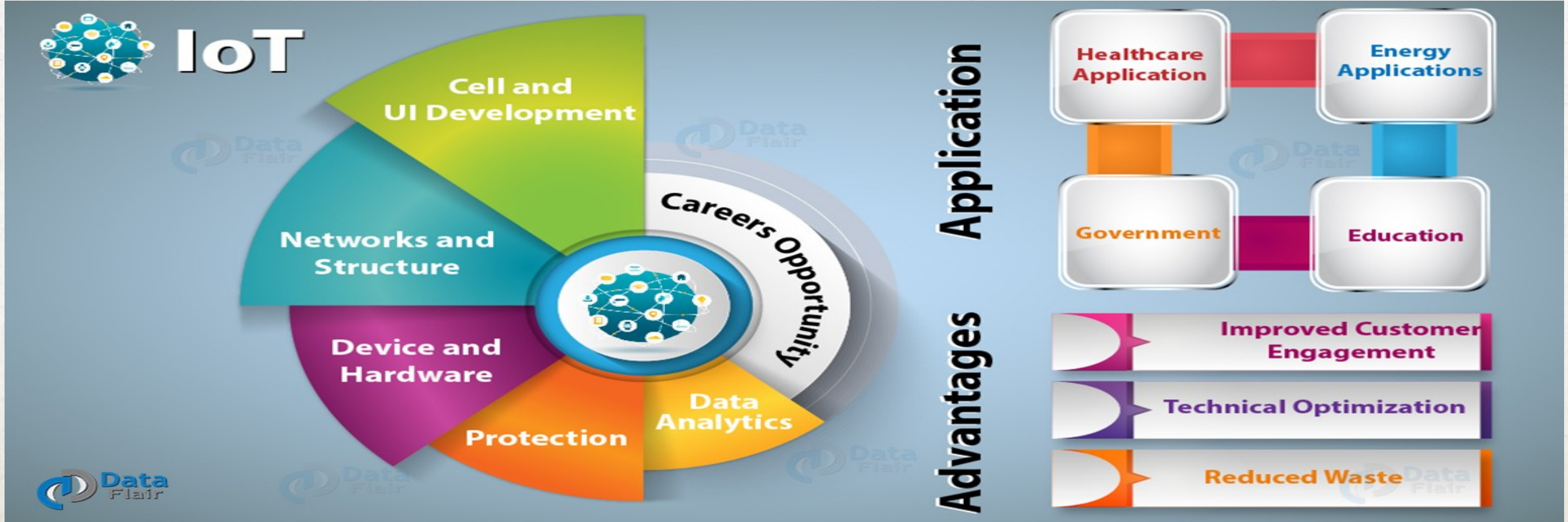
IoT provides a way to monitor energy usages not only at the appliance-level but also at the grid level, house-level or even at the distribution level. Smart systems such as Meters & Smart Grids are installed at various organizations to monitor energy consumption.



•**Education Applications:** IoT's yet another great application lies in the field of education. IoT helps in fulfilling the gaps and loopholes in the education industry. It improves the quality of education being offered to students by optimizing the cost. It also improves administration and management by taking into consideration students' response and performance.

•**Government Applications:** The smart city initiative by our government is an example of how efficient and big this technology is. Its incorporation in sectors like transportation, healthcare, armed forces, and security is commendable.

•**Do you know: The Top IoT Companies in World?**



Advantages of IoT

- IoT has created opportunities to directly connect and create a link between the physical world to the computer-based systems by using sensors and the internet.
- The interconnection of these multiple embedded devices results in automation of different fields thereby, enabling advanced applications.
- This would then result in improving accuracy, efficiency along with almost no manual intervention. It encompasses technologies such as smartphones, smart meters, smart grids, smart homes, intelligent transportation, and smart cities.

5.1 Customer Engagement Enhancement

- IoT improves customer experience by automatically detecting problems and providing solutions.
- For e.g. as we discussed above, how an issue in Rajesh's car was automatically detected by the sensors.
- The driver and the manufacturer will get notified about it.
- Till the time driver reaches the service station or a mechanic, the

5.2 Technical Optimization

- If the technology is great, the experience is bound to be great.
- IoT has played a major part in improving technologies and making them better.
- Like in the above example, the manufacturer collected the data from different car sensors and analyzed it to improve its design.

5.3 Reduced Waste

- With the latest technology, IoT provides real-time insights on crucial problems leading to effective decision making & management of resources. For example, if a manufacturer finds fault in engines of multiple cars, it might give him an insight on major fault and he can track the manufacturing plant of those engines and can rectify the issue with

Conceptual framework (2020) of IoT

- IoT= Services+ Data+ Networks + Sensors
- IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network **without requiring human-to-human or human-to-computer interaction**
- A **thing** in the internet of things can be a **person** with a heart monitor implant, a **farm animal with a biochip** transponder, an **automobile** that has built-in sensors to alert the driver when tire pressure is low or any other **natural or man-made** object that can be **assigned an IP address** and is able to *transfer data over a network*

