Internet-of-Things – Principle and Applications

Lê Thế Dũng, Ph.D.

Dep. of Computing Fundamentals, FPT University, Viet Nam

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Outlines

- Introduction to IoT
- How Does IoT Work?
- IoT Achitectures
- IoT Applications
  - IoT in Smart Healthcare
  - IoT in Smart Transportation
  - IoT in Smart Energy
- Market Opportunity of IoT
- Challenges of IoT
- Advantages of IoT
- Disadvantages of IoT

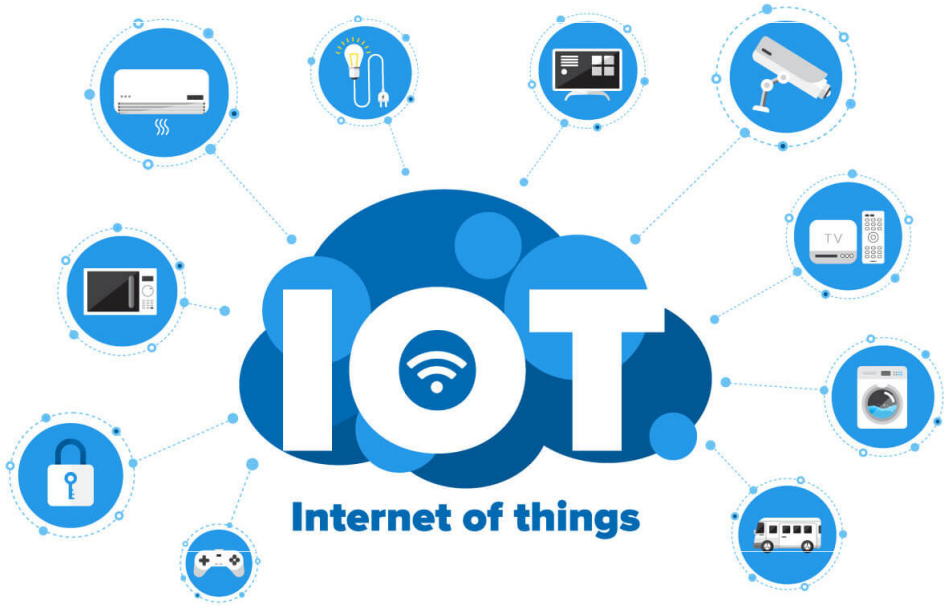
Internet of Things

(IoT)

- What is Internet?
  - The Internet is the global system of interconnected computer networks that use the Internet protocol suite (TCP/IP) to link devices worldwide.
  - It is a network of networks that consists of private, public, academic, business, and government networks of local to global scope, linked by a broad array of electronics, wireless, and optical networking technologies.
  - The Internet carries an extensive range of information resources and services, such as the inter-linked hypertext documents and applications of the World Wide Web (WWW), electronic mail, telephony, and peer-to-peer networks for file sharing.
- What is things?
  - Objects link sensor, computer, mobile phone, user.

What is Internet-of-Things (IoT)?

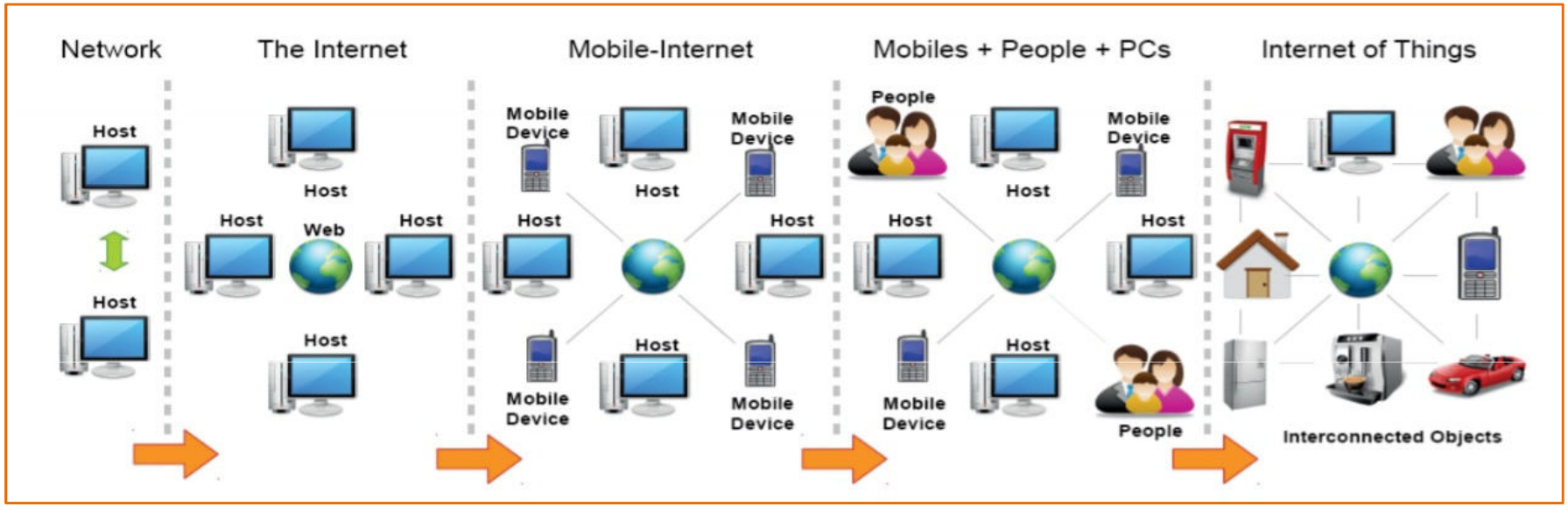
- Internet of Things (IoT) is a network of physical objects or people called "things" that are embedded with software, electronics, network, and sensors that allows these objects to collect and exchange data.



- The goal of IoT is to extend to internet connectivity from standard devices like computer, mobile, tablet to relatively dumb devices like a toaster. IoT makes virtually everything "smart," by improving aspects of our life with the power of data collection, AI algorithm, and networks.

Evolution of the Internet

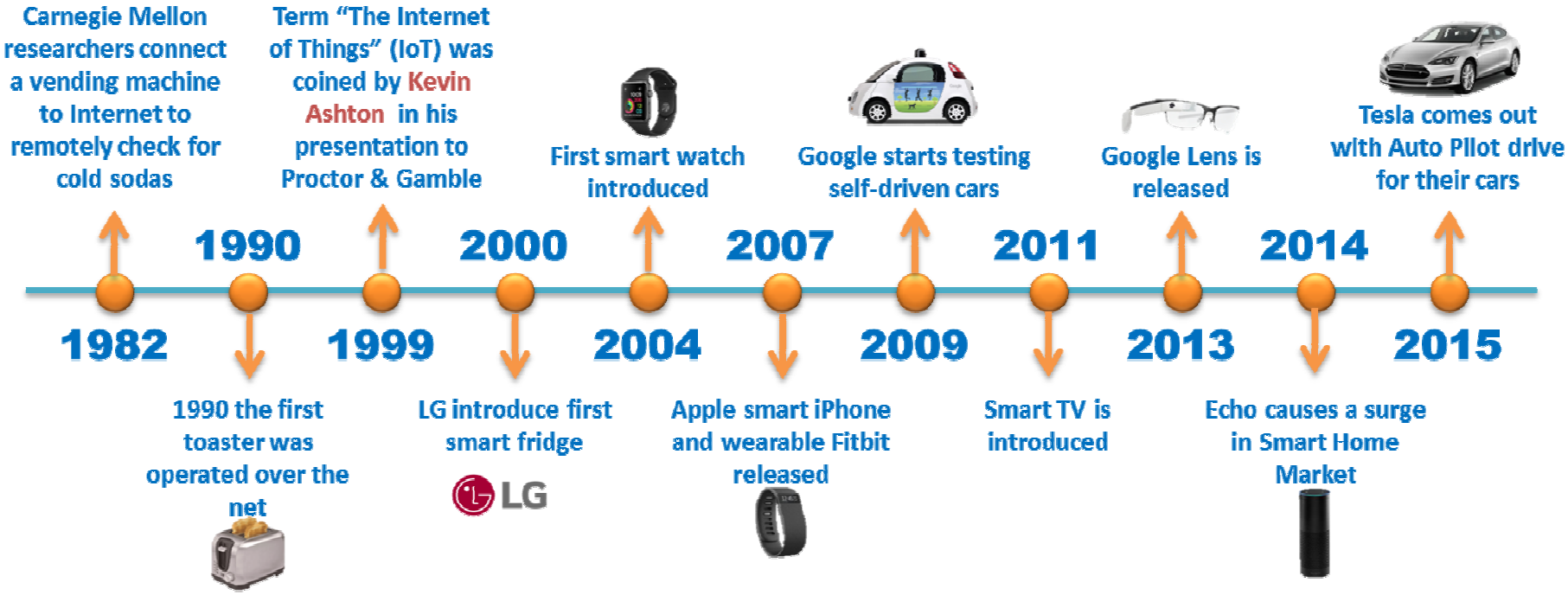
- In the late 1960s, communication between two computers was made possible through a **computer network**. In the early 1980s, the TCP/IP stack was introduced and then the commercial use of **the Internet** started in the late 1980s.
- In 1991 the World Wide Web (WWW) became available which made the Internet more popular. Then, mobile devices connected to the Internet shaped up the **mobile Internet**. With the emergence of social networking, **users started to become connected together over the Internet**.