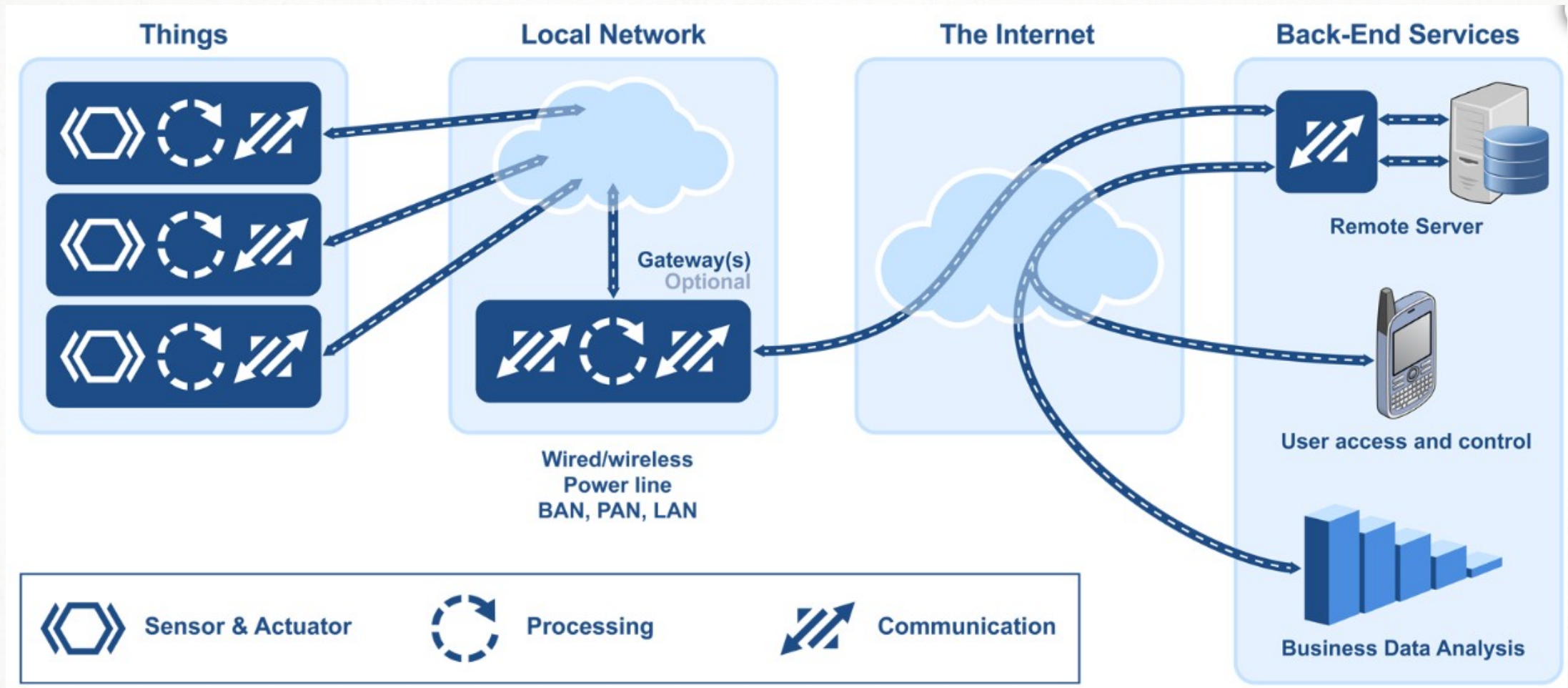
Conceptual framework (2020) of IoT Cont'd...

- IoT is also considered as a worldwide network of intelligent objects that are interconnected and uniquely representable on the basis of communication-based protocols

How to Think about the Internet of Things (IoT)

- There are four main components of an IoT system
 - The **Thing** itself (that is, the device)
 - The **local network** (this can include a gateway, which translates proprietary communication protocols to Internet Protocol).
 - The **Internet** (the Global Network)
 - **Back-end services** (enterprise data systems, or PCs and mobile devices).

The Internet of Things from an embedded systems point of view



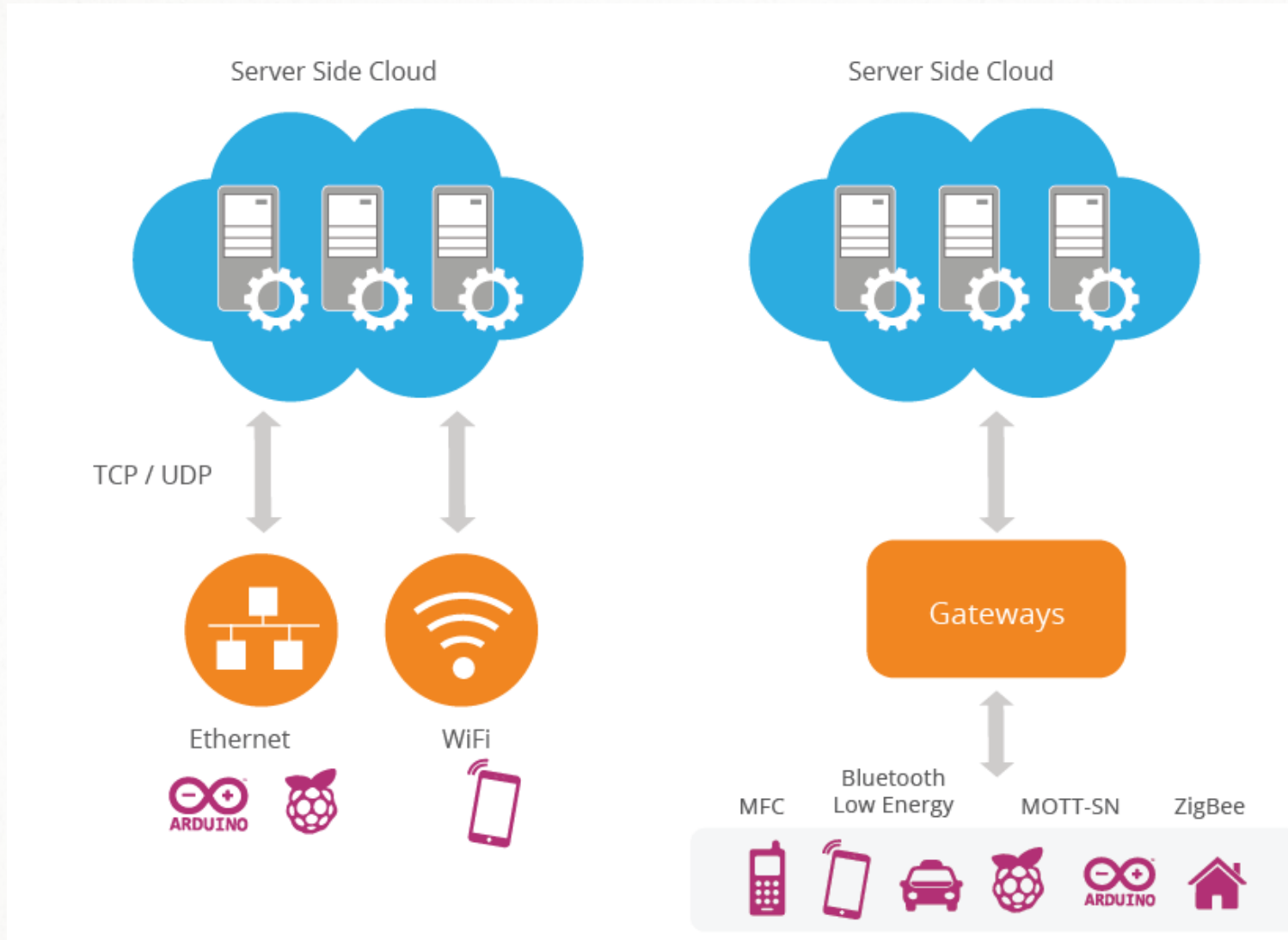
Types of Devices(Things)

- There are three types of Devices in IoT:
 - **The smallest devices** have embedded 8-bit System-On-Chip (SOC) controllers.
 - **Small home routers and derivatives of those devices.**
Commonly, these run a cut-down or embedded Linux platform, such as OpenWRT, or dedicated embedded operating systems.
 - Have very limited 32 bit Atheros and ARM chips
 - **The most capable IoT platforms that are full 32-bit or 64-bit computing platforms**
 - Systems such as the Raspberry Pi or the BeagleBone, may run a full Linux OS or another suitable Operating System, such as Android.

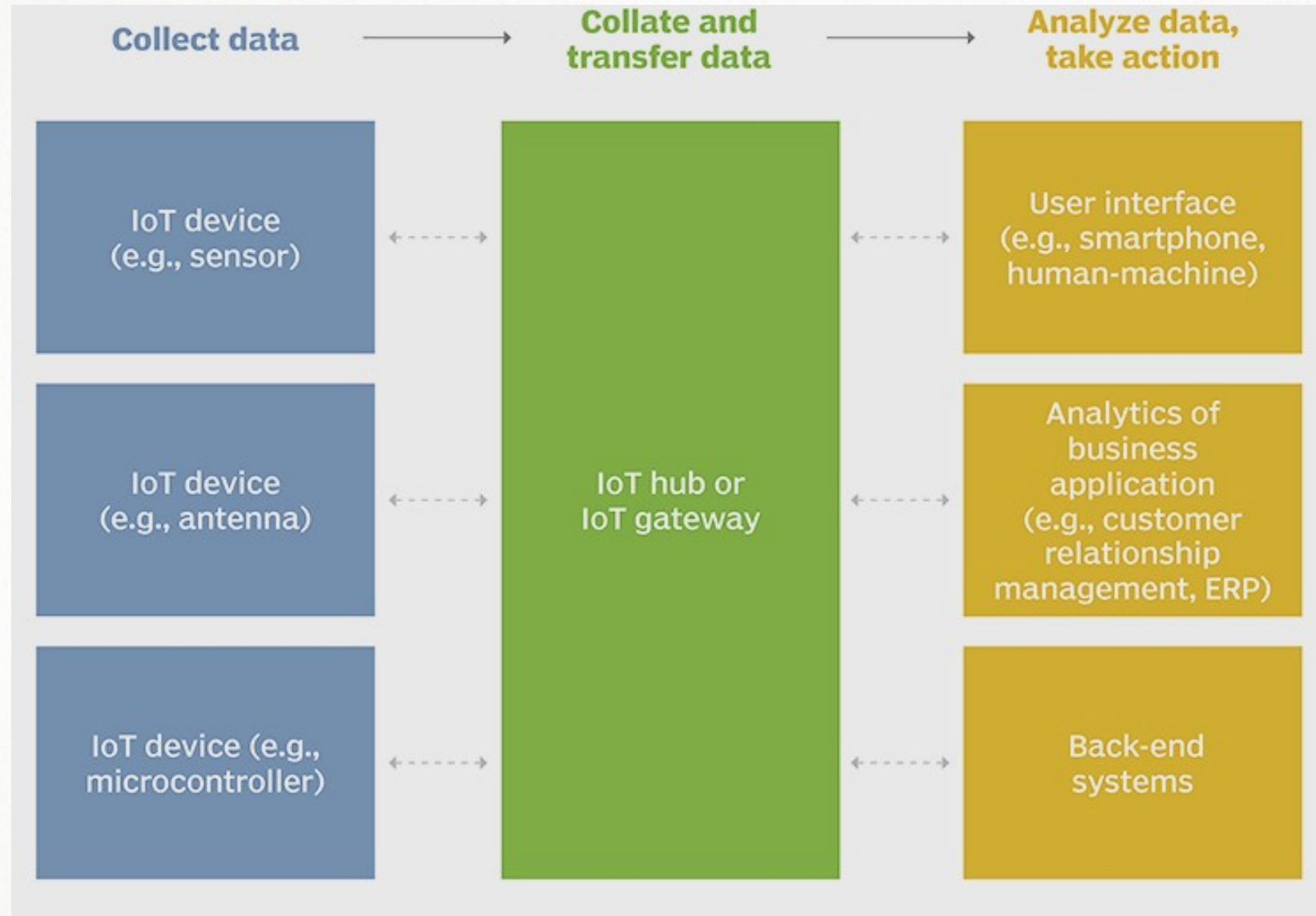
IoT Communication Mechanisms

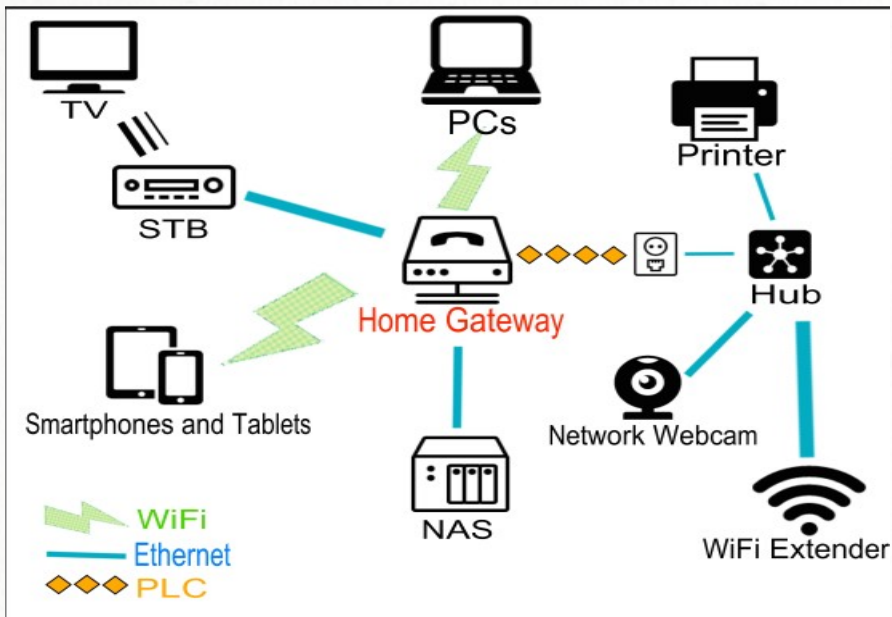
- Communication between devices and the Internet or to a gateway includes many different models
 - Direct Ethernet or Wi-Fi connectivity using TCP or UDP (we will look at protocols for this later)
 - Bluetooth Low Energy (BLE)
 - Near Field Communication (NFC)
 - Zigbee or other mesh radio networks
 - SRF and point-to-point radio links
 - UART or serial lines
 - SPI or I2C wired buses

The two major modes of connectivity (Communication)



Example of an IoT System