- The next step in the IoTs is where objects around us will be able to connect to each other (e.g. machine to machine) and communicate via the Internet. IoT promises to create **a world where smart objects around us are connected to the Internet** and communicate with each other with minimum human intervention.

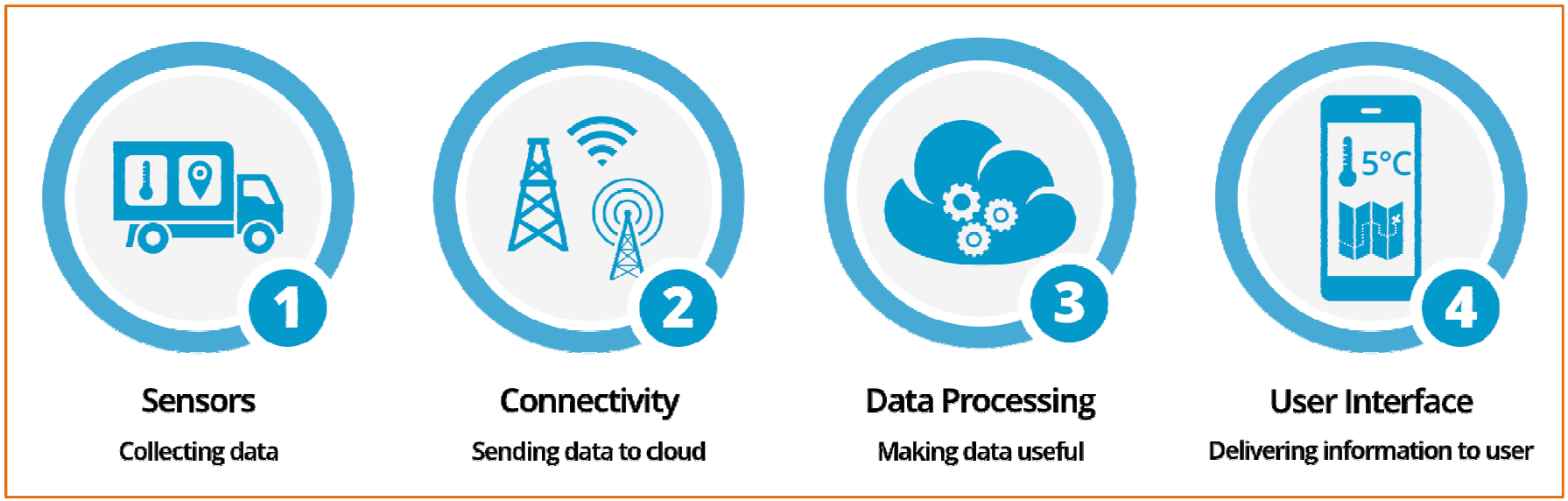
History of IoT

- 1970 – The actual idea of connected devices was proposed.
- 1990 – John Romkey created a toaster which could be turned on/off over the Internet.
- 1995 – Siemens introduced the first cellular module built for M2M.
- 1999 – The term "Internet of Things" was used by Kevin Ashton during his work at P&G which became widely accepted.
- 2004 – The term was mentioned in famous publications like the Guardian, Boston Globe, and Scientific American.
- 2005 – UN's International Telecommunications Union (ITU) published its first report on this topic.
- 2008 – The Internet of Things was born.
- 2011 – Gartner, the market research company, include "The Internet of Things" technology in their research.



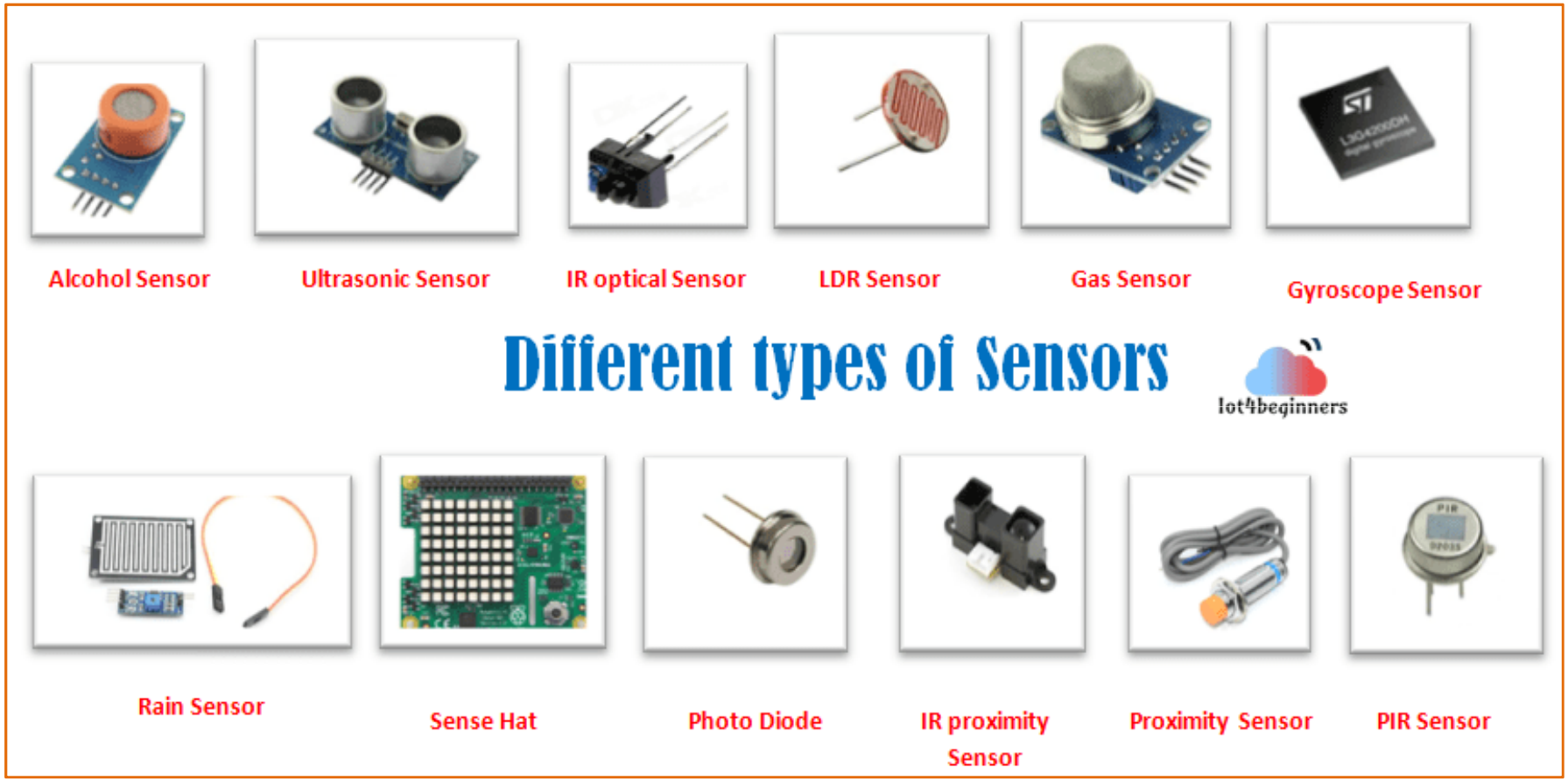
How Does IoT Work?