A gateway is a generic name for a networking device that is used to connect multiple networks together. It is a hardware unit that acts as a gate between two different networks with different architectures and protocols.

A gateway may be a repeater, firewall, server, bridge, router or any other device that enables traffic flow in and out of the network.

Gateway is like a check post for network where all data must pass through prior to being routed.

It understands and converts between two networking models, allowing users to communicate across networks. It basically allows users to share, protect, store and access data over a network. In enterprise networks, a gateway acts as a node for a proxy server and a firewall. It provides communication to a remote network that is outside the boundary of host network nodes.

A gateway serves two major functions: connecting devices with each other and connecting devices to other networks. In simple terms, a gateway is a device that is use to join dissimilar systems.

Pros and cons of IoT

■ Advantage

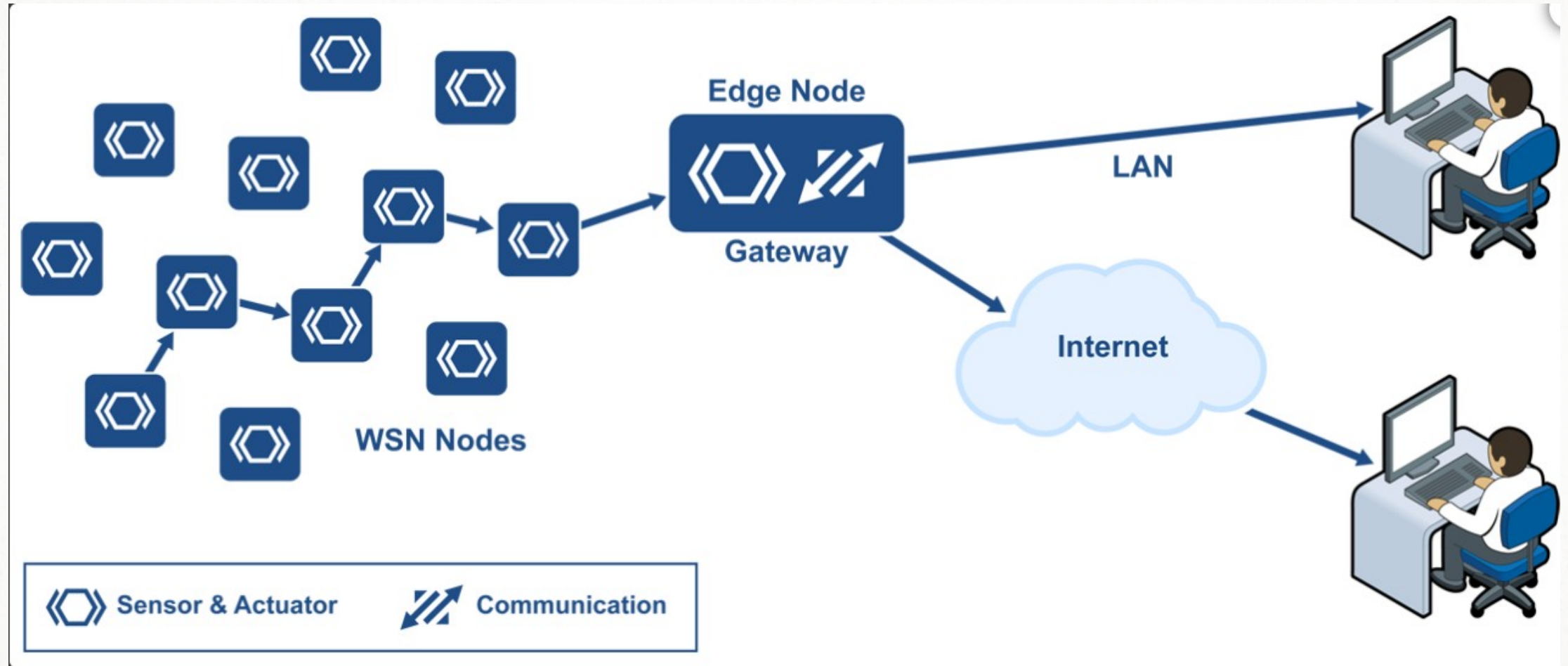
- Improved(active) Customer Engagement
- Technology Optimization
- Reduced Waste
- Enhanced Data Collection(sensors do that)