- IoT is a system of Internet-connected devices. These devices are essentially mini-computer processors that use machine learning to act on data collected by sensors.
- A complete IoT system integrates four parts:
  - Sensors/Devices
  - Data Collection and Connectivity
  - Data Processing and/or Machine Learning
  - User Interface

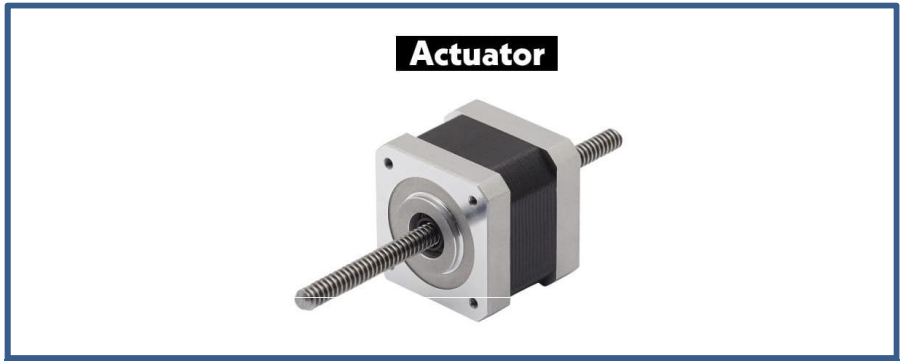


Sensors/Devices

- Sensors or devices are a key component that helps you to collect live data from the surrounding environment. All this data may have various levels of complexities. It could be a simple temperature monitoring sensor, or it may be in the form of the video feed.



Sensors and Actuators

Sensor	Actuator
	
It is a device that senses and measures changes in physical quantities.	It is a device that converts an electrical signal into mechanical movement.
Its input is a physical quantity.	Its input is an electrical signal.
Its output is an electrical signal.	Its output is mechanical work.
It takes input from the environment.	It takes input from the system or signal conditioning unit.
It provides output to a system.	It provides output to the environment.
It is connected at the input of a system.	It is connected at the output of a system.
A sensor may or may not require extra power source to operate.	Actuator require extra power source to operate.

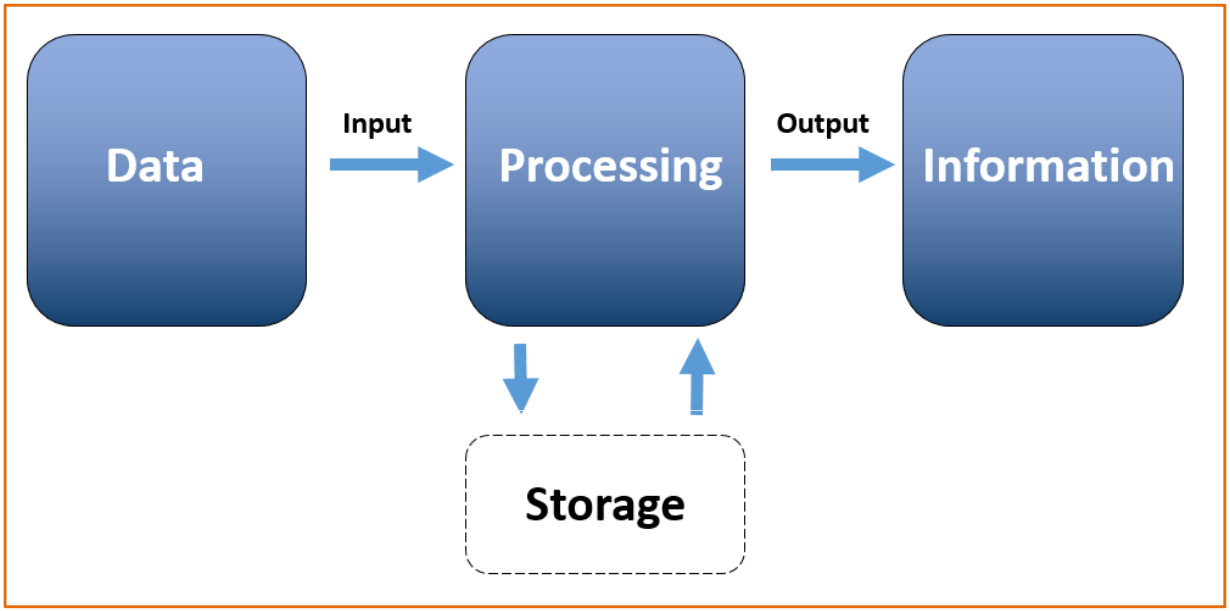
Data Collection and Connectivity

- Data are passed from a device or sensor to the cloud via some types of connection. How these devices connect varies and depends on the purpose of the device.
- The common methods today include: HTTP/S, Bluetooth, RFID, FTP.

Communication Protocols	Transmission rate	Spectrum	Transmission range
RFID	424 kbps	135 Khz	>50 cm
		13.56 MHz,	>50 cm
		866–960 MHz	>3 m
		2.4 Ghz	>1.5 m
NFC	100 kbps–10 Mbps	2.45 GHz	
ZigBee	256 kbps/20 kbps	2.4 GHz/900 MHz	10 m
Bluetooth	1 Mbps	2.4 GHz	10 m
BLE	10 kbps	2.4 GHz	10 m
UWB	50 Mbps	Wide range	30 m
WiFi	50–320 Mbps	2.4/5.8 GHz	100 m
Wi-Max	70 Mbps	2–11 GHz	50 km
UMTS/CDMA/EDGE/MBWA	2 Mbps	896 MHz	~

Data Processing

- Once that data is collected, and it gets to the cloud, the software performs processing on the gathered data.
- This process can be just checking the temperature, reading on devices like air conditioners or heaters. However, it can sometimes also be very complex like identifying objects, using computer vision on video.

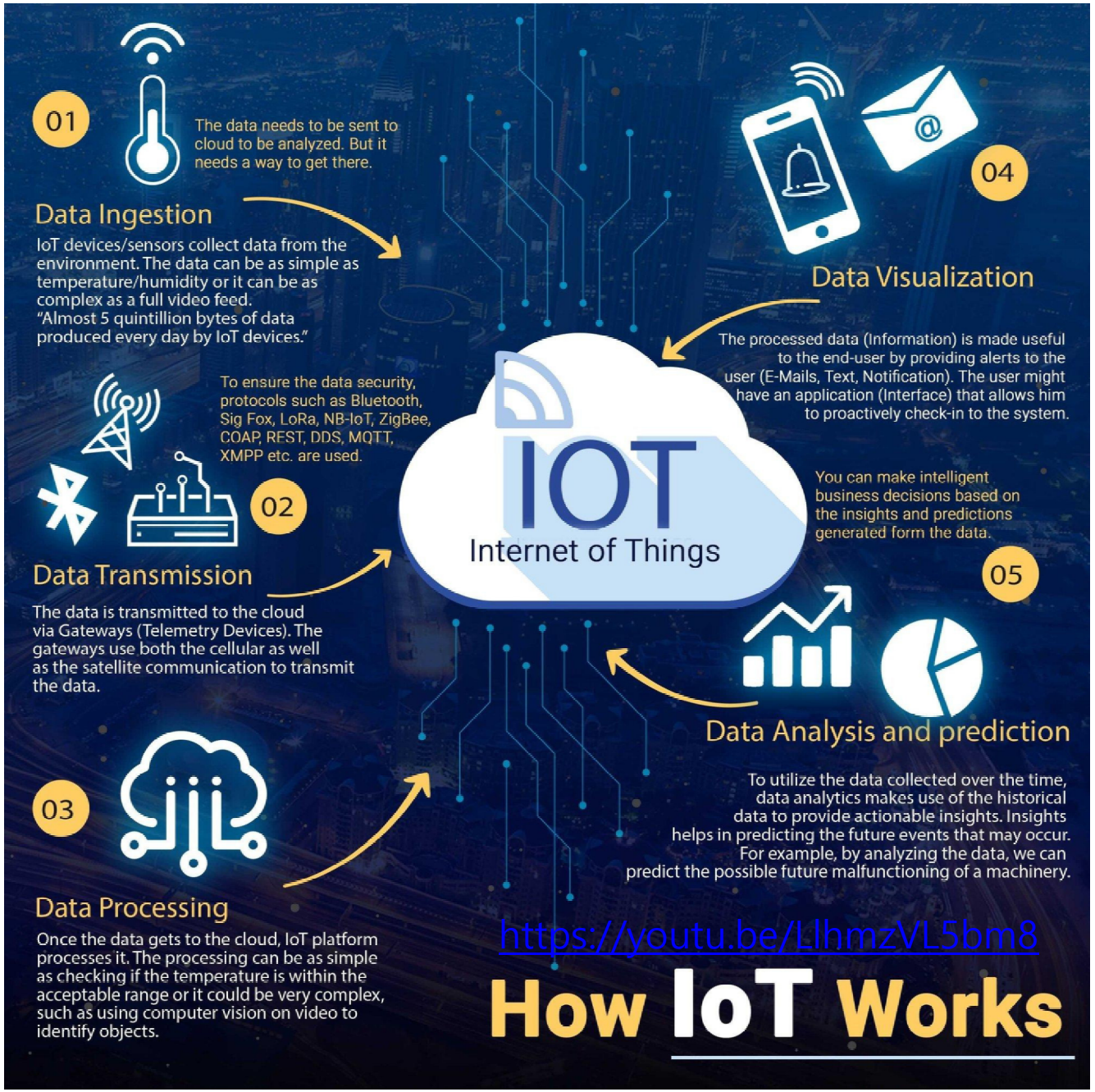


- The data processing cycle consists of three stages: Input (Data), Processing (+Storage), and Output (information).

User Interface

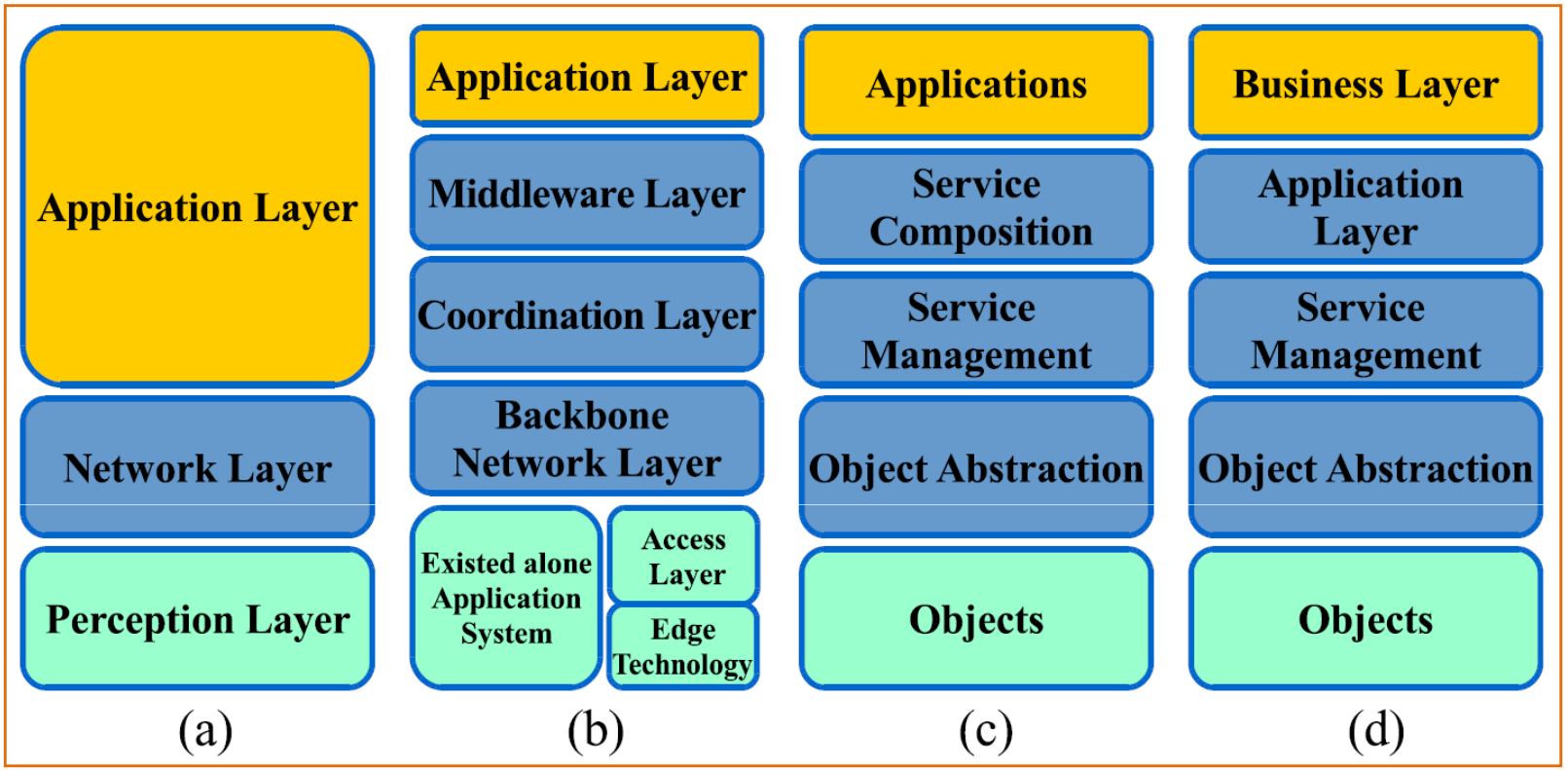
- The information needs to be available to the end-user in some way which can be achieved by triggering alarms on their phones or sending them notification through email or text message.
- The user sometimes might need an interface which actively checks their IoT system.
  - For example, the user has a camera installed in his home. He wants to access video recording and all the feeds with the help of a web server.
- However, it's not always one-way communication. Depending on the IoT application and complexity of the system, the user may also be able to perform an action which may create cascading effects.
  - For example, if a user detects any changes in the temperature of the refrigerator, with the help of IoT technology the user should able to adjust the temperature with the help of their mobile phone.

How IoT Works – A Summary



IoT Architecture

- The IoT should be capable of interconnecting billions or trillions of heterogeneous objects through the Internet, so there is a critical need for a flexible layered architecture.



The IoT architecture. (a) Three-layer. (b) Middle-ware based. (c) SOA based. (d) Five-layer.

IoT Architecture (cont.)

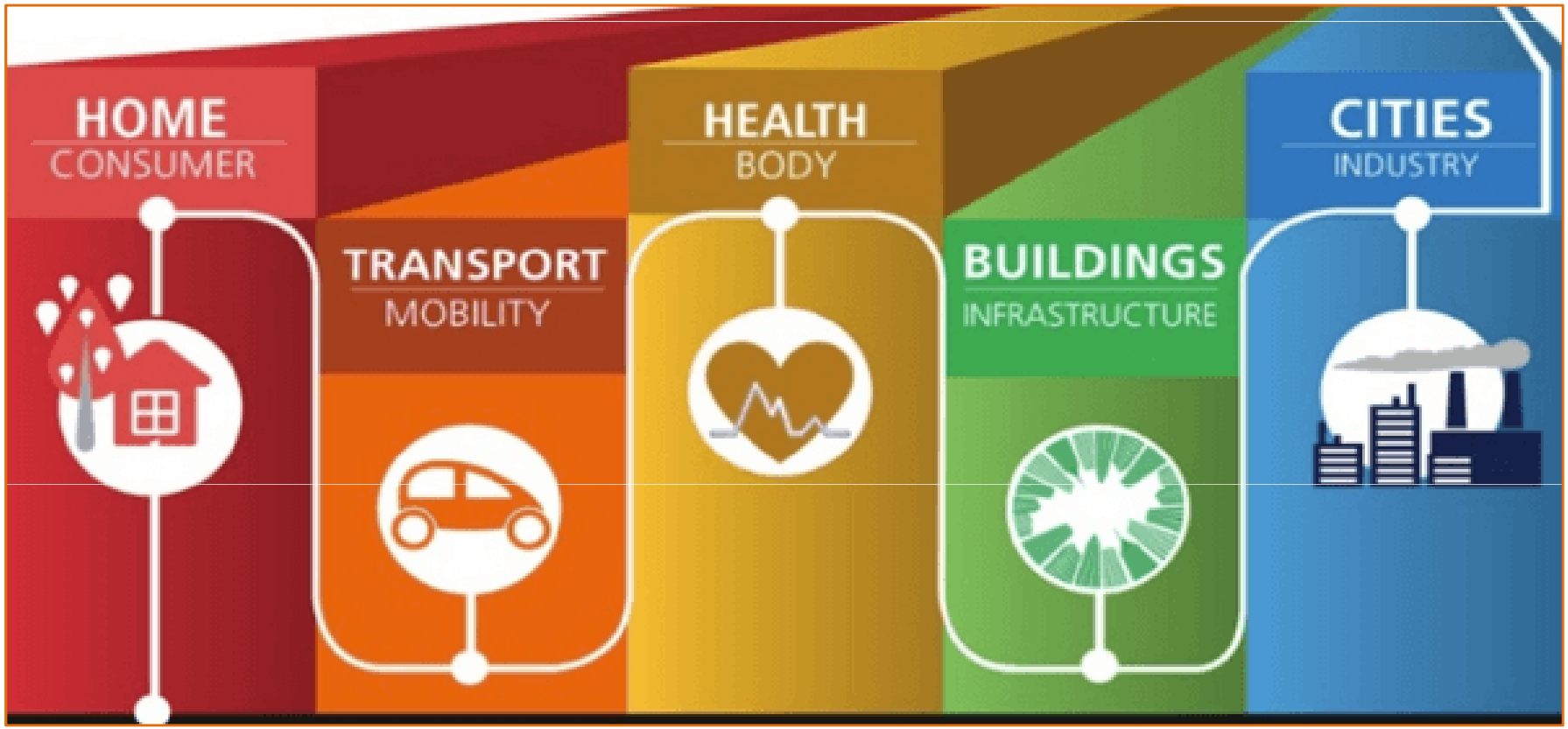
Layer Name	Description
Objects Layer	The objects (devices) or perception layer, represents the physical sensors of the IoT that aim to collect and process information. Standardized plug-and-play mechanisms need to be used by the perception layer to configure heterogeneous objects. The perception layer digitizes and transfers data to the Object Abstraction layer through secure channels.
Object Abstraction Layer	Object Abstraction transfers data produced by the Objects Layer to the ServiceManagement layer through secure channels. Data can be transferred through various technologies such as RFID, 3G, GSM, UMTS, WiFi, Bluetooth Low Energy, infrared, ZigBee, etc. Furthermore, other functions like cloud computing and data management processes are handled at this layer.
Service Management Layer	Service Management or Middleware (pairing) layer pairs a service with its requester based on addresses and names. This layer enables the IoT application programmers to work with heterogeneous objects without consideration to a specific hardware platform. Also, this layer processes received data, makes decisions, and delivers the required services over the network wire protocols.