Pros and cons of IoT

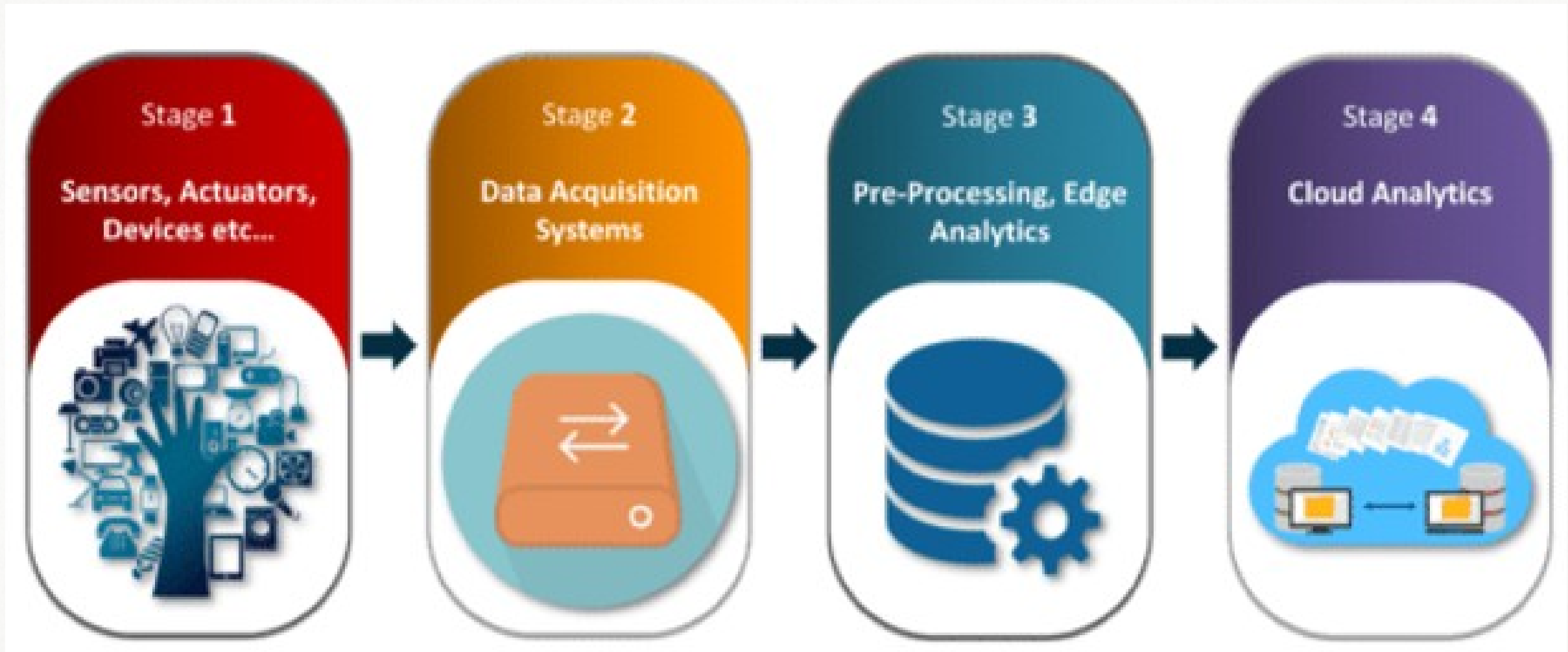
■ Disadvantages

- **Increased Security Concern**(more devices and more info created and shared)
- **Big Data Management** issue(handling huge numbers)
- **The higher chance of system corruption** (if there is a bug in any part of the system)
- **Device Interoperability**(multiple, different device vendors with no accepted standard)

Wireless sensor network installed in a factory, connected to the Internet via a gateway



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

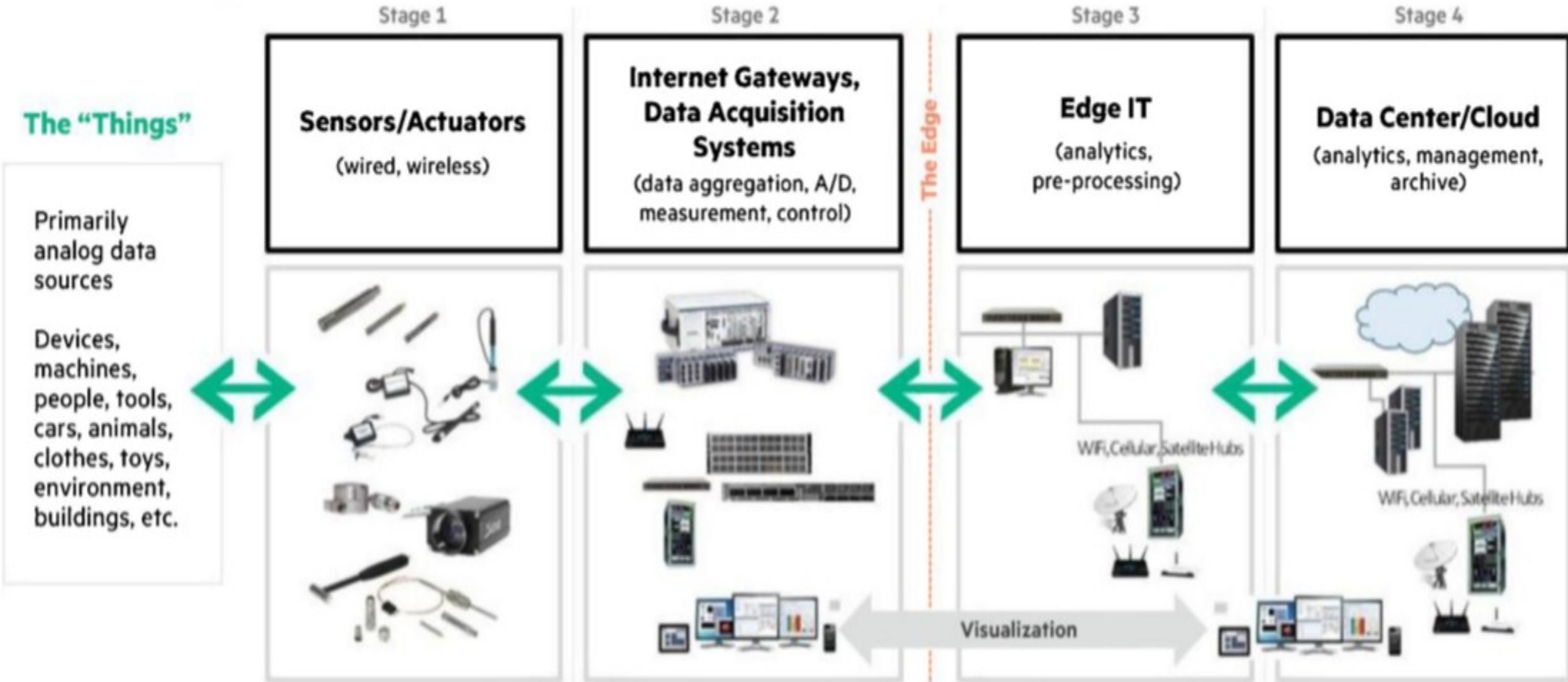
■ Stage 3 (Edge Analytics)