IoT Architecture (cont.)

Layer Name	Description
Application Layer	The application layer provides the services requested by customers. The application layer covers numerous vertical markets such as smart home, smart building, transportation, industrial automation and smart healthcare.
Business Layer	The business (management) layer manages the overall IoT system activities and services. The responsibilities of this layer are to build a business model, graphs, flowcharts, etc. based on the received data from the Application layer. The Business Layer makes it possible to support decision-making processes based on Big Data analysis.

IoT Applications

- IoT solutions are widely used in numerous companies across industries. Some most common IoT applications are given below:



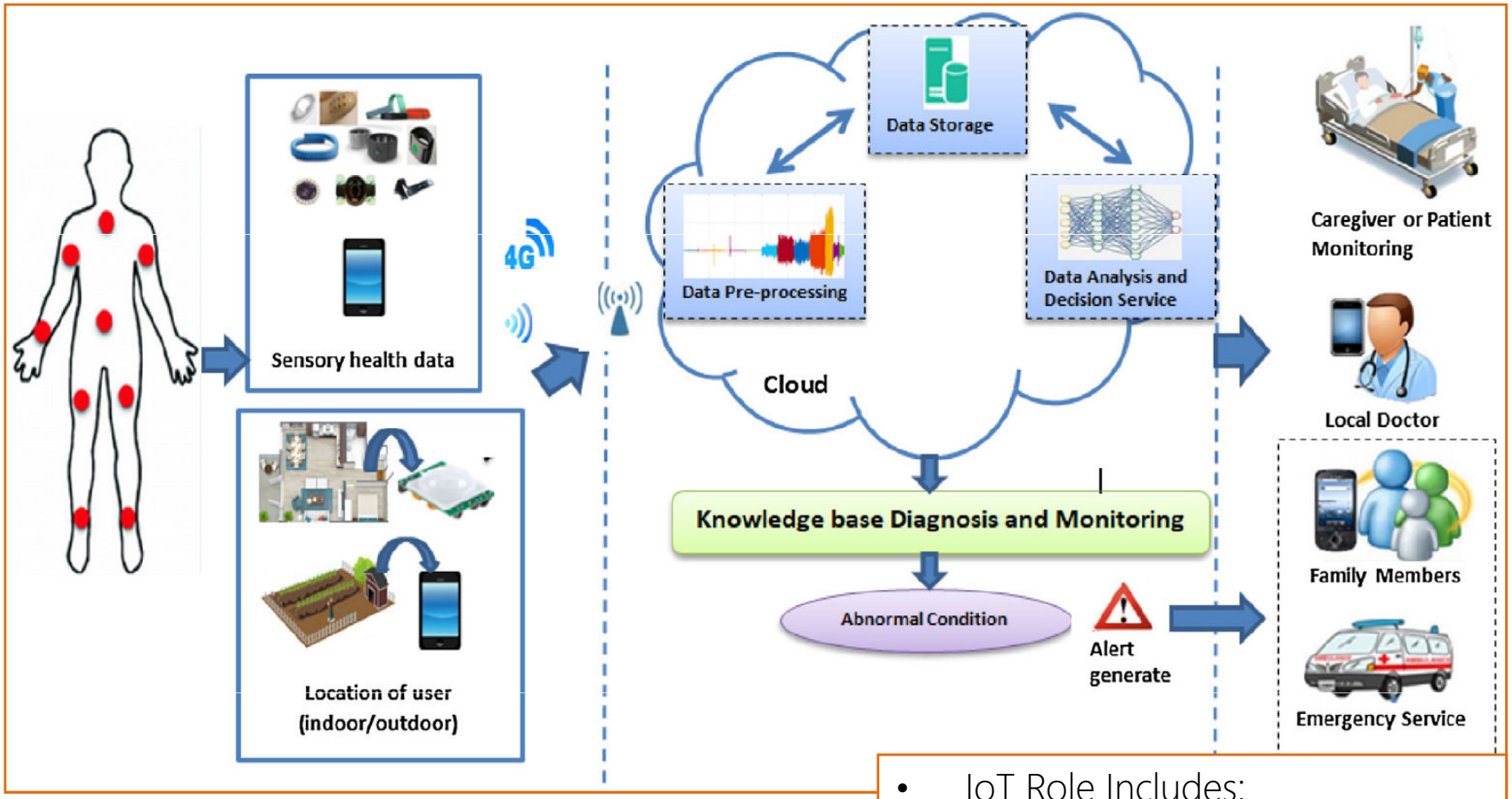
IoT Applications (cont.)

Application type	Description
Smart Thermostats	Helps you to save resource on heating bills by knowing your usage patterns.
Connected Cars	IoT helps automobile companies handle billing, parking, insurance, and other related stuff automatically.
Activity Trackers	Helps you to capture heart rate pattern, calorie expenditure, activity levels, and skin temperature on your wrist.
Smart Outlets	Remotely turn any device on or off. It also allows you to track a device's energy level and get custom notifications directly into your smartphone.
Parking Sensors	IoT technology helps users to identify the real-time availability of parking spaces on their phone.
Connect Health	The concept of a connected health care system facilitates real-time health monitoring and patient care. It helps in improved medical decision-making based on patient data.

IoT Applications (cont.)

Application type	Description
Smart City	Smart city offers all types of use cases which include traffic management to water distribution, waste management, etc.
Smart Home	Smart home encapsulates the connectivity inside your homes. It includes smoke detectors, home appliances, light bulbs, windows, door locks, etc.
Smart Supply Chain	Helps you in real time tracking of goods while they are on the road, or getting suppliers to exchange inventory information.