- 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.

How IoT Works - the 4 stages



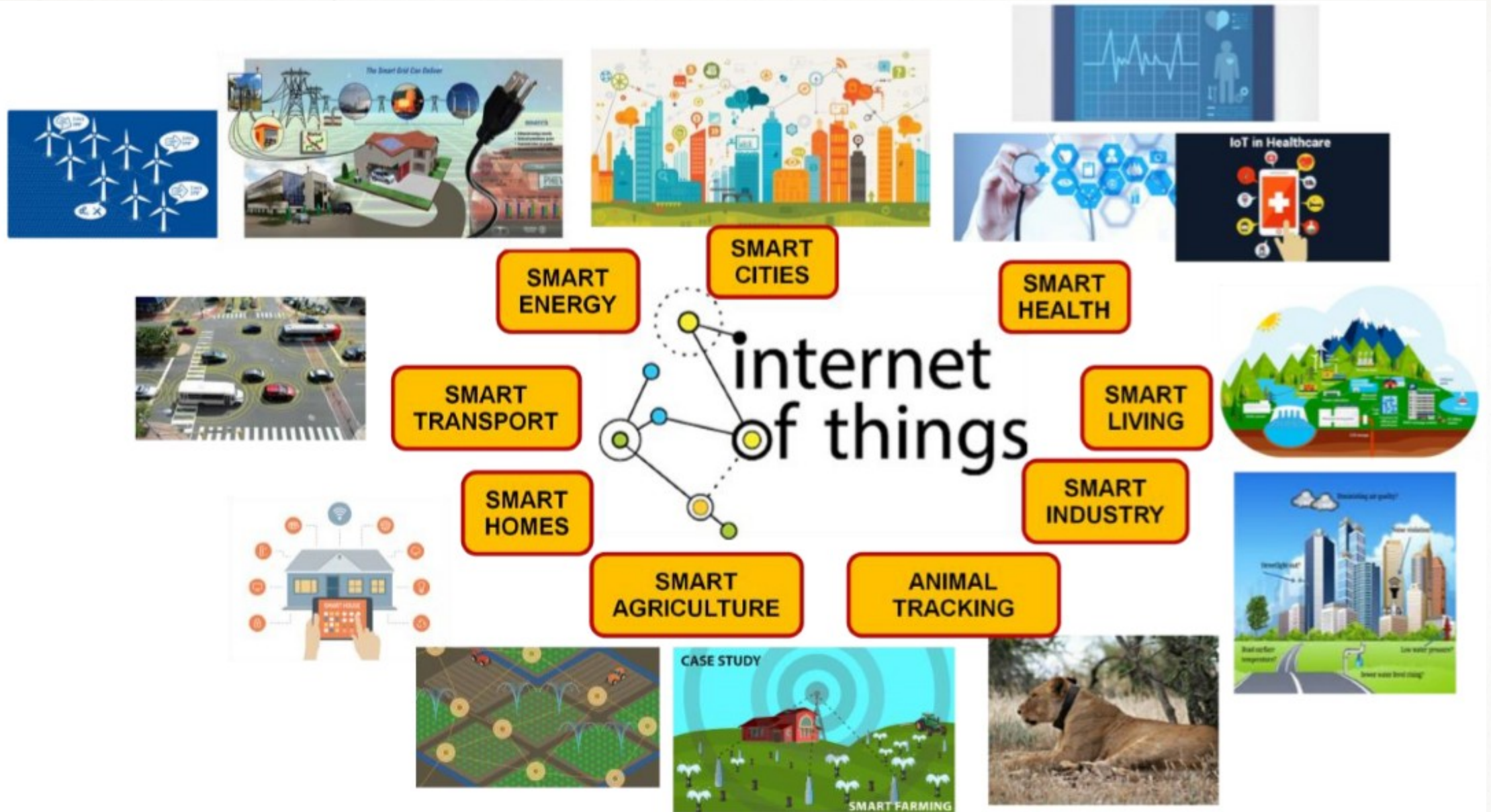
IoT- Architecture : Application Layer

Application covers “smart” environments/spaces in domains such as:

- Transportation,
- Building,
- City,
- Lifestyle,
- Retail,
- Agriculture,
- Factory,
- Supply chain,
- Emergency,
- Healthcare,
- User interaction,
- Culture and tourism,
- Environment and Energy.

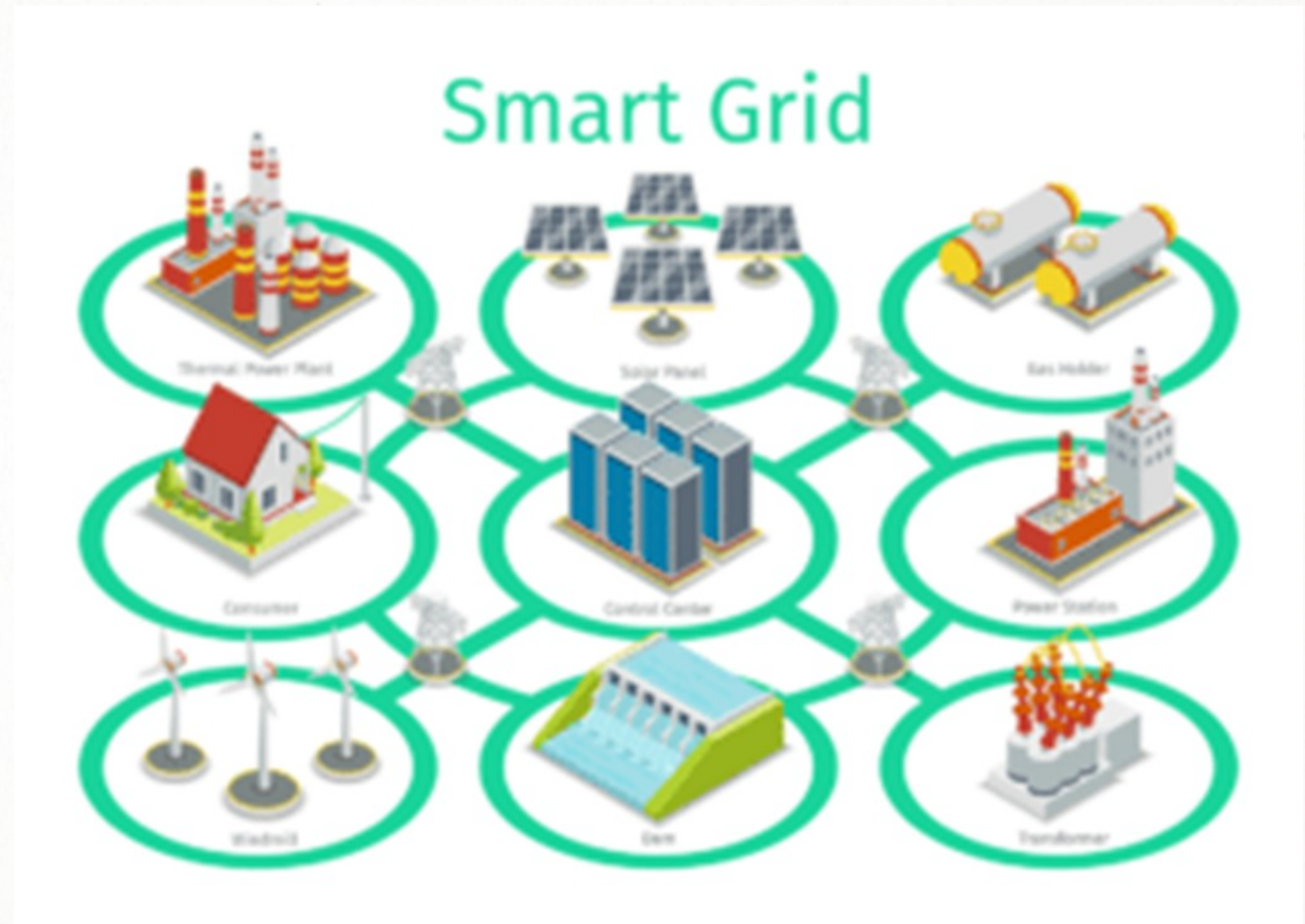
IoT- Trend, Devices and Networks-Cont'd... Wireless radio technologies comparison

Standard	IEE 802.15.4	Bluetooth	Wi-Fi
Frequency	868/915 MHZ, 2.4 GHz	2.4 GHz	2.4, 5.8 GHz
Data rate	250 Kpbs	723 Kpbs	11 to 105 Mpbs
Data rate	250 Kpbs	723 Kpbs	11 to 105 Mpbs
Power	Very Low	Low	High
Battery Operation	Alkaline (months to years)	Rechargeable (days to weeks)	Rechargeable (hours)



IoT Across Application - Smart Energy Applications

- With smart grids energy distribution can be optimized.
- These grids also keep collecting real-time data which helps in distributing electricity efficiently and also to reduce the outages.



IoT Across Application - Smart City Applications

- **Lighting** : intelligent and weather adaptive lighting in street lights.
- **Smart Roads and Intelligent High-ways** with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams
- **Smart Parking**: Real-time monitoring of parking spaces availability in the city making residents able to identify and reserve the closest available spaces
- **Waste Management**: Detection of rubbish levels in containers to optimize the trash collection routes.
 - Garbage cans and recycle bins with RFID tags allow the sanitation staff to see when garbage has been put out