IoT in Smart Healthcare

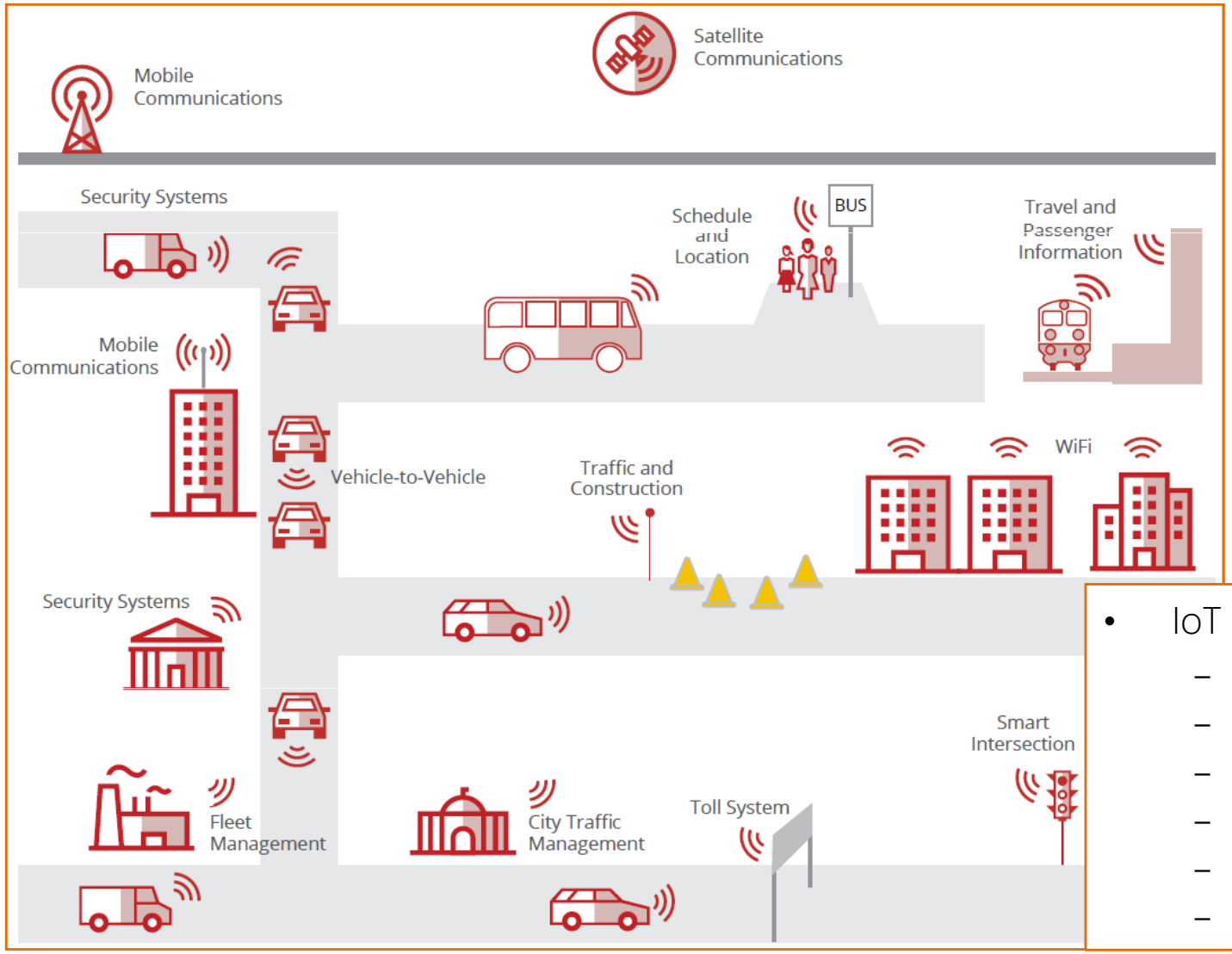


Functional framework for healthcare system.

Source: https://doi.org/10.1016/B978-0-12-819664-9.00007-7

- IoT Role Includes:
  - Real-time monitoring
  - Better emergency response
  - Easy access of patient data
  - Connectivity among stake holders
  - Remote access to healthcare

IoT in Smart Transportation



- The global connected car market will recover from the impact of the global coronavirus pandemic and grow to around 121 billion U.S. dollars by 2025.

Source:
https://www.statista.com/statistics/725025/connected-cars-global-market-size-projection

- IoT Role Includes:
  - Traffic management
  - Real-time vehicle tracking
  - Vehicle-to-Vehicle communication
  - Scheduling of train, aircraft
  - Automatic payment/ticket system
  - Automatic toll collection

Ecosystem and infrastructure of the next-generation car.

IoT in Smart Energy

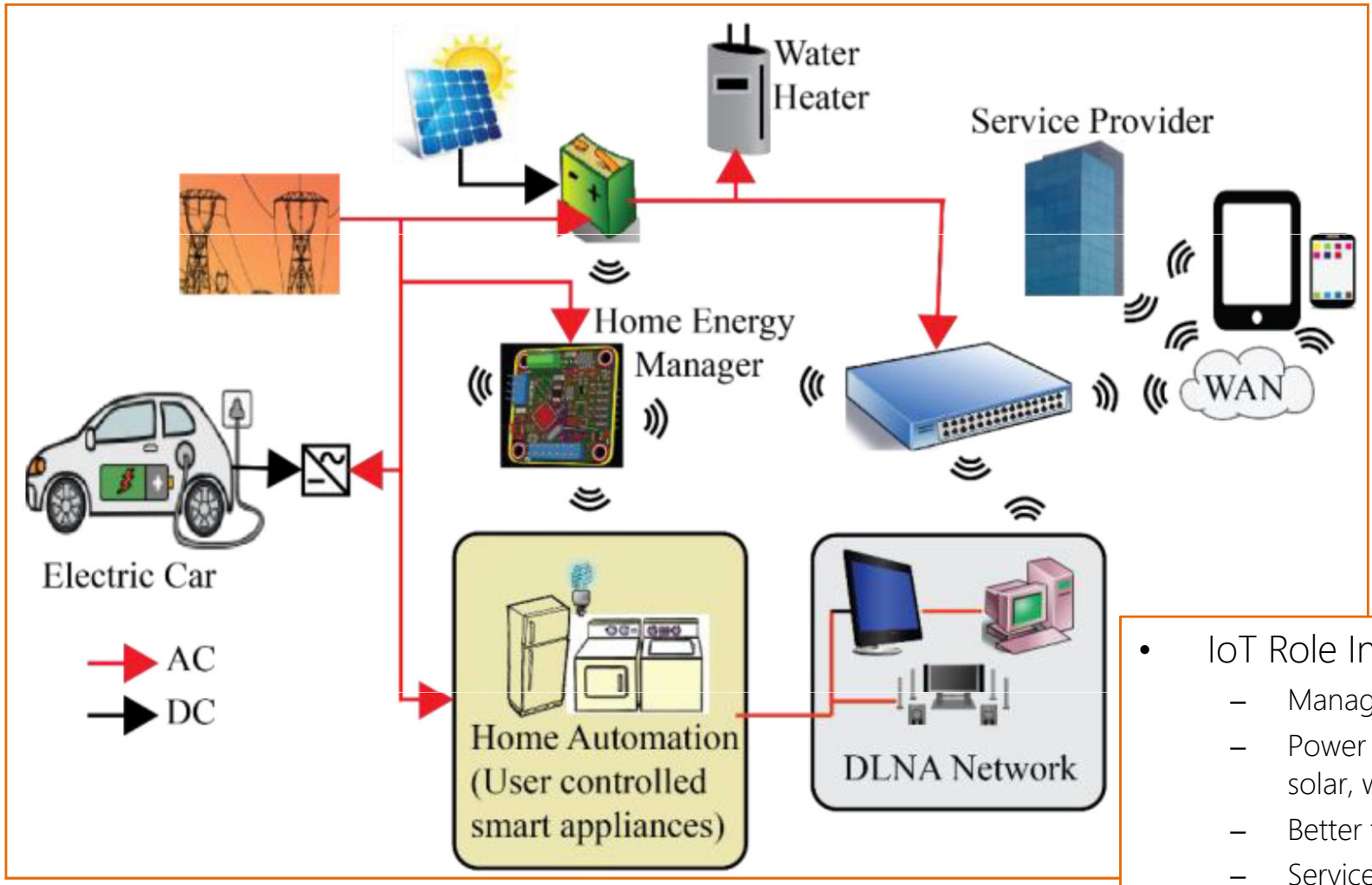


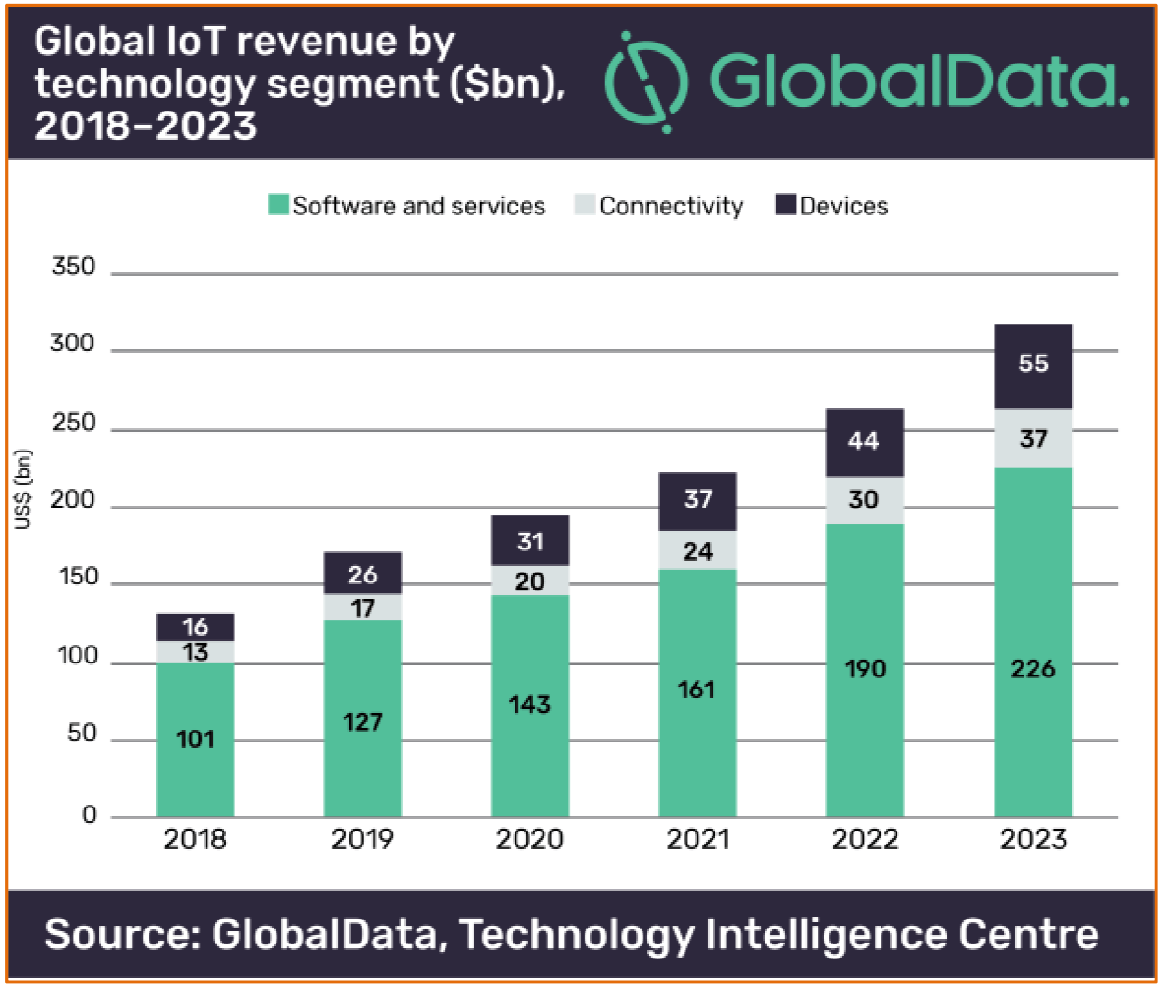
Illustration of a smart energy system.

Source: https://doi.org/10.1109/MCE.2016.2556879

- IoT Role Includes:
  - Management of energy usage
  - Power generation dispatch for solar, wind, etc.
  - Better fault-tolerance of the grid
  - Services for plug-in electric vehicles (PEV)
  - Enhancing consumer relationships

Market Opportunity of IoT (cont.)

- According to a study carried out by Global Data, the IoT market is projected to reach $318bn new worth by 2023 (in constantly rise compared to the previous years).



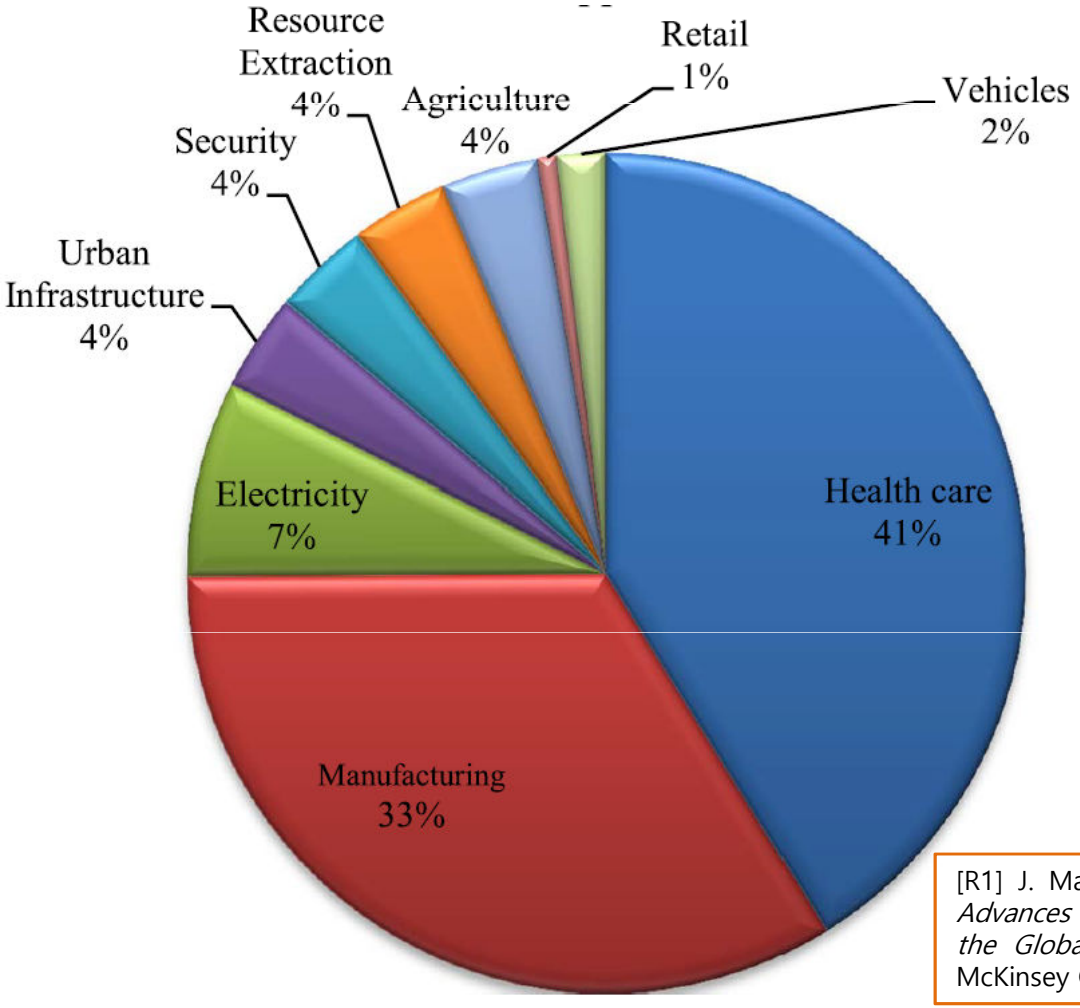
IoT market projections [R2].

[R2] Global IoT market to reach $318 billion by 2023, says GlobalData. Michelle Froese, Windpower Engineering & Development. Accessed at:

https://www.windpowerengineering.com/business-news-projects/global-iot-market-to-reach-318-billion-by-2023-says-globaldata/

Market Opportunity of IoT

- The IoT offers a great market opportunity for equipment manufacturers, Internet service providers and application developers.