IoT Across Application - Smart City Applications

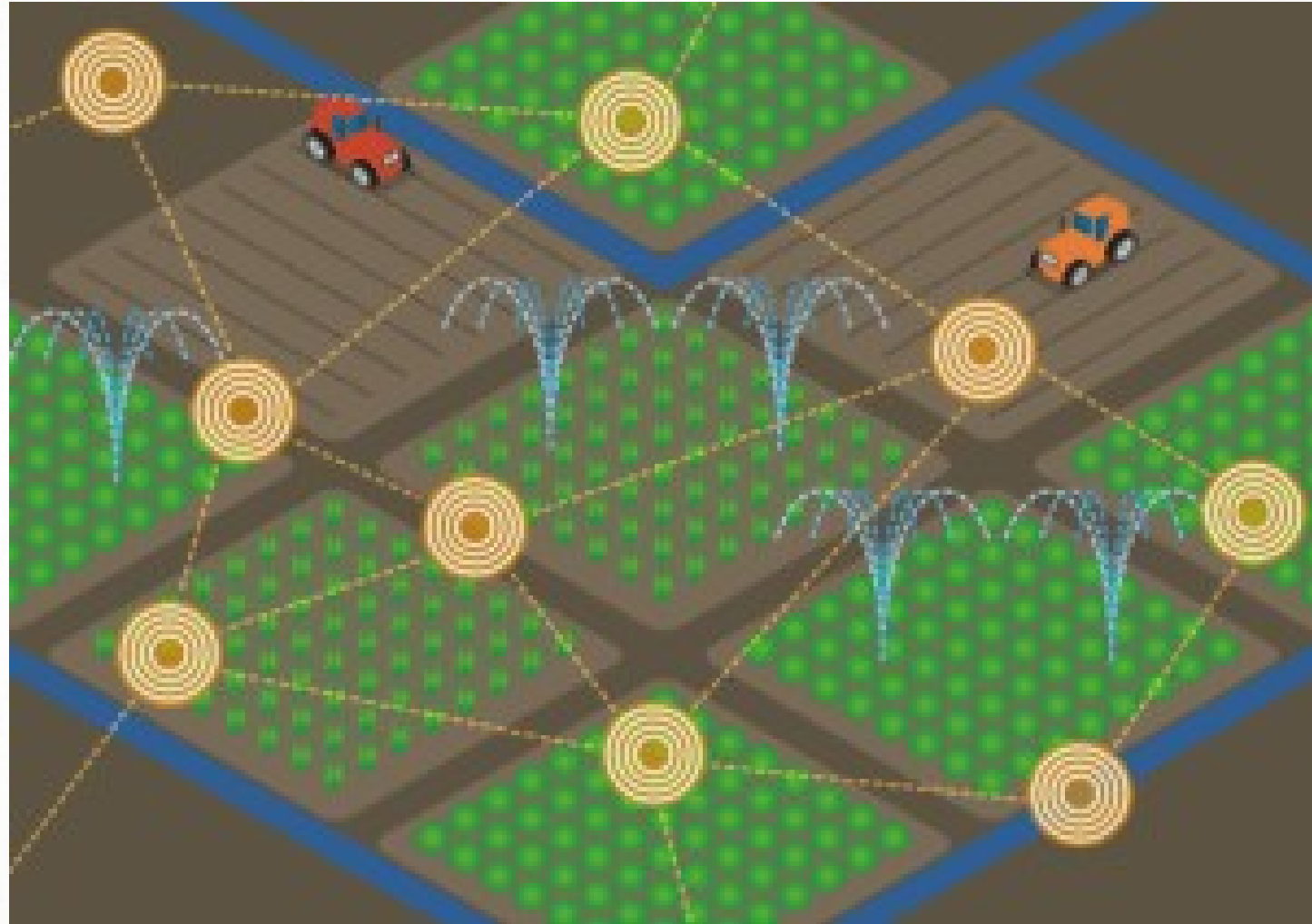
- In Smart Cities, the development of smart grids, data analytics, and autonomous vehicles will provide an intelligent platform to deliver innovations in
 - Energy management,
 - Traffic management, and
 - Security,by sharing the benefits of this technology throughout society

IoT- in Agriculture – Smart Agriculture

- Green Houses: Control micro-climate conditions to maximize the production of fruits and vegetables and its quality,
- Compost: Control of humidity and temperature levels in alfalfa, hay, straw, etc. to prevent fungus and other microbial contaminants,
- Animal Farming/Tracking: Location and identification of animals grazing in open pastures or location in big stables, Study of ventilation and air quality in farms and detection of harmful gases from excrements,
- Offspring Care: Control of growing conditions of the offspring in animal farms to ensure its survival and health,
- Field Monitoring: Reducing spoilage and crop waste with better monitoring, accurate ongoing data obtaining, and management of the agriculture fields, including better control of fertilizing, electricity and watering

IoT-in Agriculture – Smart Agriculture

- The task of irrigation can be automated with the help of IoT.
- A set of sensors such as light, humidity, temperature can be used to continuously monitor the field conditions



IoT Application- Smart Healthcare Application

- Smartwatches and fitness devices have changed the frequency of health monitoring.
- People can monitor their own health at regular intervals.
- Not only this, now if a patient is coming to the hospital by ambulance, by the time he or she reaches the hospital his health report is diagnosed by doctors and the hospital quickly starts the treatment.
- The data gathered from multiple healthcare applications are now collected and used to analyze different disease and find its cure.
- Hospitals often use IoT systems to complete tasks such as inventory management, for both pharmaceuticals and medical instruments

IoT Tools and Application Development Platforms

- Below are some Cloud IoT platforms

- Google Cloud IoT
- Microsoft Azure IoT Suite
- SAP
- Salesforce IoT
- Oracle Internet of Things
- Cisco IoT Cloud Connect
- Bosch IoT Suite
- IBM Watson Internet of Things
- ThingWorx IoT Platform
- Huawei Cloud Core

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

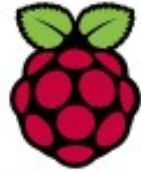
- Tessel 2
- Eclipse IoT
- Arduino
- PlatformIO
- Kimono Create
- IBM Watson
- Raspbian (**Raspberry Pi**)
- OpenSCADA
- Node-RED
- Device Hive

IoT hardware platforms - So many IoT Chips

So Many Boards

Typical options:

- MCU
- FPGA
- CPU



Raspberry Pi & Compatibles



STM32 - Nucleo



LinkIt™
by MediaTek



Samsung
ARTIK™



DE10-Nano



UP and UP Squared



Beaglebone



LATTEPANDA



, UNO, MEGA, Leonardo, Yun, ...