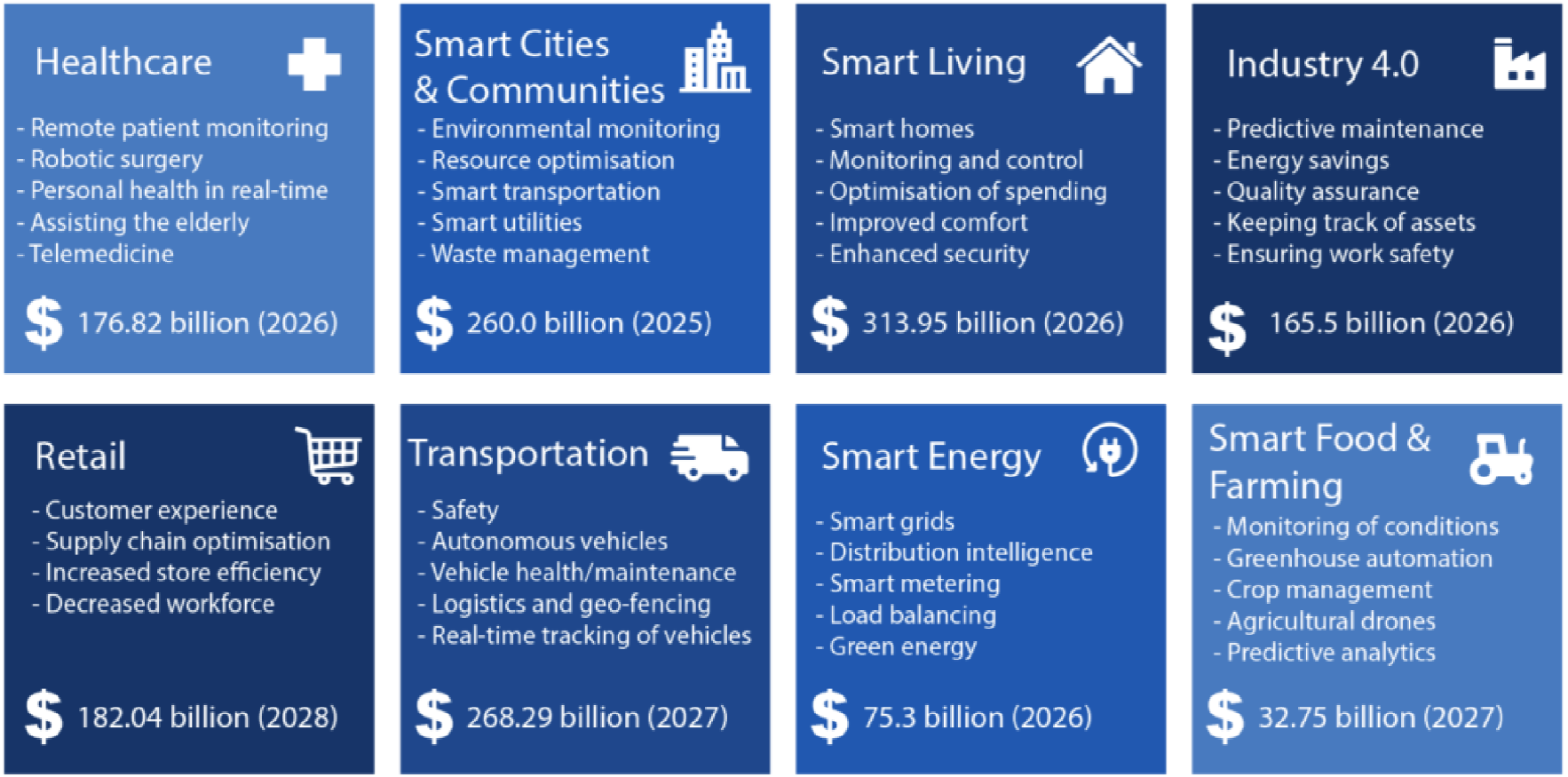


[R1] J. Manyika *et al., Disruptive Technologies: Advances that Will Transform Life, Business, and the Global Economy. San Francisco, CA, USA:* McKinsey Global Instit., 2013.

Projected market share of dominant IoT applications by 2025 [R1].

Challenges of IoT

- Some sectors in which IoT has the highest impact are illustrated below. It is worth noting that these sectors partly overlap (e.g., Smart City and Smart Living).



Estimated global market potential (by 2030) for each IoT sector.

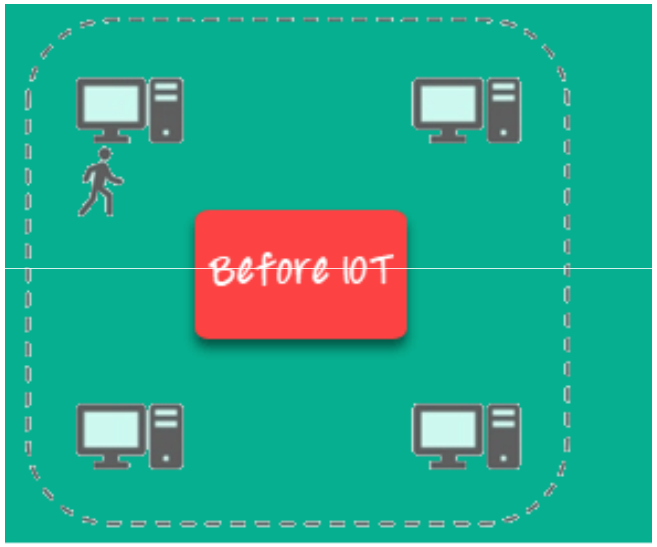
Source: https://centriabulletin.fi/iot-next-phase

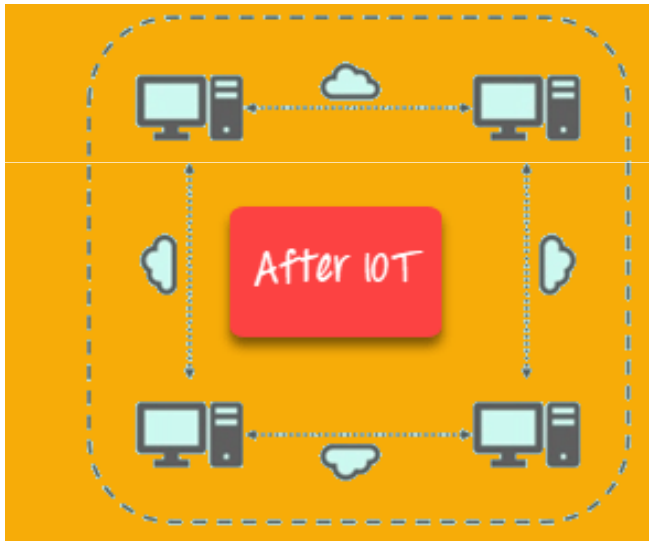
Challenges of IoT

- At present, IoT is faced with many challenges, such as:
  - Insufficient testing and updating
  - Concern regarding data security and privacy
  - Software complexity
  - Data volumes and interpretation
  - Integration with AI and automation
  - Devices require a constant power supply which is difficult
  - Interaction and short-range communication

Advantages of IoT

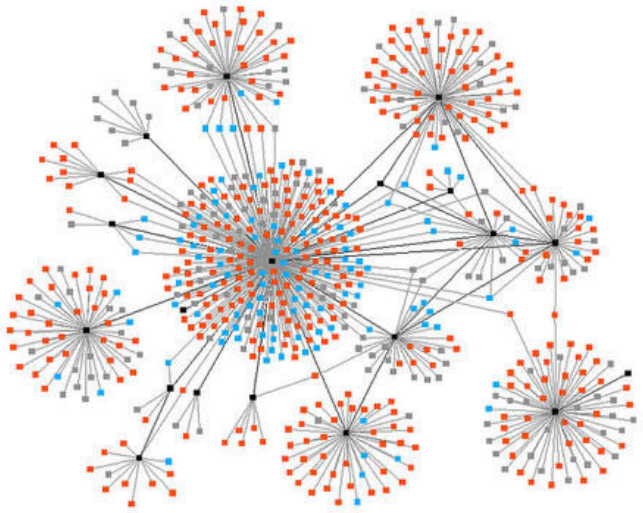
- Key benefits of IoT technology are as follows:
  - **Technical Optimization:** IoT technology helps a lot in improving technologies and making them better. Example, with IoT, a manufacturer is able to collect data from various car sensors. The manufacturer analyzes them to improve its design and make them more efficient.
  - **Improved Data Collection:** Traditional data collection has its limitations and its design for passive use. IoT facilitates immediate action on data.
  - **Reduced Waste:** IoT offers real-time information leading to effective decision making & management of resources. For example, if a manufacturer finds an issue in multiple car engines, he can track the manufacturing plan of those engines and solves this issue with the manufacturing belt.
  - **Improved Customer Engagement:** IoT allows you to improve customer experience by detecting problems and improving the process.





Disadvantages of IoT

- Some disadvantages of IoT are as follows:
  - **Security:** IoT technology creates an ecosystem of connected devices. However, during this process, the system may offer little authentication control despite sufficient security measures.
  - **Privacy:** The use of IoT, exposes a substantial amount of personal data, in extreme detail, without the user's active participation. This creates lots of privacy issues.
  - **Flexibility:** There is a huge concern regarding the flexibility of an IoT system. It is mainly regarding integrating with another system as there are many diverse systems involved in the process.
  - **Complexity:** The design of the IoT system is also quite complicated. Moreover, it's deployment and maintenance also not very easy.
  - **Compliance:** IoT has its own set of rules and regulations. However, because of its complexity, the task of compliance is quite challenging.



IoTs Companies

The 10 Largest IoT Companies in The World: Summary

Rank	Company	Annual Revenue (2022)
1	Apple	$365.82 billion
2	Google	$278.1 billion
3	Samsung Electronics	$244.4 billion
4	Microsoft	$198.3 billion
5	Intel	$79.02 billion
6	IBM	$79 billion
7	Bosch IoT	$78.74 billion
8	Siemens	$62.27 billion
9	Cisco	$49 billion
10	SAP	$27.84 billion

Source: https://history-computer.com/largest-internet-of-things-iot-companies-in-the-world

Summary

- Introduction to Internet of Things (IoT): The Internet of Things (IoT) is a network of physical objects or people called "things" that are embedded with software, electronics, network, and sensors which allows these objects to collect and exchange data.
- The actual idea of connected devices was proposed in 1970.
- Four Key components of IoT framework are 1) Sensors/Devices, 2) Connectivity, 3) Data Processing, 4) User Interface.
- Various applications of IoT are Smart Thermostats, Connected Cars, Activity Trackers, Smart Outlets, Connect Health, etc.
- Technical Optimization, Improve Data Collection, Reduced Waste, Improved Customer Engagement are key benefits of IoT.
- Security, Privacy, Complexity, Compliance, are key challenges of IoT.

Video: Internet Of Things (IoT) In 10 Minutes

THANK YOU ALL FOR LISTENING

QUESTIONS AND ANSWERS